GROUNDWATER AND SURFACE WATER CONDITIONS REPORT - 2015

United Water Conservation District

OPEN-FILE REPORT 2017-01

PREPARED BY

GROUNDWATER RESOURCES DEPARTMENT
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Groundwater Resources Department
March 2017

THIS REPORT IS PRELIMINARY AND IS SUBJECT TO MODIFICATION BASED UPON FUTURE ANALYSIS AND EVALUATION

Cover Photo: Santa Clara River upstream of Freeman Diversion.

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EXECUTIVE SUMMARY / ABSTRACT

United Water Conservation District is a public agency that encompasses nearly 213,000 acres of central and southern Ventura County. The District covers the downstream (Ventura County) portion of the valley of the Santa Clara River, as well as the Oxnard coastal plain. The District serves as the steward for managing the surface water and groundwater resources within all or portions of eight groundwater basins. This report includes data and records from the 2014 and 2015 calendar years, including basic information and discussion on the operation of the District's facilities, weather and hydrologic information, groundwater levels and available storage within the basins, and the quality of surface water and groundwater.

The years 2014 and 2015 marked the third and fourth consecutive year of drought in the state. Locally, the 2012-2015 drought period qualifies as the driest four consecutive years on record, and also includes some of the driest years ever recorded. District operations, and surface water and groundwater hydrology within the District's service area have been severely impacted by the drought. Surface water diversions, conservation releases, and groundwater recharge amounts are at an all-time low, causing increased reliance on groundwater pumping to meet irrigation demands on the Oxnard coastal plain. Groundwater elevations in many basins are at or near historic lows, exacerbating groundwater quality issues such as saline water intrusion and elevated nitrate concentrations in some areas.

The District's projects and programs are implemented to manage, mitigate, or eliminate water resource issues and concerns that threaten the water resources. These issues and concerns include, but are certainly not limited to, groundwater overdraft and the intrusion of saline water in the Oxnard Plain and Pleasant Valley basins, the gradual, long-term declining water levels in the Santa Paula Basin, degraded water quality in the Oxnard Forebay basin and the Piru basin, and issues related to management of the water resources of the Piru, Fillmore and Mound basins. In addition, United is also concerned with quagga mussel control in Lake Piru, water quality and riverbed stabilization of the Santa Clara River and ensuring surface water for environmental initiatives. Most of these concerns have become more acute due to the current drought conditions.

To address these issues and concerns, United implements a wide variety of activities. Some of the activities are District-wide, for example: water levels are monitored in an extensive network of wells thorough the District, and a significant number of these wells are sampled as a part of a water quality monitoring program. In addition, stream gauging and channel surveys are performed periodically to identify dry reaches and locations of rising groundwater, and to quantify surface water volumes and flow rates under various hydrologic conditions. These data are important to United's habitat conservation efforts and the facilitation of fish passage at the Freeman Diversion, as well as optimizing various District operations (e.g., annual conservation release, diversion of water to recharge basins or for use in-lieu of groundwater pumping by agricultural operations on the Oxnard

Plain and in Pleasant Valley basin). Currently, the largest project underway by the groundwater department is the development of a groundwater flow model for the basins of the Oxnard coastal plain. This is a multi-year, multi-faceted project that requires the expertise of several groundwater science specialties and relies on the District's long record of water-level, water quality, stream gauging and facility operations data. When completed, the groundwater flow model will be a primary evaluative tool for various proposed water management scenarios and will assist stakeholders with enhancing the sustainability and reliability of local water resources. Other projects by the groundwater department include assisting basin stakeholders with implementation of the Sustainable Groundwater Management Act, regional water supply studies, recycled water initiatives, preliminary studies on a proposed iron and manganese treatment plant at El Rio, preliminary studies on a solar power facility, creating and updating surface water models, geophysical investigations and saline intrusion studies.

Issue-specific projects are also implemented by United to assist local stakeholders in the management of local water resources (e.g., 2014 and 2015 Piru and Fillmore Basins Biennial Groundwater Conditions Report, analyses of groundwater conditions in the Santa Paula basin as a part of the Technical Advisory Committee) and the pursuit of grant funds (e.g., Local Groundwater Assistance Program grants from CA Department of Water Resources, Fox Canyon Groundwater Management Agency Groundwater Supply Enhancement Assistance Program) to help defray the costs of some of the groundwater projects.

The benefits of the surface water and groundwater projects and programs operated by United are shared by the many groundwater pumping entities within the District and those who receive those waters. Many of the benefits are in the background and not readily recognized or apparent to individual water users, however, the positive impacts of the District's activities are significant to the agricultural, municipal, and industrial economies of Ventura County.

1 INTRODUCTION AND BACKGROUND

United Water Conservation District (also “United” or “District”) is a public agency that encompasses nearly 213,000 acres of central and southern Ventura County. The District covers the downstream (Ventura County) portion of the valley of the Santa Clara River, as well as the Oxnard Plain. The District serves as a steward for managing the surface water and groundwater resources for all or portions of eight interconnected groundwater subbasins (Figure 1-1). It is governed by a seven-person board of directors elected by division, and receives revenue from property taxes, groundwater extraction (pump) charges, recreation fees, and water delivery charges. The developed areas of the District are a mix of agriculture and urban areas, with prime agricultural land supporting high-dollar crops such as avocados, berries, row crops, tomatoes, lemons, oranges, flowers, ornamental nursery stock and sod. Approximately 370,000 people live within the District boundaries, including those living in the cities of Oxnard, Port Hueneme, Santa Paula, Fillmore and eastern Ventura.

The District is authorized under its principal act (California Water Code Section 74000 et seq) to exercise multiple powers. These powers include the authority to conduct water resource investigations, acquire water rights, build facilities to store and recharge water, construct wells and pipelines for water deliveries, commence actions involving water rights and water use, prevent interference with or diminution of stream/river flows and their associated natural subterranean supply of water, and to acquire and operate recreational facilities in connection with dams, reservoirs or other District works.

This report includes general information about the District’s mission and detailed data on the operation of the District’s facilities, weather and hydrologic information for calendar years 2014 and 2015, including discussion regarding groundwater levels and storage within the basins, and the quality of the surface water and groundwater. Recent and current studies and investigations conducted by the District’s Groundwater Department are also detailed. This report updates information presented in a similar report detailing District conditions in 2013 (UWCD, 2014), and provides additional context to underscore the effects of the current drought conditions, where appropriate.

1.1 UWCD MISSION STATEMENT AND GOALS

The District’s mission statement is:

United Water Conservation District shall manage, protect, conserve, and enhance the water resources of the Santa Clara River, its tributaries and associated aquifers, in the most cost-effective and environmentally balanced manner.

In order to accomplish this mission, United Water Conservation District follows these guiding principles:

- Construct, operate, and maintain facilities needed now and in the future to put local and imported water resources to optimum beneficial use;
- Deliver safe and reliable drinking water that meets current and future health standards to cities and urban areas;
- Provide an adequate and economical water supply to support a viable and productive agricultural sector;
- Fight overdraft and seawater intrusion and enhance the water quality of the aquifers through the use of District programs;
- Monitor water conditions to detect and guard against problems and to report those conditions to the public;
- Seek opportunities to develop cooperative programs with other agencies in order to maximize use of District resources and promote mutually beneficial projects;
- Acquire and operate high-quality public recreational facilities that are financially self-supporting;
- Balance District operations with environmental needs to maximize use of the region's water resources; and
- Conduct District affairs in a business-like manner that promotes safe investment policy, sound financial audits and the utmost in professional and financial integrity.

The District recognizes that many of the projects and activities required to implement these guiding principles have long timelines for development and initiation, and the positive impacts of these projects and activities may be realized over many years. This is consistent with the District's mission to provide for the long-term health of the water resources within the District. To fulfill its mission, the District retains technical experts in the fields of engineering, hydrogeology, surface water hydrology, environmental science, ecology, and regulatory compliance, as well as administrative personnel with specialties in accounting and finance.

1.2 UWCD HISTORY

The original founding organization for United Water Conservation District was called the Santa Clara River Protective Association. It was formed in 1925 to protect the runoff of the Santa Clara River from being appropriated and exported outside the watershed. The Santa Clara Water Conservation District (Santa Clara WCD) was formed in 1927 to further the goals of the Association by protecting water rights and conserving the waters of the Santa Clara River and its tributaries. The Santa Clara WCD began a systematic program of groundwater recharge in 1928, primarily through constructing spreading grounds along the Santa Clara River. Sand dikes were constructed on the Santa Clara River near Saticoy to divert river water into spreading grounds in nearby upland areas.

As groundwater overdraft and seawater intrusion on the Oxnard Plain were recognized in the 1940s, it was clear that the Santa Clara WCD did not have the financial ability to raise money to construct the facilities necessary to combat the problem. With the help of the City of Oxnard, a new district was organized in 1950 under the Water Conservation District Law of 1931. The new district was called

United Water Conservation District for its unification of urban and agricultural concerns. Substantial bond measures were approved by the constituents of the District, allowing United to construct a number of water conservation projects, including:

- Santa Felicia Dam (1955) to capture and store winter runoff on Piru Creek to release in controlled amounts during the dry season. The 200-foot high dam can currently store about 82,000 acre-feet (AF) in Lake Piru. The reservoir is located downstream of a State Water Project reservoir, enabling the District to receive Northern California water via flows down middle Piru Creek without the construction of expensive delivery pipelines;
- A pipeline to new spreading grounds at El Rio; and
- Municipal wells at the El Rio spreading grounds to produce water for the Oxnard-Hueneme (O-H) pipeline (1954) that supplies drinking water to the cities of Oxnard and Port Hueneme, a number of mutual water companies, and the two Navy bases at the coast. The O-H system supplies water from the Oxnard Forebay basin (the recharge area for the Oxnard Plain basin), rather than pumping individual wells in coastal areas of the Oxnard Plain that could accelerate seawater intrusion.
- A pipeline to Pleasant Valley (1958) delivering surface water diverted from the Santa Clara River to offset groundwater pumping for crop irrigation.

Following increasing intrusion of seawater from the 1950s to the 1980s, United Water built several new facilities to increase recharge to the aquifers and to decrease groundwater pumping in areas affected by the intrusion. These facilities provide both direct present benefit, and long-term benefits, to the groundwater aquifers and to the groundwater extractors in the District. The Pumping Trough Pipeline (PTP) was constructed in 1986 to convey diverted river water to agricultural pumpers on the Oxnard Plain, thus reducing the amount of groundwater pumping in critical areas. The Freeman Diversion (1991) replaced the temporary diversion dikes in the Santa Clara River with a permanent concrete structure, allowing diversion of storm flows throughout the winter. A major additional benefit of the Freeman Diversion was the stabilization of riverbed elevations upstream of the facility, correcting the long-term incision of the river related to decades of in-channel gravel mining in the Saticoy vicinity.

Following the construction of the Freeman Diversion, United constructed additional facilities to expand and optimize recharge operations in the Oxnard Forebay. These facilities include:

- Noble spreading basins (1995) were constructed from an existing gravel mining pit to expand recharge capacity of the Saticoy Recharge Facility.
- Saticoy well field (2003) was constructed to pump down the groundwater mound that develops beneath the Saticoy spreading grounds during periods of heavy spreading.
- Rose and Ferro basins (2009), former mining pits located in the Oxnard Forebay to be used for future groundwater recharge activities. In 2015 United completed a pipeline connection to the Rose basin, but infrastructure has not yet been constructed to convey water to the Ferro basin.

1.3 UWCD ORGANIZATION

The District is governed by a seven-person board of directors elected by division, and receives revenue from property taxes, groundwater extraction (pump) charges, recreation fees, and water delivery charges. The District currently employs about 50 full-time staff. Management, professional staff and administrative staff work out of the District's headquarters in Santa Paula. Operations staff are based at field offices located at Lake Piru, Saticoy and El Rio.

1.4 UWCD OPERATIONS AND FACILITIES

United Water Conservation District operates a series of water conservation facilities from the tributaries of the Santa Clara River to the Oxnard Plain and Pleasant Valley (Figure 1-1). These facilities store winter runoff for later release during the dry season, divert water from the Santa Clara River, recharge the aquifers through the natural river channel and off-channel spreading basins, and deliver surface water and groundwater to cities and growers so that groundwater pumping is reduced in critically overdrafted areas.

1.4.1 SANTA FELICIA DAM AND LAKE PIRU

Santa Felicia Dam (SFD) was constructed in 1955 for the conservation of runoff on Piru Creek. The main function of the dam is to retain the high flows in Piru Creek during the winter and spring months, and release the stored water in the fall when the basins of the Santa Clara River valley and the facilities that receive water from the Freeman Diversion have the capability to receive the most benefit from the release. The current capacity of the Lake Piru, based on a 2015 bathymetric survey, is nearly 82,000 AF (See Figure 1.4-1 for storage history). The operational minimum pool is set at 20,000 AF of storage to help prevent the accumulation of sediment around the outlet works for the Santa Felicia Dam. However, due to the drought conditions, volume of water stored in Lake Piru as of December 31st, 2015, was only 11,500 AF.

1.4.2 PIRU DIVERSION AND SPREADING GROUNDS

The Piru Diversion has historically been operated to divert surface water from lower Piru Creek into the Piru Spreading Grounds for groundwater recharge, however this facility has not been operated since September 2008. The diversion is located on the western bank of Piru Creek just south of the old Center Street Bridge in the town of Piru. Part of the diversion dam is built under the two roadway bridges crossing lower Piru Creek at Center Street.

The existing diversion consists of an earthen berm that extends out across the stream channel, a sluice channel that can accommodate approximately 200 cubic feet per second (cfs), and a diversion structure with trash rack, and four 24-inch inlets leading to a 48-inch diversion pipe that conveys diverted water to the 44-acre spreading grounds. The structure lacks a fish screen and is not in compliance with National Marine Fisheries Service (NMFS) standards for diverting water in a stream that could possibly contain endangered southern California steelhead. The diversion will not be put back into operation until an incidental take permit has been issued and the diversion facility has been retrofitted.

1.4.3 FREEMAN DIVERSION AND SATICOY RECHARGE FACILITY

The Freeman Diversion is located on the Santa Clara River about 10.5 miles upstream from its mouth at the Pacific Ocean. The concrete diversion structure was completed in 1991 and replaced the previous diversion method of building temporary sand and gravel diversion dikes, levees, and canals. The prior method of diverting water from the Santa Clara River near Saticoy had been in practice since the 1920s. With each high flow in the river the dikes were washed out, eliminating the ability to divert water until construction crews were able to work in the riverbed with bulldozers to restore the diversion levees. Construction of the Freeman Diversion has increased the conservation of flood flows by extending the time each year when flows can be diverted and not discharged to the ocean. The current facility consists of the following structures: diversion structure, fish passage facilities, headworks, canal, flocculation building, and desilting basin.

Water releases from Lake Piru and a portion of the natural runoff from the Santa Clara River are diverted by the Freeman Diversion. The diversion is operated to redirect surface water from the Santa Clara River to United's Saticoy Recharge Facility, which includes the Saticoy, Noble, and Rose recharge basins and allows recharge of the aquifers underlying the Oxnard Forebay and the Oxnard coastal plain. The remainder of the diverted water is delivered directly to agricultural users to satisfy irrigation demand "in lieu" of the users pumping groundwater (or routed to the El Rio Recharge Facility). These deliveries are designed to reduce groundwater pumping in areas where overdraft conditions and related water quality issues exist, such as areas where aquifers are most susceptible to lateral seawater intrusion, the compaction of marine deposits that can expel saline water, and the upwelling of brines.

1.4.4 EL RIO RECHARGE FACILITY

The El Rio Recharge Facility includes the El Rio recharge basins and other facilities, and is located approximately two miles southwest of the Saticoy Recharge Facility, adjacent and northeast of the community of El Rio (Figure 1-1). Surface water diverted from the Santa Clara River is delivered here via the El Rio branch of the main supply line. Water can be distributed among ten recharge basins by pipelines, distribution canals and control gates. The total area of the recharge ponds is approximately 80 acres.

1.4.5 MUNICIPAL WATER DELIVERIES

United built the Oxnard-Hueneme (O-H) system in 1954 to move municipal groundwater extraction on the Oxnard Plain away from coastal areas subject to seawater intrusion. The well field for the O-H system surrounds the El Rio recharge basins, and water produced by the well field is a blend of recharge water that has filtered down through the aquifer, and water drawn laterally from surrounding areas. The El Rio well field includes both upper and lower aquifer wells, allowing a blending of sources for water quality purposes. In practice, the Lower Aquifer System (LAS) wells are rarely used, as they are primarily used as alternative wells when the shallower wells screened in the Upper Aquifer System (UAS) have high nitrate concentrations. The LAS wells were used extensively in 2014 and 2015.

In addition to the recharge basins and production wells at the El Rio Recharge Facility, treatment and distribution facilities for the O-H potable system exist at this location. Well water is routed to a water treatment facility for chloramine treatment, then two 8,000,000 gallon clear wells provide storage and contact time before water is delivered by pipeline to users. Four variable-frequency drive booster pumps draw water from the clear wells, matching demand on the pipeline and maintaining pressure in the distribution pipelines.

The California Department of Health Services requires the publication of an annual water quality summary of water delivered public water systems. The 2015 Consumer Confidence Report for the O-H water delivery system is included in Appendix A. United operates the O-H delivery system as an enterprise fund; water rates are set and approved by the users to support operation and improvements to the system without subsidies from United's other rate payers. Major customers include the City of Oxnard, the Port Hueneme Water Agency, and a number of mutual water companies in the southern Oxnard Forebay and on the Oxnard Plain.

1.4.6 AGRICULTURAL WATER DELIVERIES

Water deliveries to growers are distributed by two pipelines, the Pumping Trough Pipeline (PTP) and the Pleasant Valley Pipeline. These distribution systems are discussed separately in the following two subsections. See Figure 1-1 for locations.

1.4.6.1 PTP DELIVERY SYSTEM

The Pumping Trough Pipeline was designed to serve surface water from the Santa Clara River to a portion of the Oxnard Plain located east of the City of Oxnard. In the 1970s the aquifers of the UAS were severely overdrafted in this vicinity, and there were fears that seawater would be drawn from coastal areas to this central portion of the Oxnard Plain. Five LAS wells were constructed along the PTP pipeline to balance pipeline pressures and provide additional water to the system when surface water supplies are incapable of meeting demand. Like the O-H System, the PTP delivery system is operated as an enterprise fund. The four UAS wells of the Saticoy well field, completed in 2003, can also provide groundwater to the agricultural pipelines when groundwater elevations are high near the Saticoy Recharge Facility.

1.4.6.2 PLEASANT VALLEY DELIVERY SYSTEM

Water diverted from the Santa Clara River is delivered to the Pleasant Valley County Water District (PVCWD) via the Pleasant Valley Pipeline. The pipeline terminates at United's Pleasant Valley Reservoir, located east of the Camarillo Airport near the City of Camarillo. PVCWD operates the reservoir and eleven LAS wells in the western Pleasant Valley basin and a portion of the Oxnard Plain basin, supplying water to agricultural customers via a delivery system linking the wells and the reservoir. The delivery of diverted river water to PVCWD offsets pumping of irrigation wells in the area. United is obligated by contract to supply, on an annual basis, 12.22 percent of the water diverted at the Freeman Diversion to PVCWD. Since 2002 PVCWD has also purchased and received surface water from the Conejo Creek Diversion, operated by Camrosa Water District.

1.5 GROUNDWATER ISSUES AND CONCERNS

United's core mission is to manage, conserve, protect and enhance the water resources that exist within the District boundaries. United operates Santa Felicia Dam and maintains contractual arrangements with a number of upstream agencies to store or convey surface runoff from the upper portions of the Santa Clara River watershed to the lower (Ventura County) portions of the watershed. United does not regulate the use of groundwater within the District boundaries, but operates a number of facilities intended to maximize the conjunctive use of surface water and groundwater resources. Aside from United's annual State Water imports of up to 3,150 acre-feet, the Ventura County portion of the Santa Clara River valley is wholly dependent on local water resources for irrigation and potable supply, an uncommon arrangement in southern California where most areas regularly import large quantities of water. Significant quantities of State Water are however purchased from Calleguas Municipal Water District by the cities of Oxnard and Camarillo for urban use on the Oxnard coastal plain.

Despite long-term efforts to import more water to the District and optimize the use of local resources, water deficits exist in a number of areas throughout the District. In some places the depletion of groundwater reserves has simply resulted in lowered water tables. In other areas significant water quality problems have developed in response to conditions of overdraft. Water quality problems can also be related to land use practices, or exist naturally.

Listed below are summaries of several of the water supply and water quality issues that exist within United's district boundaries. Many of these issues are exacerbated and have become more acute in the current drought conditions. In some cases, United's involvement includes groundwater recharge or water delivery to actively address issues related to overdraft. In other cases, United has conducted or sponsored research in order to better define existing problems and help identify potential physical projects or management strategies to mitigate the problem. United management and staff are knowledgeable concerning groundwater management practices and have expertise in conducting monitoring programs and with applying various methods for evaluating basin conditions (e.g., Bachman et al., 2005). United's water management activities go well beyond the storage, distribution and deliberate recharge of water within the watershed of the Santa Clara River. For example, United is actively involved in various watershed management activities and has helped to coordinate the formation of local Groundwater Sustainability Agencies as mandated by the 2014 Sustainable Groundwater Management Act.

1.5.1 DROUGHT CONDITIONS

The water years 2012-2015 stand as the region's driest four consecutive years in terms of rainfall. While the hydrology of the current drought is comparable to some of the other prolonged drought periods in recent history (e.g. 1895-1901, 1946-1951), its impacts to the region are arguably more severe due to the present-day level of development. The impacts within United's boundaries are multifold, including diminished flow in surface water bodies, a reduction in recharge to groundwater basins, less interaction between surface water and groundwater, and changes in the operation of District facilities.

With diminished rainfall there is less natural runoff from the Santa Clara River and Calleguas Creek watersheds. Both the direct infiltration of rainfall and the percolation of stream flow are important sources of recharge to area groundwater basins. Dry antecedent soil conditions require more rainfall before water can move down beyond the root zone of plants and serve as groundwater recharge. Dry soil conditions also need more applied irrigation when less soil moisture is provided by precipitation.

Declining groundwater elevations related to drought in the Piru and Fillmore basins has resulted in diminished groundwater discharge near the downstream boundaries of those basins. Groundwater discharge from the Fillmore basin normally provides summer base flow in the Santa Clara River that is diverted by the Freeman Diversion to help meet water demands on the Oxnard coastal plain. These base flows have been greatly diminished in the recent drought years. For the past two decades base flows in Arroyo Las Posas have provided an important source of recharge to the northern Pleasant Valley basin, but these flows are also greatly diminished in recent years. Base flow from the upper Santa Clara River is also diminished, providing less water that serves as recharge to the Piru basin downstream of the Los Angeles County line.

Due to low lake levels in Lake Piru, United has not been able to conduct a conservation release since the fall of 2012. Annual conservation releases usually exceed 30,000 AF, and provide both recharge to downstream basins and direct surface water deliveries to agricultural users on the PV and PTP systems. Similarly, diversions of Santa Clara River flow were at an all-time low during 2014 and 2015. Groundwater recharge at the Saticoy and El Rio facilities were only a fraction of average amounts in these years, totaling less than 2,000 AF to each facility per year. Surface water deliveries to the PTP and PV systems were minimal in 2014 and zero in 2015, and the water supplying PTP customers has shifted to the five LAS wells that normally serve as a supplement to river water. The cessation of surface water deliveries to the PTP and PV pipelines was also motivated by customer concerns that the quagga mussel infestation in Lake Piru could possibly spread downstream and become established in distribution pipelines and farm irrigation systems that receive water diverted from the Santa Clara River.

1.5.2 OVERDRAFT CONDITIONS

Historic Ventura County precipitation records indicate that the region has experienced several extended drought periods over the past century. Available records show that groundwater elevations commonly decline during periods of below-average rainfall. The period 1923-1934 was relatively dry, experiencing only two years with rainfall totals greater than average. Although relatively few water level records exist for water wells on the southern Oxnard Plain during this time, a number of records show water levels below sea level in the early 1930s. The period 1935-1944 was relatively wet, but the summer of 1945 marked the start of another extended dry period. By the early 1950s a number of wells on the southern Oxnard Plain again recorded water levels below sea level. Water levels recovered somewhat in the late 1950s, but depleted basin conditions persisted in the early 1960s before the onset of wetter conditions in the late 1960s. In the Piru and Fillmore basins, historic low water levels were recorded in the early 1950s and the early 1960s. Wide areas of the Oxnard Plain had water levels below sea level again in the mid-1970s and late 1980s, before an extended wet period beginning in 1991 allowed substantial recovery of the aquifers of the UAS. The aquifers of the UAS and LAS on the Oxnard coastal plain are now again substantially depleted following persistent drought conditions beginning in the year 2012. Each of these drought periods witnessed water levels below sea level near the coast, resulting in episodes of lateral seawater intrusion from the near-shore Hueneme and Mugu submarine canyons.

In fall 1975 UAS groundwater elevations in the entire southeastern quadrant of the Oxnard Plain were below sea level, with the sea level contour extending from Port Hueneme northeast as far as 5th Street and Rice Road (SWRCB, 1979). These depleted basin conditions led the State Board to threaten the adjudication of water rights under Water Code Section 2100. Local pumpers expressed a preference for local control of the overdraft problem, and the Fox Canyon Groundwater Management Agency (FCGMA) was authorized by Legislative act in 1982. The act became effective in January 1983, and the initial goals of the agency were to bring the aquifers of the UAS into balance by the year 2000, and eliminate overdraft in (LAS) Fox Canyon aquifer by the year 2010 (FCGMA, 2007). Major investments were made by United, cities and other water agencies to construct infrastructure to enhance recharge and convey water to areas with the greatest pumping depressions and to import State Water Project water. In addition, significant regulatory programs were enacted by the FCGMA to reduce groundwater pumping. These investments and programs were largely successful in eliminating overdraft in the UAS under wet and average climatic conditions, while the aquifers of the LAS have remained in a condition of chronic overdraft over wide areas of the Oxnard coastal plain. Following the onset of drought conditions in 2012, many areas in both the basins of the Santa Clara River valley and the Oxnard coastal plain are now at or near their record low water levels. The California Department of Water Resources (DWR) recently revised their list of basins "subject to critical overdraft." Southern California has six basins designated as subject to critical overdraft, and the Oxnard Plain and Pleasant Valley basins have been assigned this designation. The Oxnard Plain and Pleasant Valley basins are the only two coastal basins on the list.

While the distribution of pumping depressions is different today than when the State Board was threatening adjudication in the late 1970s, UAS groundwater levels in 2015 were generally as low as they were during periods of drought in the 1960s and 1970s (see section 5.3, Figures 5.3-24 and 5.3-29). In the LAS, the deepest pumping depression now commonly straddles the boundary of the Pleasant Valley and Oxnard Plain basins, east of the City of Oxnard and south of the City of Camarillo. Available LAS water level records indicate that groundwater levels in only the northern-most portions of the Oxnard Forebay and Pleasant Valley basins remained above sea level in fall 2015, while groundwater levels throughout the entire Oxnard Plain basin were below sea level (see section 5.3, Figure 5.3-31). The greatest LAS water level depression was observed in the southern Pleasant Valley basin, where an area of about three square miles had groundwater elevations more than 150 feet below sea level.

Overdraft conditions in the Oxnard Plain and Forebay groundwater basins continue today with the average annual overdraft amount estimated to be about 20,000 to 25,000 ac-ft/yr (UWCD, 2015). Land subsidence related to groundwater overdraft has not been thoroughly investigated on the Oxnard Plain, but one estimate suggests up to 2.6 feet of permanent land subsidence (Hanson et al., 2003).

1.5.3 SALINE WATER INTRUSION

High chloride concentrations were first detected in the Oxnard Plain wells in the vicinity of the Hueneme and Mugu submarine canyons in the early 1930s and became a serious concern in the 1950s (CA DWR, 1971). Early monitoring programs used only existing production wells and abandoned wells as monitoring points, and sampling of these wells indicated that there was a widespread area of elevated chloride concentrations in the Hueneme to Mugu areas. In 1989, the United States Geological Survey (USGS) initiated their Regional Aquifer-System Analysis (RASA) study and other cooperative studies with United, the FCGMA and Calleguas Municipal Water District on the Santa Clara-Calleguas groundwater basin. As part of those studies, a series of 14 nested well sites, with three or more wells installed at each site, were drilled and completed at specific depths in the Oxnard Plain basin (Densmore, 1996).

Figure 1.5-1 shows the locations of the RASA well sites on the Oxnard Plain. Prior to the RASA study, it was believed that an area of the UAS extending from approximately Channel Islands Blvd. (2 miles north of Port Hueneme) and across to the area near Highway 1 and Nauman Road, then south to include the area underlying Point Mugu Navy base was intruded by seawater. The installation of a dedicated monitoring network and detailed chemical analysis of water samples from the new wells and other existing wells yielded new interpretations on the extent of seawater intrusion on the Oxnard Plain. The 1991 inland extent of UAS seawater intrusion as interpreted by the USGS was less than previously believed, as some production wells used as monitoring points in previous studies recorded poor quality related to leakage of water down from the Semi-perched aquifer and not the intrusion of seawater. The USGS also determined that some areas with high-chloride groundwater on the Oxnard Plain have not been intruded by seawater, and instead are impacted by subsurface brine migrating into fresh water aquifers from surrounding and underlying formations (Izbicki, 1992; Stamos et al., 1992; Izbicki et al., 1995; USGS, 1996).

In addition to drilling the monitoring wells, the USGS conducted geophysical surveys to determine the general extent of the high-saline areas (Stamos et al., 1992; Zohdy et al., 1993). This work indicated that the high-saline areas consisted of two distinct lobes, with relatively fresh water separating the lobes (USGS, 1996). These areas were resurveyed using similar geophysical methods in 2010 by United (UWCD, 2010b). Additional down-hole conductivity surveys by the USGS (also resurveyed by United) indicate that the edges of the lobes are relatively distinct, with the first saline intrusion occurring in thin individual beds of permeable sand and gravel. As intrusion continues, more individual beds are impacted, resulting in increasing chloride levels in water produced by the well. Thus, the interpretation of high-chloride areas shown on Figure 1.5-1 and other enclosed maps combine measured concentrations from the monitoring wells, geophysical measurements, and study results about the nature of the intrusion front.

Major and minor ion chemistry and certain isotope studies of samples collected from the RASA monitoring wells indicate that chloride degradation in the Oxnard Plain and Pleasant Valley basins is related to four sources and processes (Izbicki, 1991, 1992; Izbicki et al., 2005a). The four major types of chloride degradation that have been documented are:

- Lateral Seawater Intrusion: the inland movement of seawater (under the influence of a landward hydraulic gradient);
- Cross Contamination: the introduction of poor quality water into fresh water aquifer zones via existing wellbores that were improperly constructed, improperly destroyed, or have been corroded by poor-quality water in the Semi-perched aquifer;
- Compaction of Salt-Laden Marine Clays: the dewatering of marine clays, interbedded within the sand and gravel-rich aquifers, yields high concentrations of chloride-enriched water; and
- Lateral Movement of Brines from Tertiary formations: the lateral movement of saline water from older geologic formations that have been uplifted by faulting to positions adjacent younger freshwater-bearing formations.

Chloride degradation from each of the processes identified above is directly related to water levels in the basin. The water balance of the Oxnard Plain and the offshore component of the aquifer units is a dynamic relationship between groundwater recharge, groundwater extraction and change in aquifer storage. The primary source of groundwater recharge for the Oxnard Plain groundwater basin is the unconfined northeastern portion of this basin, known as the Oxnard Forebay (and formerly as the Montalvo basin or Montalvo Forebay). High water levels in the Forebay exert a positive pressure on the confined aquifers of the Oxnard Plain, and water flows from the recharge areas toward the coast. While the pressure exerted by high water levels in the Forebay propagates rapidly through the aquifers, the actual movement of water is very slow, approximately 3 feet per day or less in the

Forebay (Izbicki et al., 1992). The pressure (piezometric) surface of the confined aquifer is diminished by the extraction of water from the system. If pressure heads at the coast fall below sea level, the lateral intrusion of seawater will occur, resulting in aquifers being recharged with seawater due to landward pressure gradients. The dewatering of marine clays will occur if heads in the surrounding sediments remain below their historic levels for prolonged periods, allowing formerly immobile salts to be expelled into surrounding aquifer material. The slow compaction of these clays also contributes to land subsidence.

United recently published a report detailing 2015 water quality and groundwater elevation conditions in the coastal areas of the Oxnard Plain and Pleasant Valley (UWCD, 2016a). The Saline Intrusion Update was prepared to report on recent conditions and summarize previous investigations regarding areas impacted by or vulnerable to seawater intrusion and degradation by other saline waters. Maps that present 2015 chloride conditions and show the interpreted inland extent of high-chloride water in the various aquifers of the Oxnard Plain basin are shown in Section 5.3. Groundwater elevations in the coastal portions of all the confined aquifers of the Oxnard coastal plain were well below sea level in fall 2015. Direct lateral saline intrusion is now occurring near the Hueneme and Mugu submarine canyons, and chloride concentrations associated with brine migration is increasing in a number of the coastal monitoring wells, most notably in the area surrounding Mugu Lagoon.

1.5.4 DECLINING WATER LEVELS IN SANTA PAULA BASIN

In addition to the overdraft conditions in the coastal basins, long-term declining water levels have been observed in the Santa Paula basin. Groundwater elevations in many of the wells (43 of 57 wells) in both the eastern and western portions of the Santa Paula basin failed to fully recover to 1998 levels after near-record precipitation in 2005. This observation is consistent with an observed long-term, gradual decline in basin groundwater elevations (Santa Paula Basin TAC, 2017).

In March 1996, as a result of legal action relating to declining groundwater levels in the Santa Paula basin during the 1984 to 1991 drought and the City of Ventura's stated intention to increase pumping from the basin, the Superior Court of the State of California for the County of Ventura approved a Stipulated Judgment for Santa Paula basin (*United Water Conservation District vs. City of San Buenaventura,* original judgment March 7, 1996, amended judgment August 24, 2010). The Stipulated Judgment established pumping allocations for each basin pumper. Representatives from United, the Santa Paula Basin Pumpers Association (SPBPA) and the City of Ventura submit an annual report detailing basin issues and conditions to the Court.

An evaluation of the spatial and temporal distribution of groundwater pumping in the basin concluded that no significant changes in pumping locations occurred over a 30-year study period (1980 to 2009) and that water level fluctuations observed from 1980 to 2009 in the Santa Paula basin cannot be attributed solely to spatial or temporal variations in pumping (UWCD, 2011b). More recently, members of the Santa Paula Basin Technical Advisory Committee (TAC) has completed or initiated several specialty studies better understand the hydrogeology of the basin and to provide additional data, analysis and interpretations on the possible hydrologic cause(s) of the observed decline in groundwater elevations (Section 2.1.3).

In 2003, a basin study titled "Investigation of Santa Paula Basin Yield" was conducted by experts from the City of Ventura, Santa Paula Basin Pumpers Association and United. The study concluded that the yield of the basin is probably near the historic average annual pumping amount of 26,000 AF (Santa Paula Basin Experts Group, 2003). With new data from recent specialty studies the TAC is continuing to expand the database of available information for the basin.

In the summer of 2014 United retained Daniel B. Stephens and Associates to conduct a new analysis to determine the operational yield of the Santa Paula basin so that future groundwater extractions can be limited to an annual yield that will not result in the continued long-term decline in groundwater levels. Finalization of this study, following the review and input by members of the TAC, is expected in early 2017. In tandem, the SPBPA is sponsoring studies to enhance the operational yield of the basin, should the yield of the basin be less than the current pumping allocations.

1.5.5 UPWELLING SALINE WATER

The upwelling of saline waters has been documented in a number of production wells in the Pleasant Valley basin. Advancements in the tools used in sampling pumping production wells has allowed for the documentation of flow and water quality profiles in long-screen production wells (Izbicki et al., 2005a, 2005b). Data from some area wells indicate that poor water quality at the wellhead results from saline water entering the well from specific aquifer zones. High chloride concentrations most commonly observed in the deepest portion of a well may be indicative of brines migrating from deeper zones towards a water level depression (low pressure area) created by long-term overpumping. This upwelling of brines is another form of saline intrusion, and like the compaction of marine clays, occurrence is not limited to coastal areas (Izbicki, 1992). An increase in the number of LAS wells recording increases in chloride concentrations suggest areas impacted by brine intrusion are increasing, most notably in the Pleasant Valley basin. Available 2015 samples from LAS wells in the Pleasant Valley basin recorded chloride concentrations ranging from 44 to 224 mg/l, with 8 of 21 wells at or above the water quality objective of 150 mg/l chloride. High chloride concentrations were also documented in shallow wells and wells completed in both shallow and deep aquifers.

1.5.6 EXPORTATION OF GROUNDWATER

As agricultural land value continues to increase throughout the District, and as continued urbanization removes farmland from the valley floor, the development of the hillside lands located near a reliable supply of water is also expanding. In many cases the hillside properties will not support a productive well, and water is supplied to the property from a nearby groundwater basin or established surface water diversion. Both water supply options result in the increased use of existing water resources. Most basins within the District lack clear policy or regulation regarding the "export" of water from the basin floor to surrounding uplands, or from one basin to another, although numerous area ranches have employed such arrangements for many years.

The export of groundwater has been an issue of concern in the Piru and Fillmore basins, as recent development of hillside orchards has increased groundwater production from these basins during a period of drought. A well pumping large quantities of groundwater from near the downstream boundary of the Fillmore basin for export to users in the Santa Paula basin may present administrative challenges, as some Fillmore pumpers remain uncomfortable with this practice. Among other groundwater management issues, the export of groundwater must be addressed under the Sustainable Groundwater Management Act (SGMA).

1.5.7 NITRATE IN FOREBAY GROUNDWATER BASIN

The Oxnard Forebay is vulnerable to nitrate contamination for some of the same reasons the basin is valued for water resource projects. The coarse alluvial sediments common to the area allow the rapid vertical transport of water from the near-surface to the water table. During wet periods, the regional water table is often only tens of feet below the land surface in the Forebay. Nitrate is highly soluble and mobile, making it susceptible to leaching from soils and transport to groundwater. Public supply wells in some areas of the Oxnard Forebay periodically exceed the California State Water Resources Control Board's Division of Drinking Water (DDW) maximum contamination level (MCL) for nitrate (45 mg/l as nitrate or 10 mg/l nitrate as N). Exceedance of this MCL can result in methemoglobinemia ("blue baby syndrome") a condition where ingested nitrogen interferes with blood's ability to carry oxygen. Infants less than three months of age are most sensitive to this condition (Canter, 1997). United has conducted a series of studies to determine the extent of nitrate concentrations and the possible causes of this contamination. The Santa Clara River, which provides much of the natural and artificial recharge to the Forebay, is consistently low in nitrate (averaging 7 mg/l nitrate (UWCD, 1996a)). Nitrate loading to the groundwater is principally related to land uses within the Forebay, with the most significant sources being agricultural fertilizers and septic systems. United's groundwater recharge activities in the Oxnard Forebay introduce large volumes of low-nitrate water to the groundwater flow system, providing a water quality benefit to both local wells and wells located greater distances down-gradient from the recharge facilities.

Nitrate levels in the El Rio area have fluctuated widely through time, with highest nitrate levels commonly observed during and following drought periods, and relatively low nitrate levels are often recorded during wet periods (UWCD, 1998). Nitrate levels tend to stay relatively low during wet periods when low-nitrate Santa Clara River water is spread by United in the El Rio recharge basins and natural recharge to the basin is abundant. However, when there is not sufficient river water to spread at El Rio, nitrate levels in the O-H wells often rise, particularly in the northeastern (up-gradient) portion of the spreading grounds. Blending with water from other O-H wells with low nitrate concentrations keeps nitrate concentrations in delivered water within the health standard for potable supply.

During the drought of the late 1980s and early 1990s, nitrate peaks increased in intensity. Following previous droughts, nitrate concentrations in the wells generally decreased to low levels during the intervening wet years. However, following the 1980s to 1990s drought, nitrate levels in a series of wells even increased during the dry season of wet or average precipitation years when flow in the Santa Clara River was low and United was not recharging water at El Rio. The distribution of nitrate both laterally and with depth is difficult to document with certainty, but the sampling of monitoring wells installed over the past decade has shown that the highest nitrate concentrations are often recorded in the shallowest portions of the aquifer (UWCD, 2008). Whereas the large-scale groundwater flow patterns within the UAS of the Forebay are believed to be fairly well understood, the individual flow paths of small volumes of water are often complex. This complexity of flow paths, unknown travel times, and an imprecise knowledge of nitrogen inputs often limits what can be concluded about nitrate provenance from the basic chemical analyses common to many routine groundwater monitoring programs.

In response to long-term concerns about water quality in the Oxnard Forebay and down-gradient areas, and a regulatory order issued by the Los Angeles Regional Water Quality Control Board, areas of high-density septic systems in the greater El Rio area have been converted to sanitary sewers. More than 1,400 properties were connected to sewer between the years 2005 and 2011, with project costs totaling $35 million. The County of Ventura managed the eleven phases of this successful project. Ongoing programs also exist to promote efficient irrigation and fertilizer practices among area growers. These educational programs are conducted regularly by the University of California Cooperative Extension, the Ventura County Farm Bureau and various agricultural product suppliers or manufacturers. Despite these programs to reduce nitrate loading to groundwater, a number of wells in the Forebay continued to exhibit nitrate concentrations above the MCL in 2015, and nitrate concentration have increases in many wells since 2013. These increasing nitrate concentrations are a direct result of the extended period of drought the region is currently experiencing. In 2014 and 2015 United produced water from the LAS wells of O-H system to blend with water produced from the UAS wells in order to maintain acceptable nitrate concentrations in the O-H potable water delivery system.

1.6 SURFACE WATER ISSUES AND CONCERNS

Complex and variable interactions between surface water and groundwater flow systems exist within the valley of the Santa Clara River. Along the length of the Santa Clara River there are several areas where flow in the river commonly percolates entirely, resulting in dry reaches of the riverbed. Surface flow resumes some distance downstream as “rising groundwater” contributes flow to the river, usually near a boundary of one of the groundwater basins in the valley. Flow from tributary streams sometimes reaches the confluence with the river, while at other times stream flow percolates to groundwater upstream of the main river channel.

Given the complex dynamics related to the gaining and losing reaches of the Santa Clara River and its major tributaries, management activities for both water resources and environmental protection are more complicated than might be imagined. Flows in the river are naturally variable both seasonally and annually, but dry river reaches are common in all but the wettest of years. These variables often complicate permitting requirements and management efforts to maintain various river habitats. In addition, water quality issues generally require consideration of the interaction of surface water and groundwater, as do efforts to convey stored surface water to points lower in the watershed via natural stream channels.

1.6.1 QUAGGA MUSSELS IN LAKE PIRU

Quagga mussels were first discovered in Lake Piru in December of 2013. Since then United has been evaluating the degree of infestation and has prepared the Lake Piru Quagga Mussel Monitoring and Control Plan. United has submitted the plan to the California Department of Fish and Wildlife and has been working to implement components of the plan. The quagga infestation has required increased maintenance on the intake barge and pumps of the potable water delivery system for the Lake Piru Recreation Area.

The overall goals and objectives of the Quagga Mussel Monitoring and Control Plan are to: (1) contain and minimize the spread of quagga mussels to other water bodies outside of Lake Piru; (2) control the quagga population within Lake Piru to minimize, to the extent feasible, environmental and operational effects; (3) collect monitoring data to further characterize and better understand the extent and effects of the infestation within Lake Piru and downstream areas; and (4) use the information obtained from the control and monitoring efforts to adaptively manage the quagga infestation and modify the plan when appropriate.

1.6.2 SANTA CLARA RIVERBED STABILIZATION

The construction of the Freeman Diversion structure accomplished two primary objectives for the District: creating a diversion structure highly resistant to storm damage, and stabilizing the elevation from which surface water is diverted from the river. Following extensive mining of aggregate from the channel of the Santa Clara River in the Forebay area, riverbed elevations near Saticoy had dropped by about twenty feet by the late 1980s. Scour associated with large flow events in the river allowed the riverbed degradation to propagate ever farther upstream, and United was repeatedly required to move its Saticoy diversion location farther upstream. The Freeman Diversion has prevented further down-cutting of the river upstream of the facility as expected, and some recovery of channel elevations between Santa Paula Creek and the Freeman Diversion has been documented (Stillwater Sciences, 2007).

When the Freeman Diversion was constructed, the riverbed elevation upstream of the structure was elevated about ten feet, and materials excavated during construction were used to raise floodplain elevations in an area extending approximately 2,000 feet upstream of the facility. The dam structure extends about 90 feet in the subsurface and rests on a bench of low-permeability Pico Formation. While the facility was not intended to pond surface water, it does act as a partial barrier to groundwater flow in the subsurface. Groundwater elevations at an upstream location near the diversion structure now vary little from the crest elevation of 162 feet, as groundwater moving through shallow river alluvium stages up behind the Freeman structure. Construction of the Freeman Diversion has benefited groundwater elevations in the Santa Paula basin, as the earlier incision of the river that was lowering the discharge elevation for shallow groundwater in the basin was arrested and partially restored in the area upstream of the diversion structure (Santa Paula Basin Experts Group, 2003). Shallow groundwater levels upstream of the Freeman Diversion have however declined by about five feet since 2012 with the onset of drought conditions.

1.6.3 INCREASED CHLORIDE CONCENTRATIONS IN THE SANTA CLARA RIVER

The watershed of the Santa Clara River is one of the largest in southern California, draining over 1,600 square miles in Los Angeles and Ventura Counties. The Piru groundwater basin underlies the Santa Clara River just west of the LA-Ventura County line, and the nature of the river channel is such that much of the time the entire flow of the river emanating from upstream areas infiltrates to groundwater in the eastern portions of the Piru basin. Water quality in the river has suffered periodically due to land use practices in Los Angeles County, and water quality impacts have been shown to persist in the groundwater of the Piru basin for many years after corrections have been made to restore surface water quality.

In the 1950s and 1960s brines from oil production in the greater Newhall area were discharged to the Santa Clara River, and very high chloride and TDS concentrations were recorded during this period. These practices ceased in the early 1970s following the passage of the federal Clean Water Act, but residual degradation of groundwater quality was noted when water quality objectives were formulated by the Regional Water Quality Control Board years later (UWCD, 2006). Another episode of chloride contamination has occurred more recently and is associated with wastewater discharges from the City of Santa Clarita. Beginning in 1999, rapid urban growth and the increasing popularity of self-regenerating water softeners resulted in increased flow and rising chloride concentrations in the Santa Clara River at the Los Angeles County line. A clear trend of increasing chlorides continued until late 2004, when recorded chloride concentrations in the river peaked around 150 mg/l. Wells in the eastern Piru basin responded rapidly to the changes in the quality of the recharge water to the basin, and a group of concerned growers and other Ventura County interests repeatedly requested that the Regional Board to take action to regulate the chloride discharges which exceeded regulatory limits and advisory thresholds for agricultural use (100 mg/l).

Following several years of study and a successful groundwater modeling effort to predict the impacts of various discharge scenarios on downstream areas, a compromise solution emerged that was endorsed by most area stakeholders and approved by the Regional Board in fall 2008. The approved project was to allow chloride discharges as high as 117 mg/l to the Santa Clara River, and to construct a series of extraction wells, desalting facility and pipeline to convey blended water across the dry reach of the Piru basin. Following significant opposition by ratepayers, the local (Santa Clarita) board of the Sanitation Districts of Los Angeles County did not authorize the rate increases necessary to implement the approved project.

In 2012 and 2013 the Upper Basin Purveyors, Kennedy-Jenks Consultants and Santa Clarita Valley Sanitation District of Los Angeles County worked with United to explore cheaper alternatives to the original project. Various proposals that would have eliminated the need for construction of a reverse osmosis (RO) plant, associated brine disposal facilities, and the pipeline down the Piru basin were evaluated. Ventura County interests were not convinced that the various modifications to the original project proposal would result in sufficient chloride export from the Piru basin, and they did not support the proposed reductions in the scope of the project.

Following abandonment of the 2008 proposed blending and export project, the Sanitation Districts proposed RO treatment for a portion of their waste stream, allowing a blended discharge that complies with the 100 mg/L chloride discharge limit. Disposal of the brine produced by the RO treatment process remain a significant challenge. A proposal for deep well injection was met with significant local resistance and was abandoned. The most recent proposal by the Sanitation Districts is a process to concentrate brine produced by the RO plant and trucking the brine to an existing wastewater treatment plant in Carson that pipes its effluent to the coast for ocean disposal. The Regional Board now requires that this project be completed by July 2019.

The current compliance strategy relying on RO treatment will allow the discharge of water at less than 100 mg/L, but will result in significantly less total discharge to the SCR. The brine component is removed from the discharge stream, and the improved quality of the effluent makes it more attractive for reuse within the Eastern groundwater basin. The Sanitation Districts estimate that the combined discharge from the Saugus and Valencia WWTPs will be reduced by about 33 percent. In practice, discharge from the Valencia plant will likely be reduced by about half, while discharges from the Saugus plant should remain near historic levels.

In the meantime, the successful removal of most water softeners from Santa Clarita and lower chloride concentrations in imported State Water has resulted in wastewater chloride concentrations below the peak concentrations seen in the mid-2000s. High chloride groundwater associated with the worst of the past discharges continues to migrate with groundwater flow across the Piru basin, and now extends past the midpoint of the basin. The highest chloride concentrations in Piru basin wells were observed in in the area east of Piru Creek, with 2015 maximum chloride levels ranging from 130 mg/l to 136 mg/l. United's monthly sampling of surface water in the Santa Clara River near the upstream margin of the Piru basin recorded chloride concentrations ranging from 122 to 147 mg/l in 2015.

1.6.4 FISH PASSAGE AT SANTA FELICIA DAM

NMFS has required that United evaluate the feasibility of both the upstream and downstream passage of southern California steelhead over Santa Felicia dam. United has convened a panel of fish passage experts to evaluate the range of facilities that might be required to allow fish passage over the 200-foot-high dam. The Final Santa Felicia Fish Passage Feasibility Assessment Finding Report was distributed to NMFS and California Department of Fish and Wildlife (California DFW) on February 26, 2016. The Final Report will be filed with the Federal Energy Regulatory Commission (FERC) once consultation with NMFS and California DFW is complete and consensus on the preferred fish passage alternative can be reached. The expert panel recommended an adaptive management strategy, as adult steelhead are exceedingly rare in the Piru Creek watershed.

1.6.5 ENVIRONMENTAL FLOWS AT FREEMAN DIVERSION

The Freeman Diversion currently provides bypass flows for the upstream and downstream migration of the endangered southern California steelhead. State Water Rights Permit 18908 allows United to divert its license amounts as long as 40 cfs is provided through the fish ladder for 48 hours after the total river flow subsides below 415 cfs. These migration flow requirements are limited to storms that occur between February 15th and April 31st of each year. In consultation with NMFS, United is currently operating the bypass flows to better meet the needs of the species for migration between the ocean and the Freeman Diversion. The bypass flows released for this reporting period are based on bypass flow operation plans developed in 2009 and 2010. The 2009 plan addresses the bypass flows for upstream migration of adult steelhead and the 2010 plan focuses on the bypass flows provided for downstream migration of smolts (juvenile steelhead). The plans are fairly complicated due to the potential for widely varying river conditions on any given year. Section 4.5.4 discusses the actual bypass flows implemented recently, along with the loss of yield associated with these bypass flow operation plans.

In preparation for its future application package for incidental take permits, United submitted a draft Multiple Species Habitat Conservation Plan (MSHCP) to NMFS in October 2016 (UWCD, 2016c). The draft MSHCP proposes instream flow operations which can be used as a conservation measure to promote both upstream and downstream passage of southern California steelhead and Pacific Lamprey. Modifications to the proposed instream flow operations are likely to occur before the issuance of the incidental take permits. United is also working with NMFS to develop appropriate interim bypass flows that would remain in effect until issuance of the incidental take permits.

2 PROJECTS AND INITIATIVES

Figure 2.1-1 presents a matrix introducing projects currently underway by United's Groundwater Department and details the issues those projects address. The projects vary in scope and application. The various groundwater and surface water projects are discussed in the following sections of this report.

2.1 GROUNDWATER

Section 2.1 introduces groundwater-related projects that are under development by United. These projects cover a wide range of projects that are discussed separately in the following sub-sections of this report.

2.1.1 SUSTAINABLE GROUNDWATER MANAGEMENT ACT

On January 1, 2015 California legislation (AB 1739, SB 1168 and SB 1319) was enacted and requires that every groundwater basin in California to be managed sustainably by the year 2042. These three sustainability bills are collectively known as the Sustainable Groundwater Management Act (SGMA). Under the legislation, local Groundwater Sustainability Agencies (GSAs) will be responsible for writing and implementing Groundwater Sustainability Plans (GSPs) for all significant groundwater basins in the state. Basins considered to be subject to critical overdraft must be managed to achieve sustainable conditions by the year 2040, and other high and medium-priority basins must be managed sustainably by 2042.

Groundwater basins that have gone through a court adjudication process (such as the Santa Paula basin) are exempt from a number of the SGMA requirements, but also have new requirements for reporting basin conditions to the DWR. All other basins, including those formally governed under AB 3030, will be managed under the new legislation. The eight groundwater basins within United's district boundaries are classified either medium or high priority basins by DWR. In addition, the Oxnard Plain and Pleasant Valley basins are two of the six southern California basin designated as "subject to critical overdraft" by DWR.

Eligible local agencies have until June 30, 2017 to organize and form GSAs. Under the legislation, an eligible agency is considered a local public agency that has water supply, water management, or land use responsibilities in a basin (CA DWR, 2016). In January 2015 the board of the FCGMA accepted the authority to be the GSA for the basins within its jurisdiction. United has representation on the Technical Advisory Committee for the GSP and supports the FCGMA in its efforts under SGMA to sustainably manage the basins within the District, including the Oxnard Forebay, Oxnard Plain, Pleasant Valley and West Las Posas basins. A team of consultants has been retained by FCGMA to study the basins and craft a plan for achieving sustainable operating conditions. United has been actively involved with local stakeholders in the creation of GSAs for the Mound, Piru and Fillmore basins. Through the process of GSA formation, groundwater users are forming alliances and organizing themselves in pumpers associations so that they may participate directly and be represented in SGMA initiatives.

SGMA requires that GSPs include plans to achieve sustainable groundwater management to avoid undesirable results, such as chronic depletion of groundwater, reduction of groundwater storage, water quality degradation (including the migration of contaminant plumes or saltwater intrusion), surface water depletions, or land subsidence. GSPs must also include long-term planning goals and measurable objectives with interim milestones in increments of five years that are designed to achieve the basin's sustainability goals within twenty years of GSP implementation. Representatives of high and medium-priority basins identified as subject to critical conditions of overdraft have until January 31, 2020 to submit GSPs to the DWR. Other high and medium-priority basins have an additional 2 years (until January 31, 2022) to submit GSPs.

Under SGMA, basin boundaries are based on DWR Bulletin 118 boundaries, however, a process has been established that enables local agencies to request that DWR modify those boundaries. Basin boundaries can be a source of confusion in the region, as local and governmental agencies may use different locations to define boundary basins. Revised basin boundaries will be published in DWR Bulletin 118 in January 2017 (CA DWR, 2016). Following the formation of basin GSAs, another basin boundary modification request period is scheduled for 2018, based on anticipated demand from local agencies and GSAs for additional basin boundary modifications (CA DWR, 2016).

2.1.2 THE UNITED GROUNDWATER FLOW MODEL

United has developed a hydrostratigraphic conceptual model and numerical groundwater flow model (the United model) for the aquifers underlying the Oxnard coastal plain. The United model was originally planned as an update of the USGS model (Hanson et al. 2003), but soon evolved into a distinct, new model, with revised grid, layering system, and boundary conditions. As environmental stewardship, climate change, drought preparedness, and increased use of recycled water have become integral aspects of groundwater management, the level of analysis required to support such planning has become increasingly more detailed both temporally and spatially, as compared to the early 1990s when the USGS model was developed. The United model is still being tested and updated as new data become available; however, based on calibration results to date and an initial review by an expert panel, it is a significant improvement over past groundwater models of the region, and is a suitable tool for evaluating changes associated with either specific water supply projects (such as well fields, water deliveries, recharge projects, reservoir releases, etc.) or regional changes within the model domain (changing irrigation demands, changing rainfall patterns, extended drought, etc.).

Development of the United model began with considerable effort to review and update the hydrostratigraphic conceptual model for the Oxnard Plain, Oxnard Forebay, Pleasant Valley, and Mound groundwater basins, with the goal of explicitly representing each major aquifer and aquitard present in the study area. The hydrostratigraphic conceptual model for the basins was updated based on review of geophysical and lithologic logs from hundreds of gas, petroleum, and water wells in the study area, delineating seven aquifers and resulting in significant adjustment to aquifer top and bottom elevations in some key areas. The USGS model, in comparison, contained only two model layers, representing the UAS and the LAS. In addition, the geometry of some faults and folds was adjusted in United's conceptual model during construction of multiple new cross sections within the model domain.

Following completion of the hydrostratigraphic conceptual model, a numerical model grid was developed using MODFLOW-NWT (USGS, 2011), with 2,000-foot uniform grid spacing and 13 layers representing the seven recognized aquifers and six aquitards present in the model area. The simulation period of the United model for calibration was January 1985 through December 2012, with 336 monthly stress periods with variable recharge and pumping rates. The current active domain of the United model includes the Oxnard Forebay, Mound, Oxnard Plain, Pleasant Valley, and West Las Posas basins, some of the western portion of the Santa Paula basin, and the submarine (offshore) outcrop areas of the principal aquifers that underlie these basins. The active model domain spans approximately 282 square miles, of which 60% (169 square miles) is onshore and 40% (113 square miles) is offshore. The domain of the model will eventually be expanded to include the Santa Paula, Fillmore and Piru groundwater basins.

The groundwater flow model was calibrated by adjusting input parameters, including: hydraulic conductivity, specific yield, storage coefficient, stream-channel conductance, general head boundary head and conductance, horizontal flow barrier conductance, recharge rates, and multi-node well conductance. By comparing simulated groundwater levels with measured groundwater levels, and adjusting model input parameters to minimize differences between the two, a set of calibrated model parameters was determined to yield an optimal fit based on manual and automated calibration simulations. Calibration results to date indicate that the model is well calibrated throughout most of the Oxnard Forebay, Oxnard Plain, and Pleasant Valley basins and requires further calibration in the Mound basin, West Las Posas basin and the northeast margin of the Pleasant Valley basin.

Following initial calibration, the model was peer-reviewed by an expert panel, including:

- Dr. Sorab Panday, of GSI Environmental, Inc., co-author of the two most recent versions of MODFLOW: MODFLOW-NWT and MODFLOW-USG;
- Jim Rumbaugh, of Environmental Simulations Inc., creator of Groundwater Vistas, a widely used MODFLOW pre- and post-processor; and,
- John Porcello, of GSI Water, Inc., a consultant with extensive experience in groundwater modeling in general, and specific experience with hydrogeologic conditions in Ventura County.

Several modifications were made to the model following the review, and model documentation is currently in preparation, in response to recommendations provided by the expert panel. United is planning to complete the model documentation in 2017, and can share the documentation with interested parties at that time.

2.1.3 SANTA PAULA BASIN SPECIALTY STUDIES

In March 1996, the Superior Court of the State of California for the County of Ventura approved a stipulated Judgment for the Santa Paula basin (*United Water Conservation District vs. City of San Buenaventura etc, Ventura County Superior Court Case No. CIV115611,* Judgment entered March 7, 1996, and amended August 24, 2010) [hereinafter "Judgment"]). The Judgment recognized that all of the parties have an interest in the Santa Paula basin, and in the proper management and protection of both the quantity and quality of this important groundwater supply. The basin is a significant water resource in the County of Ventura. Members of the Santa Paula Basin Pumpers Association and the City of San Buenaventura exercise rights to pump water from the basin for reasonable and beneficial uses. United Water Conservation District does not produce water from the basin, but the basin is located within its boundaries and the District is authorized to engage in groundwater management activities and to commence actions to protect the water supplies which are of common benefit to the lands within the District or its inhabitants.

In 2010 the Judgment was amended to join various groundwater pumpers that were not previously joined as parties to the adjudication, and to clarify certain provisions pertaining to shortage conditions, the responsibilities of the Santa Paula Basin Pumpers Association and groundwater production by its members, and water rights transfer procedures.

The Judgment provides for the creation of a TAC. The committee is charged with establishing a program to monitor conditions in the basin, including, but not necessarily limited to, verification of pumping amounts; measurements of groundwater levels; estimates of inflow to and outflow from the basin; increases and decreases in groundwater storage; analyses of groundwater quality; studies relative to the basin; development of programs for its conjunctive use and operation; and other information useful in developing a management plan for the basin. The Judgment also authorizes the TAC to consider and attempt to agree on the safe yield of the basin.

The Judgment among other things requires the TAC to monitor and annually report individual and cumulative groundwater production from the basin. The Judgment further specifically provides that "United Water Conservation District shall have the primary responsibility for collecting, collating, and verifying the data required under the monitoring program, and shall present the results thereof in annual reports to the Technical Advisory Committee." United submits draft annual reports to the Santa Paula Basin TAC members for review, comment, and approval.

The 2008 Annual Report, filed with the Court in 2010, noted that the TAC has observed a long-term, but gradual, decline in basin groundwater elevations. The Annual Report stated that the TAC would over the following 12-24 months seek to determine the cause of the long-term gradual decline in the groundwater elevations, and formulate remedial actions to reverse the problem should it persist (UWCD, 2009).

In 2011 the Santa Paula Basin TAC created a Santa Paula Basin Working Group to investigate the cause of the long-term gradual decline in groundwater elevations. The Working Group consists of technical experts from (or consulting for) United, the Santa Paula Basin Pumpers Association and the City of San Buenaventura. The Working Group completed a number of studies intended to address the cause of the long-term gradual decline in groundwater elevations in the basin.

In August 2011, the TAC issued a list of ten work items which were evaluations and studies to be completed for the Santa Paula basin. These items are listed below:

- Investigation of hydrologic base period, consisting of evaluations of rainfall and streamflow in Santa Paula basin. (GEI Consultants, 2012a, 2012b, and 2015)
- Investigation of underflow between the Fillmore and Santa Paula basins (Bachman, 2015).
- Evaluate groundwater confinement (Kenneth D. Schmidt and Associates, 2016) and differentiate measured wells by aquifer (in progress).
- Evaluate water level trends in both confined and unconfined parts of the Santa Paula basin. (on hold)
- Identify crop change over time (Frank B. and Associates, 2013).
- Investigation of groundwater storage change (planned).
- Evaluate historical changes to the Santa Paula Creek channel and potential effects on basin recharge (draft in review, Hopkins Groundwater Associates, 2016)
- Refine and finalize spatial and temporal Pumping Trends Report (UWCD, 2011b).
- Compilation of Santa Clara River infiltration data (UWCD, 2013c).
- Compilation of Santa Paula Creek infiltration data (UWCD, 2013d).

Most of these studies have now been completed and have served as supporting documents for the recent effort to determine the safe yield of the Santa Paula basin. United hired a technical consultant to assess the safe yield of the basin and the Santa Paula Basin Pumpers Association has commissioned a concurrent study to examine approaches to increasing the operational yield of the basin. A draft report of the safe yield study was submitted to the TAC for review in March 2016, followed by a revised draft in October 2016 (incorporating revisions and additional information resulting from TAC review). The yield study determined that the current pumping allocation cannot be supported by the basin; pumpers have the opportunity to fund various projects to increase the operational yield of the basin rather than reducing the pumping allocations of individual parties. It is anticipated that both the safe yield and yield augmentation studies will be completed in early 2017.

2.1.4 DISTRICT-WIDE GROUNDWATER LEVEL MONITORING

United monitors groundwater elevations in all or portions of the eight groundwater basins within the District boundaries. The regular monitoring of a large number of wells in the multiple aquifers throughout the District is necessary to adequately define the regional influences of groundwater extractions as well as natural and artificial groundwater recharge to the basins. Measurements are collected from both active production wells and dedicated monitoring wells. “Nests” of monitoring wells exist in some locations, allowing determination of heads in various aquifer units, and the vertical gradients between aquifer zones at these locations. United's archive of over 200,000 water level measurements was a critical source of data for calibration of the groundwater flow model.

In excess of 3,000 water level measurements were collected by District staff in 2015, on either a monthly, bimonthly, quarterly or semi-annual basis. The semi-annual runs are the most extensive runs and are scheduled to document annual high groundwater conditions in spring and annual low groundwater conditions in fall. The locations of wells measured by United and others at various frequencies are shown by basin on Figure 2.1-2, and on various figures in Section 5 of this report.

Beginning in 2009, United greatly increased its efforts to instrument additional wells in each groundwater basin with pressure transducers ("transducers"). These units consist of a compact pressure transducer and data logger, and are commonly suspended in a well by a special cable that allows records to be retrieved without removing the device from the well. The transducers are programmed to record water levels at frequent time intervals, allowing the acquisition of data sets that would be impossible or impractical to collect by hand. The automated collection of head measurements are very useful in evaluating transient events, such as tidal influences, the area of influence surrounding pumping wells, and water table responses to both natural and artificial recharge events. As of fall 2015 United had 109 pressure transducers deployed throughout the basins within the District (Figure 2.1-2).

Groundwater conditions in the Oxnard Forebay tend to be more dynamic than in other basins within the District. Groundwater mounding associated with recharge to the basin variously occurs beneath United's spreading grounds and the channel of the Santa Clara River. United has transducers installed in 41 Forebay wells. Analysis of these records has led to a much better understanding of groundwater storage within the basin, and how United's recharge activities influence the percolation of river flows in the upstream portions of the Forebay.

In the Santa Paula basin, a more extensive groundwater elevation monitoring effort was initiated in 1998 and is continuing. The monthly, bimonthly and semi-annual monitoring of wells is conducted to assist technical work in progress to determine the perennial yield of the basin, and related to a March 1996 Court Settlement regarding pumping in the basin. The use of pressure transducers was expanded beginning in 2011, and 22 basin wells are now instrumented with transducers. Several of these transducers were purchased by the Santa Paula Basin Pumpers Association and the City of Ventura. Currently, seven additional production wells are equipped with transducers maintained by the well owners, and these records are periodically shared with the members of the TAC.

Beginning in the spring of 1999, the number of Upper and Lower Aquifer System wells monitored in the Oxnard Forebay, Oxnard Plain, Pleasant Valley and Mound basins was increased substantially. The increased frequency and distribution of groundwater elevation data in these basins of the Oxnard coastal plain is intended to better define areas of groundwater abundance and deficit, and how these conditions relate to groundwater recharge and extraction in the basins, and geologic features within and between the basins. The implementation of an extensive semi-annual (spring and fall) water level measurement program in these basins was also intended to define the extremes of water levels throughout the year. Pressure transducers are useful for determining seasonal high and low groundwater elevations, and United currently has transducers installed in 33 Oxnard Plain wells. A number of other Ventura County agencies routinely measure and record groundwater elevations in their wells, most commonly on a monthly or quarterly basis. Most cities and the larger mutual water companies measure water levels in their wells, often under both static and pumping conditions. Water levels are also routinely measured in monitoring wells at a number of environmental sites, such as landfills, large scale contaminant sites, or near wastewater percolation ponds. United obtains water level records from these various sources and archives the records in a central database. This extensive archive of recorded groundwater elevations has been used in support of a number of groundwater investigations, and has proven valuable for the calibration of United's groundwater flow model.

The Groundwater Section of the Water Resources Division of the Ventura County Watershed Protection District (VCWPD) also maintains a long-term groundwater elevation monitoring program (VCWPD, 2016). As with United's monitoring program, the lengthy water levels records now associated with many of the wells in the County's program are valuable records for assessing long-term changes in water levels within area basins. United and the County of Ventura regularly exchange groundwater elevation records. The County of Ventura in turn reports groundwater elevation records to the DWR as part of the California Statewide Groundwater Elevation Monitoring (CASGEM) program. This reporting program was authorized by the Legislature in 2009 as part of bill SBX7 6, and encourages local agencies to develop monitoring programs that adequately characterize groundwater conditions in their areas and regularly report the records to DWR for archiving and improved public accessibility.

2.1.5 DISTRICT-WIDE GROUNDWATER QUALITY MONITORING

United's water quality monitoring program integrates the District's sampling with sampling conducted by a variety of other organizations. Together, this monitoring serves the following varied purposes:

- For purveyors' wells, monitoring of a variety of regulated constituents ensures that groundwater is safe for potable use, and ensures taste and odor are within established guidelines.
- The coastal saline water monitoring well network allows monitoring of the migration of saline water by direct seawater intrusion and the migration of chloride from other sources. The network of wells allows sampling of the full series of aquifers from the near-surface to the deep Grimes Canyon aquifer.
- Monitoring of wells allows documentation of both abrupt and long-term changes in water quality.

United samples numerous monitoring and production wells on a regular basis in order to evaluate the quality of groundwater throughout the District. Monitoring programs sometimes focus on specific areas within the District, typically for a specific type of degradation or improvement of water quality, such as saline intrusion in coastal areas or nitrate in the Oxnard Forebay. In addition to United's regular sampling programs, water quality data are routinely acquired from other sources, most notably California's DDW and the Groundwater Section of the Ventura County Watershed Protection District. Other sources of information include the California DWR, the USGS, cities, consultant reports and technical studies, landfill operators and individual well owners.

United routinely samples production wells and dedicated monitoring wells throughout the District, but monitoring is performed with increased frequency and density in two critical areas. One such area is the Oxnard Forebay basin, where United operates its main groundwater recharge facilities and the well field supplying the O-H potable water system. The monitoring serves to document both typical conditions and the variability of groundwater quality in areas of groundwater recharge and areas of groundwater production near specific land uses. Another area of frequent monitoring is the coastal portion of the Oxnard Plain near and between the Hueneme and Mugu submarine canyons. Elevated chloride levels from the intrusion of saline waters continue to be a concern in this area, especially in the area surrounding the naval base at Point Mugu. Since the early 2000s there has been renewed interest in documenting the changing chloride conditions in the Piru basin. Water quality monitoring has increased in that basin, with much of the increased sampling of production wells being performed by the Groundwater Section of the Ventura County Watershed Protection District. Changing water quality conditions are also a concern in the Pleasant Valley basin.

When water is delivered to the public, the DDW enforces minimum monitoring requirements to assure that delivered water is free of chemical and biological contaminants. Testing requirements vary depending on the number of people served by the system and a system's vulnerability to contamination, as determined by the DDW. United regularly collects samples from the wells supplying the O-H potable water system, with sampling frequency exceeding the minimum DDW requirements. Water purveyors throughout California are required to report results of all water analyses to the DDW, and United regularly obtains these water quality records from the DDW for integration into United's water quality database.

United's groundwater staff regularly collects water quality samples from approximately 155 monitoring wells located throughout the District. Nearly all of these wells are PVC wells with an internal diameter of two inches. A portable submersible sampling pump is lowered into the well in order to purge the well prior to collecting a sample. Alternatively, an air compressor and long air hose are used to purge deeper wells, where compressed air is released in the well below the water surface and water is "air lifted" out of the well as the air expands and rises to the surface. Most of the monitoring wells have a short screened interval, allowing the collection of water from a limited section of the aquifer. Many monitoring wells were installed as a "nest" or cluster of wells in a single borehole, allowing the collection of piezometric head and water quality samples from multiple depths at the same location. United measures field parameters (temperature, pH, specific conductance) during sampling, but all water quality analyses are performed by a commercial laboratory.

United also monitors a number of private domestic and irrigation wells throughout the District as part of its regional monitoring programs. The sampling of production wells spares the expense of drilling new monitoring wells, and provides examples of water quality pumped by groundwater users.

However, the long screen intervals common to most production wells often draws water from multiple water-bearing zones, which can mask poor quality water that may source from specific aquifer zones. The Groundwater Section of the Ventura County Watershed Protection District also conducts annual sampling of a number of production wells in Ventura County, commonly in the fall of the year. The County sampled 215 wells in 2015, 126 of which were in located within United's district boundaries. This sampling complements the sampling performed by United and significantly contributes to the water quality sample coverage in several local basins.

The distribution of wells sampled by United is shown on Figure 2.1-3. As shown in the map, the Oxnard Forebay and the coastal areas of the southern Oxnard Plain have the highest density of sampled wells. Production wells belonging to private parties and monitored by United are concentrated around the Oxnard Forebay and in the basins of the Santa Clara River Valley. The figure includes a table detailing the number of wells monitored by United in each basin.

Special water quality studies are occasionally conducted within Ventura County. One significant recent study was the Groundwater Ambient Monitoring and Assessment (GAMA) program, conducted by the USGS in cooperation with the CA State Water Resources Control Board. This project sampled a number of "representative" wells throughout the Santa Clara River valley and the Oxnard Plain in order to assess the quality of local groundwater commonly used for public supply. Many wells were sampled in spring 2007 for a broad suite of compounds at very low concentrations in order to document both the character of natural waters and the nature of contamination where it exists. While the identities of the wells sampled in the study remain confidential, results from this sampling effort allowed characterization of groundwater in the study area. Contamination related to human activities was found to be relatively uncommon, and associated with shallow wells screens and younger waters when present. Older and deeper groundwater in some areas has somewhat elevated mineral content, and may have elevated iron and manganese concentrations related to reducing groundwater conditions (Burton et al, 2011). The geologic setting and nature of the area's aquifers are largely responsible for the high mineral content in the water, resulting in some aesthetic issues but not health concerns.

2.1.6 SALINE WATER INTRUSION MAPPING

The intrusion of saline waters remains the principal water quality threat to the groundwater resources of the Oxnard Plain and the Pleasant Valley basin. As described in Section 1.5.3, the movement of brines into fresh aquifer units remains a concern as long-term overdraft conditions persist in these basins, and chloride impacts are no longer limited to the coastal areas adjacent the Hueneme and Mugu submarine canyons. Water with elevated chloride concentration is not suitable for either potable use or for use as irrigation water. In recent years United has conducted several investigations to better define the extent of saline water in the coastal basins. Some of the projects associated with this effort include:

- Seismic reflection survey on south Oxnard Plain – this project focused on meso-scale geologic structures/features that were postulated to impact groundwater movement on the south Oxnard Plain (UWCD, 2011a);
- Time domain electromagnetic survey in the Port Hueneme and Point Mugu areas – this project was designed to reassess the areal extent of saline water intrusion and compare it to a similar survey conducted by the USGS in the early 1990s (UWCD, 2010b);
- Borehole electrical conductivity surveys in existing piezometers in the Port Hueneme and Point Mugu areas - conductivity profiling in existing wells/piezometers was performed to determine if the saline waters have begun to impact strata other than the screened intervals of the wells; and
- A feasibility study was conducted to evaluate the technical and economic viability of using groundwater degraded by past episodes of saline intrusion as source water for a brackish water treatment facility that would produce high-quality water for growers in overdrafted areas (Carollo, 2014).

To date, three of these projects have been completed and results are contained in the respective Open-File and project reports.

2.1.7 FOREBAY AQUIFER DELINEATION/MAPPING USING SURFACE GEOPHYSICS

Reconnaissance-level time domain surveys performed by UWCD in 2010 identified previously unrecognized geologic conditions (e.g., faults, thick LAS clay sequences) underlying several of the District's recharge basins. Previous investigations (e.g., Daniel B. Stephens & Associates, 2008) depict the presence of clay units (aquitards) in the northwestern portion of the Oxnard Forebay, but the lateral continuity and presence/absence of faulting were not addressed. Groundwater recharge in the Oxnard Forebay is a critical component of the region's water supply system and the Oxnard Forebay is envisioned as a potential location for increased groundwater pumping and a potential location for the introduction of recycled water for aquifer recharge. As the groundwater resource utilization in the Forebay intensifies, a more refined understanding of the hydrogeologic conditions is needed to facilitate optimization of this resource.

Following the initial (2010) time domain electromagnetic (TDEM) survey in the Forebay, United purchased TDEM equipment and conducted additional surveys. In fall 2011 and summer 2012 an additional 139 soundings were made throughout the Forebay basin. These readings allowed the identification of several areas of anomalous resistivity in the subsurface, suggesting some areas of higher and lower permeability. The TDEM readings also identified some fault traces in the subsurface and generally confirmed the existing mapping of the Forebay boundary where shallow confining layers become prevalent (UWCD, 2013a). The FCGMA provided funding for this surface geophysical survey with a grant from their *Groundwater Supply Enhancement Assistance Program (GSEAP)*.

In 2013 the TDEM surveys were expanded into adjacent areas in the western Santa Paula basin and the eastern Mound basin. United Water field crews enjoyed extensive cooperation from land owners who readily provided access to their property. Survey sites were limited to open spaces and agricultural areas as overhead power lines and buried metallic objects interfere with the electrical fields that allow the mapping of subsurface properties. This data has been processed and modeled, and results will be published in early 2017.

2.1.8 PROPOSED BRACKISH WATER DESALTING FACILITY

United hired an engineering firm to perform a feasibility study for a proposal to pump brackish water from impacted aquifers along the coastal area of the southern Oxnard Plain. A well field of new UAS production wells in the greater Ormond Beach area would supply poor-quality groundwater to a plant site where reverse-osmosis membranes would purify the water. Brine generated by the treatment process would be discharged to the nearby Salinity Management Pipeline, operated by Calleguas Municipal Water District. Product water would be sold to growers who desire low TDS water for the production of high-value crops such as berries.

Production wells supplying the desalting facility would extract brackish groundwater associated with past episodes of seawater intrusion during times of drought. New plumes of seawater intrusion are now expanding under the current drought conditions as groundwater elevations in UAS wells near Port Hueneme remain well below sea level. In the early years of operation the supply wells will be managed to remove existing saline water from UAS aquifers. In later years extractions would act as a hydraulic control (extraction barrier) to prevent the landward migration saline groundwater past the well field. United's groundwater flow model will be used to evaluate the potential impacts of the proposed operation of the facility as part of the permitting and approval process for the project, should it be deemed feasible and economical.

The feasibility study was completed in 2014 and the following conclusions were made:

- Brackish groundwater in the South Oxnard Plain is suitable for treatment by reverse osmosis at an acceptable recovery range of 72 to 80 percent.
- With the exception of pH, the "ideal" (agricultural) product water quality can be met with traditional pretreatment, desalination, and post treatment systems.
- An amortized water cost of $998 to $1,111 per AF for the design water condition is competitive with imported water and has superior quality.
- Utilizing impaired groundwater treated to low TDS levels reduces salt import into the region, unlike irrigation with imported water.
- Connection to the SMP at the intersection of Hueneme Road and Edison Avenue is a viable option for brine disposal.
- Additional water quality sampling should be performed to confirm that the RO concentrate will comply with NPDES permit discharge limits in place for the SMP.

In order to advance the desalter project beyond the initial study and toward design and construction, the feasibility study suggested several additional preliminary steps to be taken, including: formalize a groundwater usage agreement with the FCGMA, finalize locations for wells and the desalter plant site, conduct an electrical infrastructure investigation and a geotechnical survey, finalize the pipeline routing, and an environmental impact study should be conducted in accordance with CEQA guidelines. During 2015, United was involved in ongoing stakeholder engagement, discussions with land owners and project evaluation.

2.1.9 PROPOSED IRON AND MANGANESE TREATMENT PLANT

When the five LAS wells for the PTP were constructed in the mid-1980s, three additional LAS wells were constructed in the Oxnard Forebay. These LAS wells are registered as public supply wells for the O-H system, but two of the wells can be configured to provide supplemental water to the PTP system. O-H LAS wells #12 and #13 have occasionally provided water to the PTP system during periods of peak demand when surface water is scarce, but they are primarily maintained as standby wells for the potable O-H system (Well #14 provides water only to the El Rio facility as it is isolated from the PTP system). A number of the UAS wells at El Rio are plagued by high nitrate concentrations during times of drought, and the LAS wells provide a blending source with low nitrate concentrations. Nitrate is a primary health standard, and water exceeding the MCL for nitrate cannot be delivered to customers.

While nitrate concentrations in the LAS wells are low, the wells commonly produce water that exceeds the secondary health standards for iron and manganese. Iron and manganese can cause staining of clothing and fixtures, and causes operational challenges for the Port Hueneme Water Agency who operates a RO system to treat water purchased from United. These LAS wells are not commonly operated due to the higher lift costs associated with producing water from the LAS and the Fe and Mn concentrations common to the wells. The LAS wells were operated extensively in 2014 and 2015 when high nitrate concentrations were common in the in UAS wells of the O-H system. Over the past ten years iron and manganese concentrations in the O-H LAS wells have remained relatively stable, averaging 0.64 mg/L and 0.2 mg/L, respectively. The California secondary standard for iron is 0.3 mg/L and 0.05 mg/L for manganese.

In accordance with the CCR, when delivered water exceeded the secondary MCLs for Fe and Mn, UWCD issued a survey to all of its O-H Pipeline customers regarding potential options to address the LAS well exceedances of these secondary MCLs. The results of the survey prompted United's Engineering Department to study the feasibility and cost of constructing an iron and manganese treatment plant at the El Rio Recharge Facility.

After analyzing available water production and water quality data, it was determined that iron and manganese treatment of LAS wells is feasible at the El Rio Facility. Several scenarios were developed to identify the optimal size of such a facility and it was determined that the treatment of one LAS well is sufficient to achieve the project objectives. The existing configuration of the LAS wells would allow systematic cycling between wells #12 and #13, ensuring reliability and redundancy. A variety of typical iron and manganese treatment methods were reviewed. As a result of the review, it was recommended to proceed with using the existing gaseous chlorine system for oxidation and construct a granular filtration system. Pilot testing confirmed that MnO_2 sand and pyrolusite are suitable media for the removal of iron and manganese to levels below detection limits.

The feasibility study concluded that given the current state of increasing nitrate concentrations in UAS wells at the El Rio Facility and uncertainty regarding rainfall in the coming years, iron and manganese treatment of LAS wells would assist in ensuring a reliable supply of water for OH Pipeline users in the future. The next step would be to design and construct an iron and manganese treatment plant based on proposed design criteria. United is now seeking commitment from the O-H customers that they wish to fund and construct the project.

2.1.10 PROPOSED PIRU SOLAR FACILITY

United has explored opportunities for the District to implement a solar power program. The proposed Piru Solar Facility would include the installation of 5,760 solar photovoltaic modules on a 21.5 acre portion of the 73 acre parcel owned by the District near Piru. The property was previously used as a groundwater recharge facility (spreading basins) by the District, but this use was suspended in 2008 when the diversion of water from Piru Creek was discontinued due to permitting issues. The land surrounding the project site is predominantly rural, with agriculture and undeveloped land.

The project is intended to offset much of the cost of the current electrical energy demand of the District's various water facilities (~11.1 million kilowatt-hours, costing approximately $1.5 million annually). The majority of the District's electricity needs are related to the production and transmission of water by District wells and pipelines. The O-H wells and booster pumps, and the PTP system account for 73 and 22 percent of the energy consumed, respectively.

The proposed project is a 2.0 megawatt alternating current (MW-AC) or 2.4 megawatts direct current[1] (MW-DC) solar photovoltaic energy generation facility. It would be connected to Southern California Edison's electricity grid at an existing utility pole adjacent to the site. The proposed solar facility would be automated to allow operation with no staffing present. Production and system performance data, as well as onsite weather data, would be monitored and gathered electronically.

To date, the District has funded geotechnical studies, topographic surveys, preliminary evaluations by Southern California Edison (SCE), as well as fiscal impact estimations. All of these studies and evaluations are encouraging and provide a common benefit for multiple groups of stakeholders. The project is technically feasible and projects a positive cash flow (i.e., the savings exceed the debt service and operations costs) once operational. The Water Supply Agreement between United and the O-H customers has expired, and bonding for the Piru Solar Facility cannot proceed until a new agreement is in place.

[1] Electricity is generated from the solar PV panels in DC and then converted to AC electricity to be transferred to the electric grid. There is some electricity lost in the conversion of DC to AC, which is why the facility generates 2.4 MW-DC but delivers 2.0 MW-AC of available electricity to the grid.

2.2 SURFACE WATER

The interaction of surface water and groundwater is complex and dynamic in the valley of the Santa Clara River. Surface water flows are often highly variable both between years and seasonally within single years. The water quality of stream flow also commonly varies throughout the year, with mineral content typically increasing as flows decrease. United's interest in surface water flows has historically centered on the Santa Clara River near Saticoy, where water is diverted from the river and routed to various facilities for either groundwater recharge or direct use as irrigation water. Because of various regulatory requirements imposed upon the District by the federal government, United has recently devoted more effort to the study and characterization of flow in the river and its major tributaries in order to better understand and document aquatic habitat within the Ventura County portion of the watershed of the Santa Clara River. Of particular interest are seasonal migration opportunities for the endangered southern California steelhead and how United's activities affect flows in Piru Creek and the Santa Clara River.

2.2.1 RISING GROUNDWATER MONITORING

United has been monitoring rising groundwater in the Santa Clara River near the downstream ends of the Piru and Fillmore groundwater basins since the 1920s. Monitoring includes identifying reaches with flowing surface water, dry reaches, and locations of rising groundwater, and measurement of discharges near basin boundaries and nearby tributaries, as needed. The monitoring of rising groundwater is conducted to document surface water flows between groundwater basins, establish relationships between groundwater elevations and rising groundwater, and document potential habitat for fish under varying hydrologic conditions. Recent results from this monitoring are presented in Section 5.2.2.

2.2.2 SURFACE WATER MODELS

2.2.2.1 HYDROLOGICAL OPERATIONS SIMULATION SYSTEM (HOSS)

The HOSS surface water model is a hydrology-based operations model that simulates flow magnitudes in the Santa Clara River downstream of the Freeman Diversion. The HOSS is based upon the earlier hydrology-based Freeman Operations Model (FOM), developed by United to simulate the effects of Freeman Diversion operations on Santa Clara River flows downstream of the Diversion. Development of the FOM relied upon several decades of historical flow gage data, measurements of groundwater elevations near the river, and diversion flow rates. The HOSS is a more user-friendly operations model with a graphical user interface (GUI) that incorporates United's original hydrology-based model (FOM) (R2, 2016). The HOSS calculates the magnitude of flow at five locations in the Santa Clara River (both upstream and downstream of the Freeman Diversion) using operational rules defined in various scenarios developed to inform the MSHCP. The main outputs from the model are the magnitude of diversion flows, and the magnitude of flows within the "critical reach" of the Santa Clara River in the Oxnard Forebay basin. The critical reach is the section of the Santa Clara River extending from approximately the Highway 118 bridge downstream to the Highway 101 bridge, and includes transects to measure flow characteristics at a series of "critical riffles." Critical riffles are natural cobble and gravel bar structures where shallow channel depths can pose challenging conditions for the upstream migration of southern California steelhead. Since the 1990s, the HOSS has been expanded to include additional operational rule sets and refined to better represent surface and ground water interactions within the critical reach. In general, the HOSS processes total river flow entering the Freeman Diversion facility and relies on operational rules determine the amount of water that is diverted, the amount of water that continues to flow downstream past the diversions structure, and then estimates the amount of water that is lost to or gained from groundwater along the critical reach. While the HOSS is currently configured to compare alternative operational scenarios specifically for the MSHCP, it was also designed to be a flexible tool that can be used for other purposes in the future.

HOSS simulation results have been used in a number of projects, including (i) calculation of effects of various operational scenarios on fish migration opportunities through the migration corridor between the estuary and the Freeman Diversion to help inform the MSHCP, (ii) calculation of effects of various operational scenarios on habitat availability for endangered species downstream of the Freeman Diversion, (iii) and to help determine flows going into the estuary to determine any potential effects various operating scenarios may have on the system.

2.2.2.2 OXNARD PLAIN SURFACE WATER DISTRIBUTION MODEL

The Oxnard Plain Surface Water Distribution Model is essentially a water routing model used to simulate amounts of groundwater recharge in United's recharge basins and supply to surface water delivery systems, based on a series of adjustable hydrologic inputs (e.g. total river flow, diversions, surface delivery demands) and operational assumptions. All model calculations are performed in Excel software, using hydrologic inputs from the period of record between January 3, 1944 and December 31, 2015.

The first version of the model was developed in 2016, and used to calculate input files of managed aquifer recharge, surface water deliveries and pumping demands for use with the groundwater model described in Section 2.1.2. An example output of the model is provided on Figure 2.2-1, showing daily surface water distribution for a potential future scenario of increasing maximum diversion rates to 750 cfs and distributing water to the Ferro recharge basin (using 2010 hydrologic conditions). It is anticipated that the model will be further refined in the future to include and model effects of new potential sources of water (i.e. reclaimed water) or expansions and changes to the operation of United's recharge facilities.

2.2.3 STREAM FLOW MEASUREMENTS

Flows in the Santa Clara Watershed are recorded by United, USGS and the Ventura County Watershed Protection District. Flows in the main stem of the Santa Clara River are recorded by the USGS at the Los Angeles/ Ventura County line (funded by United) and by the VCWPD downstream at Victoria Bridge near Oxnard. United also records continuous flows diverted at the Freeman Diversion. All of the major Ventura County tributaries to the Santa Clara River are gaged. United Water funds the USGS to monitor flows both above and below Lake Piru. The VCWPD funds the USGS to record flow in Sespe Creek and Santa Paula Creek while the VCWPD records flow in Hopper Creek and Pole Creek. In 2016, United installed continuous flow monitoring devices for all flow paths over the Freeman Diversion facility (auxiliary pipe, fish ladder, dam crest), which, in combination with the existing flow monitoring devices in the bypass channel and diversion canal, provide continuous measurement of total streamflow immediately upstream and downstream of the Freeman Diversion.

In addition, manual discharge measurements are made by United staff at various locations that are not equipped with recording gauging stations. These data provides the information needed to estimate benefits to each basin during the conservation and State Water releases, the discharge/percolation rates in various river reaches, and adjustment of environmental flows.

2.2.4 SURFACE WATER QUALITY MONITORING

United maintains a surface water quality monitoring program and samples from a number of locations either seasonally, monthly or every two weeks. Sampling sites are generally located near groundwater basin boundaries or on major tributaries near their confluence with the Santa Clara River. Sampling of tributaries and the upstream reaches of the Santa Clara River assure that waters are acceptable for natural groundwater recharge. Sampling is conducted on a quarterly basis and consists of either a full general mineral suite or several key constituents. Water temperature and pH is documented at the time of sample collection. Sampling is conducted more frequently along the Santa Clara River near the Los Angeles County line (monthly) and at the Freeman Diversion (every two weeks).

Beginning in January 1999, United has sampled the Santa Clara River near Blue Cut and the Los Angeles County line each month. This monitoring is intended to improve understanding of how urbanization and community water supply decisions in the Santa Clarita area affect the quality and quantity of water flowing into Ventura County. From the late 1990s through 2003 discharges from the Valencia Water Reclamation Plant increased steadily in both volume and chloride concentration, with chloride concentrations exceeding 200 mg/l at the end of this period. Discharge rates continued to increase for several more years before diminishing slightly. Chloride concentrations in the discharges improved following a successful ban of self-regenerating water softeners in area homes. Chloride concentrations in the Santa Clara River at the County line have remained elevated in the recent period of drought.

Water quality monitoring of the river water diverted at the Freeman Diversion is performed every two weeks to confirm that the water is acceptable for use in both aquifer recharge and for irrigation deliveries. The mineral content of water in the river at this location exhibits a strong negative correlation with flow, where higher flows are less mineralized. Nitrate concentrations are routinely low in the river and do not show a strong correlation with flow. The County of Ventura maintains and operates composite sampling device at the Freeman Diversion, and samples storm flow and dry weather base flows several times per year. These samples are analyzed for a broad suite of constituents, including organic contaminants and metals, as required by the Countywide NPDES Stormwater Permit (administered by the Los Angeles Regional Water Quality Control Board).

In recent years both the City of Fillmore and the City of Santa Paula have eliminated discharges of treated wastewater to the Santa Clara River upstream of the Freeman Diversion. Santa Paula's new treatment plant came on-line in 2010 and utilizes percolation basins for wastewater disposal. Fillmore completed a new plant in 2009 and now distributes reclaimed water to both percolation basins near the plant site and a network of subsurface irrigation systems constructed in parks and school fields throughout the city.

2.3 RECYCLED WATER INITIATIVES

United's long-term water resource management strategy has relied heavily on the concept of the conjunctive use of surface water and groundwater – optimizing the use of surface water when it is available and depending on groundwater reserves when dry conditions prevail in the watershed of the Santa Clara River. As effective as United's groundwater recharge facilities are in wet periods, they are largely dormant when there is little surface water available for diversion, distribution and recharge. United wishes to continue its basin recharge operations during periods of drought, and is investigating options to purchase reclaimed water for both groundwater recharge and for direct delivery to satisfy irrigation demands.

Wastewater from the City of Oxnard has for decades been viewed as a potential source of reclaimed water for the Oxnard coastal plain (County of Ventura, 1980). In the late 1970s the County of Ventura led a regional water quality planning effort supported by a federal Section 208 planning grant. This diverse program evaluated water quality threats and problems in groundwater basins throughout Ventura County, including water quality problems such as saline intrusion associated with groundwater overdraft in the Oxnard Plain basin. Planning for construction of the Pumping Trough Pipeline and the Freeman Diversion were included in the 208 Plan. Another long-term solution for basins with overdraft problems was the increased use of reclaimed wastewater, particularly on the Oxnard Plain and in the Las Posas Valley. Projected flows from the City of Oxnard's water reclamation plant were more than 20 mgd in 1985 and nearly 30 mgd in the year 2000. The projections have proven to be too high, given less population growth than anticipated, the success of various water conservation measures and the departure of a number of large industrial water users from Oxnard's service area.

By the early 2000s the City of Oxnard was advocating a water and wastewater program called Groundwater Recovery Enhancement and Treatment ("GREAT"). The City sought to increase water supply reliability during drought, reduce water supply costs, increase water supply security in meeting growing demands, and make use of recycled water. The proposed GREAT program included a number of significant elements, including: upgrading the City's water reclamation plant to tertiary treatment, constructing an Advanced Water Purification Facility (AWPF), a recycled water delivery system, groundwater injection wells, and constructing a groundwater desalter and a concentrate collection system (Kennedy/Jenks Consultants, 2002). To date the City has been unable to fund several elements of this ambitious program, but a groundwater desalter has been in operation of a number of years and the AWPF recently came on-line, and is capable of producing about 7,000 AF of high-quality recycled water per year. The treatment process for the AWPF includes microfiltration, reverse osmosis and advanced oxidation. Production from the AWPF may be expanded in the future, depending on the City's ability to fund the expansion and the magnitude of the wastewater stream produced within the Oxnard service area. The City now has an interest in constructing a number of Aquifer Storage and Recovery (ASR) wells in the central portion of the Oxnard Plain basin. Current regulations require a delay between the time advanced-treatment recycled water is produced and it is blended and delivered to potable customers as a safety measure, and the City proposes to use aquifer storage, in part, to satisfy this requirement.

The City of Oxnard currently uses some of the reclaimed water produced at the AWPF for landscape irrigation and irrigation of a golf course located near the Santa Clara River, but much of the treated water is sold to growers on the southern Oxnard Plain and to Pleasant Valley County Water District. United has also signed a purchase agreement with the City in order to purchase reclaimed water from the AWPF. United is a "Tier Four customer" and will likely be offered water primarily in wet periods when agricultural demands are low. New delivery pipelines are required in order for United to take delivery of AWPF water, and United is evaluating options to determine what projects would provide the most benefit and require the least expenditure of capital.

The delivery option specifically mentioned in United's purchase agreement with the City of Oxnard is a new pipeline connecting the PTP to the City's existing distribution pipeline along Hueneme Road. The City's existing pipeline terminates at Olds Road, so approximately 2.5 miles of new pipe would be required to extend the pipeline east to Nauman Road then north to the PTP at the intersection of Etting Road and Hailes Road. This connection would functionally convert the PTP to a recycled water system, and this new source of high-quality water would allow for less pumping of United's five LAS wells that supply the system when surface water supplies are inadequate to meet demand.

A second alternative being considered is the conveyance of reclaimed water to the Oxnard Forebay where it could be spread in United's existing recharge basins. The City has extended their "Redwood Line" north of Highway 101, allowing the delivery of AWPF water for park and landscape irrigation in the RiverPark development. United would need to construct a booster station and nearly three miles of additional pipeline to convey recycled water up Vineyard Avenue to the Saticoy Recharge Facility. Recycled water could then be spread along with surface water from the Santa Clara River. United is using a groundwater flow model, and has received permission to conduct a tracer experiment, to determine groundwater travel times to downgradient receptor wells. A minimum of two months travel time is required before reclaimed water can be extracted from potable wells. This project has a greater potential to utilize reclaimed water from the AWPF during rainy periods when irrigation demands on the PTP and other areas of the Oxnard coastal plain are minimal.

Yet another alternative, which would likely be constructed along with the RiverPark-Saticoy pipeline, is a new pipeline located along Central Avenue between Vineyard Avenue and Rose Avenue that would allow the delivery of reclaimed water to the Oxnard Forebay segment of United's existing agricultural supply pipeline. This pipeline currently delivers surface water to the PTP and to PVCWD. If this alignment is selected as the preferred pipeline alternative the Nauman Road connection to the PTP would not be built.

United is eager to help facilitate productive use of the high-quality reclaimed water produced by the AWPF. It is recognized, however, that the City of Oxnard intends to make full use of AWPF water in the future in order to offset pumping from the Oxnard Plain basin and State Water imports. Uncertainty related to how long AWPF water might be available to United and other direct agricultural customers on the Oxnard coastal plain complicates the planning process for these proposed facilities, as it is difficult to assess whether investments in new pipelines will pay off with the life span of the project unknown.

3 HYDROGEOLOGY OF DISTRICT

United Water Conservation District overlies all or portions of eight groundwater basins in central and southern Ventura County. The geologic setting of the basins, the regional aquifers, and some characteristics of each basin are discussed in this section. Discussion related to 2014-2015 conditions in the various basins are included in Chapter 5 of this report.

3.1 GEOLOGIC SETTING

The groundwater basins within United's district boundaries are part of the Transverse Ranges geomorphic province where the mountain ranges and basins are oriented east-west rather than the typical northwest-southeast trend of much of California. The geology associated with the Transverse Ranges is primarily east-to-west trending folds and faulting (fold axes trend east-west). This configuration creates the elongate mountains and valleys that dominate Santa Barbara County and Ventura County.

The boundaries of United Water Conservation District are located within the more regional Ventura basin, which is an elongate east-to-west trending structurally-complex syncline within the Transverse Range province (Yeats et al., 1981). The eight groundwater subbasins of the Ventura basin that underlie the District are the Piru, Fillmore, Santa Paula, Mound, Oxnard Forebay, Oxnard Plain, and Pleasant Valley basins (Figure 1-1). The western portion of the West Las Posas Basin also falls within the District boundary. All the subbasins are share hydrologic connection (CA DWR, 1980; Hanson et al., 2003), and the common vernacular is to use the shorter term "basins" rather than subbasins.

The Santa Clara River Valley occupies the Ventura basin, which is one of the major sedimentary basins in the geomorphic province. The total stratigraphic thickness of upper Cretaceous, Tertiary, and Quaternary strata exceeds 55,000 feet (Sylvester and Brown, 1988). Only the uppermost portions of these deposits, however, contain fresh water.

Active thrust/reverse faults border the basins of the Santa Clara River Valley, contributing to the uplift of the adjacent mountains and down-dropping of the basins. The Piru, Fillmore, and Santa Paula basins are bounded by the Oak Ridge fault to the south and the San Cayetano fault system to the north. The Oxnard Plain and Mound basins extend across the offshore marine shelf to the shelf/slope break (the edge of the shelf).

The basins are filled with substantial amounts of Tertiary and Quaternary sediments that were deposited in both marine and terrestrial settings. The basins on the coast, including the Mound basin, are filled with recent sediments deposited on a wide delta complex that formed at the terminus of the Santa Clara River. Figure 3.1-1 shows the local formations which form the mountain ranges, surface/subsurface geology, and the major faulting in relation to the eight subbasins within United's district boundary.

3.2 AQUIFERS

Most of the coastal basins within United Water Conservation District have a shallow perched aquifer zone, and the aquifers of all the basins can be classified as part of an Upper and Lower Aquifer System (e.g., Turner, 1975; Mukae and Turner, 1975). The UAS consists of the Oxnard and Mugu aquifers. The LAS consists of the Hueneme, Fox Canyon and Grimes Canyon aquifers. The aquifers contain gravel and sand deposited along the ancestral Santa Clara River, from alluvial fans along the flanks of the mountains, from a coastal plain/delta complex at the terminus of the Santa Clara River, and marine deposits from transgressional seas. The aquifers are recharged by infiltration of streamflow (primarily the Santa Clara River), artificial recharge of diverted streamflow, mountain-front recharge along the exterior boundary of the basins, direct infiltration of precipitation on the valley floors of the basins and on bedrock outcrops in adjacent mountain fronts, the percolation of reclaimed water from sanitary sewers and irrigation return flow in some agricultural areas.

Figure 3.2-1 is a schematic of the major UAS and LAS aquifers, showing their subsurface sequence, formation and age. The figure shows representative depths in feet, and includes the layering used in United's groundwater flow model. Also note that the clay layers (aquitards) separating the aquifers may be thin or discontinuous at various locations.

3.2.1 PERCHED/SEMI-PERCHED

On the Oxnard Plain, the uppermost silt and clay deposits of the Oxnard aquifer are overlain by sand layers of the "Semi-perched aquifer," which generally contains poor-quality water. This zone extends from the surface to about 100 ft in depth. The confining clay of the upper Oxnard aquifer generally protects the underlying aquifers from contamination from surface land uses. Deep percolation of rainfall and irrigation return flows are the major components of recharge to the Semi-perched aquifer. Although difficult to quantify, there is likely some vertical leakage of water between this Semi-perched aquifer and underlying confined aquifer units. The Semi-perched aquifer is rarely used for water supply on the Oxnard Plain.

3.2.2 UPPER AQUIFER SYSTEM

The Upper Aquifer System (UAS) consists of the Oxnard and Mugu aquifers. These aquifers are characterized by recent alluvium (Oxnard aquifer) of Holocene age and older alluvium (Mugu aquifer) of late Pleistocene age. The Oxnard aquifer rests unconformably on the Mugu aquifer. A clay layer commonly occurs between the two aquifers.

Recent river channel deposits comprise the uppermost water-bearing units along portions of the Santa Clara River basins. These deposits are generally up to 100 ft in thickness. In the Santa Paula basin, water level records from nested monitoring wells indicate that this upper alluvial aquifer is somewhat isolated from the underlying aquifers of the San Pedro formation. The alluvial unit, from which there is considerable water production in the Santa Clara River basins, may be time-equivalent to portions of the UAS on the Oxnard Plain, but has not been assigned to the UAS in the literature.

3.2.2.1 OXNARD

The Oxnard aquifer materials generally consist of lagoonal, beach, river, floodplain and alluvial fan deposits (Turner, 1975). The Oxnard aquifer is present throughout the Oxnard Plain and other basins. The Oxnard aquifer is the primary aquifer used for groundwater supply on the Oxnard Plain. This highly-permeable assemblage of sand and gravel is generally found at a depth of approximately 100 ft to 250 ft below land surface elevation.

3.2.2.2 MUGU

The Mugu aquifer materials generally consist of lagoonal, beach, river, floodplain, alluvial fan terrace and marine terrace deposits. The Mugu aquifer rests unconformably on the LAS. Basal conglomerates occur in many areas (Hanson et al., 2003). In the Oxnard Plain, these coarse-grained basal deposits comprise the Mugu aquifer (Turner, 1975). The Mugu aquifer is generally penetrated at a depth of 255 ft to 500 ft below land surface.

3.2.3 LOWER AQUIFER SYSTEM

The Lower Aquifer System (LAS) consists of the Grimes Canyon, Fox Canyon, and Hueneme aquifers (Figure 3.2-1). The LAS is part of the Santa Barbara, San Pedro, and Saugus formations of Plio-Pleistocene age (Mukae and Turner, 1975).

In any of the basins, the aquifers of the LAS may be isolated from each other vertically by low-permeability units and horizontally by regional fault systems. The LAS is folded and tilted in many areas, and has been eroded along an unconformity that separates the Upper and Lower Aquifer Systems.

3.2.3.1 HUENEME

The Hueneme aquifer is considered to underlie the Oxnard Plain basin (Hanson et al., 2003). The Hueneme aquifer materials generally consist of terrestrial fluvial sediments, and marine clays and sands. In the basins along the Santa Clara River, the deeper aquifer system is generally considered to be the San Pedro Formation (Mann, 1959) or the time-equivalent Saugus Formation, although the USGS considers this deeper aquifer to be equivalent to the Hueneme aquifer (Hanson et al., 2003).

3.2.3.2 FOX CANYON

The Fox Canyon aquifer underlies the Las Posas, Pleasant Valley, Oxnard Forebay and Oxnard Plain basins. The Fox Canyon aquifer materials generally consist of marine shallow regressive sands and some clays. The Fox Canyon aquifer is the lower unit in the San Pedro formation. This same unit also extends north into the Mound basin, but the character of the sediments change to more finely-bedded deposits (UWCD, 2012).

3.2.3.3 GRIMES

The lowest water-bearing unit of the East Las Posas and Pleasant Valley basins is commonly referred to as the Grimes Canyon aquifer (CA DWR, 1954; Turner, 1975). The Grimes Canyon aquifer materials generally consist of marine shallow regressive sands. The Grimes Canyon aquifer is not mapped in the northern Oxnard Plain of in the Mound basin.

3.3 GROUNDWATER BASINS

The groundwater basins within the District vary in their water production and ability to be recharged rapidly. The groundwater basins detailed below are really subbasins of the larger basin of the Santa Clara River Valley (CA DWR, 2003). Hydraulic connection exists between all basins within the District boundaries. The Fillmore basin receives recharge as underflow from the Piru basin, and the Santa Paula basin receives significant recharge from the Fillmore basin. Often, a component of the flow between groundwater basins occurs as surface water around the basin boundaries. The Mound basin receives recharge from the Santa Paula basin as well as from the Oxnard Plain and Oxnard Forebay basins, although head differentials across the western Santa Paula basin boundary are greater than those between the other basins of the Santa Clara River valley. The Oxnard Forebay basin is widely recognized as the primary recharge area for aquifers in the Oxnard Plain. Many of the confining clays present in the aquifer systems of the Oxnard Plain are absent or discontinuous in the Oxnard Forebay basin, creating a window for recharge to other down-gradient aquifers. High groundwater elevations in and near the Oxnard Forebay promote groundwater flow to the nearby Mound and West Las Posas basins. The Pleasant Valley basin is more distant from the Oxnard Forebay and receives less direct benefit from United's recharge operations, but pipelines have been constructed to convey irrigation water directly to water users in Pleasant Valley and on the southern Oxnard Plain. The calibration of United's groundwater flow model has identified that much of the groundwater flow from the Oxnard Forebay is in the UAS, but there is significant vertical flux from the UAS downward to the LAS across the Oxnard coastal plain.

3.3.1 PIRU

The Piru basin consists of recent and older alluvium underlain by San Pedro (Saugus) Formation. The recent and older alluvium is made up of coarse sand and gravel that are present to a depth of approximately 60 to 80 feet throughout the basin. The San Pedro Formation consists of permeable sand and gravel and extends to a depth of approximately 8,000 feet. Two faults bound the Piru basin, the Oak Ridge fault to the south and the San Cayetano fault to the north (UWCD, 1996b).

Groundwater flow in the alluvium of the Piru basin tends to be westerly, parallel to the river channel. Similarly, the flow gradient in the San Pedro Formation is westerly with a small north/south component as the groundwater moves parallel to the axis of the syncline that forms the basin. The basin is considered to be an unconfined groundwater basin. The Santa Clara River and Piru Creek are major sources of recharge to the Piru basin, with minor sources from smaller streams, from outcrops to the north of the basin, and from percolation of rainfall. United's Piru spreading grounds located just west of Piru Creek have not been used in recent years due to low water levels in Lake Piru and permitting issues at the facility (the diversion structure lacks a fish screen). The Piru basin readily accepts large volumes of recharge as surface water percolates to groundwater in the channel of the river. During United's conservation releases from Lake Piru a significant percentage of flow infiltrates through the river channel and serves to recharge the Piru basin.

Under low-flow conditions (up to approximately 100 cfs), all of the surface flow of the Santa Clara River coming from Los Angeles County commonly infiltrates into the Piru basin above the confluence of Piru Creek, so that there is no continuity of river flow across the basin. Continuous surface flow may extend the length of the basin following large winter storms, during large releases from Castaic Lake, and in the winter and early spring of exceptionally wet years. A lengthy "dry gap" of approximately five miles commonly exists in the central portion of the Piru basin, extending from the point of complete percolation of surface water east of Piru Creek to areas near the downstream end of the basin. During United's conservation releases flows ranging from 100-200 cfs are often required to establish surface flow between Piru Creek and the west end of the basin. In the area west of Hopper Creek groundwater flow is constricted as the basin narrows and shallow groundwater intersects the river channel. This "rising groundwater" contributes or restores surface flow in the river near the west end of the basin. When groundwater levels in the Piru basin are high, the area of rising groundwater extends farther east than in drier times, and the total flow of the discharge to surface water is greater. At the lower end of the Piru basin, a significant amount of groundwater flows into the Fillmore basin as underflow (Mann, 1959).

The channel of the Santa Clara River stays along the basin's southern edge over the length of the basin, likely secured in that position by the alluvial fans of Piru and Hopper Creeks entering the basin from the north. Chloride impacts associated with wastewater discharges sourcing from Los Angeles County over the past decade are observed in wells along the northern portions of the middle of the basin. The northerly extent of these chloride impacts suggests the primary groundwater flow paths down the basin are north of the modern river channel. Groundwater flow paths are likely influenced by both geologic structure within the basin and the extraction of groundwater in the northern portions of the basin.

3.3.2 FILLMORE

The Fillmore basin consists of varying alluvial deposits resting on the San Pedro Formation. The younger alluvial deposits are comprised of recent sands and gravels of the Santa Clara River and Sespe Creek in the southern and eastern parts of the basin. Southward-sloping alluvial fan material from the Sespe uplands in the north-central portion of the basin, and alluvial fan material of the Pole Creek fan underlies the City of Fillmore (UWCD, 1996b). Alluvial thickness varies from about 60 to 120 ft. The San Pedro Formation, folded into an east-west syncline, underlies most of the Fillmore basin. Along the main axis of the syncline, the San Pedro Formation reaches a depth of about 8,400 feet. Near the western boundary of the Fillmore basin the San Pedro Formation extends to a depth of 5,000 to 6,000 feet.

Groundwater flow in the alluvium of the Fillmore basin is generally east-to-west. Groundwater that infiltrates from Sespe Creek flows generally moves towards the southwest. In the San Pedro Formation, the movement of groundwater is believed to be southerly beneath the Sespe fan, changing to westerly near the axis of the syncline. The basin is considered an unconfined groundwater basin. The Santa Clara River and Sespe Creek are two major sources of recharge to the Fillmore basin, as is underflow from Piru basin. As with the Piru basin to the east, the Fillmore basin readily recharges in years of abundant rainfall and streamflow.

The Fillmore basin narrows at the downstream end, resulting in an extensive area of rising groundwater and gaining flow in the Santa Clara River. Extensive wetlands exist in this area, and are easily visible on aerial photographs. Groundwater underflow to the Santa Paula basin is thought to be substantial, although one older interpretation suggests surface flow related to rising groundwater comprises a larger component of the discharge from the basin (Mann, 1959).

3.3.3 SANTA PAULA

The Santa Paula basin is located along the Santa Clara River, extending from approximately Kimball Road and the town of Saticoy in the west to Santa Paula Creek in the east. The basin is bounded by the Sulphur Mountain foothills on the north and South Mountain on the south. The basin is elongated in a northeast-southwest direction, about 10 miles long and as much as 3.5 miles wide. The surface area of the basin is approximately 13,000 acres, and ranges in elevation from 130 feet above sea level near Saticoy to 270 feet above sea level near the City of Santa Paula. Ongoing uplift along the Oak Ridge and other faults has created a deep basin, with Plio-Pleistocene deposits exceeding 10,000 feet in thickness.

The principal fresh water-bearing strata of the Santa Paula basin are the Pleistocene San Pedro Formation, Pleistocene river deposits of the ancient Santa Clara River, alluvial fan deposits shed from the uplifted mountain blocks, and recent river and stream sediments deposited locally along the Santa Clara River and its tributaries. These water-bearing sediments are underlain by relatively impermeable Pliocene and older units. The sediments of the basin have been warped into a syncline that is oriented in a northeast-southwest direction along the center of the basin. To the east, the Santa Paula basin has hydraulic connection with the Fillmore basin. To the south, the Oak Ridge fault forms a partial barrier to groundwater movement. To the north, the portion of the aquifer represented by the San Pedro Formation is exposed in an outcrop along the Sulphur Mountain foothills. The Santa Paula basin borders the Oxnard Forebay and Mound basins on the west. The western boundary of the Santa Paula basin is complex, with local uplift and faults mapped by some investigators. Although there is general agreement that there is hydraulic connection between Santa Paula basin and the Mound basin, the degree of connection is uncertain.

Long-term records of groundwater elevations within the Santa Paula basin demonstrate that the basin has a more muted recharge response to wet years than the Piru and Fillmore basins to the east. Much of the recharge likely occurs in the eastern portion of the basin (Santa Paula Basin Experts Group, 2003). Groundwater levels in many wells in the central and western portions of the basin show significant seasonal variability (UWCD, 2013b), suggesting confined aquifer conditions occur in most of the basin. During high rainfall years, monitoring wells in the southern portion of the basin near the Freeman Diversion, and historically some other wells near Saticoy, have shown artesian flow.

3.3.4 MOUND

The principal fresh water-bearing strata of the Mound basin are the upper units of the San Pedro Formation and overlying Pleistocene deposits that are interpreted to be correlative with the Mugu aquifer of the Oxnard Plain basin. There is an upper confining layer of Pleistocene clay approximately 300 feet in thickness. The sediments of the basin extend several miles offshore.

The sediments of the basin have been warped into a syncline that is oriented in an east-west direction that roughly follows Highway 126. Structural disruption along the Oak Ridge fault in the southern portion of the basin has resulted in considerable uplift and erosion of the San Pedro and younger sediments. This disruption is the cause of the topographic “mounds” near the intersection of Victoria Avenue and U.S. 101, for which the basin is named. The Montalvo anticline has traditionally been used to define the southern extent of the basin. These structural features generally offset only the deeper LAS units of the adjacent Oxnard Plain. The deposits of the UAS overlie the faults and folds along the southern margins of the basin, but the character of the deposits change as they extend to the north, becoming more finely bedded and fine-grained (UWCD, 2012).

The limited number of wells in the Mound basin, especially in the northern half of the basin, complicates efforts to ascertain the primary sources of recharge to the basin. There likely is some component of recharge from precipitation falling on aquifer units that outcrop in the hills along the northern margin of the Mound basin (Figure 3.1-1), but no wells exist to provide evidence of this occurrence. There is general agreement that the basin benefits from recharge from the Oxnard Forebay and Oxnard Plain to the south, especially during periods of high water level on the Plain (GTC, 1972; Fugro, 1996; UWCD 2012). The hydrogeologic boundaries of the Mound basin are not coincident with the structural boundaries of the basin, so there is hydrologic connection between the Mound basin and adjoining groundwater basins (UWCD, 2012). The amount of recharge from the Santa Paula basin to the east is also unclear, but high heads in some wells in the eastern Mound basin suggests some degree of connection and recharge. Mann (1959) suggested that there is little underflow from the Santa Paula basin to the Mound basin, although more recent studies suggest it may be significant (Fugro, 1996; UWCD, 2012).

Groundwater flow in the Mound basin is generally to the west and southwest with modest to weak gradients, especially in times of drought. The poor distribution and limited number of wells with water level records complicates efforts to contour groundwater elevations in the basin. During periods of drought and increased pumping, a pumping trough forms along the southern portion of the basin that significantly modifies groundwater gradients.

3.3.5 OXNARD FOREBAY

Both UAS and LAS aquifers are present in the Oxnard Forebay and Oxnard Plain basins. The Oxnard Forebay maintains direct hydraulic connection with confined aquifers of the Oxnard Plain basin, which extends several miles offshore beneath the marine shelf where outer edges of the aquifer are in direct contact with seawater. In areas near Port Hueneme and Pt. Mugu where submarine canyons extend nearly to the coastline, the fresh-water aquifers may be in direct contact with seawater a short distance offshore.

The Forebay is the main source of recharge to the Oxnard Plain basin. Recharge to the Forebay benefits other coastal basins (Mound, West Las Posas, and Pleasant Valley) but a majority of the water recharged to the Forebay flows downgradient to the confined aquifers of the Oxnard Plain. The shallow sediments of the basin are dominated by coarse alluvial deposits of the ancestral Santa Clara River. The absence of low-permeability confining layers between surface recharge sources and the underlying aquifers in the Forebay allow rapid groundwater recharge in the Forebay. The recharge to the Forebay comes from percolation of Santa Clara River flows, artificial recharge from United's spreading basins, irrigation return flows, percolation of rainfall, and likely lesser amounts of underflow from the Santa Paula basin and mountain-front recharge from the nose of South Mountain. In the area of the Forebay between the El Rio and Saticoy spreading grounds, the LAS has been uplifted and truncated along its contact with the UAS. In this area recharge from surface sources may enter both the UAS and the underlying LAS. The USGS estimates that about 20% of the water recharged to this area reaches the LAS, with the remainder recharging the UAS. In some areas of the Forebay significant clays are present among the deposits of the LAS.

3.3.6 OXNARD PLAIN

The Oxnard Forebay is hydraulically connected with the aquifers of the Oxnard Plain basin, which is overlain by an extensive confining clay layer. Thus, the primary recharge to the Oxnard Plain basin is from underflow from the Forebay rather than the deep percolation of water from surface sources on the Plain. Natural and artificial recharge to the Forebay serves to raise groundwater elevations in this up-gradient area of the groundwater flow system for the Oxnard Plain. Changes in the volume of groundwater in storage in the Forebay changes the hydrostatic pressure in the confined aquifers extending from the margins of the Forebay to the coastal and offshore portions of these continuous aquifer units. High water levels in the Forebay are desirable, as they are required to maintain offshore pressure gradients from the Forebay to coastal areas. While the physical movement of groundwater out of the Forebay is fairly slow, the pressure response in the confined aquifers distant from the

Forebay responds more rapidly to significant recharge events in the Forebay. When groundwater levels are below sea level along the coastline, there can be significant recharge by seawater flowing into the aquifers.

Vertical gradients also commonly exist between aquifer units on the Oxnard Plain, resulting in water movement through low-permeability units that occur between most of the major aquifers. When LAS water levels are significantly lower than UAS water levels (creating a downward gradient), there is substantial leakage of UAS water into the LAS through the various aquitards that separate the aquifer units. Accordingly, recharge to the LAS occurs throughout the Oxnard Plain and is not limited to the Oxnard Forebay. A downward pressure gradient also commonly exists between the Semi-perched aquifer and the Oxnard aquifer, as heads in the shallow confined Oxnard aquifer may be lowered regionally by drought conditions or locally by pumping wells. The movement of poor quality water from the Semi-perched aquifer to the Oxnard aquifer has been documented in some locations, with abandoned or improperly constructed wells being one notable pathway for this downward flow (Izbicki, 1992; Stamos et al., 1992).

The highly-permeable deposits of the UAS are relatively flat lying across approximately the upper 400 feet of the Oxnard Plain. In the northern Oxnard Plain heads are often similar in the Oxnard and Mugu aquifers, but heads in the Mugu aquifer are considerably deeper in the greater area surrounding Mugu Lagoon. Deposits of the LAS are generally finer-grained than those of the UAS and have been deformed by folding and faulting in many areas. An uneven distribution of pumping, along with structural and stratigraphic changes within the deposits of the LAS result in varied heads among the deep wells across the Oxnard Plain and Pleasant Valley. As a result of faulting and uplift of the underlying marine deposits near Mugu Lagoon the LAS is not hydraulically connected to the Pacific Ocean in this area (Izbicki, 1996a; Hanson et al., 2003).

3.3.7 PLEASANT VALLEY

The Pleasant Valley basin is bounded to the south by the Santa Monica Mountains, to the north by the Camarillo Hills, and to the west by the Oxnard Plain. The Bailey fault trends northeast near the base of the Santa Monica Mountains, and the Camarillo fault runs along the base of the Camarillo Hills to the north.

The Pleasant Valley basin is differentiated from the Oxnard Plain basin by a general lack of productive UAS aquifers (Turner, 1975). The UAS is composed of alluvial deposits about 400 feet thick. In Pleasant Valley much of the UAS is fine grained and not extensively pumped for water supply (Turner, 1975; Hanson et al., 2003). UAS deposits in the Pleasant Valley basin are comprised of sediments sourcing from the Calleguas Creek watershed, a much smaller and less mountainous drainage than that of the Santa Clara River which deposited the UAS deposits on the Oxnard Plain.

The LAS is composed of the Hueneme, Fox Canyon, and Grimes Canyon aquifers to a depth of about 1,400 feet. The Hueneme aquifer is composed of alternating layers of sand and finer-grained deposits. The Fox Canyon and Grimes Canyon aquifers are composed of thick sequences of relatively uniform marine sand. The Fox Canyon aquifer is the major water-bearing unit in the basin.

In Pleasant Valley the LAS is surrounded and underlain by partly consolidated marine deposits and volcanic rocks. Marine deposits are present in the Camarillo Hills and in the western edge of the Santa Monica Mountains near the coast. Volcanic rocks consisting of basalts, submarine volcanic flows, and debris flows are present in the Santa Monica Mountains along the southern edge of the valley (Weber et al., 1976). The underlying marine deposits and volcanic rocks both contain high-chloride water.

Under predevelopment conditions groundwater movement in the UAS and LAS was likely from recharge areas in the eastern part of Pleasant Valley toward the Oxnard Plain to the southwest. The LAS in Pleasant Valley appears to be fairly isolated from sources of recharge, and the time since recharge of the ground water ranges from 3,000 to more than 6,000 years before present (Izbicki, 1996b). Over the past two decades water levels in two wells in northern Pleasant Valley have recovered more than 250 feet. The re-establishment of surface flow in Arroyo Las Posas that subsequently percolates at the northern margin of the basin is now recognized as a source of recharge to the basin. The degree to which this large recharge mound serves to recharge the LAS the central portion of the basin is not well established. The City of Camarillo is proposing construction of a large-scale desalter to treat and utilize this water, which tends to be more mineralized than the older water native to the basin.

High-chloride concentrations are present in water from wells throughout the Pleasant Valley basin, especially along the southern edge of the basin near the Bailey Fault. Wells yielding high-chloride water in this area may have been drilled too deep and directly penetrate deposits having high-chloride water, or brines may have invaded deep freshwater aquifers from surrounding and underlying deposits as a result of pumping. Regardless of the source, changing hydraulic pressure as water levels within the Lower Aquifer System decline as a result of pumping wells, especially during dry periods, may increase chloride concentrations in water produced from deeper wells if the proportion of high-chloride water yielded to the well from underlying deposits increases (Izbicki et al., 2005a). Chloride concentrations in water from deep wells in the Pleasant Valley basin tend to increase during dry periods when groundwater pumping increases. Conversely, chloride concentrations in some wells tend to decrease during wetter periods when alternative sources of irrigation water are available from surface supplies and less groundwater is pumped from the basin. In addition to water from surrounding and underlying rocks, irrigation return flow also may contribute to high chloride concentrations in deep wells that are partly screened in the UAS.

3.3.8 LAS POSAS

The West Las Posas basin lies adjacent the northeast Oxnard Plain in the area south of South Mountain and north of the Camarillo Hills. The basins generally consists of a broad alluvial plain sloping to the south, and is drained by Beardsley Wash, which flows west around the Camarillo Hills.

Only the western portion of the West Las Posas basin lies within United's District boundary. Tree crops are the dominant land use in this agricultural area. Much of this area is served by groundwater imports from the Oxnard Plain, but some agricultural pumping is reported from deep wells near Beardsley Wash and other wells along the South Mountain foothills.

Most groundwater production in the West Las Posas basin is from deposits of the San Pedro Formation. Beneath most of the Las Posas Valley, the upper San Pedro Formation consists of low permeability sediments with lenses of permeable sediments which are age-equivalent to Hueneme Aquifer on Oxnard Plain (CA DWR, 1975). The permeable lenses form isolated, yet, locally important water sources. The water-bearing zones in the upper San Pedro Formation are not well connected. Some recharge to the deeper Fox Canyon aquifer may source from downward leakage from the upper San Pedro Formation. Many wells in the Las Posas basin are perforated in the Fox Canyon aquifer, making it the principal water-bearing unit (Mukae, 1988). The Fox Canyon aquifer is exposed almost continuously along the southern flank of South Mountain. South of the outcrop, beds of the Fox Canyon aquifer dip below the valley and are folded into a series of anticlines and synclines. Groundwater in the Fox Canyon aquifer exists under confined conditions beneath the valley and unconfined conditions at the valley margins where the aquifer is folded upward and exposed at the surface. Much of the groundwater recharge to the western portion of the West Las Posas basin is believed to source from the Oxnard Plain. Minor amounts of recharge are derived likely from infiltration of precipitation and runoff in the outcrop areas.

4 2014 - 2015 DISTRICT OPERATIONS

This section details operations performed by the District associated with diversion of surface water and groundwater recharge. Details of operations are presented for the years 2014 and 2015, with some discussion devoted to comparison to historical conditions. The water years 2012 through 2015 stand as the regions driest four consecutive years in terms of rainfall, and availability of surface water is at an all-time low, severely impacting District operations.

4.1 SANTA FELICIA DAM CONSERVATION RELEASES

United's conservation releases are designed to replenish the Piru, Fillmore and Santa Paula basins by direct percolation water from the Santa Clara River flow. The remaining portion of the release is diverted at the Freeman Diversion and is either spread for groundwater recharge in the Oxnard Forebay, or is distributed to agricultural users in the Oxnard Plain or Pleasant Valley basins via the PTP and PV surface water delivery systems. The timing, duration and flow rates of conservation release is adjusted to optimize benefits within the District. The volume of the release in most years is limited by the wet season runoff from the Piru Creek watershed and, to a lesser degree, the amount of State Water purchased by United and delivered via release down middle Piru Creek. United seeks to maintain a minimum pool of 20,000 AF of storage in Lake Piru that is intended to keep sediment deposited by inflow to the lake away from the outlet works near the dam. Normally, releases below this level are only done when State Water released from Pyramid Lake is expected to fill the lake back to the minimum pool shortly after the conservation release. Due to the ongoing drought conditions and requirements to release minimum flows for habitat in lower Piru Creek, storage in Lake Piru has dropped to 11,500 AF (as of December 31, 2015).

The following varied objectives are considered when deciding how much stored water is to be released:

- Provide enough storage capacity in Lake Piru to minimize the chances of spilling in the following year;
- Increase groundwater storage in downstream basins;
- Satisfy agricultural demands for surface water deliveries to the Pleasant Valley and the PTP systems;
- Meet the flow requirements in the FERC Santa Felicia Water Release Plan in Piru Creek to support southern California steelhead;
- Maintain a minimum pool of 20,000 AF of storage in Lake Piru;
- Hold over enough water in the lake in case the following year is a dry year.

As detailed in the 2013 Groundwater and Surface Water Conditions Report (UWCD, 2014), United's last conservation releases occurred in 2011 (31,700 AF) and 2012 (35,100 AF). Due to ongoing drought conditions, no conservation releases have occurred since 2012.

4.2 IMPORTATION OF STATE WATER

Ventura County has a 20,000 AF allocation for State Water. United's share of the allocation is 5,000 AF, the City of Ventura's share is 10,000 AF, and Casitas MWD has allocation for 5,000 AF. Port Hueneme Water Agency uses 1,850 AF of United's allocation and takes delivery directly through Calleguas MWD. United's remaining 3,150 AF of water is permitted to be released from Pyramid Lake and sent to Lake Piru through the natural water course of middle Piru Creek. Due to environmental constraints, United may receive delivery of this water only from November 1st through the end of February of each year. When available deliveries by DWR are less than United's full allocation, United has occasionally purchased a portion of the allocation belonging to either the City of Ventura or Casitas MWD to maximize the deliveries to the county. State Water releases cannot exceed the conveyance limit of 3,150 AF in Piru Creek without additional environmental work to evaluate whether larger releases would cause problems for endangered species in middle Piru Creek.

Typically, United's fall conservation release will end before the State Water is available for release to Lake Piru. In order to functionally release the State Water that same year, United may continue the release below the lake's minimum pool to the volume of State Water being purchased, knowing that the delivery of State Water will fill the lake back to the minimum pool by the end of November. The purchase of State Water allows the conservation release to be extended a few extra days. The volume of water that percolates into each basin on the extended days of the release is considered to be a direct benefit to each basin.

Table 4-1 presents a summary of all the State Water purchased by United, along with the direct benefit of groundwater recharge to each basin. Detailed stream flow measurements are taken near the basin boundaries throughout the annual releases to determine where the State Water is percolating. In 2014 and 2015, the State Water Project made available 5% and 20%, respectively, potentially giving United 158 AF and 600 AF, respectively, of its annual allocation of 3,150 AF. However, due to the dry streambed conditions in middle Piru Creek that conveys State Water to Lake Piru, it was calculated that little to none of the water available in 2014 would have made it to Lake Piru. Therefore United purchased no State Water in 2014. The 600 AF of State Water purchased in November of 2015 has not yet been released from Lake Piru, as a conservation release has not been conducted since that time.

Table 4-1. Summary of State Water Releases from Santa Felicia Dam from 1991-2015 (AF).

Year State Water Purchased	Releases			Delivered to PV and PTP	Recharge to lower basins
	From Santa Felicia Dam	To upper basins (Fillmore and Piru)	To lower basins (Santa Paula and coastal)		
1991	4,836	3,603	1,233	0	1,233
1992	988	84	904	0	904
2000	2,200	406	1,794	69	1,725
2002	3,150	1,455	1,695	192	1,503
2003	3,150	2,041	1,109	70	1,039
2004	4,047.5	3,348	700	228	472
2007	1,890	844	1,046	116	930
2008	1,980	673	1,307	306	1,001
2009	3,150	1,045	2,105	724	1,381
2010	3,150	917	2,233	559	1,674
2011	2,520*				
2012	3,150+2,520	1,770	3,900	1,097	2,803
2013	2,242**				
2014					
2015	630**				
Total	34,842	16,186	18,026	3,361	14,665

* Released in 2012 conservation release
** Remains in the Lake at the time of the publication of this document

The benefit to groundwater levels in the Piru basin of the conservation release along with the State Water released can be seen on Figure 4.2-1. Since November of 2007 a transducer has been recording water levels in a monitoring well near the Santa Clara River in the Piru basin. The graph shows the immediate rise in water levels in the well during the releases (shown in red). Because the well is approximately 600 feet from the active channel in the river, a groundwater (recharge) mound builds rapidly when the release starts then dissipate a little more slowly at the end of the release. Water levels are always considerably higher following the release compared to the projected trends if water was not released from Lake Piru. As there has not been a conservation release since 2012, and little rain, groundwater elevations in this well have continued to decline.

4.3 FEDERAL ENERGY REGULATORY COMMISSION LICENSED FLOW IMPLEMENTATION

United's original water rights license for Santa Felicia Dam requires a minimum release of 5 cfs or natural inflow, whichever is less. Due to the conditions in a new Federal Energy Regulatory Commission (FERC) License which was adopted in 2011, the bypass flows have now been changed to a minimum of 7 cfs. The new License conditions also require higher flows to maintain downstream habitat when the monthly cumulative precipitation is above the historic average measured at County Station 160, located at the guard station entering Lake Piru. Release requirements of 200 cfs for fish migration flow were also included in the new License, allowing increased opportunity for fish migration in Piru Creek when the Santa Clara River has elevated flows due to storm runoff and surface flows in the river are continuous from Piru Creek to the estuary of the Santa Clara River near Ventura Harbor. Migration releases are triggered when the USGS gauging station on the Santa Clara River near the Los Angeles County line measures above 200 cfs at 8:00 am and the mean flow is forecasted to stay above 200 cfs for the following 24 hours. Migration flow releases are to continue as long as mean daily flows at the County line remain over 200 cfs.

Based on recommendations from NMFS, FERC has also imposed license conditions regarding the rate at which United may decrease flows when ending conservation and migration releases. Release ramping rates must be adjusted so that water depths in lower Piru Creek never decreases more than two inches per hour. The FERC Bypass Flow Plan was adopted in May of 2011. As an example, ramping down the conservation release in fall 2011 took five days and a minimum of 25 adjustments to reduce flow from 300 cfs to 7 cfs.

During a series of storms between February 26 and March 2, 2014, the trigger conditions for migrations flows were met, and releases to lower Piru Creek were increased to 200 cfs. Due to the relatively low rainfall during the storms, the 200 cfs release was maintained for only 30 hours, after which a six-day ramping process was initiated to return to the minimum 7 cfs habitat flow release. In 2015 the habitat and migration flow triggers were not met, so the minimum bypass flow of 7 cfs was maintained throughout the year. All of the additional water released from SFD for the habitat flows (7 cfs instead or 5 cfs or less) either percolated into the Piru basin or was used by downstream diverters along lower Piru Creek.

4.4 SANTA CLARA RIVER FLOW DIVERSIONS

United's average annual diversion of water from the Santa Clara River near Saticoy is 57,800 AF (61-year average, 1955 – 2015). In wet years, diversions can be significantly higher: for instance, 94,000 AF was diverted from the Santa Clara River by United in the 2011 water year. Wet years offer rare and important opportunities to recharge the groundwater basins of the Santa Clara River valley and Oxnard coastal plain, and various operational strategies are implemented to assure maximum yield at the diversion. Such strategies include limiting turn-outs when turbidity is high in the river, shifting the locations of recharge operations to reduce groundwater mounding near the river, alternating ponds to maximize percolation rates, and using SCADA controls to optimize canal levels and flow. Completion of the Freeman Diversion (1991) and the construction of additional recharge basins (Noble basins, 1995) has allowed United to divert and recharge more water during wet years compared to pre-1991 operations when earthen diversions (vulnerable to storm damage) were built in the river channel.

Under the current drought conditions, water diversions have been very low, and operational strategies for spreading water have differed from those common to more normal conditions. United's Board of Directors declared the existence of drought conditions in 2014, and adopted a new policy on priorities for the use of surface water diverted from the Santa Clara River. Under this new policy, highest priority is given to diluting nitrate in the groundwater beneath and surrounding the El Rio Recharge Facility in order ensure that drinking water produced for the O-H system meets or exceeds drinking water standards. Other priorities include delivery of surface water to agricultural customers in Pleasant Valley and on the Oxnard Plain, and groundwater recharge in the Oxnard Forebay.

Annual diversion totals at the Freeman Diversion in 2014 and 2015 were 4,500 and 2,500 AF, respectively, corresponding to the third-lowest and lowest amounts diverted since 1956 (Figure 4.4-1). Low diversion amounts are due in part to the extremely low rainfall and streamflow during water years 2012-2015 (see Section 5.1), but are also related to new requirements for additional bypass flows for fish migration. Other years with similarly-low diversion amounts have occurred in the past, but never for a period extending longer than one year, as is currently the case.

4.4.1 EL RIO RECHARGE BASINS

The most recent year when recharge to El Rio exceeded the 61-year average was in 2011, when El Rio became the preferred location to recharge water due to the mounding of groundwater following extensive groundwater recharge at the Saticoy Recharge Facility.

Recharge at El Rio in 2014 and 2015 totaled 1,935 AF and 1,285 AF, respectively, or 8% and 6% of the 61-year average (Table 4-2). In 2014 and 2015 El Rio was the preferred facility for recharge because water was needed to help dilute elevated nitrate in the UAS in the area surrounding the O-H well field.

Table 4-2. Recharge to El Rio for calendar years 2014 and 2015.

Recharge to El Rio (AF)			
	2014 Year	2015 Year	average since 1955
Jan	0	703	2,575
Feb	0	261	2,965
Mar	1,588	321	3,303
Apr	218	0	2,594
May	0	0	1,921
Jun	0	0	985
Jul	0	0	814
Aug	0	0	1,069
Sep	0	0	1,511
Oct	0	0	1,659
Nov	0	0	1,449
Dec	129	0	2,033
Totals	1,935	1,285	22,879

4.4.2 SATICOY RECHARGE BASINS

In the dry years 2014 and 2015, only small volumes of water were recharged at Saticoy (Table 4-3). A total of 1,231 AF of water was routed to the Saticoy basins for groundwater recharge in 2015, which is far below the average of 22,000 AF for the 61-year period since construction of Lake Piru. Priority was given to the El Rio facility in an effort to maintain acceptable nitrate concentrations in the UAS wells supplying the O-H system. In 2014 the Saticoy facility recharged 387 AF, just 2% of the 61-year average.

The lower volume of water recharged at Saticoy in 2014 and 2015 was due in part to the lower flows in the Santa Clara River, resulting in less water available for diversion at the Freeman Diversion. The prioritizing of recharge at the El Rio Recharge Facility also contributed to the low recharge totals at the Saticoy Recharge Facility.

Table 4-3. Recharge to Saticoy for calendar years 2014 and 2015.

Recharge to Saticoy (AF)			
	2014	2015	Average since 1955
Jan	0	387	2,090
Feb	0	374	2,255
Mar	135	337	3,123
Apr	152	133	2,876
May	67	0	2,221
Jun	0	0	1,365
Jul	0	0	1,161
Aug	0	0	1,011
Sep	0	0	1,361
Oct	0	0	1,846
Nov	0	0	1,188
Dec	0	0	1,547
Totals	387	1,231	22,043

4.4.3 NOBLE RECHARGE BASINS

The Noble basin, historically, was the last of United's Saticoy facilities to be used for groundwater recharge. It is difficult to maintain these basins during the wet season due to greater water depths in the basins and proximity to shallow groundwater. The last time this basin saw significant use was during 2011, when 10,679 AF was recharged.

More recently, United's operations staff has routed more turbid water from high river flows to the Noble basins in order to preserve the percolation capacity of the other recharge basins at Saticoy and El Rio. In March 2014 a total of 578 AF of river water was delivered to the Noble basin for groundwater recharge (Table 4-4). The Noble basins received no water for recharge in 2015.

Table 4-4. Recharge to the Noble basins for calendar years 2014 and 2015.

Recharge to Noble Basins (AF)			
	2014	2015	average since 1995
Jan	0	0	242
Feb	0	0	716
Mar	578	0	1073
Apr	0	0	1133
May	0	0	488
Jun	0	0	355
Jul	0	0	164
Aug	0	0	89
Sep	0	0	117
Oct	0	0	123
Nov	0	0	120
Dec	0	0	152
Totals	578	0	4,772

4.4.4 ENVIRONMENTAL BYPASS FLOWS AT THE FREEMAN DIVERSION

The Freeman Diversion is operated to provide bypass flows for the upstream and downstream migration of the endangered southern California steelhead. The bypass flows provided in 2014 and 2015 are detailed in the 2009 and 2010 Freeman Diversion bypass flow plans. The flow criteria are designed to increase the magnitude and extend the duration of flows for upstream migration opportunities and to provide volitional downstream passage for smolts to the estuary when conditions are favorable. While achieving the goals set forth for the migration of steelhead, United's diversion volumes have been reduced as more bypass flow remains in the lower Santa Clara for fish.

In 2014 a single storm triggered only eight days of bypass flows. In 2014 an estimated 17,800 AF of water was directed past the diversion. Being a dry year, some of this water percolated as groundwater recharge in the Forebay reach of the Santa Clara River. United estimates that 16,000 AF of water made it across the Forebay reach of the Santa Clara River in 2014, providing water to the estuary and the lower reach of the river.

In 2015 there were no storms that produced enough runoff to trigger bypass flow requirements and therefore all water during the year was diverted. As noted above, only 2,500 AF was diverted in 2015.

Table 4-5 summarizes the loss in potential diversions and estimates the total loss to groundwater recharge in the Oxnard Forebay by considering the percolation of water in the Santa Clara River channel downstream of the Freeman Diversion. Losses were relatively low compared to previous years due to the limited opportunities for bypass flows under the current drought conditions. These bypass flows have been implemented since 2010. Prior to 2010 different bypass flow requirements were implemented in accordance with United's ongoing consultation with NMFS.

Table 4-5. Losses in diversions and groundwater recharge.

Year	Loss in Potential Diversions due to additional bypass flows (AF)	Loss in Total Recharge to Forebay (AF)
2014	1,400	1,000
2015	0	0

4.5 PTP DELIVERY SYSTEM

The Pumping Trough Pipeline delivers a combination of surface water diverted at the Freeman Diversion, Saticoy well field water, water from the system's five LAS wells (and occasionally water from O-H wells 12 and 13) to agricultural users on the pipeline. The total water deliveries by the PTP system were less in 2014 (6,777 AF) and 2015 (5,476) compared to the 2011-2013 period (8,389 - 8,944 AF), and the source of water in the PTP has shifted from mostly surface water to entirely groundwater as surface water has been less available in recent years. The PTP system has struggled to meet demand at times in recent years, and a number of growers have shifted back to private UAS wells.

Due to ongoing drought conditions in 2014 and 2015, almost all demands on the PTP system was met by the District's PTP wells (Figure 4.5-1). Any surface water available for diversion was recharged at the El Rio basins whenever possible, due to the need to reduce nitrate concentrations in El Rio UAS wells. Following discovery of the quagga mussel infestation in Lake Piru, users of the PTP system also opted not to receive any surface water deliveries starting in 2014, out of concern that the infestation could spread to and affect farm irrigation systems.

4.6 PLEASANT VALLEY COUNTY WATER DISTRICT DELIVERIES

United's deliveries to PVCWD vary from year-to-year depending on surface water supply from the Freeman Diversion. In 2011 when there was substantial surface water in the Santa Clara River the District was able to provide 11,200 AF of surface water, augmented with a small volume of water from the Saticoy well field. As the ongoing drought progressively reduced surface water availability, deliveries to PVCWD have continued to fall (Figure 4.6-1). In 2014, only 215 AF of surface water was delivered, and no deliveries were made in 2015. The Saticoy wells have not been operational since 2014 due to low groundwater levels. Table 4-6 shows the total amount of water delivered in 2014 and 2015, along with the percent of total diversions. As mentioned in section 1.4.6.2, the District is required to deliver a minimum of 12.22 % of the total diversions to PVCWD on an annual basis. This contractual minimum was not met in 2014 because the timing of potential surface water deliveries did not coincide with demands by PVWCD users. Following the discovery of quagga mussels in Lake Piru, PVCWD requested that their system be isolated from United's in order to prevent a potential infestation by quagga.

Table 4-6. Percent of Freeman diversions delivered to PVCWD.

Year	Total delivered to PVCWD (AF)	Percent of Total Diversions
2014	215	4.7%
2015	0	n/a

4.7 SATICOY WELL FIELD USAGE AND CREDIT SYSTEM BALANCE

In conjunction with the conservation releases from Santa Felicia Dam, United temporarily stores water beneath the Saticoy Spreading Grounds for later pumping and delivery to the overdrafted areas of the Pleasant Valley and Oxnard Plain basins. United constructed the Saticoy well field in 2003, allowing for the pumping of mounded groundwater for delivery to the PV and PTP systems. The FCGMA thereafter adopted a resolution that created a pump-back storage program for the Saticoy Spreading Grounds and the Saticoy well field. Water recharged by a Lake Piru conservation release can be pumped back from Saticoy within a period of two years. At the end of the two years the storage credits expire. Below is a table showing the history of the credit balance of this system. To date, a total of 33,400 AF have been stored during the conservation releases at Saticoy, with a total of 11,616 AF extracted for deliveries to the PV and PTP irrigation delivery systems. The credit system does not include water associated with United's State Water imports. As of October of 2013, water levels in the well field had fallen below the pumps in the wells, so the wells are currently not being used. As of 2015 all credits have expired, as shown in Table 4-7.

Table 4-7. Credit accounting for the Saticoy Well Field, values in AF.

Calendar Year	Start of the year		Total Extractions to Surface Water Deliveries	End of the year	
	First Year Storage*	Second Year Storage		Remaining Second Year Storage to Expire	Remaining First Year Storage
2007	7,846	0	1,753	0	6,093
2008	4,711	6,093	3,845	2,248	4,711
2009	8,715	4,711	2,455	2,256	8,715
2010	2,414	8,715	759	7,956	2,414
2011	2,221	2,414	737	1,677	2,221
2012	5,974	2,221	1,590	631	5,974
2013	1,552	5,974	477	5,497	1,552
2014	0	1,552	0	1,552	0
2015	0	0	0	0	0

* Water stored in the prior year's conservation release.

4.8 CASTAIC LAKE FLOODFLOW RELEASE

United is the lead member of a water conservation agreement between the California Department of Water Resources and the Downstream Water Users (DWUs). The DWUs consist of United, Los Angeles County, Newhall Land and Farming, and Valencia Water District. The program is designed to hold natural runoff from the Castaic Creek watershed in Castaic Lake for later release in a manner that allows the flows to percolate in the basins downstream of the dam, benefiting the DWUs. United takes the lead role for the DWUs in requesting the storage and release of flood flows, and in monitoring releases to make sure that flows benefit the DWUs in both Los Angeles and Ventura County. The most recent event when captured flood flows were released occurred in 2011 and totaled approximately 11,000 AF. Due to the ongoing drought conditions, no flood flows have been retained for a later release since 2011. Flood flow volumes from relatively small rainfall events in 2014 and 2015 were used to maintain water level in the Castaic Lake Lagoon below the dam. The water stored in Castaic Lagoon percolates downstream, providing some minor benefit to the DWUs.

4.9 BOUQUET RESERVOIR RELEASES

United has an agreement with the Los Angeles Department of Water and Power (LADWP) that provides for the release of flow from Bouquet Reservoir to recharge the aquifers of the Santa Clara River Valley to the extent that they were recharged by runoff from the Bouquet Canyon watershed prior to construction of the reservoir. The agreement stipulates that LADWP release between 2,100 and 2,194 AF per year. This quantity is based on historical annual inflows to the reservoir. The agreement requires a continual release of 5 cfs between April 1st and September 30th; and 1 cfs between October 1st and March 31st of each year.

The prescribed flows were interrupted following an extreme weather event in 2005 that raised streambed elevations and the stream channel shifted toward Bouquet Canyon Road. In several locations the streambed is now higher than the road, and on occasion stream flows have entered the road, posing a threat to public safety. When stream flow is observed on the road, flows from Bouquet Reservoir are reduced. To complicate matters, this area of Bouquet Creek is designated critical habitat for unarmored three-spine stickleback, and flow changes require special consideration for this species. United has been participating in the stakeholder meetings to ensure that the deficit of water will eventually be released for the benefit of downstream users. As of December 2015 the total deficit of releases totals more than 5,540 AF.

5 2014 - 2015 HYDROLOGIC CONDITIONS

This section details the range of hydrologic conditions observed throughout United's district boundaries. Conditions are presented for the years 2014 and 2015, with some discussion devoted to comparison to historical conditions. The water years 2012 through 2015 stand as the region's driest four consecutive years in terms of rainfall. Consequently, runoff volumes, water levels in a number of groundwater basins, and water levels in Lake Piru are all experiencing all-time lows.

5.1 PRECIPITATION

United participates in data collection in partnership with the Ventura County Watershed Protection District and maintains three rainfall gages, and two of sites also measure pan evaporation. The VCWPD maintains approximately 125 gages around the County (Figure 5.1-1). United's gages are located at field offices in El Rio and at the guard station at Lake Piru. United also maintains records from the gage at the office in Santa Paula for its own use, as VCWPD abandoned this site several years ago. United's monitoring stations showed that precipitation was about 40% and 60% of average for the 2014 and 2015 water years, respectively. In water year 2014, about 60% of the annual precipitation occurred in December and January, while in water year 2015, about 75% of the annual precipitation occurred in February and March. Table 5-1 shows the precipitation across the District's monitoring sites for 2014 and 2015, compared to the average for each station.

The long-term historic precipitation record for Santa Paula is shown on Figure 5.1-2. The ongoing drought (water years 2012 – 2015) can be classified as the driest four consecutive years on record, with an average of 8.1 inches of rainfall per year during this period. Periods of similar four-year drought conditions were observed in 1900, 1901 and 1951 (Figure 5.1-2). The current drought is exceptional because of its intensity, and all four years have been very dry. Years 2013 and 2014 ranked the 3rd and 4th driest years since 1870, respectively, while years 2012 and 2015 ranked the 25th and 27th driest years (Table 5-2).

Table 5-1. Annual Precipitation for water years 2014 and 2015.

Rainfall at UWCD Stations (Inches)				
Water Year	Saticoy # 261	El Rio # 239	Lake Piru # 160	Santa Paula # 245
2014	6.49	6.39	8.17	6.17
2015	10.38	9.52	12.18	10.63
Average	15.5	15.46	19.81	17.41*
Averaging period	1985-2015	1950-1992	1950-1992	1890-2016

Table 5-2. Ranked thirty driest years since 1870 for Santa Paula (#245).

Rank	Year	Precipitation		Rank	Year	Precipitation		Rank	Year	Precipitation
1	2007	4.98		11	1987	7.4		21	1870	10
2	1877	5		12	1924	7.57		22	1873	10
3	**2013**	**6.03**		13	1951	8.15		23	1885	10
4	**2014**	**6.12**		14	1948	8.27		24	1925	10.01
5	1898	6.42		15	1894	8.49		**25**	**2012**	**10.18**
6	1899	6.54		16	1871	9		26	1989	10.45
7	1961	6.62		17	1972	9.11		**27**	**2015**	**10.63**
8	1959	6.67		18	1964	9.42		28	1999	10.69
9	2002	6.98		19	1900	9.57		29	1953	10.82
10	1990	7.25		20	1949	9.79		30	1879	11

5.2 SURFACE WATER

The Santa Clara River Watershed is extensively monitored by multiple agencies for rainfall, daily stream discharge and flood flows. Data for many of the monitoring sites goes back to the early 1900s giving a relatively long period of record for comparison purposes. Below is a brief discussion of 2015 conditions under the ongoing drought and how they compare to more typical conditions and to the historical record. Daily and monthly data for all the sites discussed can be obtained on-line at websites maintained by the USGS and VCWPD.

5.2.1 LAKE PIRU

The water level in Lake Piru at the end of calendar year 2015 was 970 ft, 85 feet below the spillway elevation, and the lowest lake level recorded since 1977. At this level lake storage totals approximately 11,400 AF (Figure 5.2-1). Figure 5.2-1 shows a significant gain in storage in 2011, storage depletion associated with reservoir releases in 2011 and 2012, and only minor increases in storage in the years 2012 through 2015.

When water levels are below the operational minimum storage pool of 20,000 AF, and there is increased risk that sediment will accumulate around the outlet works when storm runoff enters the lake. Additionally, the next conservation release may be delayed as storm water runoff will be retained in the lake to increase lake levels above minimum pool. The low lake levels also impact recreation at the lake, as the lake area available for recreation is reduced and boat launching opportunities are difficult or restricted at times.

5.2.2 SANTA CLARA RIVER SYSTEM

The Santa Clara River is the largest river system in southern California remaining in a relatively natural state. The headwaters start on the northern slopes of the San Gabriel Mountains and the river flows approximately 84 miles to an estuary and river mouth at the Pacific Ocean near Ventura Harbor on the northern Oxnard Plain. Major tributaries include Castaic Creek and San Francisquito Creek in Los Angeles County, and Piru, Hopper, Sespe and Santa Paula Creeks in Ventura County. While the Los Angeles portion of the watershed accounts for 40% of the total area, it commonly produces only about 20% of the total river flow, with dry-season base flows sustained in some reaches by discharges from wastewater treatment plants and rising groundwater from the Eastern groundwater basin. As mentioned in other sections of this report, long reaches of the main stem of the Santa Clara River remain dry for most of the year, except during the wetter years.

5.2.2.1 RISING GROUNDWATER MONITORING

Recent monitoring of rising groundwater near the downstream boundaries of the Piru and Fillmore basins has shown a gradual retreat of the rising groundwater, a loss of connected surface flows, and significantly reduced length of the wetted stream channel, since the onset of the drought in 2011 (Figure 5.2-2). The length of the wetted stream channel in the Ventura County portion of the river decreased from ~ 17 miles in the fall of 2012 to less than ~ 8 miles in the fall of 2015, and is expected to continue to decrease during 2016. The reductions in wetted stream channel length result in significant reductions in habitat for fish and other aquatic life in the Ventura County portion of the Santa Clara River. Groundwater discharges observed near the downstream end of the groundwater basins also decreased significantly, from 25 cfs at Piru basin and 32 cfs at Fillmore basin in the fall of 2011, to dry conditions at Piru basin and 5 cfs at Fillmore basin in the fall of 2015. Groundwater discharge to surface water and groundwater elevation are strongly correlated at the downstream boundary of both basins (Figures 5.2-3 and 5.2-4). Therefore, given historic observations that surface water flows related to rising groundwater comprise a large component of river flow near the Piru and Fillmore basin downstream boundaries, groundwater conditions associated with the current drought have significantly reduced the transport of groundwater from up-gradient basins to down-gradient basins.

5.2.2.2 FLOW IN THE SANTA CLARA RIVER WATERSHED

Surface water flows in the Santa Clara River system were well below normal for the 2014 and 2015 water years. Only a handful of rainfall events, with relatively low rainfall amounts, occurred during each of these two years. Given the dry soil conditions in the watershed following the prolonged drought conditions, runoff amounts associated with the rainfall events were low.

USGS station 111090000, Santa Clara River near Piru, measures the entire contribution of the Los Angeles County portion of the watershed that flows into Ventura County. This station recorded peak flows of 1,750 cfs and 4,120 cfs in 2014 and 2015, respectively, but flows receded to under 100 cfs within a couple of days after each peak. Significant releases from Castaic Lake were not conducted in 2014 and 2015. Base flows existed year-round at the county line, largely due to discharges from the Valencia Water Reclamation Plant (WRP), but dropped as low as 2-3 cfs during the summer months.

Table 5-3. Total runoff for various stream flow stations (AF).

USGS/VCWPD Stream flow Stations	2014	2015	Median	Period of record for median
Santa Clara River at County line USGS 11108500/Santa Clara River near Piru USGS 11109000[1]	20,631	25,302	32,583	1953-2015
			35,323[2]	1975-2015[2]
Piru Creek above Lake Piru USGS 11109600	9,988	3,942	26,750	1956-2015
Piru Creek below Santa Felicia Dam USGS 11109800	6,504	6,356	33,235	1956-1968; 1974-2015
Sespe near Fillmore USGS 11113000	18,547	8,529	37,846	1944-1985; 1991-1992; 1994-2015
Santa Paula Creek VCWPD 709	1,788	1,028	8,184	1928-2015

[1]Station was moved from County line to near Piru in 1996.

[2]Only includes years after Valencia Water Reclamation Plant started discharging.

Table 5-3 shows the annual water year runoff for selected monitoring sites upstream of the Freeman Diversion, and a comparison to the median runoff volumes for each site. Flows in Sespe Creek, Santa Paula Creek and Piru Creek above Santa Felicia Dam generally represent natural runoff produced by rainfall. Because Pyramid Lake (located on Piru Creek above Lake Piru) adopted an "inflow equals outflow" flow regime in recent years, the gage above Lake Piru now represents a more natural flow regime. Both the Piru Creek below Santa Felicia Dam and the Santa Clara River near Piru/County line gages represent a more regulated stream flow, with SFD on Piru Creek and effluent discharged upstream of County line by the Valencia WRP.

Annual runoff volumes during the 2014 and 2015 water years were significantly below the median volumes for all stations. The reduction was least pronounced at the Santa Clara River near Piru station, where base flows were sustained by wastewater discharges. Figures 5.2-5 through 5.2-9 show the annual runoff volumes observed during the current drought years (2012-2015) compared to the period of record for each station. In most cases, runoff volumes for the years representing the current drought were well below median values, and some annual flow volumes were among the lowest observed.

5.2.2.3 WATER QUALITY

United maintains a surface water quality monitoring program and collects samples from a number locations at frequencies ranging from quarterly to every two weeks. Sampling sites are generally located on the Santa Clara River near groundwater basin boundaries and at the major tributaries near the confluence with the river. Additional water quality sampling sites include the Santa Clara River at the Freeman Diversion and the stilling wells where surface water arrives at United's El Rio Recharge Facility. Sample analysis commonly consists of either a full inorganic general mineral suite or several key constituents such as TDS, chloride and nitrate. This surface water quality monitoring provides documentation of variations in surface water quality and information on the quality of water that is recharging the groundwater basins within the District. Sampling is conducted every three months at most of the sites, but more frequently at some key locations (every month for the Santa Clara River near County Line, and every two weeks at Freeman Diversion).

Water quality at the various sampling sites throughout the District tends to vary seasonally, with the lowest annual mineral concentrations commonly recorded in the winter and spring when flows are greater. Results from United's 2015 surface water sampling are shown on Figures 5.2-10 and 5.2-11, where the annual recorded minimum concentrations of chloride and TDS, respectively, are displayed over the annual maximum values. The range in values is from four seasonal samples at most locations, so the true range in quality in the water bodies is likely greater than what was documented. In 2015 several sites had dry channel conditions at the time of scheduled sampling, so fewer than four annual samples were collected at those locations. With the dry conditions in the watershed in 2015, the mineral content of surface waters tended to be higher at some locations. At locations when rising groundwater is a primary component of surface flow, dry season water quality tends to be fairly stable year-to-year.

Water quality in Piru Creek is influenced by water stored in Pyramid Lake located higher in the Piru Creek watershed, which receives large volumes of water from the State Water Project. Water in middle Piru Creek is a blend of State Water and local runoff from the upper Piru Creek watershed. When chloride concentrations in State Water are high, the chloride in middle Piru Creek (below Pyramid dam) and Lake Piru can be much higher than what would occur naturally. In 2015 the maximum-recorded chloride in Lake Piru was 97 mg/l. Chloride concentrations as high as 115 mg/l were recorded flowing into the lake, but the 2015 flows associated with these high chloride concentrations were minor.

Chloride concentrations in the Santa Clara River near the Los Angeles County line are also influenced by chloride in imported State Water, as Castaic Lake Water Agency delivers State Water to water retailers in the greater Santa Clarita area. In years past, approximately 50% of the total chloride in wastewater discharges is from the chloride load in imported State Water (LACSD, 2008). Additional chloride loading occurs during beneficial use of the delivered water, but chloride loading has been significantly reduced in recent years as the Los Angeles County Sanitation District has managed a successful campaign to remove thousands of self-regenerating water softeners from the community. The Sanitation Districts are trying to satisfy regulatory requirements for the quality of their effluent, but the approach to be taken is not yet clear as community residents have resisted funding a chloride TMDL proposed by the Sanitation Districts and approved by the Los Angeles Regional Water Quality Control Board in December 2008.

Over the past few decades chloride concentrations in the Santa Clara River have varied considerably near the Los Angeles County line as water quality at this location is heavily influenced by discharges from the Valencia Water Reclamation Plant. From the late 1990s through 2003 the discharges from the Valencia plant increased steadily in both volume and chloride, with chloride concentrations exceeding 200 mg/l near the end of this period. Since 2003 chloride concentrations in the discharges have fallen somewhat: however, chloride in the river commonly exceeds the 100 mg/l surface water objective during months without significant rainfall (Figure 5.2-12). The lower chloride concentrations in the Santa Clara River in recent years are largely related to lower chloride in wastewater discharges from the Valencia WRP (see section 5.3, Figure 5.3-6). This is likely the result of lower chloride levels in State Water Project imports and the successful ban of self-regenerating water softeners in City of Santa Clarita area homes. Prior to 1970 the discharge of oilfield brines significantly impaired water quality in the river at this location, but flows associated with this poor-water quality were likely minor.

Beginning in January 1999, United has sampled the Santa Clara River near the Los Angeles County line each month for chloride and other analytes. Sampling in 2015 documented chloride concentrations ranging from 122 to 147 mg/l. Chloride concentrations in the water released from Lake Piru ranged from 80 to 98 mg/l over the same time period (Figure 5.2-10).

Sespe Creek at times has high chloride concentrations, both historically and in recent years. Low chloride concentrations are also commonly measured in the runoff from the Sespe watershed, and the source of elevated chloride has not been determined.

In recent years both the City of Fillmore and the City of Santa Paula have eliminated discharges of treated wastewater to the Santa Clara River. Santa Paula's new treatment plant came on-line in 2010 and now utilizes percolation basins for wastewater disposal. Fillmore completed a new plant in 2009 and now distributes reclaimed water to both percolation basins near the plant site and a network of subsurface irrigation systems constructed in parks and school fields throughout the City. The City of Fillmore has banned the installation of self-regenerating water softeners as part of its efforts to reduce chloride loading to the watershed. There are now no Ventura County water reclamation plants discharging flow to the Santa Clara River, except for the City of Ventura plant that discharges to the estuary at the coast. Continuous river flow from Los Angeles County line to the Freeman Diversion is uncommon, but when there is connection, flows are usually high in the lower watershed and the recycled water component sourcing from Los Angeles County is very minor. The maximum-recorded chloride concentration in the Santa Clara River at Freeman Diversion in 2015 was 116 mg/l (Figure 5.2-13). Even higher chloride concentrations were recorded in the summer and fall of 2014 when flow in the river was very low. In the summer and fall of 2015 when chloride in the Santa Clara River was recorded at concentrations greater than 100 mg/l, flow in the river was approximately ten cfs or less.

United frequently monitors water quality in the Santa Clara River at the Freeman Diversion, the point where water is diverted from the river for either direct deliveries to agricultural users or groundwater recharge in the Oxnard Forebay. Samples are collected at the Freeman Diversion approximately every two weeks to confirm that the water is acceptable for use in both aquifer recharge and for irrigation deliveries. The TDS and chloride content of water in the river at this location exhibits a strong negative correlation with flow, with higher flows being less mineralized (Figure 5.2-13 and Figure 5.2-14). Under dry watershed conditions groundwater discharge (rising water) from the Fillmore basin comprises a large portion of the river flow at the Freeman Diversion. Under wetter conditions tributary flow, most notably from Sespe and Santa Paula Creeks, contribute flow to the lower river and improves water quality compared to low-flow conditions. High river flows resulting from the direct runoff of precipitation commonly has the lowest dissolved mineral content, as does the recession limb of hydrographs from large flow events (Figure 5.2-14). United commonly diverts large volumes of water from the river for groundwater recharge during these periods of high flow and good water quality. Recorded TDS concentrations at the Freeman Diversion ranged from 1240 to 1870 mg/l in 2015 (Figure 5.2-11). As with chloride concentrations at this location, poor quality is associated with low flows in the river, and this water is generally used for irrigation deliveries rather than groundwater recharge. In 2015, however, summer diversions were recharged at El Rio because of persistent high nitrate concentrations in the O-H wells.

Nitrate concentrations in the Santa Clara River at Freeman Diversion show some negative correlation with flow but concentrations are routinely low in the river during both high and low flows (Figure 5.2-13). A weak seasonal signature has been observed, with nitrate concentrations rising slightly in the fall (UWCD, 2008). For the nine samples collected at Freeman Diversion in 2015 the maximum-recorded nitrate concentration was 8.2 mg/l (as NO_3), well below the CA Division of Drinking Water primary health standard of 45 mg/l. Sample collection for the Santa Clara River at Freeman Diversion was limited in 2015, as the river was commonly dry or had very little flow at this location.

The County of Ventura maintains and operates a composite sampling device at the Freeman Diversion that samples storm flow and dry weather base flows several times per year. These samples are analyzed for a broad suite of constituents, including organic contaminants and metals, as required by the Countywide NPDES Stormwater Permit. Detections of organic contaminants such as pesticides are uncommon and generally of low concentration (Ventura Countywide Stormwater Quality Management Program, 2015)

5.2.3 CALLEGUAS CREEK

United does not actively gage or sample surface water in the Calleguas Creek watershed. Much of the monitoring activity in the Calleguas Creek watershed is currently associated with the Salts TMDL under development for the watershed, the Ventura Countywide Stormwater Quality Management Program, and the Ventura County Agricultural Irrigated Lands Group (VCAILG).

5.3 GROUNDWATER

Groundwater is utilized extensively for municipal and agricultural use throughout the boundaries of United Water Conservation District, as imported water supplies are unavailable over much of this area. United has a responsibility to monitor conditions in the basins throughout the District so that the basins are understood and managed as needed. Many small water supply projects are completed without United's direct involvement, but proponents of most large water projects engage United's support in some way (e.g., data sets, technical support, financial assistance, etc.).

The following sections detail 2015 basin conditions within the eight groundwater basins which fall wholly or partially within United's district boundaries. Groundwater elevations have fallen considerably in a number of areas since 2011, the last year with significant rainfall. In 2015, rainfall and streamflow were well below average, which limited the amount of recharge to the basins. Below-average precipitation and the subsequent low inflow into Lake Piru resulted in United's inability to perform fall conservation releases from Lake Piru. The last time prior to 2013 that there was no conservation release was in 1990 during the previous drought. While the focus of this report is recent conditions, some discussion in the following section is devoted to comparing current conditions to past periods of abundant rainfall or drought, or periods pre-dating some major water supply projects within the District.

5.3.1 PIRU BASIN

The unconfined Piru basin has the capacity to rapidly accept water from the channel of the Santa Clara River and tributary streams. Groundwater in storage within the basin is slowly discharged to the Fillmore basin located downstream, so in some ways the Piru basin acts as a "forebay" to downstream groundwater basins in the Santa Clara River valley. Surface water flow resulting from the discharge of rising groundwater at the west end of the basin is greater when groundwater elevations are higher in the downstream portions of the basin. Groundwater elevations in several wells have recently fallen below historic lows. Over the past decade chloride impacts sourcing from Los Angeles County have migrated down past the midpoint of the basin.

5.3.1.1 WATER LEVELS

Historical groundwater elevations for United's Piru basin key well, located northwest of the confluence of Piru Creek and the Santa Clara River, are shown in the hydrograph on Figure 5.3-1. The historical record for this well shows that groundwater elevations in the Piru basin fluctuate dramatically, and that the basin is capable of rapid water level recovery following periods of drought. Water level recovery at this location is largely related to channel recharge associated with high and prolonged flow in the Santa Clara River and in Piru Creek, such as that which occurs during reservoir releases or large winter storms.

The basin fills in wet years such as 1998 and 2005, as shown by the flat-topping of groundwater elevations at 620 feet (Figure 5.3-1). The winter of 2011 was moderately wet but the basin did not fill to historical highs. Water levels in this key well recovered by about 15 feet in response to United's fall 2012 conservation release, but have fallen continuously since that time. Water levels in this well have fallen at least 100 feet since the spring of 2011, to an elevation below the water levels recorded in the drought conditions of 1991. This well has been dry (groundwater elevations have fallen below the depth of the well) since November 2015.

Piru basin groundwater levels have benefited from the recharge of recycled water discharged to the Santa Clara River by water reclamation plants in Los Angeles County. Historically the Santa Clara River has maintained perennial flow in the vicinity of Blue Cut and the County line, with the flow sustained by groundwater discharge from the Eastern groundwater basin. The City of Santa Clarita began importing State Water in 1980, and steady growth in that community resulted in steady increases in wastewater discharges to the river until recent years, when discharge has diminished slightly. United's fall conservation releases from Lake Piru provide an additional source of recharge to the basin. Release volumes vary year-to-year, and variable channel conditions and release flow rates affect the percentage of the released water that percolates in the Piru basin. Recharge through the channel of Hopper Creek is likely another source of significant recharge during wet years. Reclaimed water from the community of Piru is distributed to recharge ponds near the confluence of Hopper Creek and the Santa Clara River.

Groundwater elevation contours were interpreted from measured 2015 spring high groundwater elevations and 2015 fall low groundwater elevations and are shown on Figures 5.3-2 and 5.3-3 respectively. Groundwater flow is consistently from east-to-west, roughly following the land surface gradient of the river channel. In the eastern portion of the Piru basin, groundwater flow paths angle to the northwest towards areas of groundwater pumping north of the Santa Clara River. Depths to groundwater are greater along the northern portions of the basin where alluvial fan deposits elevate the land surface.

The tight contours shown in the eastern Piru basin, just west of United's District boundary, indicate that this eastern portion of the basin is an area of significant recharge. This is the area where surface water sourcing from the Santa Clara River watershed in Los Angeles County infiltrates to groundwater and the river often goes dry. Spring 2015 measured groundwater elevations were approximately 50 feet higher in this area compared to fall 2015. Spring-to-spring water level declines over the past four years of drought have averaged about 10 feet per year (UWCD 2016b).

Under typical conditions, groundwater rises near the structural constriction at the western (downstream) end of the basin, contributing surface flow to the Santa Clara River. This reach was however dry in fall 2014 and much of calendar year 2015. This is a rare condition, directly related to drought conditions and low water levels in the Piru basin. Recorded groundwater elevations at the basin boundary were about 10 feet lower in fall 2015 compared to spring 2015. Near Hopper Creek, water levels were also about 10 feet lower in the fall than they were in the spring. The contours show groundwater flow from the Piru basin to the Fillmore basin to the west.

5.3.1.2 GROUNDWATER EXTRACTIONS

Reported groundwater extractions from 113 active wells in the Piru basin totaled 14,139 acre-feet for the 2015 calendar year. This is about 1,600 acre-feet more than the historical average for the 1980 to 2015 period of record. A portion of the Piru basin extends east of United's District boundary and any pumping from this portion of the basin is not reported to United. Historical annual extractions for the Piru basin are shown in the histogram on Figure 5.3-4. Only a small percentage of groundwater pumping in the Piru basin is for municipal and industrial use, consistent with agriculture being the dominant land use within the basin.

Figure 5.3-5 is a map showing reported groundwater extractions from individual wells in Piru and Fillmore basins for the 2015 calendar year. Pumping magnitude is indicated by dot size and color. Agriculture is the predominant land use within the Piru basin, and pumping is shown to be distributed throughout the basin. Few active wells exist along the southeastern margin of the basin, and some cropland south of the Santa Clara River is irrigated with water piped from other areas. Two private mutual water companies operate within the basin. The Piru Mutual Water Company diverts water from Piru Creek for agricultural use in the north-central portion of the basin, and Warring Water Company pumps water primarily for domestic use in the town of Piru.

In some canyon and upland areas, orchards are irrigated with groundwater produced from lower areas within the basin and pumped to higher elevations. Additional development of hillside areas surrounding the alluvial basin floor results in increased groundwater demand on the basin. Over the past decade a large number of orange orchards were removed from the valley floor and replaced by row crops or box tree nurseries (for further discussion see 2014 and 2015 Piru and Fillmore Basins Biennial Groundwater Conditions Report, 2016).

The primary losses of groundwater from the Piru basin are the result of discharge of groundwater to the Santa Clara River at the western boundary of the basin, the subsurface outflow of groundwater to the Fillmore basin and extraction of groundwater by wells.

5.3.1.3 WATER QUALITY

Over the past fifteen years the main water quality concern in the Piru basin has been impacts associated with high chloride concentrations in the Santa Clara River flows sourcing from Los Angeles County. Discharge from the Valencia Water Reclamation Plant located next to the river at Interstate 5 significantly influences the flow and water quality of this reach of the river, which normally percolates completely in the eastern Piru basin (UWCD, 2006; CH2M Hill, 2006). The chloride concentration of plant discharges began to increase in the late 1990s and peaked at over 210 mg/l in 2003 (Figure 5.3-6). The high chloride concentrations associated with these discharges has made a steady advance with groundwater flow down the Piru basin. The extent of chloride impacts now reaches Hopper Creek in the western third of the basin (Figure 5.3-7).

Irrigation of salt-sensitive crops such as strawberries and avocado with water over 100 mg/l chloride is generally not recommended, and growers in Ventura County remain concerned about the westward progression of these impacts. Since 2009 chloride concentrations in Los Angeles County wastewater discharges have generally been improving, largely the result of a successful campaign to remove self-regenerating water softeners from Santa Clarita residences. More recently, increases in chloride concentrations discharged from the Valencia Plant can be attributed to increases in chloride concentrations in imported State Water Project deliveries (Figure 5.3-6). See section 1.6.2 for a discussion of the current project proposal by the Sanitation Districts of Los Angeles County to comply with the 100 mg/l chloride discharge limit.

In the western portion of the basin chloride concentrations are generally less than 70 mg/l, indicative of background levels within the basin (CA DWR, 1989). The Piru basin generally does not have problems with nitrate contamination, and samples collected in 2015 show only two wells exceeding the MCL of 45 mg/l. Many wells record TDS concentrations of 1,200 mg/l or less, but in the area immediately west of Hopper Creek the 2015 maximum TDS concentrations of wells in this area ranged as high as 2,410 mg/l. Water quality of the Piru basin is characterized more thoroughly in the 2014 and 2015 Piru and Fillmore Basins Biennial Groundwater Conditions Report (UWCD, 2016b).

5.3.2 FILLMORE BASIN

The City of Fillmore overlies the northeast portion of the Fillmore basin, and relies entirely on groundwater for water supply. Sespe Creek is the largest tributary to the Santa Clara River and enters the Fillmore basin from the north. Sespe Creek is an important source of recharge to the basin, providing high-quality water from a largely undeveloped watershed draining the southern slopes of the Pine Mountain complex in the Los Padres National Forest. Groundwater supports extensive acreage of commercial agriculture in the basin, ranging from row crops and nursery stock near the valley floor to citrus and avocado plantings at both low and high elevations. Groundwater discharge to the downstream Santa Paula basin is thought to be significant, and the extensive wetlands near this basin boundary are supported by rising groundwater. This groundwater discharge to the Santa Clara River in the area east of Santa Paula Creek commonly sustains surface flow downstream in the Santa Paula basin.

5.3.2.1 WATER LEVELS

Water levels in many wells in the Fillmore basin behave in a manner similar to the Piru basin. Water levels from a key well in the Bardsdale area shows that water levels rise to a threshold elevation in significant wet years, as evidenced by the flat topping of groundwater elevations in 1998 and 2005 (Figure 5.3-8). In this vicinity south of the confluence of Sespe Creek and the Santa Clara River, groundwater elevations do not fluctuate as dramatically as those in the Piru basin.

Groundwater elevations at United's key well for the basin show that in 2011, a moderately wet year, the basin did not fill completely. In 2015 the recorded minimum groundwater elevation at United's key well was approximately 8 feet lower than the recorded low groundwater elevation during the 1987 to 1991 drought.

Fillmore basin groundwater levels benefit from increased discharge from the Piru basin as that basin has sustained fairly high water levels in recent decades. The Fillmore basin also benefits from

United's fall conservation release from Lake Piru which helps stabilize groundwater elevations. The unconfined Fillmore basin receives most of its recharge from the Santa Clara River and Sespe Creek. The upland areas in the northern portion of the basin likely receive more recharge from direct precipitation and mountain front recharge.

Groundwater elevation contours are shown for spring and fall 2015 on Figures 5.3-2 and 5.3-3. Groundwater flow is predominantly east-to-west in the area of the Santa Clara River alluvium. In the Pole Creek fan area underlying the City of Fillmore, groundwater flow is generally westerly, but at times trends somewhat northerly towards active production wells on either side of Sespe Creek. Well control in the Sespe Upland area is relatively poor, but groundwater flow here is thought to be predominantly towards the southwest. Along the valley floor groundwater gradients are quite uniform and are similar in the spring and fall of 2015. Groundwater flow converges near the west end of the basin where the groundwater flow aligns with the orientation of the river valley. Groundwater elevations recorded in wells located in the Sespe Upland area and in the Pole Creek fan area of the basin generally exhibit more variability than wells located on the valley floor.

The relatively tight contours shown in the eastern Fillmore basin near the basin boundary show a steeper groundwater gradient as water moves from the constriction of the Piru narrows and into the basin. In this area surface water commonly infiltrates to groundwater, resulting in diminished surface flow and a greater component of flow as groundwater. As in Piru basin, groundwater is forced to the surface near the downstream end of the Fillmore basin as geologic structure constricts the main aquifer units of the Fillmore basin. In this area groundwater elevations are more stable than elsewhere in the basin and extensive wetlands are clearly visible on aerial imagery. At this discharge area for the basin, groundwater level elevations have remained relatively stable over the past four years. A review of water levels over the same period for Piru and Fillmore basins denote an overall flattening (shallowing) of the groundwater gradients in both basins (UWCD, 2016b). Continued underflow recharge to the Santa Paula basin from Fillmore basin has led to less dramatic declines of water levels in Santa Paula basin than those observed in Fillmore basin during the past four years of drought.

5.3.2.2 GROUNDWATER EXTRACTIONS

Reported groundwater extractions from 305 wells in the Fillmore basin totaled 47,722 acre-feet for the 2015 calendar year. This is 3,124 acre-feet more than the historical average from 1980 to 2015. The historical annual extractions for the Fillmore basin are shown in the histogram on Figure 5.3-9. Both recently and historically, agriculture has been the predominant user of groundwater in the basin.

Figure 5.3-5 is a map showing reported groundwater extractions from individual wells in the Piru and Fillmore basins for the 2015 calendar year. The City of Fillmore pumps from three wells located in the north Pole Creek fan area near Sespe Creek. There are numerous wells in the Bardsdale area pumping small volumes of water, as there is no mutual water company distributing potable water in this area. Water from a number of wells in the Sespe Upland area is pumped to orchards at higher elevations. Groundwater extractions from wells at the Fillmore Fish Hatchery located north of the

Santa Clara River at the eastern boundary of the basin accounts for a significant portion of the pumping from the basin (6,365 acre-feet in 2015, totaling 13% of the groundwater extraction from the basin). In 2015 the single well with the greatest pumping from the Fillmore basin was a Farmers Irrigation Company well that was completed in 2012 just east of the Fillmore/Santa Paula basin boundary. Water pumped from that well exported for agricultural use in Santa Paula basin.

Twelve mutual water companies deliver water in the Fillmore basin, serving water primarily to irrigated agriculture. Fillmore Irrigation operates a surface water diversion on Sespe Creek, supplying water to nearby agricultural lands. Several water companies operate wells near the valley floor and pump water to higher elevation where groundwater is not as plentiful. Plantings in Timber Canyon and many areas of the Sespe Uplands are served by such arrangements. Plantings of citrus and avocado remain the primary agricultural land use at higher elevations, while row crops and nurseries now complete with orchards for land on the valley floor.

Discharge of groundwater to the Santa Clara River at the western boundary of the basin, subsurface outflow of groundwater to the Santa Paula basin and extraction of groundwater by wells are the three primary losses of groundwater from the basin. The extensive wetlands and stands of *Arundo donax* (an invasive giant cane) at the west end of basin likely transpire large volumes of water. By some estimates *Arundo donax* may transpire up to six times the amount of water as native vegetation (CA Invasive Plant Council, 2011).

5.3.2.3 WATER QUALITY

The Fillmore basin is not known for having any pervasive water quality problems. TDS concentrations can be somewhat elevated in some locations, as in other groundwater basins along the Santa Clara River Valley. The City of Fillmore no longer uses wells near the Santa Clara River, favoring locations near Sespe Creek where TDS tends to be lower. Naturally-occurring boron sourcing from the Sespe watershed, however, is sometimes a concern for citrus growers and the City of Fillmore. Deeper aquifer units may have elevated concentrations of iron and manganese, a common occurrence throughout Ventura County.

Chloride concentrations from well samples collected in 2015 are shown on Figure 5.3-7. Recorded chloride concentrations exceeding 70 mg/l are uncommon, and the highest concentrations are observed along the southern edge of the basin. Concentrations in the 40s and 50s in the downstream/discharge portion of the basin are likely indicative of background chloride concentrations in the basin. While elevated chloride concentrations are sometimes observed in surface water in Sespe Creek, wells near the channel of Sespe Creek record chloride levels common to the rest of the basin.

5.3.3 SANTA PAULA BASIN

Groundwater storage is less variable in the Santa Paula basin than in the Piru and Fillmore basins, as confined aquifer conditions prevail in this basin. Pumping in the Santa Paula basin is managed by a stipulated Judgment which assigns pumping allocations to each basin pumper and restricts the amount of groundwater each pumper can extract (on a seven-year rolling average). The City of Santa Paula occupies the eastern portion of the basin and relies entirely on groundwater for its water supply. Extensive water delivery systems have long existed in the basin, delivering water to areas of the basin with poor water quality and areas that are not readily recharged.

5.3.3.1 WATER LEVELS

Long-term records of groundwater elevations in the Santa Paula basin indicate that groundwater levels do not recover as readily in wet years as they do in the Piru and Fillmore basins. The channel of the Santa Clara River is located south of the Oakridge fault in the central portion of the basin and overlies older sedimentary units of low permeability. The Santa Paula basin receives significant recharge as groundwater underflow from the Fillmore basin. Gauging of surface water flows at various locations along Santa Paula Creek and the Santa Clara River suggests the amount of recharge the basin receives from these sources, at least during low-flow conditions, is limited. An extensive flood control project on lower Santa Paula Creek, completed in the late 1990s, is believed to have negatively affected the amount of basin recharge derived from the watershed of Santa Paula Creek.

Historical groundwater elevations dating from 1923 to present are shown in a hydrograph for United's key well for the basin (Figure 5.3-10). This well is located near Peck Road and Highway 126 in the eastern portion of the basin. In contrast to the key wells from the Piru and Fillmore basins, this Santa Paula basin well shows a long-term decline in water levels. The hydrograph shows that before the onset of drought conditions the recorded high groundwater elevation for 2015 was approximately 22 feet lower than the recorded high groundwater elevation in 1998. The low water level measured in fall 2015 was within 3.5 feet of the February 1991 historic low recorded elevation for this well.

Evaluation of the key well hydrograph and other the hydrographs for other wells located throughout the basin show that water levels in many of the wells (43 of 57 wells) in both the eastern and western portions of the Santa Paula basin failed to fully recover to 1998 levels after near-record precipitation in 2005. This lack of complete recovery is consistent with an observed long-term, gradual decline in basin groundwater elevations (Santa Paula Basin TAC, 2015).

Figure 5.3-11 and Figure 5.3-12 show groundwater elevation contours in the Santa Paula basin for spring and fall 2015, respectively. The spring contours represent the measured annual basin high groundwater elevations and the fall contours represent the annual basin low groundwater elevations. The difference between the spring high groundwater elevations and the fall low groundwater elevations is approximately 10 feet throughout the basin.

The contours show a general east-to-west groundwater flow direction, with groundwater underflow from the Fillmore basin to the Santa Paula basin and groundwater underflow from the Santa Paula basin to the Mound basin and the Oxnard Forebay. The complex subsurface geology related to extensive faulting in the most western portion of the basin complicates the interpretation of groundwater flow in this area.

5.3.3.2 GROUNDWATER EXTRACTIONS

A histogram of reported basin pumping from 1980 to 2015 is shown on Figure 5.3-13. In recent years municipal pumping has accounted for 20 to 25 percent of the total pumping from the basin. The total reported groundwater extractions from wells within the adjudication boundary of the Santa Paula basin was 25,900 acre-feet for the 2015 calendar year. A new Farmers Irrigation Company well located in the Fillmore basin immediately east of the Santa Paula basin adjudication boundary pumped an additional 4,065 AF for delivery to the Santa Paula basin.

A 2003 “Investigation of Santa Paula Basin Yield” was conducted by the Santa Paula Basin Experts Group, comprised of engineers and hydrogeologists selected by the City of Ventura, the Santa Paula Basin Pumpers Association and United. The study suggested that the yield of Santa Paula basin is probably near the historic average pumping rate of about 26,000 acre-feet per year. A new investigation of the safe yield of the Santa Paula basin commissioned by United is in the final stages of review by the TAC, as modest declines in water levels have been observed in recent years when annual extractions have averaged about 26,000 acre-feet per year.

Figure 5.3-14 is a map showing groundwater extractions by wells in the Santa Paula basin and nearby areas in year 2015. The map shows significant pumping within the Santa Paula city limits and near the Fillmore basin boundary. Numerous wells pump in agricultural areas in the central portion of the basin. Few active wells exist north, west and south of this vicinity. In the western third of the basin, significant pumping is reported south of Highway 126 and west of Ellsworth Barranca, and in the area north of Highway 126 and west of Brown Barranca.

Several private irrigation companies are active in the Santa Paula basin, operating wells and delivery pipelines that distribute large quantities of water across the basin. Farmers Irrigation Company pumps groundwater primarily from the eastern portion of the basin and distributes the water by pipeline for agricultural use in the central and westerner portions of the basin. Also affiliated with Farmers Irrigation Company are Canyon Irrigation Company and Thermal Belt Mutual Water Company. Canyon Irrigation operates the Harvey Diversion on Santa Paula Creek, and some wells in the eastern basin, delivering water primarily to growers in the area east of Santa Paula Creek. Thermal Belt Mutual pumps groundwater from the east basin for pipeline distribution for agriculture in the Foothill Road area and upland area of the north-central basin. Alta Mutual Water Company extracts water from the Saticoy area in the west basin, and delivers water primarily to agricultural areas north of Telegraph Road. These extensive water delivery systems were largely established to deliver water to areas of the Santa Paula basin having poor-quality groundwater. In the canyons and foothills along the northern flank of the basin, both well production and water quality are generally poor.

5.3.3.3 WATER QUALITY

Water quality varies throughout the Santa Paula basin, but water quality is generally worse in the western portion of the basin. The maximum recorded TDS concentrations for Santa Paula basin wells and surrounding areas in calendar year 2015 are shown on Figure 5.3-15. Most of the wells with TDS concentrations less than 1,000 mg/l are located in the eastern third of the basin. Sulfate is commonly a large contributor to the elevated TDS concentrations found in wells in the western portion of the basin. Deeper wells in the basin tend to have elevated iron and manganese concentrations, and both the City of Santa Paula and City of Ventura operate treatment facilities to reduce these constituents in delivered municipal water. Recorded nitrate concentrations from wells within the basin are generally low, but two irrigation wells recorded nitrate concentrations slightly over the MCL of 45 mg/l, similar to past years.

United conducts groundwater quality sampling at the two nested monitoring well sites in the Santa Paula basin, and in several production wells in the basin. Mineral concentrations are observed to vary with groundwater elevation in some wells. More detailed characterizations of groundwater quality in the Santa Paula basin can be found in other publications (CA DWR, 1989; Santa Paula Basin TAC, 2017).

5.3.4 MOUND BASIN

The Mound basin is located in the westerly portion of the District and over time has experienced a progression of groundwater use that was historically dominated by agriculture, followed by a period of time when municipal and industrial pumping was dominant, and most recently a return to greater pumping by agriculture than by municipal and industrial users. The City of Ventura overlies much of the Mound basin, although significant agricultural areas remain, primarily in the southern portion of the basin.

5.3.4.1 WATER LEVELS

Historical groundwater levels for a key monitoring well in the Mound basin are shown on Figure 5.3-16. Measured water levels have varied over about a 90-foot range over the period of record for this well, located in the eastern portion of the basin near Kimball Road. An extended period of low water levels was recorded in the late 1980s and early 1990s when water levels declined to more than 30 feet below sea level. Water levels recovered in the 1990s and generally have remained more than 15 feet above sea level over the past decade, except when falling below sea level in 2004. Since 2013 water levels have declined somewhat, recently ranging between 4 and 12.5 feet above sea level.

Recharge of the aquifers in this basin comes from multiple sources, including direct precipitation, mountain-front recharge, and subsurface flow from adjoining basins (e.g., Santa Paula, Oxnard Forebay, and Oxnard Plain). Recharge from the Oxnard Forebay and Oxnard Plain is thought to be significant, most notably during periods of high water levels in these adjacent basins (GTC, 1972; UWCD, 2012). The aquifers utilized for groundwater production are confined.

Groundwater elevation records exist for nearly 60 active and historic wells located within the Mound basin. A number of important wells have water levels dating to the late 1920s, allowing an evaluation of long-term water level trends within the basin. However, the distribution of wells is heavily skewed towards the southern half of the basin, with relatively few wells existing north of Telephone Road. In the western portion of the basin wells are concentrated along Olivas Park Drive and near the railroad tracks south of Highway 101. This poor distribution of active and historic wells complicates the assessment of potential mountain-front recharge to the basin from the north. The southern and eastern boundaries of the basin are defined by structural features, and water level records from adjacent areas help assess the nature of the basin boundaries in these areas. Water level trends for many wells within the basin are similar, with evidence of recharge from adjacent basins to the east and south (UWCD, 2012). The main groundwater flow pattern is down the axis of the basin from east-to-west. The slope of the potentiometric surface within the basin is fairly flat during dry periods, and the gradient increases somewhat following periods of above-average rainfall. During dry periods, groundwater elevations in many wells fall below sea level.

The contouring of past water level conditions is complicated by sparse data. Available groundwater elevation data for the spring and fall of 2015 are presented on Figures 5.3-17 and 5.3-18. Increased collection of water level records is recommended in this basin to better define groundwater gradients between this basin and adjacent basins. The installation of monitoring wells north of the Santa Clara River near the northwestern margin of the Forebay have been helpful in better defining the flow of groundwater from the Oxnard Forebay to areas north of the Montalvo anticline (see Section 2.1.8). Relatively few wells, however, exist along the southeastern portion of the Mound basin, an area of sparse well records and known structural complexity. Available water level records show depressed water levels along the southern margin of the Mound basin in spring and fall 2015, which likely promotes groundwater flow from the Oxnard Forebay and Oxnard Plain.

5.3.4.2 GROUNDWATER EXTRACTIONS

The City of Ventura is the major municipal and industrial groundwater pumper in the Mound basin, with wells located near the Ventura County Government Center. Agricultural pumping was historically the majority use of groundwater in the Mound basin, but municipal and industrial use exceeded or approximately equaled agricultural use for the period 1999 through about 2006 (Figure 5.3-19). Municipal pumping peaked in 2003 and declined fairly steadily through 2011. Since 2011, municipal pumping has increased slightly, averaging 3,000 AF. Since the mid-1980s agricultural pumping has averaged nearly 4,100 acre-feet per year, with a peak annual production of 5,850 acre-feet reported in 1990. Agricultural pumping in 2015 was 3,500 AF, the highest agricultural usage since 2010.

5.3.4.3 WATER QUALITY

The quality of the groundwater produced by most wells within the Mound basin is suitable for municipal and agricultural uses, however, water quality is variable between wells, and many records indicate somewhat elevated concentrations of TDS, sulfate, hardness and other analytes. Municipal production wells Victoria #2 and Mound #1, located in the central portion of the basin, have elevated TDS, recording maximum concentrations of about 1,500 mg/l and 2,100 mg/l, respectively, in 2015 (Figure 5.3-20). Water quality appears to be relatively stable among many of the Mound basin wells having long-term water quality records, but some wells record an increase in TDS. Available records from wells nearest the coast do not show evidence of saline intrusion.

A map showing maximum recorded TDS concentrations in Mound basin wells from 2015 is shown as Figure 5.3-20. The map plots TDS (by summation) from production well samples collected by the Groundwater Section of the Ventura County Watershed Protection District, as well as TDS (by total filterable residue) as sampled by United and the City of Ventura. TDS in the production wells ranged from 1,070 to 3,000 mg/l. Sulfate commonly contributes roughly half the TDS in these samples, and water quality results are often variable among nearby wells.

Records from existing monitoring wells within the basin reveal very poor quality water at depths up to several hundred feet in the central portion of the basin. Water from these wells is thought to be connate or perched waters that are not utilized for groundwater supply. The three 2015 samples recording TDS greater than 3,000 mg/l are from monitoring wells with screened intervals shallower than 510 feet below the land surface.

5.3.5 OXNARD FOREBAY

The Oxnard Forebay basin is an area of critical importance to the water resources of the Oxnard Plain. This is the unconfined portion of the Oxnard Plain where units of low permeability are generally absent or discontinuous, allowing water to percolate deep into the ground and recharge the aquifers which extend from the Forebay to the Oxnard Plain. The basin readily accepts large volumes of recharge water in wet years when abundant surface water is available for recharge. A time series of estimated changes in available groundwater storage within the Forebay is shown on Figure 5.3-21. The graphic shows that storage in the basin can also fall rapidly in years without significant rainfall and recharge. In the dry conditions that have prevailed since spring 2011, groundwater storage in the Forebay has fallen by about 117,000 AF.

Coarse gravel deposits deposited by high flows of the ancestral Santa Clara River are common in the Oxnard Forebay. These gravels have historically been extensively mined, both within the river channel and in nearby upland areas. The high permeability of these coarse alluvial deposits also comprise an ideal substrate for groundwater recharge. Groundwater recharge occurs naturally where water percolates through the bed of the Santa Clara River. United diverts water from the river and distributes it to a series of recharge basins in both the central and northeastern portions of the basin. United's recharge activities are sometimes termed "artificial recharge" because the activities augment the recharge that would naturally occur in this area. The term “managed aquifer recharge” is also used to describe these activities and has become more popular in recent years.

Groundwater recharge to the Forebay serves to raise groundwater elevations in this up-gradient area of the groundwater flow system for the Oxnard coastal plain. High water levels in the Forebay increase the hydrostatic pressure in the confined aquifers extending from the margins of the Forebay to the coastal and offshore portions of these continuous aquifer units. While the physical movement of groundwater out of the Forebay is fairly slow, the pressure response in the confined aquifers distant from the Forebay responds more rapidly to significant recharge events in the Forebay. During wet climatic years the Forebay has the ability to quickly accept large volumes of water, allowing storage of surface water that otherwise would be lost from the watershed. Water stored in the Forebay slowly moves out to the outlying areas, flowing naturally from areas of high elevation to areas of lower elevation on the Oxnard Plain and near the coast, which serves to raise or sustain groundwater elevations in wells in the down-gradient areas. Groundwater extraction by wells, both in the Forebay and in the confined aquifers of the Oxnard Plain, hastens the decline of Forebay water levels as water is removed from the system. Under drought conditions, groundwater elevations in the Forebay may fall below sea level, resulting in flattened groundwater gradients and only minor groundwater flow out of the Forebay. These conditions now exist for the first time since completion of the Freeman Diversion in 1991, with groundwater levels in much of the Forebay measured below sea level in 2015. While there have been very wet years in the past where groundwater storage in the Forebay has recovered greatly, United’s ability to divert and recharge water is now more constrained by regulatory requirements relating to fish migration opportunities. Significant recovery of groundwater storage in the Forebay can still be expected in future wet years, but the degree of recovery may well be less than what has been observed in the past.

5.3.5.1 WATER LEVELS

Groundwater elevation contours for the UAS in the spring of 2015 are shown on Figure 5.3-22. During 2014 and 2015, 387 AF and 1,231 AF of water was recharged at United’s Saticoy recharge basins, and 1,935 AF and 1,285 AF at the El Rio facility. These amounts were well below long-term averages, as diversions from the Santa Clara River were at historic lows. Recorded groundwater elevations at the northern portion of the Forebay were less than 60 feet above sea level in spring 2015. Despite a lack of significant recharge activities, a flatter but familiar pattern of groundwater flow radiating from the up-gradient portion of the Forebay to surrounding areas is readily apparent. Some of this recharge to the Oxnard Forebay sources from underflow from the Santa Paula basin. Groundwater elevations near the southern boundary of the Forebay were lower than 10 feet below sea level in spring 2015.

Figure 5.3-23 displays UAS groundwater elevation contours for the Oxnard Forebay and Plain in fall 2015. Groundwater elevations near United’s Saticoy Recharge Facility ranged from 0 to 60 feet above sea level, but elevations fall quickly to levels below sea level near the midpoint of the basin. A pumping depression associated with the O-H well field at the El Rio Recharge Facility is apparent, where some water levels are more than 30 feet below sea level. With low water levels around the perimeter of the Forebay there exists the potential for shallow groundwater of the semi-perched aquifer on the Oxnard Plain to drain into the Forebay. This reverse flow out of this semi-perched aquifer would be difficult to document without additional wells, but there is some concern about the potential for water quality impacts to the Oxnard aquifer.

Historical water level hydrographs from selected wells in the Forebay are shown on Figure 5.3-24. UAS water levels in the Forebay fluctuate by as much as 120 feet, with groundwater elevations dropping below sea level in drought periods and recovering during wet periods. Historic highs were recorded in a number of wells following consecutive wet years and the expansion of United's recharge facilities. Extremely dry conditions in the Santa Clara River watershed since spring 2011 have resulted in significant declines among some key wells in the Forebay: in less than five years the water level in United's key well near the Saticoy Recharge Facility has fallen more than 100 feet and levels in another well in the down-gradient portion of the basin has fallen more than 75 feet.

5.3.5.2 GROUNDWATER EXTRACTIONS

Reported 2015 groundwater extractions from the Forebay totaled nearly 19,400 acre-feet. Figure 5.3-25 shows reported extractions for the basin since 1980. The 2015 reported pumping from the Forebay was less than the average annual extraction rate of 25,000 AF. Pumping from the Forebay is variable due to changing municipal demand among the O-H users, but agricultural production is relatively stable year-to-year. United's O-H well field is the largest pumping center in the basin, delivering water to coastal areas as part of a management strategy to move pumping away from coastal areas vulnerable to saline intrusion. The City of Oxnard is the largest O-H customer. The City's other two sources of water are their own wells on the Oxnard Plain and State Water imported by and purchased from Calleguas Municipal Water District.

In the 2015 calendar year only 1,285 AF were spread for groundwater recharge at the El Rio Recharge Facility (in contrast to 2011 when some 37,800 AF of water was diverted for recharge at El Rio). Over this same period 10,817 AF was pumped by El Rio wells for deliveries to the O-H system. In most years United recharges more water at El Rio than is pumped for delivery to O-H customers.

The distribution of UAS pumping for calendar year 2015 is shown on Figure 5.3-26. Significant pumping is apparent surrounding the El Rio Spreading Grounds, where municipal pumping in the basin is centered. The majority of the pumping in the up-gradient areas of the Forebay is for agricultural purposes. Wells screened in units of the LAS are relatively uncommon in the Oxnard Forebay, and 2015 pumping from LAS wells is shown on Figure 5.3-27. Based on reported 2015 production from Forebay wells and aquifer picks associated with perforated intervals for individual wells, approximately 62% of the produced groundwater sourced from the UAS, 26% from the LAS, and 12% from wells screened in both the UAS and the LAS.

5.3.5.3 WATER QUALITY

Water quality records from Oxnard Forebay basin wells near the Santa Clara River and United's recharge facilities show that groundwater quality in these areas is generally similar to that of the Santa Clara River. The most recharge from the river takes place when flows are high, when water quality in the river is best. Some characterization of Santa Clara River water quality is included in Section 5.2 of this report. During a typical dry season when river flows are lower and mineral content is generally higher, much of the diverted surface water is blended with well water and used for irrigation in areas served by the PTP and Pleasant Valley pipelines. In 2015 the limited surface water available was routed to El Rio to dilute high nitrate concentrations in the UAS in this vicinity.

Occasional high nitrate concentrations in UAS wells has historically been the water quality issue causing concern in the Forebay. A definitive evaluation of sources of nitrate and flow paths to area wells has proven difficult, but septic systems and fertilizer from irrigated agriculture are commonly believed to be major contributors of nitrate to the groundwater flow system (UWCD, 1998). The highest nitrate concentrations are often observed during drought periods, when nitrogen inputs continue but the diluting influence of natural and artificial recharge is reduced. High nitrate has also been documented in wells as water levels rise following periods of drought, as nitrogen stored in the vadose zones is mobilized as sediments become saturated by a rising water table. Installation of additional monitoring wells in the Forebay has contributed to the understanding that the highest nitrate concentrations are often observed in the shallowest wells (UWCD, 2008). Once high-nitrate water enters the groundwater flow system its movement is likely very complex. An incomplete understanding of nitrate inputs to the Forebay basin and the complexity of water movement in the unsaturated and saturated zones of the subsurface make predictions of future nitrate impacts to area wells impractical.

Maximum-recorded nitrate concentrations from wells in the Forebay and northern Oxnard Plain in 2015 are shown on Figure 5.3-28. With dry conditions prevailing since 2011, nitrate concentrations have increased in a number of production and monitoring wells in the Forebay. Five of the nine active (UAS) O-H wells recorded annual-maximum nitrate concentrations over the health standard. Other public supply wells in the El Rio community recorded high nitrate concentrations, but purchased water from the O-H system so as to not deliver water which exceeded the MCL for nitrate. Near United's Saticoy Recharge Facility, recorded nitrate concentrations in wells ranged from one to eight mg/l, values that match the range of nitrate concentrations recorded for Santa Clara River water recharged nearby.

A major effort to sewer the El Rio community was completed in 2011, significantly reducing nitrate loading in this areas of shallow unconfined groundwater. Residents and regulators are hopeful that significant nitrate impacts will be avoided in future droughts, but a cautionary statement from a recent UC Davis report on nitrate contamination is repeated here as a reminder that flow paths to production wells are often not well understood, and may be longer and more complex than many might imagine: "Travel times of nitrate from source to wells range from a few years to decades in domestic wells, and from years to many decades and even centuries in deeper production wells. This means that nitrate source reduction actions made today may not affect sources of drinking water for years to many decades" (Harter and Lund, 2012).

5.3.6 OXNARD PLAIN BASIN

Early newspaper accounts suggest that the confined aquifers of the Oxnard Plain were first drilled for water supply wells in the early 1870s. Artesian conditions existed on the Oxnard Plain at this time, and the well installations that received press coverage were wells providing impressive flow at the land surface without a pump in the well. Artesian conditions are believed to have persisted through the late 1800s. The town of Oxnard was established in 1897, and in 1899 a large sugar beet processing facility began operations. The large water demands associated with irrigation of beets and other crops on the Oxnard Plain, along with the growing population and industrial uses, lowered the pressure in the Oxnard aquifer. By the turn of the century widespread artesian conditions were generally absent, requiring wells to be fitted with pumps to lift water from elevations below the land surface (Freeman, 1968).

Over the approximately 115 years since the initial depressuring of the Oxnard Aquifer in the late 1800s, artesian conditions have periodically returned to the Oxnard Plain during wet climatic cycles. Documentation of water levels in the aquifers of the Oxnard Plain are sparse until the early 1930s, but artesian conditions were documented in Oxnard City well #9 in the winters of 1917, 1919, 1922 and 1923 (CA Division of Water Rights, 1928). The early 1940s was a wet period, and widespread artesian conditions likely existed at that time. The year 1945 marked the beginning of a long dry period during which water levels fell across the plain and problems with saline intrusion intensified in coastal areas. These alarming developments at a time of urban and economic growth in Ventura County prompted significant investments in water resource projects, including the O-H well field and recharge basins at El Rio and a pipeline to deliver water to urban areas on the coastal plain. In subsequent years pumping patterns continued to change as the City of Oxnard grew. The city once had water supply wells distributed throughout its service area, but the city's pumping is now centralized in two primary well fields. As farmland around the city margins has converted to urban areas, pumping has generally been transferred to the City of Oxnard's main well field on the northern Oxnard Plain near City Hall. Much of the population growth in the cities of Oxnard and Port Hueneme has been supported by State Water Project supplies, imported and delivered by Calleguas Municipal Water District.

Widespread artesian conditions were again present on the Oxnard Plain in the late 1990s following the completion of the Freeman Diversion and high precipitation totals in 1993, 1995 and 1998. More recently, artesian conditions periodically existed in coastal areas north of and surrounding Port Hueneme, and were more common in UAS wells than in wells with deeper screened intervals. Near Mugu Lagoon in the southernmost portion of the Oxnard Plain, water levels have remained below sea level for decades in both the UAS and LAS.

Following a period of drought in the 1970s and expansion of the areas impacted by saline intrusion, the FCGMA was established in 1982 as a local agency with regulatory authority to bring overdraft conditions under control in southern Ventura County. The agency has successfully implemented a number of mandatory cutbacks for production from public supply wells, and agricultural pumpers are required to demonstrate the use of efficient irrigation practices. One early strategy was a shift of pumping from the UAS to the LAS on the Oxnard Plain. This shift in pumping resulted in improved conditions in the UAS but considerable overdraft of deeper aquifers. An update to the FCGMA's management plan was completed in 2007, and describes a number of projects and strategies that might be employed to bring pumping in the Oxnard Plain, Pleasant Valley and Las Posas basins into balance with recharge to the aquifers of these highly-developed basins (FCGMA, 2007). The FCGMA now has additional authority as the Groundwater Sustainability Agency for the Oxnard Plain and other basins, and new studies to define sustainable yield of the basins are underway.

The primary water quality concern on the Oxnard Plain is water quality degradation associated with the intrusion of saline waters. The direct lateral intrusion of seawater remains the primary threat in coastal areas, with the near-shore submarine canyons at Port Hueneme and Point Mugu exposing aquifer beds to the sea. The vertical movement of deep brines and shallow water of poor quality has also been documented. This movement of poor-quality groundwater is also related to overdraft conditions, but is not limited to coastal areas. Nitrate problems have been documented periodically in specific Oxnard Plain wells. In some cases this nitrate problem is likely related to the downward movement of poor-quality water, in other locations it may be related to nitrate contamination sourcing from the Oxnard Forebay (UWCD, 2008).

5.3.6.1 WATER LEVELS

As discussed in the groundwater basin descriptions of the Oxnard Forebay and Oxnard Plain, large volumes of groundwater flow from the Oxnard Forebay to the Oxnard Plain. Contouring of recorded UAS water levels from wells shows that groundwater flows radially from recharge areas in the Forebay to surrounding areas (Figures 5.3-22 and 5.3-23). Recharge from the Forebay normally serves to raise or sustain water levels in wells on the Oxnard Plain, countering the decline in groundwater elevations resulting from groundwater extractions. When water levels are high across the basin groundwater may flow past the coastline to the offshore extension of the aquifers of the plain, or exit the system at near-shore canyons as discharge to the sea. In fall 2015 water levels in all coastal areas of the Oxnard Plain basin were below sea level.

Precipitation totals at United's monitoring stations for the 2014 and 2015 water years were only 40% and 60% of average, respectively. The years 2012 through 2015 are the driest four consecutive years on record for the Santa Paula station, with an average of 8.1 inches/year of rainfall during this period. The lack of any significant storm event resulted in very low flows in the Santa Clara River throughout the last four years, limiting the amount of water available for natural and artificial recharge in the Forebay. Recorded high water levels on the Oxnard Plain in spring 2015 were similar to those measured in fall 2014.

Contours of UAS groundwater elevations in spring and fall 2015 water levels are shown on Figures 5.3.22 and 5.3-23. Conditions are far from typical, with heads in much of the Forebay and virtually all the Oxnard Plain measured below sea level. Between spring 2012 and spring 2015 the zero elevation contour moved about ten miles inland, from near Mugu lagoon to the northern portion of the Forebay. The -10 foot contour is drawn within about a mile of the coast across the entire Oxnard Plain coastline, indicating landward gradients at all locations. The potentiometric surface in the interior portions of the basin is quite flat, with a few minor pumping depressions indicated. In 2015 the lowest groundwater elevations were recorded in the middle of the basin, and not at the southern margin as is common. By fall 2015, UAS groundwater elevations were lower than in the spring, with the -20 foot contour drawn near the coast all along the margin of the basin. In the area south of Hueneme Road, piezometric heads in the Mugu aquifer of the UAS are commonly at least 20 feet lower than those in the Oxnard aquifer. This is likely related to low water levels in the underlying LAS aquifers, which promotes downward vertical flow in this area and depressed heads in the Mugu aquifer (UWCD, 2016a).

Selected hydrographs for UAS wells on the Oxnard Plain are shown on Figure 5.3-29. It is typical for water levels in the confined aquifers of the Oxnard Plain to exhibit a distinct annual signature, with increased pumping stresses and reduced recharge in the summer and fall resulting in water level declines of ten feet or more, followed by some degree of recovery the following winter and spring. The absence of notable recharge to the basin in winter 2015 resulted in near-continuous water level declines in many wells over the past four years. Fall 2015 water levels are below sea level in all the wells shown on Figure 5.3-29.

Groundwater elevations from LAS wells were contoured for the spring and fall of 2015 for the Oxnard Forebay, Oxnard Plain and Pleasant Valley basins, as shown in Figures 5.3-30 and 5.3-31. In the spring of 2015 a pumping depression centered near the Oxnard Plain/Pleasant Valley basin was clearly visible. In fall 2015 the depression is much deeper and broader, having expanded to the east in the Pleasant Valley basin. Groundwater elevations on the coastal plain south of the Camarillo Hills and northeast of Round Mountain were more than 150 feet below sea level, and elevations of 90 feet below sea level were recorded at the coast near the Mugu submarine canyon. Available records show that water levels in only small portions of the coastal basins remain above sea level (near the recharge areas in the northern Oxnard Forebay and northern Pleasant Valley basin).

These contours reflect an interpretation of LAS groundwater flow in the area near the West Las Posas basin boundary that is based on the evaluation of well construction records, the interpretation of geophysical well logs and the construction of stratigraphic cross-sections for the area. This work has shown that a number of wells in the Oxnard Forebay and northern Oxnard Plain, utilized in the past for LAS contours and previously classified as LAS wells, are likely influenced by the higher heads common to the UAS. Some of these wells may be screened in both the LAS and UAS. South of a certain point these "shallow LAS" wells are absent, and wells are screened much deeper due to structural and stratigraphic changes in the subsurface. The inclusion of the "shallow LAS" wells in earlier contouring resulted in a steep break in groundwater elevations that suggested the presence of a structural barrier to groundwater flow. United's revised interpretation of LAS groundwater elevations south of the Oxnard Forebay functionally expands the pumping depression seen along the eastern Oxnard Plain and western portions of the Pleasant Valley basin north towards the Forebay. LAS groundwater elevations commonly remain above sea level near the Saticoy Recharge Facility, however, indicating that the LAS pumping depression does not extend north to this area of the Forebay. Water level records and associated contouring shows that in the aquifers of the LAS, groundwater flows from the Oxnard Forebay to the large pumping depression in the eastern Oxnard Plain and the Pleasant Valley basin. United's groundwater flow modelling shows that significant volumes of water leaving the Forebay in the UAS later recharges the LAS as downward vertical flow in various areas of the coastal plain where the UAS is less isolated from the LAS.

In the northwestern Oxnard Plain, LAS groundwater flow is likely from the Oxnard Forebay towards the coast. Few LAS wells exist in this area (Figure 5.3-27), as recharge to the Oxnard Forebay is very effective in sustaining UAS groundwater elevations in this area (UWCD, 2010a). LAS wells near Victoria Avenue and the northern boundary of the Oxnard Plain record groundwater elevations similar to nearby UAS wells (UWCD, 2010a).

Historical water level records from selected LAS wells on the Oxnard Plain are shown on Figure 5.3-32. Periods of drought (notably ~1989-1991 and 2012-present) are clearly evident in some of the wells, with measured water level declines exceeding 100 feet in some wells. Annual water level fluctuations of greater than thirty feet are common in the confined conditions of the LAS. As shown in the figure, the LAS hydrographs show fall 2015 water levels at more than 100 feet below sea level in Pleasant Valley and in the east-central Oxnard Plain. Water levels in wells near the coast are more muted, as recharge by seawater prevents heads from falling as low as they do in inland areas.

While the occurrence of land subsidence is not well documented in Pleasant Valley and on the Oxnard Plain, concern about increased subsidence is justified as water levels in the LAS approach historic lows.

5.3.6.2 GROUNDWATER EXTRACTIONS

The groundwater resources of the Oxnard Plain are heavily utilized to support overlying land uses. The area is famous for its highly-productive agriculture, supporting year-round production of a wide variety of agricultural products. Groundwater supports much of the agriculture on the Oxnard Plain, but surface water deliveries also service some areas. The area also supports an extensive urban population. The Cities of Oxnard and Ventura maintain active wells on the Oxnard Plain, but also rely on other sources of water. The City of Port Hueneme and other coastal communities generally maintain wells in reserve status and import water from inland areas, given their location near the coast and vulnerabilities with respect to seawater intrusion.

The distribution of reported UAS pumping shown on Figure 5.3-26 is typical of pumping patterns in recent years. The City of Oxnard operates several wells at its main well field near Third Street and

Oxnard Blvd., and at a smaller well field and blending station located two miles to the northeast. Aside from these city wells, UAS pumping is uncommon in the urban areas of the Oxnard Plain. Agricultural interests pump extensively from the UAS in the northwestern Oxnard Plain, as well as in the northeastern portion of the basin near the Oxnard Forebay. Additional pumping is distributed across the central plain east of the City of Oxnard, where a number of wells reporting minor pumping are small domestic wells. Few UAS wells are active south of Hueneme Road on the southern Oxnard Plain due to water quality issues associated with saline intrusion.

The distribution of LAS pumping on the Oxnard Plain is concentrated in the eastern half of the basin, as shown on Figure 5.3-27. LAS extractions are common for irrigation in the northeastern Oxnard Plain, as they are in the east-central portion of the basin. South of Hueneme Road LAS aquifers are pumped extensively for irrigation, in contrast to the UAS which is pumped very little in this area. Also notable is the near-absence of LAS pumping in the northwest portion of the basin. Near the northern Oxnard Plain basin boundary and north of the Santa Clara River the City of Ventura operates two LAS wells at the Buenaventura Golf Course and exports water to the Mound basin for municipal use.

A histogram of historical extractions from the Oxnard Plain are shown on Figure 5.3-33. Reported pumping for agricultural and municipal uses were greater in 2014 than in any year since 1990. The percentage of agricultural pumping is typically greater in years of below-average rainfall, as less irrigation demand is satisfied by rainfall and less streamflow is available for diversion and delivery. Based on reported 2015 production from Oxnard Plain wells and aquifer picks associated with perforated intervals for individual wells, approximately 34% of the produced groundwater sourced from the UAS, 63% from the LAS, and 3% from wells screened in both the UAS and the LAS.

Some 59,400 acre-feet of pumping reported in the Oxnard Plain basin in 2015, about 2,700 AF less than was reported in 2014. In the years 1985-1990, annual extractions totaling more than 70,000 AF were not uncommon. The Freeman Diversion was completed in 1991, and this facility has provided improved wet-year reliability and increased quantities of surface water delivered to the Oxnard coastal plain, reducing pumping demands on the basins. Municipal and Industrial pumping has been subject to cutbacks mandated by the FCGMA, beginning with 5% in 1992 and reaching 25% in 2012. Over time municipal pumping has not actually been reduced by this amount. While reductions based on the original allocation period have been achieved, pumping allocations have been transferred to the Cities of Oxnard and Camarillo as these cities have expanded into agricultural areas. Also, as noted in previous sections, large volumes of potable water are imported from both the Oxnard Forebay and from northern California, so the M&I extraction totals presented on Figure 5.3-33 are less than the total use M&I water in the Oxnard Plain basin. In contrast to the series of 5% cutbacks required of the M&I pumpers, agricultural pumpers were required to demonstrate efficient irrigation practices based on climatic data and the estimated water demands for the various crops grown within the FCGMA boundaries.

In April 2014 the FCGMA passed Emergency Ordnance E in response to the drought conditions that have exacerbated overdraft conditions on the Oxnard coastal plain. The ordinance suspended the use of conservation credits and required that all growers calculate allowed water usage based on an

Irrigation Allowance index (IAI). M&I pumping was also subject to further pumping restrictions as calculated by Temporary Extraction Allocations (TEAs) that are scheduled to beco7me more restrictive over time. Emergency Ordinance E remains in effect at the time of this publication. In late 2014 the County of Ventura passed Ordinance 4468 which prohibited the installation of new wells that would increase pumping demands on basins designated as high or medium priority by the state (the construction of replacement wells, however, remains permissible). The Oxnard Plain and Pleasant Valley basins are designated as high priority basins.

5.3.6.3 WATER QUALITY

Seawater intrusion was first recognized on the Oxnard Plain in the 1930s and since that time this issue has dominated water quality concerns in southern Ventura County (CA DWR, 1971; FCGMA, 2007). In areas not impacted by saline intrusion, groundwater quality is somewhat variable among wells but generally is adequate for most agricultural and municipal/industrial uses. Water in the confined aquifers of the Oxnard Plain tends to be somewhat mineralized (TDS, sulfate, iron, manganese) due to the marine deposition of many of the aquifers, but contamination by organic contaminants is uncommon (Burton et al., 2011). Nuisance concentrations of iron and manganese are most commonly associated with LAS wells where reducing conditions are present.

In the northern portion of the Oxnard Plain, 2015 samples from a few wells show elevated concentrations of nitrate (Figure 5.3-28). The provenance of the high nitrate detected in these wells is difficult to determine with confidence without detailed geochemical analysis, but high and variable nitrate concentrations in this confined setting may be related to the downward leakage of near-surface waters (Izbicki, 1992, Zohdy et al., 1993). On the southern Oxnard Plain nitrate is not commonly detected in monitoring or production wells, and the rare detections are likely related to corroded or improperly constructed wells.

Recorded chloride concentrations across the central Oxnard Plain were consistently low in 2015, as shown on Figure 5.4-34. These values are similar to native chloride concentrations in the basins of the Santa Clara River valley. South of Hueneme Road some wells recorded chloride concentrations greater than 16,000 mg/l, concentrations that are similar to seawater.

5.3.6.3.1 SALINE INTRUSION

Since the 1930s the southern Oxnard Plain in Ventura County has been subject to seawater intrusion. The Oxnard, Mugu, Hueneme, Fox Canyon, and Grimes Canyon aquifers are believed to be geologically vulnerable, to varying degrees, to seawater intrusion by their exposure in offshore outcrop in the walls of submarine canyons and along the broader offshore shelf. Concerns related to the expansion of intruded areas in the 1970s and 1980s helped motivate local funding for both major water infrastructure projects and cooperative studies with the USGS.

In 1989 the USGS initiated the Regional Aquifer-System Analysis (RASA) study in the Santa Clara-Calleguas groundwater basin. As part of this project a series of fourteen nested monitoring well sites were installed in coastal areas. Extensive sampling was conducted, and a number of advanced analytical techniques were used to provide a much better understanding of the nature and extent of saline intrusion on the Oxnard Plain. The USGS studies concluded that some areas considered impacted by seawater intrusion in the past were in fact subject to increased chloride concentrations from connate saline water squeezed from fine-grained sediments within and separating the aquifers (Izbicki, 1992). The USGS mapped areas of high salinity in the major aquifer units of the southern Oxnard Plain, and classified sources of salinity as either seawater intrusion or saline intrusion from local sediments. Poor quality in other wells was attributed to vertical leakage and not saline intrusion. A major product of the RASA study for the Santa Clara-Calleguas basin was a calibrated groundwater flow model. A solute transport component of the model was proposed in the scoping of the study, but this component was later abandoned after initial efforts proved unsuccessful.

United continues to sample the network of monitoring wells on the southern Oxnard Plain. In all of the recent samples from the southern Oxnard Plain, calcium or sodium are the dominant cations. Among samples not affected by high salinity, sulfate and bicarbonate are the dominant anions. For most samples impacted by saline waters, sodium and chloride are the dominant ions (UWCD, 2016a). Major ion analysis is helpful in determining chemical conditions and changes over time, but not necessarily the source of brine causing water quality degradation. Researchers from the USGS have advanced methods for determining whether high chloride is sourcing from direct seawater intrusion or rather from deep or stranded brines (Izbicki, 1992 and Izbicki et al., 2005a). The minor ions iodide and bromide, along with the trace elements boron and barium, are useful indicators for delineating the source of brines impacting fresh aquifers. Analysis of minor ion concentrations and trace element ratios from coastal monitoring wells suggest that some wells are impacted by the recent intrusion of seawater via the near-shore submarine canyons at Port Hueneme and Point Mugu. Other wells are likely impacted by inland brines, such as those expelled from buried fine-grained marine deposits. Clays within these deposits compact over time in response to regional pumping stresses, allowing the brines to enter adjacent permeable beds within the aquifer system (UWCD, 2007).

Over the past decade the sampling of coastal monitoring wells near Port Hueneme has indicated that chloride conditions have generally improved as heads in most aquifers have remained near or above sea level. United’s recent sampling of wells and contouring of groundwater elevations in this area suggest a new episode of seawater intrusion is advancing into the basin and the chloride plumes associated with past periods of drought are now migrating southeast towards the Mugu area, most notably in the UAS (UWCD, 2016a).

Figure 5.3-35 displays chloride records for selected UAS monitoring wells in coastal areas of the southern Oxnard Plain. The figure shows well A1-195 located north of Port Hueneme has recovered from chloride impacts in the early 1990s. Well A2-170 also showed significant improvement since the mid-1990s, but has recently recorded increasing chloride concentrations. The chloride plume shown east of Hueneme Harbor likely extended north from Hueneme Canyon in the early 1990s (chloride spike in well A1-195), and since that time the plume has slowly migrated towards the southeast due to the prevailing groundwater flow direction under the average to wet conditions that prevailed from the mid-1990s through 2011. Located within the plume of displaced seawater, samples from well CM4-275 remain above 4,000 mg/l chloride. Chloride concentrations rose to over 2,000 mg/l in well CM7-190 some 20 years after the drought ended, however since 2014, chloride concentrations show a declining trend. In the Mugu area, saline groundwater would likely flow out from the groundwater basin if a significant seaward groundwater gradient could be maintained, but such conditions have not existed for many years. In inland areas surrounding Mugu Lagoon, UAS aquifers remain impaired by high chloride. Well CM6-200, located in the western portion of this area, has shown some improvement in recent years, but chloride is still over 2,000 mg/l (Figure 5.3-35). Other UAS wells show continued degradation by either brines or direct intrusion of seawater (UWCD, 2016a). Located on the coast south of Mugu Lagoon and near the Mugu submarine canyon, well CM1A-220 has historically had chloride levels approaching that of seawater, recorded at 16,700 mg/l in fall 2015. With depressed water levels in the basin, another period of active seawater intrusion is now underway. While seawater is believed to be entering the aquifers of the UAS in the areas surrounding Hueneme and Mugu Canyons, high chloride concentrations from this new episode of seawater intrusion has yet to reach a number of the coastal monitoring wells.

Selected chloride time series for Lower Aquifer System monitoring wells on the southern Oxnard Plain are shown on Figure 5.3-36. Near Hueneme Canyon few wells show chloride impacts, but well CM2-760 shows increasing chloride at concentrations greater than 10,000 mg/l. In the greater Mugu area chloride degradation is severe in a number of wells, and chloride is trending upwards in many wells. Degradation by brines continues unabated in LAS monitoring wells at the Q2 well site, located about two miles north of Mugu Canyon. Degradation in these wells is related to chronically depressed water levels in the area, allowing brines to migrate into the aquifers from surrounding sediments or deeper zones hosting poor-quality groundwater (UWCD, 2016a). These trends are expected to continue as water levels remain severely depressed in the LAS in both coastal and inland areas.

Given the chronic groundwater depression that exists north and northeast of the Mugu area, water resource managers wish to better understand the extent of existing chloride impacts and the potential for further degradation. While additional monitoring wells allow the ability to sample discrete zones within an aquifer and identify vertical head gradients, expansion of the network of monitoring wells is fairly expensive. In recent years United has conducted geophysical studies to gain additional information on the extent of chloride impacts in areas where wells are not available.

In 2010 United conducted a Time Domain Electromagnetic (TDEM) geophysical survey on the southern Oxnard Plain to assess the lateral extent of saline water intrusion over four different depth ranges (UWCD, 2010b). The survey was designed to replicate a study performed by the USGS in the early 1990s, conducted as part of the RASA project (Zohdy et al., 1993). United's field survey area covered approximately 35 square miles and extended along the coast between Ormond Beach and Mugu Lagoon (approximately 7 miles) and extended inland approximately 5 miles. One hundred twenty five soundings were collected throughout the study area and the data were forward and inverse modeled for each sounding. The modeled data were used to construct resistivity maps, at four depth ranges typical of the UAS and LAS. United's TDEM investigation was successful at delineating earth resistivity values that are typical of saline and brackish water in both the Upper and Lower Aquifer Systems. Resistivities typical of saline water occurred along the coast and extended farther inland near Point Mugu with brackish water inferred at various locations inland. In some areas groundwater salinity estimates from the TDEM surveys generally correlated with samples from monitoring wells, but in some areas they do not.

An image of contoured resistivity values at depths approximating those of the Oxnard aquifer are shown on Figure 5.3-37. The area located west of Ormond Beach/Saviers Road was not included in the TDEM survey, and the water quality in this area is interpreted from well records and interpretations of groundwater flow in those areas. The figure includes a dashed line showing the interpreted inland extent of saline intrusion in the Oxnard aquifer. Extensive areas are degraded south of Hueneme Road, but the northern lobes of the inland extent as interpreted for the TDEM soundings are not confirmed by available well samples. Figure 5.3-38 shows recent chloride concentrations from Mugu aquifer wells. The TDEM soundings for this depth range suggest the presence of geologic features such as paleochannels that may affect groundwater flow and the migration of chloride.

Fall 2015 chloride concentrations from Hueneme aquifer wells are shown on Figure 5.3-39. High chloride is observed in one well near the offshore Hueneme Canyon, but the inland extend of saline intrusion in the Hueneme aquifer is interpreted to be limited. The Hueneme aquifer is not present in the coastal areas surrounding Mugu Lagoon. Fall 2015 chloride concentrations for the Fox Canyon aquifer are shown on Figure 5.3-40. Saline intrusion is not recorded near Port Hueneme, but monitoring wells near Mugu Lagoon recorded chloride as high as 5,140 mg/l. Degradation in the deeper Grimes Canyon aquifer is similar in extent (Figure 5.3-41). TDEM interpretations of high salinity in the LAS along Hueneme Road west of Saviers Road has not been confirmed by water samples from wells.

Local water managers share a common desire to better understand the extent of saline water impacts on the southern Oxnard Plain and how rapidly it might be migrating toward pumping depressions that exist within the basin. There are relatively few monitoring wells in the coastal areas of the southern Oxnard Plain and the extent of saline impacts is not precisely known, but it is well understood that elimination of groundwater overdraft conditions will largely mitigate the worsening of chloride impacts on the southern Oxnard Plain. United's modelling of groundwater flow in the aquifers of the southern Oxnard Plain indicates that vertical flow is more prevalent than most researchers recognized, and this downward vertical flow results in saline intrusion in the LAS in areas that would otherwise be protected by geologic structure near Pt. Mugu (UWCD,2016a).

5.3.7 PLEASANT VALLEY BASIN

The Pleasant Valley basin lies adjacent and east of the Oxnard Plain, occupying the area south of the Camarillo Hills. The entire area of the basin falls within the Calleguas Creek watershed. Aquifers of the Upper Aquifer System are poorly developed in this basin and dominated by fine-grained deposits. This change in UAS deposits forms the basis for the basin boundary with the Oxnard Plain.

Aquifers of the LAS are continuous with areas to the west on the Oxnard Plain. The City of Camarillo occupies the northern portion of the basin and operates public supply wells located outside of United's boundaries. Agriculture is the predominant land use in the remainder of the basin, where the Pleasant Valley County Water District (PVCWD) operates an extensive water delivery system. United has delivered surface water from the Santa Clara River to PVCWD since 1958. Completion of the Conejo Creek Diversion in 2002 brought additional surface water to the Pleasant Valley area.

5.3.7.1 WATER LEVELS

Most wells in the Pleasant Valley basin area are completed in units of the LAS. Some wells are perforated in coarse basal units of the UAS, but pumping and water level measurements from UAS wells are uncommon in the Pleasant Valley basin as the UAS is predominantly comprised of fine-grained sediments (UWCD, 2003). United does not attempt to contour UAS water levels in the Pleasant Valley basin.

Groundwater elevation hydrographs for selected LAS wells are shown on Figure 5.3-42. The LAS well located in the northeast corner of the Pleasant Valley basin near Las Posas Road and Lewis Road recorded groundwater elevations approximately 140 feet below sea level in the early 1990s. Since the early 1990s water levels in this well have increased dramatically, reaching levels of about 140 feet above sea-level in 2012. This recovery is related to increased surface water flow in Arroyo Las Posas and the associated groundwater recharge in the northern portion of the basin. Since the 1990s flow in the Arroyo Las Posas has increased dramatically, largely due to population growth in upstream areas and related water imports and wastewater discharges (LPUG, 2011). This recharge in recent years has led to the recognition that the basin is unconfined in this area and may be considered a forebay area for the Pleasant Valley basin (Hopkins, 2008). Some recovery in this well is likely related to the relatively wet period the area has experienced since the drought period ending in 1991. The degree to which this recharge has influenced water levels in the central portion of the basin remains a topic worthy of further study. Following the onset of drought conditions surface water flows in Arroyo Las Posas have subsided and water levels have fallen more than 100 feet in this northern well.

The groundwater elevation hydrograph for the LAS well located at the intersection of Las Posas Road and Pleasant Valley Road shows a clear decline during the drought conditions of the late 1980s, with water levels reaching approximately 180 feet below sea level in 1991. Since that time, with the onset of a relatively wet period, groundwater elevations increased steadily except for a slight decline during a dry period from 2002 to 2004. From 2005 through 2011 groundwater elevations remained below sea level, but higher than the water levels recorded in the late 1980s and early 1990s. This recovery is likely related to the utilization of surface water diverted from Conejo Creek and delivered to agricultural users in the basin. Camrosa Water District constructed the Conejo Creek Diversion in 2002 and has negotiated agreements to provide water to PVCWD, a major supplier of agricultural water in the Pleasant Valley basin. Diversions from Conejo Creek since 2003 have averaged approximately 4,800 acre-feet per year. Use of this water for irrigation has reduced pumping demands on the basin. Despite the general water level recovery in this well over the past twenty years, measurements from fall 2015 show levels have fallen to about 125 feet below sea level.

The groundwater elevation hydrograph for a well in the southern portion of the Pleasant Valley area, located along Laguna Road, shows a 1991 drought groundwater elevation of 174 feet below sea level. From 1993 to 2013, groundwater levels generally returned to pre-drought levels and annual-high water levels remained fairly stable. In 2014 and 2015 water levels declined and records from fall 2015 show levels have fallen to 162 feet below sea level. Annual variability in groundwater elevation appears to be greater following the drought, which could be the influence of a nearby well. Unlike some wells in the northern portion of the basin, spring high water levels recorded in this well are not appreciably higher than they were in the 1980s. The highest recorded groundwater elevation for this well is approximately twenty feet below sea level.

Groundwater elevation contours for LAS wells measured in spring and fall 2015 are shown on Figures 5.3-30 and 5.3-31. The spring LAS contours on the maps show the significant pumping depression that exists in western Pleasant Valley and the eastern Oxnard Plain, where groundwater elevations are well below sea level over a broad area. The fall map shows a pumping depression over several square miles with groundwater elevations more than 150 feet below sea level. The severely depressed water levels in the basin promote the upwelling of brines from deeper formations, the compaction of both aquifers and aquitards, and land subsidence. The pumping depression extends to the coastal area near Mugu Lagoon.

The contours for both spring and fall indicate groundwater flow from the west Oxnard Plain and from the Oxnard Forebay to the north. A steep groundwater gradient likely exists between the main pumping depression and the recharge area along Calleguas Creek in the northern part of the basin, but this area is not contoured due to sparse well control and the unknown influence of faulting in the northern basin. Vertical flow from the UAS to the LAS is thought to be significant in the areas of the LAS pumping depression where strong vertical gradients are present.

5.3.7.2 GROUNDWATER EXTRACTIONS

Maps showing reported groundwater pumping from LAS wells in the Pleasant Valley basin and on the Oxnard Plain are shown on Figure 5.3-27. The northern and eastern portions of the basin fall outside of United’s district boundary, and pumping in those areas is not shown on figures in this report. Pumping from the LAS within United’s district boundaries is concentrated along the western portion of the basin, and aligns with the areas where water levels are deepest in the basin. Pumping from the UAS is limited, and skewed towards the eastern portion of the basin (Figure 5.3-26). A majority of the UAS wells report minor pumping and are likely used for domestic supply.

Annual reported pumping for the portion of the Pleasant Valley basin within United’s district boundaries is shown on Figure 5.3-43. In 2014 reported pumping was the greatest since 1991, totaling 19,500 AF. Pumping from the Pleasant Valley basin is fairly variable, in large part due to the significant surface water deliveries that are possible during years of above-average precipitation.

United's groundwater flow model includes the northern portion of the Pleasant Valley basin that lies outside of the District. Pumping in this area is reported to the FCGMA. For the major portion of the Pleasant Valley basin that lies within the boundaries of either the FCGMA or United, reported 2015 production from the LAS was 92.5% of the total production, with 4% of pumping from the UAS and the remainder from wells screened in both aquifer systems, based on aquifer picks associated with the perforated intervals for individual wells.

5.3.7.3 WATER QUALITY

The map showing the maximum groundwater chloride concentrations recorded in 2015 is shown as Figure 5.3-34. Samples from wells in the Pleasant Valley basin are notably higher than those from the Oxnard Plain to the west (except for the intruded areas near the coast). Many wells in the Pleasant Valley basin had chloride concentrations well over 100 mg/l, a common advisory chloride level for sensitive agricultural crops. A number of the samples are from wells operated by PVCWD, which has the ability to blend well water with surface water diverted from Conejo Creek and the Santa Clara River before delivery to area growers.

During the RASA study in the early 1990s USGS investigators recognized high chloride in some Pleasant Valley basin wells. Innovative sampling techniques were employed to profile flow and chloride concentrations in deep production wells. It was recognized that the highest chloride and TDS concentrations were commonly sourcing from the deepest portions of these deep LAS wells, and that these zones contributed little water to the well. In 2001 United sought and was awarded an AB303 grant from CA DWR to study the nature of the inland saline intrusion problem in the Pleasant Valley basin (UWCD, 2003). A major part of this study consisted of depth-dependent sampling and flow profiling of eight deep production wells within the basin. The USGS was contracted to perform this work, which included chemical analysis of major ions and trace elements as well as specific isotopes and chemical tracers. The report concluded that chloride increased with pumping during past period of drought, and that increased delivery of surface water to the area of the Pleasant Valley basin pumping depression would help groundwater levels recover and likely decrease chloride concentrations in water produced from deep wells in the basin.

In 2005 the USGS published technical papers detailing the results of their sampling of Pleasant Valley wells, which included depth-dependent groundwater sampling, flow profiling, and analysis of isotopic and chemical tracers (Izbicki et al., 2005a; Izbicki et al., 2005b). The results detailed by the USGS included that: 1) high chlorides were entering wells from various sources at different depths; 2) concentrations of chlorides in the upper portion of some wells influenced by irrigation return flow were as high as 220 mg/L; 3) concentrations of chlorides in wells with depths greater than 1,400 feet were as high as 500 mg/l and had the chemical and isotopic composition trending toward oil field production water in the area; 4) higher chloride concentrations occurred in deep wells near faults that bound the valley such as the Camarillo fault in the north basin and the Bailey Fault on the south side of the basin; and 5) chlorides increase with increased pumping during droughts.

A recommendation by the USGS was that sealing off the low-yield and poor-quality lower portions of some deep wells would act to improve water quality in many production wells without sacrificing appreciable yield. The 2015 chloride concentrations shown on Figure 5.3-34 suggests that a majority of the wells in the basin are impacted by elevated chloride concentrations. These impacts are likely to continue as chronic overdraft conditions persist in the basin and deep brines migrate upward in response to the hydraulic gradients produced by over-pumping. Figure 5.3-44 displays maximum chloride concentrations from calendar year 1990, a year when extensive sampling was conducted by the USGS as part of the RASA study. In that historic drought year few wells recorded chloride less than 100 mg/l. Comparison of chloride samples from 1990 and 2015 reveals that recent samples from a number of wells record higher chloride now than they did in a past period of drought.

Recharge water sourcing from Arroyo Las Posas in the northern portion of the Pleasant Valley basin is another significant chloride input to the basin. The City of Camarillo has plans to construct a desalter to utilize this poor-quality water for beneficial use. Calleguas MWD has constructed an ocean outfall and brine line (the "Salinity Management Pipeline") to inland areas along Calleguas Creek. This pipeline is a tremendous development for the region, as a number of desalters are expected to be built to improve the quality of water delivered to both municipal and agricultural users and the salt can now be conveyed to the sea.

5.3.8 WEST LAS POSAS BASIN

The West Las Posas basin is the western-most of a series of three subbasins that are referred to collectively as the Las Posas basin. The other subbasins of the Las Posas basin are the East Las Posas basin and South Las Posas basin. The West Las Posas basin is bounded to the north by South Mountain, to the south by the Camarillo Hills, to the west by the Oxnard Plain and to the east by the East Las Posas basin. Only approximately the western one-third of the West Las Posas basin is included within United's district (Figure 1-1).

The Las Posas Basin Users Group (LPUG) is developing a Basin Specific Groundwater Management Plan for the Las Posas basin. The portion of the basin within the District, however, is excluded from the Plan. The Del Norte Water Company made a formal request of the LPUG to be excluded from the current Las Posas basin plan on the basis of groundwater conditions, groundwater source, and political jurisdiction. LPUG agreed that the District's portion of the Las Posas basin does not have to be managed under the Las Posas basin plan, because groundwater users pay pump charges for groundwater recharge and management activities conducted by United (LPUG, 2011). More recently, Del Norte MWC indicated a preference to be included in the Las Posas basin planning process, and the western Las Posas basin boundary was adjusted to include their service area and wells on the Oxnard Plain.

5.3.8.1 WATER LEVELS

Groundwater levels have been monitored for nearly a century in the Las Posas Valley. Groundwater elevations in the West Las Posas basin are monitored by UWCD and Ventura County Watershed Protection District with private entities also providing data. Fewer wells are monitored in this basin than in the other basins within the District.

In the West Las Posas basin, piezometric heads in fall 2015 ranged from approximately 140 feet below sea level in the eastern portion of the basin near the Central Las Posas fault to approximately 40-60 feet below sea level near the Oxnard Plain. Two wells at the northern margin of the basin recorded water levels at or above sea level. Available groundwater elevation data in the West Las Posas basin suggests the aquifer is receiving inflow from the Oxnard Plain and recharge along the northern flank of the valley, and a general northwest to southeast flow direction is commonly observed (LPUG, 2011). Groundwater moves across the subbasin toward an area of focused pumping near Bradley Road where there has been a long history of depressed water levels (LPUG, 2011).

5.3.8.2 GROUNDWATER EXTRACTIONS

During calendar year 2015, a reported 3,900 acre-feet of groundwater were pumped from the portion of West Las Posas basin that lies within United's boundaries. The areal distribution of pumping in the UAS and LAS in 2015 is shown on Figures 5.3-26 and 5.3-27. Reported groundwater extraction from the basin has generally increased over the past decade (Figure 5.3-45). Reported municipal pumping approximately doubled in 2011, and is associated with golf course irrigation near the southwestern margin of the basin. The Del Norte Water Company pumps water from its well yard located near Highway 118 and Santa Clara Avenue on the Oxnard Plain, and delivers this water for agricultural use in northern portions of the West Las Posas basin within United's District boundary. In 2015 Del Norte pumped and exported nearly 2,500 acre-feet from the Oxnard Plain to the West Las Posas basin.

5.3.8.3 WATER QUALITY

Water quality samples from wells in the West Las Posas basin indicate groundwater quality is generally adequate for agricultural and municipal use, however, localized exceedances of the MCL for TDS, nitrates, and sulfates have been reported (VCWPD, 2016).

The average TDS among wells sampled in 2015 was 809 mg/l, and two wells had nitrate concentrations above the MCL for nitrate. Groundwater with this degree of mineralization is common in the region. In the West Las Posas basin TDS and chloride concentrations tend to be higher in the northern and western portions of this basin compared to other areas, suggesting that mountain front recharge along the southern flank of South Mountain and inflow from the Oxnard Plain basin are more mineralized than the older connate waters of the basin (LPUG, 2011).

6 SUMMARY

The year 2015 marks the fourth consecutive year of drought conditions in southern California. The low rainfall amounts have severely impacted surface and groundwater hydrology within United's service area, and United's operations. No conservation releases from Lake Piru occurred in 2014 and 2015, due to the persistent low lake levels. Diversions of surface water at the Freeman Diversion were at an all-time low, leading to very low volumes of groundwater recharge at the Saticoy and El Rio recharge facilities, and limited to no surface water deliveries for agricultural users on the PTP and PV systems. Consequently, the demands for agricultural irrigation water has increasingly been met by groundwater pumping. Groundwater elevations have fallen in all basins, and water levels across much of the coastal plain are below sea level. A renewed period of active saline intrusion is now underway. Water quality problems associated with reduced rainfall and recharge are also apparent in some inland areas where nitrate, iron, manganese, chloride and TDS concentrations are causing problems for some users of groundwater. Much of United's current infrastructure is designed to maximize the use of surface water from the watershed of the Santa Clara River, but these projects are of limited use when the river is dry or flows are minimal. Even when wet conditions do return to the area, the recovery of groundwater storage in the coastal basins is expected to be slower than it was in 1991-1995, as United's ability to divert water at the Freeman Diversion is now less than in prior years due to regulatory constraints associated with endangered species issues.

United continues to evaluate various strategies to best manage and protect the surface and groundwater resources within the District. Current and on-going considerations include: the characterization of groundwater conditions, the most efficient use of existing infrastructure and the need for additional or modified facilities, current and future water demands, current and anticipated water quality issues, the expanded use of reclaimed water, and effective utilization of existing allocations of imported State Water Project water. United's goal is to identify the best use of local water resources and infrastructure, and to work with other agencies to implement these strategies, while honoring a coherent strategy and set of priorities that guides all future infrastructure and water management decisions.

The District's groundwater and surface water projects and programs are keyed to the issues and concerns that impact or potentially impact the water resources of the region. These issues and concerns evolve over time and United strives to adjust, modify, or devise new projects or programs in response to changing water resource challenges. Many of the projects and programs undertaken by United have long-term implementation schedules (e.g., District-wide groundwater level measurements, conservation releases, permitting and construction of infrastructure), however, these types of efforts provide the critical data needed to make sound water resource management decisions that provide for the maintenance of reliable, sustainable, local water resources for the benefit of agricultural, municipal and industrial water users in central and southern Ventura County. United is pleased that new desalters and advanced water treatment plants that are either planned or under construction in the region, and is hopeful that these facilities will serve to lessen demands on the area's groundwater basins.

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FIGURES

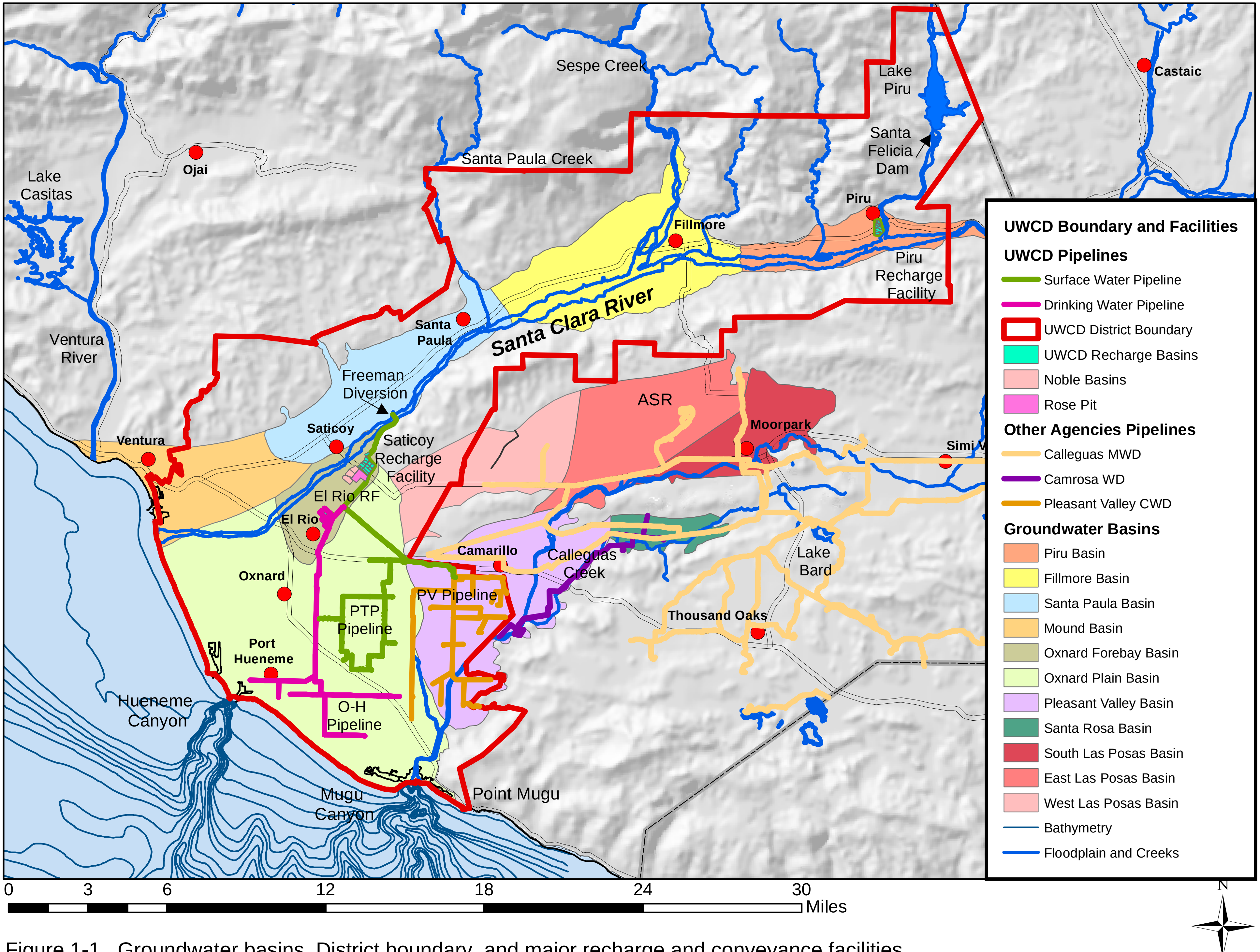

Figure 1-1. Groundwater basins, District boundary, and major recharge and conveyance facilities.

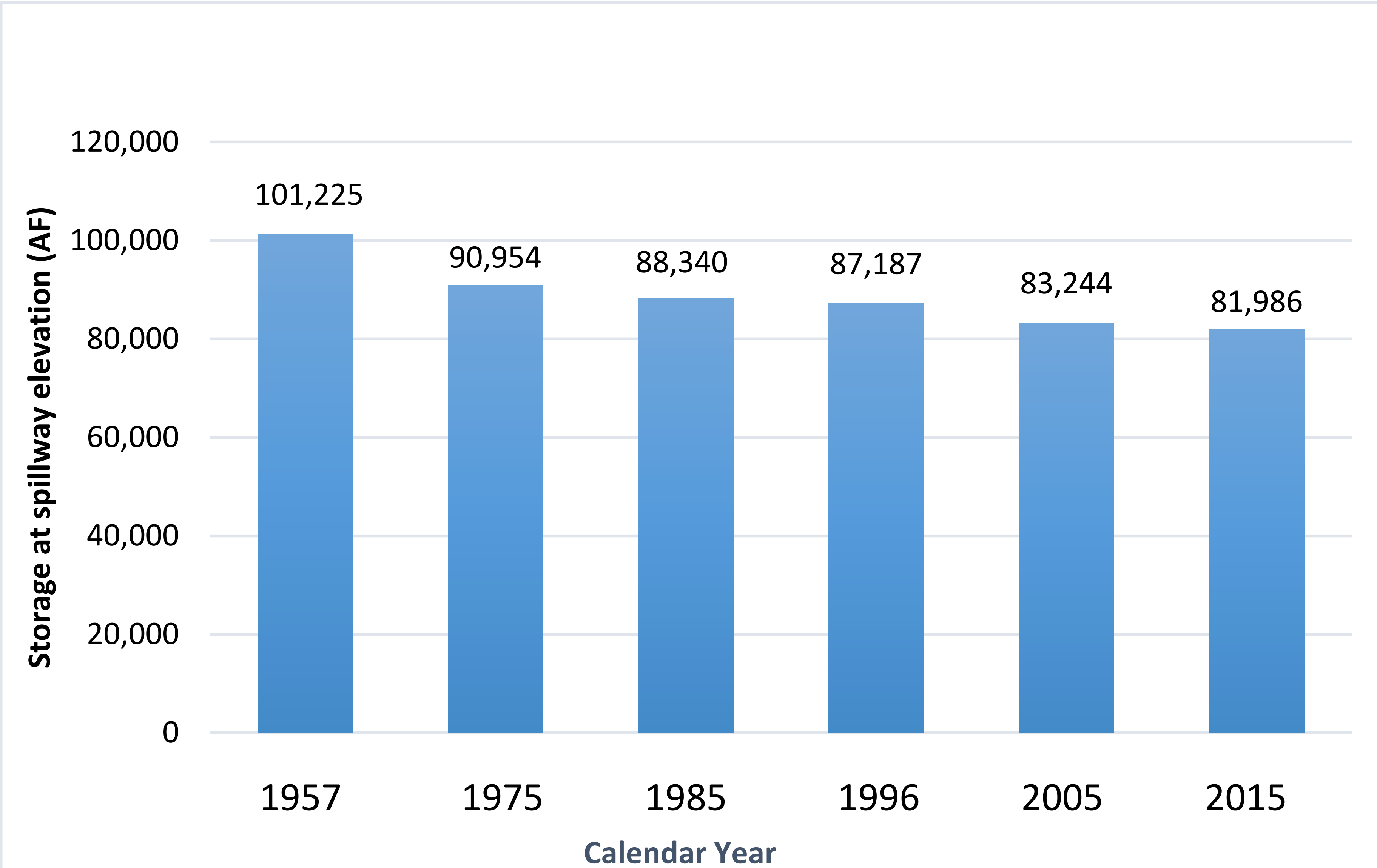

Figure 1.4-1. Historic storage capacity of Lake Piru, data from bathymetric surveys.

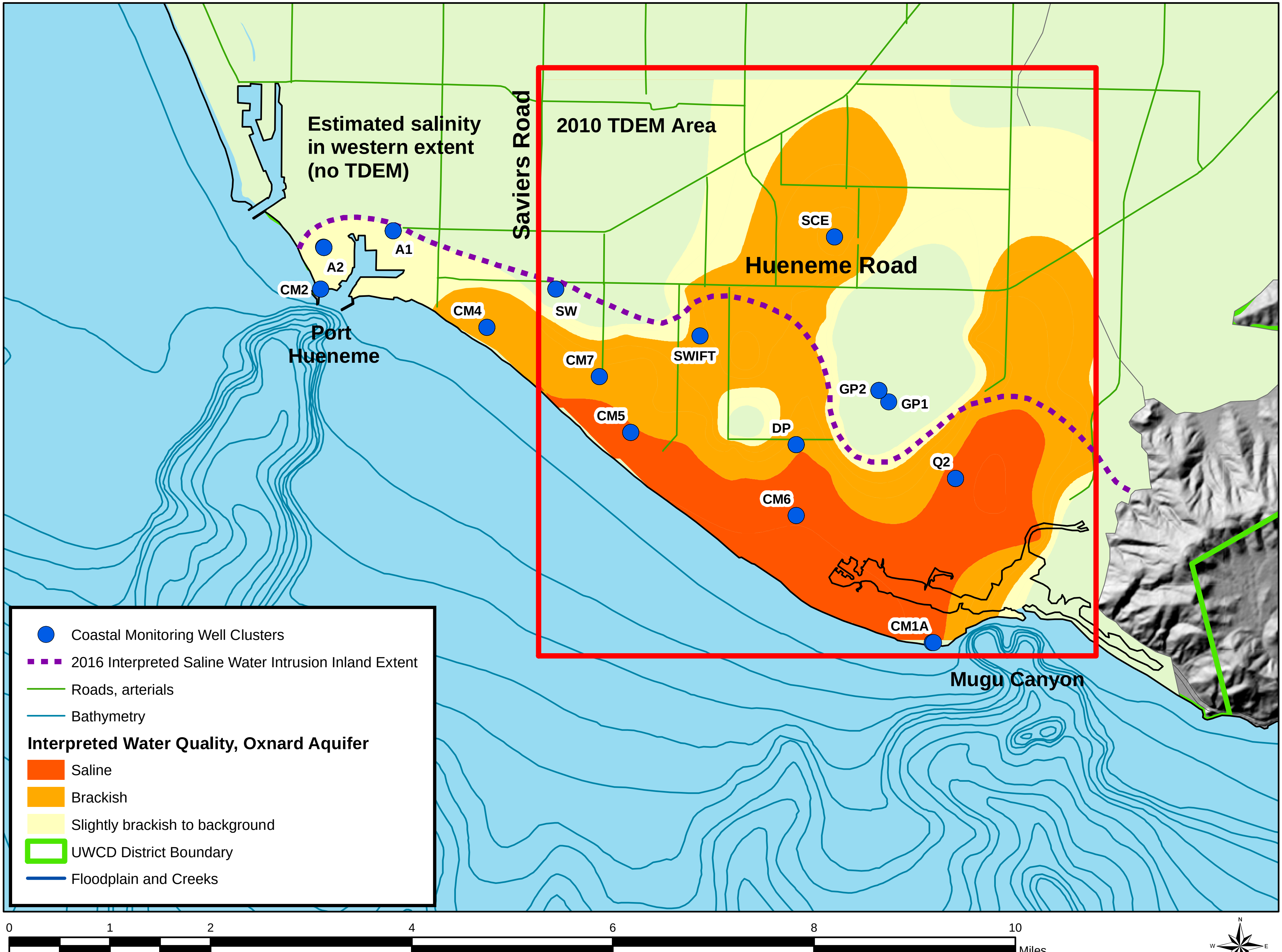

Figure 1.5-1. Locations of RASA coastal monitoring well clusters.

Projects	Overdraft Conditions	Declining Water Levels	Groundwater Exports	Saline Water Intrusion	Upwelling Saline Water	Riverbed Stabilization	Biological Opinion-SFD	Biological Opinion-Freeman Diversion	Freeman Diversion Operations	Aquifer Mapping	Recharge Optimization	Water Quality Degradation
Sustainable Groundwater Management Act	X	X	X	X	X				X	X	X	X
United GW Flow Model	X	X	X	X	X	X				X	X	X
Santa Paula Basin TAC and Specialty Studies		X	X			X			X	X	X	
District-Wide GW and SW Level Measurements / Piezometers	X	X	X	X	X	X	X	X	X		X	X
District-Wide Water Quality Sampling & Analyses	X	X	X	X	X						X	X
Proposed Brackish Water Treatment Feasibility Study	X	X		X	X						X	X
Surface Geophysical Studies (Seismic Reflection, TDEM)	X	X		X						X	X	
Proposed Iron and Manganese Treatment Plant	X	X										X
Proposed Piru Solar Facility				X								
Surface Water Models		X				X	X	X	X		X	
District-Wide Stream Gaging	X	X				X	X	X	X		X	X
Recycled Water Initiative	X	X	X								X	X

Figure 2.1-1. Groundwater and surface water projects and initiatives.

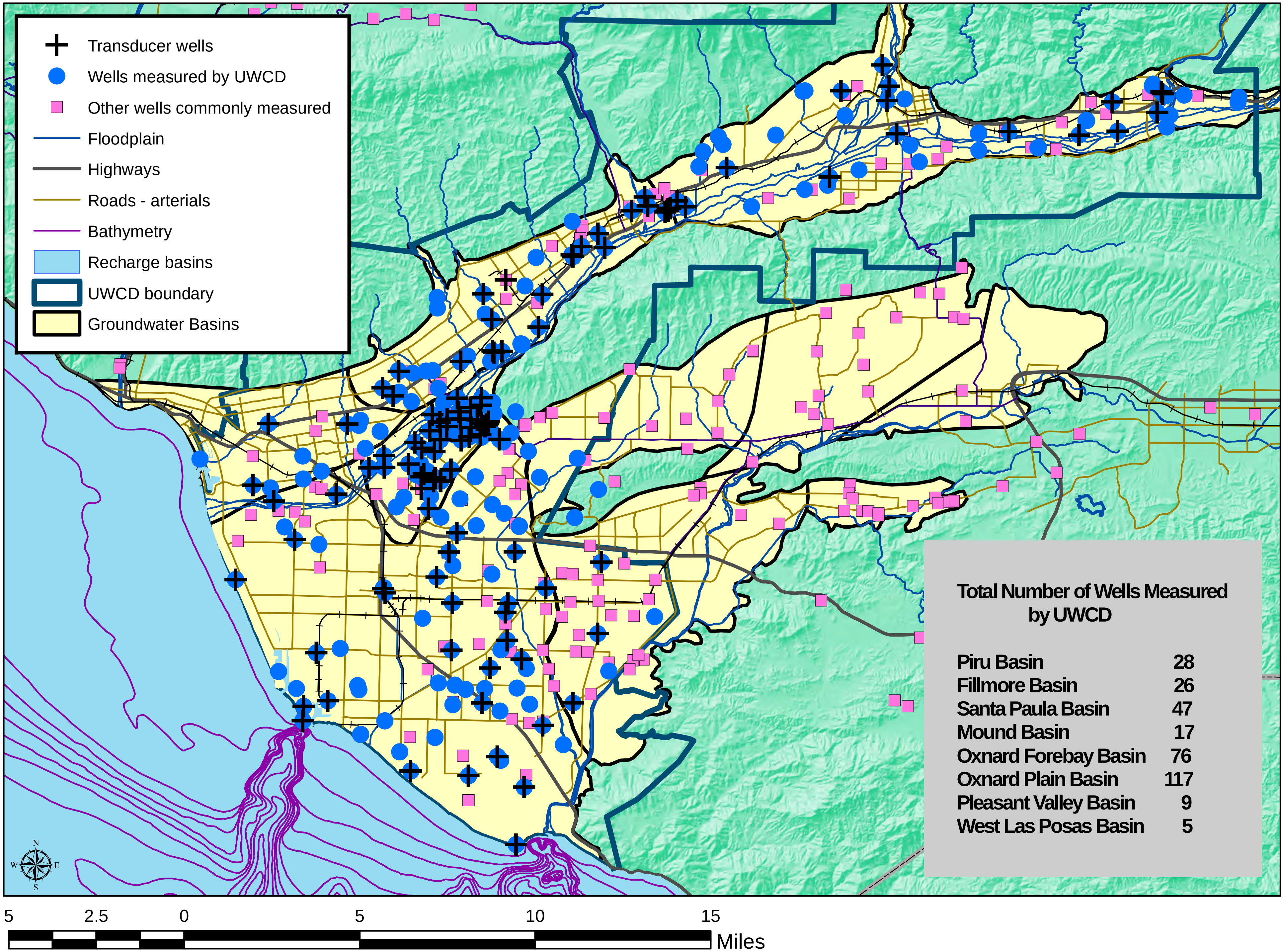

Figure 2.1-2. Wells monitored for water levels by United and other agencies.

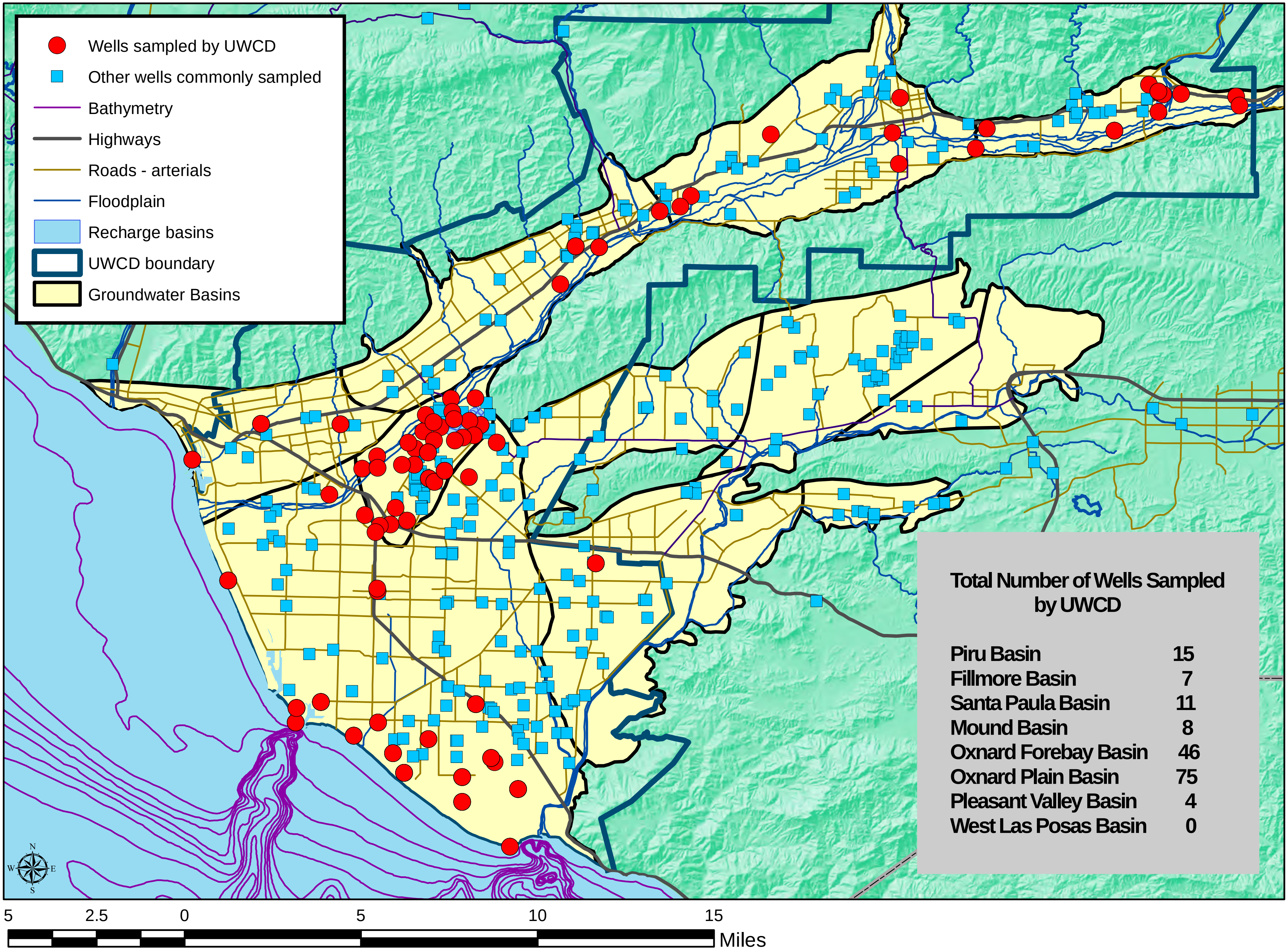

Figure 2.1-3. Wells sampled for water quality by United and other agencies.

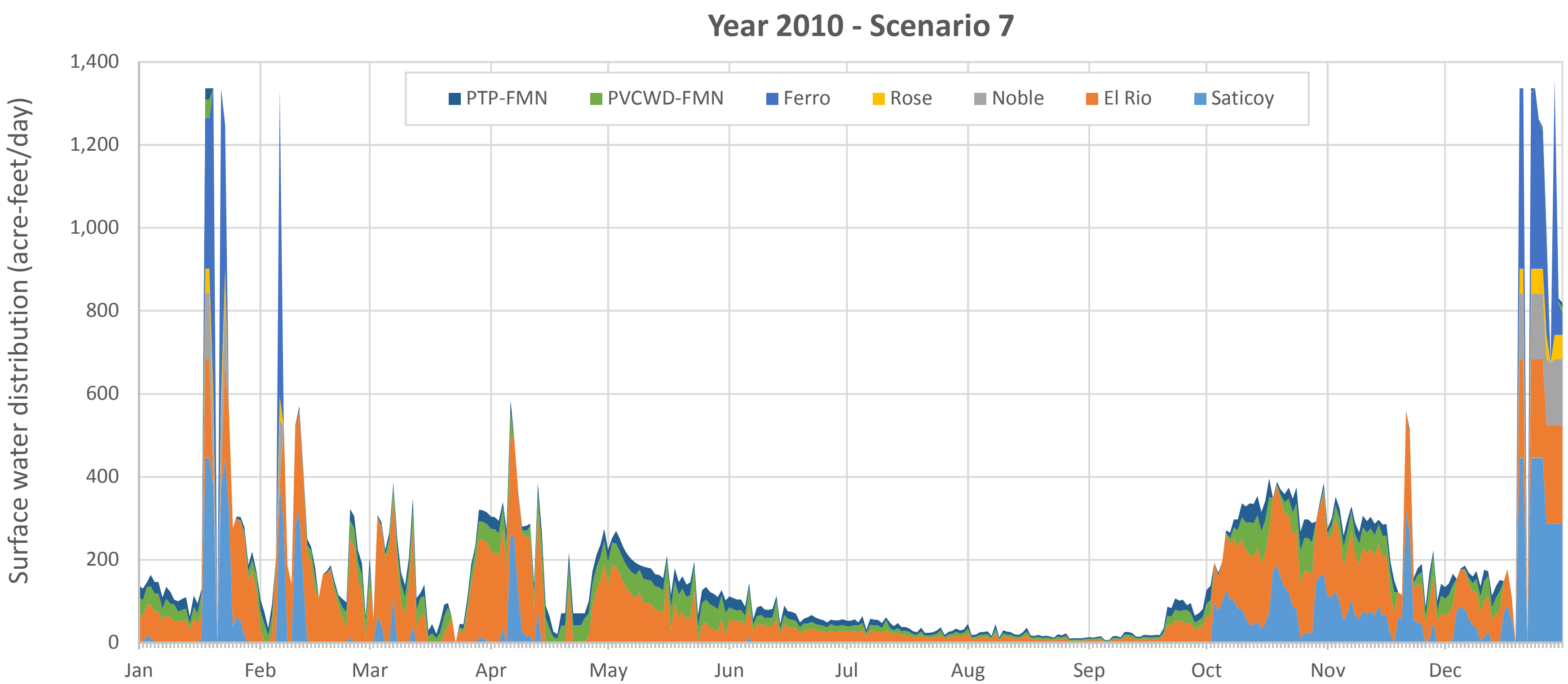

Figure 2.2-1. Surface water distribution to recharge basins and surface water deliveries for scenario 7 (model year 2010).

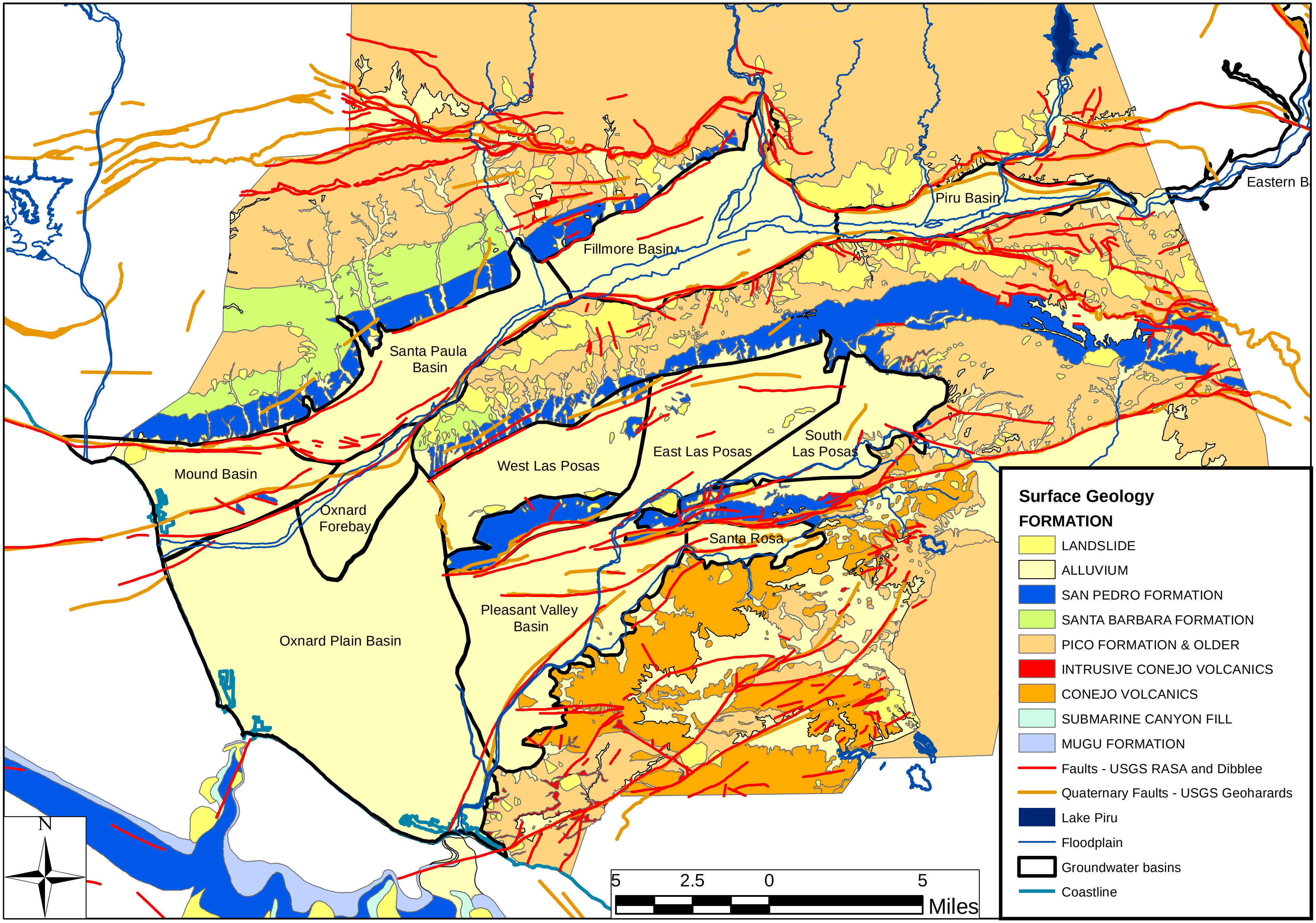

Figure 3.1-1. Surface geology and faults.

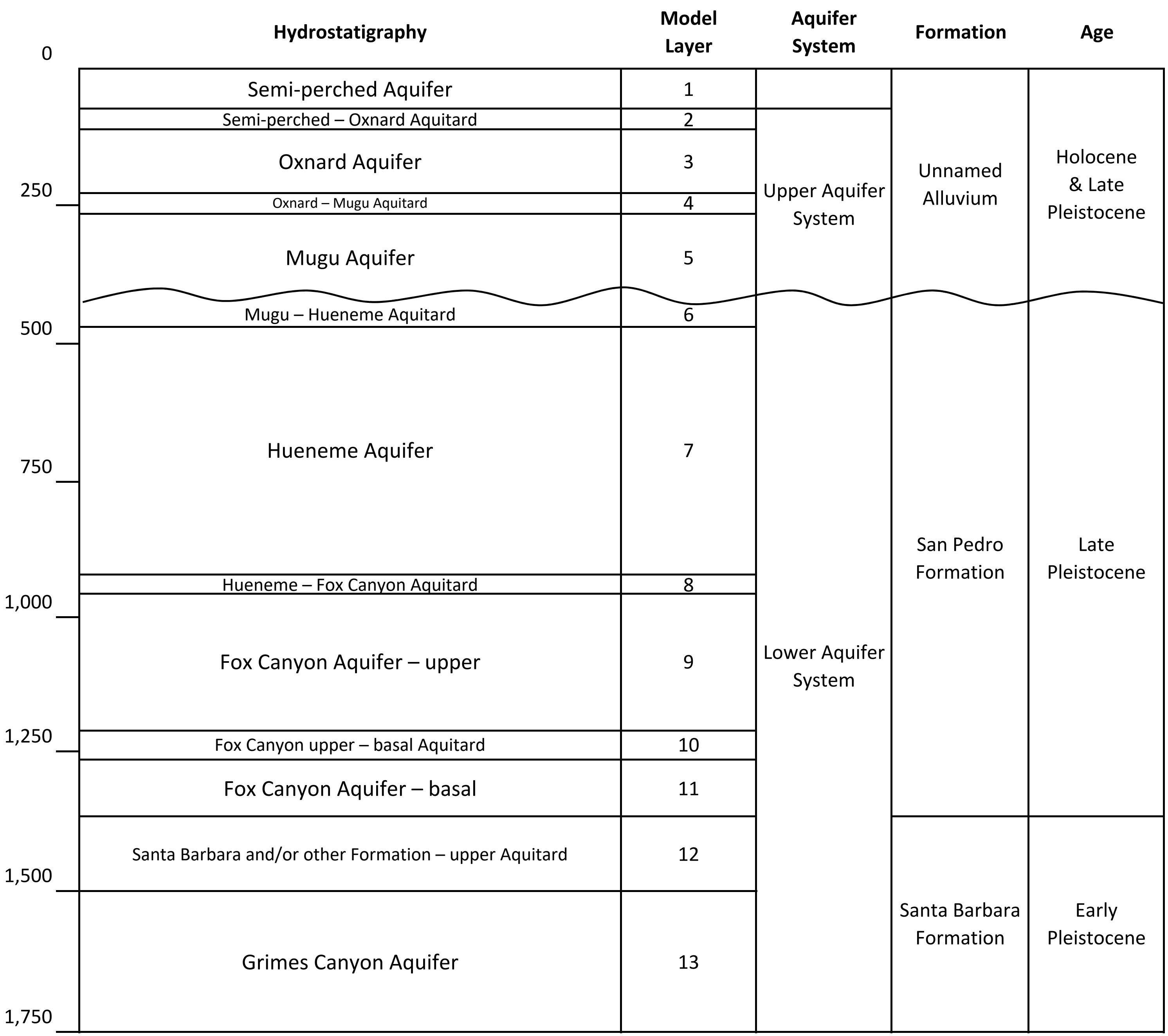

Figure 3.2-1. Schematic of Upper and Lower aquifer systems with model layers.

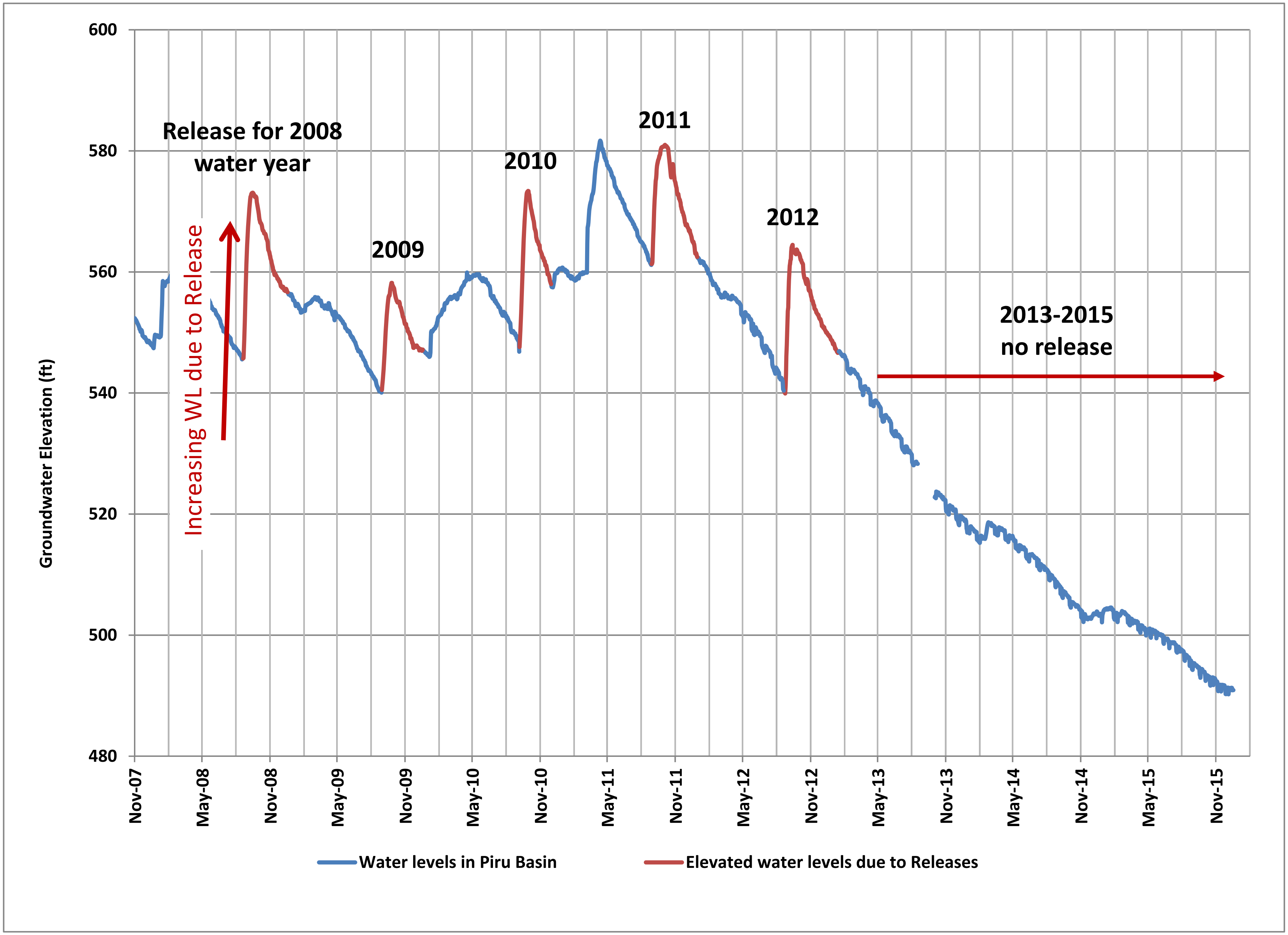

Figure 4.2-1. Groundwater response in the Piru basin from the conservation release at SFD (well 04N18W31D07S & -D04S).

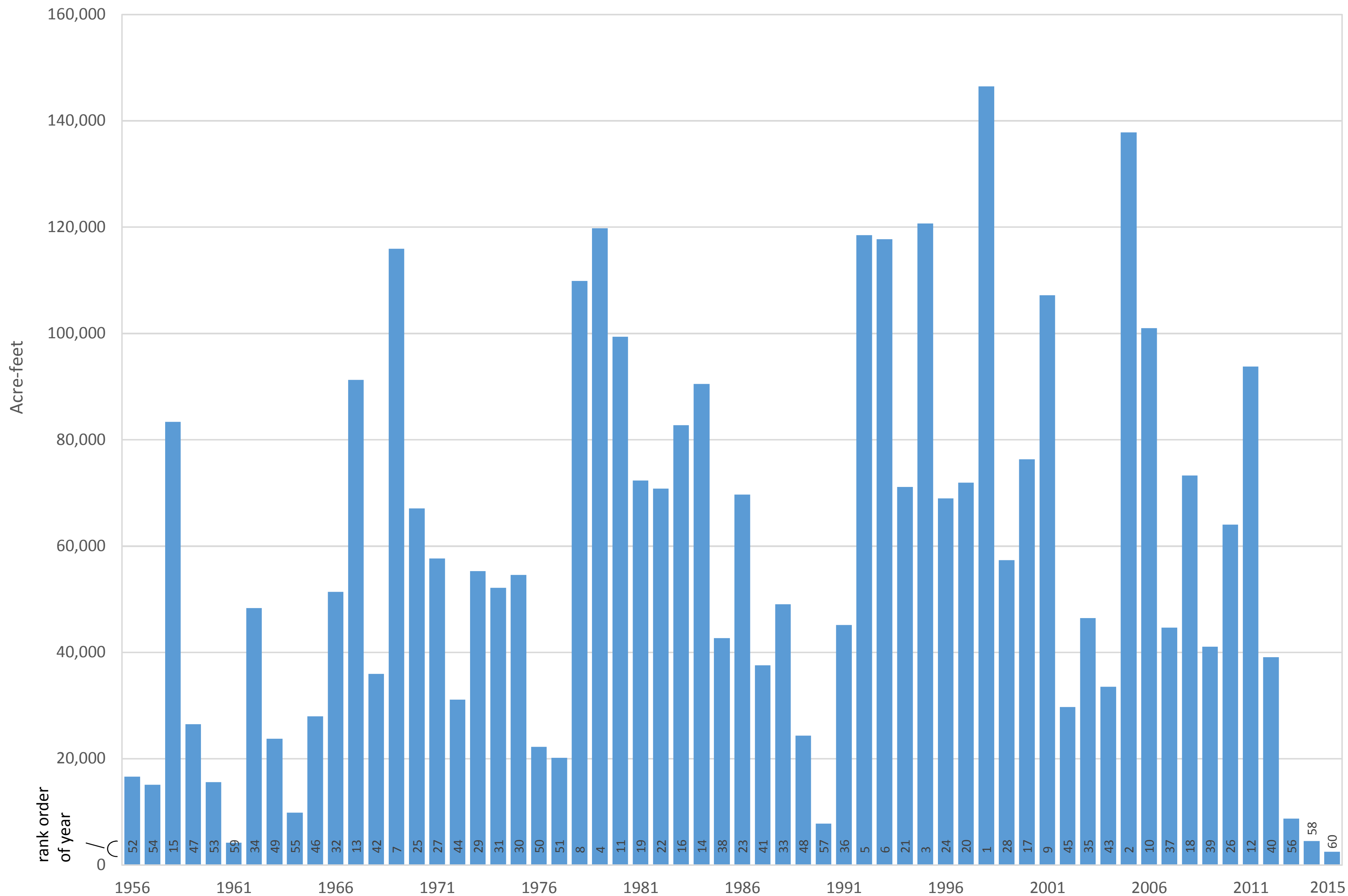

Figure 4.4-1. Historic diversion totals (calendar year) at Saticoy Diversion (1956-1990) and Freeman Diversion (1991-2015).

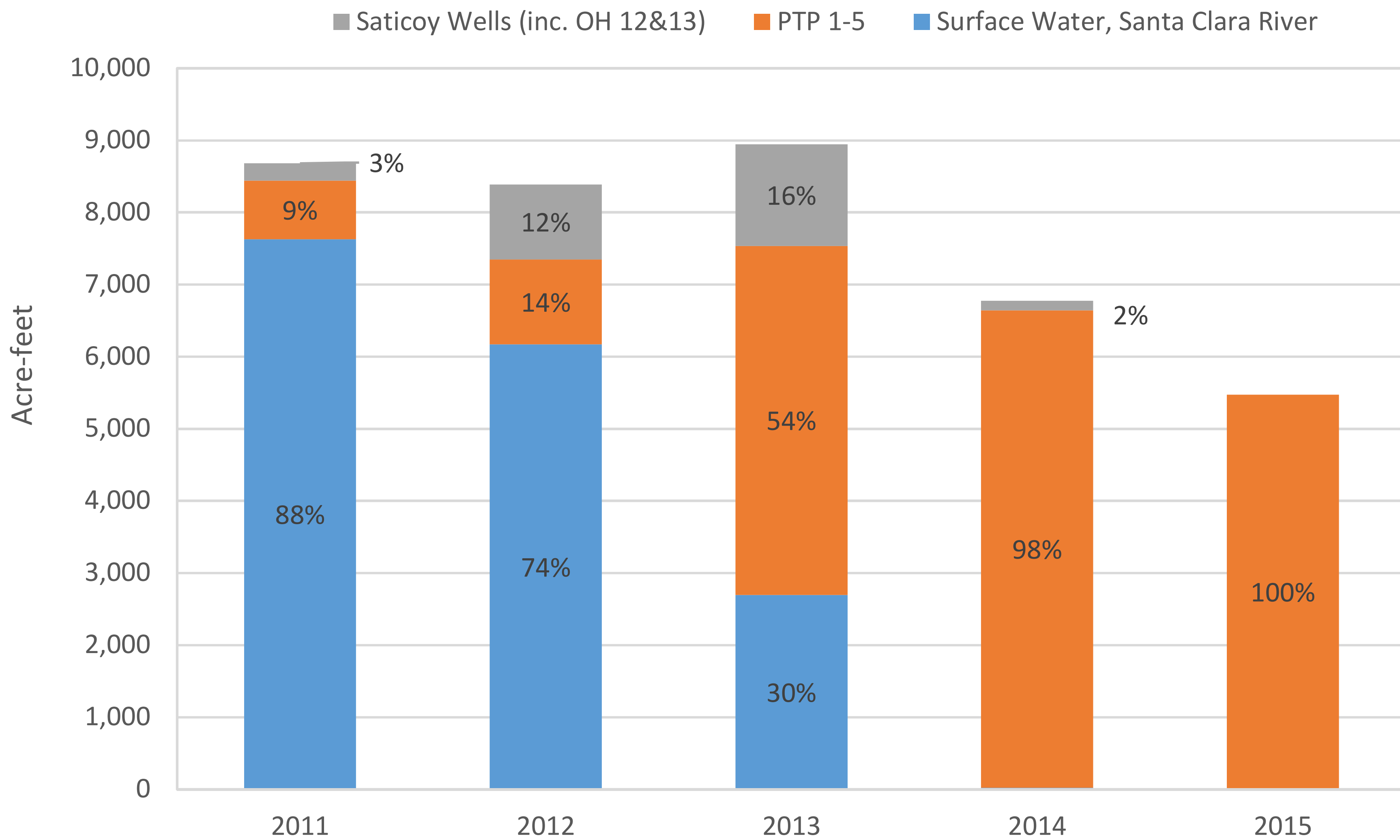

Figure 4.5-1. PTP water deliveries and source, years 2011 through 2015.

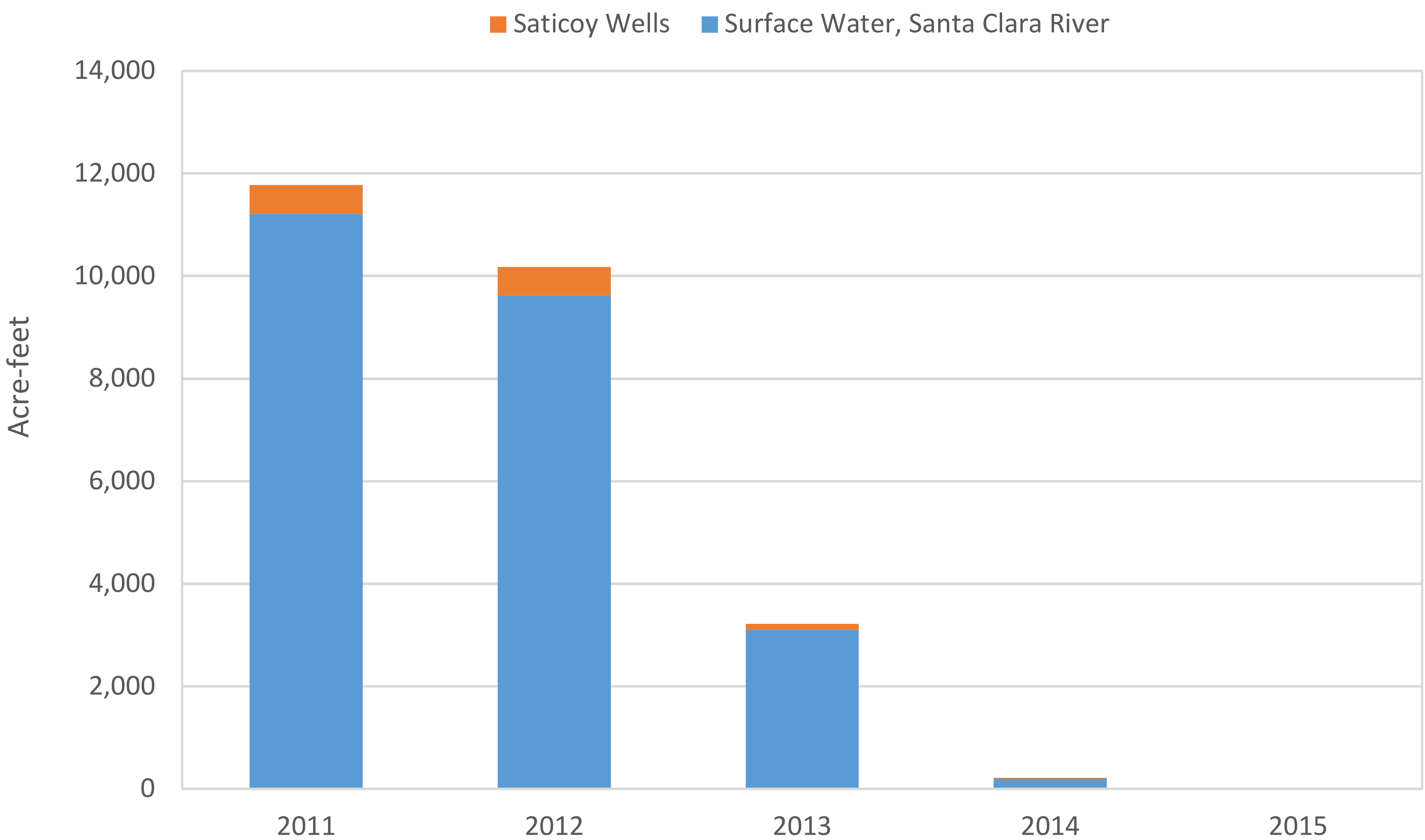

Figure 4.6-1. Pleasant Valley pipeline deliveries and source, years 2011 through 2015.

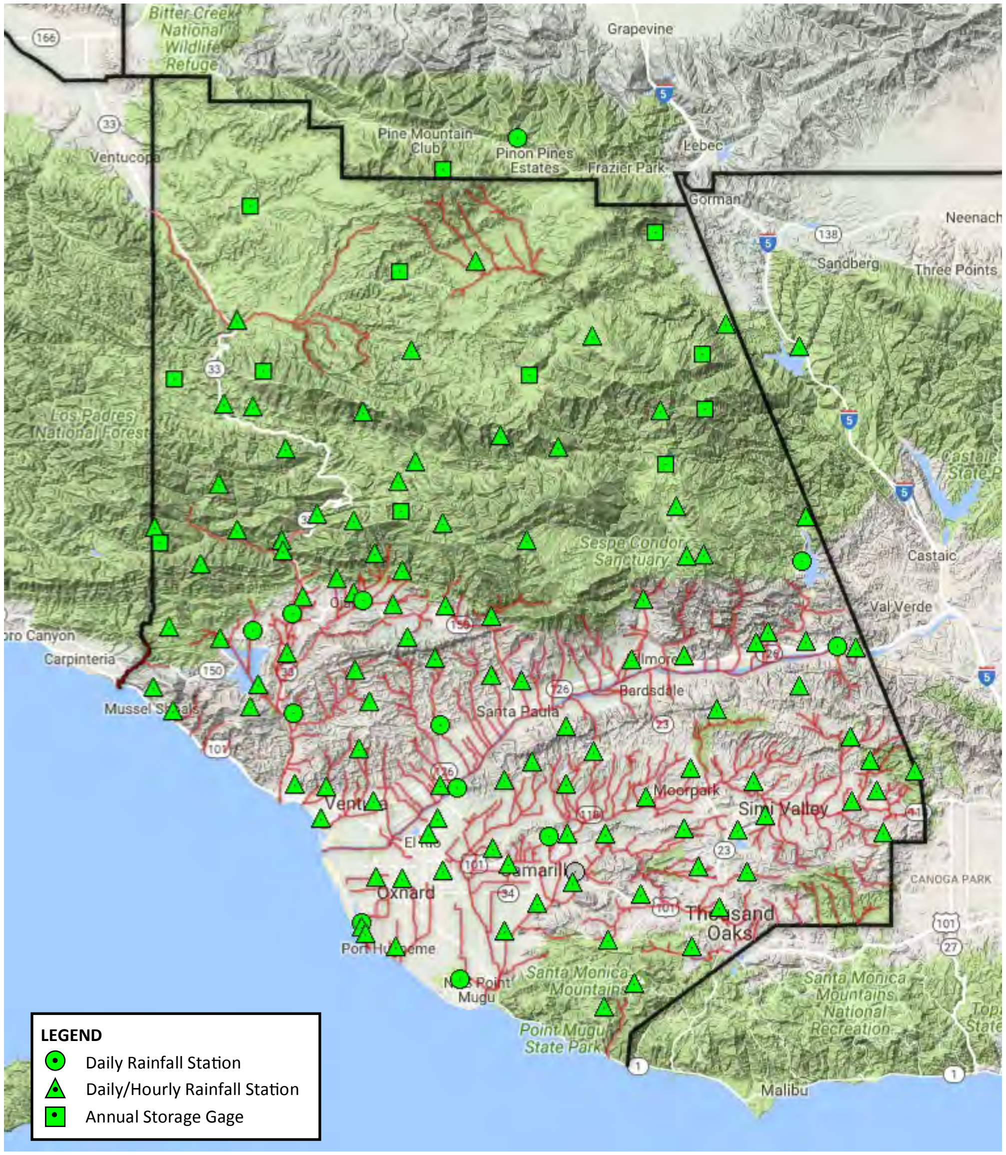

Figure 5.1-1. Active Rainfall Stations in Ventura County.

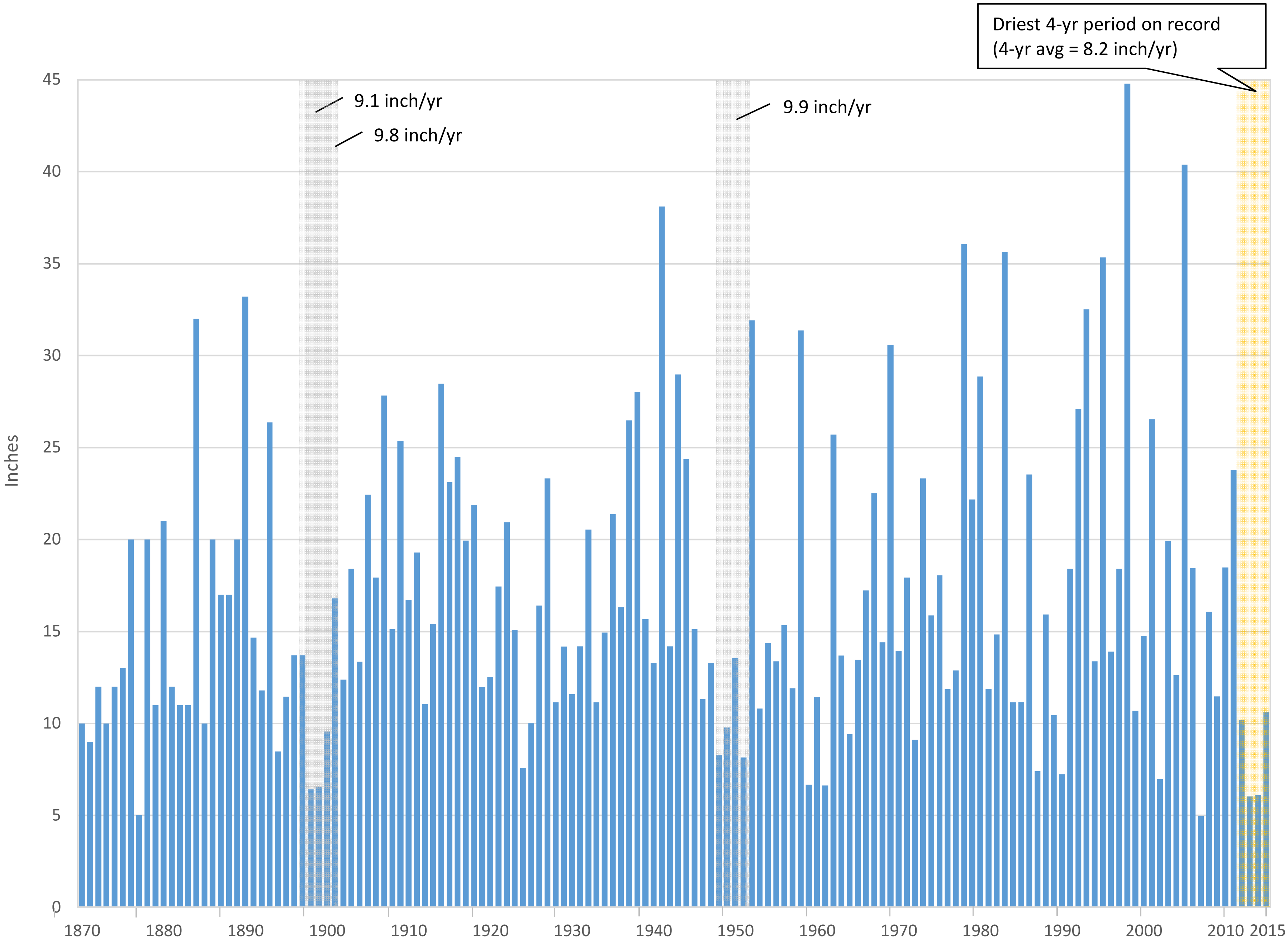

Figure 5.1-2. Historic precipitation at Santa Paula station (# 245), with indication of driest 4-year period (water years).

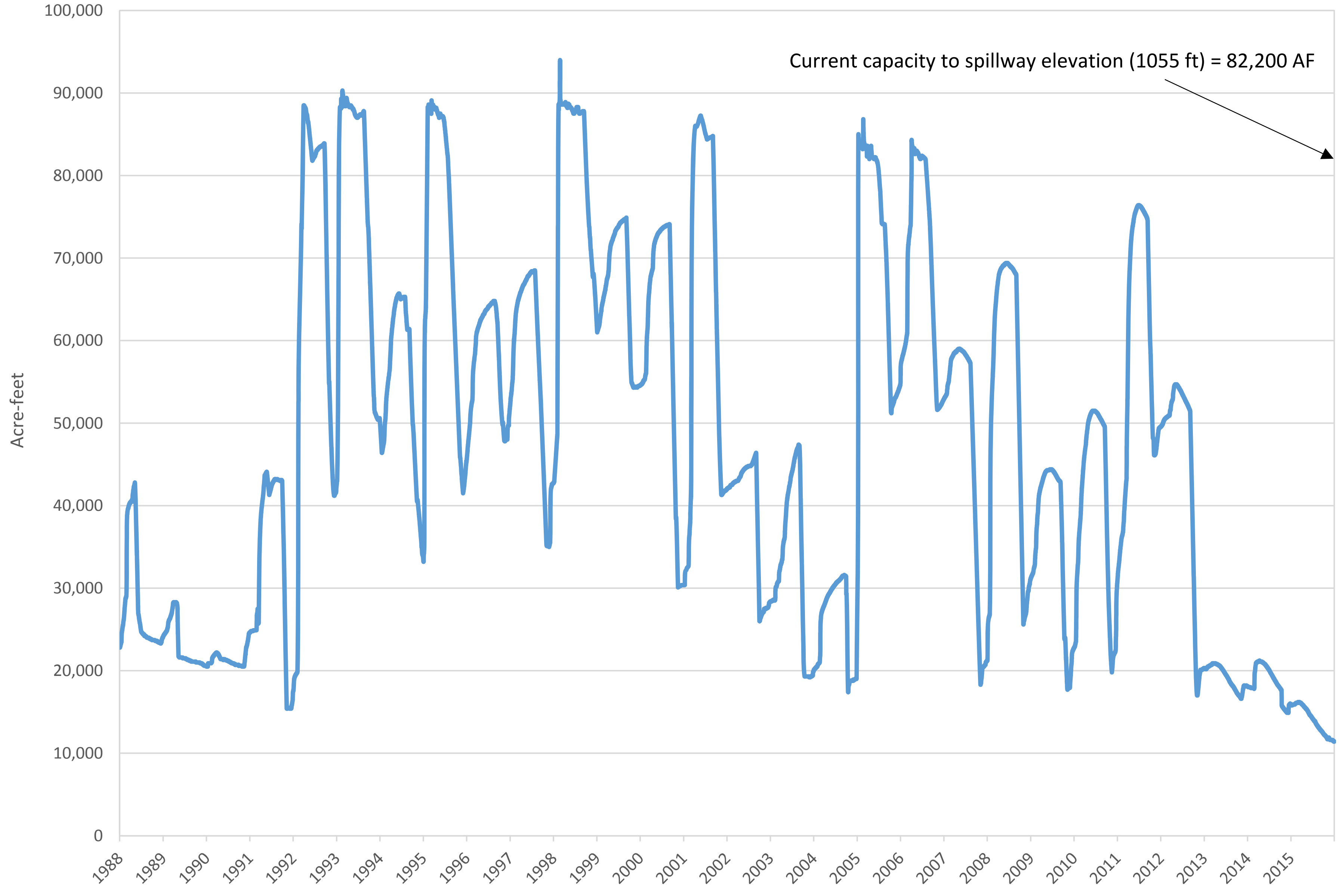

Figure 5.2-1. Historic volumes of water stored in Lake Piru.

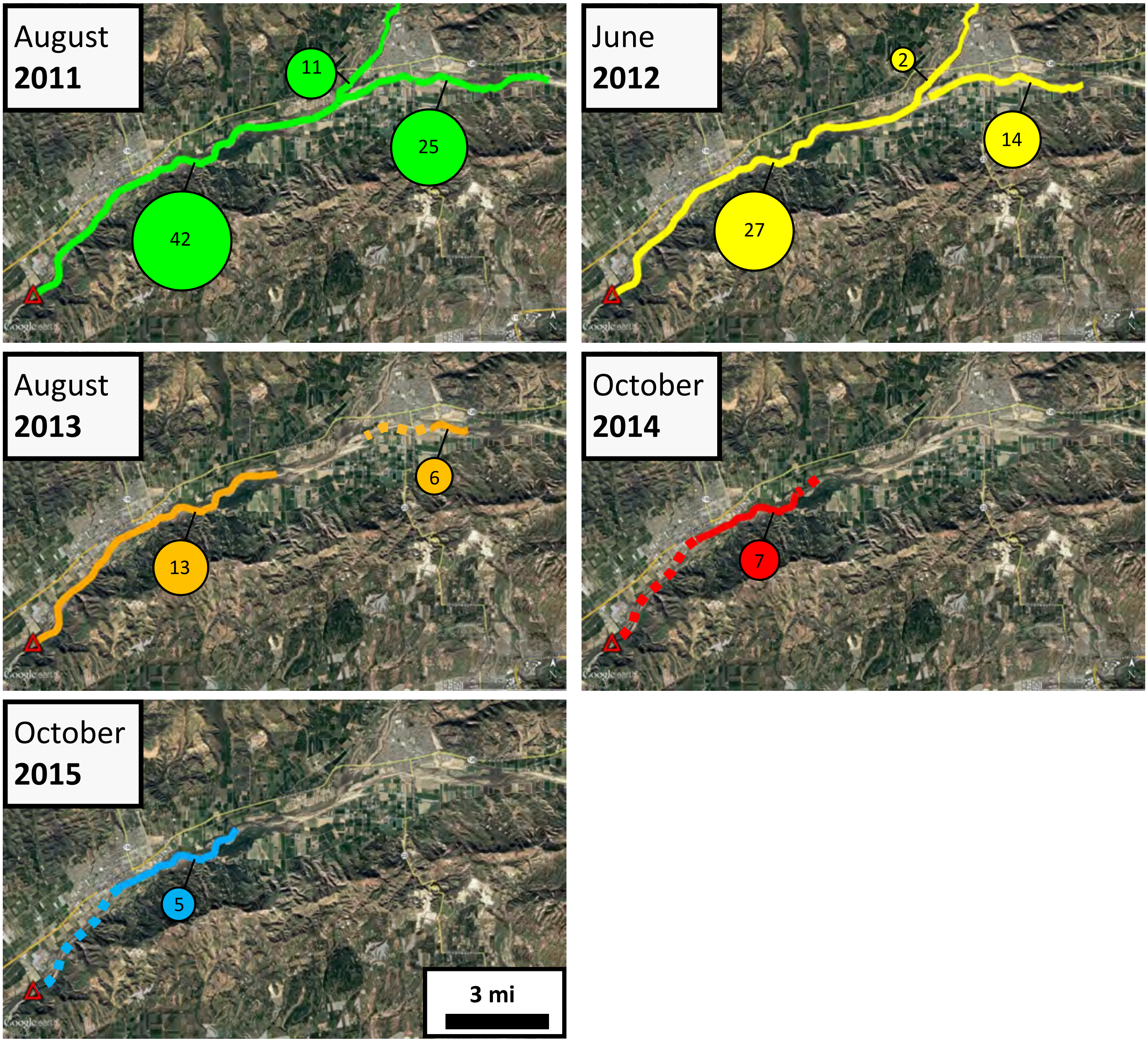

Figure 5.2-2. Length of wetted areas in the lower Santa Clara River (colored lines), upstream of the Freeman Diversion (location indicated by red triangle). Reaches where the end of the wetted area is uncertain are indicated by dotted lines. Flow rates (cfs) are indicated in circles, scaled according to magnitude.

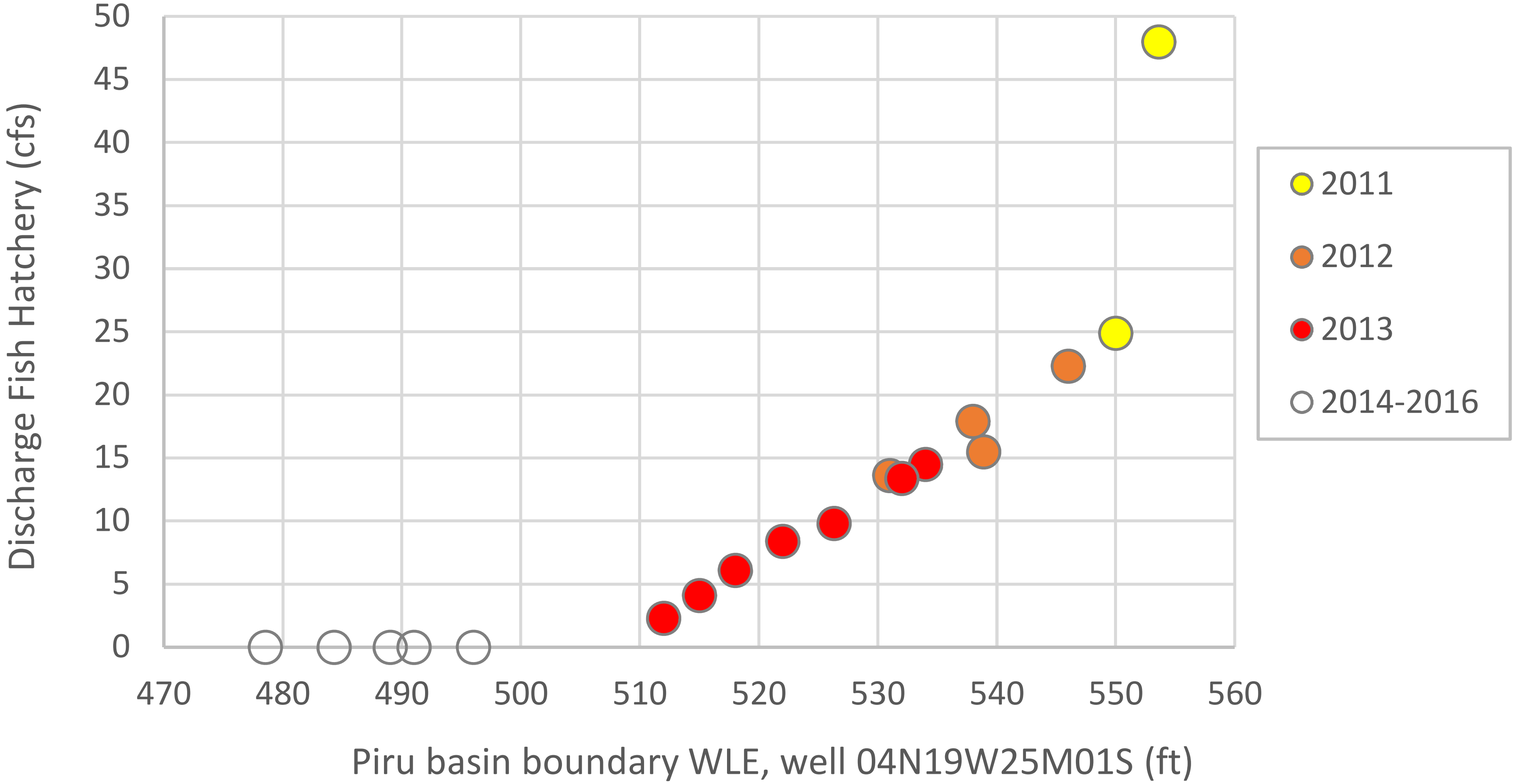

Figure 5.2-3. Correlation between surface water discharge at downstream boundary, and groundwater elevation for Piru basin.

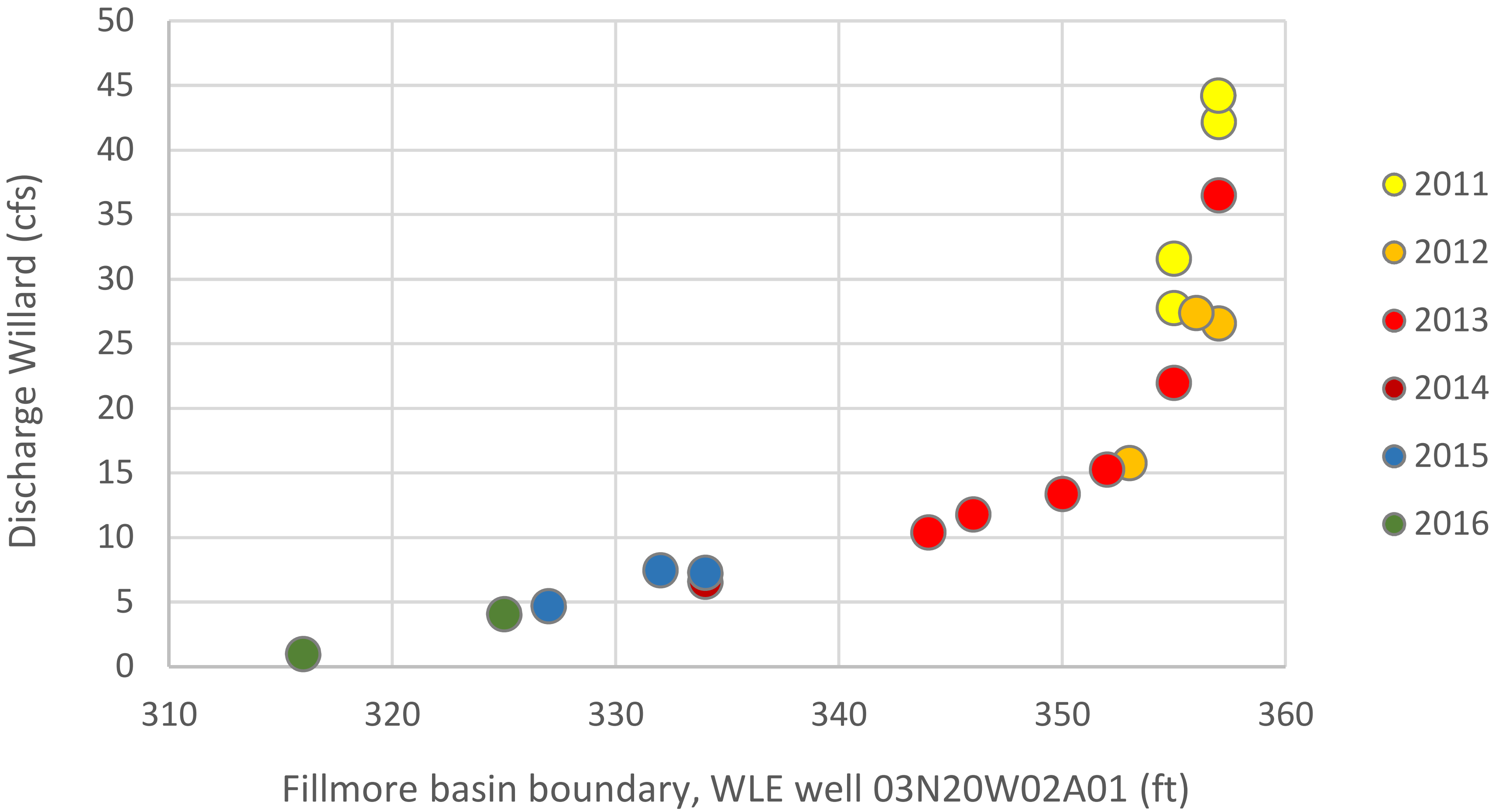

Figure 5.2-4. Correlation between surface water discharge at downstream boundary, and groundwater elevation for Fillmore basin.

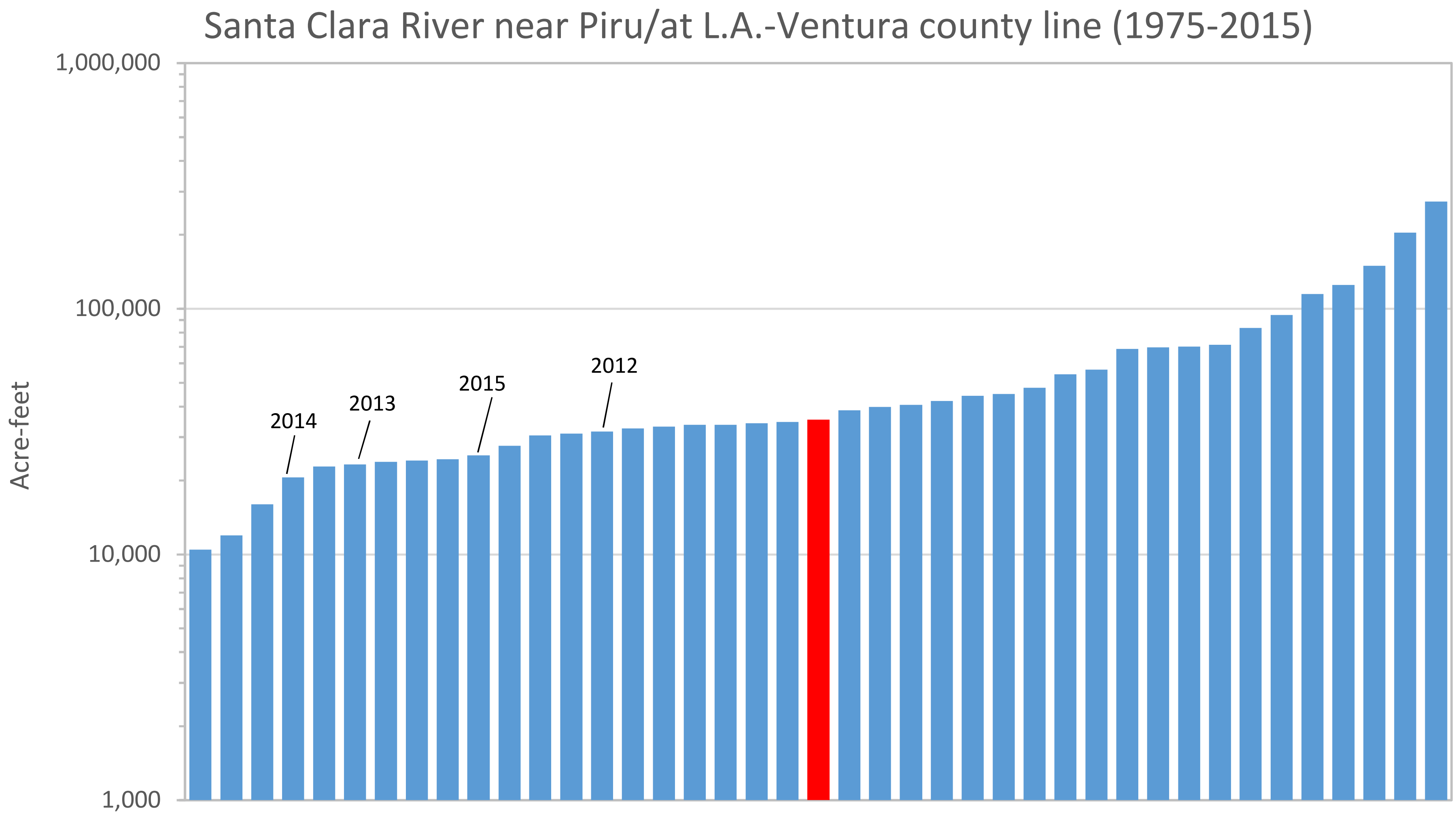

Figure 5.2-5. Historic annual runoff (ranked) in Santa Clara River near Piru (USGS 11109000) and Santa Clara River at L.A.-Ventura county line (USGS 11108500).

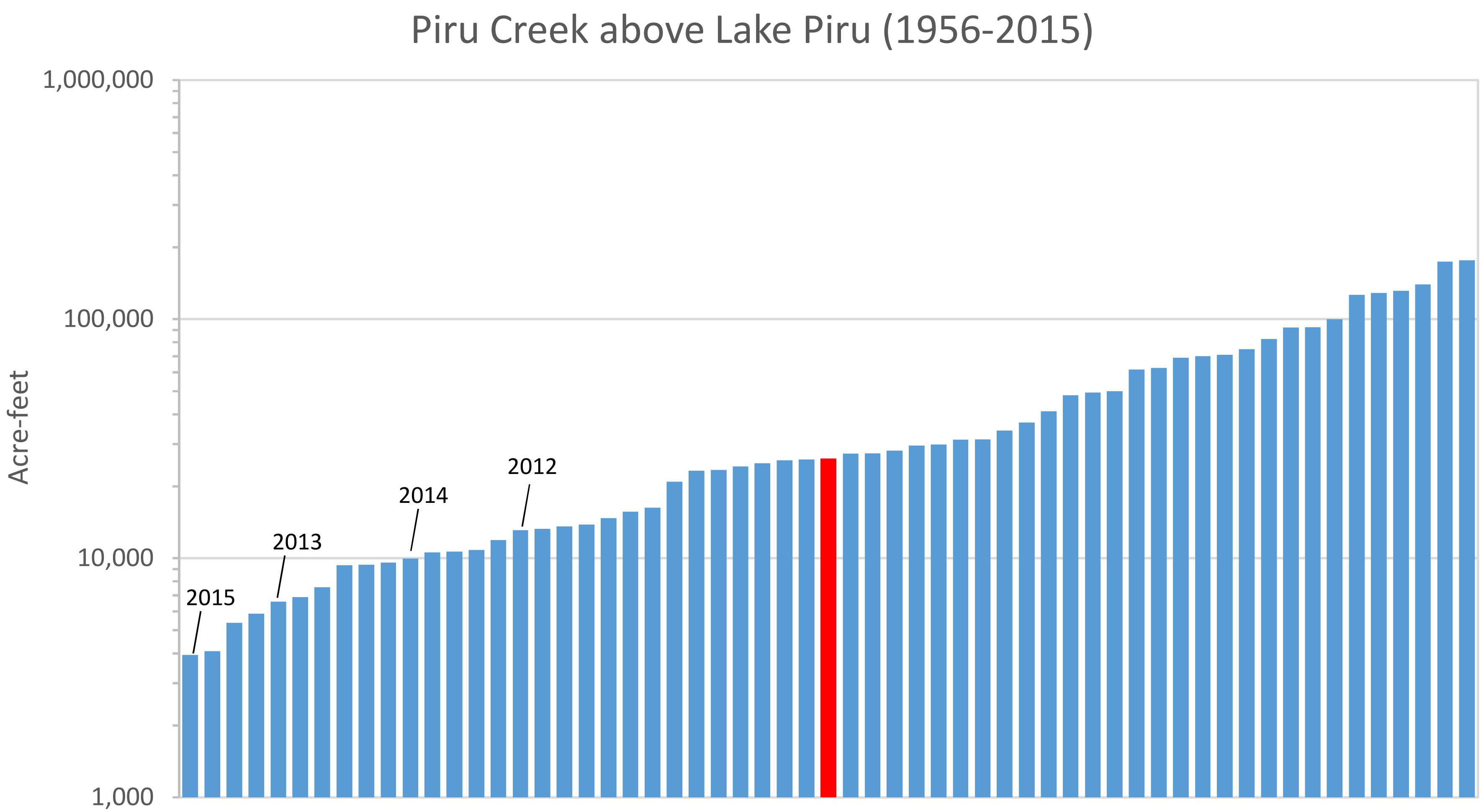

Figure 5.2-6. Historic annual runoff (ranked) in Piru Creek above Lake Piru (USGS 11109600).

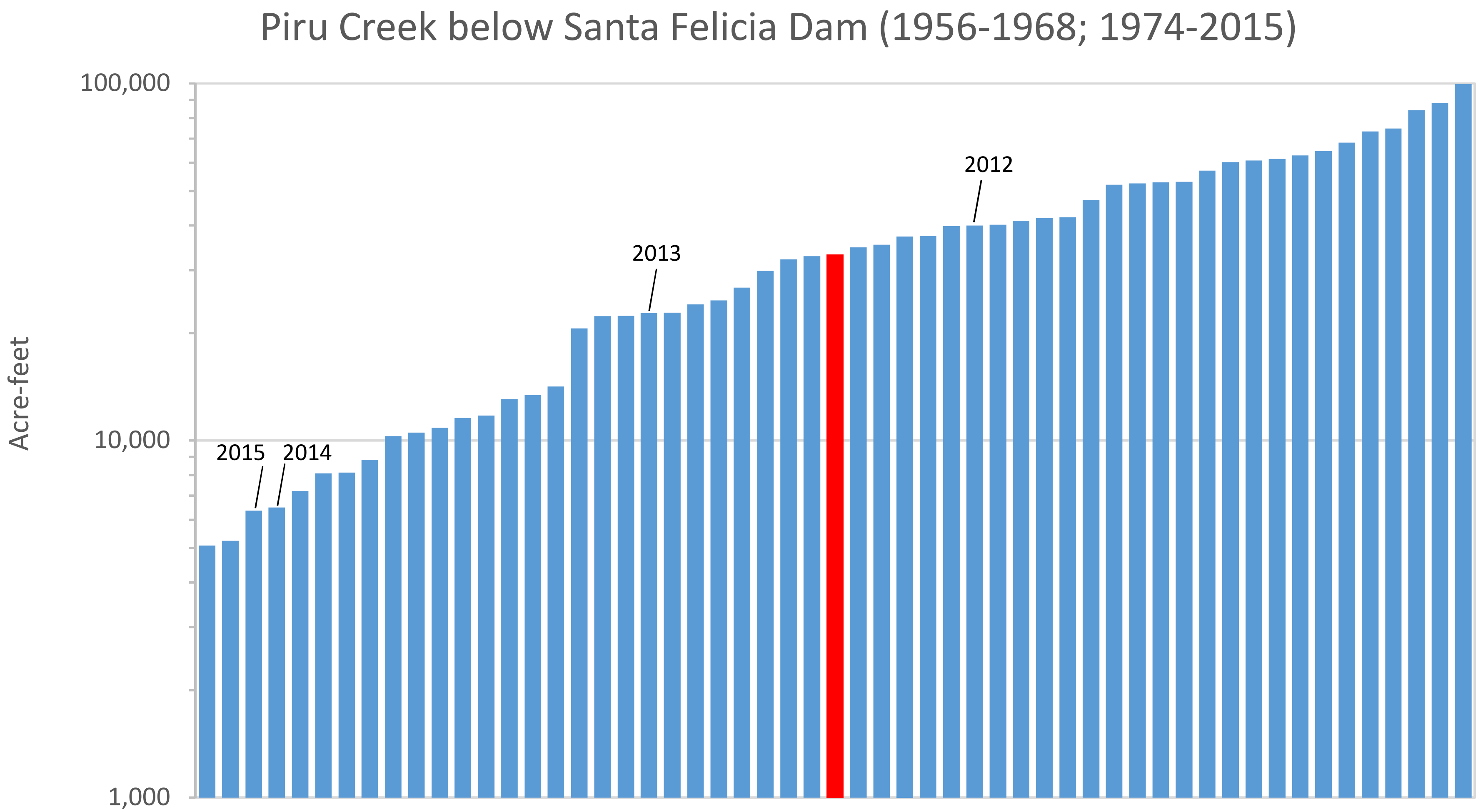

Figure 5.2-7. Historic annual runoff (ranked) in Piru Creek below Santa Felicia Dam (USGS 11109800).

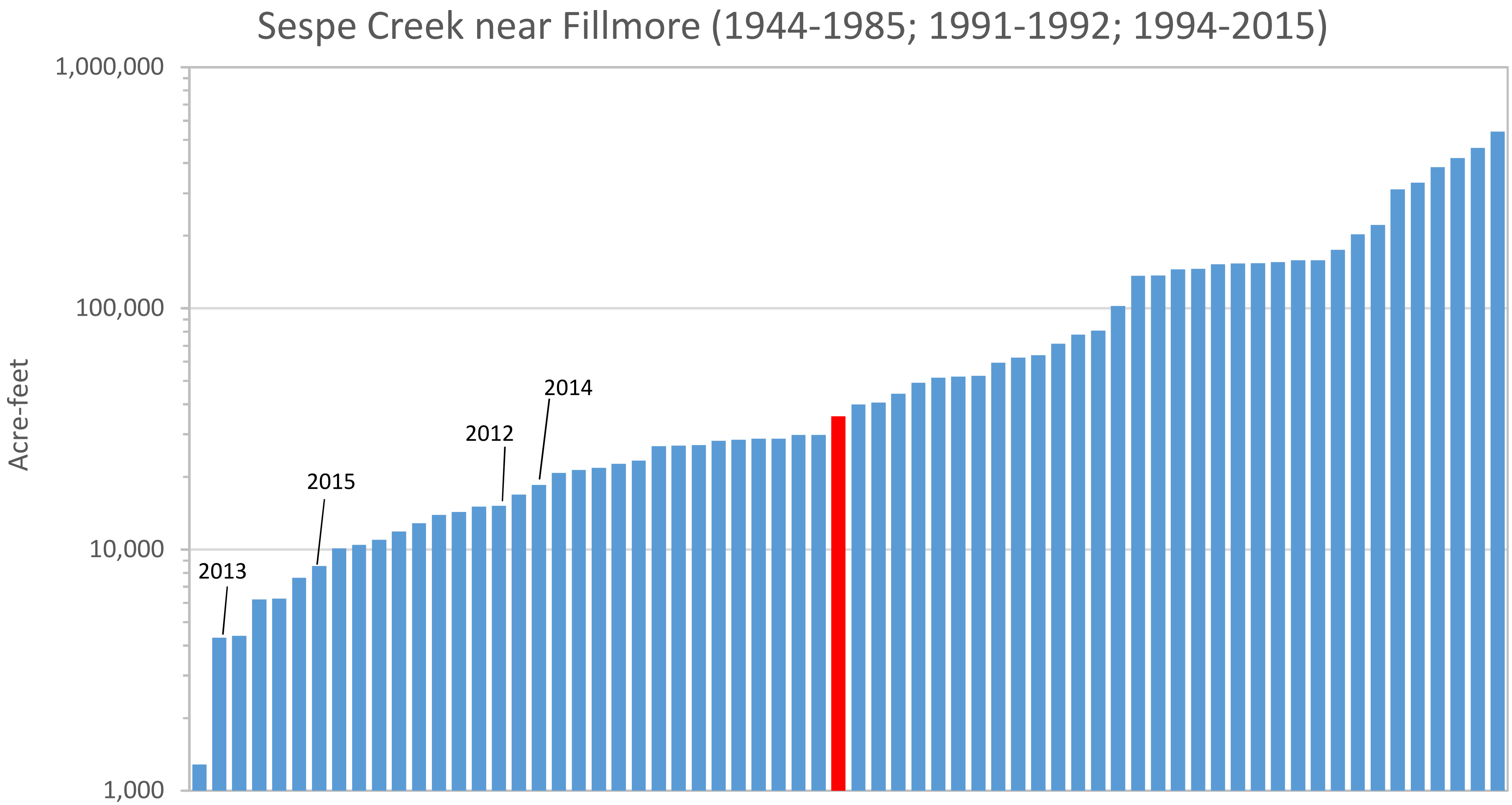

Figure 5.2-8. Historic annual runoff (ranked) in Sespe Creek near Fillmore (USGS 11113000).

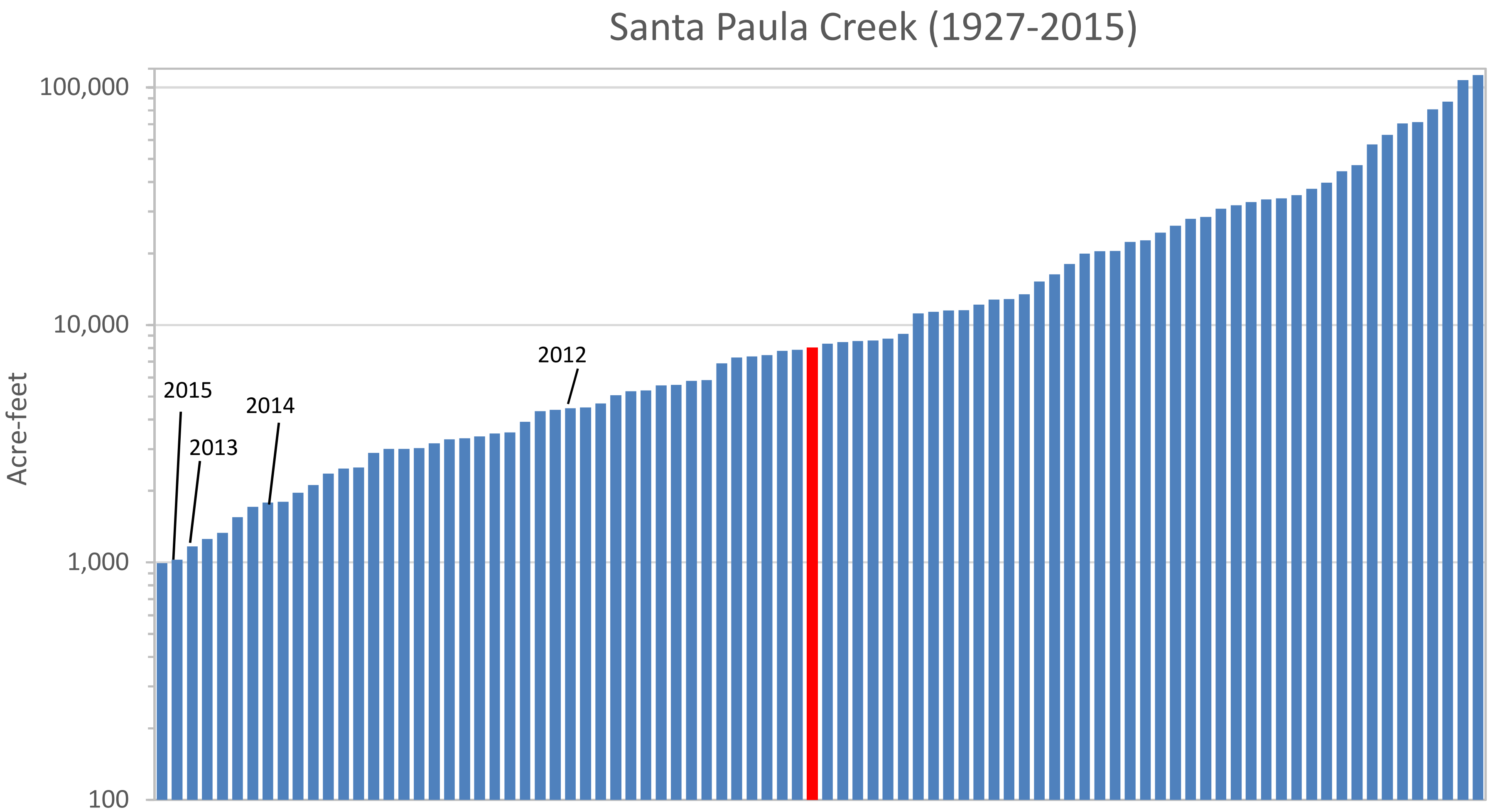

Figure 5.2-9. Historic annual runoff (ranked) in Santa Paula Creek (VCWPD 709).

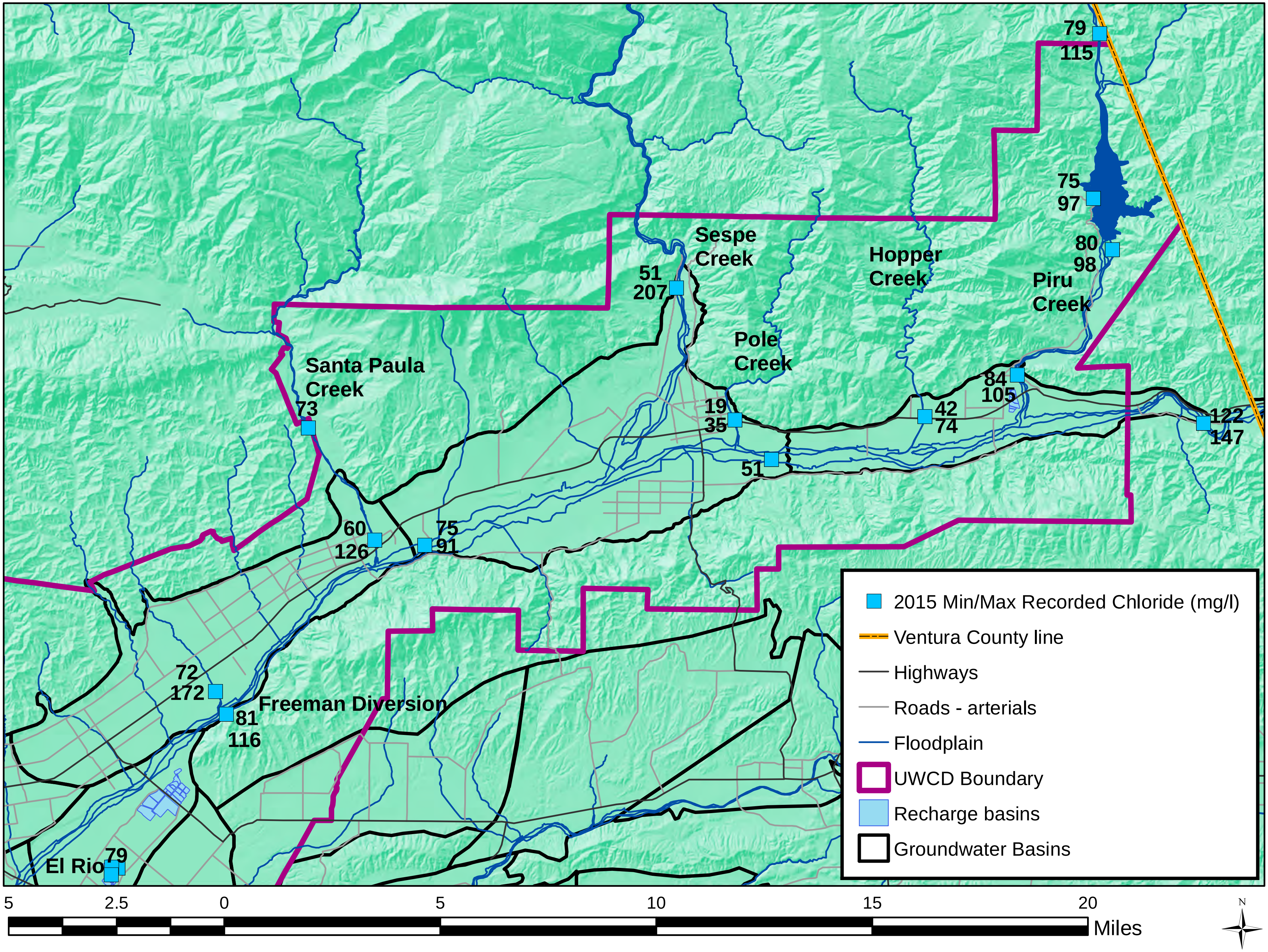

Figure 5.2-10. Recorded 2015 surface water chloride (min/max).

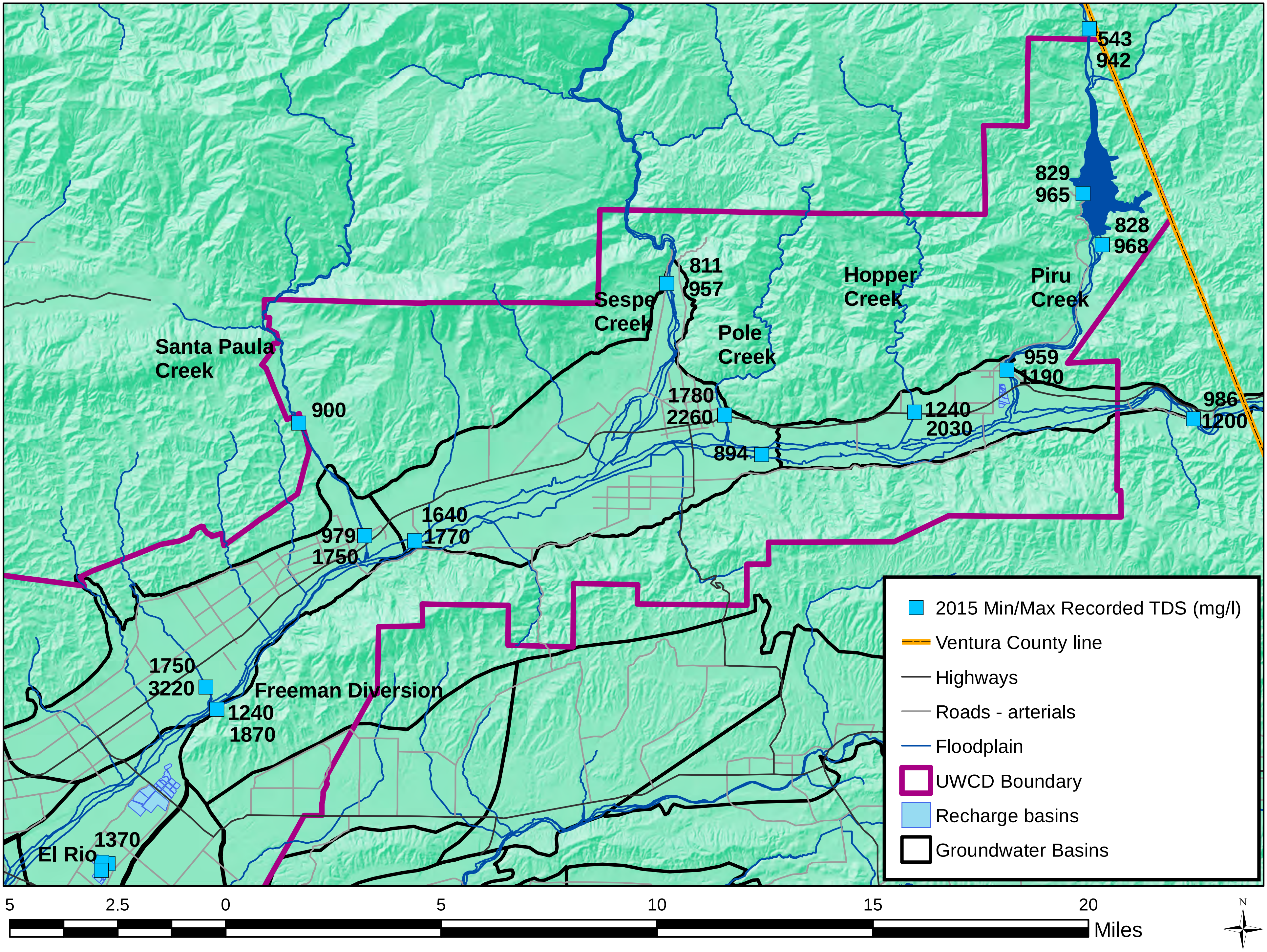

Figure 5.2-11. Recorded 2015 surface water TDS (min/max).

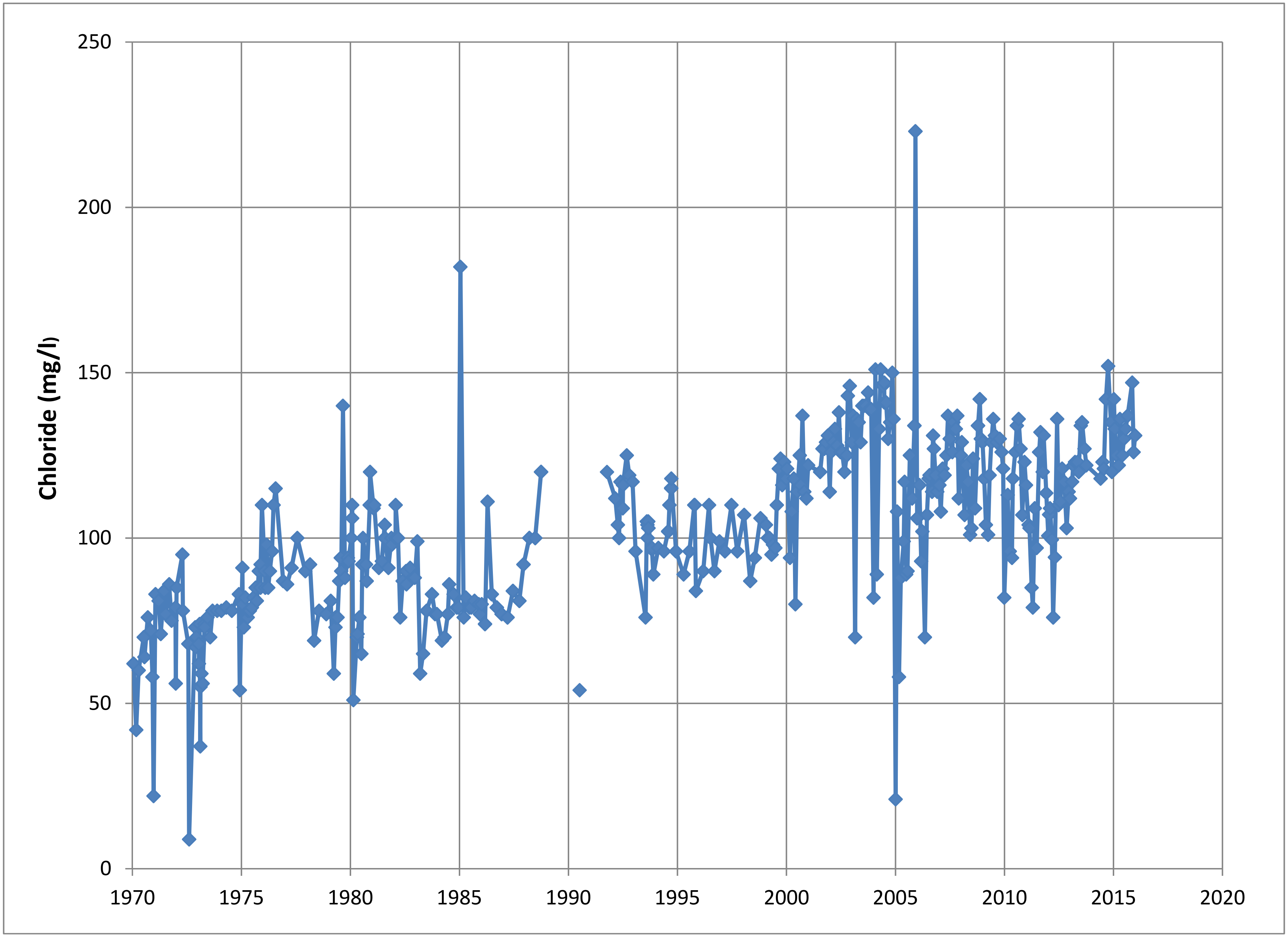

Figure 5.2-12. Historical chloride concentrations in the Santa Clara River near the Los Angeles- Ventura County line.

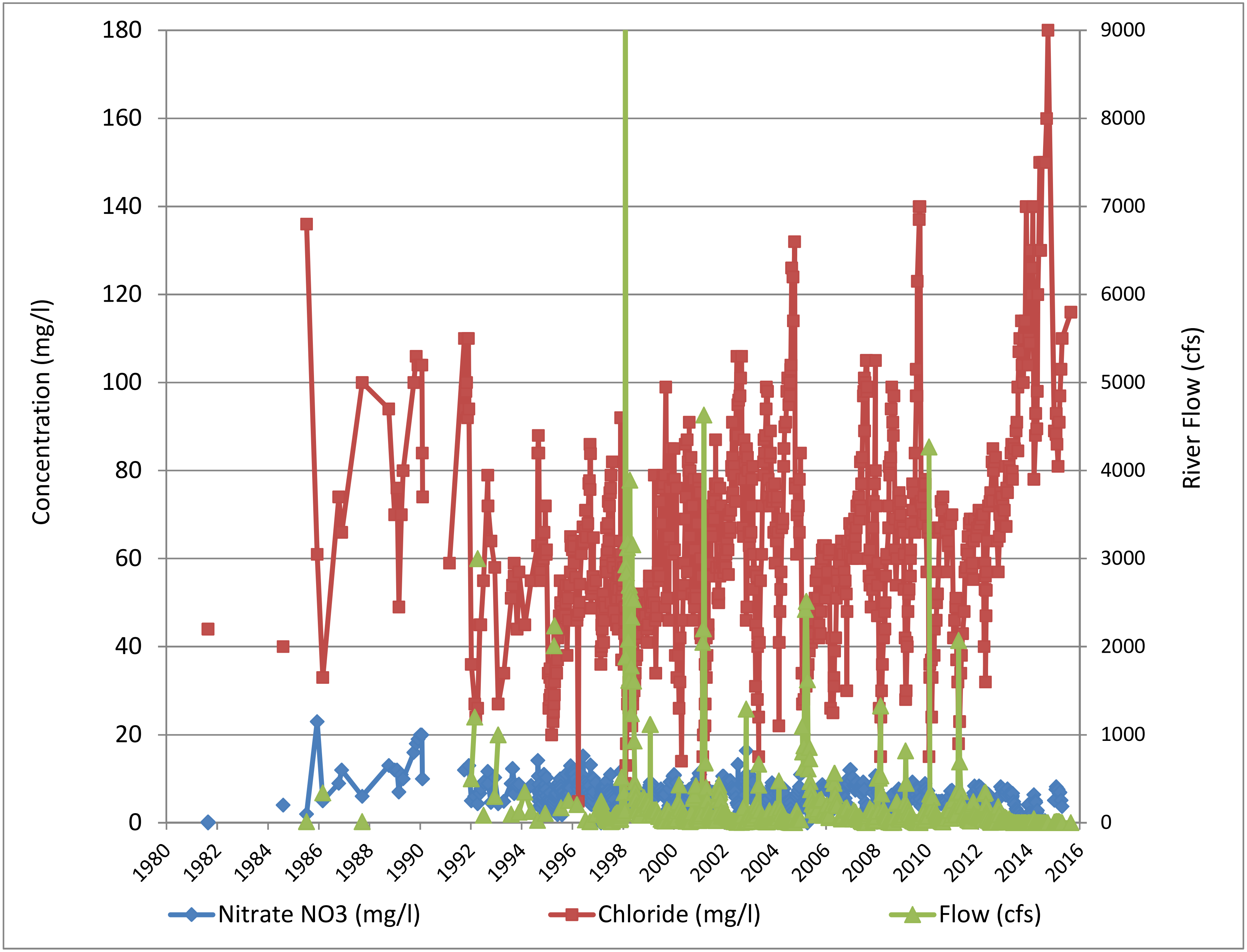

Figure 5.2-13. Historical chloride and nitrate concentrations in the Santa Clara River at Freeman Diversion.

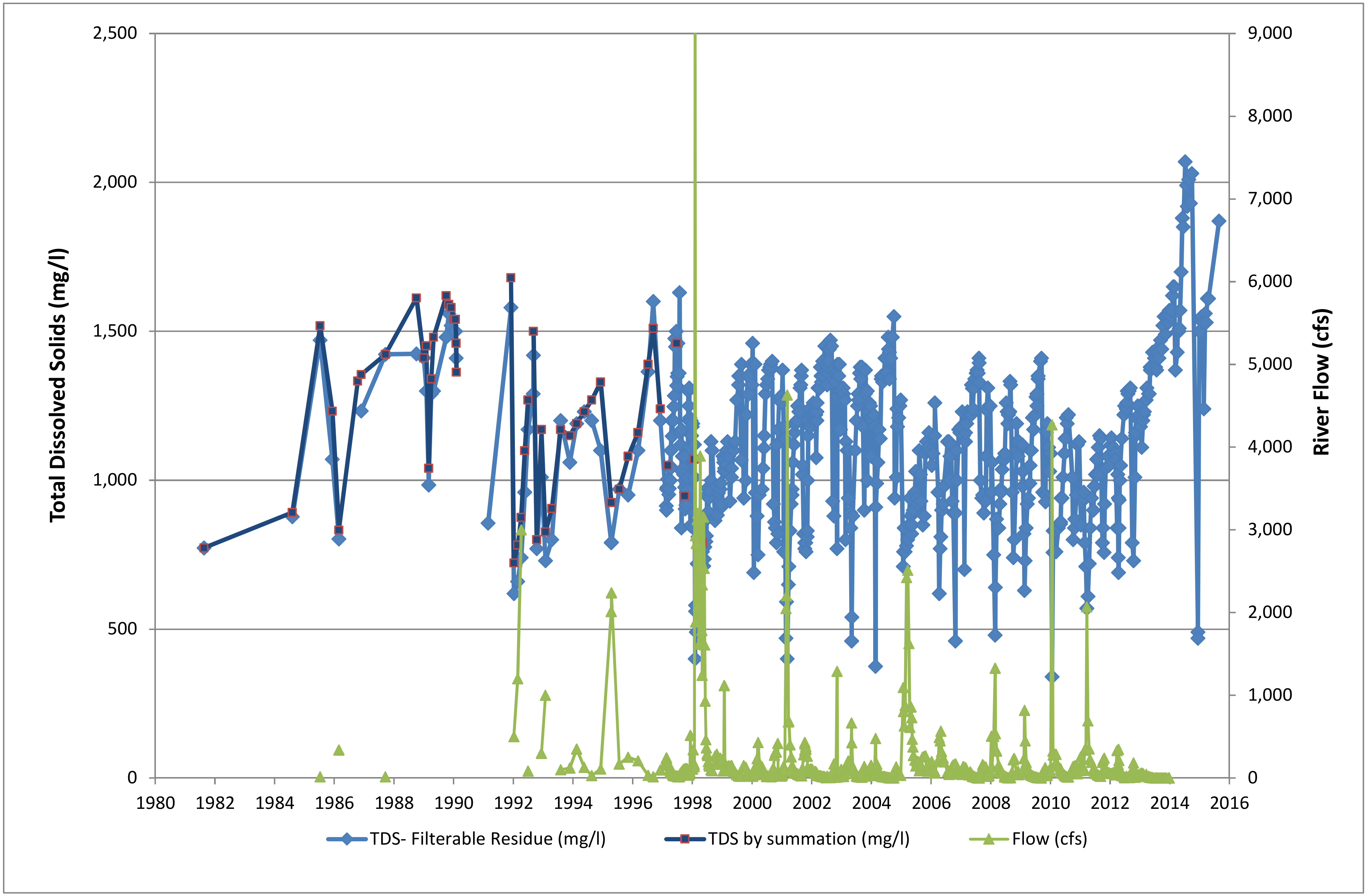

Figure 5.2-14. Historical TDS concentrations in the Santa Clara River at Freeman Diversion.

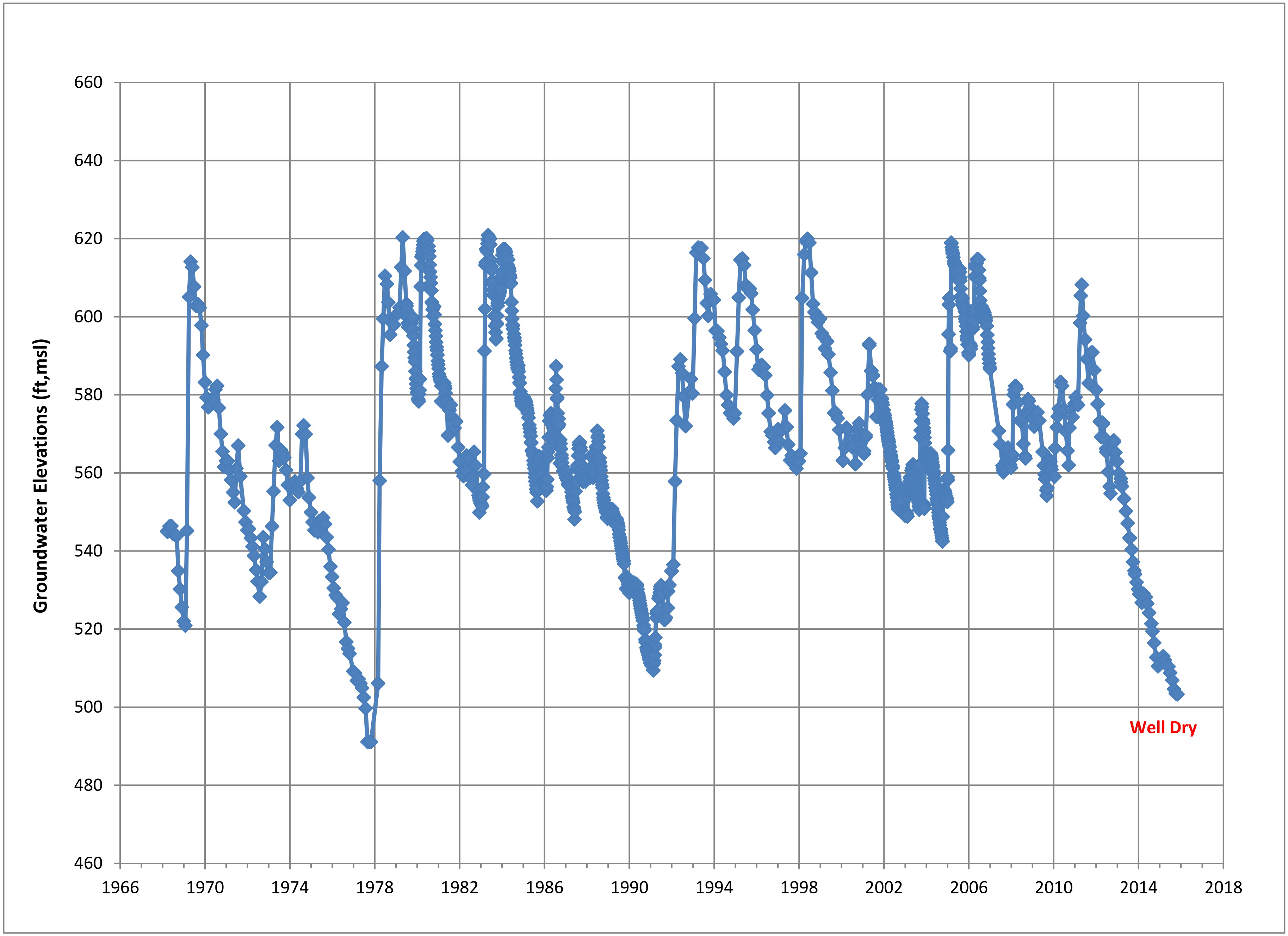

Figure 5.3-1. Historical groundwater elevations in Piru basin key well, near Piru Creek (well 04N18W29M02S).

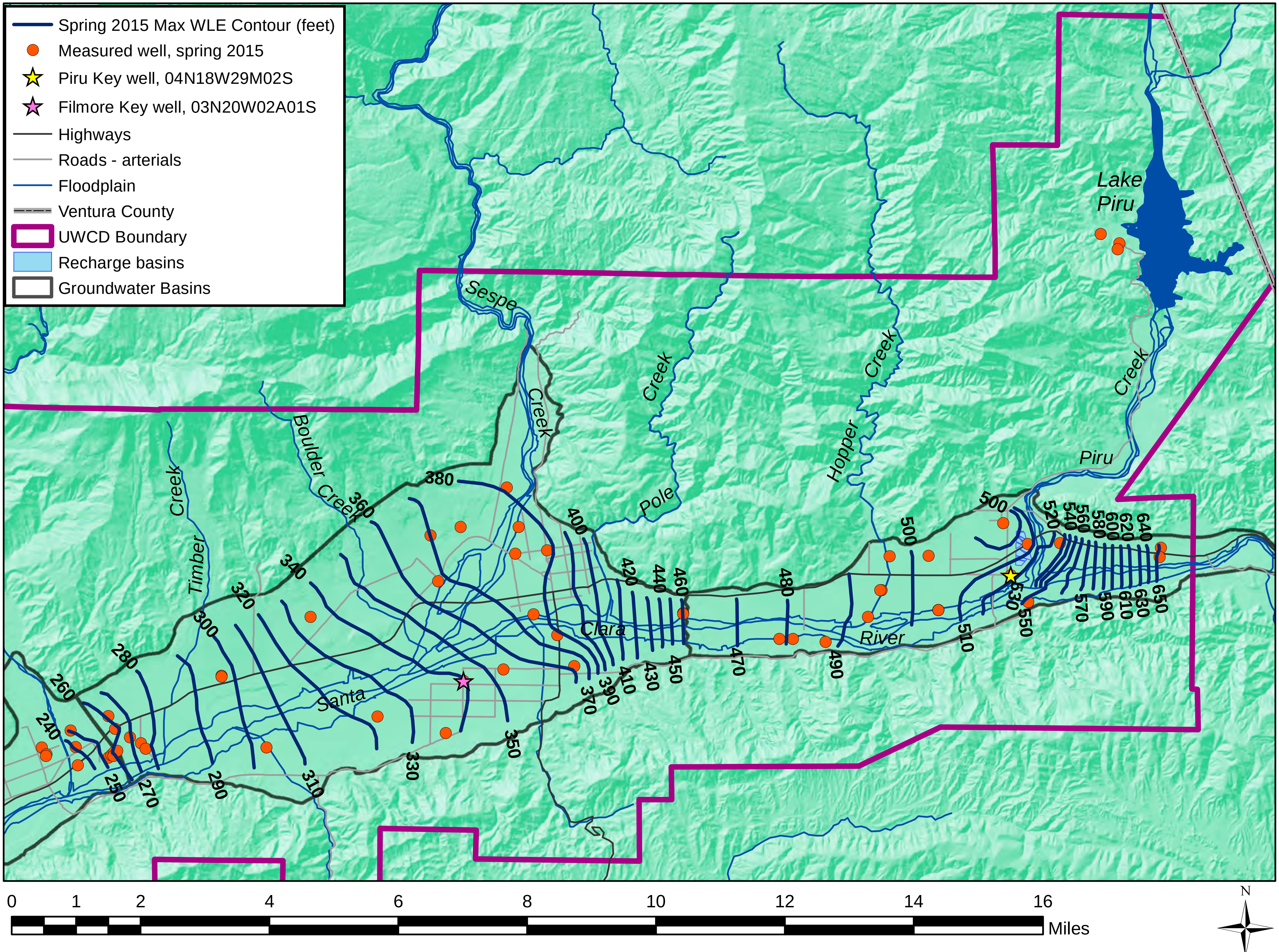

Figure 5.3-2. Piru and Fillmore basins groundwater elevations for spring 2015.

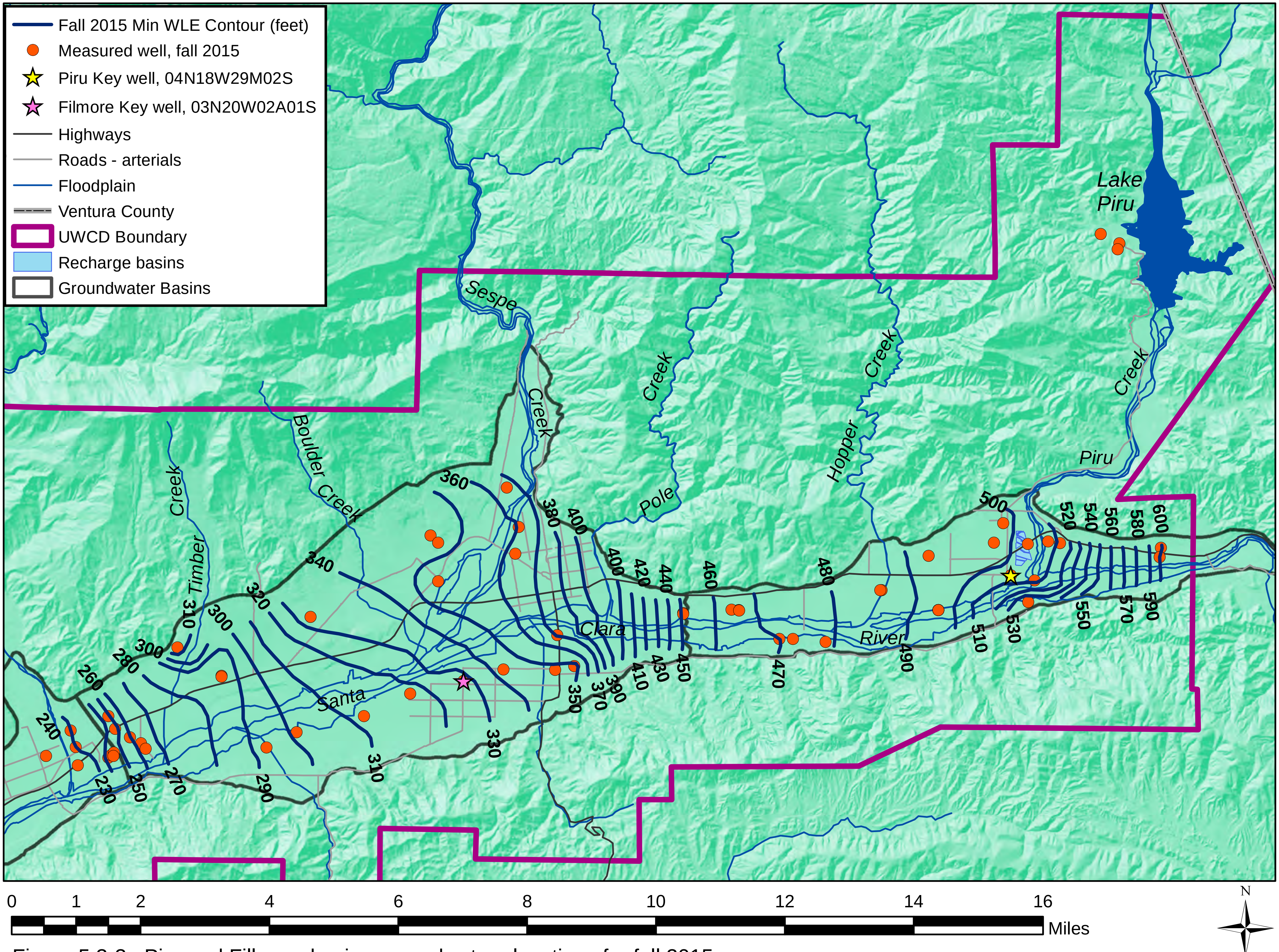

Figure 5.3-3. Piru and Fillmore basins groundwater elevations for fall 2015.

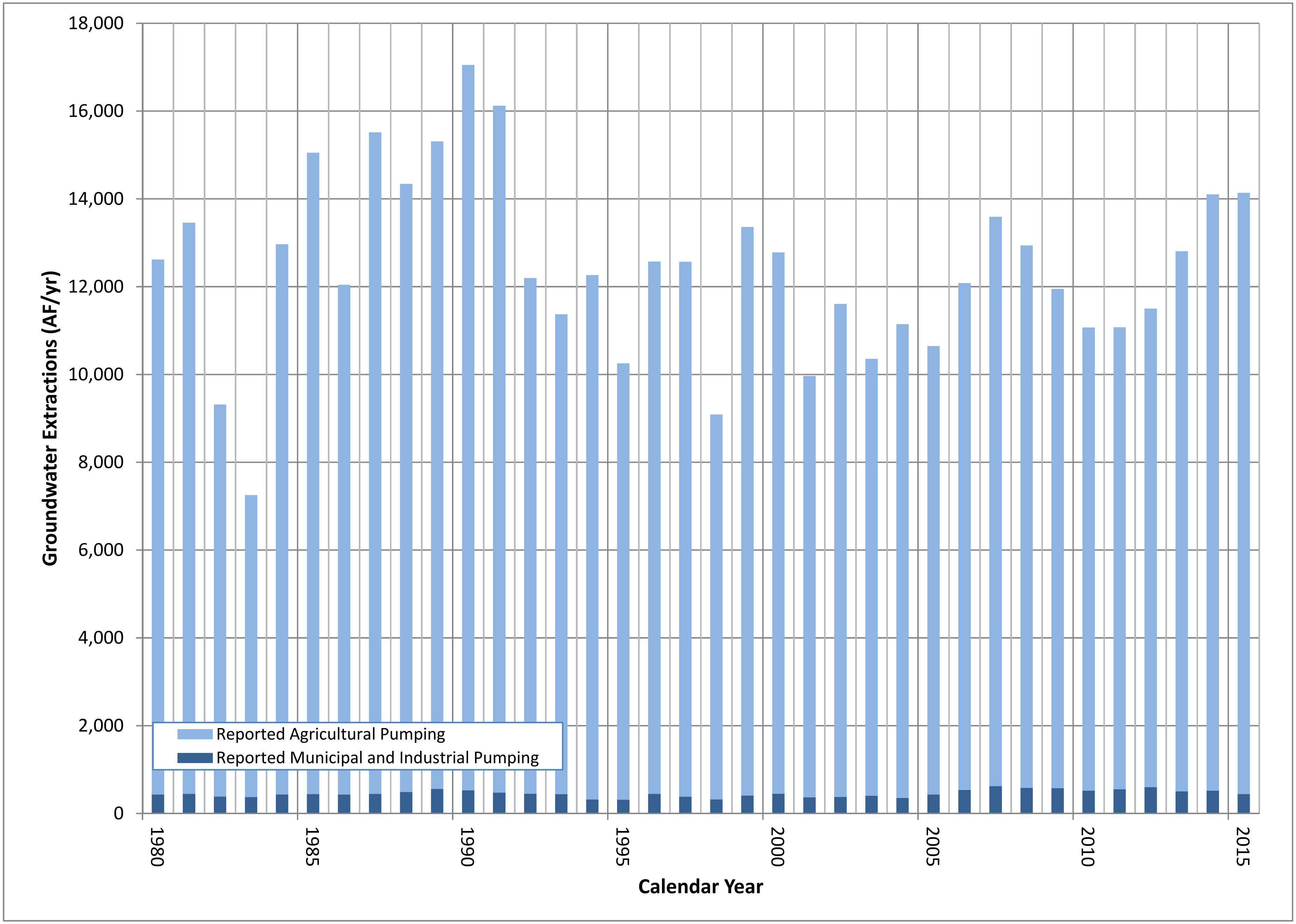

Figure 5.3-4. Historical annual groundwater extractions from Piru basin.

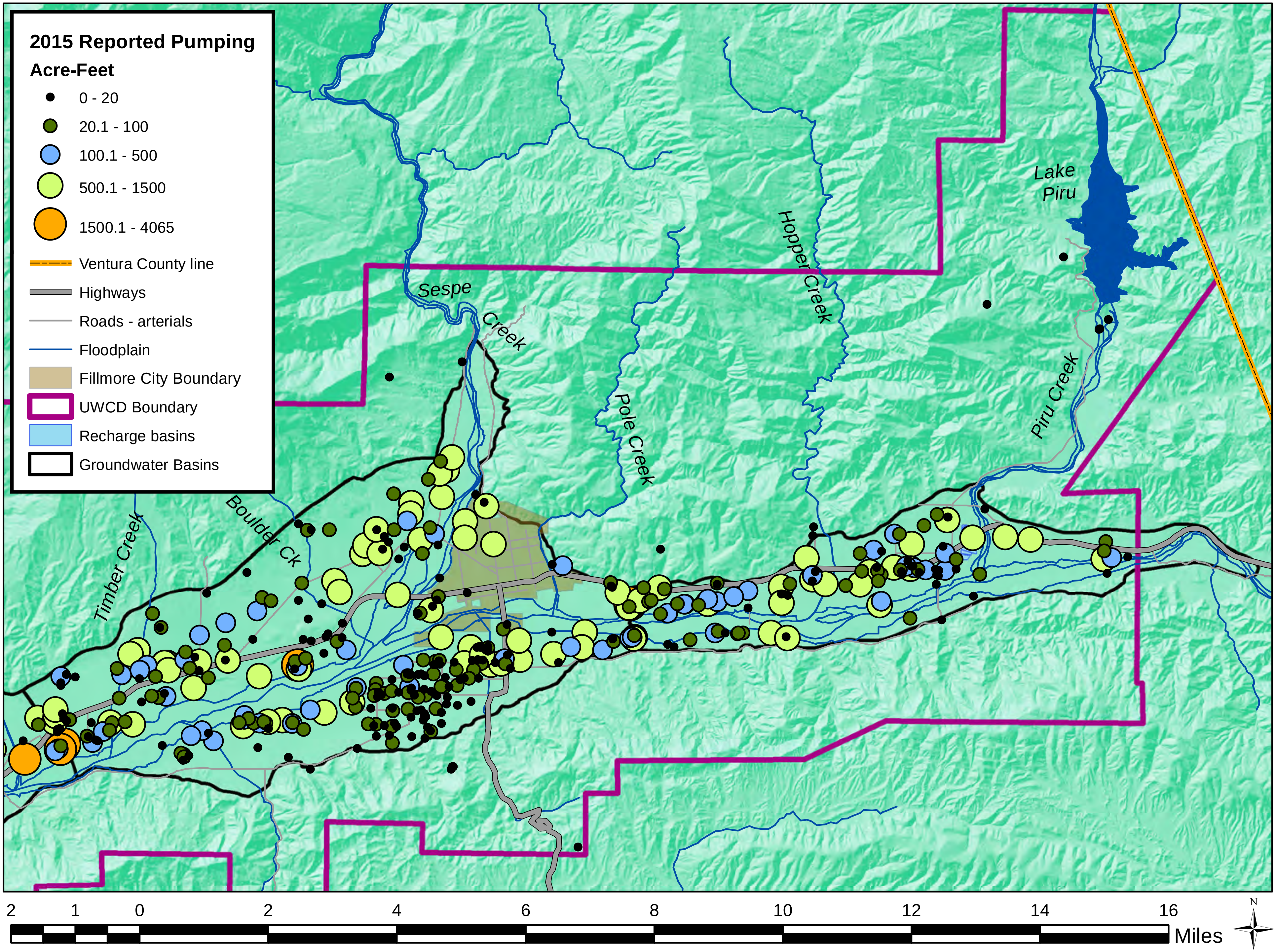

Figure 5.3-5. Reported calendar year pumping for 2015 in the Piru and Fillmore basins, and surrounding areas.

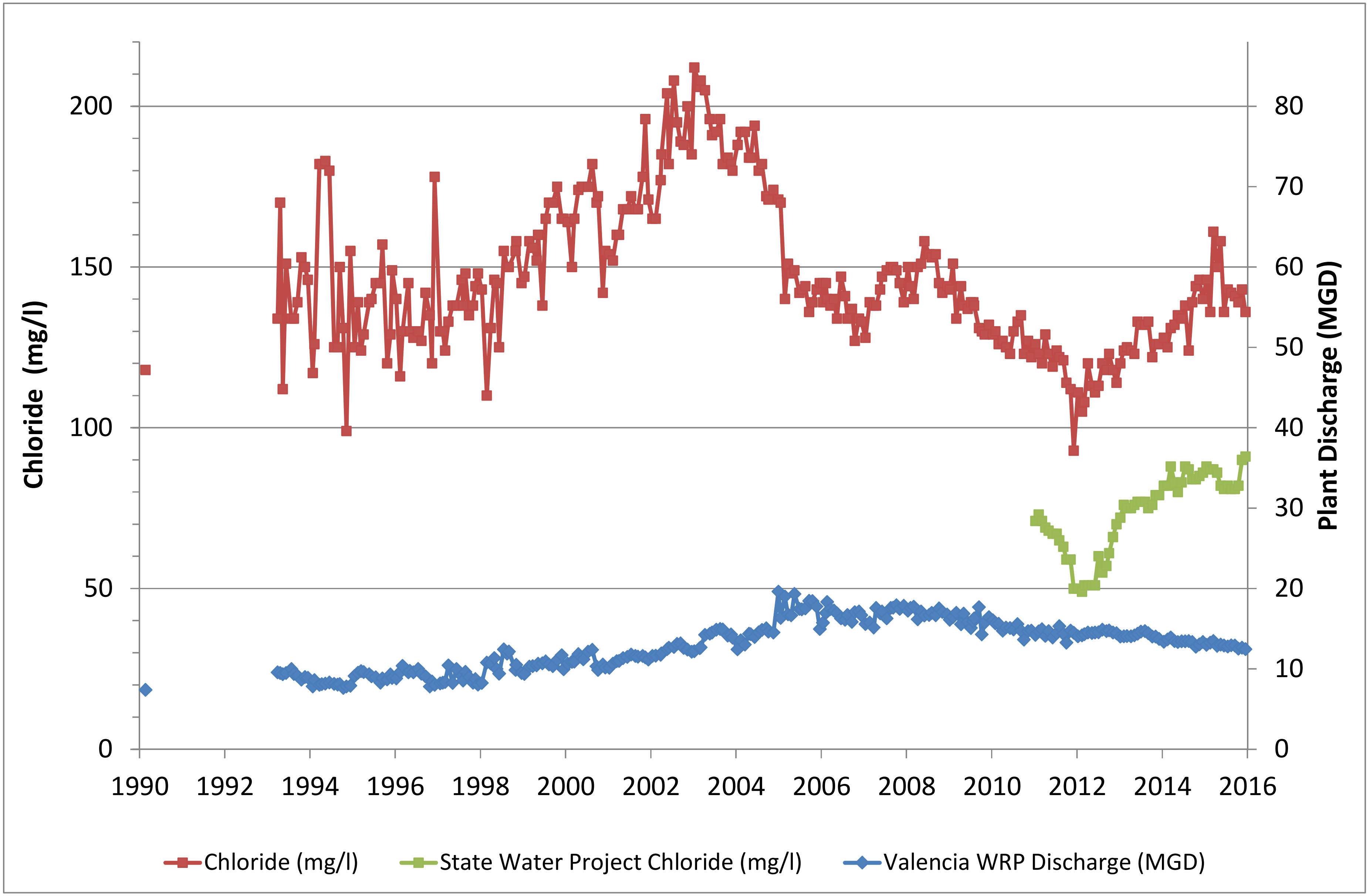

Figure 5.3-6. Historical chloride and discharge rates at Valencia WRP.

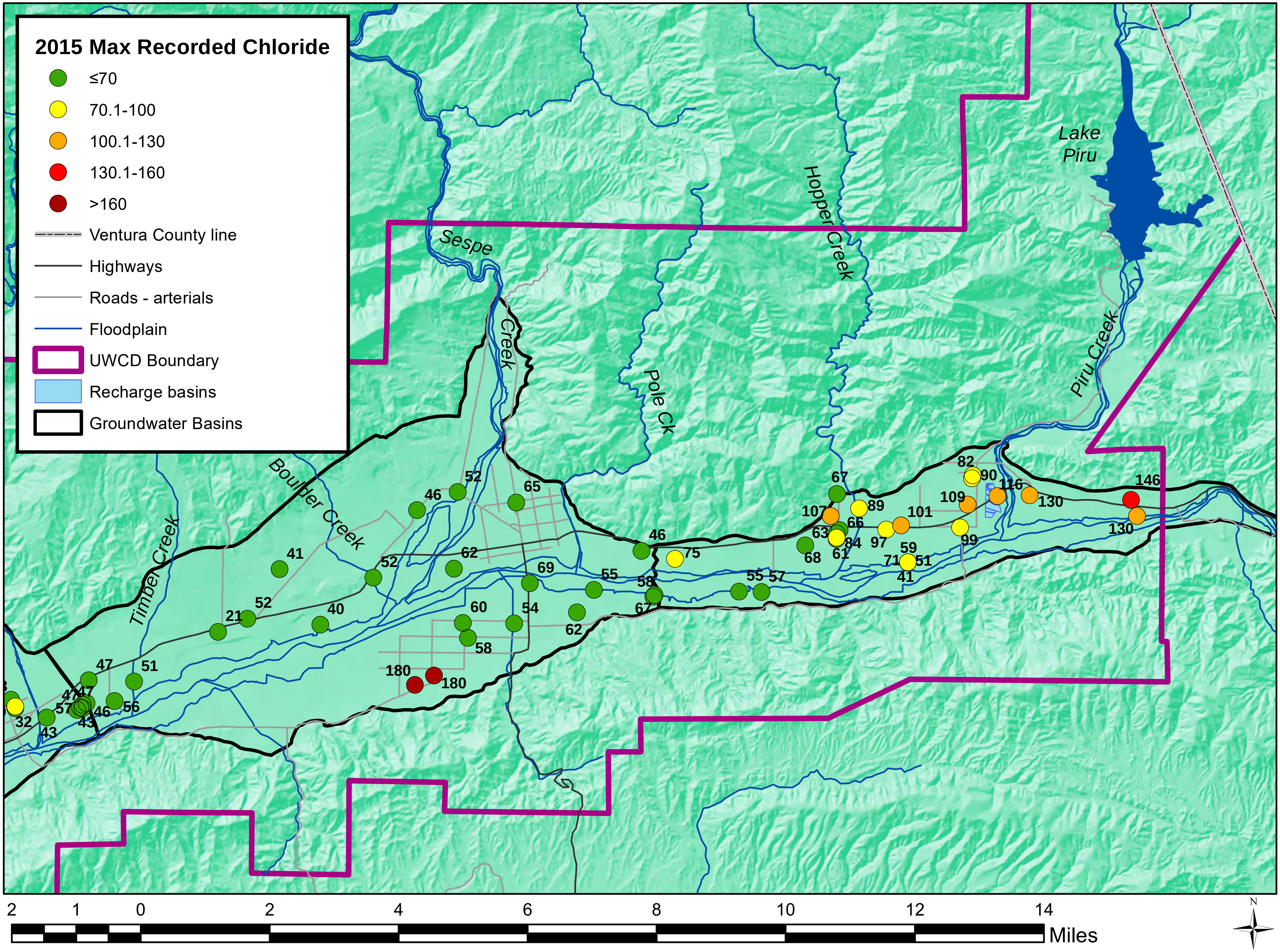

Figure 5.3-7. Maximum recorded chloride for 2015 in Piru and Fillmore basin, and surrounding areas.

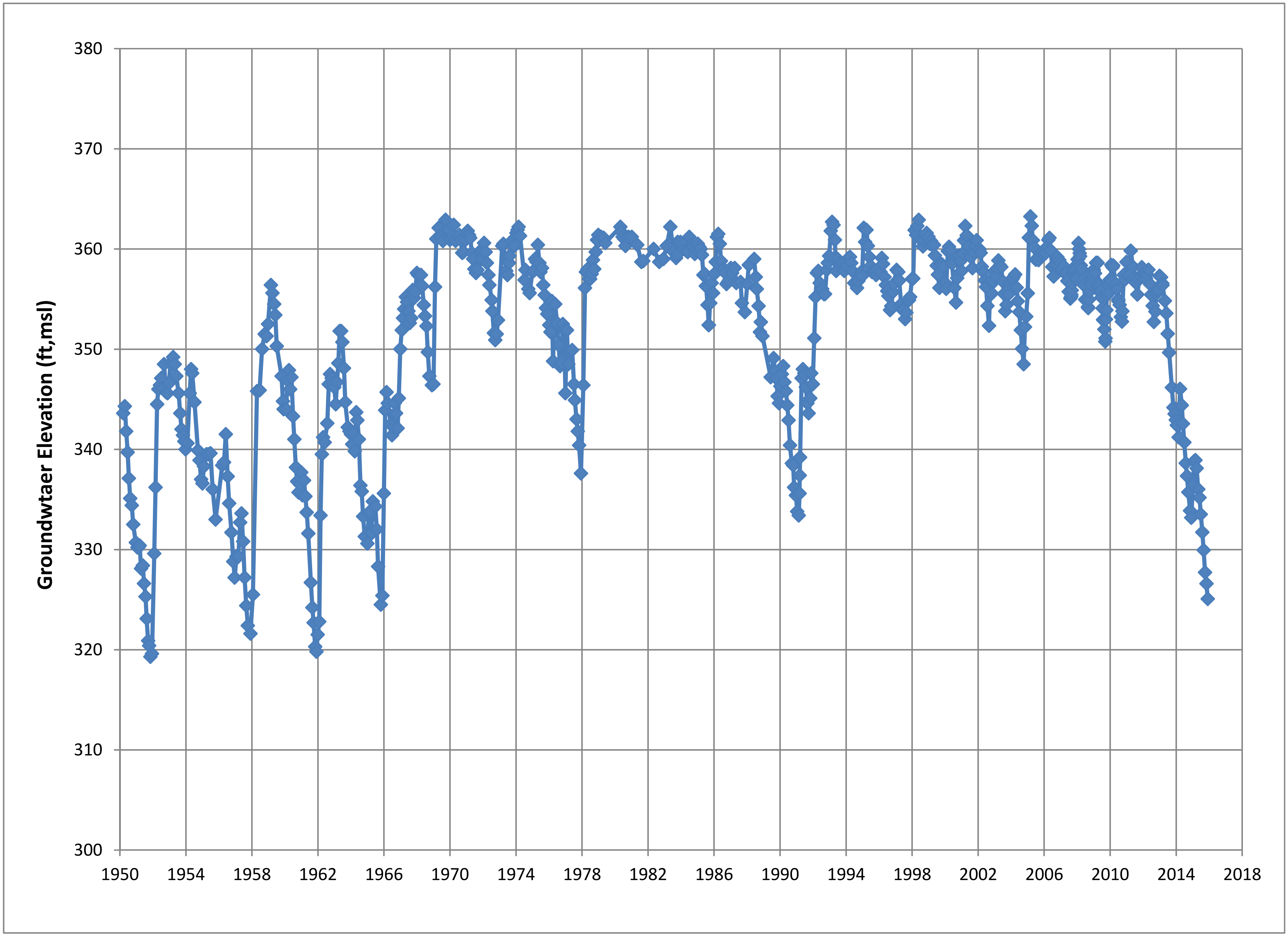

Figure 5.3-8. Historical groundwater elevations in Fillmore basin key well, Bardsdale area (well 03N20W02A01S).

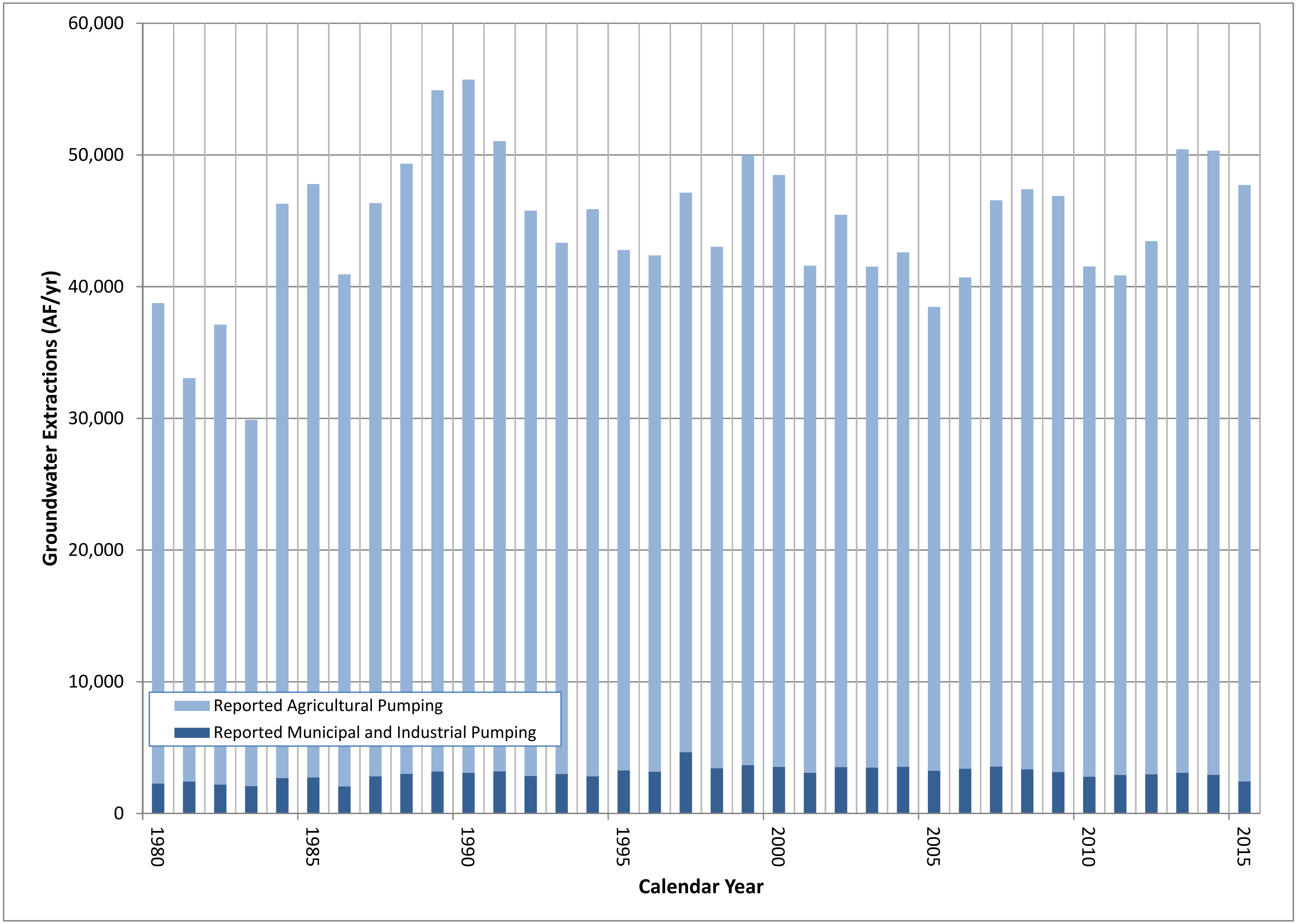

Figure 5.3-9. Historical annual groundwater extractions from Fillmore basin.

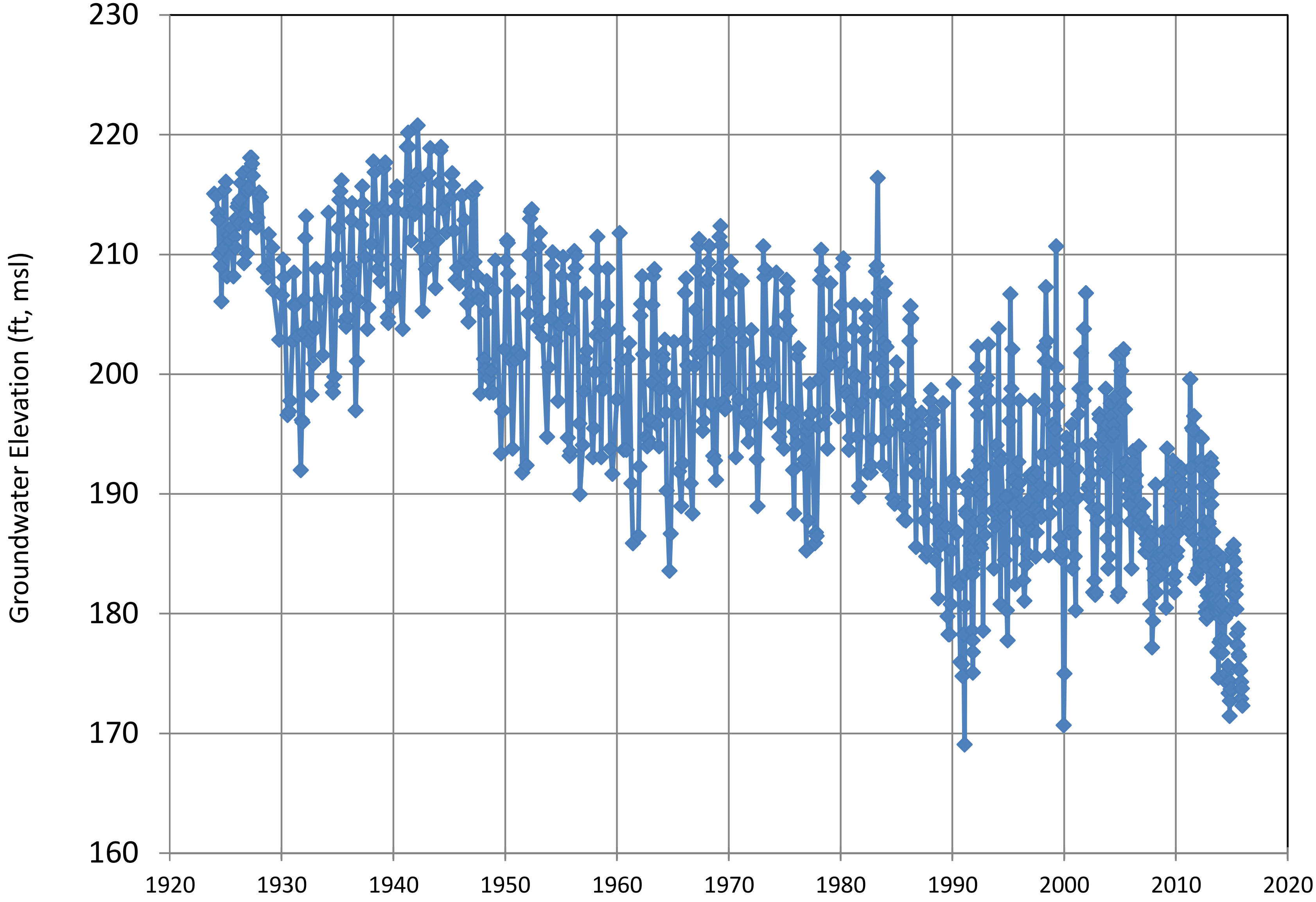

Figure 5.3-10. Historical groundwater elevations in Santa Paula basin key well, east-central basin (well 03N21W16K01S).

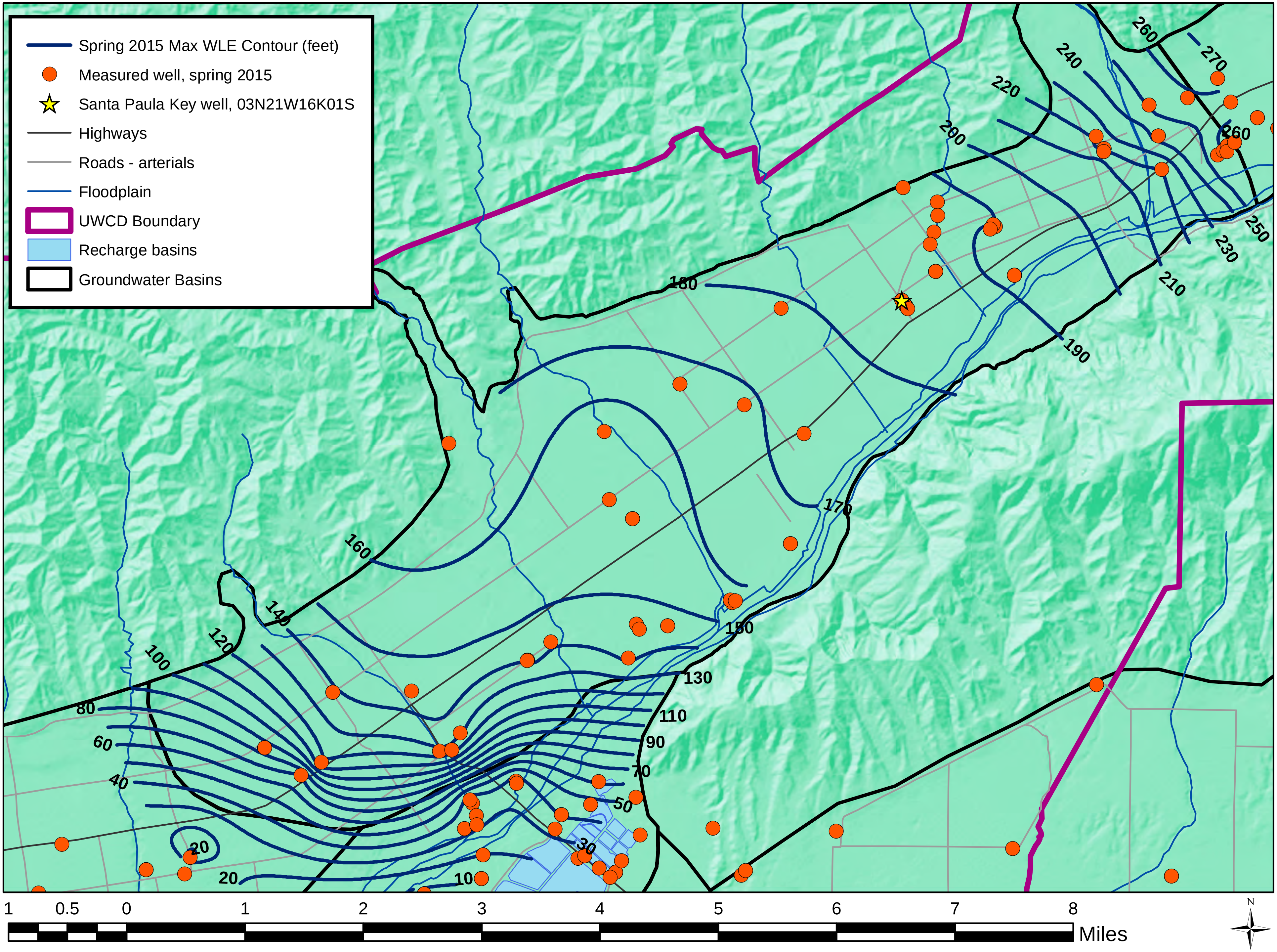

Figure 5.3-11. Groundwater elevations for spring 2015 in Santa Paula basin, and surrounding areas.

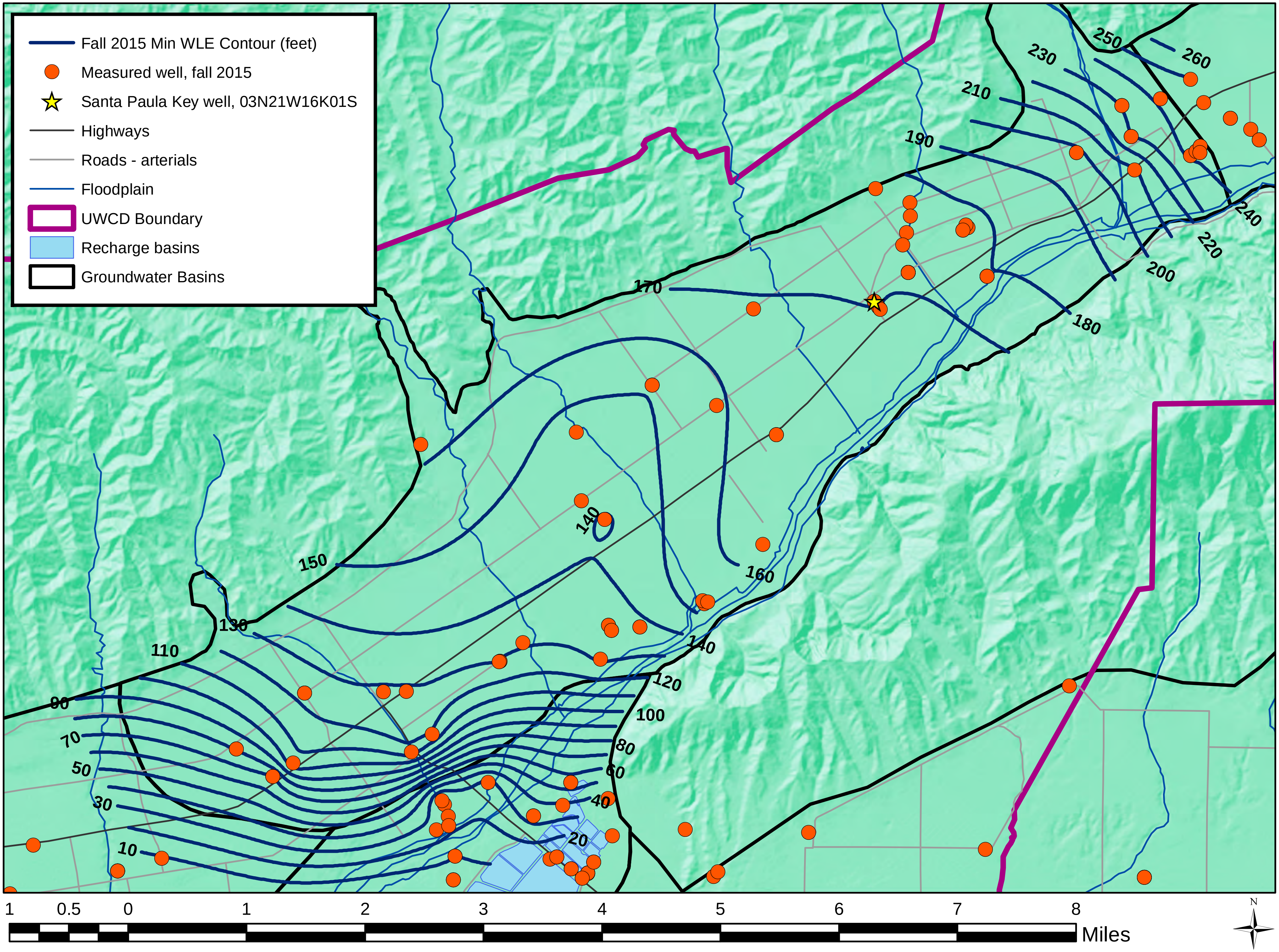

Figure 5.3-12. Groundwater elevations for fall 2015 in Santa Paula basin, and surrounding areas.

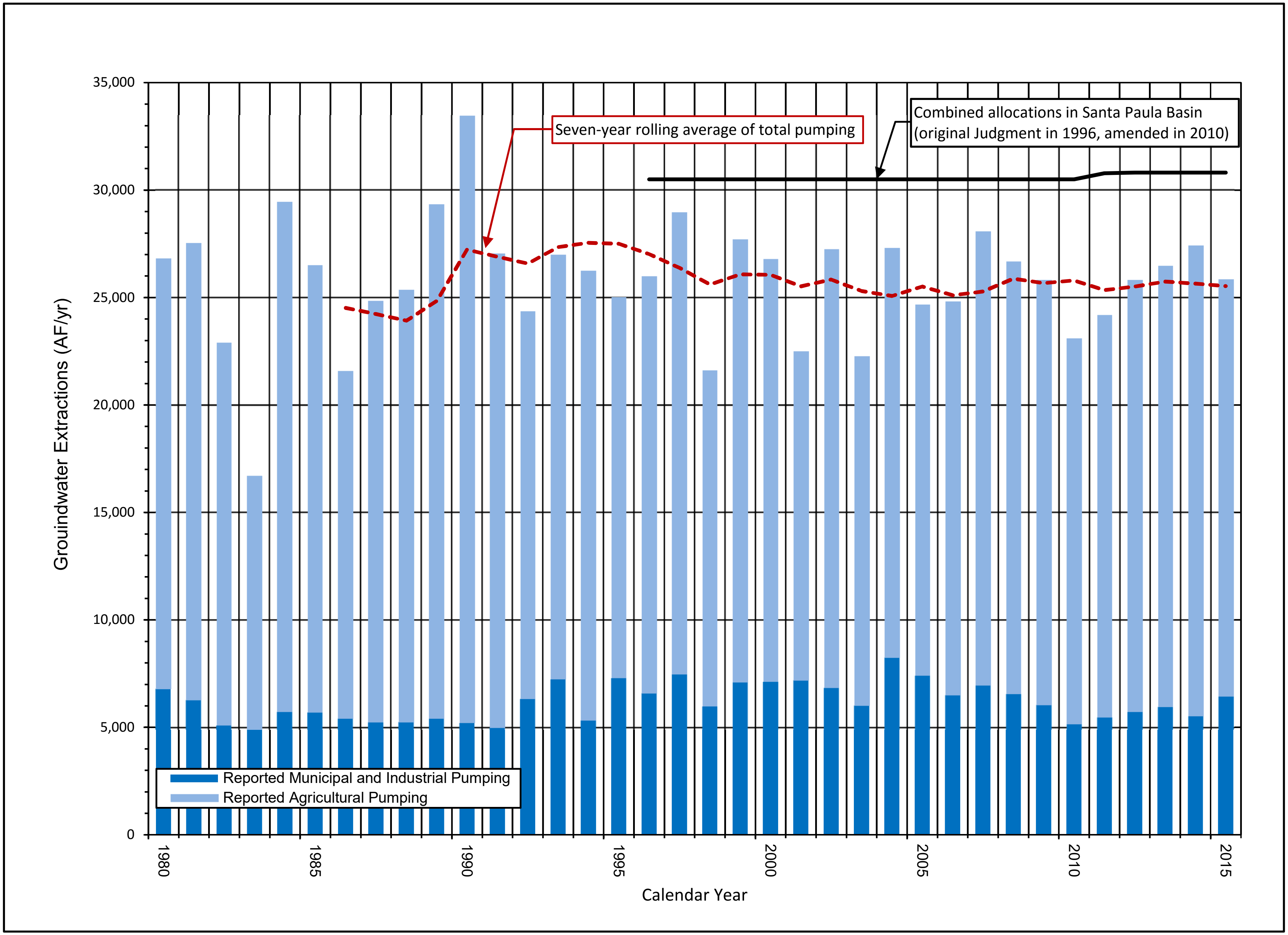

Figure 5.3-13. Historical annual groundwater extractions from Santa Paula basin.

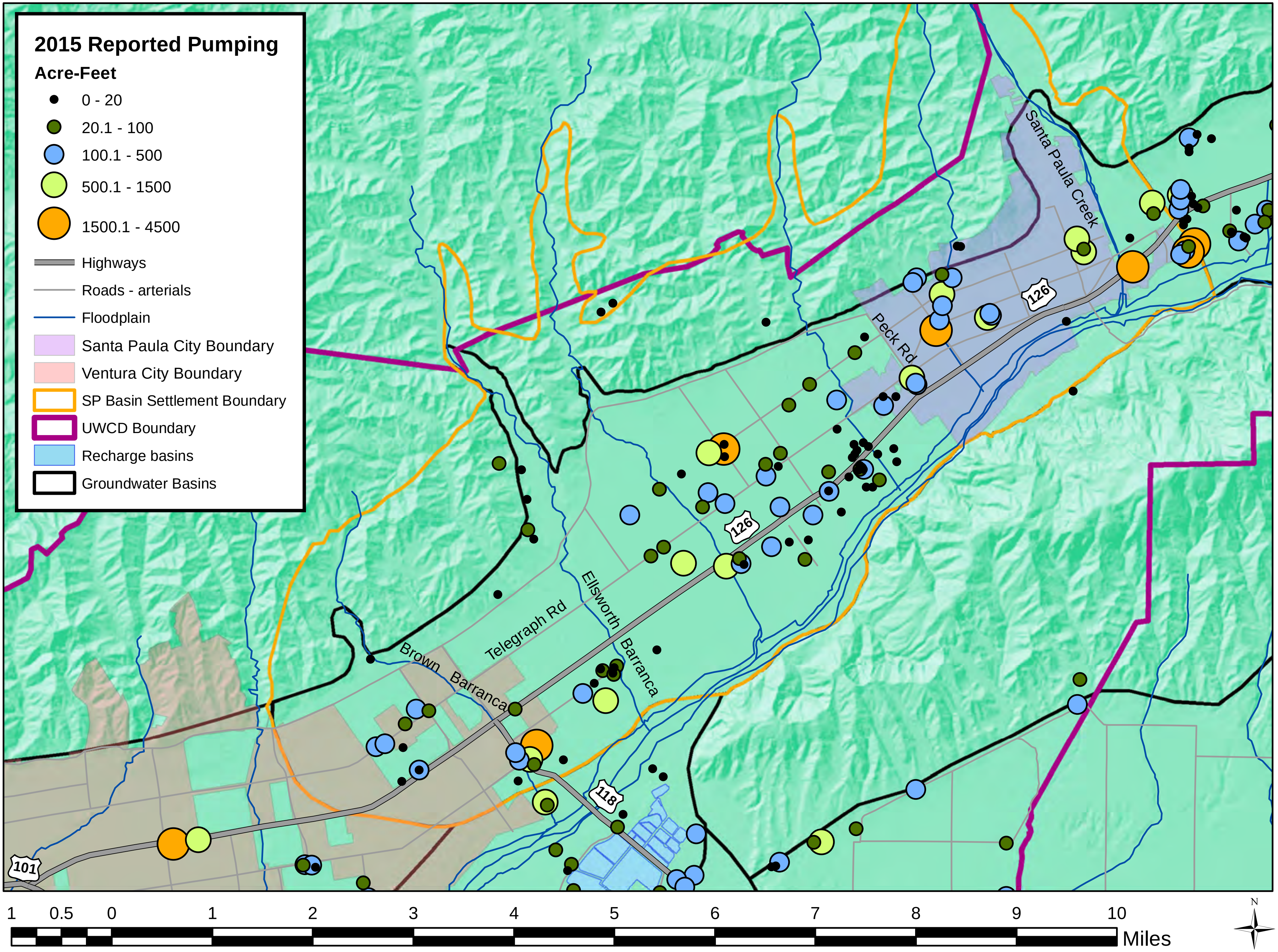

Figure 5.3-14. Reported calendar year pumping for 2015 in the Santa Paula basin, and surrounding areas.

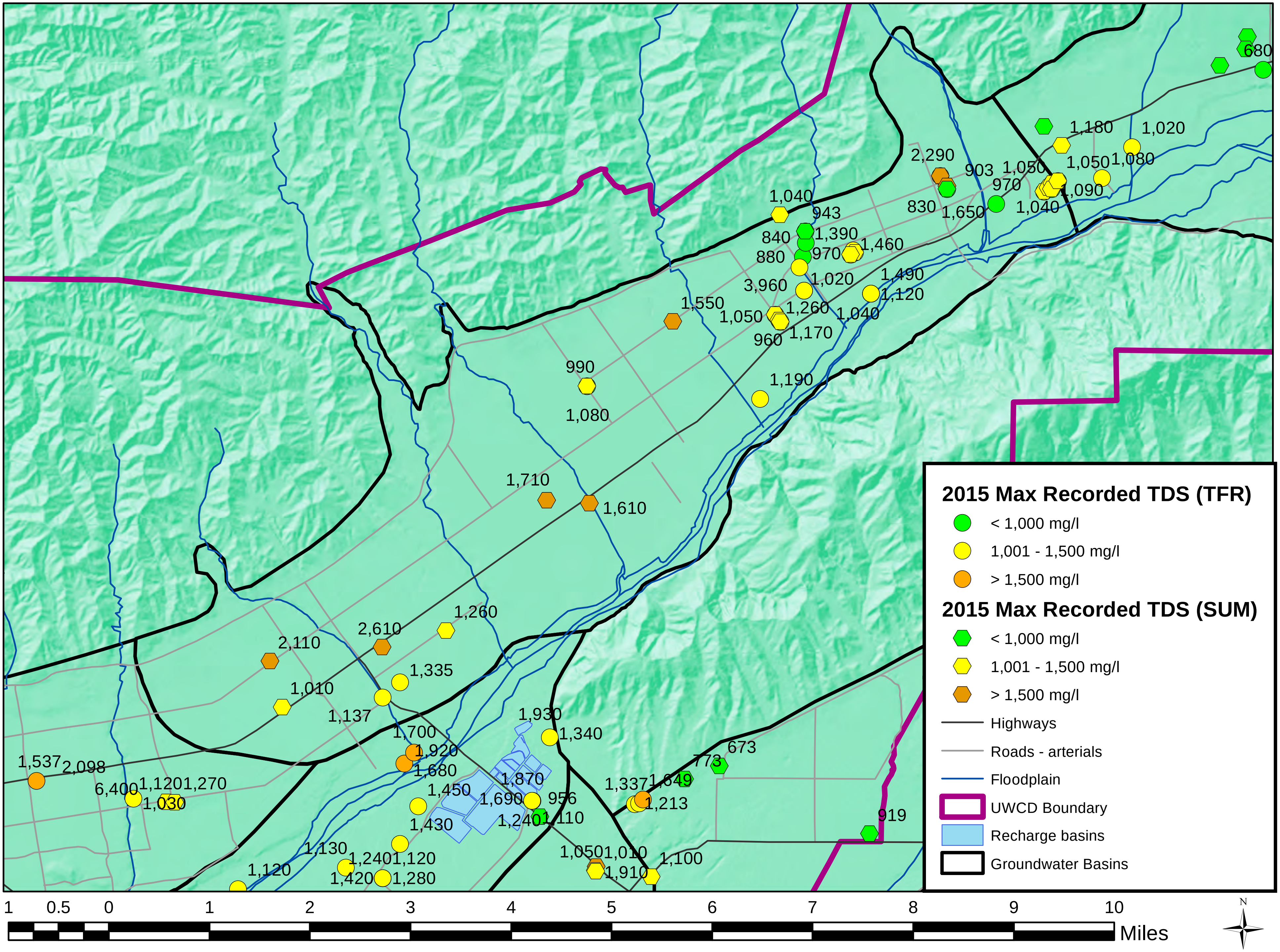

Figure 5.3-15. Maximum recorded TDS for 2015 in Santa Paula basin, and surrounding areas.

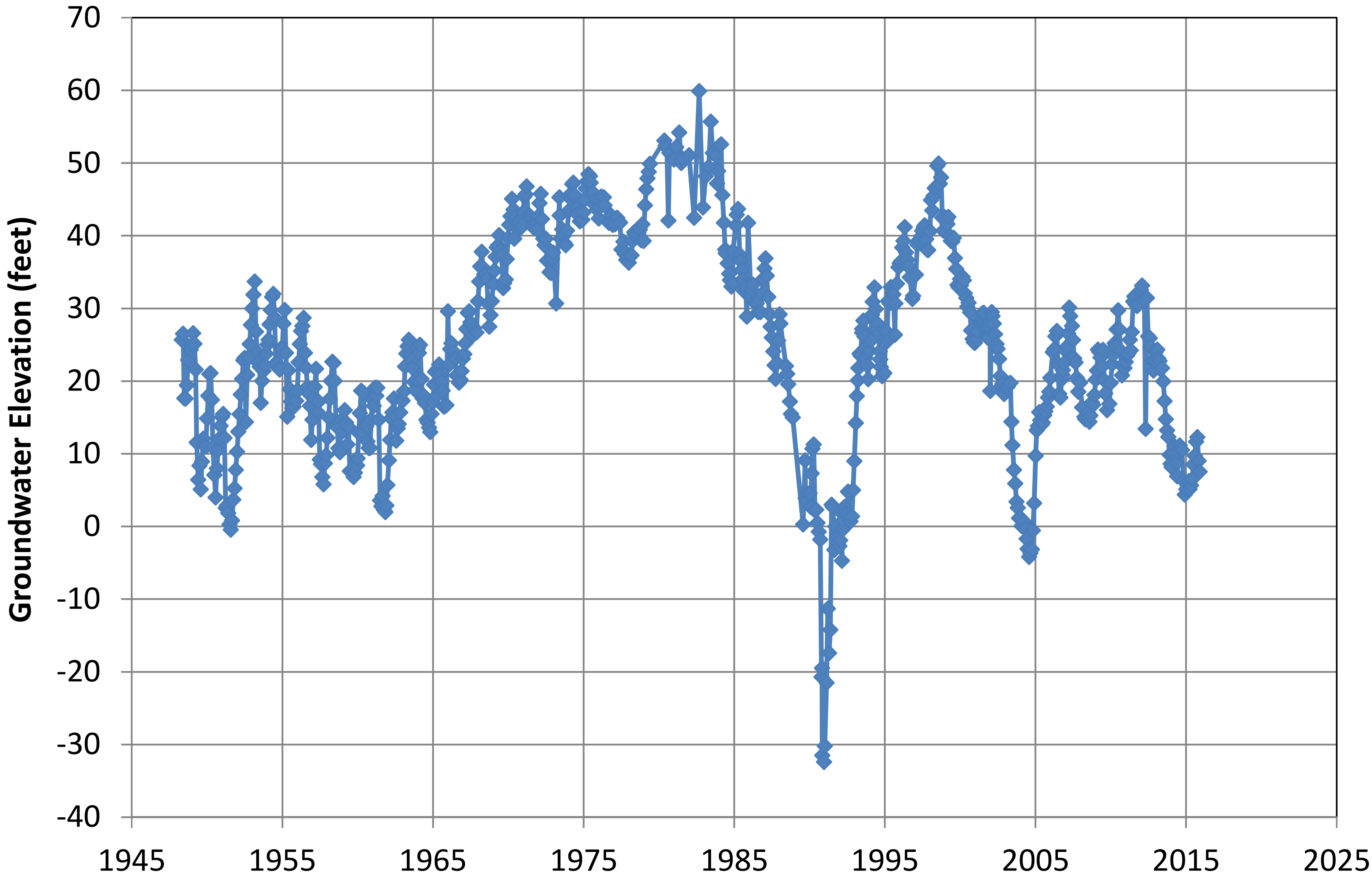

Figure 5.3-16. Historical groundwater elevations in Mound basin key well, eastern basin (well 02N22W09K04S).

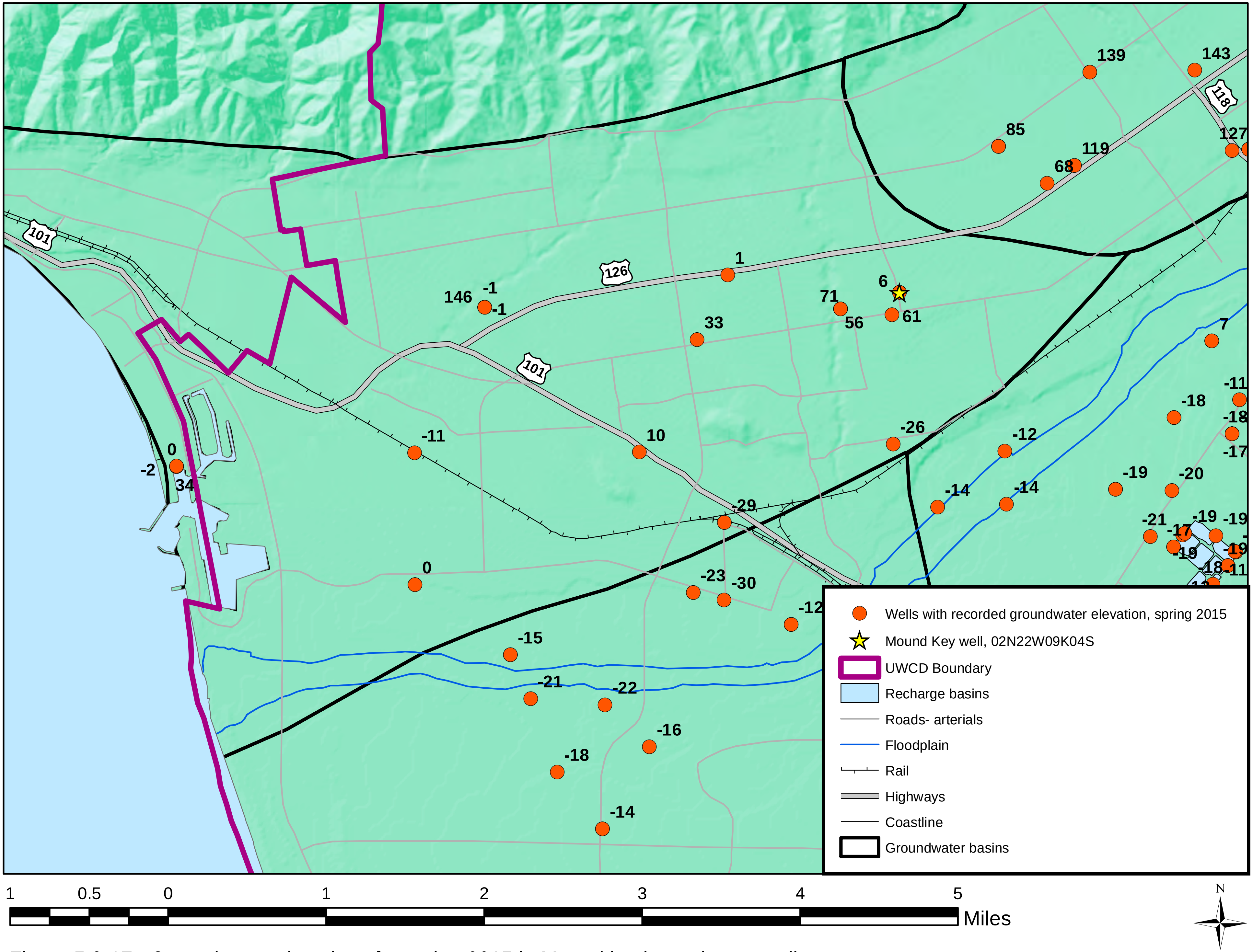

Figure 5.3-17. Groundwater elevations for spring 2015 in Mound basin, and surrounding areas.

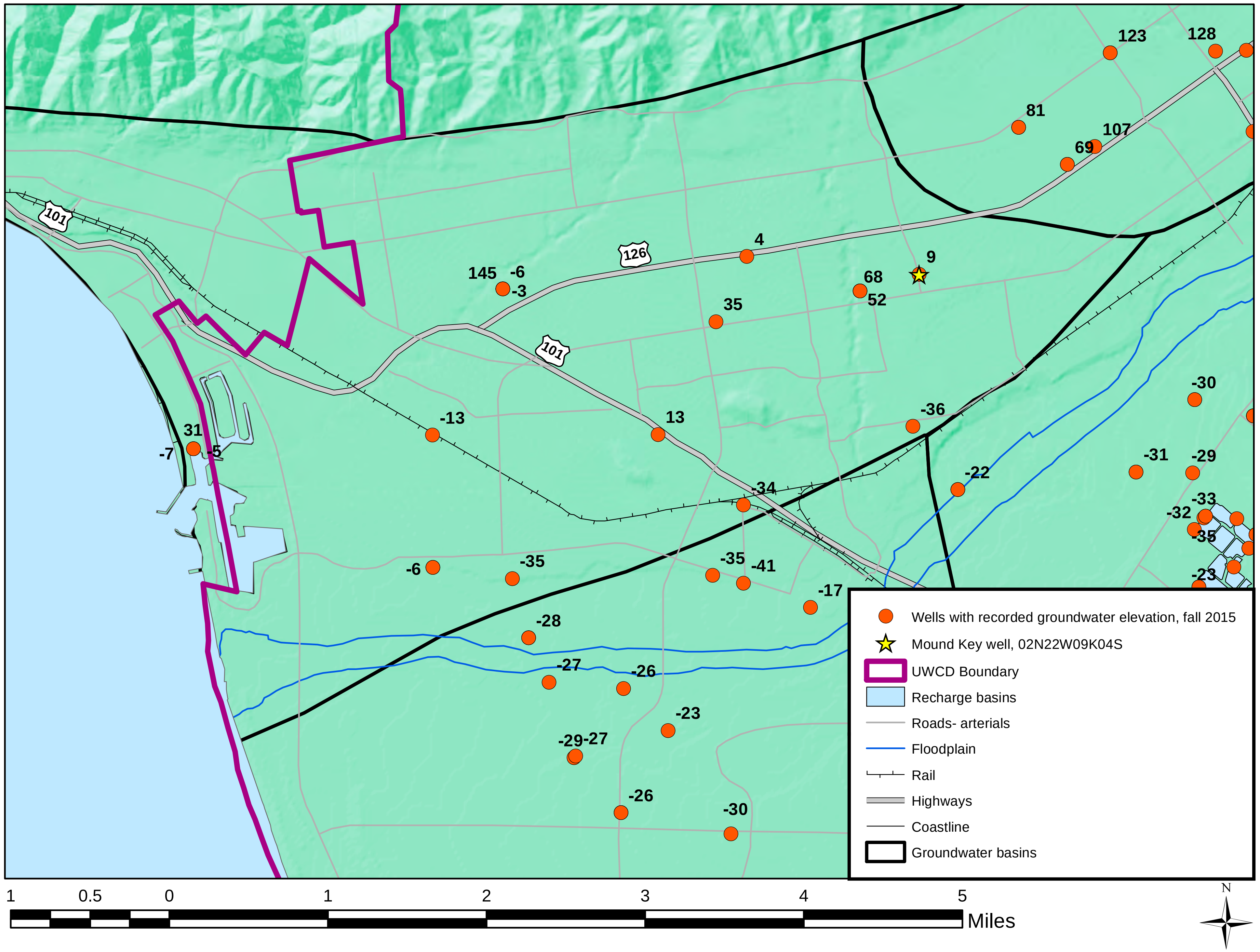

Figure 5.3-18. Groundwater elevations for fall 2015 in Mound basin, and surrounding areas.

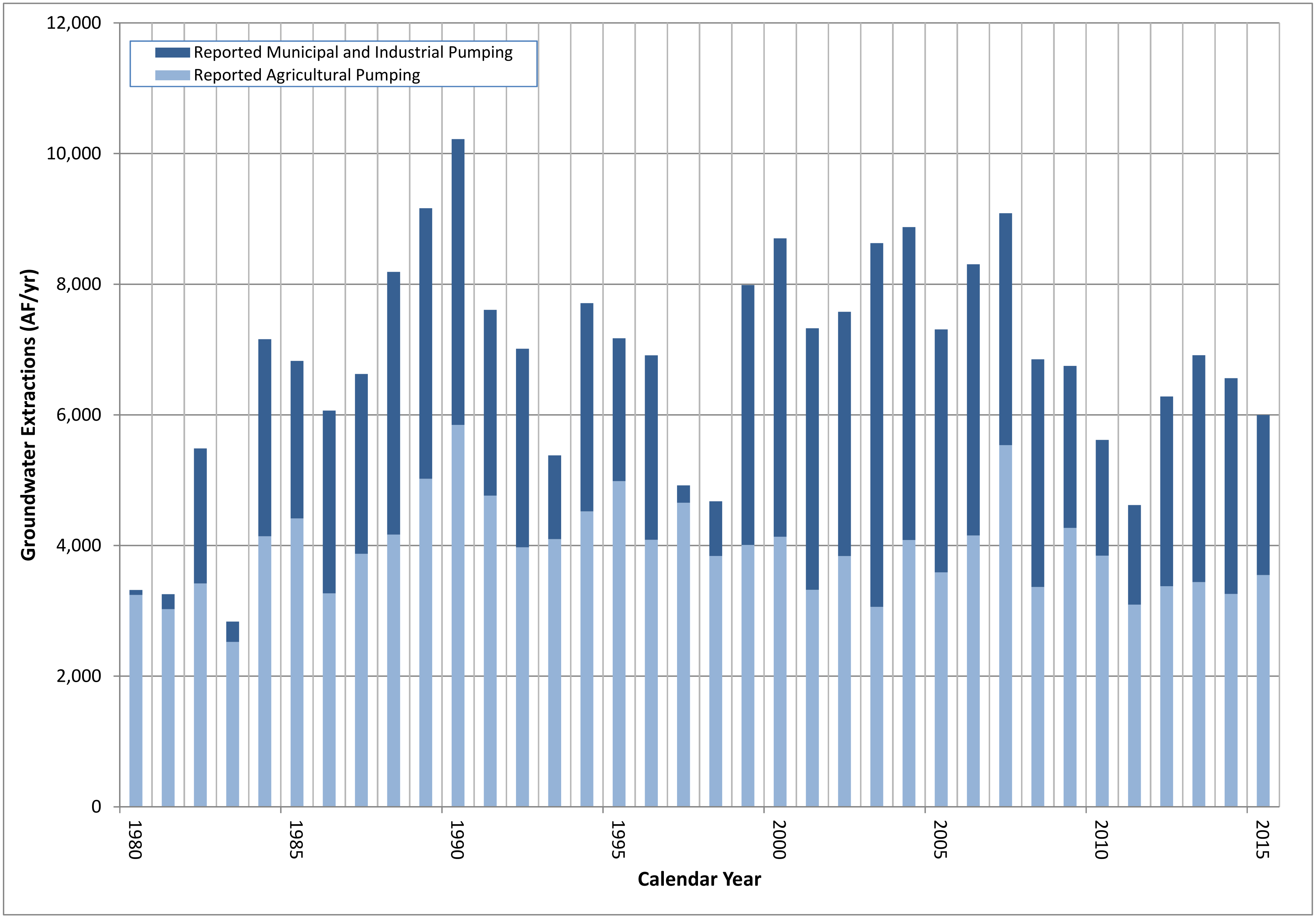

Figure 5.3-19. Historical annual groundwater extractions from Mound basin.

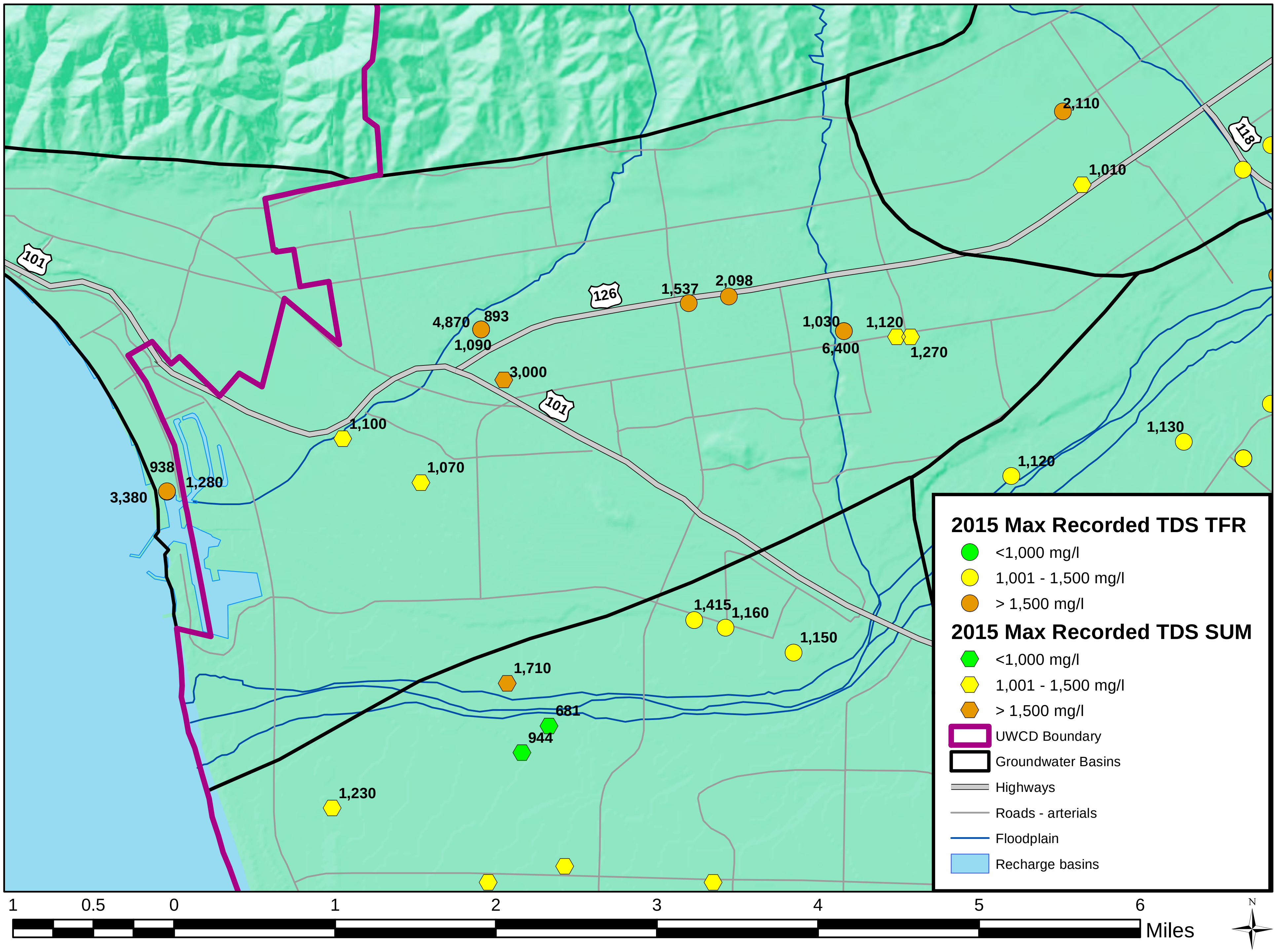

Figure 5.3-20. Maximum recorded TDS for 2015 in Mound basin, and surrounding areas.

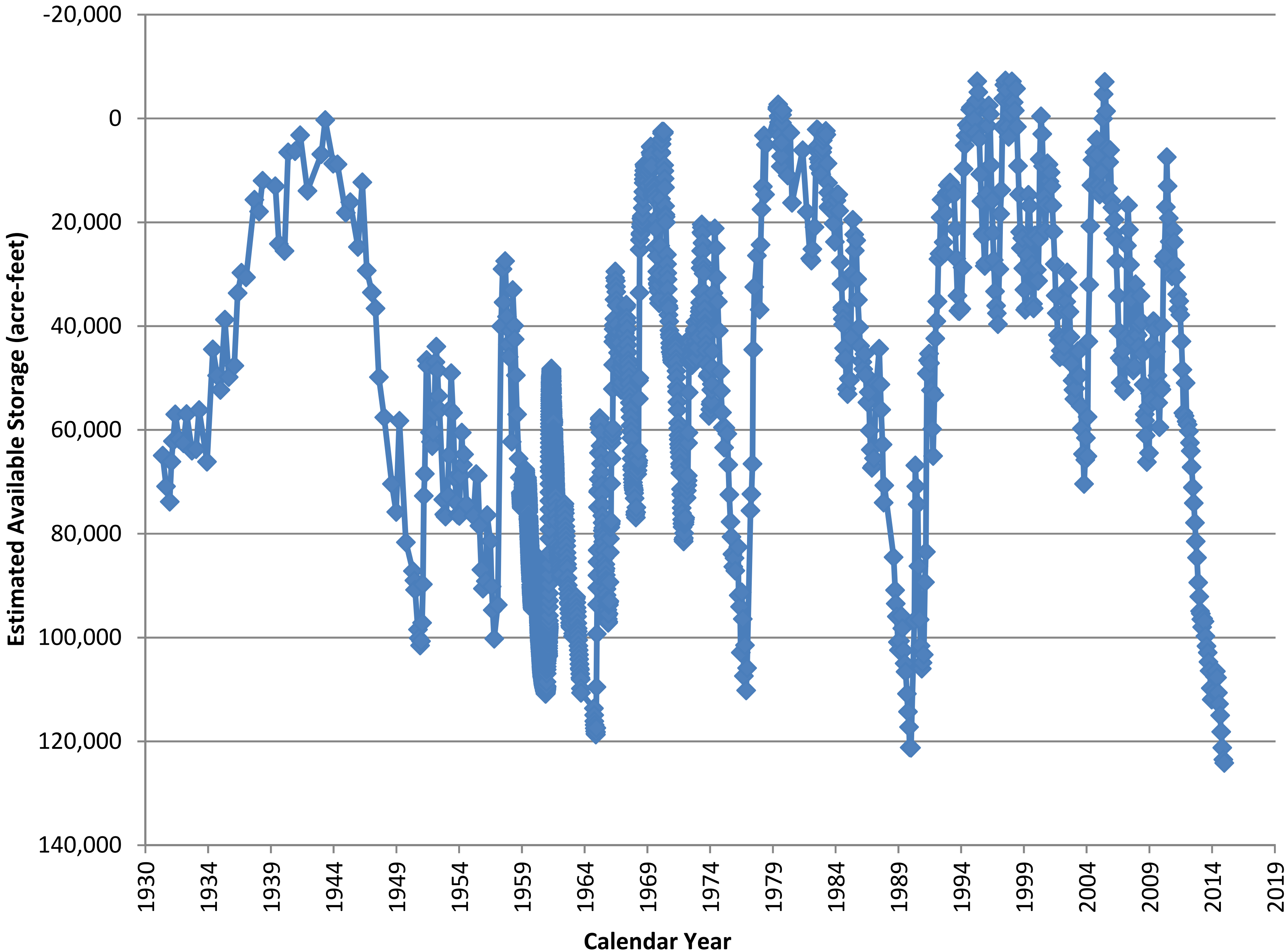

Figure 5.3-21. Historical estimates of available groundwater storage, Oxnard Forebay basin.

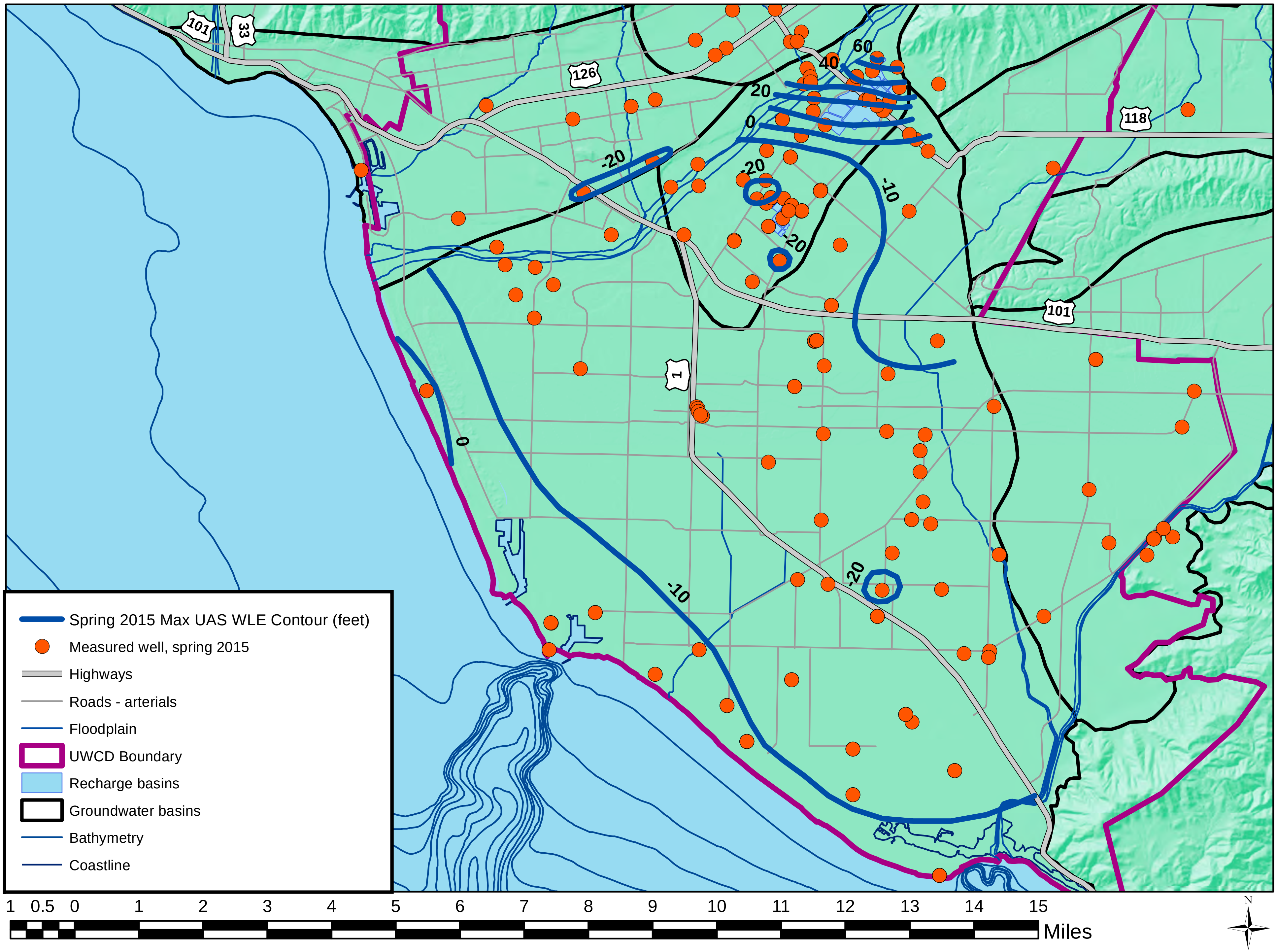

Figure 5.3-22. Upper Aquifer System groundwater elevations for spring 2015 in Oxnard Forebay and Oxnard Plain, and surrounding areas.

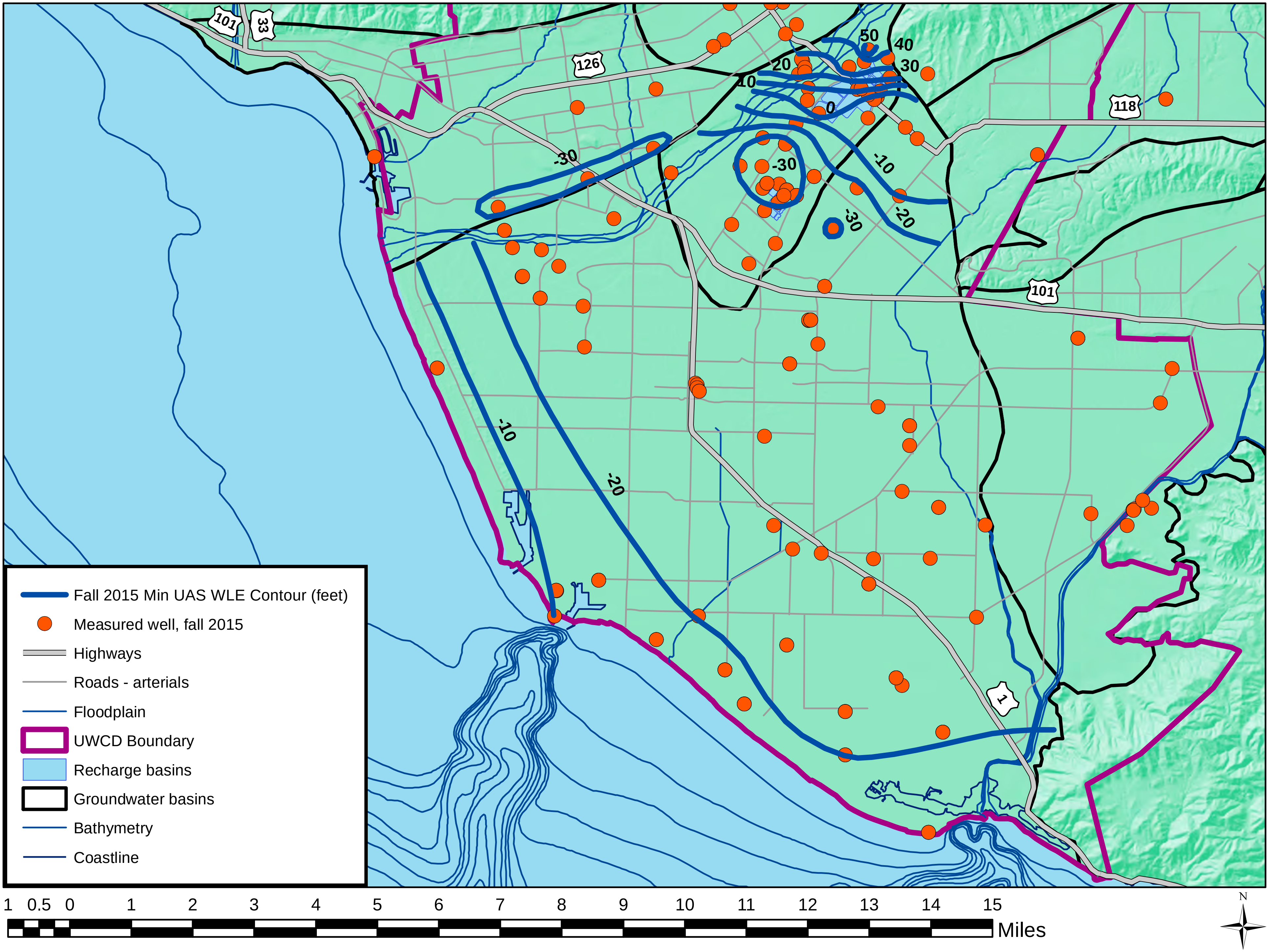

Figure 5.3-23. Upper Aquifer System groundwater elevations for fall 2015 in Oxnard Forebay and Oxnard Plain, and surrounding areas.

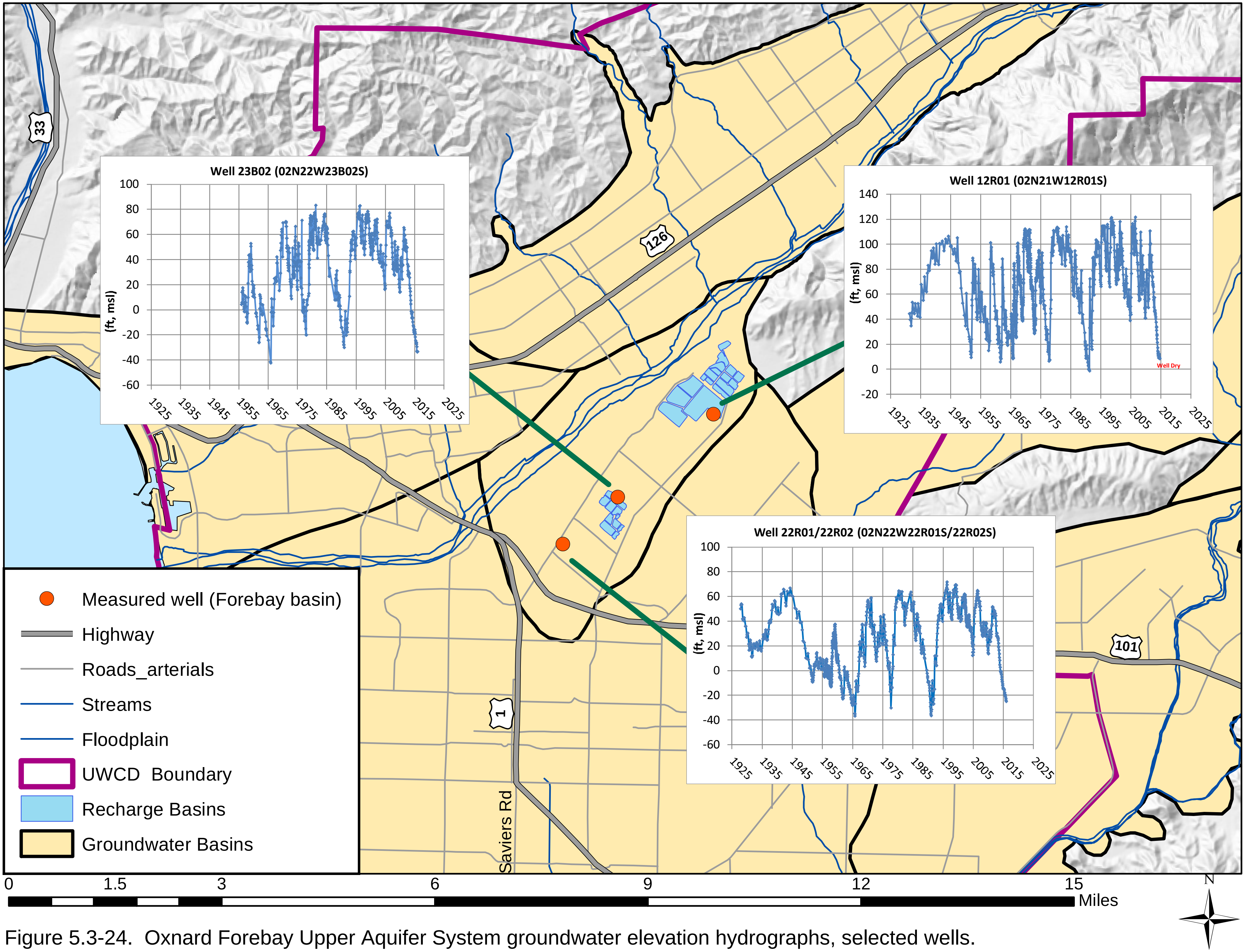

Figure 5.3-24. Oxnard Forebay Upper Aquifer System groundwater elevation hydrographs, selected wells.

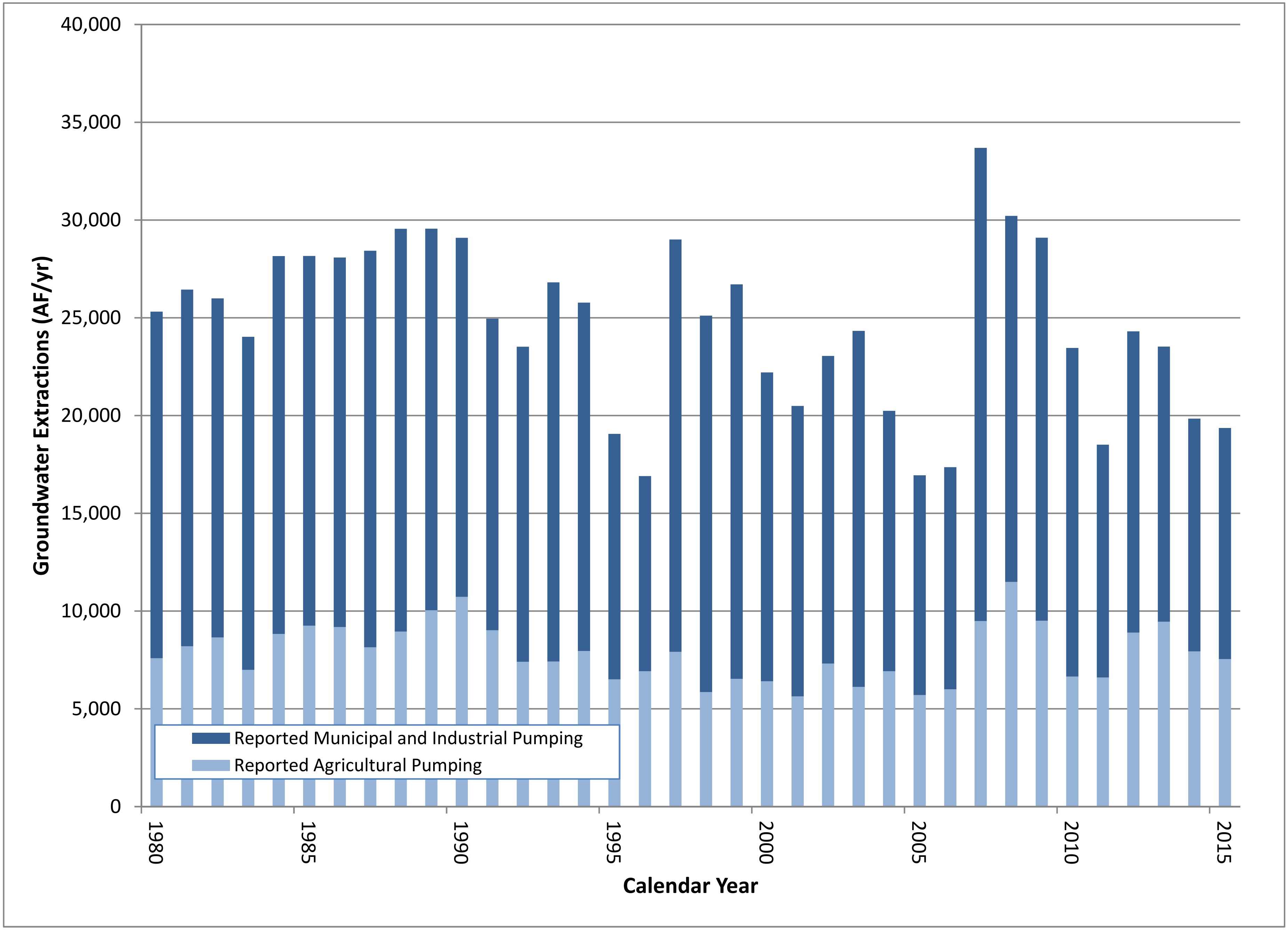

Figure 5.3-25. Historical annual groundwater extractions from Oxnard Forebay basin.

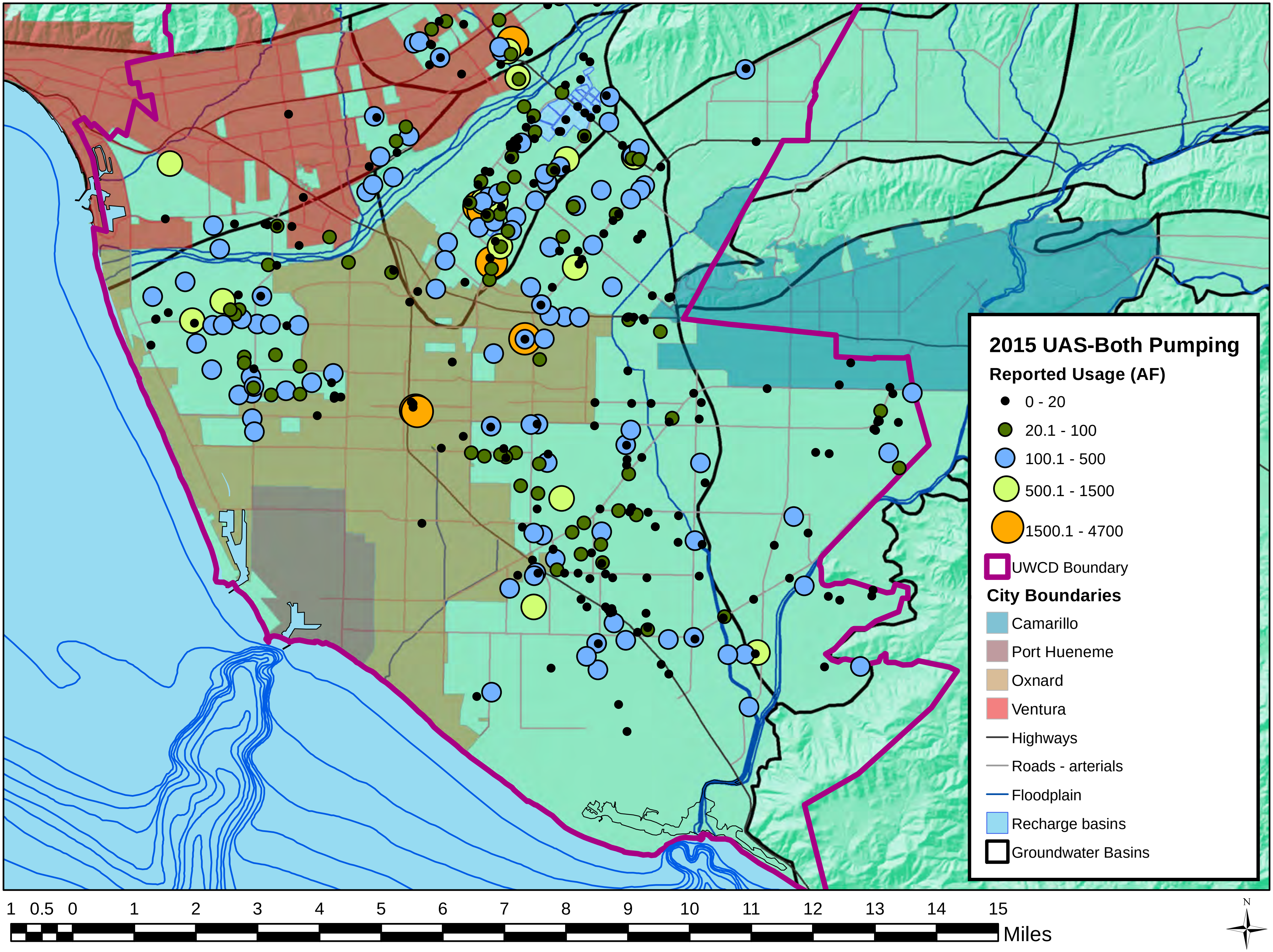

Figure 5.3-26. Reported calendar year pumping for 2015 in Upper Aquifer System wells, Oxnard coastal plain.

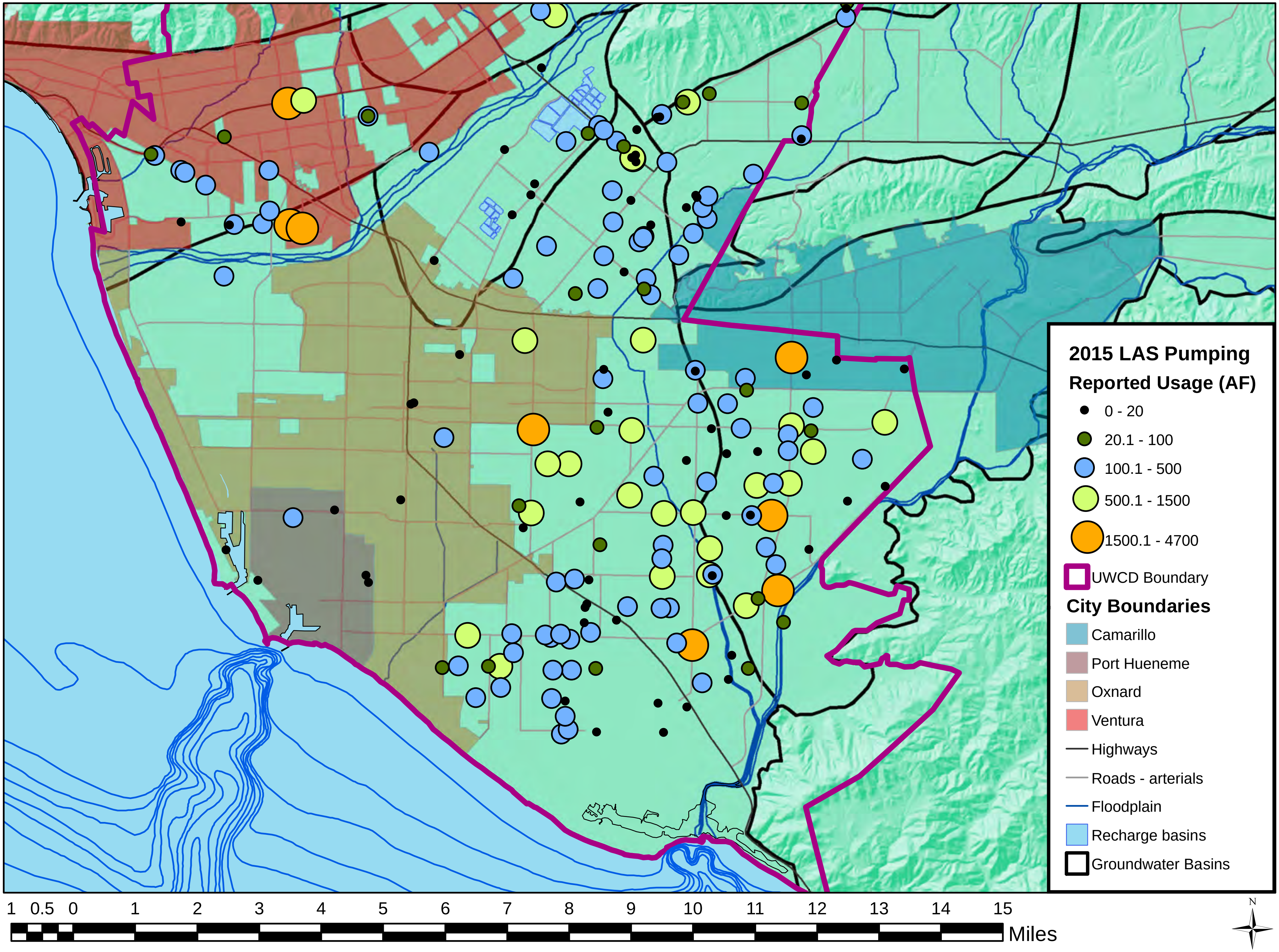

Figure 5.3-27. Reported calendar year pumping for 2015 in Lower Aquifer System wells, Oxnard coastal plain.

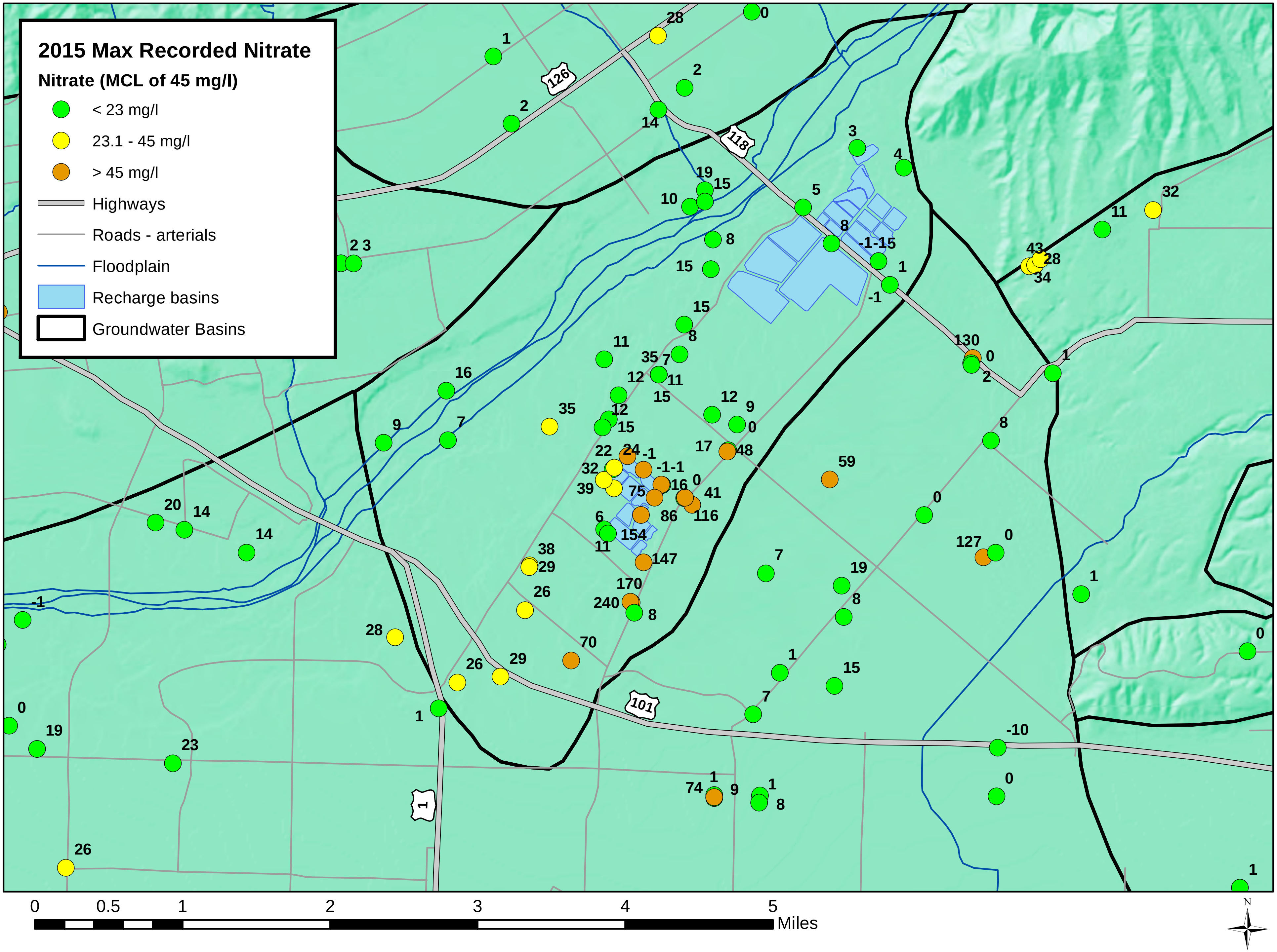

Figure 5.3-28. Maximum recorded nitrate (NO3) for 2015 in Oxnard Forebay and Oxnard Plain basins, and surrounding areas.

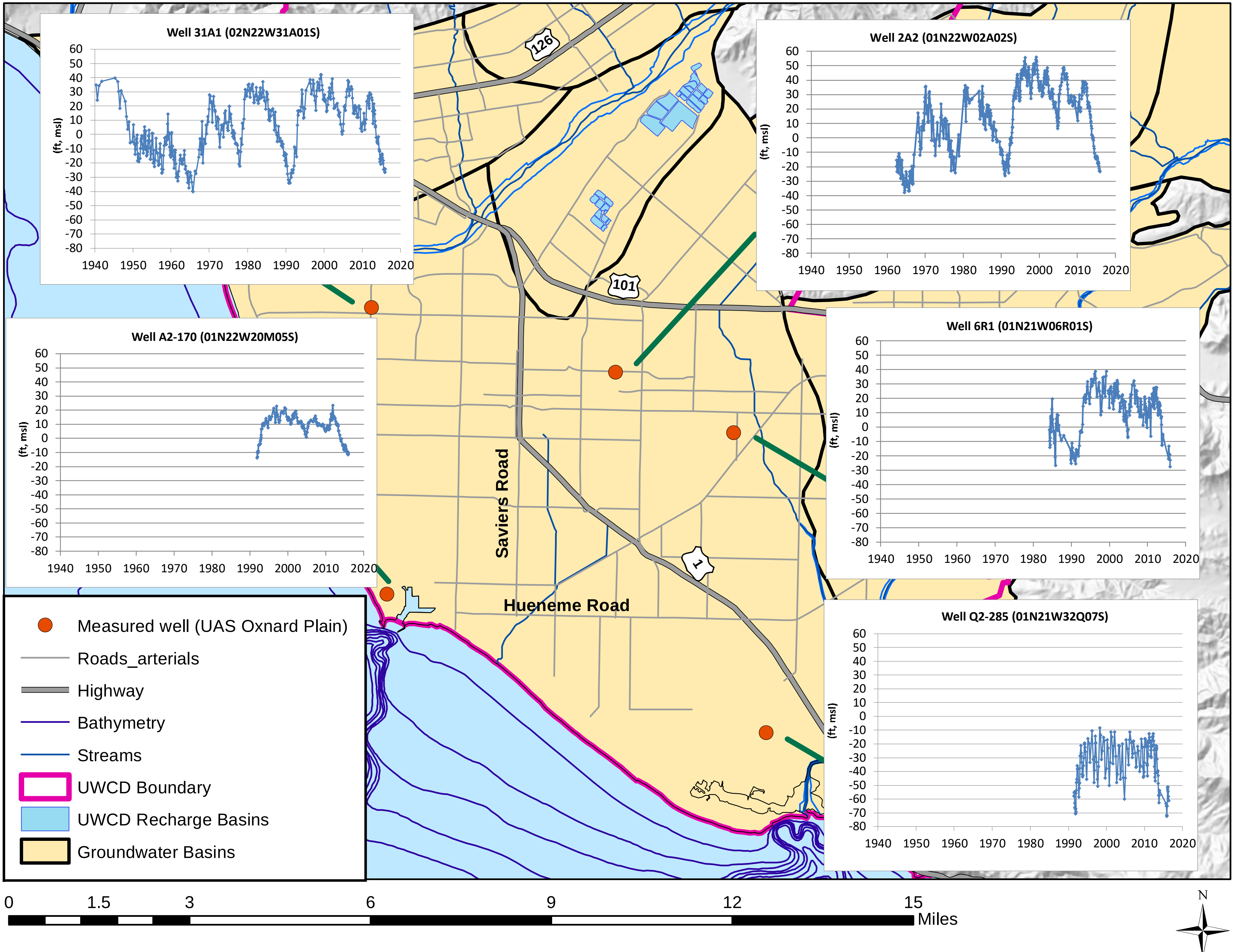

Figure 5.3-29. Oxnard Plain Upper Aquifer System groundwater elevation hydrographs, selected wells.

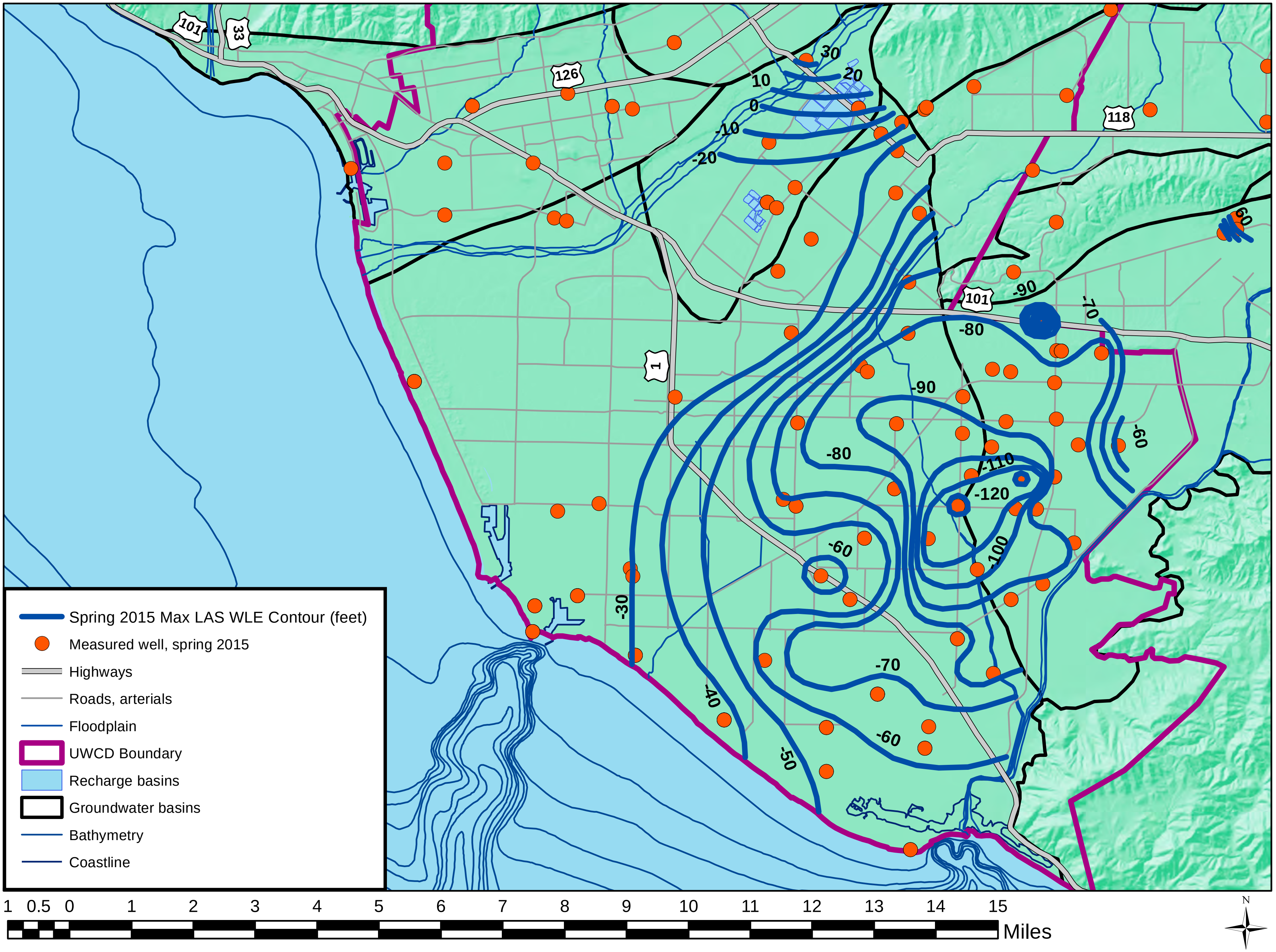

Figure 5.3-30. Oxnard Forebay, Oxnard Plain and Pleasant Valley Lower Aquifer System groundwater elevations for spring 2015.

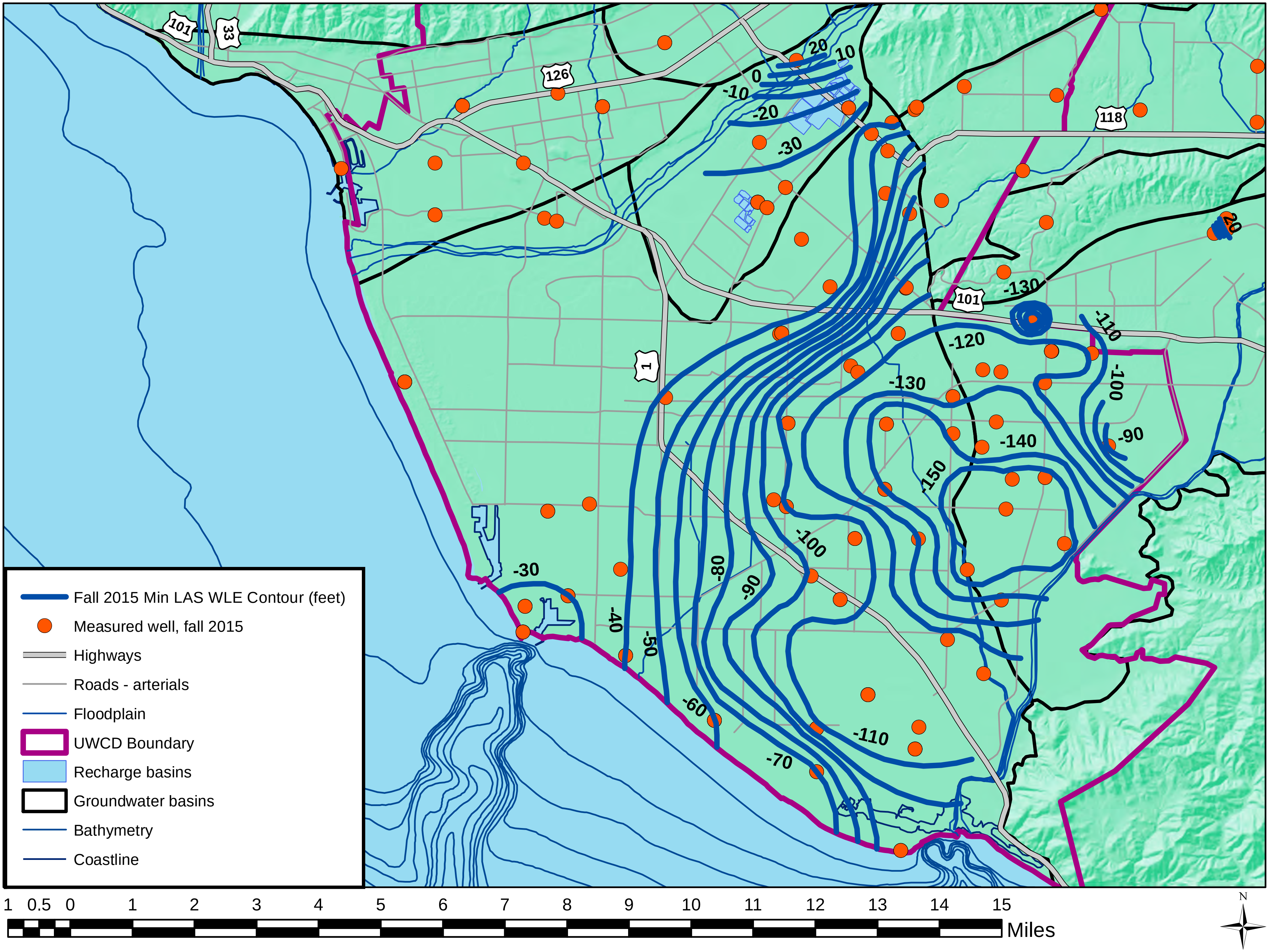

Figure 5.3-31. Oxnard Forebay, Oxnard Plain and Pleasant Valley Lower Aquifer System groundwater elevations for fall 2015.

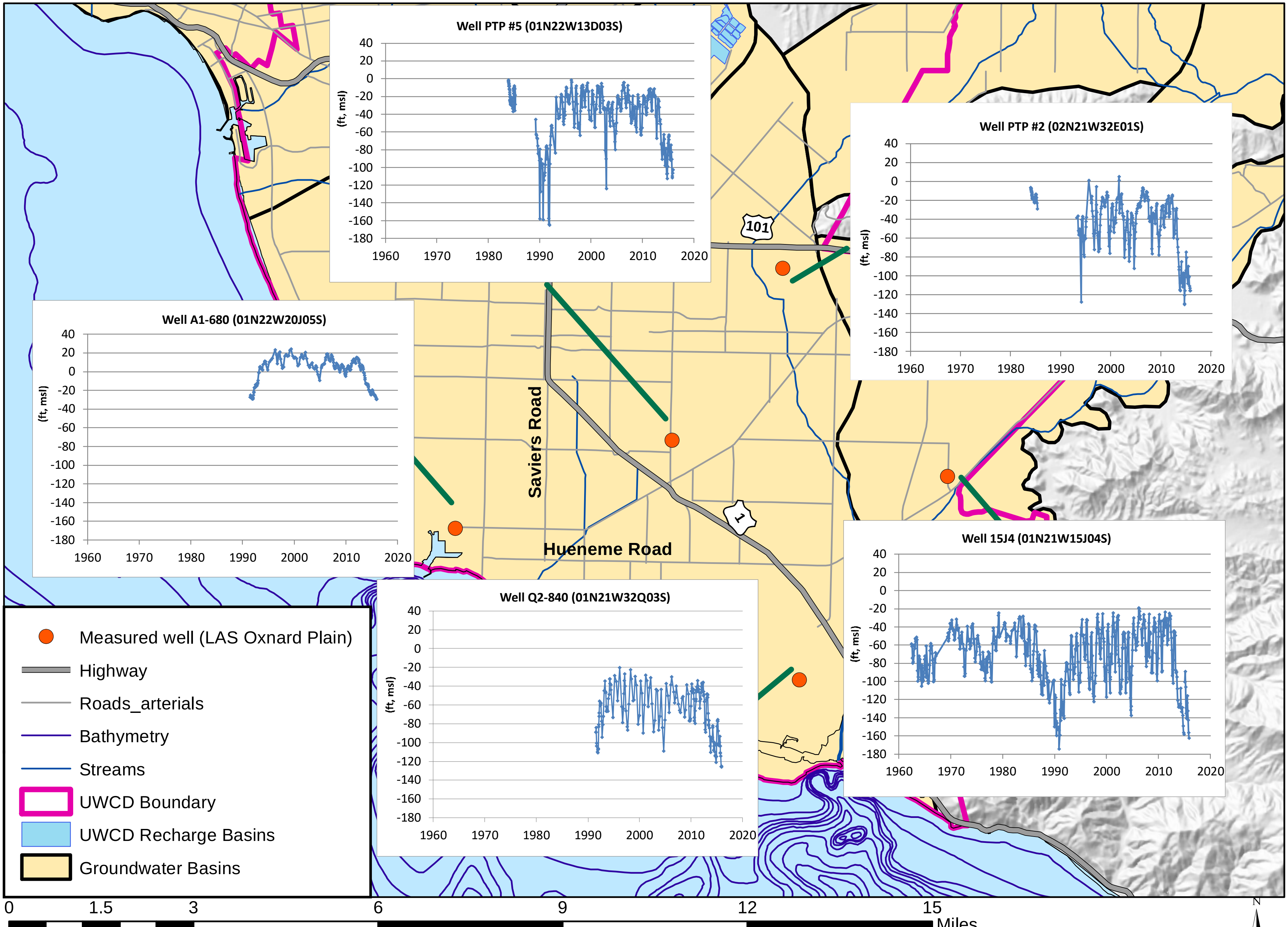

Figure 5.3-32. Oxnard Plain Lower Aquifer System groundwater elevation hydrographs, selected wells.

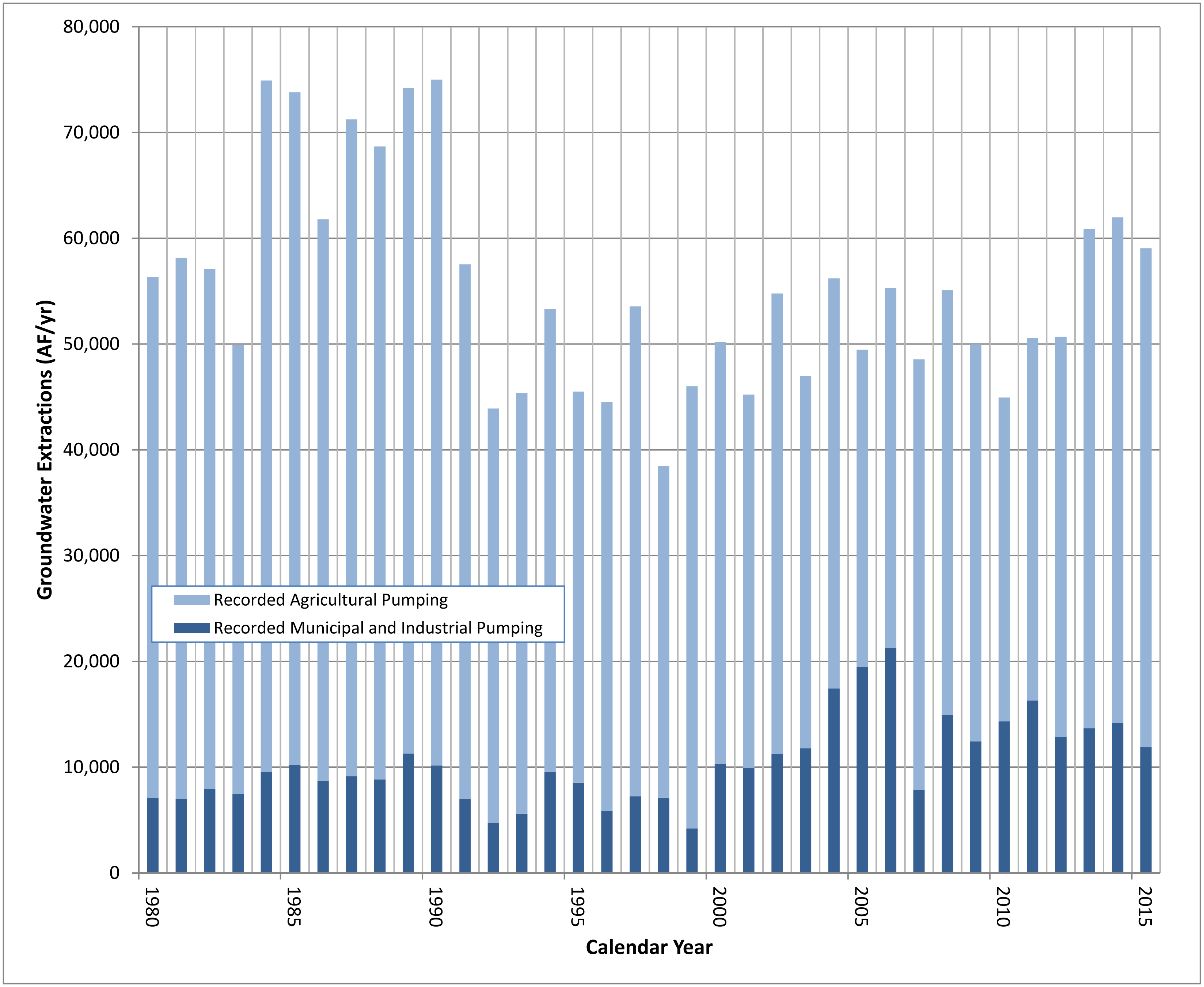

Figure 5.3-33. Historical annual groundwater extractions from Oxnard Plain basin.

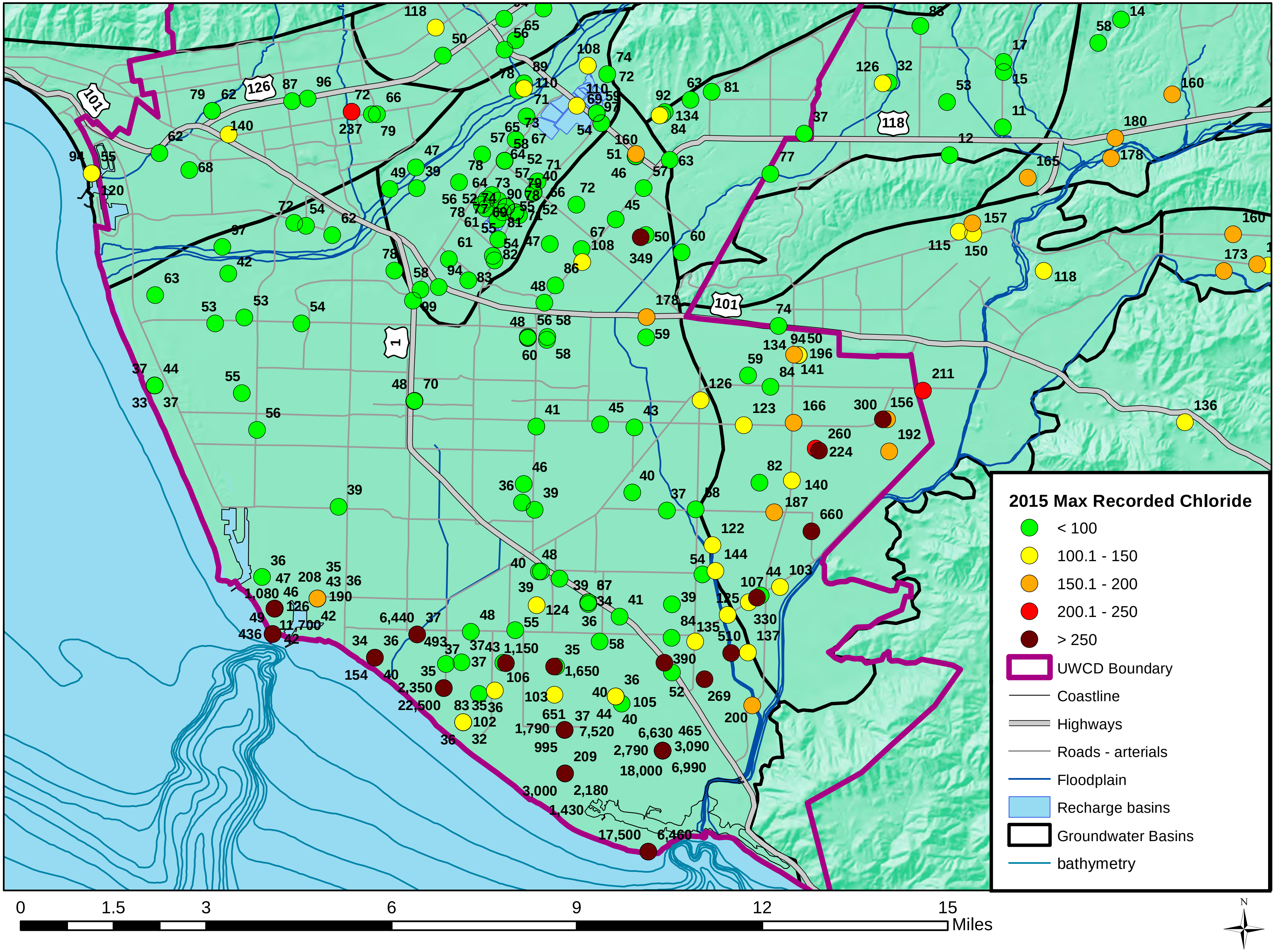

Figure 5.3-34. Maximum recorded chloride for all wells, 2015, Oxnard coastal plain.

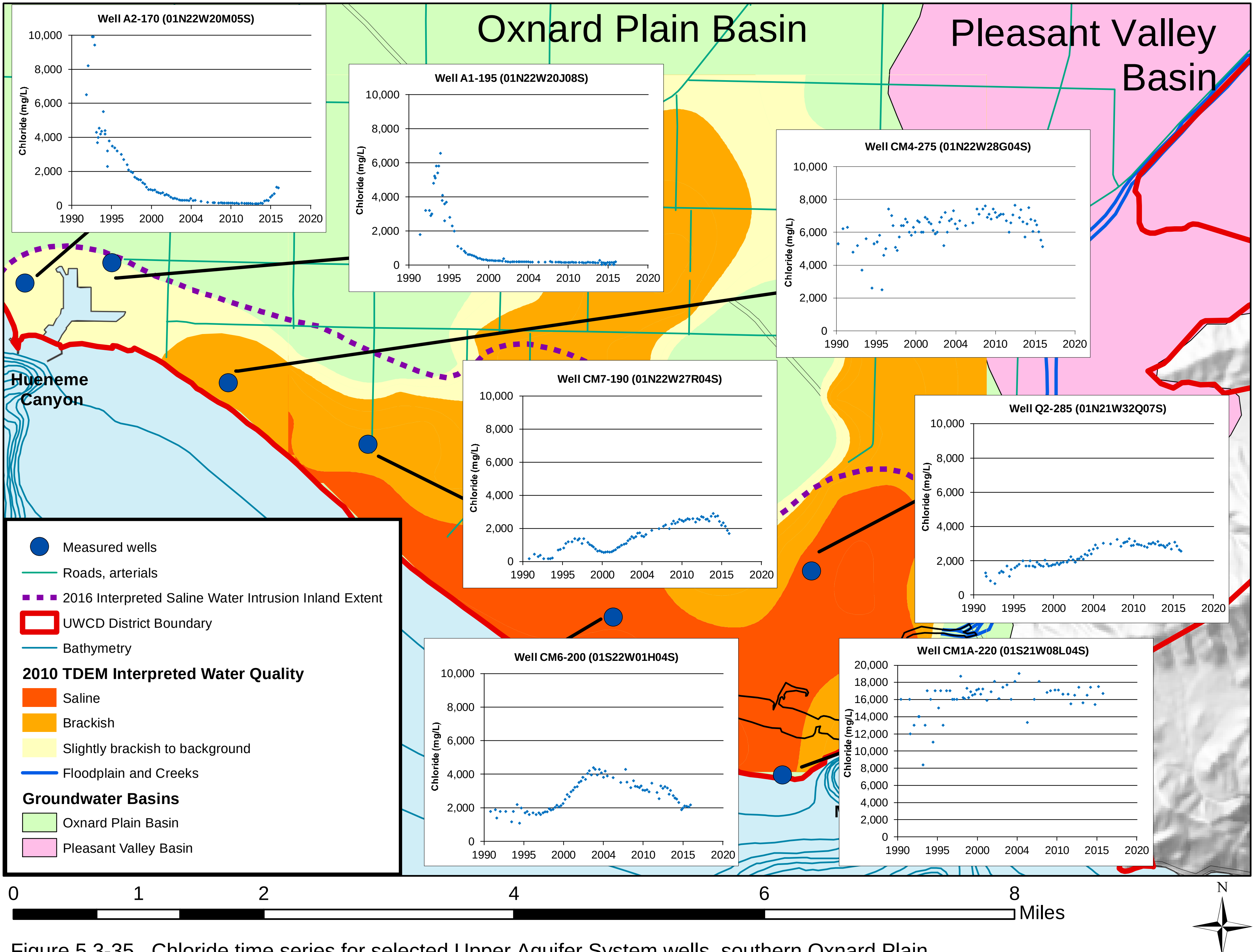

Figure 5.3-35. Chloride time series for selected Upper Aquifer System wells, southern Oxnard Plain.

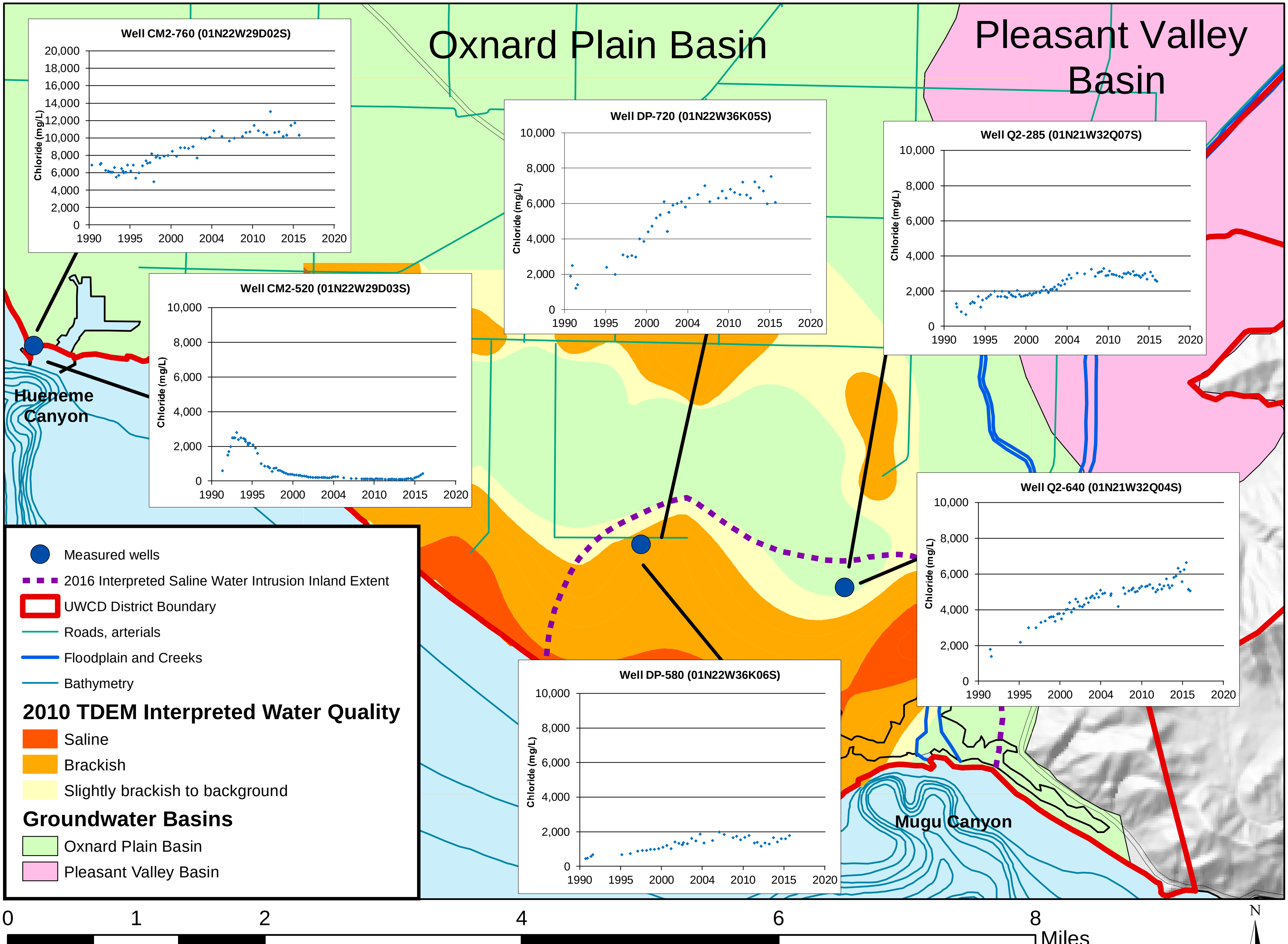

Figure 5.3-36. Chloride time series for selected Lower Aquifer System wells, southern Oxnard Plain.

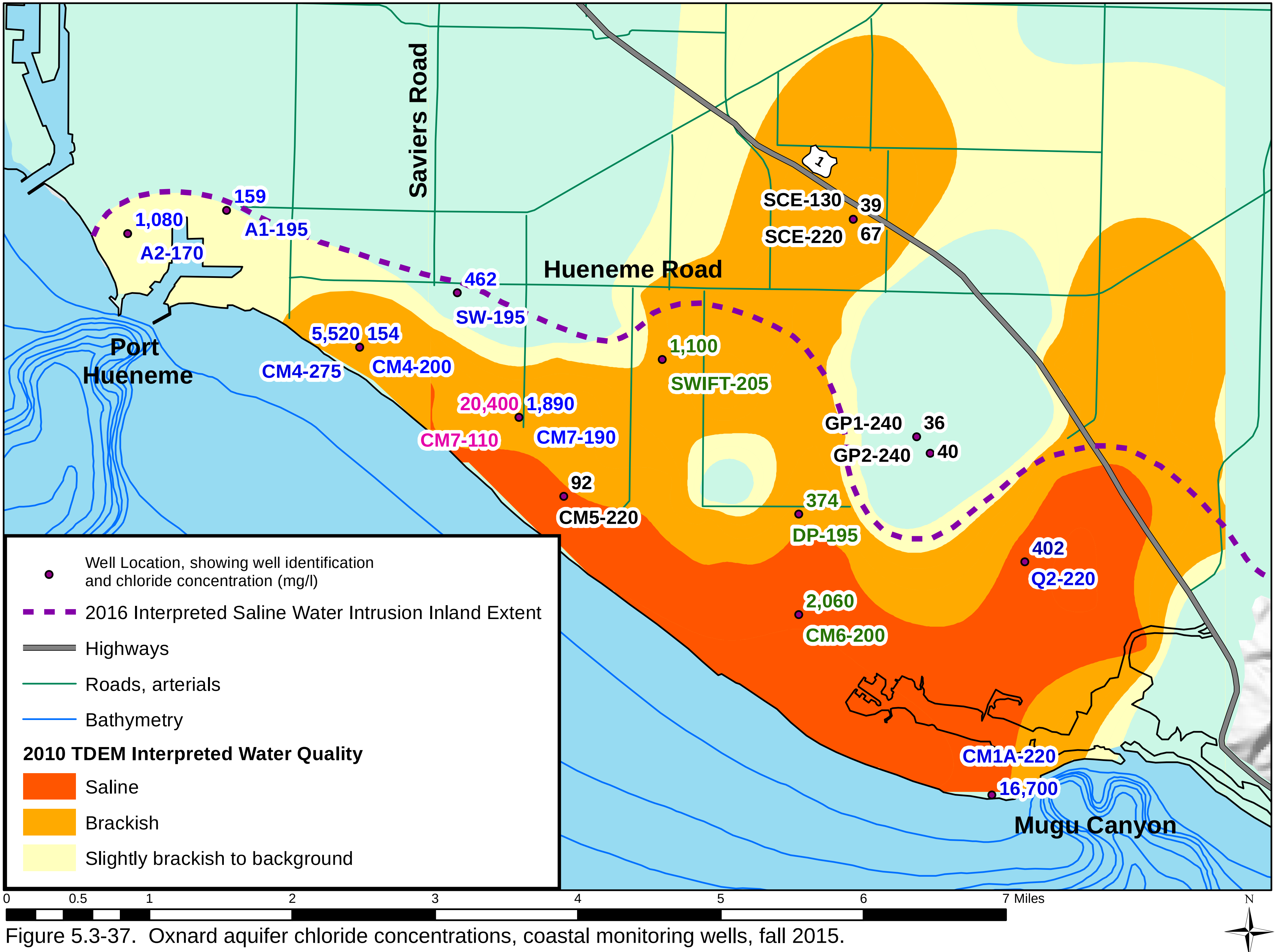

Figure 5.3-37. Oxnard aquifer chloride concentrations, coastal monitoring wells, fall 2015. Interpreted source of elevated chloride levels key: Green label = Sediments; Blue label = Seawater; Pink label = Semi-perched water; Black label = Background level.

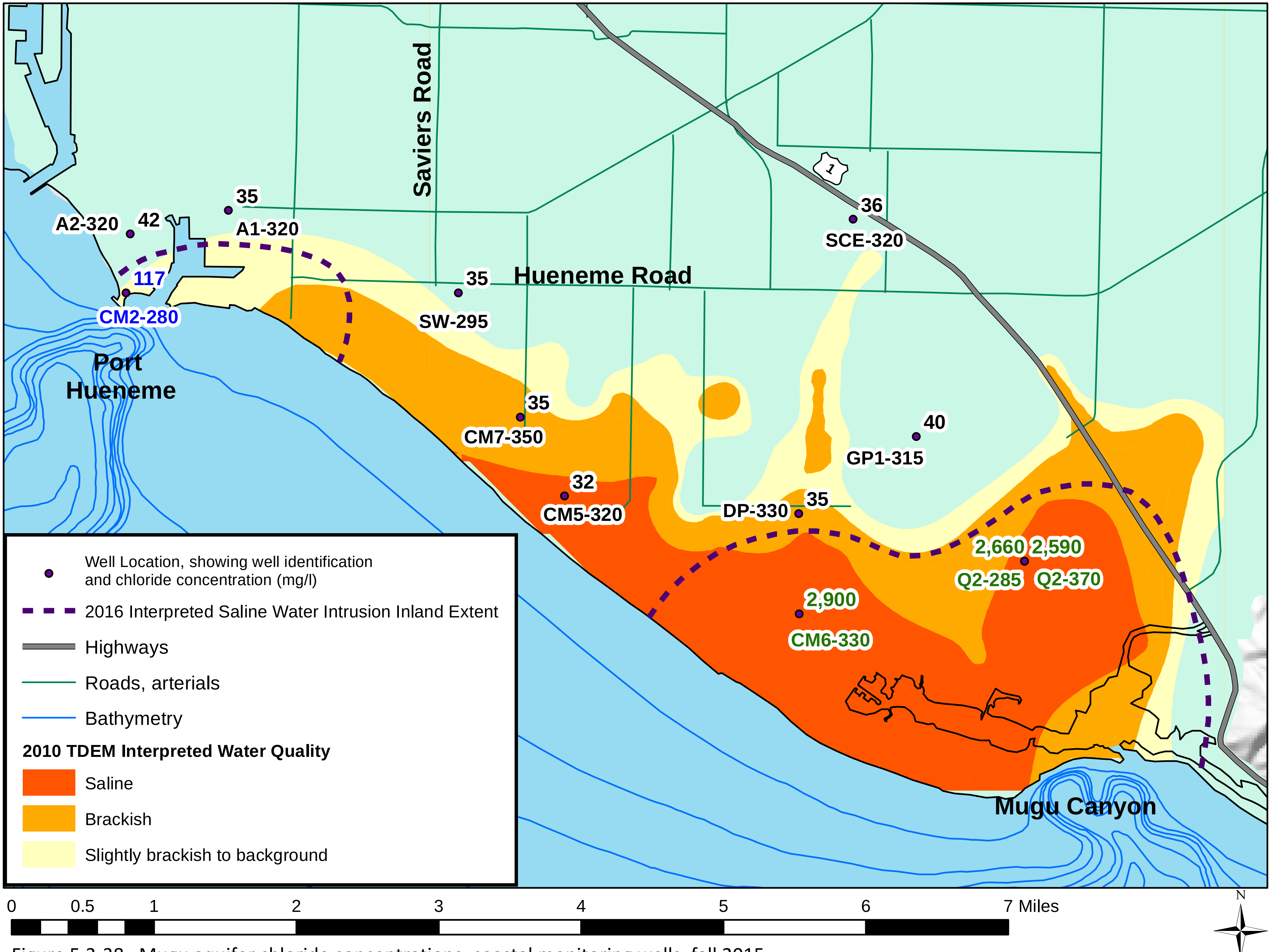

Figure 5.3-38. Mugu aquifer chloride concentrations, coastal monitoring wells, fall 2015.

Interpreted source of elevated chloride levels key: Green label = Sediments; Blue label = Seawater; Black label = Background level.

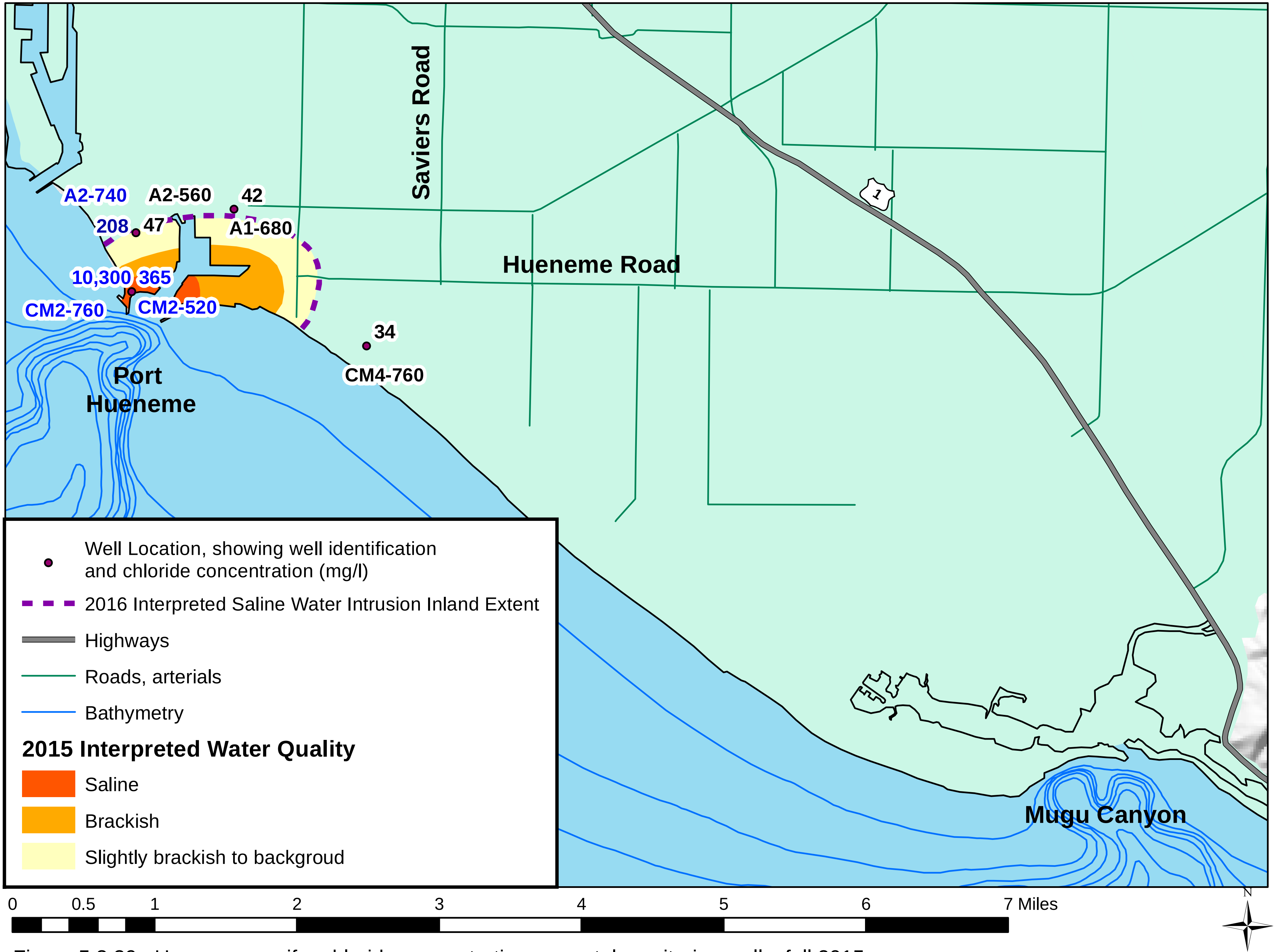

Figure 5.3.39. Hueneme aquifer chloride concentrations, coastal monitoring wells, fall 2015.
Interpreted source of elevated chloride levels key: Blue label = Seawater; Black label = Background level.

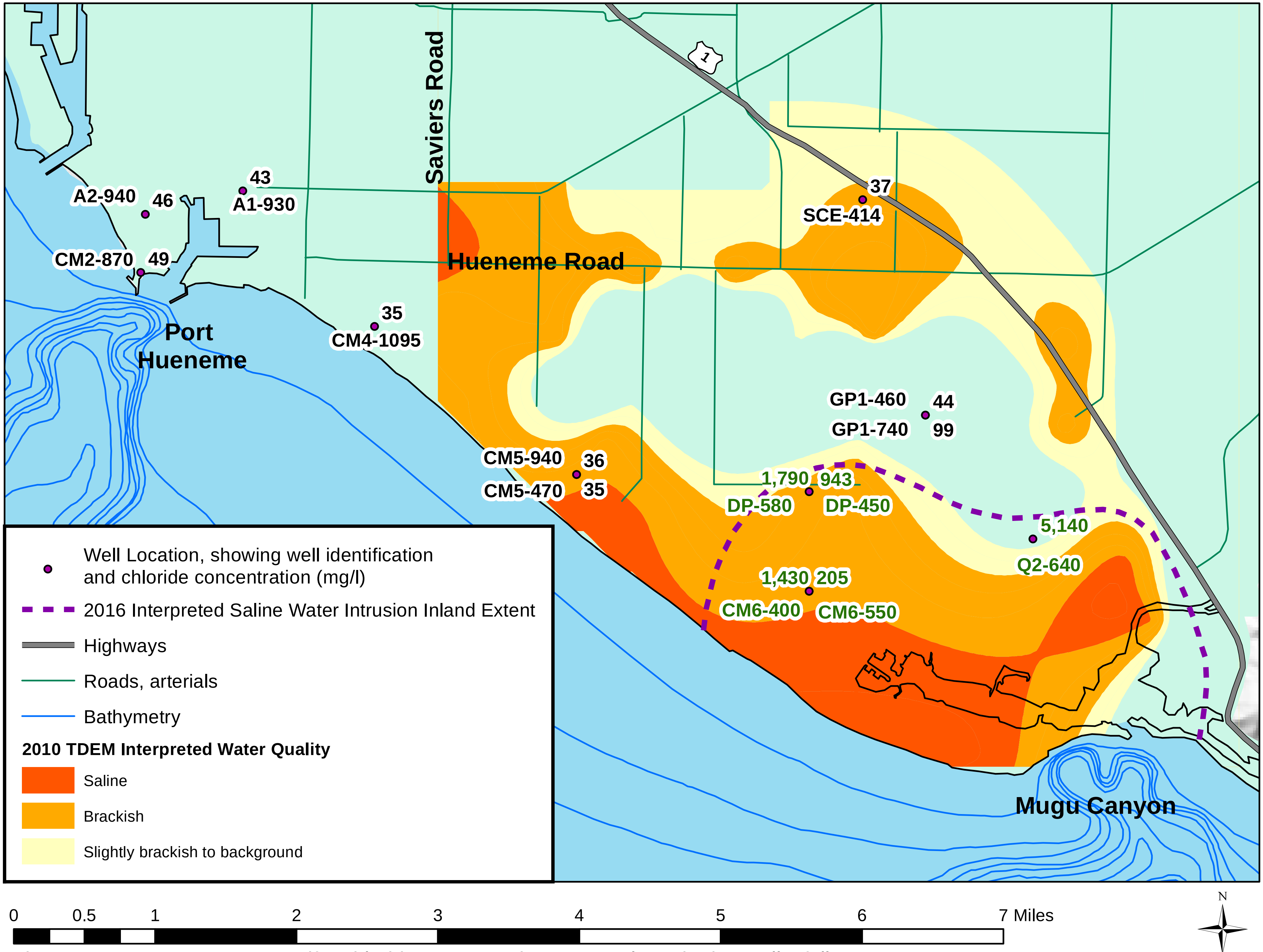

Figure 5.3-40. Fox Canyon aquifer chloride concentrations, coastal monitoring wells, fall 2015.
Interpreted source of elevated chloride levels key: Green label = Sediments; Black label = Background level.

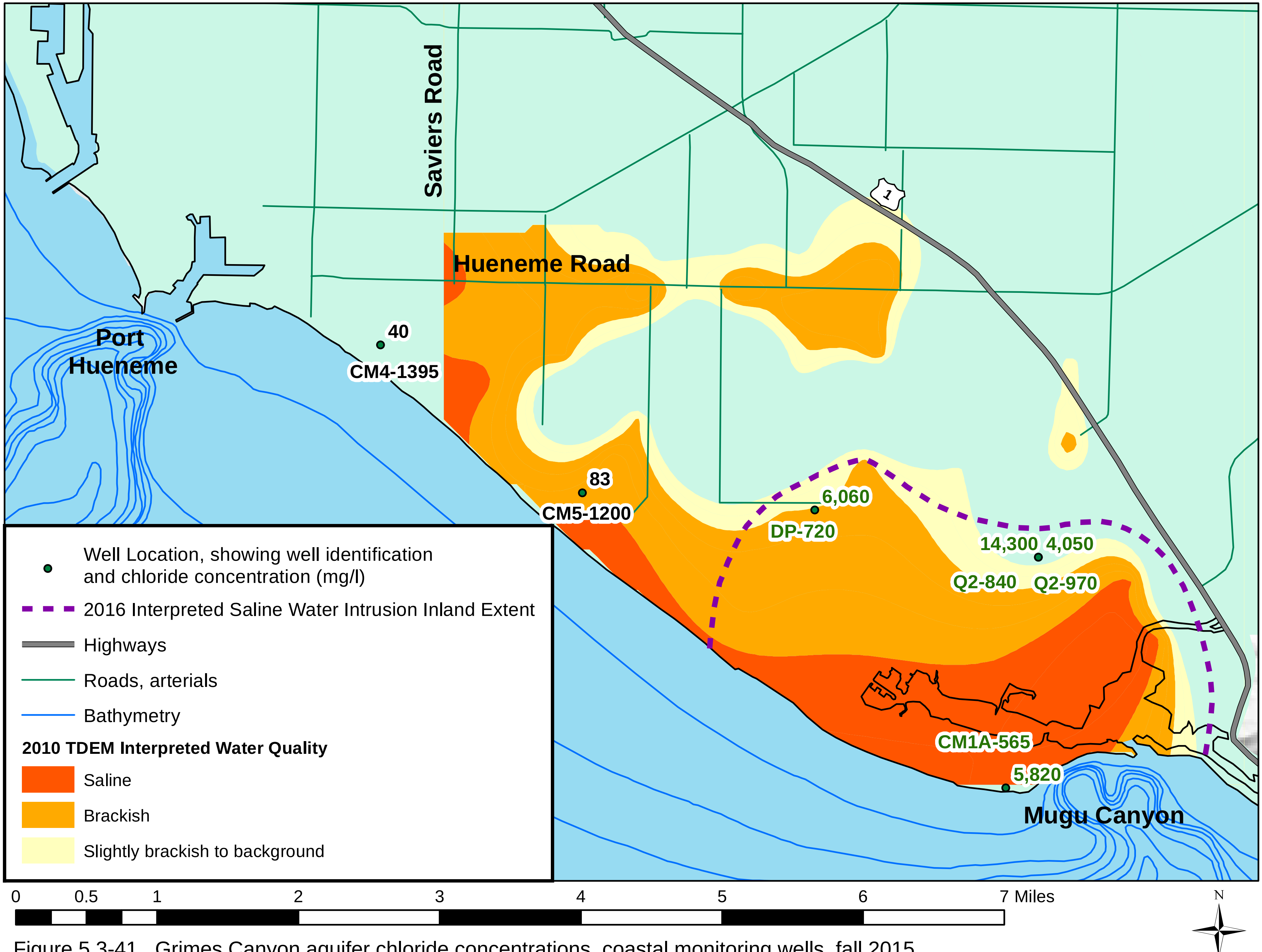

Figure 5.3-41. Grimes Canyon aquifer chloride concentrations, coastal monitoring wells, fall 2015. Interpreted source of elevated chloride levels key: Green label = Sediments; Black label = Background level.

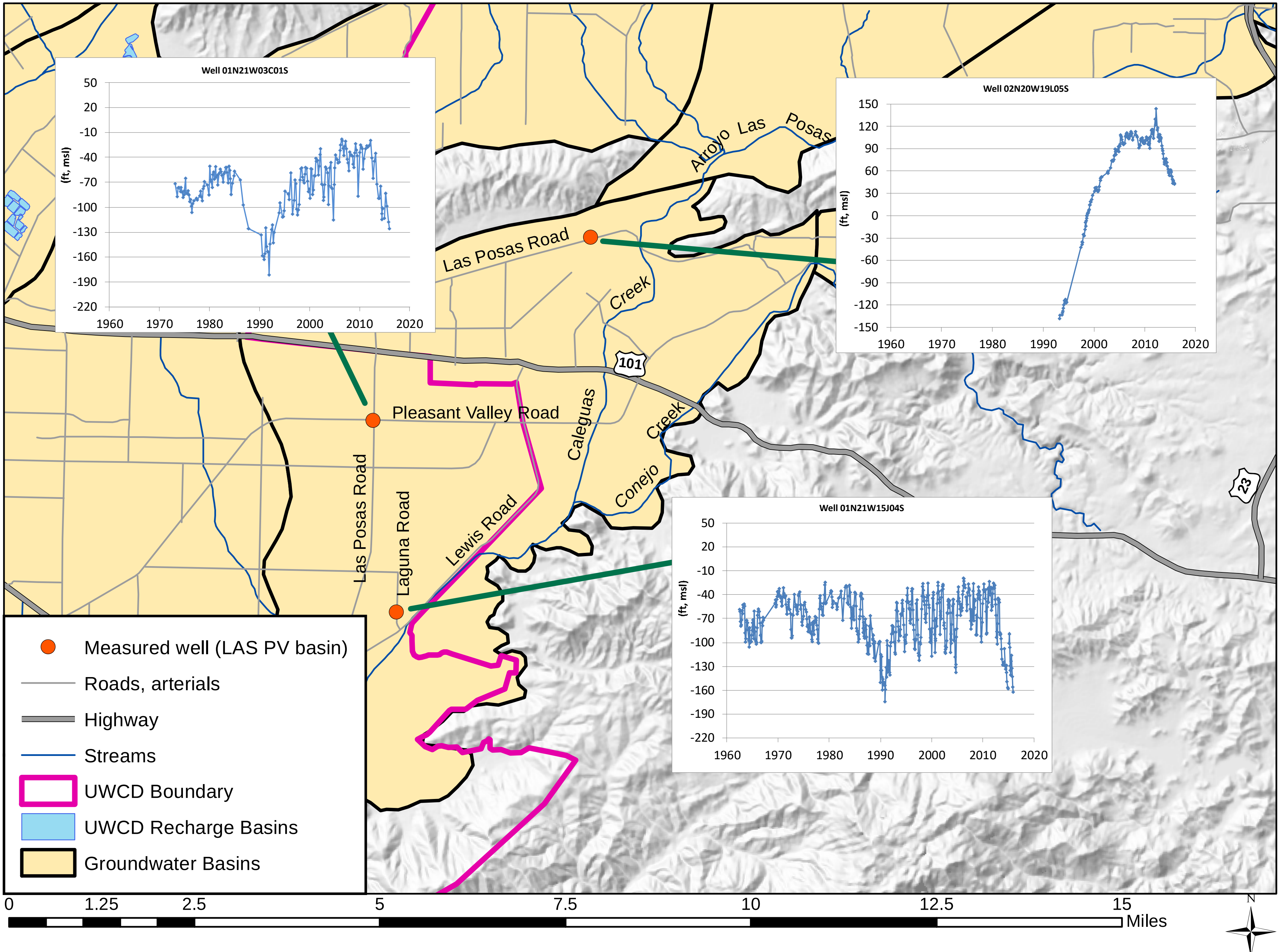

Figure 5.3-42. Pleasant Valley basin Lower Aquifer System groundwater elevation hydrographs, selected wells.

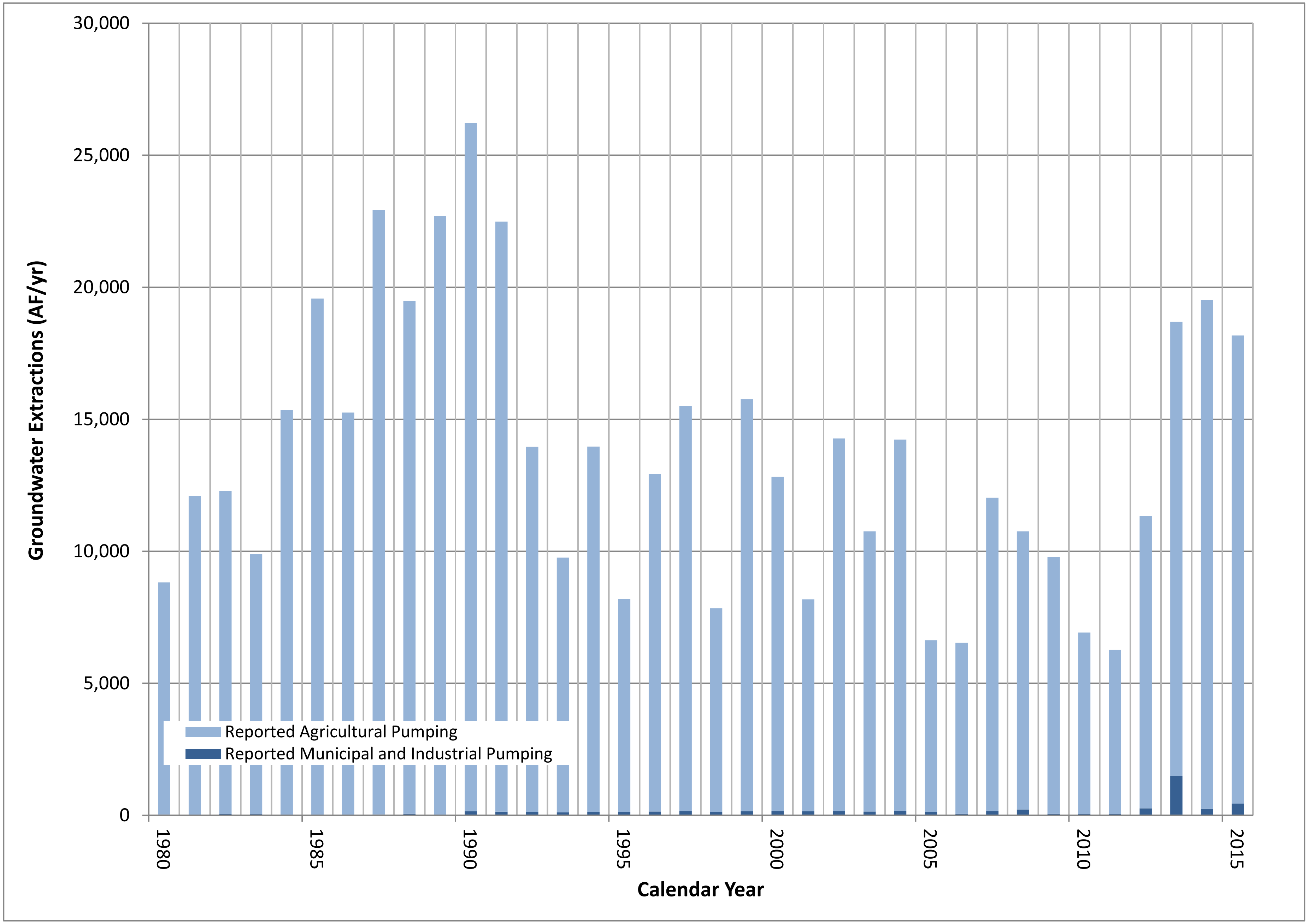

Figure 5.3-43. Historical reported groundwater extractions for Pleasant Valley basin.

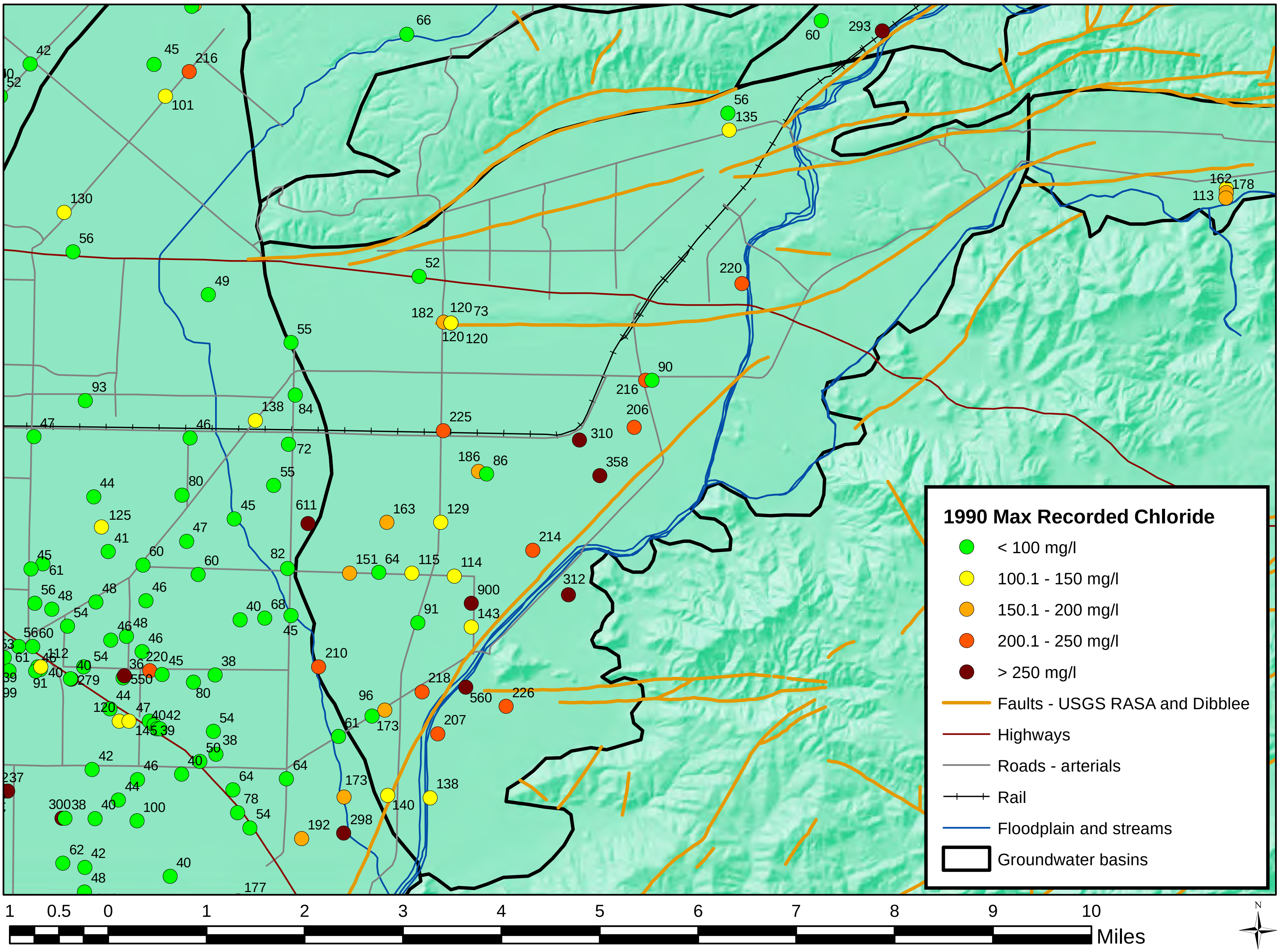

Figure 5.3-44. Maximum recorded chloride in 1990, in Pleasant Valley basin and eastern Oxnard plain.

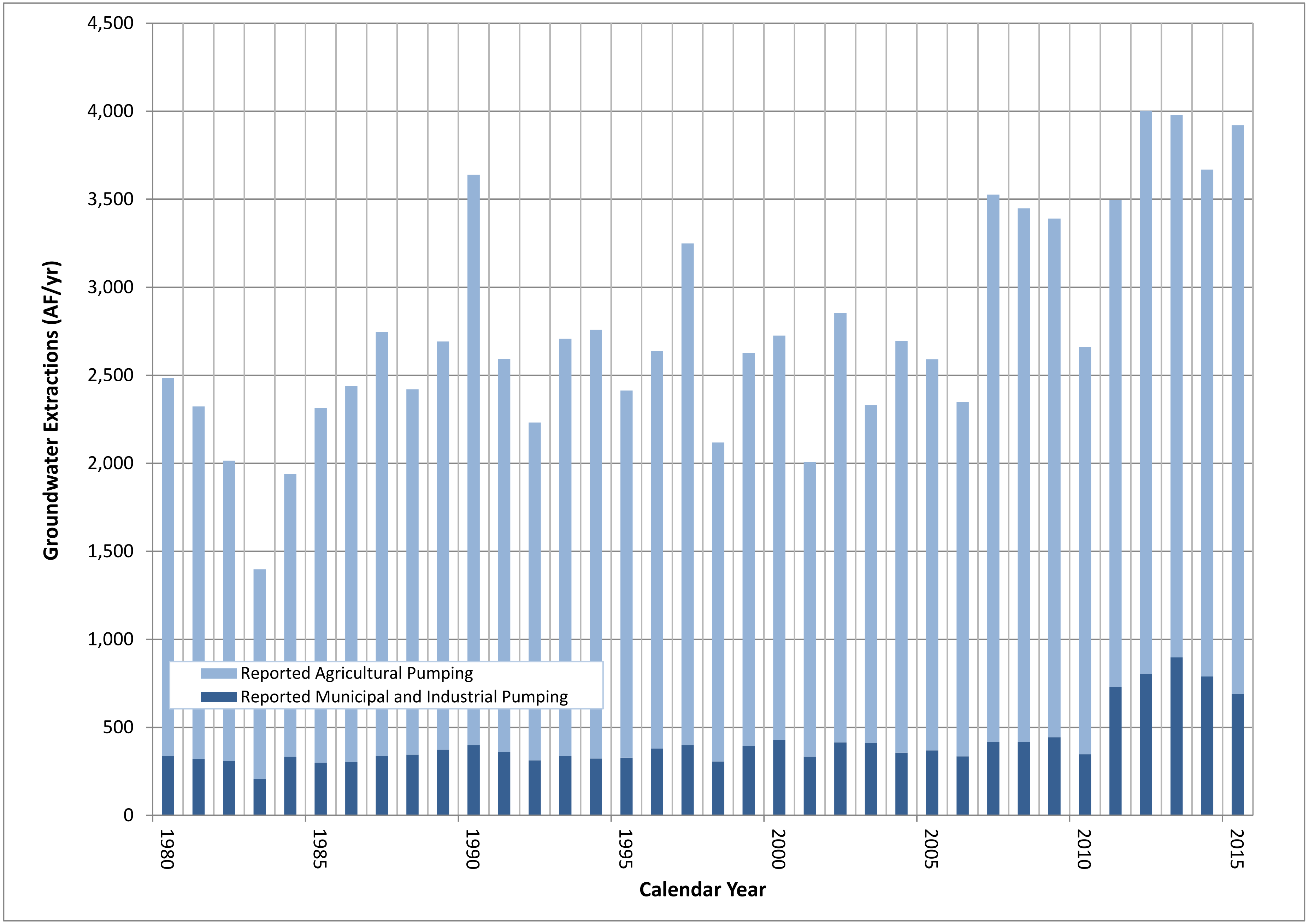

Figure 5.3-45. Historical reported groundwater extractions for West Las Posas basin.

APPENDICES

APPENDIX A
2015 CONSUMER CONFIDENCE REPORT, O-H SYSTEM

United Water Conservation District

Oxnard-Hueneme Water Delivery System

2015 Consumer Confidence Report

Testing and Results

Last year we conducted thousands of tests for over 180 chemicals and contaminants that could be found in your drinking water. We did not detect any contaminants that would make the water unsafe to drink. This report highlights the quality of water we delivered to our customers last year. Included are details about where your water comes from, what it contains, and how it compares to State standards. For more information about your water, please call our Operations & Maintenance Manager, Mike Ellis at (805) 485-5114.

Public Meetings

Our monthly Board meetings are usually held on the second Wednesday of every month at 1:00 PM in our board room at our "Irv Wilde Headquarters" located at 106 North 8th Street in Santa Paula. Our meetings are open to the public and we would welcome your questions and comments.

About Your Water Supply

United Water's Oxnard-Hueneme Delivery System supplies about 15,000 acre-feet of water per year to several agencies in the Oxnard Plain, including the city of Oxnard, the Port Hueneme Water Agency (PHWA), and several smaller water companies. These agencies supply our water to over 222,000 people, most of it treated or blended with other supplies. Our water source is 100% local groundwater, pumped from wells near El Rio, north of Oxnard. Water from those wells has its origin in the mountains and valleys of the 1,600 square mile Santa Clara River watershed. The wells are in an aquifer called the Oxnard Forebay. Our water is naturally high in minerals that affect its taste, but is safe to drink. Our groundwater is considered to be "under the influence of surface water," which means we do extensive monitoring of turbidity and other parameters to meet health regulations.

United Water Conservation District
106 North 8th Street
Santa Paula, CA 93060
805/525-4431 Fax 805/525-2661
www.unitedwater.org

Water produced by our wells is naturally filtered through the ground. We use chlorine as a disinfectant to kill bacteria, parasites, and viruses. Then we add chloramines to provide a long-lasting disinfection residual to keep the water safe until it reaches our customers. Due to the longer-lasting residual of chloramines, owners of pet fish must treat their tap water before putting it into aquariums or ponds.

Types of Potential Contamination

In general, sources of drinking water (both tap water and bottled water) include rivers, lakes, streams, ponds, reservoirs, springs, and wells. As water travels over the surface of the land or through the ground, it dissolves, naturally-occurring minerals and, in some cases, radioactive material can pick up substances resulting from the presence of animals or from human activity. Contaminants that may be present in source water include:

Microbial contaminants, such as viruses and bacteria, which may come from sewage treatment plants, septic systems, agricultural livestock operations, and wildlife.

Inorganic contaminants, such as salts and metals, which can be naturally-occurring or result from urban stormwater runoff, industrial or domestic wastewater discharges, oil and gas production, mining, or farming

Organic chemical contamination, including synthetic and volatile organic chemicals, which are by-products of industrial processes and petroleum production, and can also come from gas stations, urban stormwater runoff, agricultural application, and septic systems.

Pesticides and herbicides, which may come from a variety of sources such as agriculture, urban stormwater runoff, and residential uses.

Radioactive contaminants, which can be naturally-occurring or be the result of oil and gas production and mining activities.

In order to ensure that tap is safe to drink USEPA and the State Water Resources Control Board prescribe regulations that limit the amount of certain contaminants in public drinking water. We treat our water to meet these health regulations. The State Board's regulations also establish limits for contaminants in bottled water, which must provide the same protection for public health. Scientists and health experts are continually studying the effects of various chemicals in drinking water to make sure the public water supply is safe.

Drinking water, including bottled water, may reasonably be expected to contain at least small amounts of some contaminants. The presence of contaminants does not necessarily indicate that water poses a health risk. More information about contaminants and potential health effects can be obtained by calling the USEPA's Safe Drinking Water Hotline (1-800-426-4791).

Definitions

Public Health Goal (PHG): The level of a contaminant in drinking water below which there is no known or expected risk to health. PHGs are set by the California Environmental Protection Agency.

Maximum Contaminant Level Goal (MCLG): The level of a contaminant in drinking water below which there is no known or expected risk to health. MCLGs are set by the U.S. Environmental Protection Agency.

Maximum Contaminant Level (MCL): The highest level of a contaminant that is allowed in drinking water. Primary MCLs are set as close to the PHGs (or MCLGs) as is economically and technologically feasible. Secondary MCLs are set to protect to odor, taste and appearance of drinking water.

Primary Drinking Water Standard (PDWS): MCLs for contaminants that affect health along with their monitoring and reporting requirements, and water treatment requirements.

Maximum Residual Disinfectant Level (MRDL): The highest level of a disinfectant allowed in drinking water. There is convincing evidence that addition of a disinfectant is necessary for control of microbial contaminants.

Maximum Residual Disinfectant Level Goal (MRDLG): The level of a drinking water disinfectant below which there is no known or expected risk to health. MRDLG's do not reflect the benefits of the use of disinfectants to control microbial contaminants.

Treatment Technique (TT): A required process intended to reduce the level of a contaminant in drinking water.

Detection Limit for Reporting (DLR): The level above which a chemical is to be reported.

NA: Not applicable

ppm: parts per million, or milligrams per liter

ppb: parts per billion, or micrograms per liter

ND: none detected

pCi/L: picocuries per liter (a measure of radioactivity)

µS/cm: micro-Siemens/centimeter (a measure of conductivity)

TON: threshold odor number

Turbidity

Turbidity is a measure of the cloudiness of the water. We monitor it because it is a good indicator of the effectiveness of our water treatment. Turbidity is measured in units called NTUs. We achieved 100% compliance with turbidity standards in 2015.

Contaminants Detected in 2015

Contaminant	Units	State MCL [MRDL]	PHG (MCLG) [MRDLG]	Avg	Range	Sample Date	Viola-tion	Typical Sources in Drinking Water
Microbiological Contaminants								
Total Coliform bacteria	Absence/ Presence/ 100ml	Systems that collect <40 sam-ples/month: no more than 1 positive sample	0	Absent	Absent	2015	No	Naturally present in the environ-ment.
Fecal Coliform bacteria and *E.coli*	Absence/ Presence/ 100ml	A routine and repeat sample are total coliform positive, and one of these is fecal or *E.coli positive*	0	Absent	Absent	2015	No	Human and animal fecal waste.
Delivered water turbidity	NTU	TT	NA	0.13	0.06-0.71	2015	No	Well corrosion byproducts. Micro-scopic soil particles.
Radioactivity Contaminants								
Gross Alpha	pCi/L	15	0	3.24	2.63-4.29	2015	No	Erosion of natural deposits.
Radon	pCi/L	NA	NA	313.75	293-347	2015	No	Decay of natural deposits.
Uranium	pCi/L	20	0.43	3.55	2.6-4.26	2015	No	Erosion of natural deposits.
Inorganic Contaminants								
Arsenic	ppb	10	0.004	4.5	4-5	2015	No	Erosion of natural deposits.
Fluoride	ppm	2	1	0.5	0.5-0.5	2015	No	Erosion of natural deposits.
Nitrate (as N)	ppm	10	10	5.67	4.4-7.5	2015	No	Runoff and leaching from fertilizer use; leaching from septic tanks and sewage; erosion of natural deposits
Selenium	ppb	50	30	18.5	17-20	2015	No	Erosion of natural deposits. Discharge from mines, runoff from livestock lots.
Disinfection								
Chloramine Residual (as Cl2)	ppm	[4.0]	[4]	1.8	1.42-3.10	2015	No	Drinking water disinfectant added for treatment.
Disinfection By-Products								
Haloacetic Acids	ppb	60	NA	4.13	3-7	2015	No	By-product of drinking water disinfection.
Total Trihalomethanes	ppb	80	NA	26	22.4-31.2	2015	No	By-product of drinking water disinfection.
Disinfection By-Product Precursors								
Total Organic Carbon (TOC)	ppb	TT	NA	1.03	0.8-1.2	2015	No	Various natural and man-made sources.
Secondary Standards								
Chloride	ppm	500	NA	59	55-63	2015	No	Leaching from natural mineral deposits.
Sodium	ppm	NA	NA	96.5	95-98	2015	No	Leaching from natural mineral deposits.
Specific Conductance	µS/cm	1600	NA	1497.2	1460-1570	2015	No	Substances that form ions in wa-ter; seawater influence
Sulfate	ppm	500	NA	507.5	460-570	2015	Yes	Runoff/leaching from natural de-posits.
Total Dissolved Solids, TDS	ppm	1000	NA	1094.2	1040-1140	2015	Yes	Runoff/leaching from natural de-posits.
Total Hardness	ppm	NA	NA	584	571-597	2015	No	Leaching from natural mineral deposits.
Iron	ppb	300	NA	40	0-80	2015	No	Leaching from natural deposits.
Manganese	ppb	50	NA	24	20-30	2015	No	Leaching from natural deposits.
Unregulated Chemicals								
Boron	ppb	NA	NA	650	600-700	2015	No	Naturally present in the environ-ment.

Water Quality Data

The table on page 3 lists all of the drinking water contaminants that we detected during the 2015 calendar year. The presence of these contaminants in the water does not indicate that the water poses a health risk. In addition to the contaminants on the table, we tested for many other chemicals which were not detected at significant levels. Please call us if you would like a copy of the complete list of chemicals we tested for and the test results.

Secondary Drinking Water Standards

Chloride, Sodium, Specific Conductance, Sulfate, TDS, Total Hardness, Iron, and Manganese, are secondary standards related to the taste of the water, and water exceeding the MCL is generally safe for human consumption. Our water exceeds the secondary standards for TDS and Sulfate because of naturally occurring minerals in the water.

Source Water Assessment

United Water completed a Source Water Assessment for its drinking water wells in October 2001. The current report is available for public review at our office in Santa Paula. The assessment provides a survey of potential sources of contamination of the groundwater that supplies our wells. Activities that constitute the highest risk to our water are the following: petroleum storage tanks and fueling operations, septic systems, and animal feed lots that are no longer in use. The most recent update for the Surface Water Sanitary Survey was completed in January of 2016 and was submitted to the State Water Resources Control Board.

Cryptosporidium

Cryptosporidium is a microbial pathogen found in surface water throughout the U.S. Although filtration removes Cryptosporidium, the most commonly-used filtration methods cannot guarantee 100 percent removal. Our monitoring indicates the presence of these organisms in our source water and/or finished water. Current test methods do not allow us to determine if the organisms are dead or if they are capable of causing disease. Ingestion of Cryptosporidium may cause cryptosporidiosis, an abdominal infection. Symptoms of infection include nausea, diarrhea, and abdominal cramps. Most healthy individuals can overcome the disease within a few weeks. However, immuno-compromised people are at greater risk of developing life-threatening illness. We encourage immuno-compromised individuals to consult with their doctor regarding appropriate precautions to take to avoid infection. Cryptosporidium must be digested to cause disease, and it may be spread through means other than drinking water.

Radon

Radon is a radioactive gas that you cannot see, taste or smell. It is found throughout the U.S. Radon can move up through the ground and into a home through cracks and holes in the foundation. Radon can build up to high levels in all types of homes. Radon can also get into indoor air when released from tap water from showering, washing dishes and other household activities. Compared to radon entering the home through soil, radon entering the home through tap water will be a small source of radon in indoor air. Radon is a known human carcinogen. Breathing air containing radon can lead to lung cancer. Drinking water containing radon may also cause increased risk of stomach cancer. If you are concerned about radon in your home, you may test the air in your home. There are simple ways to fix a radon problem that are not too costly. For additional information, call the National Safety Council's Radon Hotline (800-SOS-RADON).

About Nitrate

Nitrate in drinking water at levels above 10 mg/L is a health risk for infants of less than six months of age. Such nitrate levels in drinking water can interfere with the capacity of the infant's blood to carry oxygen, resulting in a serious illness; symptoms include shortness of breath and blueness of the skin. Nitrate levels above 10 mg/L may also affect the ability of the blood to carry oxygen in other individuals, such as pregnant women and those with certain specific enzyme deficiencies. If you are caring for an infant, or you are pregnant, you should ask advice from your health care provider. Nitrate levels may rise quickly because of rainfall or agricultural activity.

Immuno-compromised Persons

Some people may be more vulnerable to contaminants in drinking water than the general population. Immune-compromised persons such as persons with cancer undergoing chemotherapy, persons who have undergone organ transplants, people with HIV/AIDS or other immune system disorders, some elderly and infants, can be particularly at risk from infections. These people should seek advice about drinking water from their health care providers. USEPA/Centers for Disease Control (CDC) guidelines on appropriate means to lessen the risk of infection by *Cryptosporidium* and other microbial contaminants are available from the Safe Drinking Water Hotline (1-800-426-4791).

Security of your Water

We have completed a Vulnerability Assessment of our OH water facilities. This work, funded by an EPA grant, has improved the security and safety of our water supply.

Hablamos Español

Este informe contiene información muy importante sobre su agua potable. Para información en español llámenos al (805) 525-4431.