GROUNDWATER AND SURFACE WATER CONDITIONS REPORT - 2011

United Water Conservation District
Open-File Report 2012-02

PREPARED BY

GROUNDWATER RESOURCES DEPARTMENT

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Groundwater Resources Department
May 2012

THIS REPORT IS PRELIMINARY AND IS SUBJECT TO MODIFICATION

BASED UPON FUTURE ANALYSIS AND EVALUATION

Cover Photo: Recharge basin at El Rio Spreading Grounds, February 2011. By John Carman

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TABLE OF CONTENTS

LIST OF FIGURES AND TABLES

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 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 2011 calendar year, 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.

Major water resource issues and concerns are the driving impetus for the District's projects and programs. Projects and programs are implemented to manage, mitigate, or eliminate those issues or concerns that threaten the water resources. Those 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, water quality of the Oxnard Forebay basin and the Piru basin, and concerns related to the management of the Piru and Fillmore basin water resources.

To address those 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 water 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 is performed periodically 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 Vern 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 District-wide project underway by the groundwater department is the update of the Ventura County Regional Groundwater Flow Model. 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, and stream gauging 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.

Issue-specific projects are also implemented by United to assist local stakeholders in the management of local water resources (e.g., AB3030 Piru/Fillmore Groundwater Management Plan, analyses of groundwater conditions in the Santa Paula basin as a part of the Technical Advisory Committee) or 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 in 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 groundwater basins (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 and ornamental nursery stock. 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 the past year, 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.

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, biology, 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 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 District 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 seawater intrusion on the Oxnard Plain was recognized in the 1940s, it was clear that the District 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. United Water then constructed 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 82,300 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
- 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.

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. In 1958 a pipeline was completed to deliver diverted surface water to Pleasant Valley County Water District, which serves agricultural water to the Pleasant Valley basin. 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, the Noble spreading basins (1995) were constructed to store and recharge additional river water, particularly during wet periods. The Saticoy well field was constructed in 2003 to pump down the groundwater mound that develops beneath the Saticoy spreading grounds during periods of heavy spreading. In late 2009 United acquired the Ferro and Rose basins, former mining pits located in the Oxnard Forebay that will be used for future groundwater recharge activities. United intends to construct facilities to convey Santa Clara River water diverted at the Freeman Diversion to these basins. An additional use for the Ferro basin under consideration is the recharge of recycled water sourcing from the City of Ventura (Carollo Engineers, 2010) or the City of Oxnard. United anticipated that the City of Ventura might desire to move recycled water to the District’s recharge basins (or alternatively, potable water from the Forebay to east Ventura) in the future and arranged for “pipe hangers” to be added to the Highway 118 bridge over the Santa Clara River during its reconstruction in 1993.

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.

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 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 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 downstream basins and the facilities at the Freeman Diversion have the capability to receive the most benefit from the release. The current capacity of the dam is 82,300 AF (See Figure 1.4-1 for storage history). The operational minimum pool is set at 20,000 AF of storage.

The 2010 conservation release reduced the storage volume down to the minimum pool of 20,000 AF. An early rain in December 2010 brought the lake up to 31,000 AF of storage by January 1, 2011. Due to the above normal rainfall in 2011, the Piru watershed produced inflows totaling 61,800 AF, approximately double the historical average. The Santa Felicia Dam is fitted with a hydro electric plant that is currently not operable although a Federal Energy Regulatory Commission (FERC) License is still required. Efforts to re-license this facility are currently underway and as part of this new license, release requirements for Santa Felicia Dam were implemented this year and are discussed in more detail in section 1.6.3.

Summary of surface water hydrology at Lake Piru:

	Calendar year 2011
Minimum Storage	31,000 AF
Maximum Storage	76,400 AF
Inflow at USGS Sta. 11109600	61,800 AF
FERC License minimum releases	4,400 AF
Conservation Release	31,700 AF
State Water (Not released)	2,520 AF

1.4.2 PIRU DIVERSION AND SPREADING GROUNDS

The Piru Diversion is operated to divert surface water into the Piru Spreading Grounds for groundwater recharge. The diversion is located on the western bank of lower 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 river channel, a sluice channel that can accommodate approximately 200 cfs, and a diversion structure with a trash rack and four 24-inch inlets leading to a 48-inch diversion pipe that conveys diverted water to the spreading grounds. The structure is not in compliance with National Marine Fisheries (NMFS) standards for diverting water in a stream that may possibly contain endangered southern California steelhead. Therefore the facilities have been included as part of the Habitat Conservation Plan (HCP) so that the facility will be covered for incidental take. The diversion will not be put back into operation until a take permit has been issued.

1.4.3 FREEMAN DIVERSION AND SATICOY SPREADING GROUNDS

The Freeman Diversion is located on the Santa Clara River about 10 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. The Freeman Diversion facility replaced the former method of building temporary sand and gravel diversion dikes, levees, and canals along the Santa Clara River near Saticoy. 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. 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, canal, headworks, flocculation building, and desilting basin. A total of 92,600 acre-feet of surface water was diverted from the Santa Clara River at the Freeman Diversion in calendar year 2011.

The diversion is operated to redirect surface water from the Santa Clara River to United's recharge basins located in Saticoy, El Rio and the Noble Basins for the purpose of recharge the aquifers underlying the Oxnard Forebay and Oxnard Plain. In 2011 a total of 71,960 AF was recharged to these basins. The remainder of the diverted water was delivered directly to agricultural users for irrigation purposes. These deliveries are designed to reduce groundwater pumping in areas where overdraft conditions and related water quality issues exist, such as where aquifers are most susceptible to saline water intrusion and the upwelling of saline waters. Water releases from Lake Piru and a portion of the natural runoff from the Santa Clara River are diverted by the Freeman Diversion.

1.4.4 EL RIO FACILITY AND SPREADING GROUNDS

The El Rio Spreading Grounds are located at the terminus of the El Rio branch of the main supply line, approximately two miles southwest of the Saticoy spreading grounds. Surface water diverted from the Santa Clara River is distributed to a series of ponds totaling approximately 80 acres for the purpose of groundwater recharge. During the 2011 water year approximately 37,850 acre-feet of surface water was routed to the El Rio Spreading Grounds and recharged to the Oxnard Forebay groundwater basin.

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. Water deliveries on the Oxnard-Hueneme Pipeline totaled 10,750 acre-feet for the 2011 calendar year, some 27,100 AF less than the volume of water that was spread in the nearby El Rio recharge basins over the same time frame.

The California Department of Health Services requires the publication of an annual water quality summary of water delivered by the O-H system. The 2011 Consumer Confidence Report for the O-H water delivery system is included in Appendix A. The O-H delivery system is operated as an enterprise fund, with water rates supporting operation and improvements to the system. Major customers include the City of Oxnard, the Port Hueneme Water Agency, and a number of mutual water companies in the Oxnard Forebay and the northern Oxnard Plain.

1.4.6 AGRICULTURAL WATER DELIVERIES

Water deliveries for agricultural purposes are achieved through two systems, the Pumping Trough Pipeline (PTP) System and the Pleasant Valley Delivery System. These 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 (PTP) delivery system was designed to serve surface water from the Santa Clara River to a portion of the Oxnard Plain where the Upper Aquifer System was determined to be in severe overdraft. Five Lower Aquifer System wells were constructed along the pipeline to provide additional water to the system when surface water supplies are incapable of meeting demand. During the 2011 calendar year a large conservation release from Lake Piru and greater-than-average flow in the Santa Clara River allowed 90 percent of the demand on the PTP to be met with surface water supplies (Table 1.4-2). Surface water deliveries to this system totaled 7,629 AF in the 2011 calendar year. The four UAS wells of the Saticoy well field, completed in 2004, can also provide groundwater to the agricultural pipelines when groundwater elevations are high near the Saticoy Spreading Grounds. The Saticoy well field pumped a total of 737 AF in calendar year 2011, and 261 AF this water was distributed to the PTP delivery system.

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 the 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, 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. Surface water deliveries to PVCWD totaled 12,189 AF in the 2011 calendar year, and an additional 476 AF of water was supplied by the Saticoy well field. Deliveries in 2011 were about 1,300 AF greater than the average annual (water year) delivery since the completion of the Freeman Diversion in 1991. Since 2002 PVCWD has also received surface water from the Conejo Creek Diversion, operated by Camrosa Water District. In 2011 PVCWD received 6,657 AF of surface water from that source. Water year 2011 deliveries to the Pumping Trough and Pleasant Valley pipelines are shown in Figure 1.4-2.

1.5 GROUNDWATER ISSUES AND CONCERNS

United's core mission is to manage, conserve and protect 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 to the lower portions of the Santa Clara River watershed. United does not regulate the use of groundwater within the District, 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 lower valley of the Santa Clara River is wholly dependent on local water resources for irrigation and potable supply, an uncommon arrangement in southern California.

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 places significant water quality problems developed in response to conditions of overdraft. In some areas water quality problems are 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. 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).

1.5.1 OVERDRAFT CONDITIONS

Although high chloride levels in groundwater was first documented near Port Hueneme in the 1930s (California Department of Water Resources [DWR], 1954), the conditions for widespread seawater intrusion in the Upper Aquifer System (UAS) on the Oxnard Plain were initiated as early as the 1940s, when groundwater levels beneath the southern portion of the Oxnard Plain basin dropped below sea level (FCGMA, 2007). Within 5 to 10 years, chloride concentrations in wells in the Port Hueneme area started to increase rapidly. At that time, seawater had only affected a few wells in the Port Hueneme area, encompassing an area less than one square mile. Overdraft conditions were recognized in the Lower Aquifer System (LAS) in the late 1980s after the impairment of water quality in the Upper Aquifer System led to the implementation of a Fox Canyon Groundwater Management Agency (FCGMA) strategy to require new or replacement wells to be drilled into the LAS to lessen pumping on the UAS. The overdraft conditions eventually expanded into the adjacent Pleasant Valley groundwater basin and resulted in up to 2.6 feet of permanent land subsidence (Hanson et al, 2003).

Overdraft conditions in the Oxnard Plain and Forebay groundwater basins continue today with the annual overdraft amount estimated to be about 20,000 to 25,000 ac-ft/yr (UWCD, 2012)

1.5.2 SALINE WATER INTRUSION

High chloride levels were first detected on the Oxnard Plain in the vicinity of the Hueneme and Mugu submarine canyons in the early 1930s (CA DWR, 1971) and became a serious concern in the

1950s. Early monitoring programs used only existing production wells and abandoned wells as monitoring points; sampling of these wells indicated that there was a widespread area of elevated chloride concentrations in the Hueneme to Mugu areas. In 1989, the U.S. Geological Survey initiated their Regional Aquifer-System Analysis (RASA) study and cooperative studies with United Water Conservation 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 Hwy 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 wells yielded new interpretations on the extent of seawater intrusion on the Oxnard Plain. It is now known that some areas of the southern Oxnard Plain are not intruded by seawater, and that high chloride readings from older production wells were the result of perched water leaking down failed well casings and contaminating the aquifer (Izbicki, 1992; Stamos and others, 1992; Izbicki and others, 1995; U.S. Geological Survey, 1996). Maps presented in this report delineate the approximate extent of high-chloride water at various depths on the Oxnard Plain (Section 4.3.6).

In addition to drilling the monitoring wells, the USGS conducted geophysical surveys to determine the general extent of the high-saline areas (Stamos and others, 1992; Zohdy and others, 1993). This work indicated that the high-saline areas consisted of two distinct lobes, with relatively fresh water separating the lobes (U.S. Geological Survey, 1996). These areas were resurveyed in 2010 by United (UWCD, 2012a). The lobes originally identified by the USGS form the basis of the areas of high chloride concentration shown on the maps in this report. Additional down-hole conductivity surveys by the USGS (also resurveyed recently 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. 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.

In addition, isotope studies of samples from the nested wells indicate that the cause of the elevated chloride levels varies on the Oxnard Plain (Izbicki, 1991; Izbicki, 1992; Izbicki et al, 2005a). Four major types of chloride degradation have been documented:

Lateral Seawater Intrusion - the inland movement of seawater adjacent to the Hueneme and Mugu submarine canyons;

Cross Contamination - the introduction of poor-quality water into the fresh water supply via existing wellbores that were improperly constructed, improperly destroyed, or have been corroded by poor-quality water in the Semi-Perched zone;

Salt-Laden Marine Clays - the dewatering of marine clays, interbedded within the sand and gravel-rich aquifers, yields high concentrations of chloride-enriched water. This dewatering is the result of decreased pressure in the aquifers, caused by regional pumping stresses (also see Section 1.5.4); and

Lateral Movement of Brines from Tertiary formations - the lateral movement of saline water from older geologic formations that have been uplifted by faulting. The lateral movement occurs across a buried fault face near Pt. Mugu where Tertiary rocks are in contact with the younger aquifers (also see Section 1.5.4).

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 the Montalvo Basin). 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 (Figure 4.3-22). 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 are 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 enter surrounding aquifer material. The slow compaction of these clays also contributes to land subsidence.

1.5.3 DECLINING WATER LEVELS

In addition to the overdraft conditions in the coastal basins discussed in previous sections, 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 Technical Advisory Committee, 2011).

An evaluation of the spatial and temporal distribution of groundwater pumping in the basin (UWCD, 2011) 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. The Santa Paula Basin Technical Advisory Committee has initiated several specialty studies (Section 2.1.3) to provide additional data on the possible hydrologic cause(s) of the observed decline in groundwater elevations.

In 2003, a basin study titled "Investigation of Santa Paula Basin Yield" by experts from the City of Ventura, Santa Paula Basin Pumpers Association and United Water Conservation District suggested that the yield of the basin is probably near the historic average pumping amount (Santa Paula Basin Experts Group, 2003).

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.

1.5.4 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 in the deepest portion of the well can 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).

1.5.5 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 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, although numerous area ranches have employed such an arrangement for many years. An export policy is currently under development for the Piru and Fillmore groundwater basins.

1.5.6 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 very 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 Department of Public Health's maximum contamination level (MCL) for nitrate, which is 45 mg/l nitrate (or 10 mg/l nitrate as N). Exceedence of this MCL can result in methemoglobinemia (or "blue baby syndrome") a condition where ingested nitrogen interferes with the 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 sometimes rise, particularly in the northeastern 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 Upper Aquifer System (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.

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" and discharges 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 seasonally and annually, but dry 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 SANTA CLARA RIVERBED STABILIZATION

The construction of the Vern 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 completed structure 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). Since completion in 1991 the elevation of the Freeman diversion point has been stable at 162 feet, and the facility has enabled the diversion of river flow soon after large storm events.

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 dam in the subsurface. Groundwater elevations at an upstream location near the diversion structure vary little from the crest elevation of 162 feet, as groundwater moving through shallow river alluvium stages up behind the Freeman structure (Figure 1.6-1). Construction of the Freeman Diversion has benefited groundwater elevations in the Santa Paula basin as incision of the river was lowering the discharge elevation for shallow groundwater in the basin was arrested and partially restored (Santa Paula Basin Experts Group, 2003).

1.6.2 INCREASED CHLORIDE CONCENTRATION IN 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 quality in surface water.

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 after 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 to 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. The local (Santa Clarita) board of the Sanitation Districts of Los Angeles County has refused to authorize the rate increases necessary to implement the approved project. 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. The chloride plume 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.

1.6.3 WATER FOR ENVIRONMENTAL INITIATIVES

Because of the Federal regulatory mandates, both Santa Felicia Dam and the Freeman Diversion have implemented bypass flows to maintain migration corridors for southern California steelhead and habitats downstream of the facilities. Santa Felicia Dam is regulated by the Federal Energy Regulatory Commission (FERC) due to a small 1.2 Mega Watt hydroelectric plant at the outlet works. The Freeman Diversion is included in a Habitat Conservation Plan (HCP) that is under development and is expected to take several years to complete.

1.6.3.1 SANTA FELICIA DAM ENVIRONMENTAL FLOWS.

The 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 the FERC license which were adopted in 2011, the bypass flows have now been changed to a minimum of 7 cfs with conditions which 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 migration flows of 200 cfs have been implemented for fisheries migration in Piru Creek when the Santa Clara River has elevated flows due to storm runoff. The trigger to initiate migration releases occurs when the USGS gauging station on the Santa Clara River above Piru measures over 200 cfs at 8:00 am and is expected to stay above 200 cfs through the following day. Migration flows are to continue as long as flows at the county line are over 200 cfs.

Based on recommendations from NMFS, FERC has also imposed license conditions on the rate at which United may decrease flows when ending conservation releases or environmental flows. Release ramping rates are to be adjusted so that flow in Piru Creek never decreases more than two inches per hour. Ramping down the conservation release in fall 2011 took five days and a minimum of 25 adjustments to go from 300 cfs down to seven cfs.

The FERC bypass flow plan was not adopted until late May 2011. As a result of the license a habitat flow of a minimum of nine cfs was implemented on May 27, 2011 and maintained until October 1st. After October 1st minimum flows were decreased to 7 cfs until the appropriate triggers are met to change the flows.

Before the final bypass flows were accepted for the license, United proposed several plans during negotiations with NMFS. Each plan was rejected for various reasons. On October 6th 2009 NMFS recommended bypass flows that would have substantially reduced the yield of the Santa Felicia Dams operations. After further negotiations, and due to United's efforts and familiarity with the hydrology, the agencies agreed upon the above mentioned plan that is now part of the license. A yield calculation was done for the operations at Santa Felicia Dam comparing the actual operations to both the approved bypass flows in the FERC license and the recommended flow proposed by NMFS during the negotiations. In 2011 the actual storage in the lake started at 31,000 Acre-Feet in January 1st, and ended up at 75,500 Acre- Feet by June 1st. If the new FERC bypass flow plans were implemented the total storage of the lake by June 1st would have been 71,700 due to some storms that would have triggered migration releases and additional habitat flows. The recommended release schedule by NMFS required a substantially higher migration flow release from the dam which would have resulted in the final storage reaching only 56,300 AF, or a loss of storage of 19,200 Acre-Feet over the actual conditions, and 15,400 acre-feet over the proposed license (Figure 2.2-1).

After the conservation release, a short duration high impulse release of 600 cfs was done in order to perform a geomorphology study as a part of the FERC license conditions. This study took an additional 2,400 AF of water and was designed to evaluate sediment transport in various reaches within Piru Creek. The experimental release water was either diverted at the Freeman Diversion or percolated upstream. Figure 2.2-1 shows the average daily flows of the geomorphic test with the conservation release.

1.6.3.2 HABITAT CONSERVATION PLAN

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. As part of the HCP development United remains consultation with National Marine Fisheries Service (NMFS) and is currently operating the bypass flows to better meet the needs of the species for migration between the ocean and the Freeman Diversion. In 2011, four storms provided sustained flow in the Santa Clara River and allowed for the fish ladder to be in operation nearly continuously from February 19th to June 8th, 2011. An estimated 2,400 to 3,000 AF of water was directed to fish migration flows that otherwise would have been used for groundwater recharge. However during this same year 92,600 AF were diverted from the river and Forebay water levels near the Saticoy Spreading Grounds reached maximum elevations due to groundwater mounding in this vicinity.

2 PROJECTS AND INITIATIVES

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

2.1 GROUNDWATER

Section 2.1 introduces the groundwater projects that have been conducted by United. These consist of a wide range of projects which are discussed separately in the following sub-sections of this report. These are the same projects introduced in Figure 2.1-1.

2.1.1 UPDATE REGIONAL GROUNDWATER FLOW MODEL

The Ventura Regional Groundwater Model (VRGWM) is a numerical modeling tool developed to evaluate multifaceted conjunctive use, water recycling, and water conservation projects designed to alleviate seawater intrusion, overdraft, land subsidence, and other problems. A calibrated groundwater flow model allows the prediction of benefits or impacts associated with either specific water supply projects (such as well fields, water deliveries, recharge projects, reservoir releases, etc.) or more global changes within the model domain (changing irrigation demands, changing rainfall patterns, extended drought). Both United and the FCGMA have relied upon the existing VRGWM for planning and groundwater management activities.

The VRGWM was originally developed by the U.S. Geological Survey as part of the Regional Aquifer Systems Analysis (RASA) in the late 1980s and early 1990s. The VRGWM simulates regional groundwater flow in the Piru, Fillmore, Santa Paula, Mound, and Oxnard sub-basins of the Santa Clara River Valley Basin, and the Pleasant Valley Basin, Arroyo Santa Rosa Valley Basin, and Las Posas Valley Basin in the Calleguas Creek watershed. The MODFLOW model uses a finite difference grid consisting of 114 rows and 229 columns for a total of over 24,000 active cells with nodal spacing of approximately 900 feet throughout most of the model domain. The model presently uses 3 layers to simulate regional groundwater flow in the region's Upper Aquifer System, Lower Aquifer System, and shallow alluvial aquifers.

Since completion of the original model by the USGS in 1996, UWCD has completed several modifications to the VRGWM to improve its predictive capabilities and better address project-specific questions:

- Model Grid Size Reduction – Reduced cell size from 1/2 mile to 1/6 mile for improved accuracy;

- Model Layer Addition – Added a third model layer to simulate groundwater flow and groundwater-surface water interactions in the shallow alluvial units in the Piru, Fillmore, and Santa Paula sub-basins;
- Conceptual Model Updates – Added/modified groundwater flow barriers and hydrogeologic properties;
- Expanded Calibration Period - Added 1994 to 2000 hydrology;
- Model Recalibration – Recalibrated the Oxnard Basin to 1998 to better reflect the new conjunctive use projects built after USGS originally calibrated the model; and
- Improved Predictive Simulations – Expanded the forward model (predictive tool) period to a full 55 years that reflect the climate and hydrology of the years 1944 through 1998.

While the existing VRGWM has been successfully used in this capacity for more than a decade, the model must be updated in order to answer the increasingly complex and detailed questions water managers are now faced with. As environmental stewardship, climate change, drought preparedness, and recycled water have become integral aspects of groundwater management, the level of analysis required to support planning has become increasingly more detailed in both time and space, as compared to the early 1990s when the model was developed. In its current form, the VRGWM is not fully capable of evaluating the complex issues Ventura County water managers are faced with today or expect to confront in future years.

Grant funds were used to start the VRGWM update process. The VRGWM update is divided into two geographic areas that will be completed in two separate, but linked project phases. The first phase includes the Oxnard Forebay and Oxnard Plain. The second phase will include other basins such as Mound, Piru, Fillmore, Santa Paula, and Pleasant Valley. Each project phase has three tasks: (1) Develop Basin Conceptual Model; (2) Develop Groundwater Flow Model; and (3) Calibrate Groundwater Flow Model. The grant funding is to facilitate completion of Tasks 1 and 2 of the first project phase, which will be completed within the two year grant period (estimated: fall 2013). The remaining VRGWM update tasks are funded via other sources.

The basin conceptual model provides the basis for developing the numerical groundwater flow model. The goal of Task 1 is to update the basin conceptual model for the Oxnard Forebay and Plain with improved geologic understanding so a more detailed groundwater flow model can be constructed. Currently, the VRGWM is based on a conceptual model that uses an aquifer system framework where multiple aquifers are grouped into upper and lower systems. This approach ignores difference in water levels and properties between the aquifers in each system, which are significant in most areas. As groundwater management issues become more complex, the need for aquifer-specific answers increases. Thus, a key objective of Task 1 is to expand the basin conceptual model to include aquifer-specific data.

Updating the basin conceptual model is a two-step process – data collection and data analysis. Data collection includes identifying and compiling available geological data. United has focused on subsurface data contained in water, oil, and gas well logs. District staff have identified available geophysical logs and prioritized the logs for digitization. The digitized logs were georeferenced and input into GIS for analysis. United's hydrogeologists thereafter identified and correlated regional hydrogeologic units (aquifers and aquitards); constructed geologic cross-sections; and identified regional facies changes that affect the occurrence and movement of groundwater within the hydrogeologic units. Geologic maps and studies were also reviewed to identify geologic structures (faults and folds) that are barriers or partial barriers to groundwater flow. Ultimately, the goal is to use this work to build a 3-dimensional (3-D) geologic model of the basins for use in developing the numerical groundwater flow model (Task 2).

The goal of Task 2 is to develop the numerical model architecture and initial inputs that will be used for calibration. The model will be constructed using USGS's Modular Three-Dimensional Ground Water Flow Model code (MODFLOW) and the commercial pre-processing package Groundwater Vistas offered by Environmental Simulations, Inc. Groundwater model development is a three-step process that includes: (1) grid design, (2) establishing boundary conditions, and (3) assigning initial parameter values. As part of the model construction process, data will be georeferenced and input into GIS.

Grid Design

United's groundwater staff will construct a finite-difference grid for the model domain based on the 3-D geologic model prepared in Task 1. Model layers will be used to represent the different hydrogeologic units, where possible. The grid node spacing will be determined by evaluating the impact of cell size on model calculation run times. The goal will be to minimize the nodal spacing while not creating excessive run times. This will depend on the number of layers and the geographic extent of the model domain. If necessary, the numerical model will be broken into separate (but linked) models for different sets of basins to achieve an acceptable level of detail and run times.

Boundary Conditions

Boundary conditions are used to represent flow barriers (no-flow boundary), recharge and discharge processes (i.e. stream percolation, pumping, etc.), and inflow/outflows to/from other basins and the ocean. The geologic model will dictate the location of no-flow barriers representing low permeability bedrock units and fault barriers. Recharge estimates will be derived from prior studies and agency records of artificial recharge, as updated by new data collected by UWCD and others since the early 1990s. The primary discharge mechanism is pumping. Pumping locations and rates are available from UWCD and FCGMA pumping records. Other Inflows and outflows to the model domain will be implemented as either specified-flux boundaries or as head-dependent flow boundaries. These include flow in and out of adjacent basins and the ocean.

Initial Parameter Values

Once the model grid has been constructed, initial aquifer parameter values (hydraulic conductivity storage coefficient, etc.) will be assigned to each active cell in the model grid. These values will be estimated using available aquifer test data and the texture descriptions from the geologic model. Partial flow barriers and estimates of their hydraulic properties (conductance) will also be input during this step. Where possible, UWCD will seek opportunities to perform aquifer tests or collect other data that will help quantify the hydraulic properties of the different aquifers and flow barriers.

Following the successful construction and calibration of the groundwater flow model, the model can be utilized to evaluate specific water supply projects or broader pumping or precipitation changes within the watershed. The evaluation of individual projects requires the construction of model input files that define changes in pumping or recharge associated with the project under consideration. Model scenarios that include the new water project are typically compared to a “base case” scenario that characterizes how the basin or basins operate without the new project. United anticipates that the calibrated VRGWM will be used to assist cities or management agencies such as the FCGMA in evaluating large and/or complex water supply or water management proposals.

2.1.2 AB3030 GROUNDWATER MANAGEMENT PLAN UPDATE

The AB3030 Groundwater Management Plan (GMP), which is currently in draft form, is a cooperative effort of United Water, the City of Fillmore, and water companies/pumpers in the Piru and Fillmore Groundwater basins (Piru/Fillmore Groundwater Management Council, 2011). The original 1996 GMP was formulated with input gained from public information meetings and hearings. This 2011 GMP is an update of the original 1996 Plan (Piru/Fillmore Groundwater Planning Council, 1996).

The GMP uses the groundwater management plan authority contained in California Water Code Section 10750 et seq. initially enacted in 1992 through Assembly Bill 3030. An initial 1995 Memorandum of Understanding (MOU) between United, the City of Fillmore, and the water companies/pumpers, was incorporated in the plan and established the GMP as a cooperative groundwater management plan for the basins. The MOU outlines the roles of the various parties in implementing the Plan (M.O.U., 1995). The Piru and Fillmore basins are considered part of the Ventura Central Basin which is subject to critical conditions of overdraft (California Department of Water Resources, 1980).

United, as the lead agency, has formally adopted the GMP, which was formulated to ensure local control of groundwater management. It is the intent of the GMP to foster local control in as many aspects of the management of the basins as possible. The draft 2011 GMP update includes numeric Basin Management Objectives (BMO) for groundwater levels, groundwater quality, and surface water quality. Water Code Section 10753.7 now requires the inclusion of BMOs in a GMP for any local agency seeking state funds administered by the California Department of Water Resources for the construction of groundwater projects or groundwater quality projects. In addition the update includes a formal groundwater export policy which was a requirement of the original GMP.

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,* Judgement 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. The 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 Technical Advisory Committee (TAC). The committee is charged with establishing a program to monitor conditions in the basin, including, but not necessarily limited to, verification of future 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*." The United Water Conservation District 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 (United Water Conservation District, 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 the United Water Conservation District, the Santa Paula Basin Pumpers Association and the City of San Buenaventura. The Working Group has initiated a series of studies that will address the cause of the long-term gradual decline in groundwater elevations.

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.
- Investigation of groundwater and surface water inflow at Fillmore-Santa Paula Basins boundary.
- Evaluate groundwater confinement and differentiate measured wells by aquifer.
- Evaluate water level trends in both confined and unconfined parts of the Santa Paula Basin.
- Identify crop change over time.
- Investigation of groundwater storage change.
- Evaluate historical changes to the Santa Paula Creek channel and potential effects on basin recharge.
- Refine and finalize spatial and temporal Pumping Trends Report.
- Compilation of Santa Clara River infiltration data.
- Compilation of Santa Paula Creek infiltration data.

The technical evaluation of the spatial and temporal pumping trends within the basin has been completed (UWCD, 2011b), and the Technical Working Group of the TAC concluded that the long-term gradual decline of water levels in the basin are not due to shifts in pumping locations or magnitude over time.

2.1.4 DISTRICT-WIDE GROUNDWATER LEVEL MONITORING

United monitors groundwater elevations in all or portions of 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 vertical gradients between aquifer zones at these locations.

In excess of 2,400 water level measurements were collected by District staff in 2011, 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 the spring and annual low groundwater conditions in the fall. The locations of wells measured by United at various frequencies are shown by basin in Figure 2.1-2. The locations of wells with groundwater elevation measurements are represented in various figures in Section 4 of this report.

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.

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 the coastal basins 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 is also intended to define the extremes of water levels throughout the year.

Beginning in 2009, United has 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 2011, approximately 65 pressure transducers were deployed throughout the District (Figure 2.1-2).

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 wastewater percolation ponds. United obtains water level records from these various sources and archives the records in a central database.

The Groundwater Section of the Water and Environmental Resources Division of the Ventura County Watershed Protection District also maintains a long-term groundwater elevation monitoring program (VCWPD, 2012). 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 California Department of Water Resources (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 WATER QUALITY SAMPLING

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 saltwater intrusion monitoring network tracks the migration of saline water by direct seawater intrusion and the movement of chloride from clay layers between the aquifers. The network monitors the full series of aquifers from the Oxnard to the Grimes Canyon aquifer.
- Monitoring of wells allows documentation of both abrupt and long-term changes in water quality.

United staff samples numerous monitoring and production wells on a regular basis in order to evaluate the quality of groundwater within the District. Monitoring programs sometimes focus on specific areas within the District, typically for a specific type of degradation or improvement of water quality. In addition to United's regular sampling programs, water quality data are routinely acquired from other sources, most notably the California Department of Public Health (DPH) and the County of Ventura's Groundwater Section. Other sources of information include the California Department of Water Resources, 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 Oxnard-Hueneme 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 area 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. In recent years there has been interest in documenting increasing chloride conditions in the Piru basin. Water quality monitoring has increased in that basin, with much of the increased sampling being performed by the Groundwater Section of the Ventura County Watershed Protection District.

When water is delivered to the public, the California Department of Public Health 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 DPH. United regularly collects samples from the wells supplying the O-H potable water system, with sampling frequency exceeding the minimum DPH requirements. Water purveyors throughout California are required to report results of all water analyses to the DPH, and United regularly obtains these water quality records from the DPH for integration into United's water quality database.

United's groundwater staff regularly collects water quality samples from approximately 150 monitoring wells located throughout the District. Nearly all of these wells are PVC wells with a 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 line are used to purge other wells, where compressed air is released in the well below the water surface and water is "air lifted" to the surface by the air exiting the well. 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 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 over 200 wells in 2011, and this sampling significantly contributed to the water quality sample coverage for several basins within United's district boundary.

The distribution of wells sampled by United is shown in 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 monitoring 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 showing the number of wells monitored 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 United States Geological Survey (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 groundwaters 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 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 el 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 1.5.2, 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 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 subprojects of this effort include:

- Seismic reflection survey on south Oxnard Plain – this subproject focused on meso-scale geologic structures/features that were postulated to impact groundwater movement on the south Oxnard Plain;
- Time domain electromagnetic survey in the Port Hueneme and Point Mugu areas – this subproject was designed to reassess the areal extent of saline water intrusion and compare it to the USGS data from the early 1990s;
- 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; and
- Collection of flow profile data and discrete-depth water quality samples - conduct flow profiling, depth-specific sampling with water quality analyses, and mass balance calculations are proposed on existing production wells to identify salinity changes for Mugu and Hueneme saline water impact areas that may be masked in a high capacity well.

To date, two of these subprojects have been completed and brief summaries of the project results are presented below.

2.1.6.1 SEISMIC REFLECTION SURVEY ON SOUTH OXNARD PLAIN

In 2010 United conducted an approximate 6 mile high-resolution seismic reflection survey in the southern Oxnard Plain that was supported by a California Department of Water Resources Grant (UWCD, 2011a). The overall purpose of the seismic reflection survey was to resolve the structural geology in the area east of Port Hueneme to provide additional subsurface data to assist with the design of the western portion of the proposed Seawater Intrusion Injection Barrier. A primary goal of the project was to better understand the structural geology and stratigraphy associated with the aquifers in the area. The seismic reflection data was obtained along four lines totaling about 6 miles in length. In spite of the semi-urban environment and the challenging site conditions, the seismic reflection survey successfully provided high-resolution images of the Plio-Pleistocene stratigraphy in the study area at depths ranging from as shallow as 60 feet to over 2,000 feet below ground surface. By correlating the stacked migrated reflection sections and data from nearby oil and water wells, United Water was able to establish an interpretation that approximates the depth, thickness, and configuration of the two major aquifer systems in the area; the Upper Aquifer System (UAS) and the Lower Aquifer System (LAS).

The base of the LAS is reported to represent the bottom of the sediments containing fresh water underlying the Oxnard Plain. United's interpretation also identified reflecting horizons within these systems that could represent the boundaries of their component aquifers such as the Oxnard and Mugu aquifers in the UAS and the Fox Canyon and Grimes Canyon aquifers in the LAS. In addition, the interpretation identified three unconformities associated with the aquifers, including a strong continuous reflector that correlates with the unconformity that forms the boundary between the UAS and LAS.

One of the objectives of the seismic reflection survey was to confirm or deny the existence of an igneous "dome" structure in the central portion of the field area (extending between the UAS and LAS). A sedimentary mound type structure was also considered to possibly occur at that location instead of the igneous dome. The existence of the structure(s) was based on conflicting data. The study concluded that no igneous dome was interpreted to exist and the subsurface materials were deemed to be sedimentary. United's interpretation of the seismic reflection data does confirm the existence of a mound of stratigraphic origin.

One significant localized thick section of low-permeability material was resolved in the data and interpretation. The body of low-permeability material is located northeast of Port Hueneme. The thick part of the body is approximately 1.8 miles (northeast-southwest direction) by 1.3 miles (northwest-southeast direction) in lateral extent and is approximately 600 feet thick. It is directly in line with the submarine canyon at Port Hueneme and is described in literature as "clay deposits Old Hueneme Canyon" (Hanson et al, 2003). It likely represents the landward extension of the submarine canyon by Port Hueneme during a transgression of the sea.

This body of low-permeability material will have an effect on the placement and design of a proposed LAS injection barrier well field to prevent further saline intrusion on the southern Oxnard

Plain. It is located directly adjacent to the saline water "plume" on the northeast side. Wells will need to avoid that area at the depths of the low-permeability material in order to be successful at injecting water. The lateral limits and thickness/depth of the materials is defined well enough for the design of the barrier injection wells. In addition the low-permeability body can be strategically used for saline water blockage in part of the injection barrier system.

2.1.6.2 TIME DOMAIN ELECTROMAGNETIC SURVEY IN THE PORT HUENEME AND POINT MUGU AREAS

United Water performed a Time Domain Electromagnetic (TDEM) geophysical survey on the southern Oxnard Plain to assess the lateral limits of saline water intrusion in the Upper Aquifer System (UAS) and Lower Aquifer System (LAS) at four different depth ranges (UWCD, 2012a). The survey was designed to replicate a study performed by the USGS in the early 1990s that provided information about the vertical and horizontal extent of saline water intrusion (Zohdy et al, 1993). The field survey area was approximately 35 square miles and extended along the coast between Port Hueneme and Point Mugu (approximately 7 miles) and inland for approximately 5 miles. One hundred twenty five (125) soundings (data points) were obtained in agricultural fields, open private land, open preservation land, game preserve land, and in open areas on the Mugu Naval Air Station. The data were forward and inverse modeled for each sounding. The model data were used to construct resistivity maps, at four depth ranges typical of the UAS and LAS.

The investigation was successful at delineating earth resistivity values that are typical of saline and brackish water in both 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. The resistivity maps also exhibited configurations that are typical of geologic features which may be groundwater pathways for the migration of saline waters.

2.1.6.3 BOREHOLE ELECTRICAL CONDUCTIVITY SURVEYS IN EXISTING PIEZOMETERS IN PORT HUENEME AND POINT MUGU AREAS

United Water performed conductivity profiling in existing piezometers along the South Oxnard Plain in summer and fall 2011 to determine if the saline waters have begun to impact strata other than the screened intervals. United Water routinely records water levels and collects and analyzes water quality samples from several piezometer nests in the south Oxnard Plain. These piezometers provide much of the information about how chloride and TDS values have changed over time. The chloride concentrations are not constant with time or depth. These piezometer nests provide the opportunity to evaluate the vertical change in TDS over time. When the piezometer nests were initially constructed, borehole geophysical logs were performed in each borehole. Changes in the conductivity over time can be used to infer changes in the water chemistry. This technology works in PVC-cased piezometers (i.e., the conductivity tool can collect readings through the casing). By relogging these piezometers, the changes in the conductivity in the formation outside of the blank casing intervals can be assessed. Conductivity profiling of the piezometers, coupled with the production profiles from existing wells, will greatly increase our ability to evaluate how the vertical distribution varies in the study area. Data from the conductivity profiling is currently being evaluated and findings have yet to be published.

2.1.6.4 COLLECTION OF FLOW PROFILE DATA AND DISCRETE-DEPTH WATER QUALITY SAMPLES

This proposed subproject includes conducting flow profiling, depth-specific sampling with water quality analyses, and mass balance calculations on production wells to identify salinity changes for Mugu and Hueneme saline water impact areas that may be masked in a high capacity well. United Water proposes to field verify the TDEM geophysical results by performing production profiles and discrete-depth water quality sampling from existing production wells located near the leading edge of the saline zones identified by the TDEM survey. Production profiles (also called flowmeter surveys) are performed on wells to determine the distribution of water entering the perforated intervals. The results of a production profile are often presented as gallons/minute (gpm) per ft of perforated interval or percentage of the total flow per perforated interval.

Inflow rates to a production well can be measured and typically the flow rates are not equal along the length of the perforations. By identifying the proportional flow rates, discrete-depth water samples can be collected from each flow interval and mass balance calculations can be used to determine the water chemistry in the aquifer surrounding the inflow zones. These techniques are in use by many water districts and the USGS to better understand the impact well hydraulics have on water quality sampling and evaluate variations in groundwater geochemistry with depth. For our study, we propose to use this technique to look for production intervals within existing wells that have elevated chloride values and determine the depths at which the well has been impacted by saline waters. Funding for this subproject has been included in United's draft budget for the 2012-13 fiscal year.

In 2002 United sponsored a similar study for a number of high-capacity production wells in the Pleasant Valley Basin. Researchers from the USGS performed flow profiling and collected water quality samples at specific depths within the screened interval of the wells under pumping conditions. The work demonstrated that deeper portions of these wells generally produced little water but tended to have higher chloride concentrations (Izbicki et al, 2005a and Izbicki et al, 2005b). This study was proposed by United and funded by DWR through an AB303 local groundwater assistance grant.

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 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 Oxnard Forebay, but the lateral continuity and presence/absence of faulting were not addressed. The Oxnard Forebay is a critical component of the region's water supply system and is envisioned as a location for expansion of future groundwater pumping and the potential 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.

The Fox Canyon Groundwater Management Agency (FCGMA) is assisting financially with a Forebay Basin surface geophysical survey being performed by United Water with a grant from their *Groundwater Supply Enhancement Assistance Program (GSEAP)*. This is an ongoing project with 50+ time domain electromagnetic (TDEM) geophysical soundings collected to date. Additional field work is planned in 2012. United Water field crews have enjoyed extensive cooperation from land owners who have readily provided access to their property.

2.1.8 PIEZOMETER INSTALLATION ALONG SANTA CLARA RIVER

In fall 2011 United contracted for the installation of eleven new monitoring wells in the Oxnard Forebay. Nine of the wells are located along either bank of the Santa Clara River, from the Saticoy area to the area near the RiverPark pits. Two wells were installed adjacent United's Noble Pit recharge basins. The boreholes were drilled by a hollow stem auger rig and most of the wells were screened from approximately 60 to 100 feet below the land surface. These new wells were installed in order to better characterize groundwater recharge sourcing from flows in the Forebay reach of the Santa Clara River, and to evaluate how recharge from United's recharge operations in areas near the river interact with groundwater mounding associated with natural recharge within the river channel. Matching funds of 50% were supplied by the Fox Canyon GMA as part of their Groundwater Supply Enhancement and Assessment Program (GSEAP). The locations of the eleven new wells are shown on Figure 2.1-2.

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 aquatic habitat within the lower 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 STREAM FLOW

Flows in the Santa Clara Watershed are recorded by United, United States Geological Survey (USGS) and the Ventura County Watershed Protection District (VCWPD). 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 tributaries are monitored coming into the Ventura County portion of the watershed. United Water funds the USGS to monitor the flows above and below Lake Piru. The VCWPD funds the USGS to record Sespe and Santa Paula Creek while the VCWPD records Hopper and Pole Creek.

Additionally in 2011, over 150 manual discharge measurements were made in locations that are not at a continuous gauging location. These data provides the information needed to estimate benefits to each basin during the conservation/State Water release, discharge/percolation rates of each basin, and adjustment of environmental flows.

2.2.2 WATER QUALITY

United maintains a water quality monitoring program and samples from a number of locations (Figure 4.2-4) 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 at Blue Cut near 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 have fallen to levels common to the early 1990s (Figure 4.3-6), the result of lower chloride levels in State Water Project imports and a successful ban of self-regenerating water softeners in area homes.

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, and samples storm flow and dry weather base flows several times per year. These samples are analyzed for a broad suite of organic contaminants and metals as part of a storm water quality program required 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.

2.2.3 SANTA FELICIA DAM CONSERVATION RELEASES

United's conservation releases are designed to replenish the Piru, Fillmore and Santa Paula Basins by direct percolation from the Santa Clara River. The remaining portion of the release is diverted at the Freeman Diversion and is either spread for percolation into the Forebay, or is sent to the Oxnard Plain or Pleasant Valley Basins via the surface water delivery system. The conservation release can be adjusted in quantity (duration and magnitude) and timing to optimize benefits within the district. The quantity in most years is limited by the supply from the wet season runoff and the amount of State Water purchased. Lake Piru maintains a minimum pool of 20,000 AF of storage that is designed to keep the sediment deposits in the lake away from the outlet works. Releases beyond this point 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.

In 2011 there was 56,400 AF of stored water available for the conservation release. The following factors were considered when deciding on how much of the stored water was to be released:

- Provide enough storage capacity in Lake Piru to minimize the chances of spilling in 2012;
- Meet the needs of the downstream basins;
- Meet the needs of the surface water deliveries to Pleasant Valley and the PTP system; and
- Hold over enough water in the lake in case 2012 was a dry year.

The analysis found that the optimal volume to be released was 31,700 AF leaving 46,100 AF (with minimum pool) in the lake for the following year in case it was dry. Figure 2.2-1 shows the basic hydrology of inflows and outflows of Lake Piru.

Because the water levels were relatively high in the Piru and Fillmore basins due to the wet year and a 11,000 AF release from Castaic Lake, the release was designed to concentrate more on the lower basins. A higher release rate normally accomplishes this goal. The release started at 400 cfs in order to cut a channel across the Piru Basin so that a higher percentage of the release would end up downstream in Santa Paula basin and the Coastal basins (the Oxnard Forebay, Oxnard Plain, Mound, West Las Posas and Pleasant Valley basins). Once the channel was cut, the release was tapered back so that the duration of the release could be extended using the same volume of water. This type of release is now called a tapered release and has been done several times in the past few years.

The timing of the release was designed to coincide with the maximum demand for the surface water deliveries out in the Oxnard Plain. Peak demand occurs with the planting of the strawberries that take place from mid September to the end of October. Heavy groundwater pumping at the end of the dry season would otherwise meet this demand. The release started on September 12 and ended on November 6. Consideration was also given to allow enough time to dry out and prepare the percolation ponds so that they are ready for the 2012 wet season.

Of the 31,700 AF released from Santa Felicia Dam in 2011, approximately 15,700 AF (50%) of the water directly percolated into the Piru and Fillmore basins (Upper basins). The remaining 16,000 AF either percolated into the Santa Paula basin or was diverted at the Freeman Diversion for groundwater recharge or surface water deliveries. Below is a table showing the estimates of the distribution of percolated flows in each basin during the conservation releases since 1999 with 2011 being near the 12 year average of the releases in terms of total quantity of the release and the direct benefit to each basin. Figure 2.2-2 shows the conservation release and the associated direct benefit to each basin. Discharge measurements were made near the Piru and Fillmore basin boundary to calculate the amount of water that percolated into the Piru Basin, and measurements were also made at Willard Rd. for the Fillmore Santa Paula basin boundary to calculate what percolated in the Fillmore Basin. The remaining discharge measured at Willard Rd. is assumed to either benefit the Santa Paula Basin or diverted at the Freeman Diversion (“Lower Basins” in following tables).

Table 2-1 Benefits of the SFD Conservation Release due to direct percolation

Year	Total Released from SFD AF	Direct Deliveries in AF. of SFD Release to:			
		Piru Basin	Fillmore Basin	Lower Basins (groundwater recharge)	Surface water Deliveries PTP and PV
1999	22,800	5,700	3,500	11,200	2,400
2000	47,200	13,800	6,100	24,150	3,150
2001	47,400	14,000	2,900	28,300	2,200
2002	20,200	8,000	5,100	6,530	570
2003	29,000	21,000	3,500	3,600	900
2004	12,200	8,000	2,150	1,600	550
2005	9,100	na	na	4,500**	0
2005	23,400	na	na	17,200**	150
2006	30,900	na	na	17,200**	1,600
2007	40,700	15,900	6,300	12,200	6,400
2008	44,400	15,400	5,700	17,400	5,800
2009	26,700	13,200	4,700	5,200	3,000
2010	33,000	14,500	4,800	10,700	3,200
2011	**31,700**	**12,400**	**3,300**	**14,100**	**1,600**
Average	29,907	12,900	4,368	12,420	2,251
13 yr. Total	448,607	154,800	52,418	186,300	33,771

*2005 had two conservation releases. Portion of the release includes spill water when the lake was full

** measured at the Freeman Diversion

2.2.4 IMPORTATION OF STATE WATER

Ventura County has a 20,000 AF allocation of State Water. United Water's share of the allocation is 5,000 AF. Port Hueneme Water agency uses 1,850 AF of the original 5,000 AF and takes delivery through Metropolitan Water District. The 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 Piru Creek. United may receive this water from November 1st through the end of February of each year. Typically the conservation release will end before the State Water has arrived in Lake Piru. In order to release the state water that year, United will continue the release below the lake's minimum pool to the volume of State Water that was purchased, knowing that state water will fill it back to the minimum pool by the end of November. The State Water allows the conservation release to be extended a few extra days due to the extra volume of water. The volume of water that percolates into each basin on the extended days of the release was considered to be the direct benefit to each basin.

In 2011 the State Water Project made available 80% of water allocations held by subscribers to the system. United received its 80% or 2,520 AF by a release from Pyramid Lake in November and December of 2011. Due to the wetter than normal conditions United chose to store the State Water until 2012 when it can be delivered at the end of the conservation release, along with any other additional State Water purchased for 2012.

The table below is a summary of all the state water purchased by United Water along with the direct benefits to each basin from percolation. Detailed stream flow measurements are taken near the basin boundaries throughout the releases to determine where the state water is percolating.

Table 2-2 Summary of State Water Release from Santa Felicia Dam

	Summary of State Water Released From Santa Felicia Dam in 1991-2011 (Values in AF)				
Year State Water Purchased	From Santa Felicia Dam	Release to Upper Basins (Fillmore and Piru)	Releases to the Lower Basins (Santa Paula and Coastal Basins)	Delivered to PV. And PTP	Recharge To Lower Basins
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	1890	844	1046	116	930
2008	1980	673	1307	306	1001
2009	3150	1045	2105	724	1381
2010	3150	917	2233	559	1674
2011	**2520***				
Total	28,542	14,416	14,126	2,264	11,862

* To be released in 2012 conservation release

The benefit of the conservation release along with the State Water released can be seen in Figure 2.2-3. Since November of 2007 a transducer has been monitoring water levels in a monitoring well near the river in the Piru Basin. The graph shows the immediate rise in water levels in a well during the releases (shown in red). Because the well is approximately 600 feet from the flow in the river, a mound will build rapidly when the release starts and dissipate a little more slowly at the end of the release. Water levels are always considerably higher following the release, compared to the projection of water levels trends before the release.

2.2.5 PIRU DIVERSION EVALUATION

The Piru Diversion has been historically operated to divert surface water into United's nearby spreading grounds for groundwater recharge however this facility has not been operated since September of 2008. The diversion is located on the western bank of lower 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 river channel, a sluice channel that can accommodate approximately 200 cfs, and a diversion structure with a 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 is not in compliance with National Marine Fisheries Service standards for diverting water in a stream that is considered by NMFS to constitute anadromous waters for Southern California steelhead. Therefore the facilities have been included as parts of United's Habitat Conservation Plan (HCP) so that the facility will be covered for incidental take. The diversion will not be put back into operation until the take permit has been issued and the facility has been retrofitted.

2.2.6 SANTA CLARA RIVER FLOW DIVERSIONS

The Freeman Diversion diverted 92,600 AF in 2011. This represents about 150% of the historical average diversions since 1955. In wet years such as 2011 various operational strategies were implemented to assure maximum yield at the diversion. Such strategies included limiting turbidity turn-outs, shifting the locations to spread water to reduce mounding near the river, alternating ponds to insure the maximum possible percolation rates, and implementing new SCADA controls to optimize canal levels. Some of these strategies are discussed below.

High flows in the river are normally associated with high turbidity. During times when the river is at its peak, diversions stop so that the sediment-laden water is not diverted. A recently implemented more aggressive schedule to divert more turbid water allowed the facility to divert 2,000 to 3,000 acre feet more than it would have in prior years. This more aggressive turn in procedure increases the use of the desilting basin, resulting in the need for more frequent cleanouts.

United's aggressive wet season spreading at Saticoy and the Noble Basin increased water levels in the surrounding area to a point where groundwater from spreading in the Saticoy and Noble basins was discharging back to the river near the Highway 118 Bridge. Rising groundwater in this area reached around 50 cfs of discharge in the river in the month of April. The spreading ponds further away from the river were used to limit the amount of discharge back to the river. The discharging water is in large part due to the degradation in the riverbed near the Highway 118 Bridge. The riverbed is currently about 20 feet lower than it was in the early 1950's allowing for a larger elevation differential between the pond and the river. A portion of the discharging water will percolate downstream of the discharging point. With the balance of the discharging river that breached the Forebay to become part of the environmental flows that were needed to maintain downstream passage for the Southern California steelhead.

Nearly 72,000 AF were spread for groundwater recharge at United's three recharge facilities. El Rio recharged nearly half of the water, with Saticoy and the Noble Basins making up the other half (Figure 2.2-4). The remaining 20,600 AF went to surface water deliveries discussed in Section 1.4.6.

2.2.6.1 EL RIO RECHARGE BASIN

Recharge to El Rio exceeded the 56 year average in all months except for August. The total volume recharged was approximately 160% of normal. El Rio became the preferred facility to recharge due to the mounding of water and discharge back to the river at the other facilities. Due to the active O-H well field surrounding the facility, the groundwater mounding does not reach the surface thereby reducing percolation rates.

Table 2-3 Recharge to El Rio for 2011 calendar year

Recharge to El Rio AF		
	2011 Year	average since 1955
Jan	3,776	2,691
Feb	3,617	3,123
Mar	5,283	3,473
Apr	6,070	2,709
May	2,188	2,035
Jun	2,594	1,053
Jul	1,459	871
Aug	224	1,144
Sep	2,283	1,604
Oct	4,370	1,705
Nov	3,520	1,548
Dec	2,461	2,138
Totals	37,845	24,096

2.2.6.2 NOBLE RECHARGE BASIN

The Noble Basin is normally the last of United's Forebay facilities to be used for groundwater recharge. It is difficult to maintain the ponds during the wet season due to greater water depths and proximity to groundwater. During 2011, water was spread into the basin for a portion of four months during the natural runoff period, and two months during the conservation release. The average spreading at this facility was nearly double the average since it was built in 1994.

Table 2-4 Recharge to the Noble Basin for calendar year 2011

Recharge to Noble Basin AF		
	2011	average since 1994
Jan	766	275
Feb	2,507	808
Mar	2,259	1,279
Apr	4,305	1,385
May	0	614
Jun	0	435
Jul	0	210
Aug	0	108
Sep	0	150
Oct	137	153
Nov	705	160
Dec	0	175
Totals	10,679	5,754

2.2.6.3 SATICOY RECHARGE BASINS

The Saticoy facilities recharged 23,400 AF in 2011, which is about average for the 55-year period since construction of Lake Piru. As mentioned above, mounding was occurring under the ponds and recharged water was flowing back out to the river. Priority was given to the El Rio facility at this time to attempt to decrease the amount of rising groundwater going back to the river. Regardless of the mounding, United was able to divert its instantaneous surface water diversion license limits with consideration to the environmental bypass flows for the entire year.

Table 2-5 Recharge to Saticoy for calendar year 2011

Recharge to Saticoy AF		
	2011	average since 1955
Jan	7,608	2,229
Feb	1,946	2,504
Mar	2,208	3,361
Apr	4,478	3,074
May	265	2,377
Jun	164	1,461
Jul	0	1,233
Aug	0	1,076
Sep	816	1,453
Oct	5,041	1,927
Nov	909	1,270
Dec	0	1,662
Totals	23,435	23,627

2.2.7 SATICOY WELL FIELD USAGE AND CREDIT SYSTEM BALANCE

In conjunction with the conservation releases from Santa Felicia Dam, United temporarily stores surface water beneath the Saticoy Spreading Ground for later delivery to the overdrafted areas of the Pleasant Valley and Oxnard Plain basins. United constructed the Saticoy well field in 2004, allowing the pumping of mounded groundwater for delivery to the PV and PTP systems. The Fox Canyon Groundwater Management Agency adopted a resolution that created a pump- back storage program of the Saticoy spreading system and its well field usage. Recharged water from the conservation release at the Saticoy Facility to the surface water delivery system can be pumped back for 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 an additional 24,900 AF have been stored during the conservation releases at Saticoy, with a total of 9,550 AF extracted for surface water deliveries. The credit system does not include the State Water that is part of the conservation release or the well field pumping when the water levels have “mounded”.

Table 2-6 Credit system for the Saticoy Well Field

	Total Available at the Start of year	Saticoy Well Field S.W. deliveries	Unused allocation	Recharged to Saticoy at end of year less state water
2006	0	0		7,846
2007	7,846	1,753	6,093	3,247
2008	9,340	3,845	5,495	5,695
2009	8,942	2,455	6,487	1,045
2010	6,740	759	5,981	1,821
2011	2,866	737	2,129	5,237

2.2.8 CASTAIC LAKE FLOODFLOW RELEASE

United is the lead member of a water conservation agreement between the California Department of Water Resources and the Downsteam Water Users (DWU). The DWUs consist of United, Los Angeles County, Newhall Land and Farming, and Valencia Water District. The program is designed to hold back flood flows in Castaic Lake and release them at a later date in a manner that allows the flows to percolate in the basins downstream of the dam, benefiting the DWU's. United takes the lead role for the DWUs in requesting the storage and releases, and by monitoring of the associated release to make sure that the flows are benefiting the basins. In 2011 approximately 11,000 AF of captured flood flows were released. Most of the released water percolated into the Piru Basin with some of it making it to the Fillmore Basin. Figure 2.2-5 shows the water level increase in a key well in Piru Basin during the associated release. Figure 2.2-6 shows the inflows/outflows from Castaic Lake in 2011.

2.2.9 BOUQUET RESERVOIR RELEASES

United has an agreement with the Los Angeles Department of Water and Power (LADWP) that provides for the release of flows from Bouquet Reservoir to recharge the aquifers of the Santa Clara River Valley to the extent that they were recharged from Bouquet Canyon outflows prior to construction of the reservoir. The agreement stipulates that LADWP release between 2,100 and 2,194 acre feet 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 resulted in raising the streambed and pushing it toward Bouquet Canyon Road. In several locations the stream is higher than the road and on occasion stream flows have entered the road posing a threat to public safety. When water 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-spined stickleback, and flow changes require special consideration for this species. United has been participating in the stakeholders meetings to ensure that the deficit of water will eventually be released. By 2008 the deficit was approximately 4,400 AF. Since releases have at times been more than the required release, the overall deficit has been reduced to 3,328 AF.

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 2011 conditions in the basins are included in Chapter 4 of this report.

3.1 GEOLOGIC SETTING

The United Water groundwater basins are part of the Transverse Ranges geologic 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 seven basins 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.

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).

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 United Water basins.

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 Aquifer System (UAS) and Lower Aquifer System (LAS) (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, and irrigation return flow in some agricultural areas.

Figure 3.2-1 is a schematic of the UAS and LAS showing their subsurface sequence. The figure also shows general depths in feet. However, more recent work with geophysical logs has suggested that some of the aquifers are actually deeper than originally thought and indicated on this schematic. Also note that the clay layers (aquicludes) shown in the UAS are inter-fingering and in some places discontinuous.

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 zone,” which generally contains poor-quality water. This zone extends from the surface to no more than 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 zone. The semi-perched zone is rarely used for water supply on the Oxnard Plain.

3.2.2 UPPER 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 occurs between the 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, 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 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 U.S. Geological Survey 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.

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 here are really sub-basins 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. The Mound basin receives recharge from the Santa Paula basin and 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 sub-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.

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 occasionally operates the Piru Spreading Grounds, a 44-acre recharge basin which diverts water from Piru Creek for groundwater recharge. 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 now 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 comprise 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 forms 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 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 8,430 feet. At the western basin boundary, the San Pedro Formation extends to a depth of 5,000 to 6,000 feet.

The groundwater flow gradient in the Fillmore basin generally creates an east to west movement of groundwater through the alluvium. Groundwater that infiltrates from Sespe Creek generally flows 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 into the Santa Paula basin is likely significant, although some suggest 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 is considered to be in hydraulic connection with the Fillmore Basin. To the south, the Oak Ridge fault forms a partial barrier to groundwater movement. On 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 more complex, with local uplift and faults mapped by some investigators. Although there is general agreement that there is some 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, suggesting some degree of confinement. During high rainfall years, monitor wells in the southern portion of the basin near the Freeman Diversion, and historically some other wells near Saticoy, have shown artesian flow. The complex subsurface geology in the western portion of the basin complicates interpretations of groundwater flow in this area.

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 basin extends several miles into the 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 Upper Aquifer System 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, 2012b).

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 2012b). 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, 2012b). 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, 2012b).

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, 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 U.S. Geological Survey 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. 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. When groundwater levels are below sea level along the coastline, there may also be significant recharge by seawater flowing into the aquifers.

Vertical gradients also commonly exist between aquifer units on the Oxnard Plain, resulting in some degree of water movement through low-permeability units that occur between most of the major aquifers. When LAS water levels are substantially lower than UAS water levels (creating a downward gradient), there may be substantial leakage of UAS water into the LAS through the confining clays. Likewise, a downward pressure gradient can exist between the Semi-perched aquifer and the Oxnard aquifer when heads in the shallow confined Oxnard aquifer are lowered (either regionally by drought conditions or locally by pumping wells). The movement of poor quality water from the semi-perched zone to the Oxnard aquifer has been documented in some locations, with abandoned or improperly constructed wells being a 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 are considerably deeper in the greater area surrounding Mugu Lagoon. Deposits of the LAS are generally finer-grained 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.

3.3.7 PLEASANT VALLEY

Pleasant Valley 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 runs along the base of the Santa Monica Mountains, and the Camarillo fault along the Camarillo Hills to the north.

The Pleasant Valley basin is differentiated from the Oxnard Plain basin by a general lack of 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). Although where coarse-grained deposits are present, wells in the UAS underlying Pleasant Valley can yield large quantities of water to wells.

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. 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). 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). Groundwater age increases with depth and water within deeper aquifers has contacted aquifer material longer, reacting to a greater extent with these materials than water in overlying aquifers. 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.

High-chloride concentrations are present in water from wells throughout Pleasant Valley, especially along the southern edge of the valley near the Bailey Fault. Wells yielding high-chloride water in this area may have been drilled too deep and directly penetrated deposits having high-chloride water, or high-chloride water may have invaded deeper freshwater aquifers from surrounding and underlying deposits as a result of pumping. However, despite their isolation from sources of ground water recharge, chloride concentrations in water from deep wells in Pleasant Valley increase during dry periods when ground-water pumping increases. Conversely, chloride concentrations decrease during wetter periods when alternative sources of irrigation water are available from surface supplies and groundwater pumping decreases. 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). In addition to water from surrounding and underlying rocks, irrigation return also may contribute to high chloride concentrations in deep wells that are partly screened in the upper aquifer system. More recently, groundwater recharge from Arroyo Las Posas in the northern portion of the basin has been recognized as an additional source of salt in the basin.

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 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 (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 FCA 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 ANNUAL HYDROLOGIC CONDITIONS

This section details the range of hydrologic conditions observed throughout United's district boundaries in the year 2011. While the emphasis is placed on surface water and groundwater conditions over the past year, some discussion is devoted to the comparison of recent conditions to conditions documented in the historical record. Recorded rainfall totals were commonly several inches greater than average, but significant storm events occurring in December 2010 and March 2011 resulted in high base flows in the Santa Clara River and its major tributaries. The groundwater response to the above-average flow in stream channels, increased surface water deliveries and reduced pumping associated with the wet conditions was favorable.

4.1 PRECIPITATION AND EVAPOTRANSPIRATION

United participates in data collection in partnership with the Ventura County Watershed Protection District's three rainfall gauges, two of which are also evaporation stations. The VCWPD maintains approximately 125 gauges around the county (Figure 4.1-1). United's gauges are located at the field offices in Saticoy, El Rio, and at the guard station at the Lake Piru. United also maintains records from the gauge at the office in Santa Paula for its own use. United's monitoring stations showed that precipitation was about 136% of normal for the water year, with December and March accounting for 65% of the rainfall. Lake Piru recorded 28.48 inches of rainfall, approximately 8.6 inches more that the average received at that location, and in the top 20% in terms of rainfall totals for this station.

Table 4-1 Monthly Precipitation for water year 2011

Monthly Precipitation Data - 2010-11 Water Year													
Gauge Location	**Gauge no.**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**
El Rio	**231**	1.87	1.01	8.43	0.53	2.34	4.58	0.00	0.55	0.10	0.00	0.00	0.00
Lake Piru	**160**	2.04	1.54	11.92	0.62	5.27	6.22	0.06	0.80	0.01	0.00	0.00	0.00
Santa Paula	**245**	2.11	1.07	9.61	0.30	3.64	6.03	0.00	0.89	0.14	0.00	0.00	0.00

4.2 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 long period of record for comparison purposes. The year 2011 overall would fall in the normal to wet category in terms of both precipitation and run-off. Below is a brief discussion of how 2011 compares 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.

4.2.1 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. The major tributaries include Castaic Creek and San Francisquito Creek in Los Angeles County, and Sespe, Piru and Santa Paula creeks in Ventura County. While the Los Angeles portion of the watershed accounts for 40% of the total area, it only produces about 20% of the total river flow, with dry-season base flows sustained by discharges from wastewater treatment plants and rising groundwater from the Eastern groundwater basin. As mentioned in other sections of this report, even though 2011 was wetter than most years, large sections of the main stem of the Santa Clara River remained dry for most of the year.

4.2.1.1 FLOW IN THE SANTA CLARA RIVER WATERSHED

Surface water flows in the Santa Clara River system were well above normal for the 2011 calendar year. The season started out wet with an early storm in December 2010, before the reporting period for this report. Figure 4.2-1 shows monthly flows in each of the tributaries. The storm peaked Sespe flows over 3,000 cfs a couple of times before runoff subsided in late February. Two smaller storms were then followed by a large March storm where the Sespe's peak flow exceeded 35,000 cfs. Flows in the Sespe were over 1,000 cfs for the next 10 days. Figure 4.2-2 shows the monthly flows in the Sespe compared to the monthly average flows. The response to the March storm was much different in the Piru watershed due to the elevation difference between the two watersheds. The higher elevations in the Piru watershed accumulated several feet of snow. The storm resulted in flows peaking at about 600 cfs in Piru Creek at Pyramid Lake. The runoff then subsided to less than 200 cfs over the next couple of days. A warm period then melted the snow, creating diurnal fluctuations in runoff of up to 600 cfs in Piru Creek (Figure 4.2-3).

The USGS station 111090000, Santa Clara River near Piru, measures the entire contribution from Los Angeles County's portion of the watershed that flows into Ventura County. This station recorded a peak flow of nearly 9,000 cfs in the March storm. Flows subsided to a little over 300 cfs within a couple of days after the peak. A large release from Castaic Lake in the month of April brought the average flow up to 11,000 AF that month.

Table 4-2 Total Discharge for various stream flow stations

USGS/VCWPD Stream flow Stations	Total Discharge for 2011
	AF
Santa Clara River Near Piru USGS Sta. 11109000	61,824
Piru Creek Above Santa Felicia Dam USGS Sta. 11109600	61,787
Piru Creek Below Santa Felicia Dam USGS Sta. 1110900	36,175
Sespe Near Fillmore USGS Sta. 1111300	124,500
Santa Paula Creek VCWPD 709	29,700
Santa Clara River at Victoria VCWPD 723	121,052

The natural runoff in most of the tributary watersheds was about 130% to 140% of average. The main exceptions were flows coming from Los Angeles County which were 156% of the average, and flows below Santa Felicia Dam which were near normal. Los Angeles County's flows may have been proportionally higher than the other watersheds for two reasons. Wastewater discharge to the river has been gradually increasing since the late 1970s, and the DWR did not appropriate any storm inflow into Castaic Lake in 2011 because all stored inflows could be beneficially used downstream in April and May. See Section 2.2.8 for discussion concerning the Castaic flood flow release.

4.2.1.2 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 weir where surface water arrives at United's El Rio recharge basins. 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 of the District. Sampling is conducted every three month at most of the sites, but more frequently at some key locations (Santa Clara River: every month 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 flow is higher. Results from United's 2011 surface water sampling are shown on Figures 4.2-4 and 4.2-5, where the annual recorded maximum concentrations of chloride and TDS, respectively, are displayed over the annual minimum 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 is documented.

Water quality in Piru Creek is influenced by 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 and Lake Piru can be much higher than what would occur naturally. In 2011 the maximum-recorded chloride above Lake Piru was 57 mg/l, a value lower than many recent years due to lower State Water chloride concentrations and above-average precipitation in the watershed.

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. Nearly 50% of the chloride load in wastewater discharges is from the chloride load in delivered water (LACSD, 2008). Additional chloride loading occurs during beneficial use of the delivered water, but 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 decade 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 4.2-6). 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 (Figure 4.3-6). This is likely the result of lower chloride levels in State Water Project imports and a 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 2011 documented chloride concentrations ranging from 79 to 132 mg/l. Chloride concentrations in the water released from Lake Piru ranged from 47 to 59 mg/l over the same time period (Figure 4.2-4). All surface water sample locations recorded lower-than-average chloride in 2011 following the abundant rainfall in the winter and spring.

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 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. Continuous river flow from Los Angeles County 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 2011 was 69 mg/l (Figure 4.2-4).

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 4.2-7 and Figure 4.2-8). Under dry conditions groundwater discharge 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 4.2-7). 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 570 to 1150 mg/l in 2011 (Figure 4.2-5).

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 4.2-9). A weak seasonal signature has been observed, with nitrate concentrations rising slightly in the fall (UWCD, 2008). For the 26 samples collected at Freeman Diversion in 2011 the maximum-recorded nitrate concentration was 8.4 mg/l, well below the CA DPH health standard of 45 mg/l.

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 organic contaminants and metals as part of a storm water quality program required by the Los Angeles Regional Water Quality Control Board. Detections of organic contaminants such as pesticides are uncommon and generally of low concentration (VCWPD, 2010)

4.2.2 CALLEGUAS CREEK

United does not actively gauge 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.

4.3 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 2011 basin conditions within the eight groundwater basins which fall wholly or partially within United's District boundaries. Following the favorable recharge conditions in the watershed in the winter and spring of the year, and large releases from Lake Piru and Castaic Lake, groundwater conditions were generally good compared to other recent years. Some discussion in the following section is devoted to comparing current conditions to past periods of drought, or periods pre-dating some major water supply projects within the District.

4.3.1 PIRU BASIN

The Piru basin has the capacity to rapidly accept water from the channel of the Santa Clara River and tributary streams. Some component of the water stored in the basin is slowly discharged to the downstream Fillmore basin, so that in some ways the Piru basin acts as a "forebay" to downstream groundwater basins in the Santa Clara River Valley. Surface water discharge of rising groundwater at the west end of the basin is greater when water levels are higher in the downstream portions of the basin. Groundwater elevations tend to remain well above historic lows, but over the past decade chloride impacts sourcing from Los Angeles County have migrated down past the midpoint of the basin.

4.3.1.1 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 on the hydrograph in Figure 4.3-1. The historical record for this well shows that groundwater elevations in the Piru basin fluctuate dramatically, and that the basin is capable of rapid recovery of water levels following drought periods. 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. Although 2011 was a moderately wet year the basin did not fill to historical highs. The 2011 recorded high groundwater elevation at United's key well is approximately 12 feet lower than recorded high groundwater elevations. The groundwater elevation recorded in this well in 1991 was 510 feet above sea level, at the end of a period of drought.

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 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 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 like 2011.

Groundwater elevation contours were interpreted from measured groundwater elevation highs from the spring of 2011 and groundwater elevation lows from the fall of 2011, and are shown in Figures 4.3-2 and 4.3-3 respectively. Groundwater flow is consistently from east to west, roughly following the land surface gradient of the river channel. Depths to water are greater along the northern portions of the basin where alluvial fan deposits elevate the land surface. Groundwater elevations were similar in the spring and fall of 2011, in part due to a large fall release from Lake Piru and a late spring release of stored runoff from Castaic Lake.

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 Los Angeles County infiltrates to groundwater and the river often goes dry. Spring 2011 groundwater elevations are approximately 20 feet higher than in fall 2011 in this area.

Groundwater rises near the constriction at the downstream west end of the basin, contributing flow to the Santa Clara River. Groundwater elevations near the constriction at the west end of the basin are historically more stable than those in the central and eastern portions of the basin. Recorded groundwater elevations are approximately the same in this area in the spring and fall of 2011. The contours also show groundwater flow to the Fillmore basin to the west.

4.3.1.2 GROUNDWATER EXTRACTIONS

Reported groundwater extractions from 101 active wells in the Piru Basin totaled 11,700 acre-feet for the 2011 calendar year. This is 720 acre-feet less than the historical average for the period 1980 to 2011, the period of available records. 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. The historical annual extractions for the Piru basin are shown in the histogram in Figure 4.3-4. 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 4.3-5 is a map showing reported groundwater extractions from individual wells in the Piru Basin for the 2011 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 crops here are irrigated with water piped in 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 pumped from lower areas of the basin and piped to higher elevations. In recent years a large number of orange orchards have been removed and replaced by row crops or box tree nurseries.

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 at the western boundary of the basin and extraction of groundwater by wells.

4.3.1.3 WATER QUALITY

Over the past decade 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 4.3-6). The chloride plume associated with these discharges has made a steady advance with groundwater flow down the Piru basin. The extent of chloride impacts is now approaching Hopper Creek in the western third of the basin (Figure 4.3-7). 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. More recently, chloride concentrations in Los Angeles County wastewater discharges are improving, the result of a successful campaign to remove self-regenerating water softeners from Santa Clarita residences and lower chloride concentrations in imported State Water Project deliveries. In the western portion of the basin chloride concentrations are generally less than 70 mg/l, indicative of background levels within the basin (DWR, 1989).

The Piru basin generally does not have problems with nitrate contamination, and samples collected in 2011 show only one well exceeding the MCL of 45 mg/l (VCWPD, 2012). Many wells record TDS concentrations of 1,200 mg/l or less, but some wells record TDS concentration twice this value (VCWPD, 2012). Water quality of the Piru basin is characterized more thoroughly in the revised Groundwater Management Plan for the Piru and Fillmore basins (Piru/Fillmore Groundwater Management Council, 2011).

4.3.2 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 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 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. Discharge to the downstream Santa Paula basin is thought to be significant, especially during high groundwater conditions such as those observed in 2011.

4.3.2.1 WATER LEVELS

Many water levels 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 4.3-8). 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. The 2011 recorded high groundwater elevation at United's key well is approximately 3.1 feet lower that the 1998 recorded high groundwater elevation, and approximately 26 feet higher than the recorded low groundwater elevation during the 1987 to 1991 drought.

Fillmore basin groundwater levels likely 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 Fillmore basin receives most of its recharge from the Santa Clara River and Sespe Creek.

Groundwater elevation contours are shown for spring and fall 2011 in Figures 4.3-2 and 4.3-3. 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 few wells exist here, which constrains interpretations of groundwater flow. Well control in the Sespe Upland area is also poor, but groundwater flow here is thought to be predominantly north to south. Along the valley floor groundwater gradients are quite uniform and are similar for the spring and fall of 2011. The contours merge at the west end of the basin where the groundwater flow is east to west. Groundwater elevations in wells located in the Sespe Upland area and in the Pole Creek fan area of the basin generally exhibit more variability than well wells along the valley floor.

The relatively tight contours shown in the eastern Fillmore Basin near the basin boundary show a steeper gradient as groundwater moves from the constriction of the Piru narrows and moves 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. At this discharge area of the basin contouring shows that spring and fall 2011 groundwater elevations are approximately the same (Figures 4.3-2 and 4.3-3). Extensive wetlands in this area are clearly visible on aerial imagery.

4.3.2.2 GROUNDWATER EXTRACTIONS

Reported groundwater extractions from 266 wells in the Fillmore Basin totaled approximately 40,855 acre-feet for the 2011 calendar year. This is 3,337 acre-feet less than the historical average from 1980 to 2011. The historical annual extractions for the Fillmore basin are shown in the histogram in Figure 4.3-9. Recently and historically, agriculture has been the predominant user of groundwater in the basin.

Figure 4.3-5 is a map depicting reported groundwater extractions from individual wells in the Fillmore Basin for the 2011 calendar year. This graphic shows that: 1) the City of Fillmore pumps from three wells located in the north Pole Creek fan area near Sespe Creek and no longer pumps from wells located near the Santa Clara River; 2) 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; 3) few active wells in the Sespe Upland area and most active wells are located at lower elevations; and 4) Groundwater extractions from wells at the Fillmore Fish Hatchery located at the eastern boundary of the basin accounts for a significant portion of the groundwater extractions of the basin. In 2011 Fillmore Fish Hatchery wells reported pumping of 9,146 acre-feet (22% of the total groundwater extractions from the basin).

Twelve mutual water companies operate in the Fillmore Basin, serving water primarily for 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. In recent years many orange orchards at lower elevations have been removed and replaced by row crops or box tree nurseries. Plantings of citrus and avocado remain the primary agricultural land use at higher elevations.

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)

4.3.2.3 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. Deeper aquifer units may have elevated concentrations of iron and manganese, a common occurrence throughout Ventura County.

Chloride concentrations from samples collected in 2011 are shown on Figure 4.3-7. Recorded concentrations exceeding 70 mg/l are uncommon, and limited to the area located south of the Santa Clara River. Concentrations in the 40s and 50s in the downstream/discharge portion of the basin are likely indicative of background chloride concentrations in the basin.

4.3.3 SANTA PAULA BASIN

Groundwater storage in the Santa Paula basin is generally less dynamic than in surrounding basins. Pumping in the Santa Paula basin is managed by a stipulated Judgment which assigns pumping allocations to each basin pumper that restricts the amount or groundwater each pumper can extract (within 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 with poor water quality or areas of the basin that are not readily recharged.

4.3.3.1 WATER LEVELS

Long-term records of groundwater elevations in the Santa Paula Basin indicate that water levels do not recover as readily as 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 sediments of low permeability. The basin likely receives significant recharge as underflow from the Fillmore basin. Recent gauging of 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, may have negatively affected the amount of recharge derived from this source.

Historical groundwater elevations dating from 1923 to present are shown in a hydrograph for United's key well for the basin (Figure 4.3-10). The well is located near Peck Road and Highway 126 in the eastern portion of the basin. The hydrograph shows that groundwater elevations in spring 2011, a moderately wet year, were higher than in spring 2010, a year of nearly average precipitation. The hydrograph also shows that the recorded high groundwater elevation for 2011 was approximately 8 feet lower than the recorded high groundwater elevation in 1998, and approximately 30 feet higher than the recorded low groundwater elevation during the 1987 to 1991 drought.

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 (UWCD, 2009; Santa Paula Basin Technical Advisory Committee, 2011).

Figure 4.3-11 and Figure 4.3-12 show groundwater elevation contours in the Santa Paula Basin for spring and fall 2011, respectively. The spring contours represent the 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 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. The relatively tight contours just west of the Santa Paula-Fillmore boundary show an area of recharge to the basin. 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.

4.3.3.2 GROUNDWATER EXTRACTIONS

A histogram of reported basin pumping from 1980 to 2011 is shown in Figure 4.3-13. In recent years municipal pumping has accounted for more than 20% of the total pumping from the basin. The total reported groundwater extractions from 124 active wells in the Santa Paula Basin totaled 24,265 acre-feet for the 2011 calendar year. This is 1,432 acre-feet below the long-term average of 25,697 acre-feet. A 2003 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 suggested that the yield of Santa Paula basin is probably near the historic average pumping of about 26,000 acre-feet per year.

Figure 4.3-14 is a map showing groundwater extractions by wells in the Santa Paula Basin in year 2011. The map shows significant pumping within the Santa Paula city limits and near the Fillmore basin boundary. Numerous wells report pumping 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 around 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 areas of the central and western 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 to agriculture in the area of Santa Paula Canyon. 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.

Farmers Irrigation Company, Thermal Belt Mutual Water Company and Canyon Irrigation Company pumped a combined total of 9,125 acre-feet in 2011. This pumping totaled approximately 38% of all groundwater extracted from the basin in 2011.

4.3.3.3 WATER QUALITY

Water quality is fairly variable 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 in calendar year 2011 are shown in Figure 4.3-15, with the highest concentrations recorded in the west. In these wells sulfate is commonly a large contributor to TDS. 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, with one well measuring nitrate over the MCL of 45 mg/l in 2011.

United conducts groundwater quality monitoring 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 thorough characterizations of groundwater quality in the Santa Paula basin can be found in other publications (DWR, 1989; Santa Paula Basin TAC, 2011).

4.3.4 MOUND BASIN

The Mound Basin is located in the westerly portion of the District and has experienced over time 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.

4.3.4.1 WATER LEVELS

Historical groundwater levels for a key monitoring well in the Mound Basin are shown in Figure 4.3-16. 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 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.

Recharge of the aquifers in this basin comes from multiple sources such as 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, 2012b).

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, 2012b). 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 quite 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 at times by sparse data. Available groundwater elevation data for the spring and fall of 2011 are presented in Figures 4.3-17 and 4.3-18. Increased collection of water level records is recommended in this basin to better define groundwater gradients between this basin and adjacent basins. The recent installation of monitoring wells north of the Santa Clara River near the northwestern margin of the Forebay should be 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.

4.3.4.2 GROUNDWATER EXTRACTIONS

The City of Ventura is the major municipal and industrial groundwater pumper in the Mound basin, with its wells concentrated in the area 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 4.3-19). Municipal pumping peaked in 2003 and has declined fairly steadily in recent years, with agricultural use predominating since 2007. Since the mid-1980s agricultural pumping has averaged nearly 4,200 acre-feet per year with a peak annual production of 5,850 acre-feet recorded in 1990. In 2011 reported agricultural pumping totaled 3,120 acre-feet with municipal and industrial pumping reaching 1,525 acre-feet.

4.3.4.3 WATER QUALITY

While the quality of the groundwater produced by most wells within the Mound Basin is suitable for municipal and agricultural uses, the basin is not known for the high quality of its groundwater. Water quality is variable between wells, and many records indicate somewhat elevated concentrations of TDS, sulfate, hardness and other analytes. Water quality appears to be relatively stable among many of the Mound basin wells having long-term water quality records, although some municipal production wells (e.g., Victoria 1 and 2) in the central portion of the basin have been experiencing declining water quality (i.e., increasing TDS values) that currently reach about 1,800 mg/L. Available records from wells nearest the coast do not show evidence of saline intrusion.

A map showing recorded TDS concentrations in Mound basin wells from 2011 is shown as Figure 4.3-20. 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 residue) as sampled by United Water and the City of Ventura. Without the sampling by the County's Groundwater Section, coverage in the basin would be very poor. The distribution of sampled wells within the basin for 2011 is better than in most prior years. TDS in the production wells ranged from 1,150 to over 2,200 mg/l. Sulfate commonly contributes roughly half the TDS in these samples, and water quality results are often variable among nearby wells.

4.3.5 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 underlying aquifers. The basin readily accepts large volumes of recharge water under wet hydrologic conditions. A time series of estimated changes in available groundwater storage within the Forebay is shown in Figure 4.3-21. The graphic shows that storage in the basin can change rapidly, especially when the basin is filling.

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, and in upland areas near the river where United distributes diverted river water to a series of recharge basins. 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" has become more popular in recent years.

Groundwater recharge to the Forebay serves to raise groundwater elevations in this upgradient area of the groundwater flow system for the Oxnard 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 system. Water stored in the Forebay slowly bleeds 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, and serves to raise or sustain groundwater elevations in wells in downgradient 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 approach sea level, resulting in flattened groundwater gradients and only minor groundwater flow out of the Forebay. Ventura County has not experienced a prolonged drought since completion of the Freeman Diversion in 1991, and estimates of available storage show the basin has filled to historic highs in subsequent years with above-average precipitation (Figure 4.3-21). Storage estimates suggest little available storage existed in the basin in spring 2011.

4.3.5.1 WATER LEVELS

Groundwater elevation contours for the Upper Aquifer System (UAS) in the spring of 2011 are shown in Figure 4.3-22. An area of closely-spaced contours is shown beneath the Saticoy and Noble recharge basins in the up-gradient portion of the basin. This is an area of groundwater mounding due to United's recharge activities. A fairly uniform groundwater gradient is interpreted to exist beneath the channel of the Santa Clara River. The groundwater elevation contours deflect around the El Rio Spreading Grounds, where in the spring the volume of water recharged at this location greatly exceeded that pumped and delivered to the southern Oxnard Plain. Overall, natural and artificial recharge to the Forebay was abundant in winter and spring 2011, largely related to two large storm events and other lesser storms that resulted in sustained high flows in the Santa Clara River.

Figure 4.3-23 displays UAS groundwater elevation contours for the Oxnard Plain in fall 2011. Groundwater mounding is again apparent beneath the Saticoy Spreading Grounds, as a portion of the water from the fall conservation release from Lake Piru is routed here for groundwater recharge. Southwest of this location groundwater elevation contours show greater spacing than in the spring of the year, and are more consistent with the regional gradient across the Oxnard Plain to the south. Adjacent to the Forebay in the northeast Oxnard Plain groundwater elevations are similar or slightly higher than elevations were in the spring. Water stored in the winter mounding of groundwater within the basin is now flowing to down-gradient areas, and in this year counters the effects of groundwater extractions which normally result in annual water level lows in the fall when pumping exceeds local recharge. The general direction of groundwater flow in the basin remains similar throughout the year. Water level records show a slight pumping depression in the fall beneath the El Rio Spreading Grounds.

Historical water level hydrographs from selected wells in the Forebay are shown in Figure 4.3-24. UAS water levels in the Forebay fluctuate by as much as 100 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 in recent years, following a number of consecutive wet years and the expansion of United's recharge facilities.

4.3.5.2 GROUNDWATER EXTRACTIONS

Reported 2011 groundwater extractions from the Forebay totaled nearly 18,500 acre-feet. Figure 4.3-25 shows reported extractions for the basin since 1980. Pumping in the Forebay has decreased for five consecutive years, with pumping totals from the past two years being below the average annual extraction rate of 25,000 AF. Pumping from the Forebay is often more variable than in other basins within the District, caused by the variable amount of groundwater pumping for delivery to the Oxnard Plain and Pleasant Valley basins. Agricultural pumping in 2011 was similar to that in 2010, but the big change from the prior year was a reduction in municipal pumping at the O-H well field at United's El Rio Spreading Grounds. O-H customers used nearly 5,000 AF less water in 2011 compared to the prior year. The reduction in use was partially related to a large construction project which required a realignment of the O-H supply pipeline.

In the 2011 calendar year some 37,800 AF of water were spread for groundwater recharge at the El Rio Spreading grounds. Over this same period 10,740 AF was pumped from UAS wells at El Rio for deliveries to the O-H system.

The distribution of UAS pumping for calendar year 2011 is shown in Figure 4.3-26. 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 irrigation purposes, including the pumping on the south side of United's Saticoy Spreading Grounds. Wells screened in units of the Lower Aquifer System are uncommon in the Forebay, and 2011 pumping from LAS wells is shown in Figure 4.3-27.

4.3.5.3 WATER QUALITY

Water quality records from Forebay basin wells near the Santa Clara River and United's recharge facilities show that groundwater quality in these areas is similar to that of the Santa Clara River. The most recharge from the river takes place when flows are high, which is generally when water quality in the river is best. Some characterization of Santa Clara River water quality is included in Section 4.2 of this report. During the 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.

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 2011 are shown in Figure 4.3-28. Few samples exceed 23 mg/l, a value half the nitrate MCL of 45 mg/l. A single Forebay well recorded very high nitrate, a shallow monitoring well in the south-central portion of the basin. Near United's Saticoy Spreading Grounds UAS nitrate concentrations ranged from three to eight mg/l, values that match the range of nitrate concentrations recorded for diverted Santa Clara River water spread nearby. The public supply wells in the El Rio community and at the El Rio Spreading Grounds also recorded relatively low nitrate concentrations in 2011.

A major effort to sewer the El Rio community was recently completed, 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).

4.3.6 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 110 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 at El Rio and a pipeline delivery system 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 now pumping is 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 in the northern Oxnard Plain. 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 surrounding Port Hueneme, and are more common in UAS wells than in wells with deeper screened intervals.

Following a period of drought in the 1970s and expansion of the areas impacted by saline intrusion, the Fox Canyon Groundwater Management Agency (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 Upper Aquifer System to the Lower Aquifer System 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 primary water quality concern on the Oxnard Plain is 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 degradation is 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).

4.3.6.1 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 4.3-22 and 4.3-23). Recharge from the Forebay 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.

Precipitation totals in 2011 were higher than average, and a large storm event in March helped sustain above-average flows in the Santa Clara River through the spring of the year. Significant natural and artificial recharge occurred in the Forebay, and mounded groundwater conditions are evident in Figure 4.3-22. A sizable storm hit the area in December 2010, allowing an early start to wet-season recharge to the basins. Artesian conditions existed in coastal areas of the north and central Oxnard Plain by March and April 2011, the period when water levels were collected for contouring spring conditions.

In fall 2011 UAS groundwater elevations in most areas of the Oxnard Plain were similar to what they were in the spring, suggesting that between spring and fall the amount of groundwater pumped on the Plain was similar to the amount of water moving from the Forebay to the Plain. It is more 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 (Figure 4.3-29). In the southern Oxnard Plain the sea level (0 feet) contour is mapped more than two miles inland from the coast in fall 2011. In this area south of Hueneme Road, piezometric heads in the Mugu aquifer of the UAS are commonly at least 20 feet lower than in the Oxnard aquifer. The selected hydrographs shown in Figure 4.3-29 show spring 2011 heads were often about ten feet below historic highs, but in some cases 60 feet higher than historic lows.

LAS heads are contoured for the spring and fall of 2011 for the Oxnard Forebay, Oxnard Plain and Pleasant Valley basins (Figures 4.3-30 and 4.3-31). These contours show a new interpretation for LAS groundwater flow. Evaluation of well construction, interpretation of geophysical well logs and construction of stratigraphic cross-sections for the area indicate that a number of wells in the Oxnard Forebay and north Oxnard Plain, utilized in the past construction of LAS contours, and previously classified as LAS wells, are likely influenced by heads in 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.

A better understanding of UAS and LAS stratigraphy and the structural deformation of the LAS has allowed United staff to better interpret water levels recorded in the Oxnard Forebay. Groundwater elevations recorded in the deep monitoring wells at the El Rio Spreading Grounds, utilized in this new interpretation, better conform to groundwater elevations of LAS wells in the central and south Oxnard Plain.

The inclusion of the “shallow LAS” wells in earlier contouring resulted in a steep break in groundwater elevations that was thought to be indicative of a structural barrier to groundwater flow. This revised interpretation of LAS groundwater elevations functionally expands the pumping depression seen along the eastern Oxnard Plain and western portions of the Pleasant Valley Basin north into the Forebay. Above sea level LAS groundwater elevations near the Saticoy Spreading Grounds, however, indicates 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.

Also notable in this interpretation (of deeper LAS wells) is higher LAS heads along the coast in the western Oxnard Plain than in most other areas of the basin. Maps showing LAS pumping locations within the basin (next section) are consistent with the contouring. The LAS contouring presented here is somewhat preliminary and subject to modification in the future as work on the hydrogeology in this area is ongoing.

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 4.3-27), as recharge to the Oxnard Forebay is very effective in sustaining groundwater elevations in this area (UWCD, 2010). LAS wells near Victoria Avenue and the northern boundary of the Oxnard Plain record groundwater elevations similar to nearby UAS wells (UWCD, 2010), and artesian conditions were observed in a LAS monitoring well near the coast in spring 2011 (Figure 4.3-30.). The exclusion of "shallow LAS" groundwater elevations from Figures 4.3-30 and 4.3-31 provides an incomplete representation of LAS heads in the northwestern Oxnard Plain.

Historical water level records from selected LAS wells on the Oxnard Plain are shown on Figure 4.3-32. Periods of drought 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. 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.

4.3.6.2 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 Plain, but surface water is available in 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 in Figure 4.3-26 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 facility some distance to the northeast. Aside from these locations UAS pumping is uncommon in the urban areas of the Oxnard Plain. Agricultural interests pump extensively from the UAS in the northwest Oxnard Plain, as well as in the northeastern portion of the basin near the Oxnard Forebay. Additional pumping is scattered 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.

The distribution of LAS pumping on the Oxnard Plain is concentrated in the eastern half of the basin, as shown in Figure 4.3-27. Near the basin boundary in the northwestern Oxnard Plain the City of Ventura operates two wells at the Ventura Municipal Golf Course, and exports water for municipal use in the Mound basin. 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.

A histogram of historical extractions from the Oxnard Plain and the portions of the Pleasant Valley and West Las Posas basins within United's District boundary are shown in Figure 4.3-33. Pumping in the portions of the West Las Posas and Pleasant Valley basins within United's district boundary are included with the Oxnard Plain due to the way records are processed within United's Finance Department. Reported pumping for both agricultural and municipal uses were slightly higher in 2011 than in 2010. Despite 2011 rainfall totals being slightly higher than 2010, the timing and rainfall totals for 2010 storms may have been more favorable for avoiding pumping for irrigation on the Oxnard Plain and surrounding areas.

The 60,300 acre-feet of pumping reported for the Oxnard Plain in 2011 was considerably less than reported pumping in 1990, when a record 105,000 acre-feet of pumping was reported. The Freeman Diversion was completed the following year, which improved the quantity and reliability of surface water delivered to the Oxnard Plain. Completion of the Conejo Creek Diversion in 2002 brought additional surface water to the Pleasant Valley area. Municipal and Industrial (M&I) pumping has been subject to cutbacks mandated by the FCGMA, beginning with 5% in 1992 and currently at 25%. Municipal pumping has not actually been reduced by this amount: pumping allocations have been transferred to the Cities of Oxnard and Camarillo, as these cities have expanded into agricultural areas. As noted in earlier sections, large volumes of potable water are imported from both the Oxnard Forebay and from northern California, so the extraction totals represented in Figure 4.3-33 are less than the total demand for agricultural and M&I water in the area.

4.3.6.3 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 due the marine deposition of many of the aquifers (TDS, sulfate, iron, manganese), 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 samples for some wells in 2011 show elevated concentrations of nitrate. The provenance of the high nitrate detected in these wells is generally difficult to determine, but high and variable concentrations are likely related to the downward leakage of near-surface waters (Izbicki, 1992, Zohdy et al, 1993). On the southern Oxnard Plain nitrate concentrations in wells are not commonly detected, and the rare detects are related to damaged or improperly constructed wells.

Recorded chloride concentrations across the central Oxnard Plain were consistently low in 2011, as shown in Figure 3.4-34. These values are similar to native chloride concentrations in the basins of the Santa Clara River Valley. South of Hueneme Road some wells record chloride concentrations of greater than 16,000 mg/l, concentrations similar to seawater.

4.3.6.3.1 SALINE INTRUSION

Since the 1930s the southern Oxnard Plain in Ventura County has been subject to seawater intrusion. The Oxnard, Mugu, Fox Canyon, and Grimes Canyon aquifers are believed to be geologically vulnerable, to varying degrees, to seawater intrusion by their exposure in offshore submarine 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 the funding of cooperative studies with the U.S. Geological Survey.

In 1989 the U.S. Geological Survey 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 classified as 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. A major product of the RASA study for the Santa Clara-Calleguas study area 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, 2007). 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 has indicated that near Port Hueneme chloride conditions have generally improved as heads in most aquifers have remained near or above sea level. United's sampling of wells and contouring of groundwater elevations in this area suggest the chloride plumes associated with past periods of drought are now migrating southeast towards the Mugu area, most notably in the UAS (UWCD, 2004). Figure 4.3-35 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 totally recovered from chloride impacts in the early 1990s. The chloride plume shown east of Hueneme Harbor likely extended north from Hueneme Canyon during the drought (chloride spike in well A1-195), and since that time the plume has slowly shifted towards the southeast (groundwater flow is perpendicular to the groundwater elevation contours shown on Figure 4.3-23). Within the plume of displaced seawater, samples from well CM4-275 remain above 6,000 mg/l, and chloride continues to rise in well CM7-190 some 20 years after the drought ended. In the Mugu area, however, 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 aquifers of the UAS remain impaired by high chloride. One well in the western portion of this area has shown some improvement in recent years, but chloride is still over 2,000 mg/l (Figure 4.3-35). Other UAS wells show continued degradation by either brines or direct intrusion of seawater (UWCD, 2007).

Selected chloride time series for Lower Aquifer System monitoring wells on the southern Oxnard Plain are shown in Figure 4.3-36. 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, 2007).

Given the chronic groundwater depression existing north and northeast of the Mugu area, basin 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 an expensive endeavor. United received California DWR grant funding in 2006 for an additional nested monitoring well installation located about a mile north of and between the existing DP and Q2 well sites, and samples from these new wells do not have high chloride concentrations (UWCD, 2007). A better understanding of the extent of saline water impacts and the rate of change in recent years will help both pumpers and water managers plan and prepare for water quality changes that may make groundwater unsuitable for beneficial uses in specific areas.

United has recently sponsored geophysical studies on the southern Oxnard Plain to assess conditions over a broad area in this productive agricultural region (see Section 2.1.6). One such project was 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, 2012a). 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 was approximately 35 square miles and extended along the coast between Port Hueneme and Point Mugu (approximately 7 miles) and inland for 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 model 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. An image of contoured resistivity values at depths approximating the lower portions of the UAS are shown in Figure 4.3-37. A second image of contoured resistivity values for the shallower portions of the LAS are shown in Figure 4.3-38. Groundwater salinity estimates from the TDEM surveys generally correlated well samples from areas monitoring wells. The work suggested that geologic features such as paleochannels may affect groundwater flow and the migration of chloride, particularly in deposits of the UAS (UWCD, 2012a).

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 the more large scale pumping to the north. There exists relative 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. Prevention of additional water quality degradation is a common goal for all stakeholders as degraded aquifers can negatively affect land values. Restoration of degraded aquifers is a difficult prospect, especially in areas already suffering from groundwater overdraft.

4.3.7 PLEASANT VALLEY BASIN

The Pleasant Valley basin lies adjacent and east of the Oxnard Plain, occupying the area south of the Camarillo Hills. 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 Lower Aquifer System are continuous with areas to the west on the Oxnard Plain. The City of Camarillo occupies the northern portion of the basin. Agriculture is the predominant land use in the remainder of the basin, where the Pleasant Valley County Water District operates an extensive water delivery system. The entire area of the basin falls within the Calleguas Creek watershed.

4.3.7.1 WATER LEVELS

Most wells in the Pleasant Valley basin area are completed in units of the Lower Aquifer System. Some wells are perforated in coarse basal units of the UAS, but pumping and water level measurements from UAS wells are uncommon as the UAS in the Pleasant Valley basin 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 in Figure 4.3-39. 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 nearly 120 feet above sea-level in 2011. 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 lead 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 is a topic of current study.

The groundwater elevation hydrograph for the LAS well located at the intersection of Las Posas Road and Pleasant Valley Road shows a clear response to drought conditions in 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 have increased steadily except for a slight decline during a dry period from 2002 to 2004. Since 2004, however, groundwater elevations have increased considerably above the water levels recorded in the late 1980s and early 1990s. This recent recovery is most 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 Pleasant Valley County

Water District (PVCWD), a major supplier of agricultural water in the Pleasant Valley basin. From 2004 to 2011, diversions from Conejo Creek have averaged approximately 5,600 acre-feet per year. Use of this water for irrigation has reduced pumping demands in the basin. Despite the water level recovery in this well over the past twenty years, recent records show levels remain 26 feet below sea level.

The groundwater elevation hydrograph for a well in the southern Pleasant Valley area, located along Laguna Road, shows a 1991 drought groundwater elevation of 174 feet below sea level. Since 1993, groundwater levels have returned to pre-drought levels and annual high water levels have remained fairly stable. 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 2011 are shown in Figures 4.3-30 and 4.3-31. The LAS contours on the maps show the significant pumping depression that exists in west Pleasant Valley and the eastern Oxnard Plain, where groundwater elevations are well below sea level over a broad area. The fall maps show groundwater elevations in the pumping depression in excess of sixty feet below sea level, and approximately twenty feet lower than water levels recorded in the spring of 2011. The contours for both spring and fall indicate groundwater flow from the west Oxnard Plain and from the Oxnard Forebay to the north. A better understanding of the stratigraphy in the area between the Oxnard Forebay and the Pleasant Valley pumping depression has resulted in a change in the way water levels are contoured in this area (see discussion in Section 4.3.6.1). A steep groundwater gradient likely exists between the 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.

4.3.7.2 GROUNDWATER EXTRACTIONS

Maps showing reported groundwater pumping from LAS wells in the Pleasant Valley basin and on the Oxnard Plain are shown in Figure 4.3-27. 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 is concentrated along the western portion of the basin, and aligns with the areas where water levels are deepest in the basin. Pumping of the UAS is limited, and skewed towards the eastern portion of the basin that lies within United's boundary (Figure 4.3-26). A majority of the UAS wells report minor pumping and are likely used for domestic supply.

A majority of the pumping in the Pleasant Valley Basin occurs within United's boundaries. In 2011 5,684 acre-feet of groundwater was pumped from LAS wells, and 881 acre-feet of water was pumped from UAS wells in the Pleasant Valley Basin within United's boundary.

4.3.7.3 WATER QUALITY

The map showing the maximum groundwater chloride concentrations recorded in 2011 is shown as Figure 4.3-34. Samples from wells in the Pleasant Valley basin are distinctly higher than those from the Oxnard Plain to the west. 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 Pleasant Valley County Water District, which blends well water with surface water diverted from Conejo Creek and the Santa Clara River before delivery to areas growers.

During the RASA study in the early 1990s USGS investigators recognized high chloride in some Pleasant Valley basin wells. Innovative techniques were employed to profile flow and chloride concentrations in deep production wells. It was recognized that the highest chloride and TDS was commonly sourcing from the deepest portions of these deep LAS wells, but these zones contributed little water to the well. In 2001 United sought and was awarded an AB303 grant from the California Department of Water Resources to study the nature of the inland saline intrusion problem in the Pleasant Valley basin (UWCD, 2003). A major part of this study was depth dependent sampling and flow profiling of eight deep production wells in 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. United staff characterized overdraft in the basin and performed groundwater modeling to assess how much additional water might be needed to bring the basin into balance. Geochemical analysis by the USGS was not complete before the project due date, and United's report titled *"Inland Saline Intrusion Assessment Project*" was submitted without the geochemical analysis. 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 1400 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 the sealing of 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 2011 chloride concentrations shown in Figure 4.3-34 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 4.3-40 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 this drought year few wells recorded chloride less than 100 mg/l. Comparison of chloride records from 1990 to 2011 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. Chloride loading associated with this recharge is currently under evaluation as part of a proposed desalter project for this area. The effort is being lead by the City of Camarillo in partnership with other parties.

4.3.8 WEST LAS POSAS BASIN

The West Las Posas basin is the western most of a series of three sub-basins that are referred to collectively as the Las Posas Basin. The other sub-basins 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 the boundaries of United Water Conservation District (Figure 1-1).

The Los Posas Basin Users Group (LPUG) is currently in the process of formulating 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. Del Norte Mutual Water Company made a formal request of the LPUG to be excluded from the 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 should not 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). Although the United portion of the West Las Posas Basin will not be managed by the LPUG plan, it will be monitored because it is hydraulically connected to the remainder of the West Las Posas sub-basin.

4.3.8.1 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 (VCWPD) with private entities also providing data. Fewer wells are monitored in this basin than for most other basins within the District.

In the West Las Posas basin, piezometric heads range from approximately 100 feet below mean sea level (msl) near the Central Las Posas fault to approximately 50 feet above msl near the

Oxnard Plain, indicating a general northwest to southeast flow direction (LPUG, 2011). The flow pattern 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. Groundwater moves across the sub-basin toward an area of focused pumping near Bradley Road where there has been a long history of depressed water levels (LPUG, 2011).

4.3.8.2 GROUNDWATER EXTRACTIONS

During calendar year 2011, a reported 3,536 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 2011 is shown in Figures 4.3-26 and 4.3-27. In addition Del Norte Water Company pumps water from its well yard, located near Highway 118 and Santa Clara Avenue on the Oxnard Plain, for agricultural use in northern portions of the West Las Posas Basin within United's District boundary. In 2011 Del Norte pumped and exported 1,455 acre-feet from the Oxnard Plain to the West Las Posas Basin.

Pumping for domestic or potable supply is minimal in the western portion of the West Las Posas basin, as agriculture remains the predominant land use in this area.

4.3.8.3 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.

Ventura County Watershed Protection District (2012) reports that six wells in the basin exceeded the MCL for TDS (average of 966 mg/L) with two wells having concentrations above the MCL for nitrate, and three wells having concentrations above the MCL for sulfate. Groundwater with this degree of mineralization is common throughout United's service area, and slightly elevated salt content does not pose a health risk. 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 the sources of higher TDS and chloride concentrations (LPUG, 2011).

5 SUMMARY

United Water 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, and effective utilization of existing allocations of imported State Water Project water. United Water'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 Water 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 Water have long-term implementation schedules (e.g., District-wide groundwater level measurements, conservation releases), 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 both agricultural and municipal and industrial water users in central and southern Ventura County.

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7 FIGURES AND TABLES

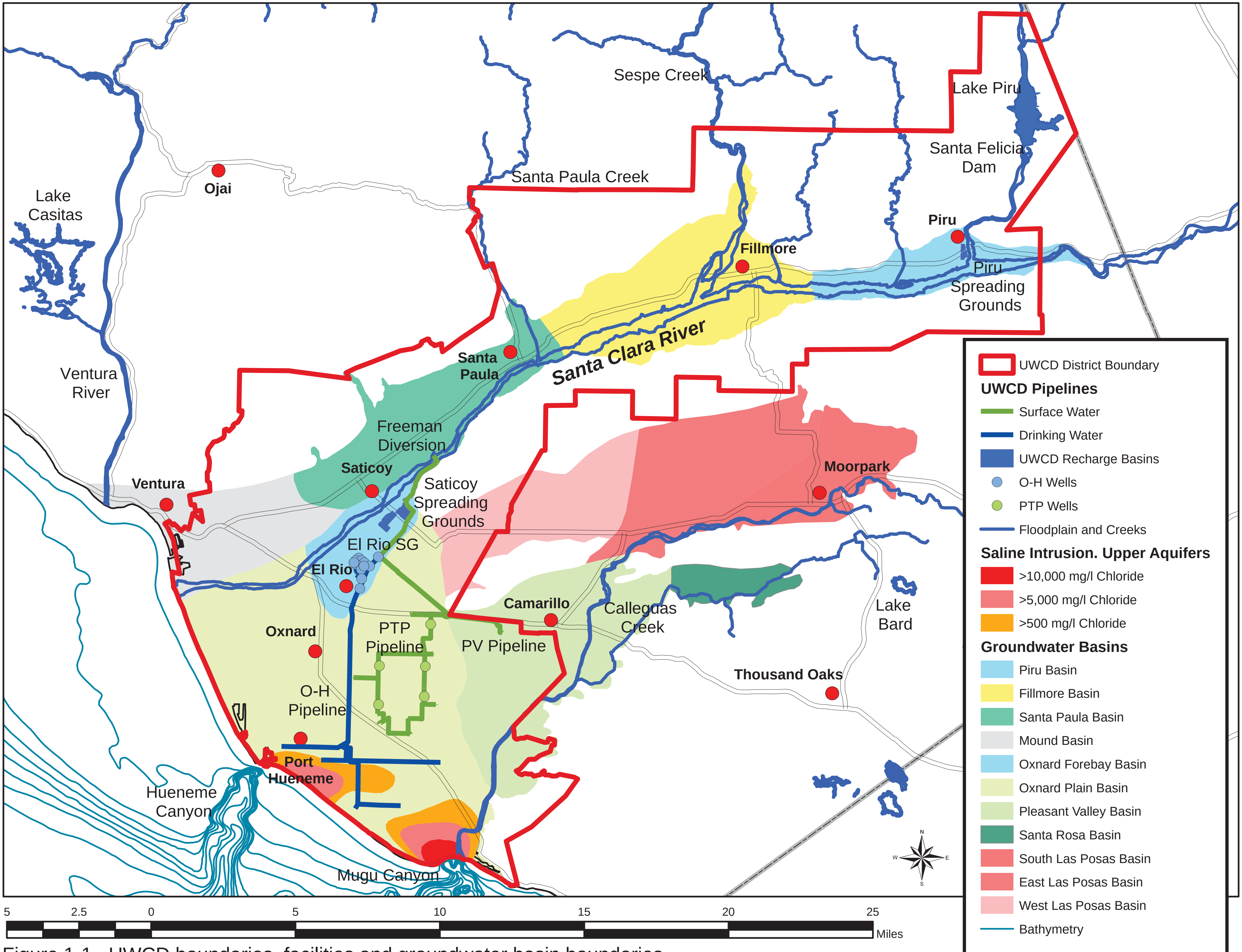


Figure 1-1. UWCD boundaries, facilities and groundwater basin boundaries

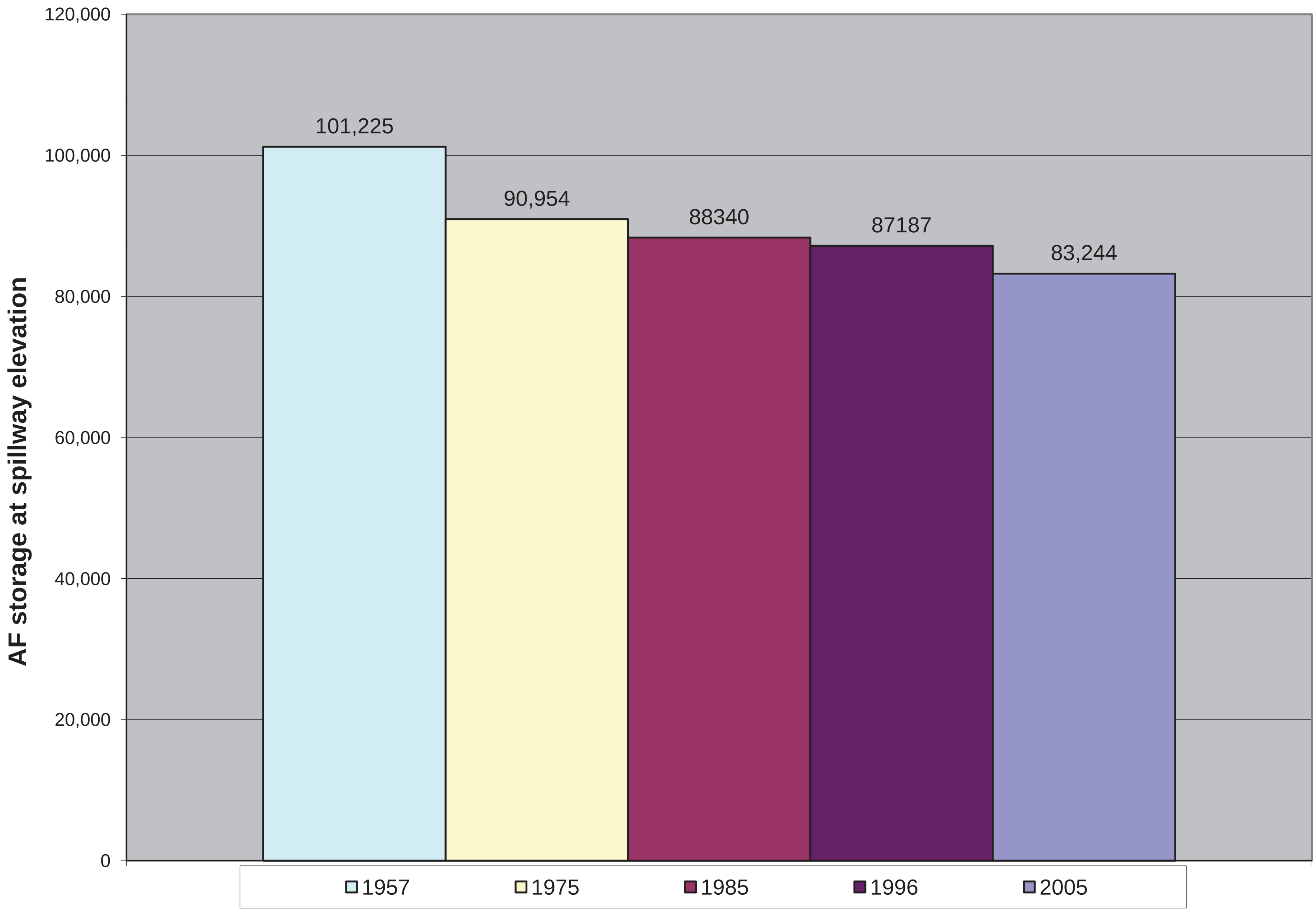


Figure 1.4-1. Silt surveys showing historic storage capacity in Lake Piru

Agricultural Water Deliveries			
	Surface water deliveries to the PTP (AF)	Ground water deliveries to the PTP (AF)	Surface water deliveries to Pleasant Valley Water District (AF)
JAN	346	160.6	385
FEB	362	85.8	453
MAR	376	0.1	643
APR	776	45.6	1,352
MAY	932	63.6	1,433
JUN	776	41.0	1,143
JUL	839	22.1	1,102
AUG	952	60.0	880
SEP	622	79.2	1,255
OCT	1,392	221.4	1,603.4
NOV	544	35.1	849.7
DEC	527	0.8	1,091.7

Figure 1.4-2. (Table showing) surface water deliveries to agriculture, 2011

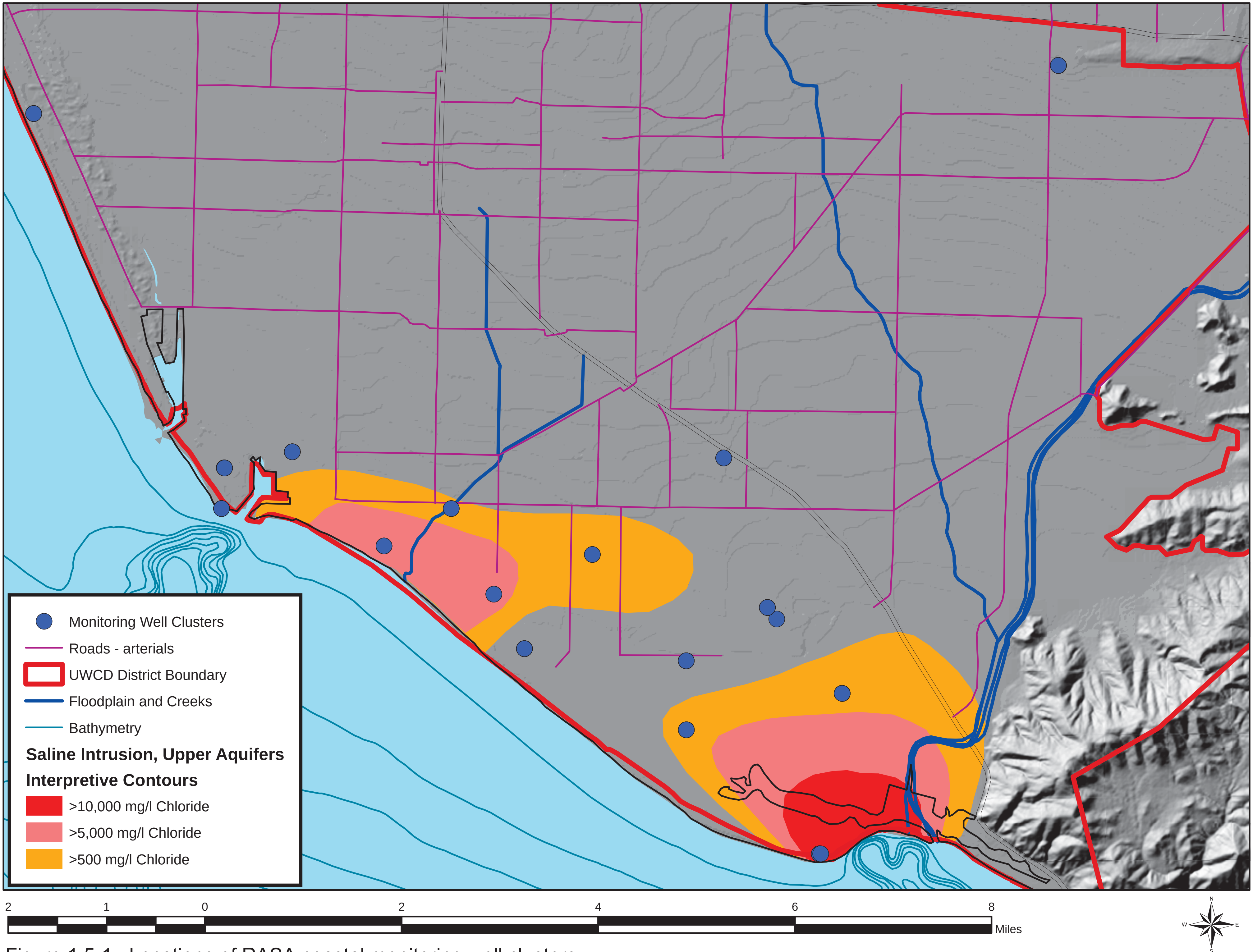


Figure 1.5-1. Locations of RASA coastal monitoring well clusters

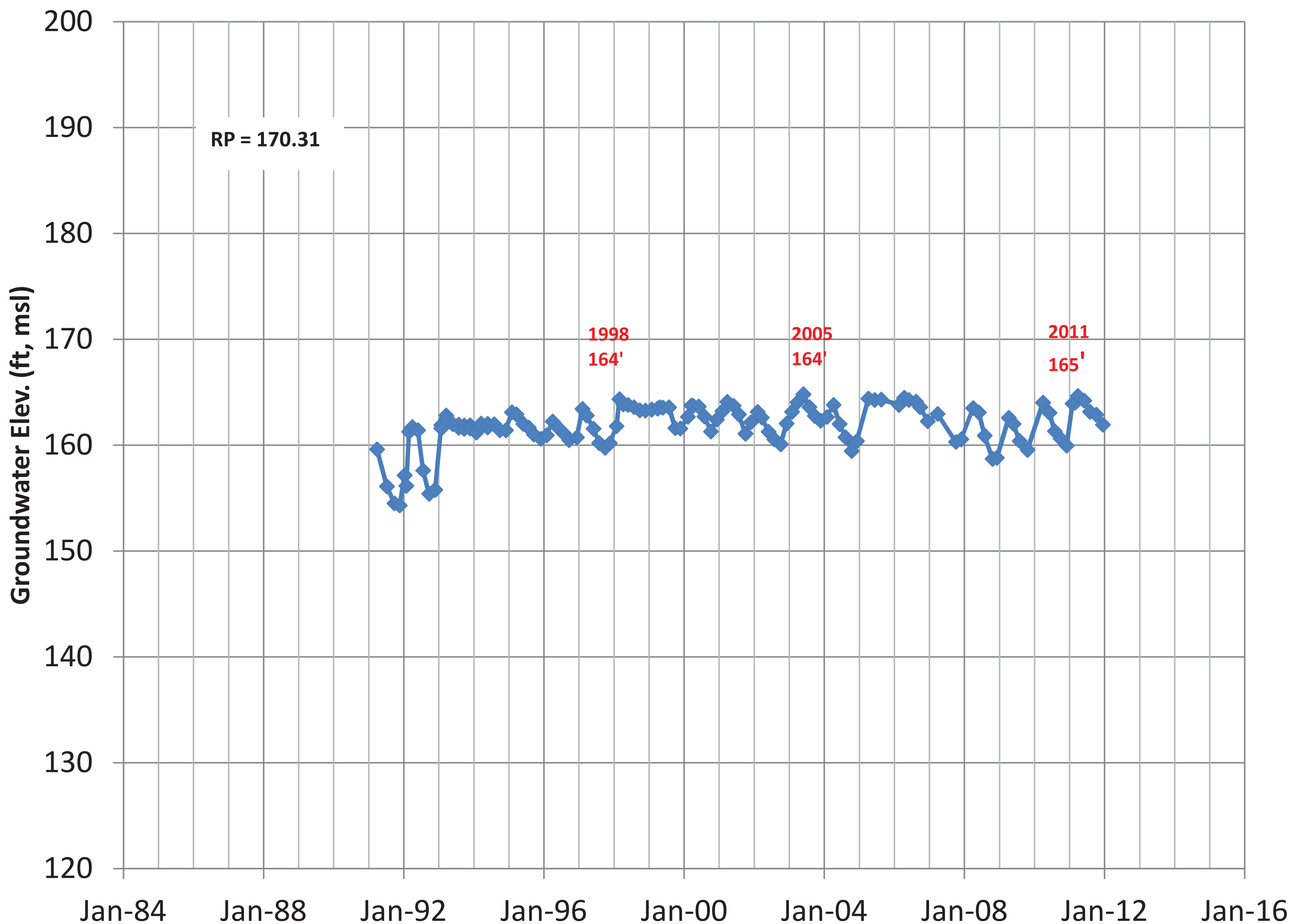


Figure 1.6-1. Groundwater elevations near the Freeman Diversion

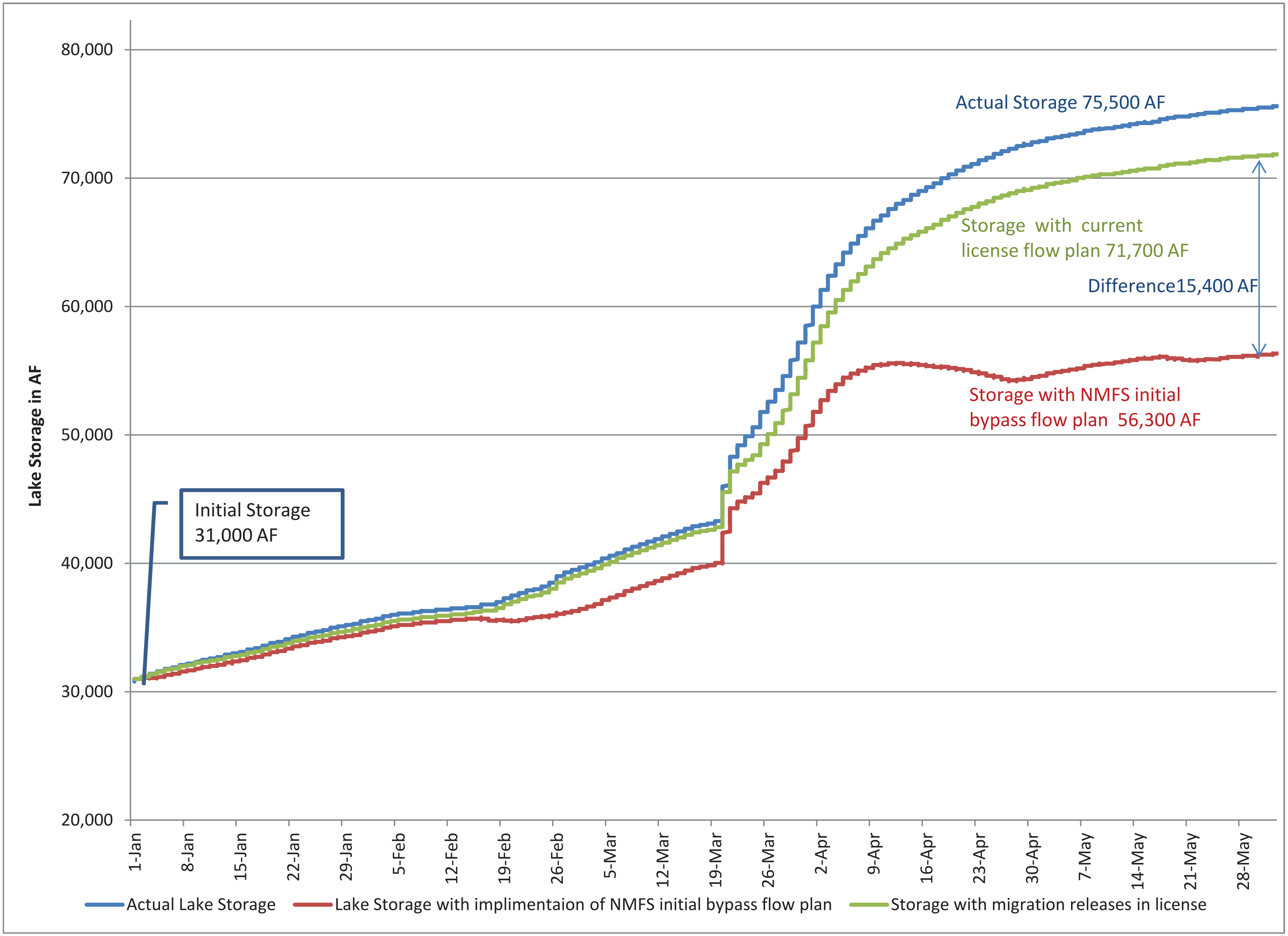


Figure 1.6-2. Possible lake levels with the current FERC license and NMFS recommended flows

Project	Overdraft Conditions	Declining Water Levels	Groundwater Exports	Saline Water Intrusion	Upwelling Saline Water	Riverbed Stabilization	Biological Opinion-SFD	Biological Opinion-VFD	VFD Operation	Aquifer Mapping	Recharge Optimization	Water Quality Degradation
Update Regional GW Flow Model	X	X	X	X	X	X				X	X	X
AB3030 Piru/Fillmore GW Management Plan Update			X								X	X
Santa Paula Basin TAC and Specialty Studies		X	X			X			X	X	X	
District-Wide GW 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
District-Wide Stream Gauging	X	X				X	X	X	X		X	X
Surface Geophysical Studies (Seismic Reflection, TDEM)	X	X		X						X	X	
SCR/Forebay Piezometer Installation		X					X	X	X		X	

Figure 2.1-1. Groundwater issues and concerns versus projects

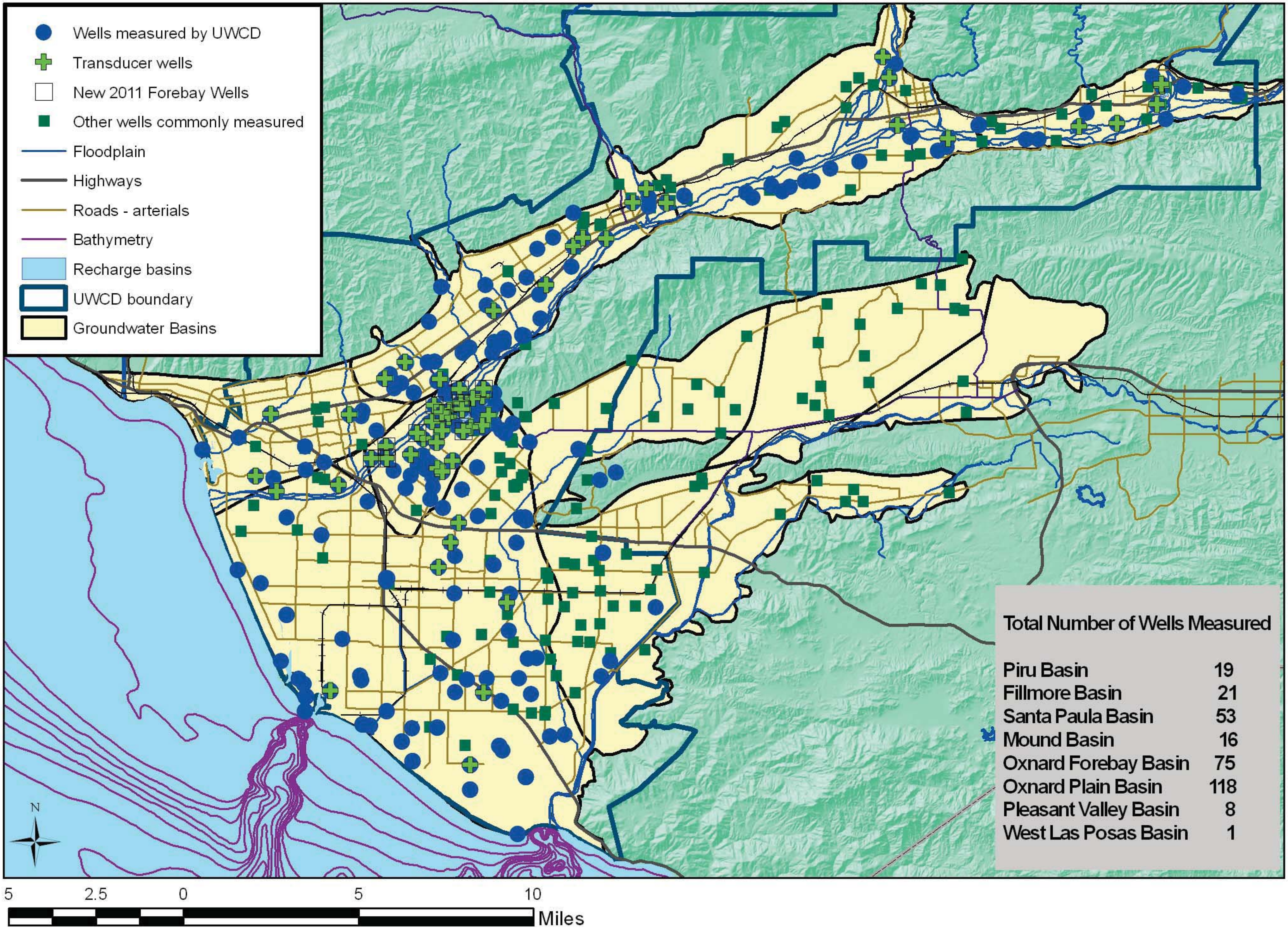


Figure 2.1-2. Wells monitored by United for water levels

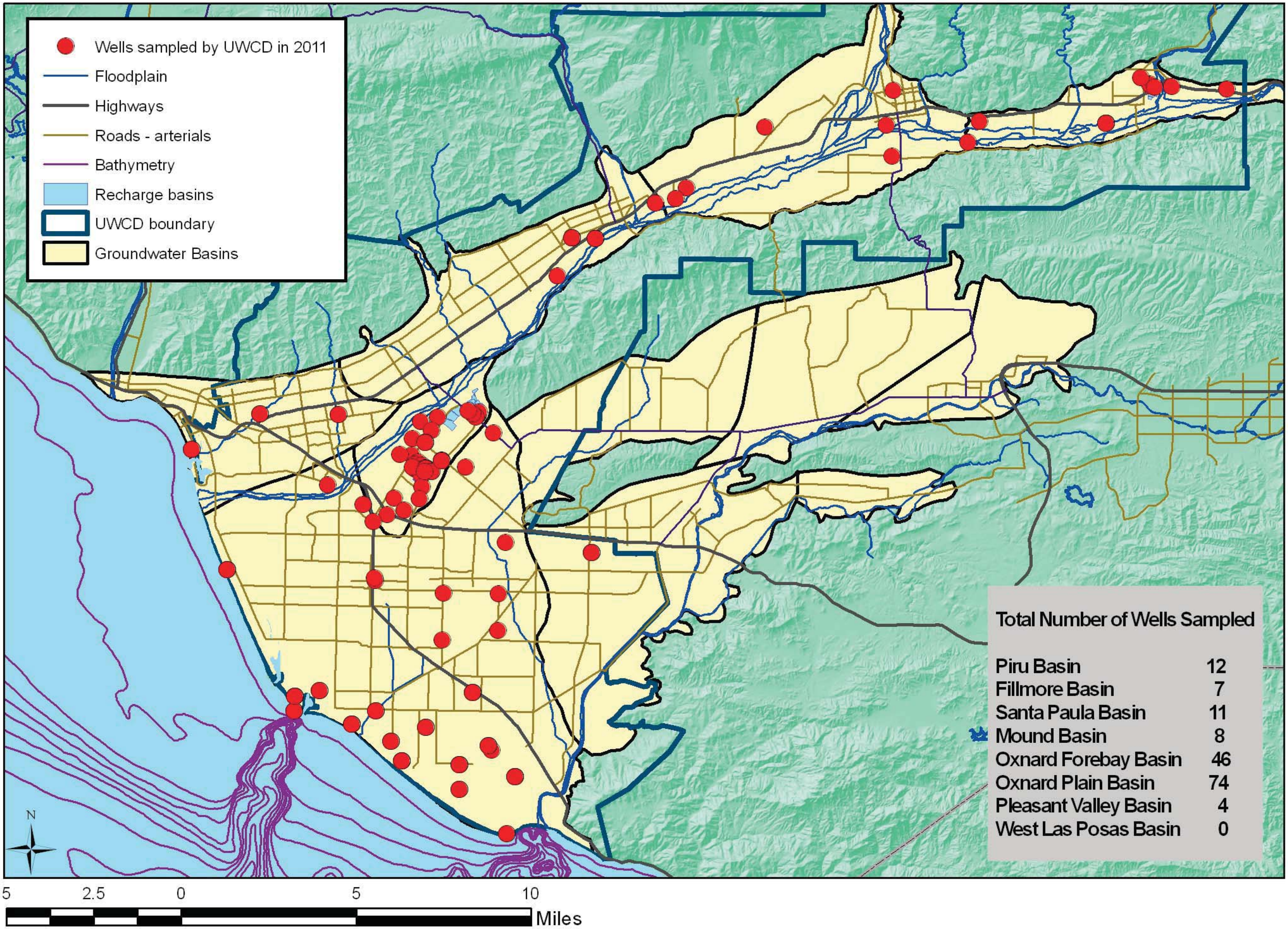


Figure 2.1-3. Wells sampled by United for water quality

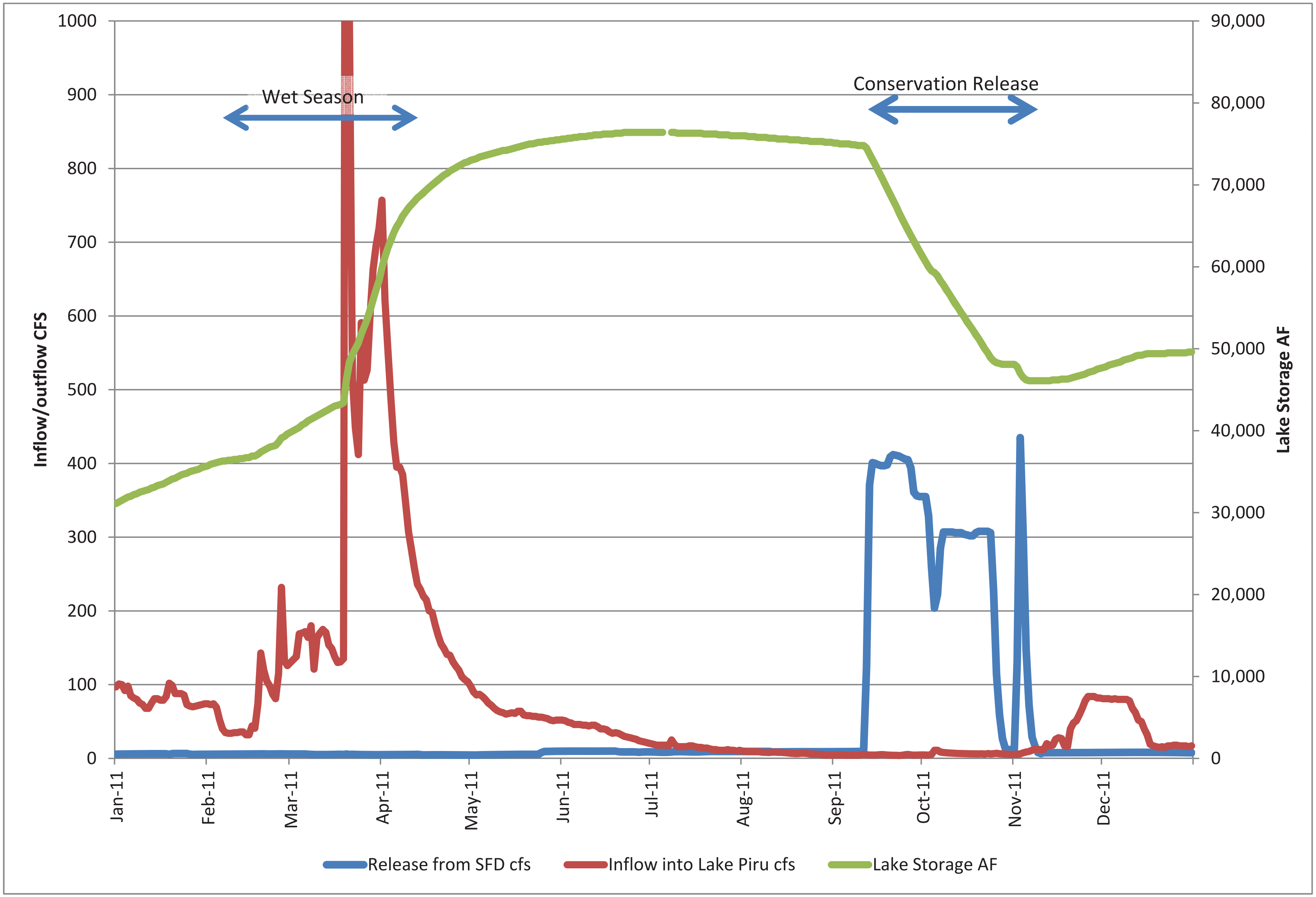


Figure 2.2-1. Basic hydrology for 2011 at Lake Piru

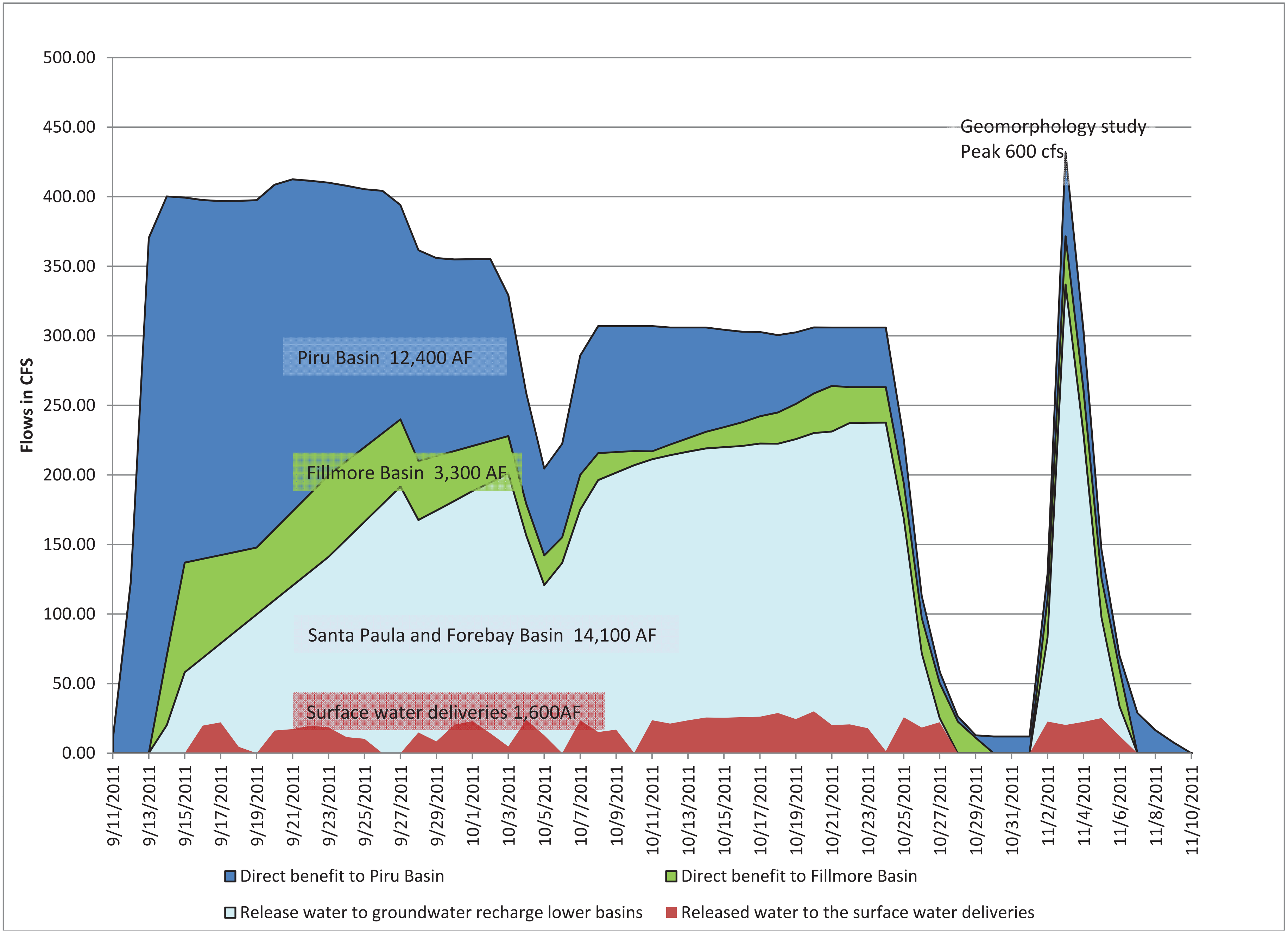


Figure 2.2-2. Benefit to each basin from direct percolation during 2011 conservation release

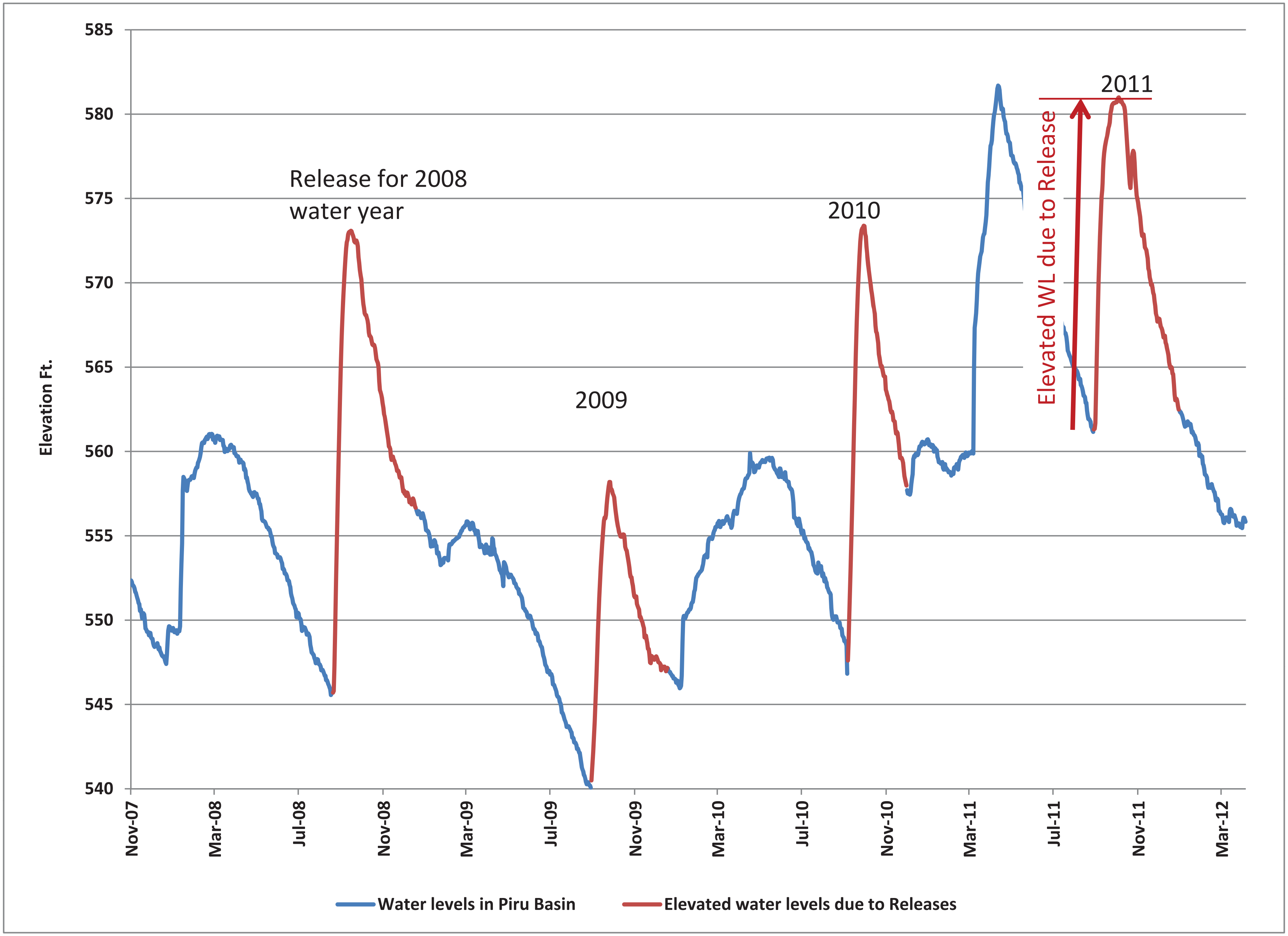


Figure 2.2-3. Groundwater response in the Piru Basin to conservation release from Santa Felicia Dam (well 04N18W31D07S)

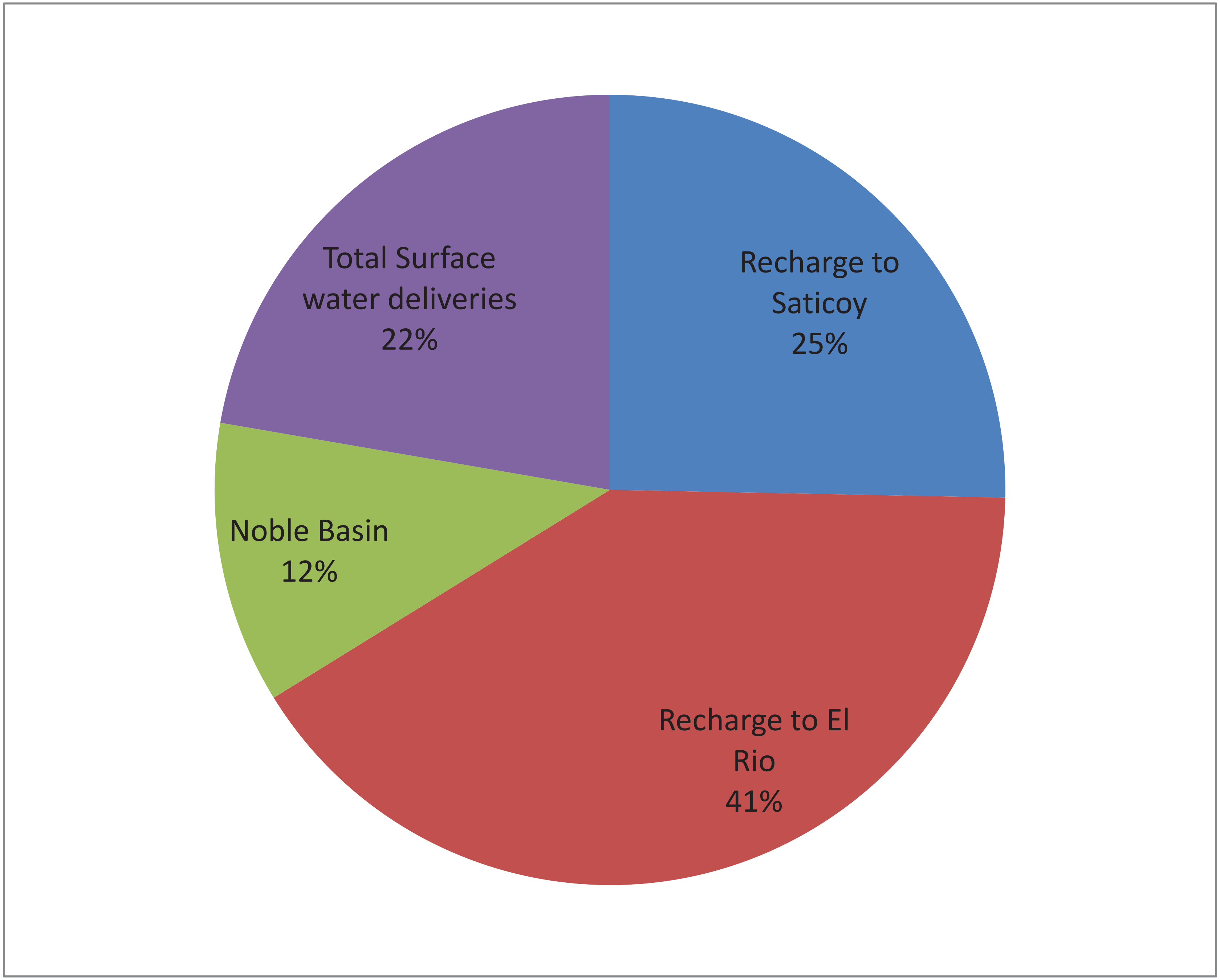


Figure 2.2-4. Distribution of water diverted at Freeman Diversion, 2011

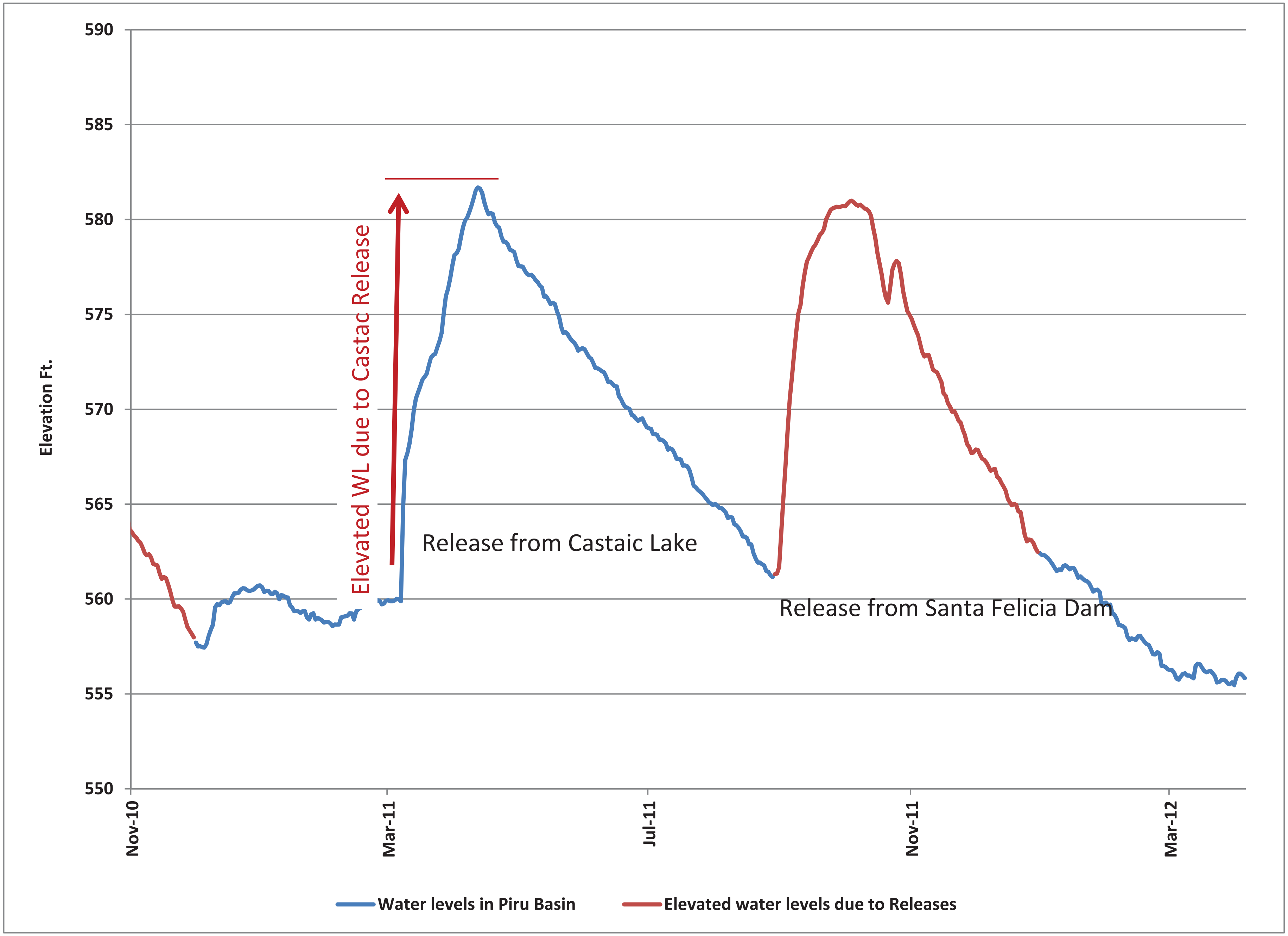


Figure 2.2-5. Groundwater response in the Piru Basin to Castaic floodflow release (well 04N18W31D07S)

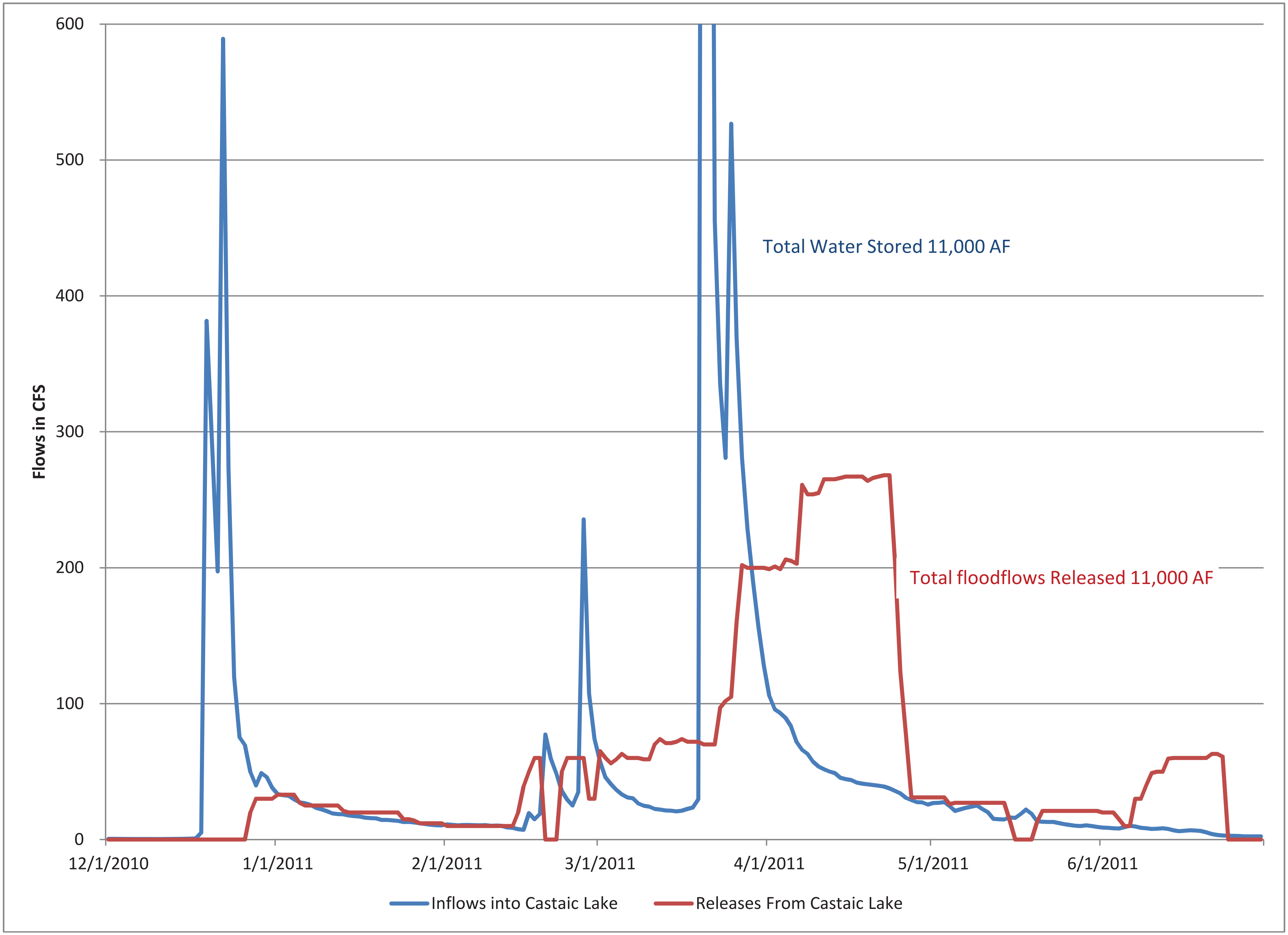


Figure 2.2-6. Conservation release from Castaic Lake for downstream water users

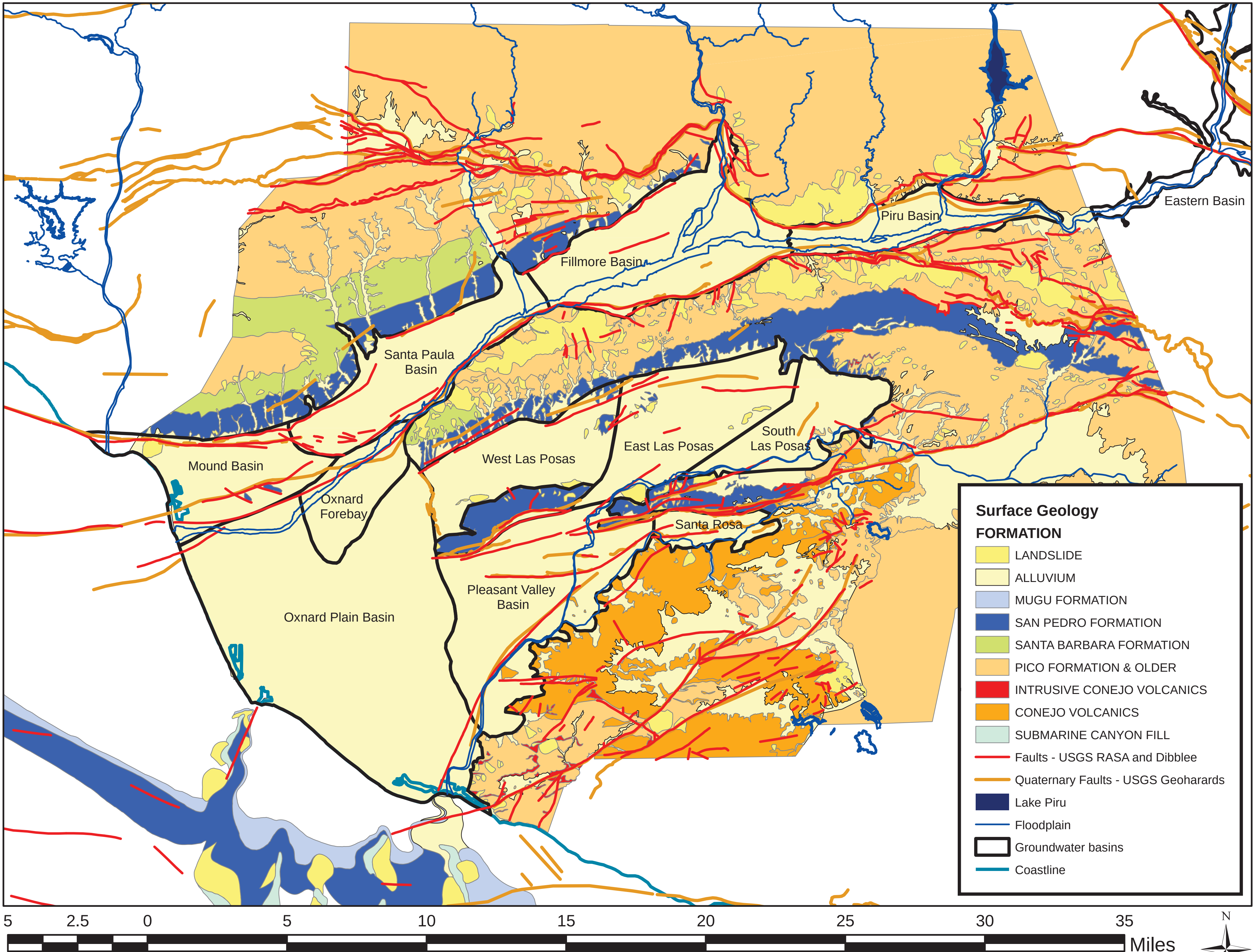


Figure 3.1-1. Surface geology and faults

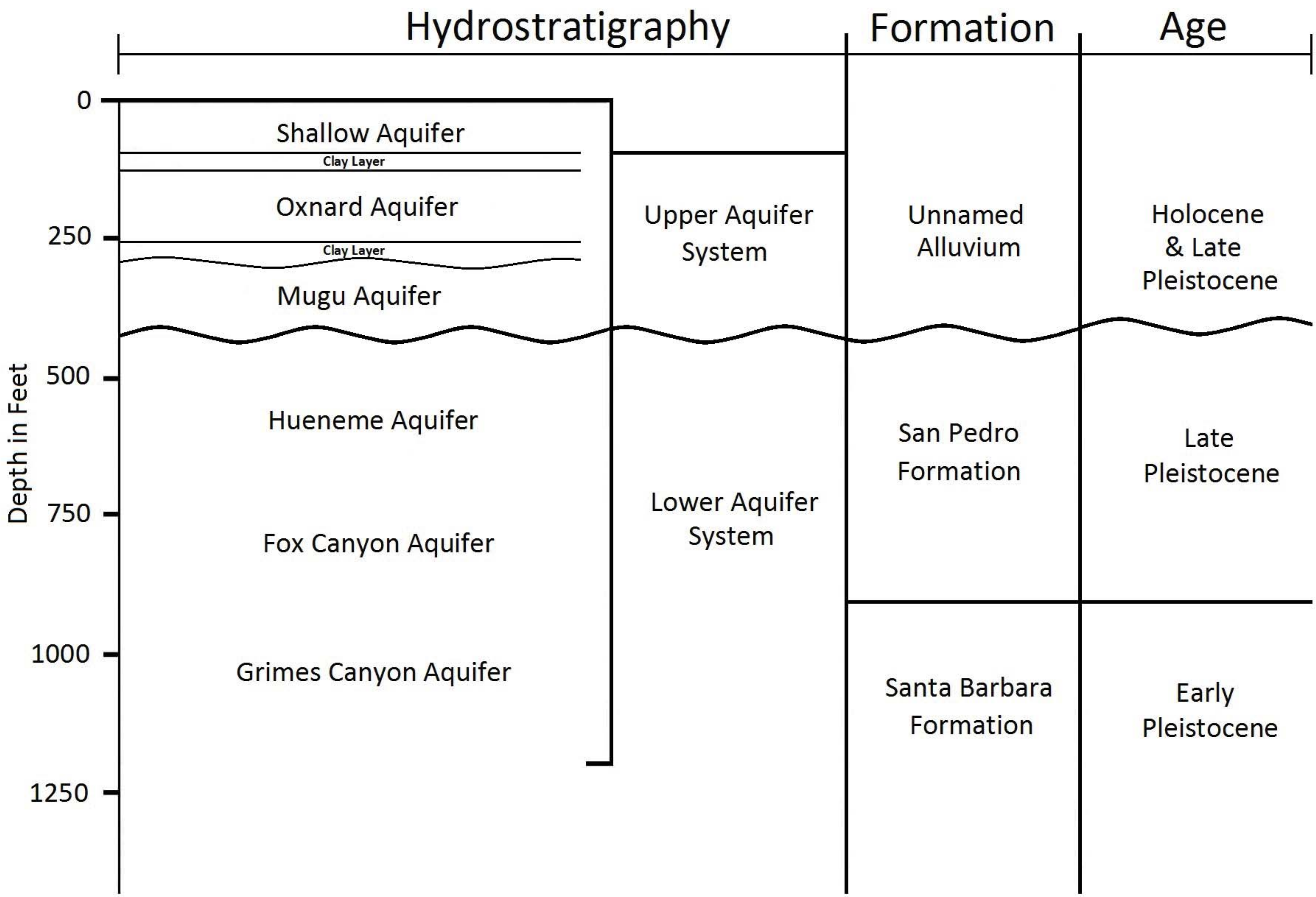


Figure 3.2-1. Schematic of UAS and LAS aquifer systems

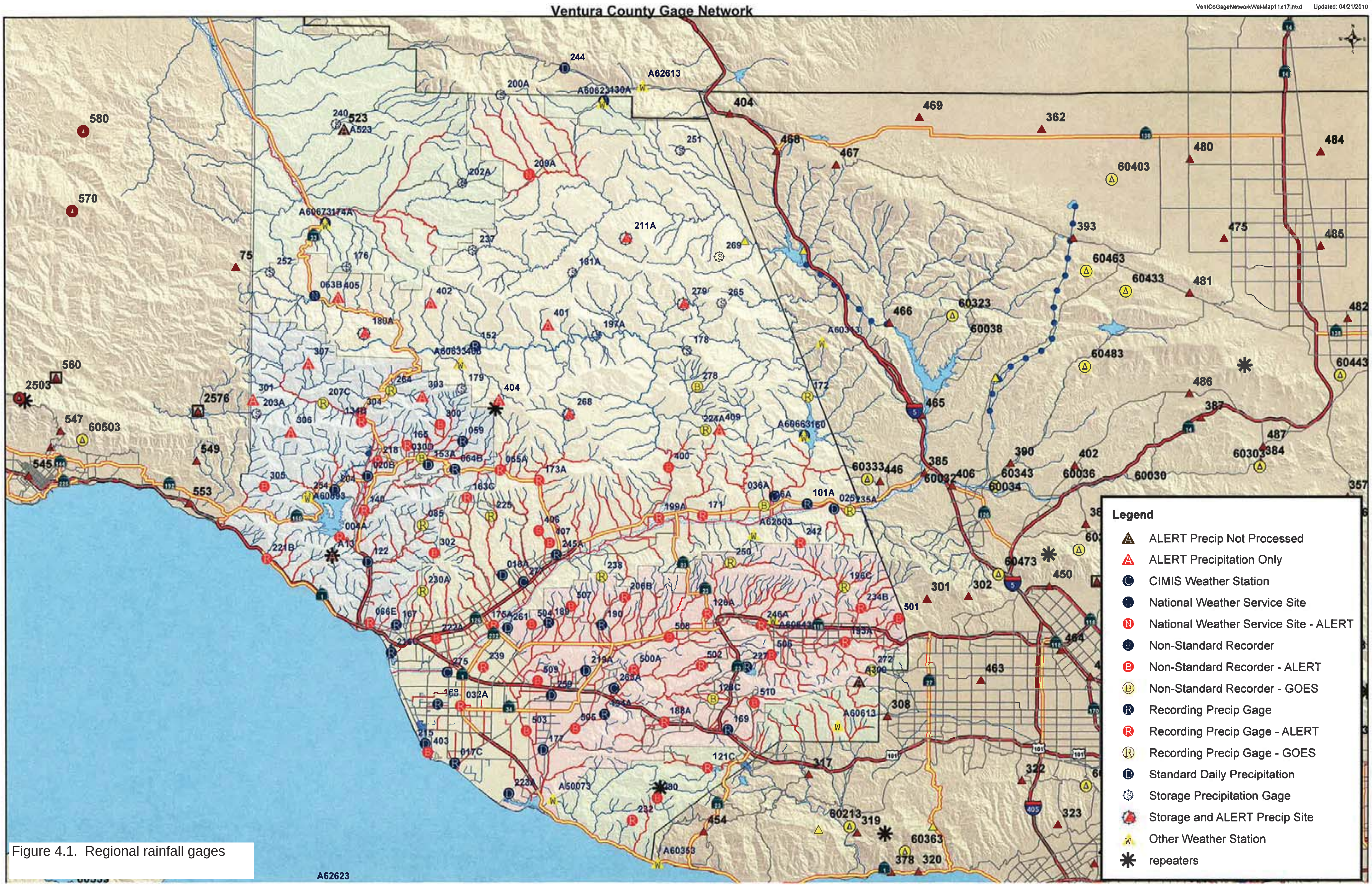


Figure 4.1. Regional rainfall gages

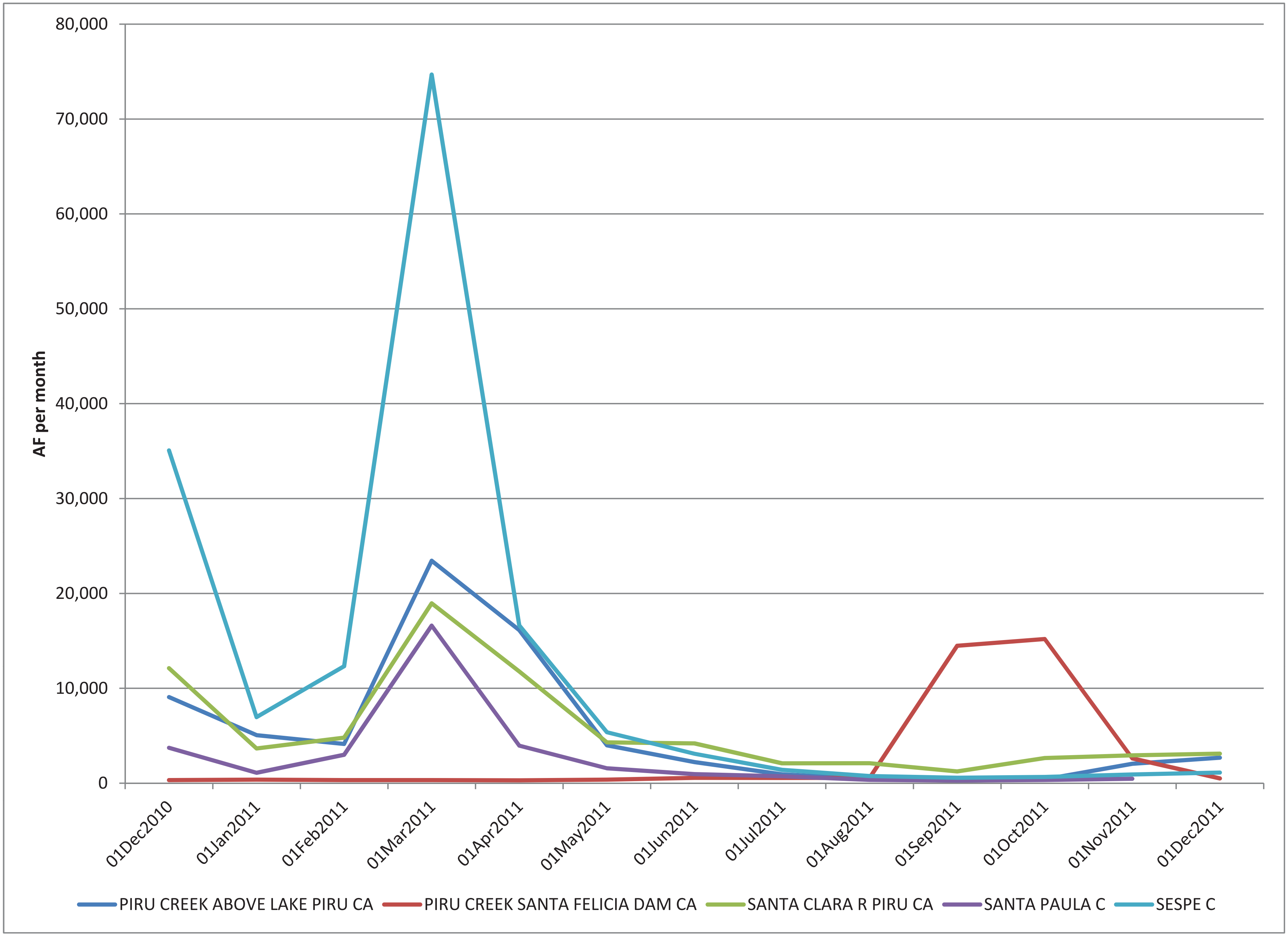


Figure 4.2-1. Monthly flows of the major tributaries in the Santa Clara River Watershed

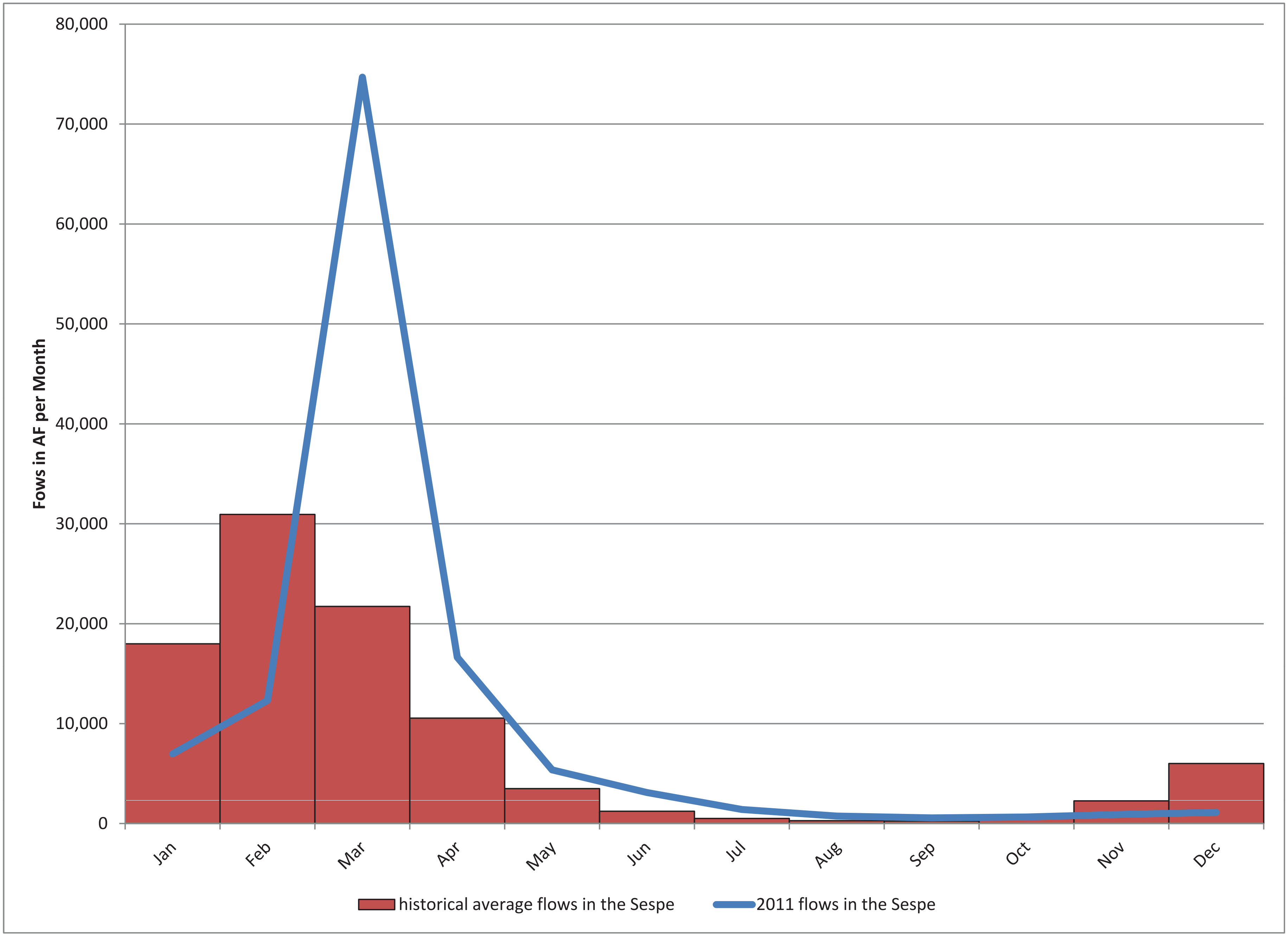


Figure 4.2-2. 2011 Flows in the Sespe Creek compared to average flows (1972-2010)

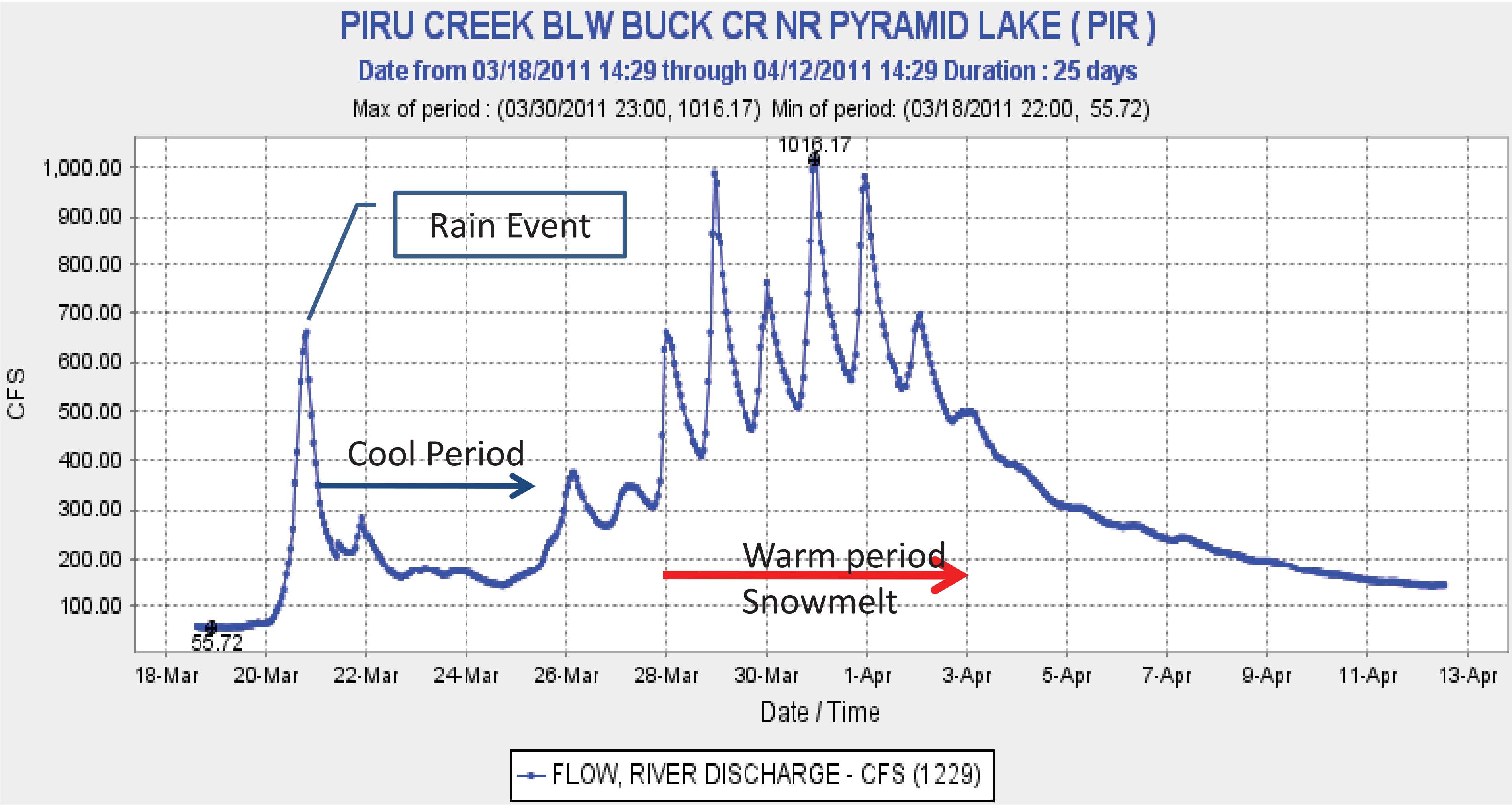


Figure 4.2-3. Spring 2011 snowmelt event in the Piru Watershed

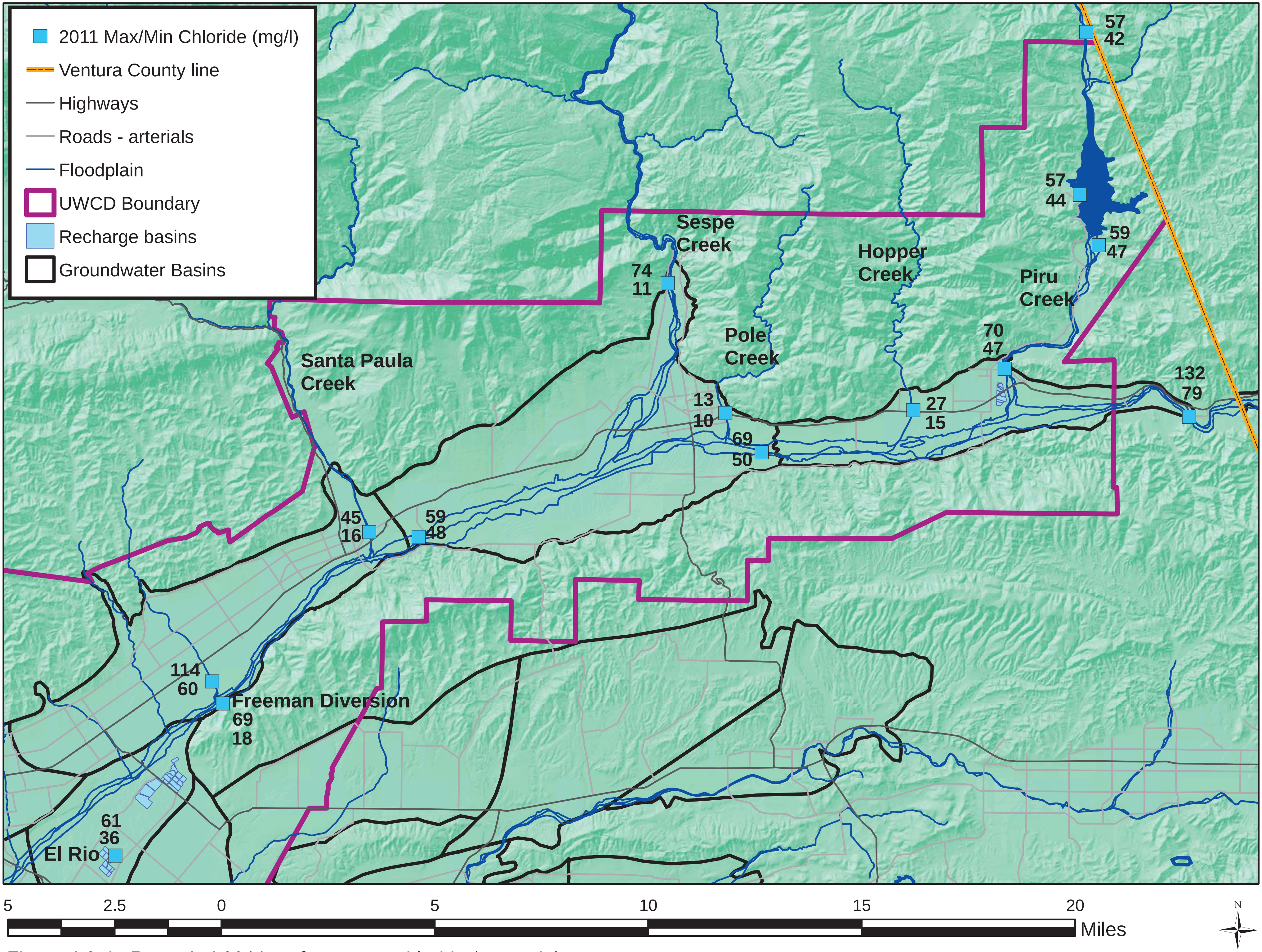


Figure 4.2-4. Recorded 2011 surface water chloride (max-min)

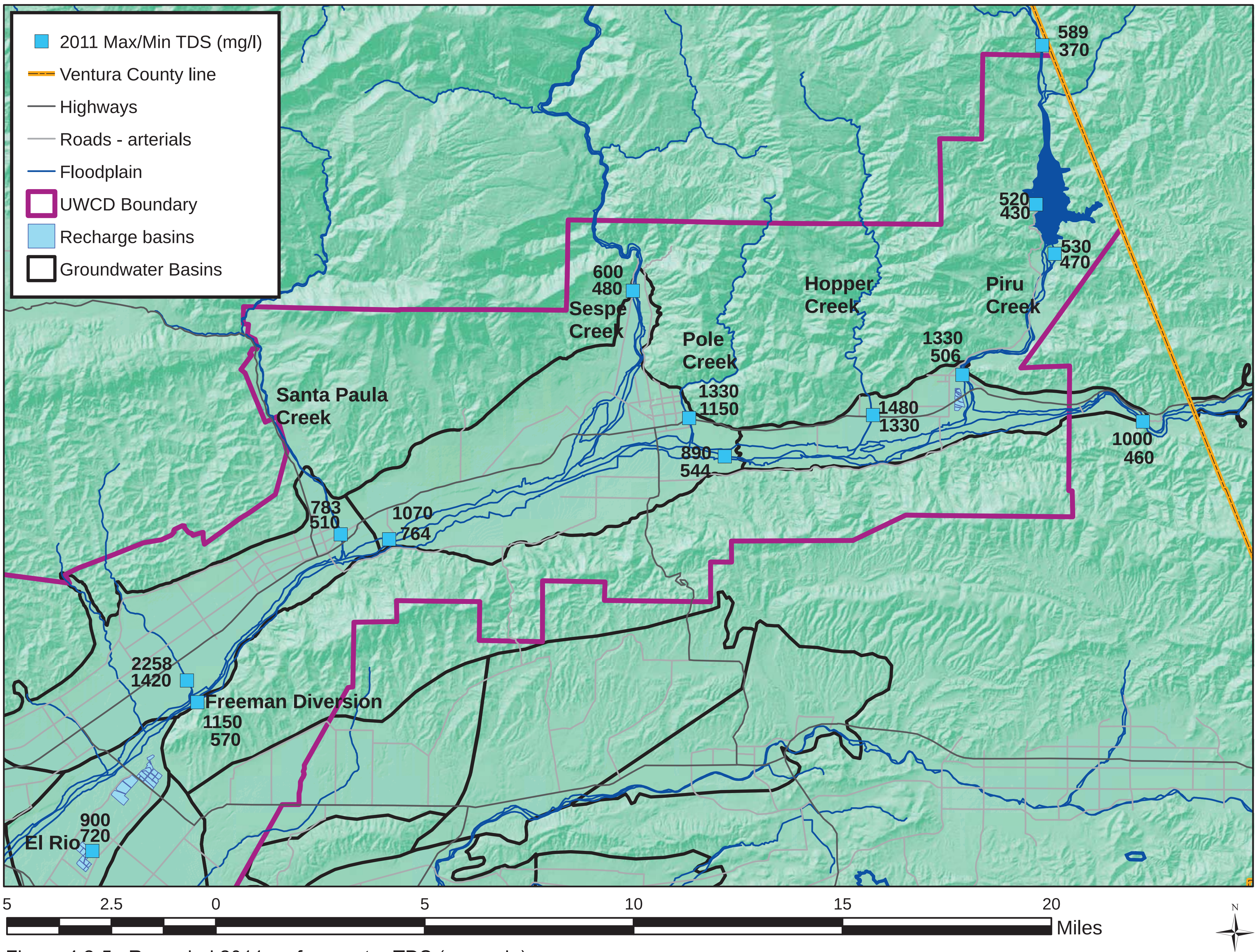


Figure 4.2-5. Recorded 2011 surface water TDS (max-min)

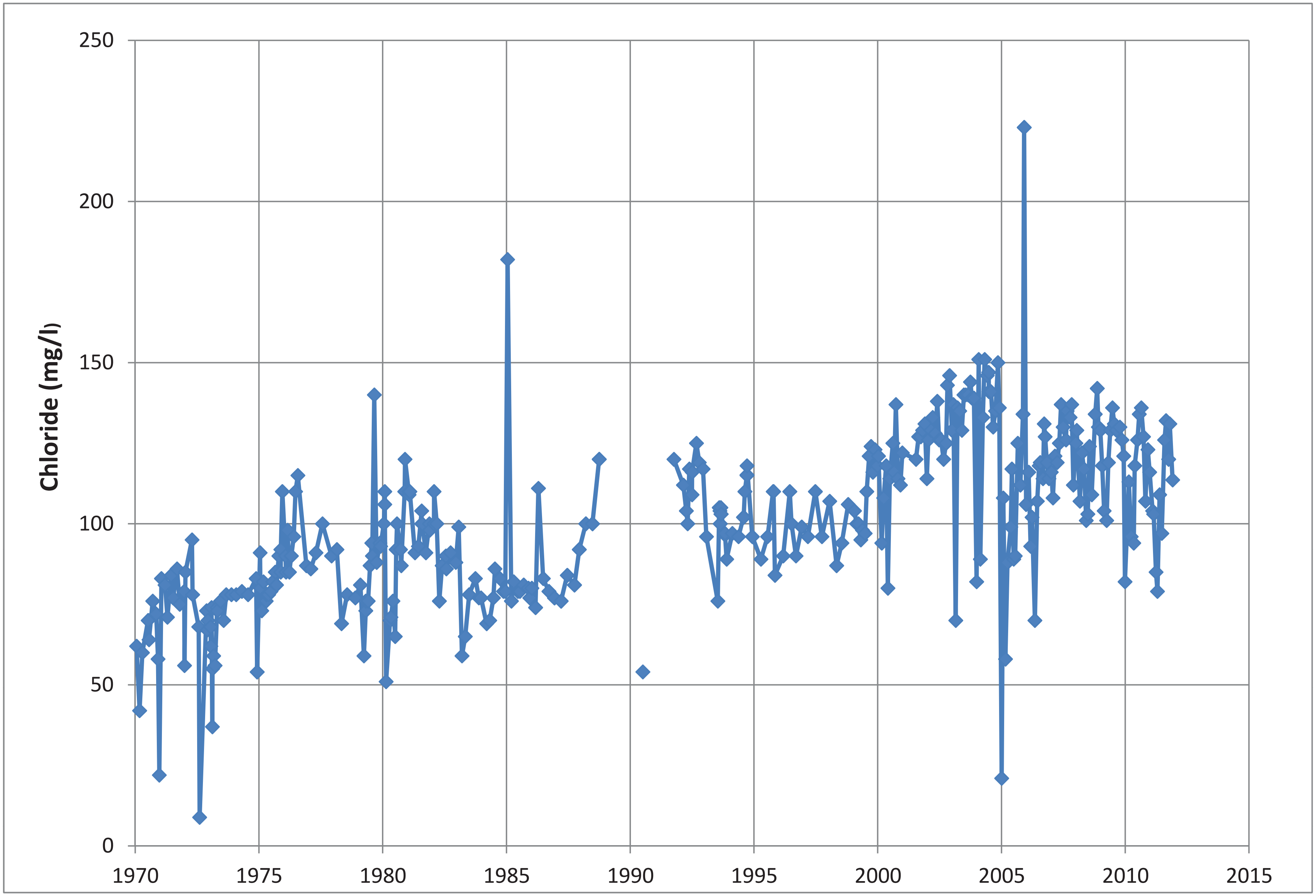


Figure 4.2-6. Historical chloride concentrations in the Santa Clara River near the Ventura-Los Angeles County line

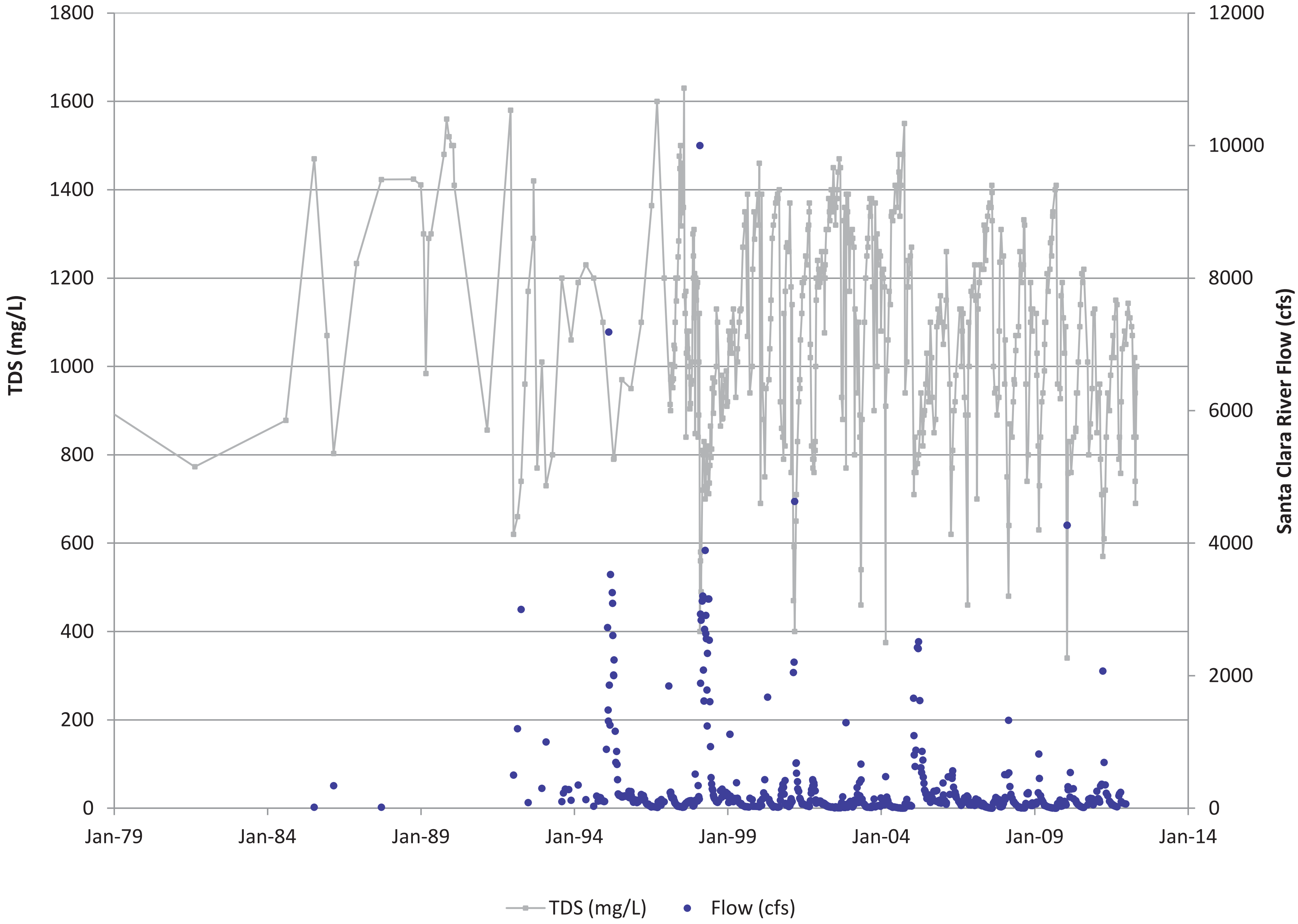


Figure 4.2-7. Historical TDS concentrations in the Santa Clara River at the Freeman Diversion

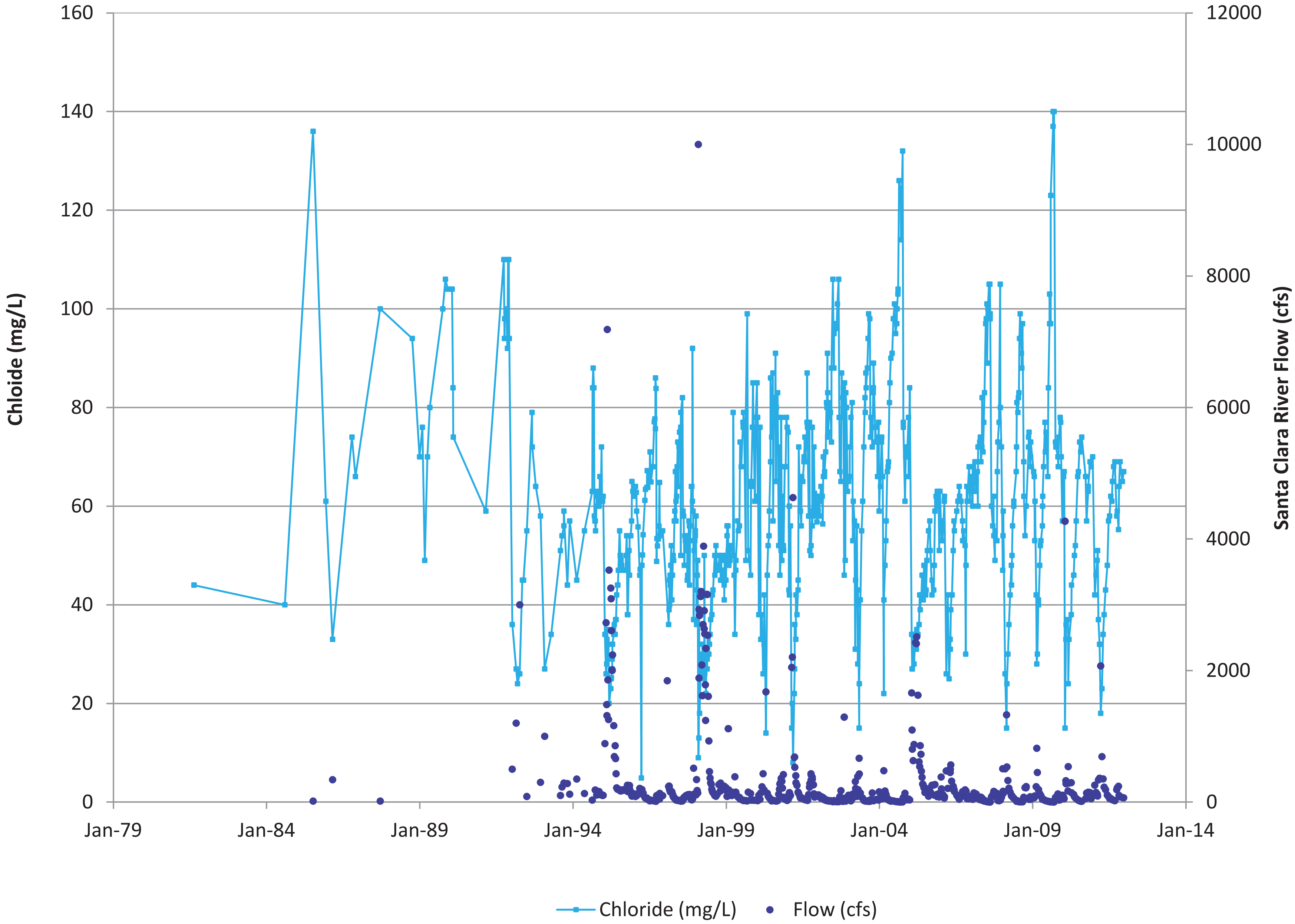


Figure 4.2-8. Historical chloride concentrations in the Santa Clara River at the Freeman Diversion

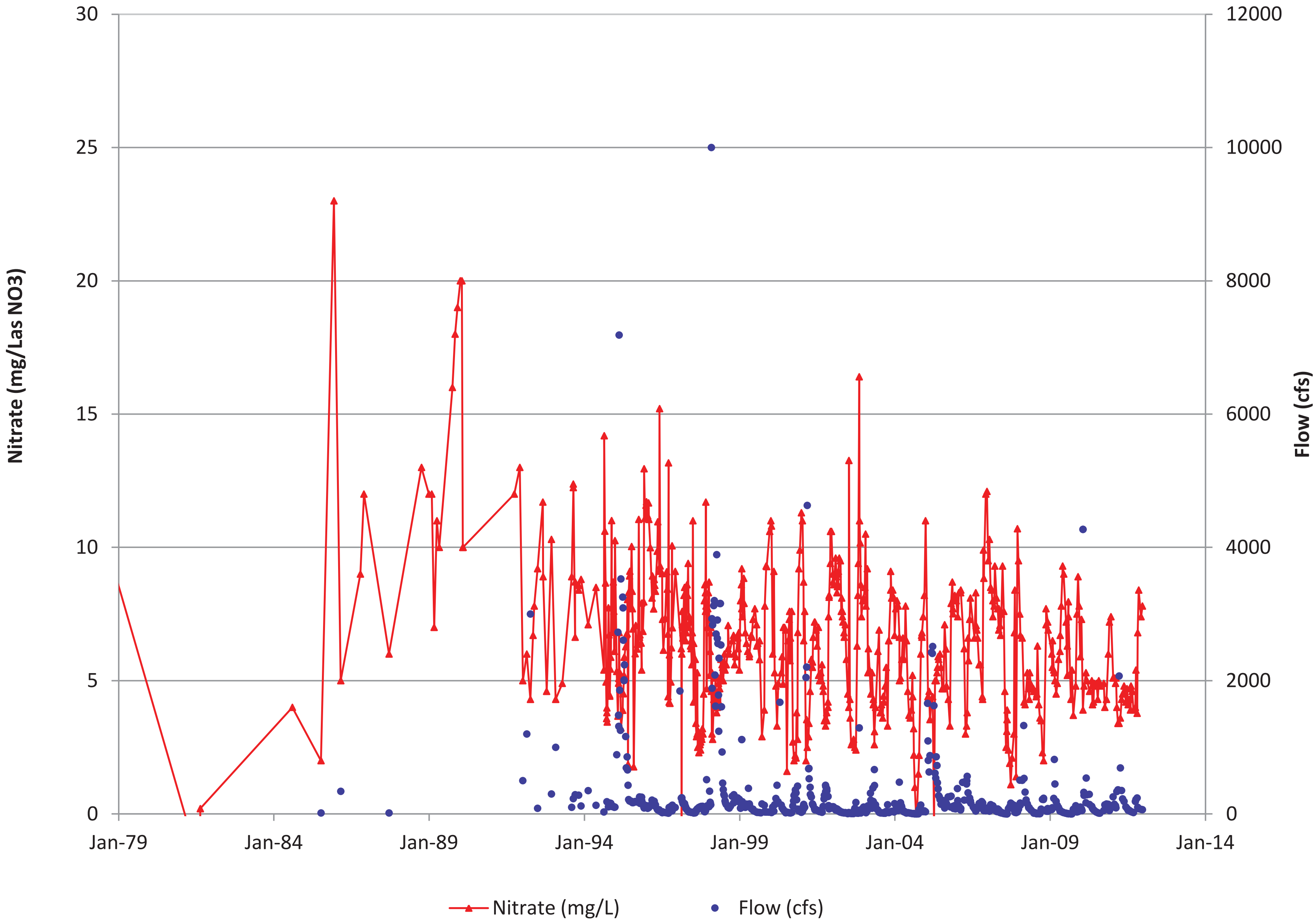


Figure 4.2-9. Historical nitrate (NO3) concentrations in the Santa Clara River at the Freeman Diversion

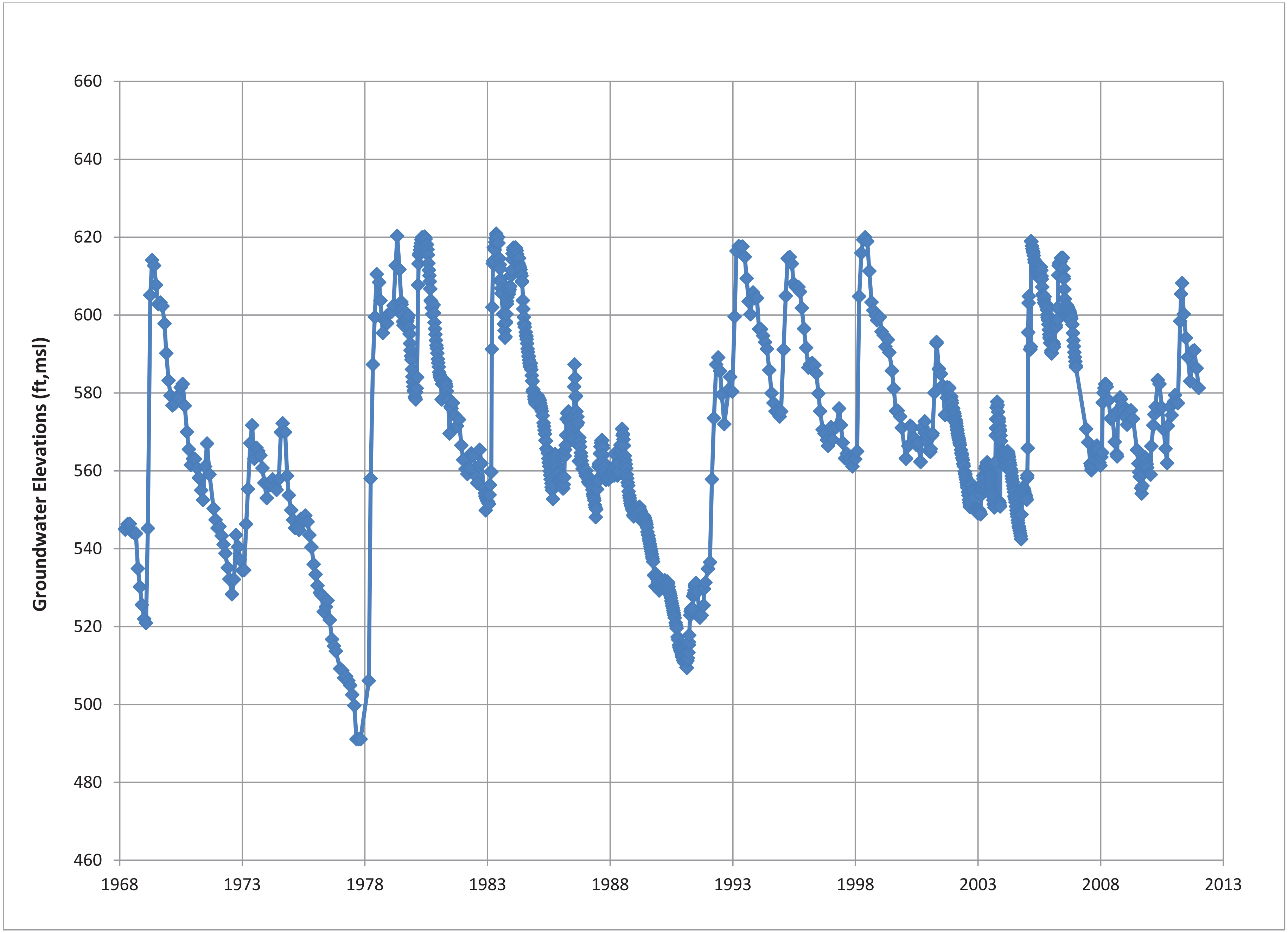


Figure 4.3-1. Historical groundwater elevations in Piru Basin key well

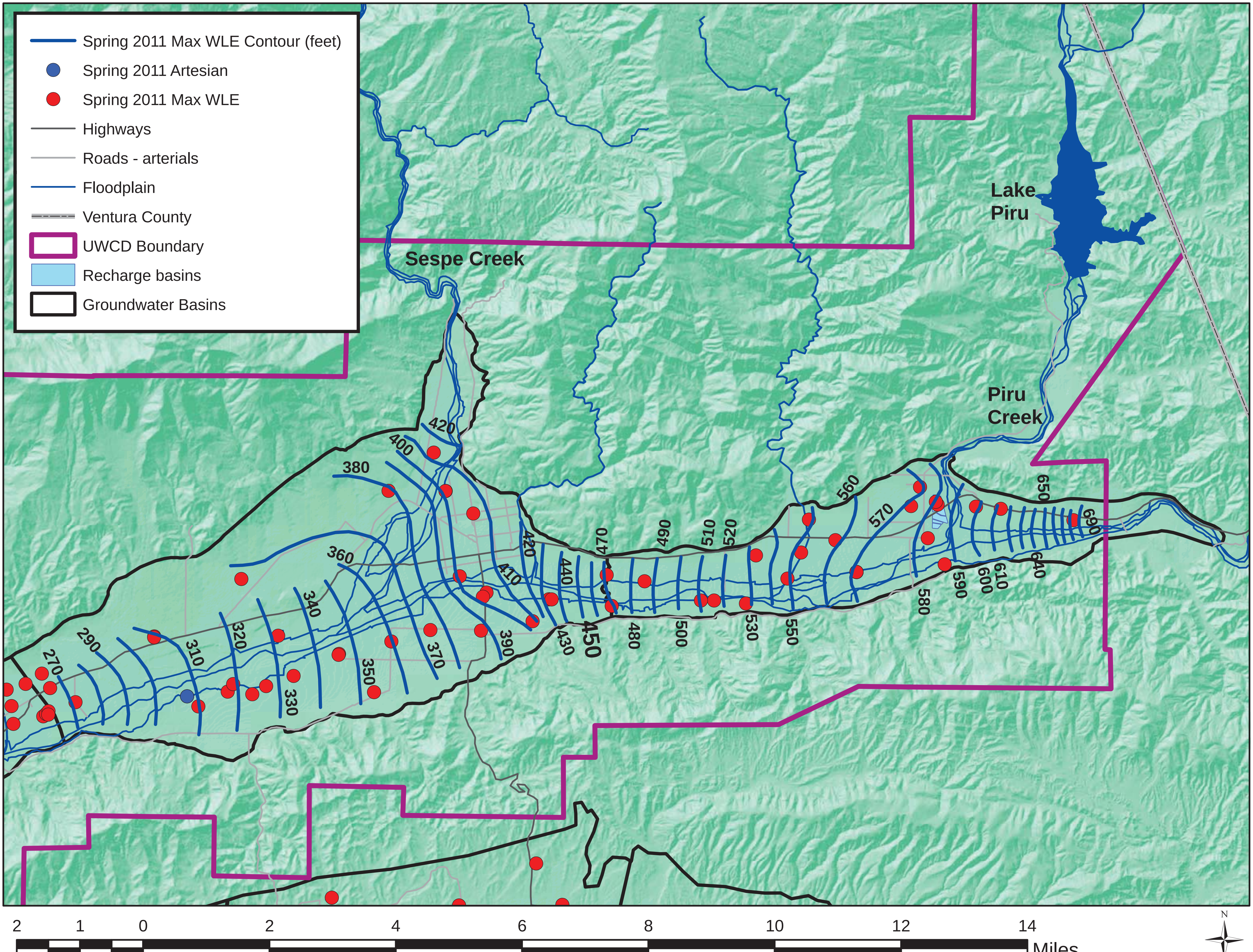


Figure 4.3-2. Piru and Fillmore basins groundwater elevations for spring 2011

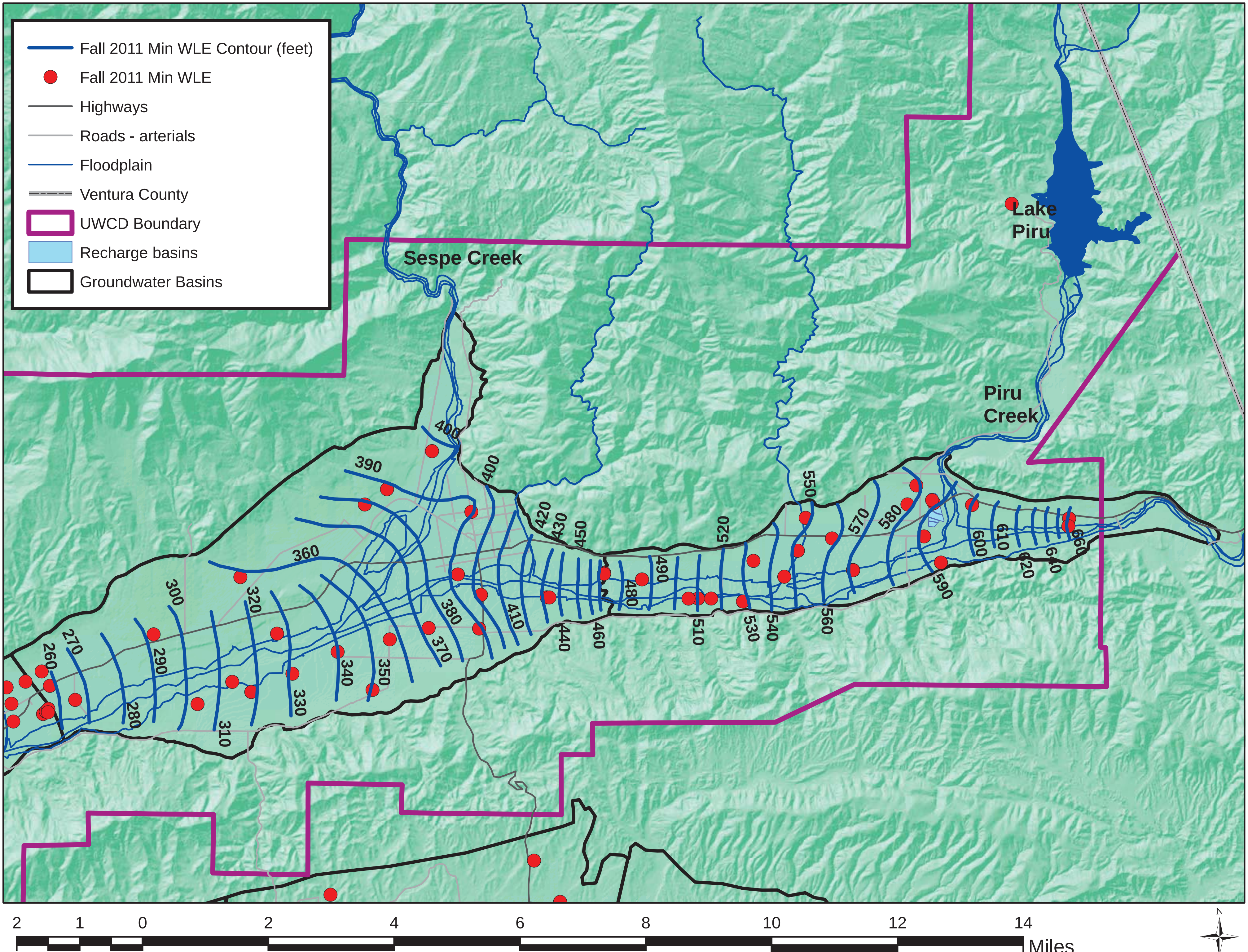


Figure 4.3-3. Piru and Fillmore basins groundwater elevations for fall 2011

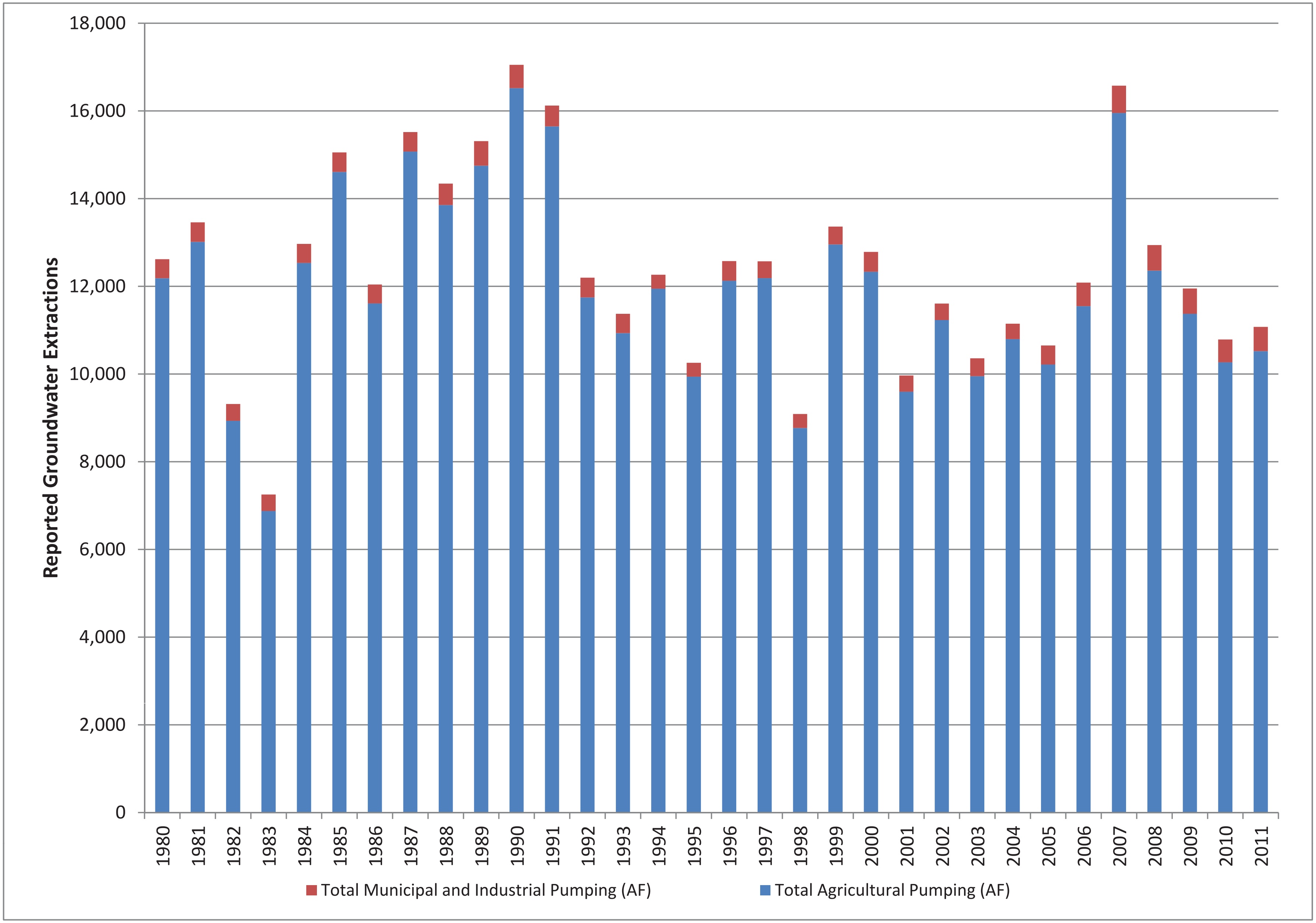


Figure 4.3-4. Historical reported groundwater extractions for the Piru Basin

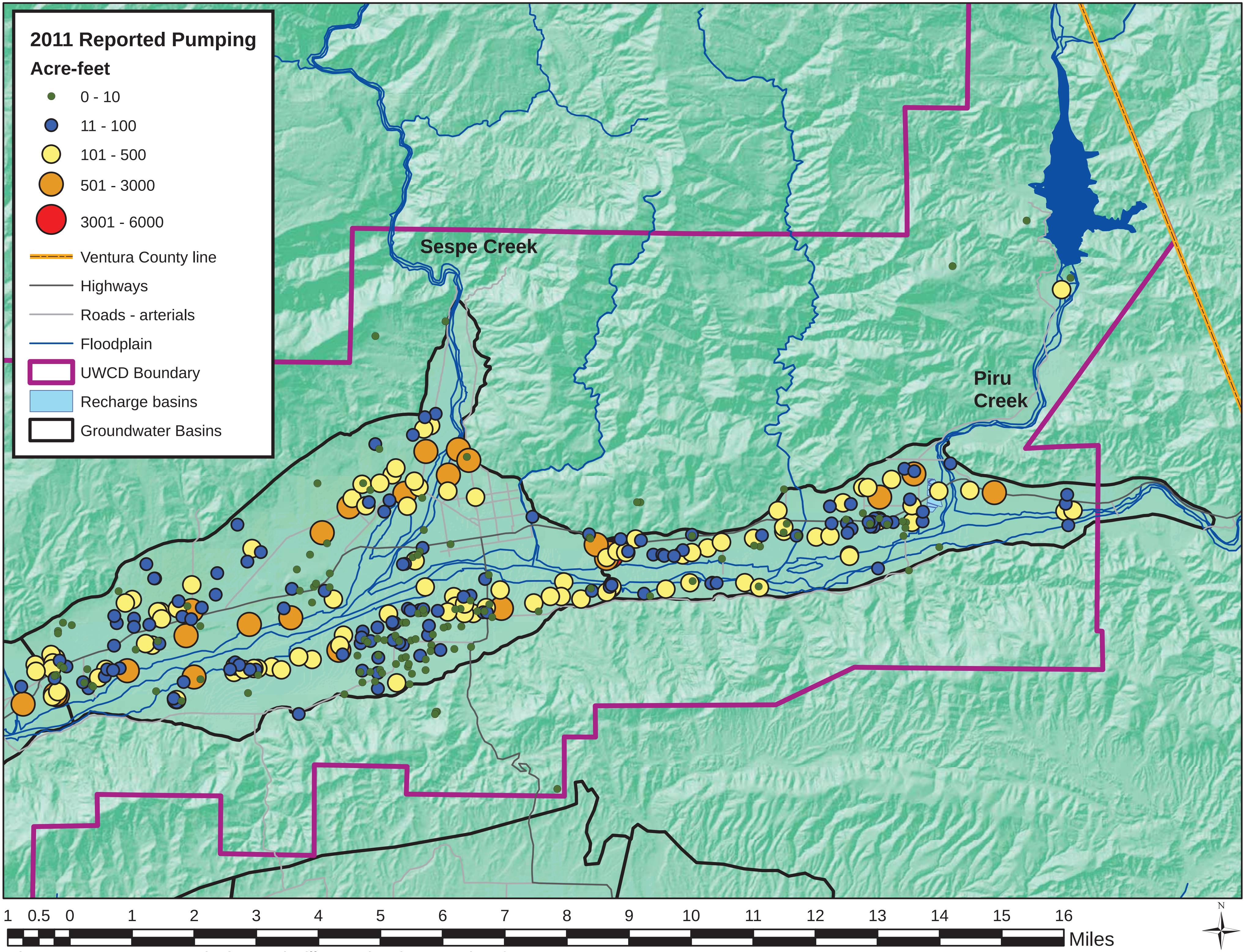


Figure 4.3-5. Reported Piru and Fillmore basin pumping for 2011

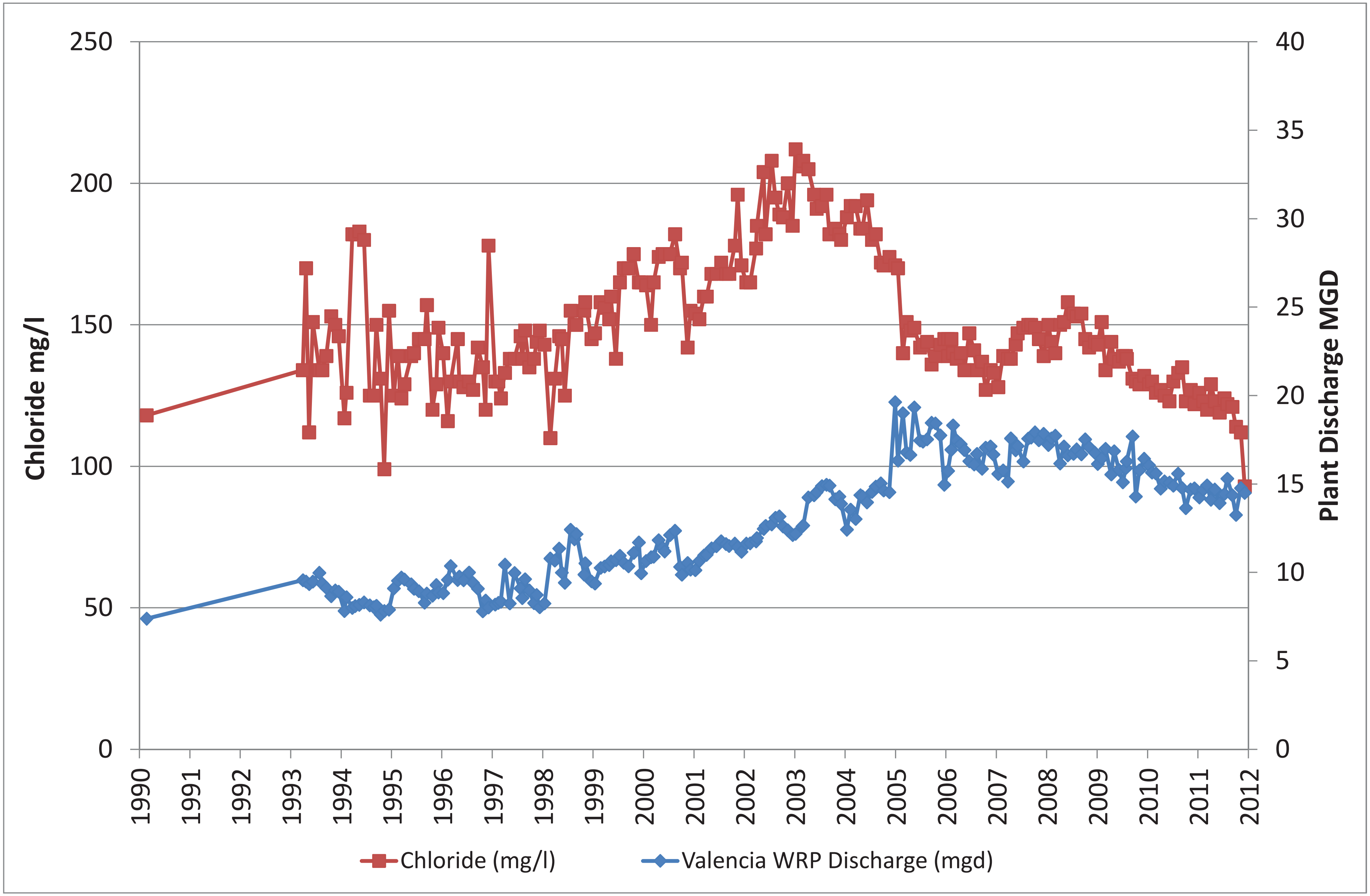


Figure 4.3-6. Historical chloride and discharge volumes at Valencia WRP

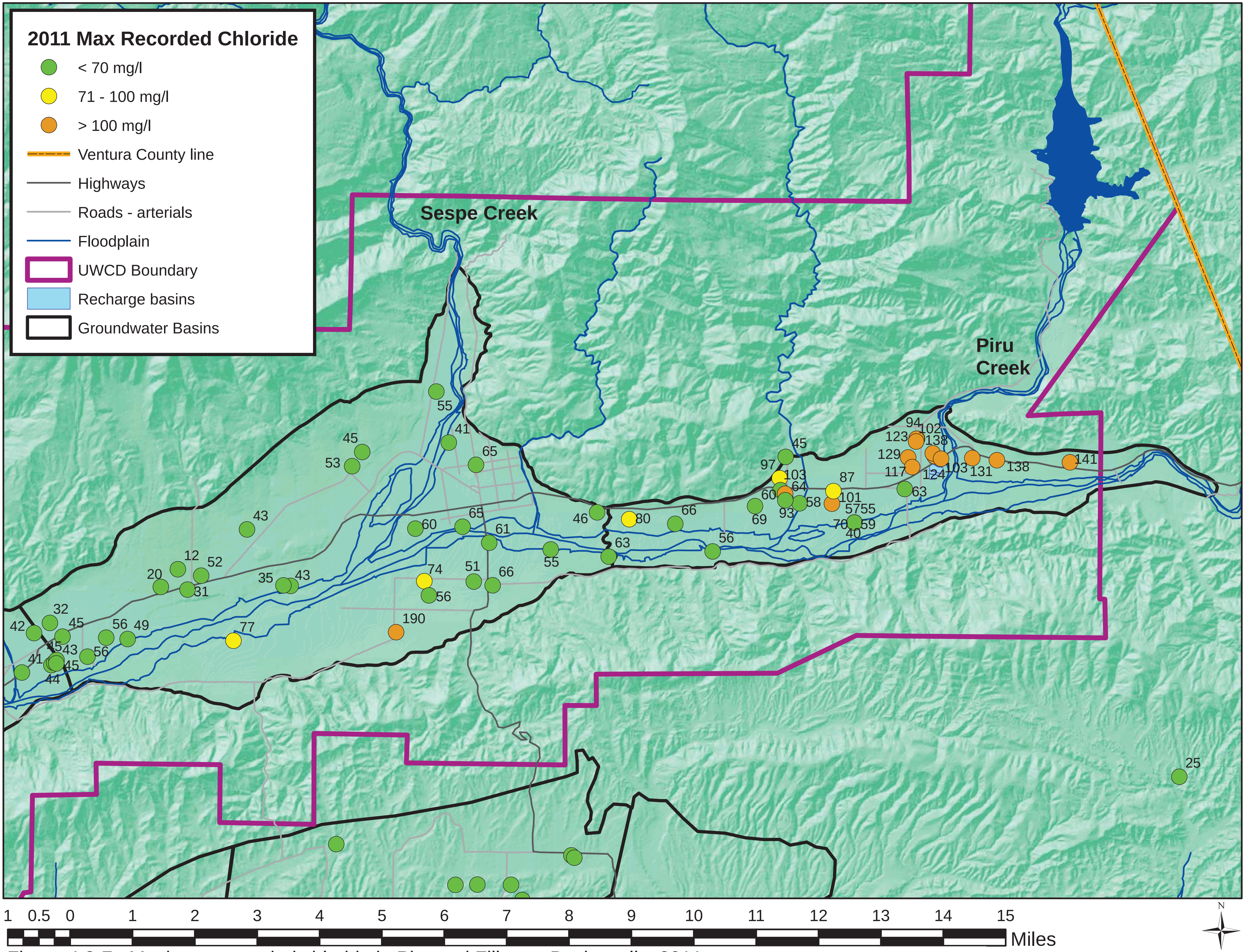


Figure 4.3-7. Maximum recorded chloride in Piru and Fillmore Basin wells, 2011

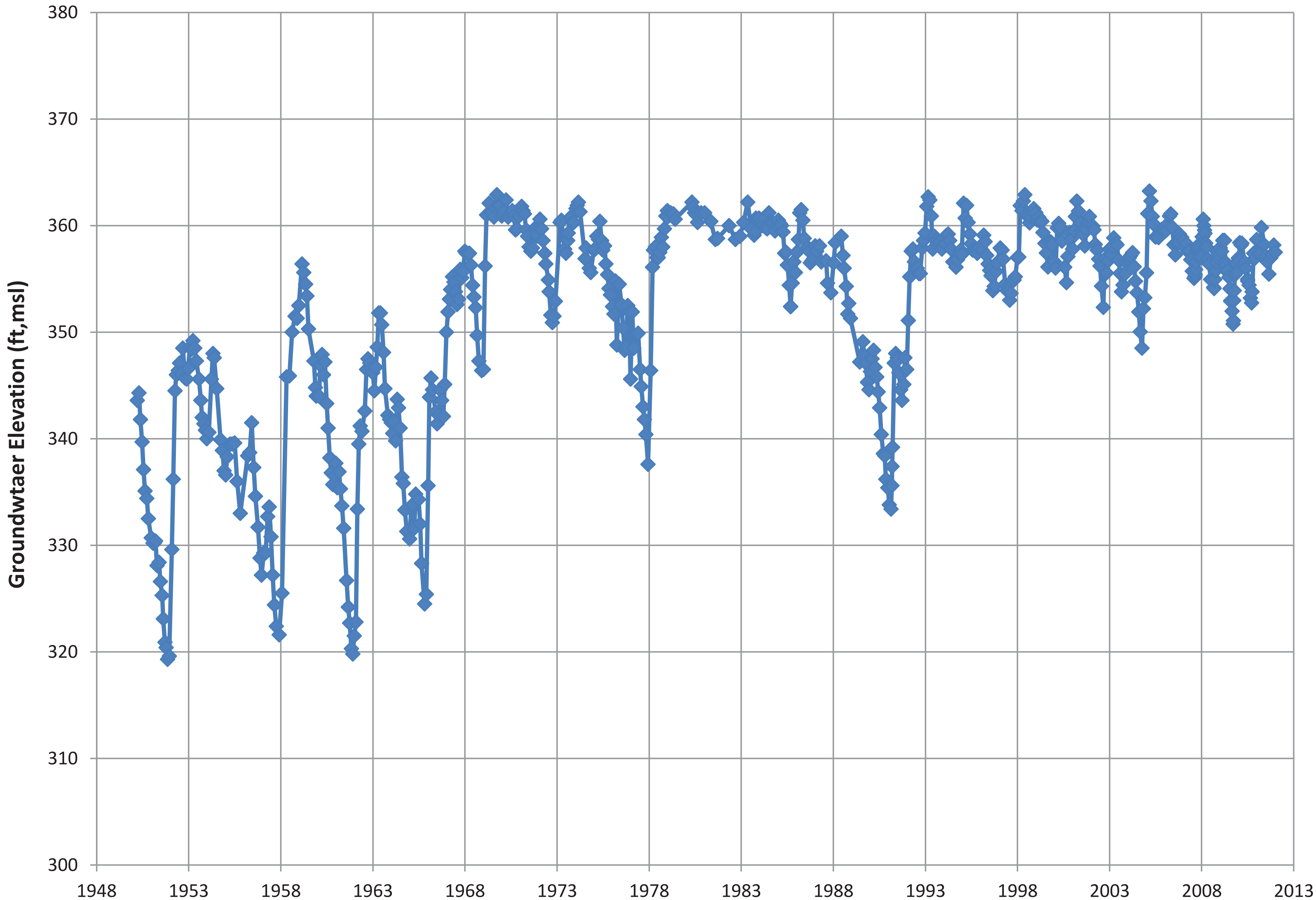


Figure 4.3-8. Historical groundwater elevations in Fillmore Basin key well

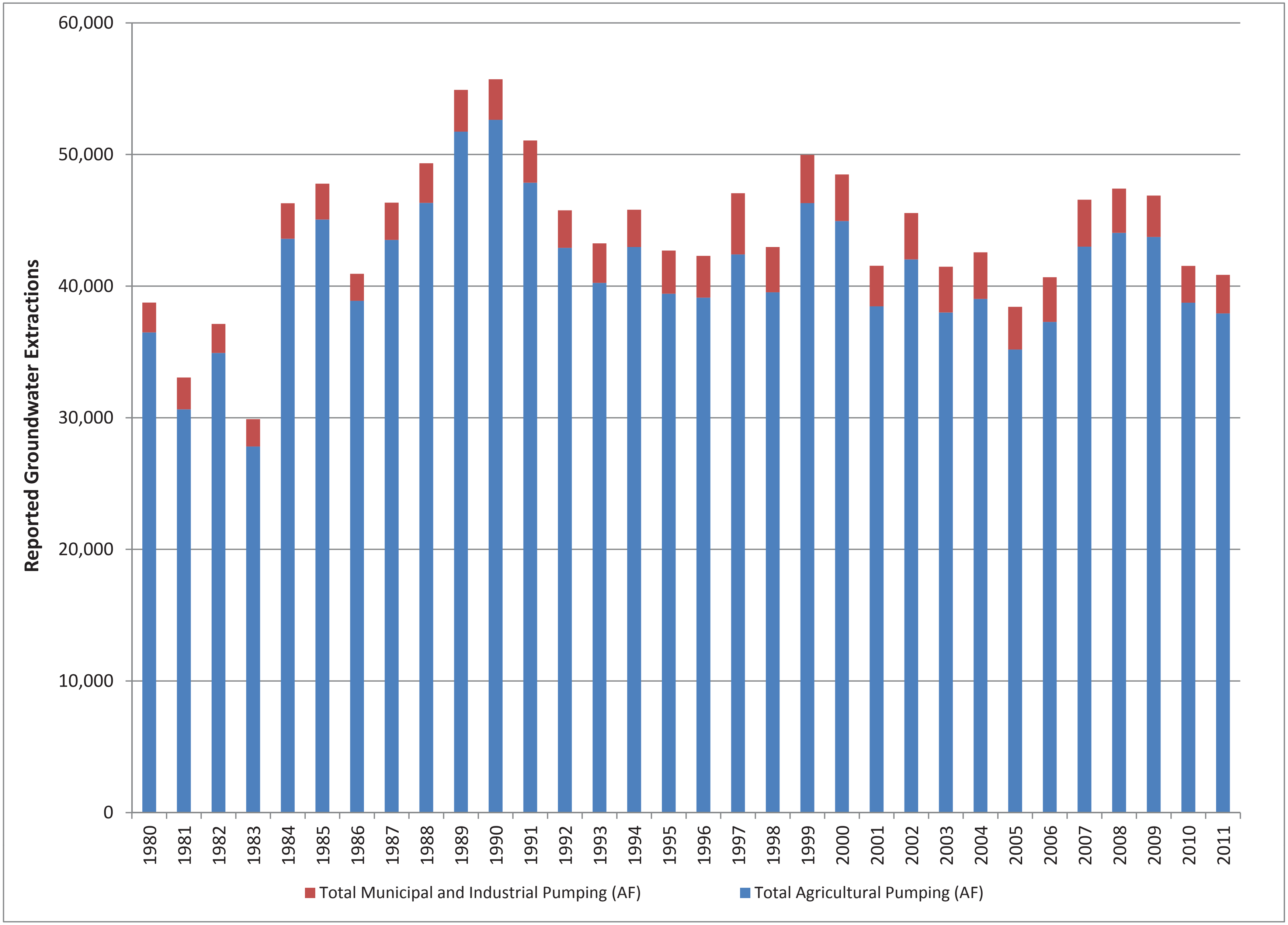


Figure 4.3-9. Historical reported groundwater extractions for the Fillmore Basin

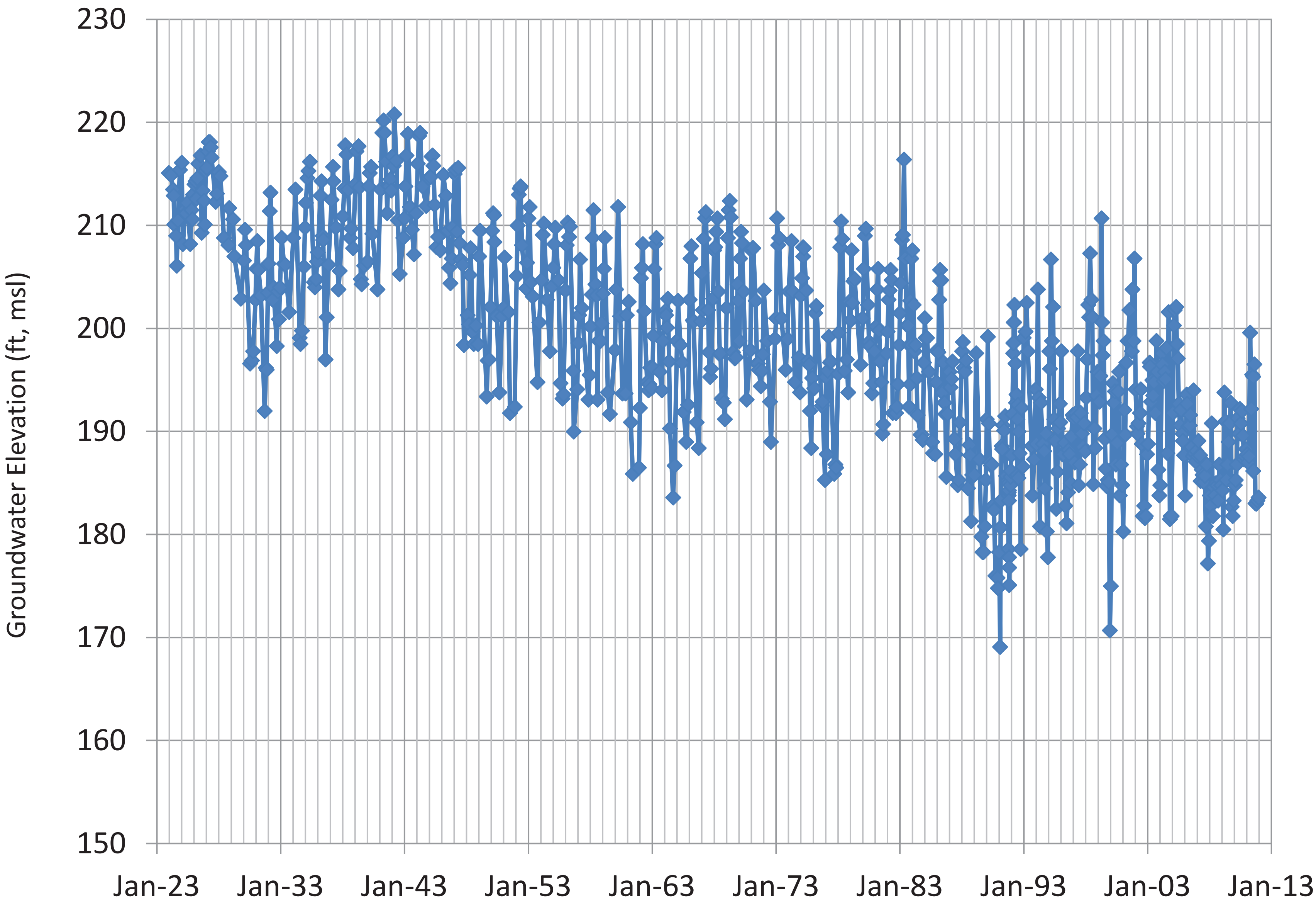


Figure 4.3-10. Historical groundwater elevations in Santa Paula Basin key well

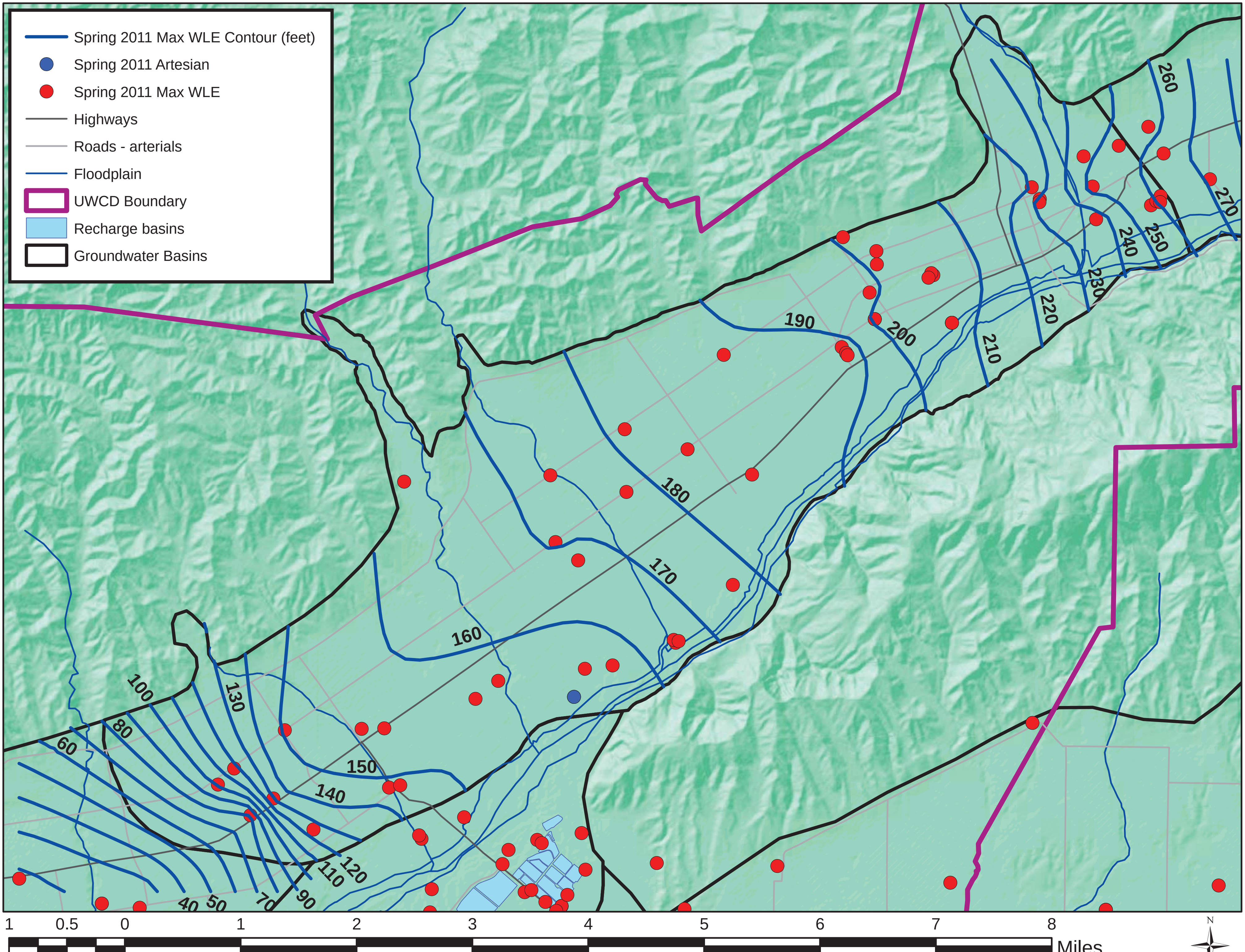


Figure 4.3-11. Santa Paula Basin groundwater elevations for spring 2011

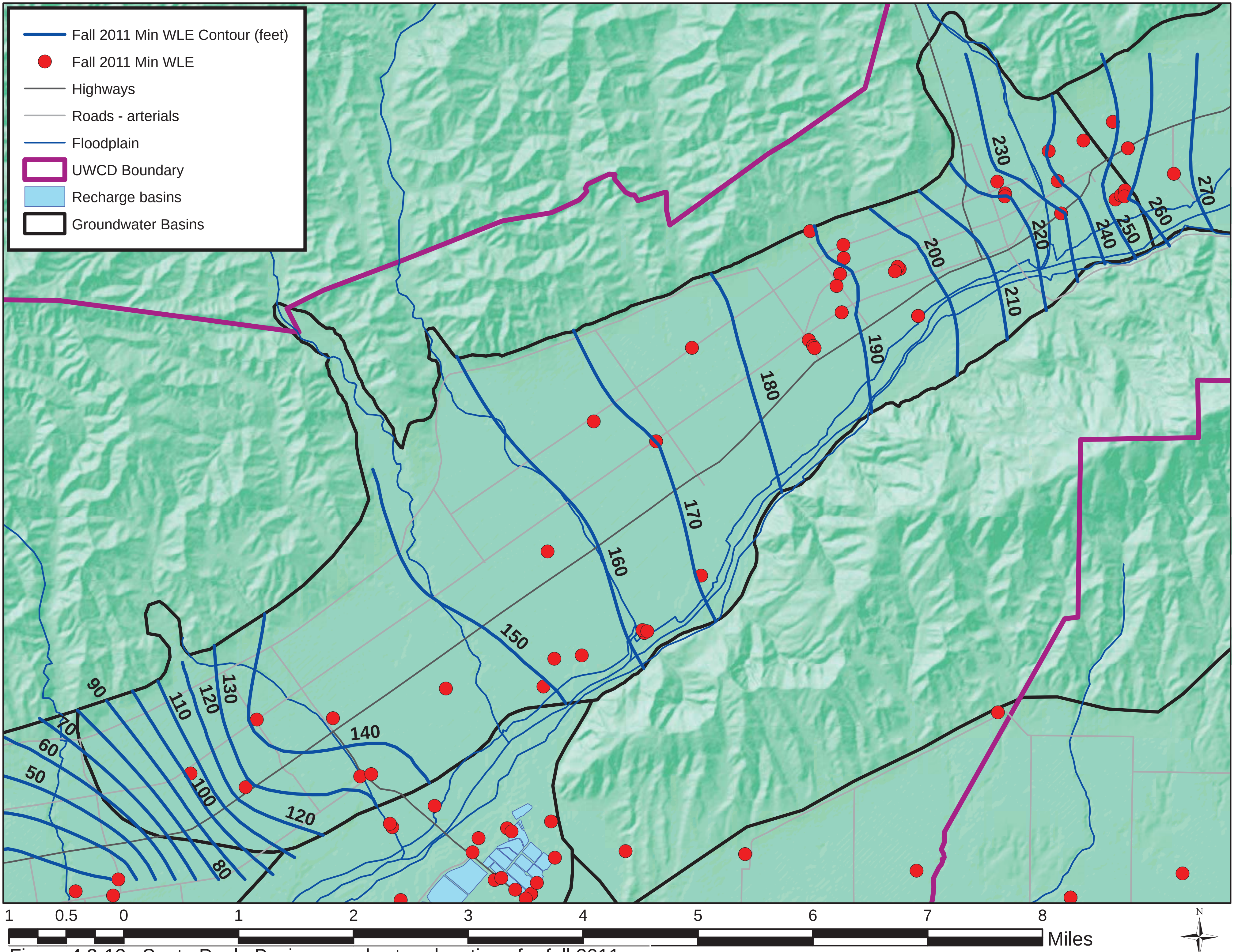


Figure 4.3-12. Santa Paula Basin groundwater elevations for fall 2011

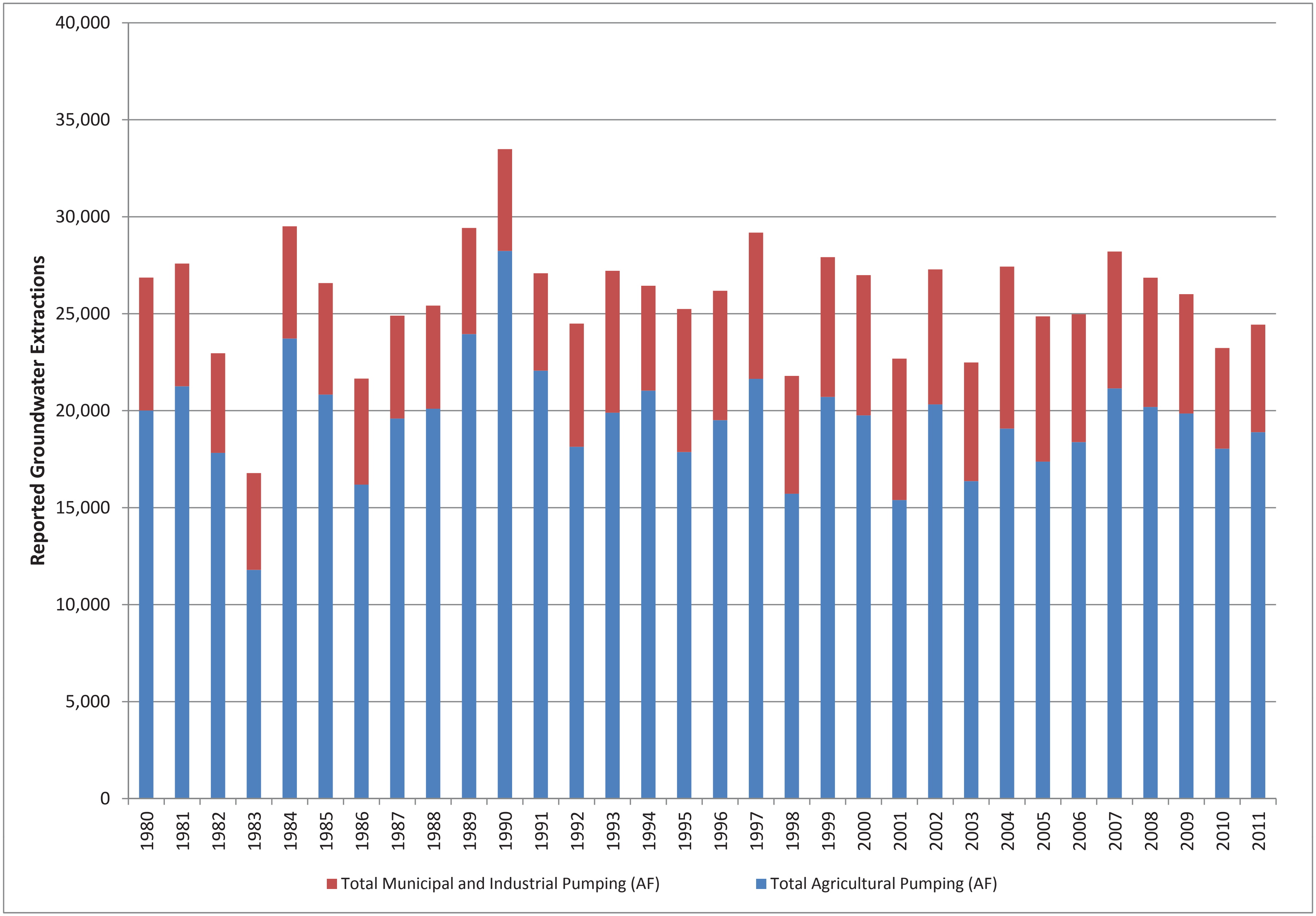


Figure 4.3-13. Historical reported groundwater extractions for the Santa Paula Basin

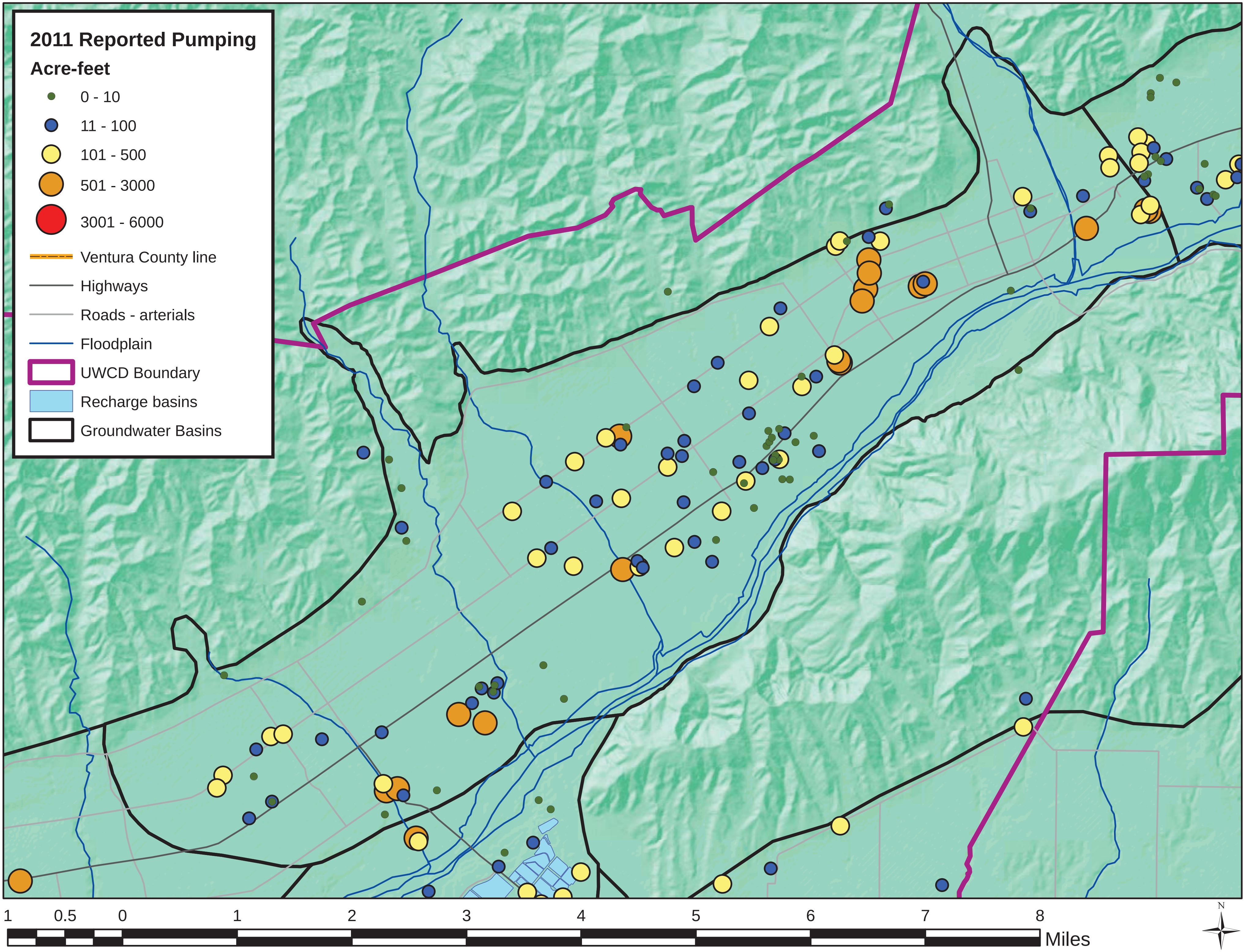


Figure 4.3-14. Reported Santa Paula Basin pumping for 2011

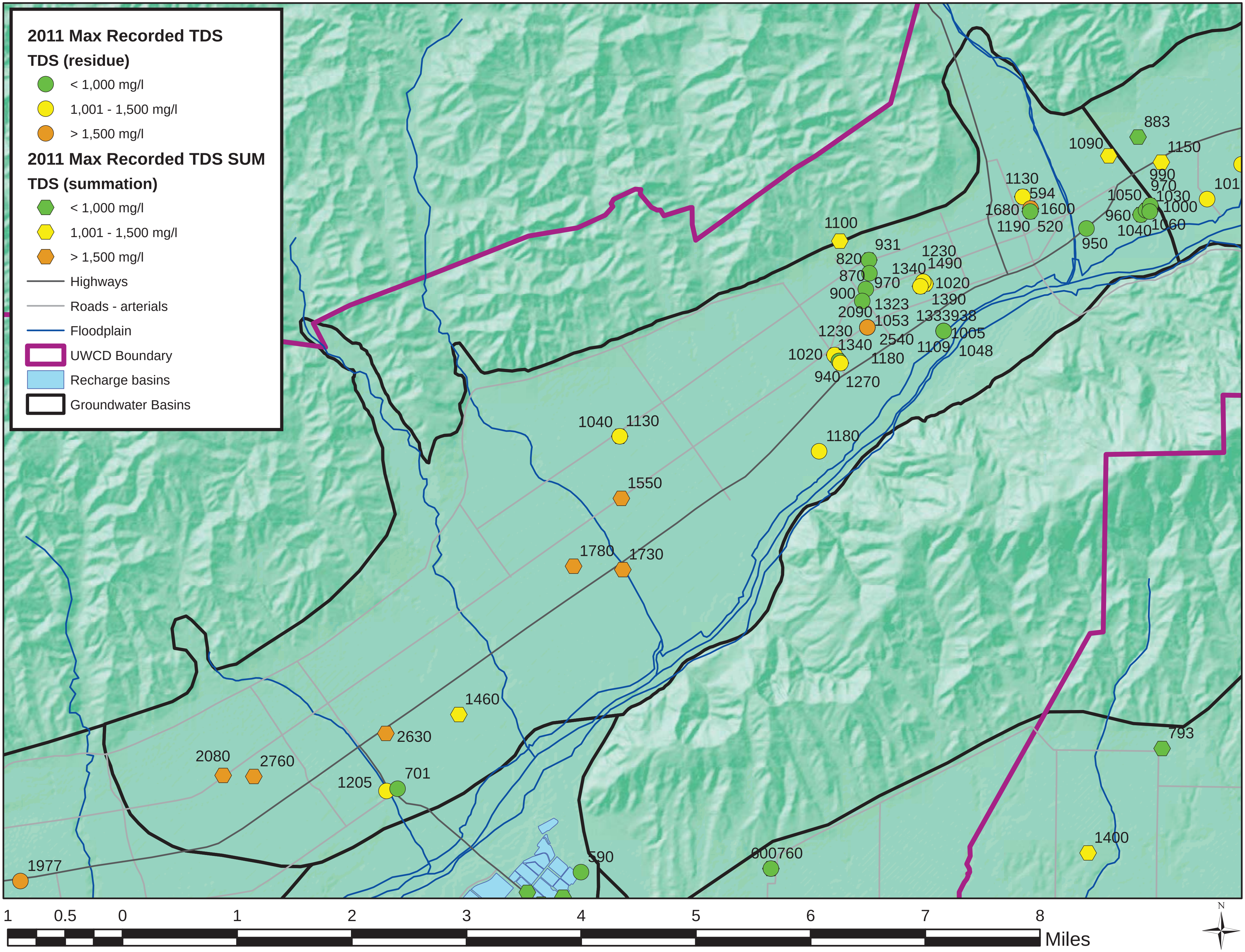


Figure 4.3-15. Maximum recorded TDS in Santa Paula Basin wells, 2011

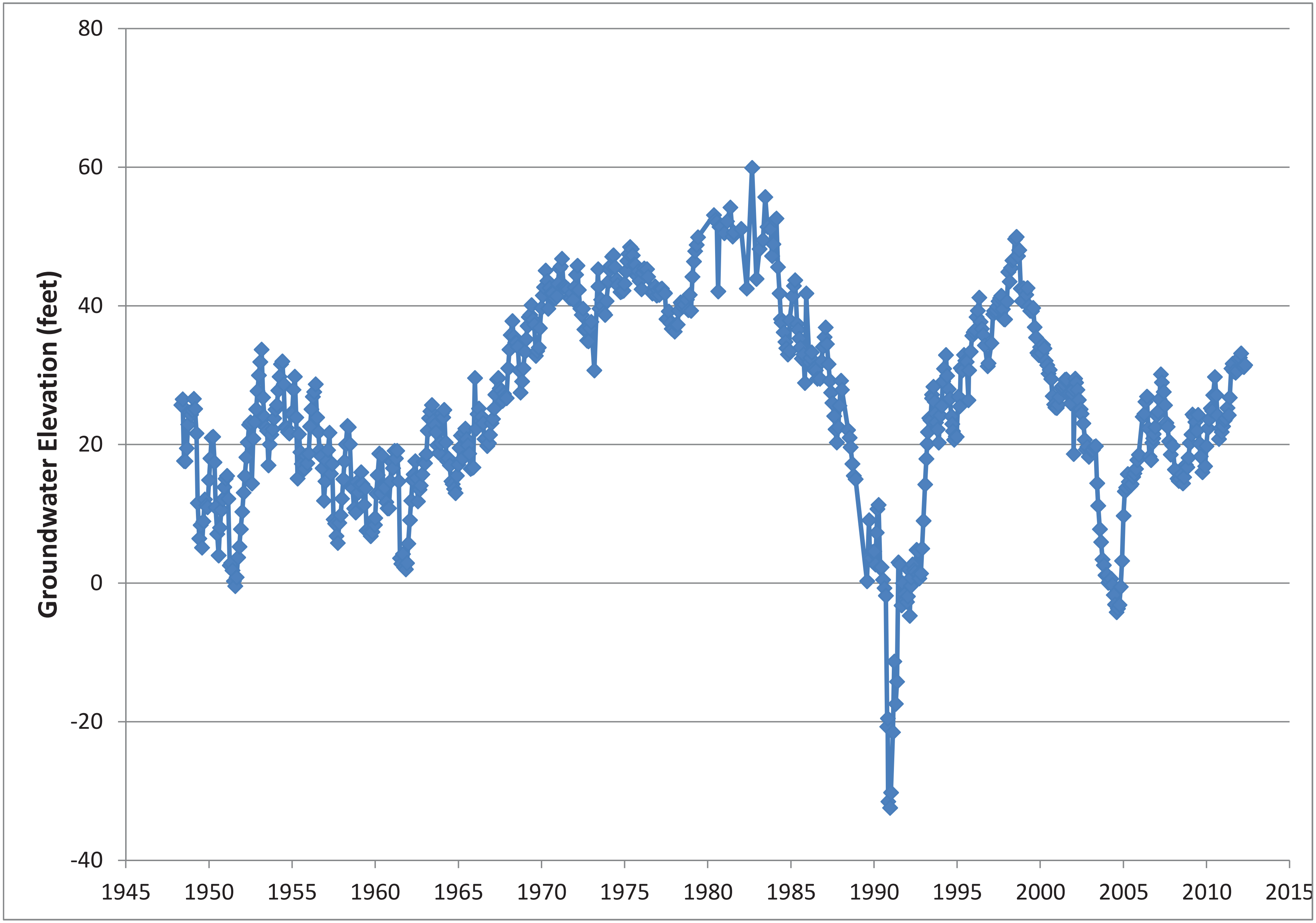


Figure 4.3-16. Historical groundwater elevations in Mound Basin key well

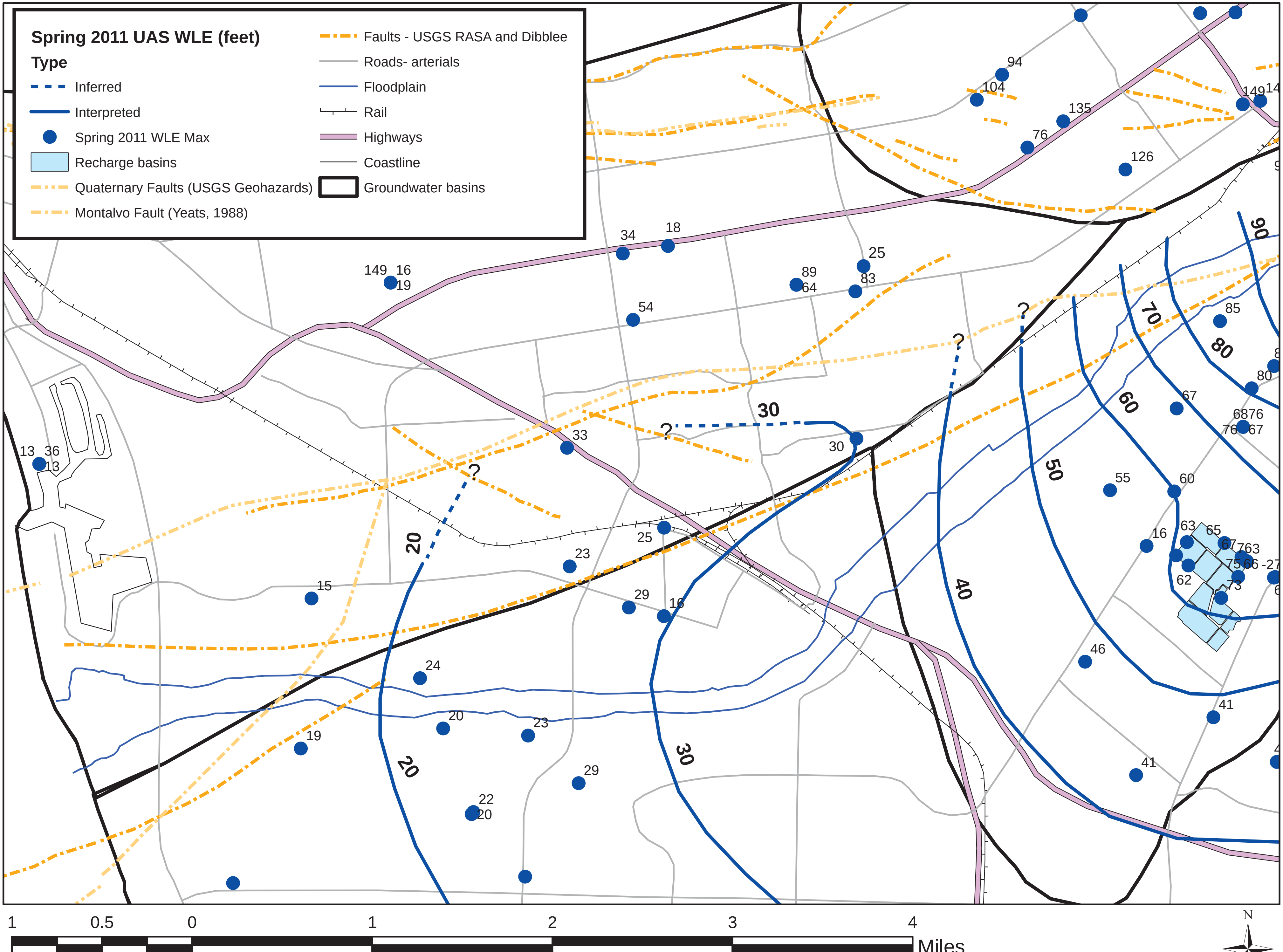


Figure 4.3-17. Mound Basin groundwater elevations for spring 2011

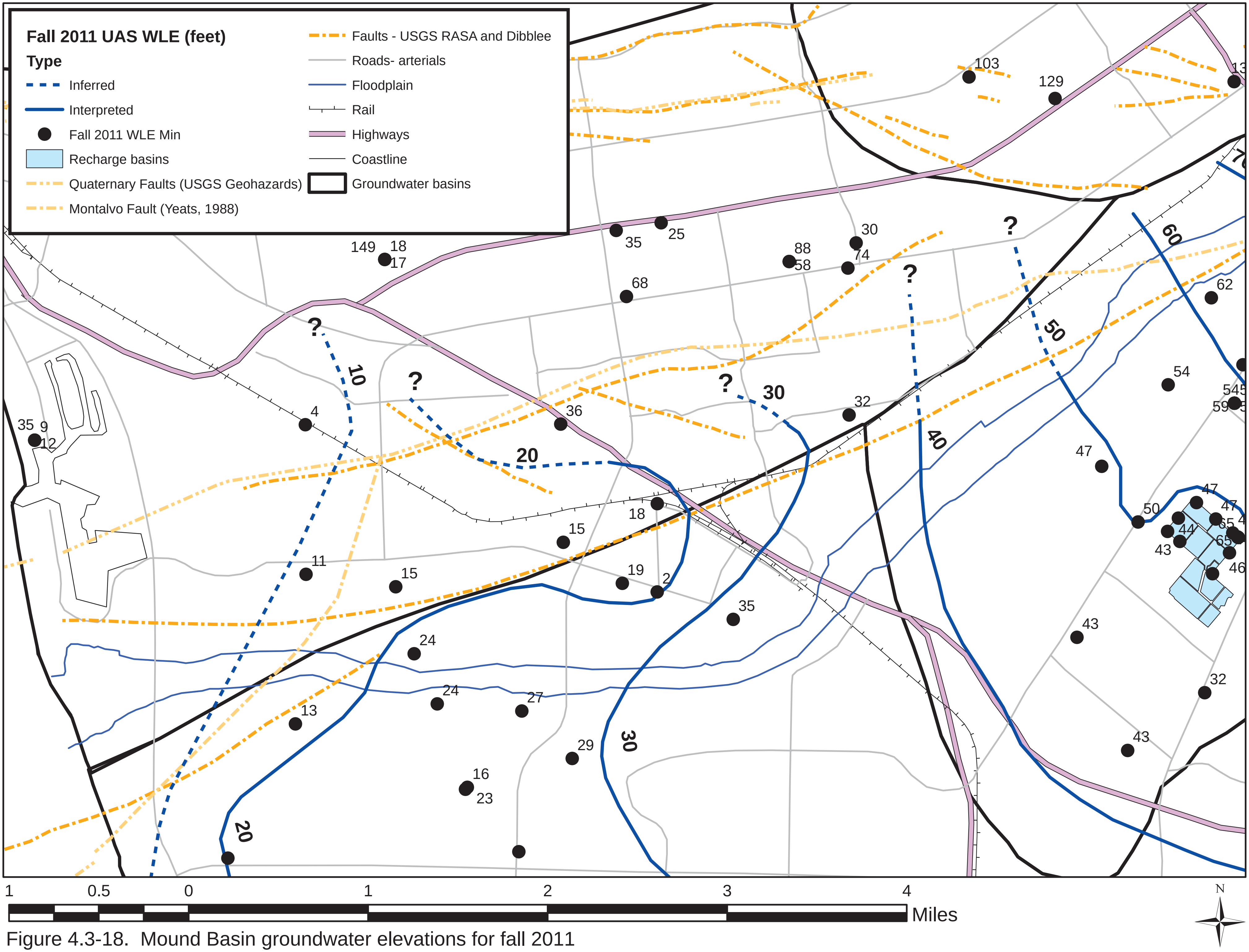


Figure 4.3-18. Mound Basin groundwater elevations for fall 2011

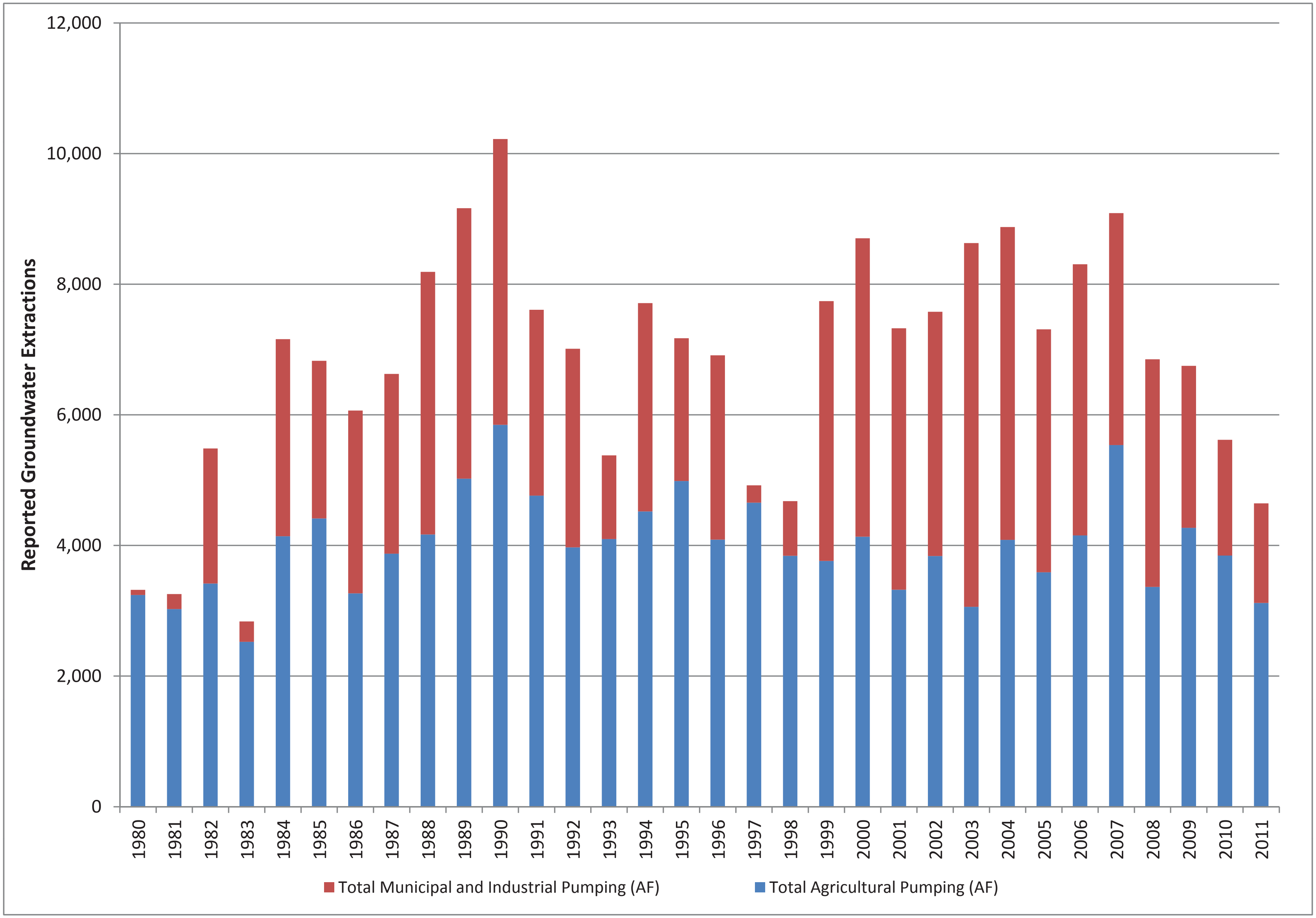


Figure 4.3-19. Historical reported groundwater extractions for the Mound Basin

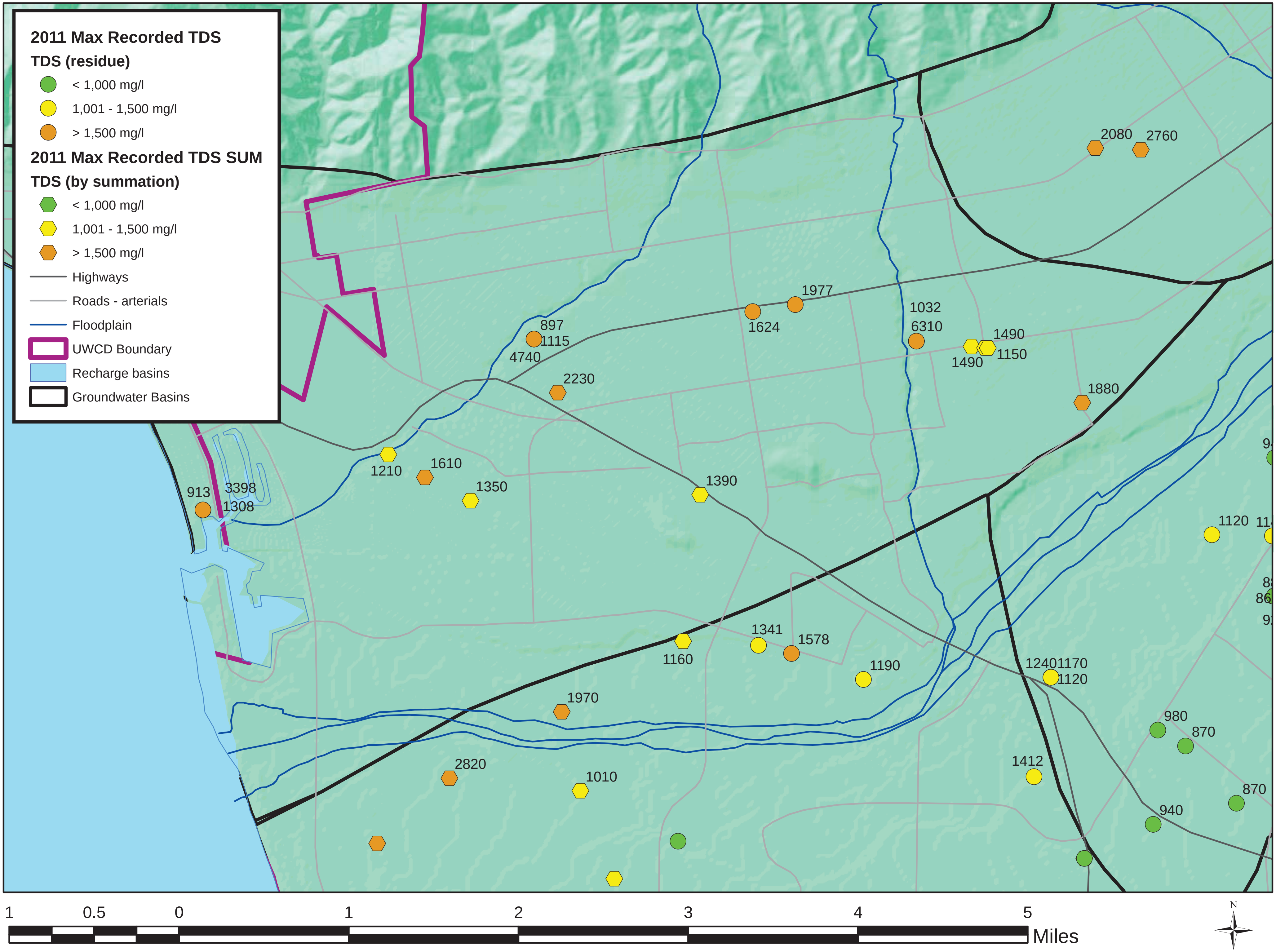


Figure 4.3-20. Maximum recorded TDS in Mound Basin wells, 2011

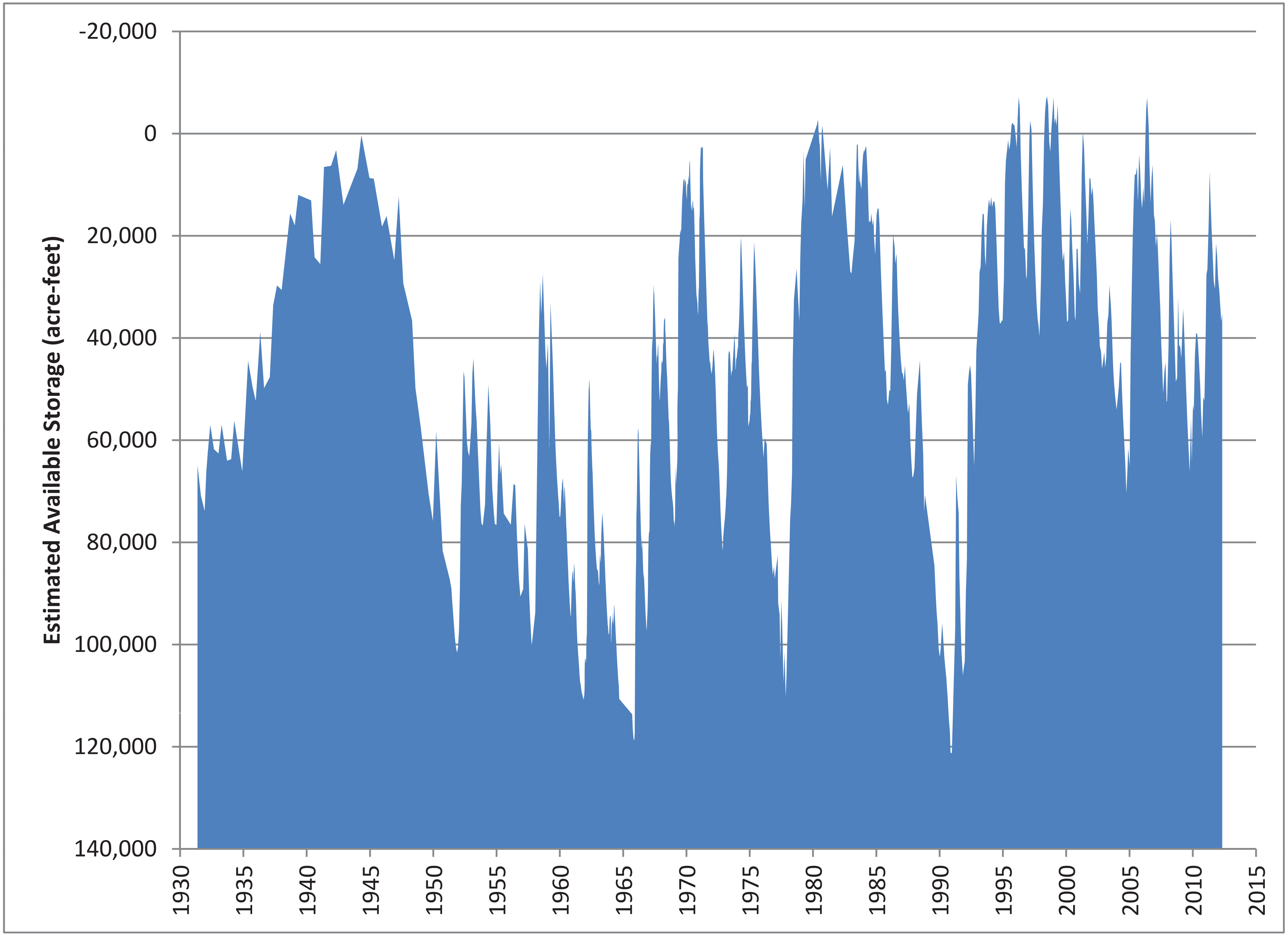


Figure 4.3-21. Historical estimates of available groundwater storage, Oxnard Forebay Basin

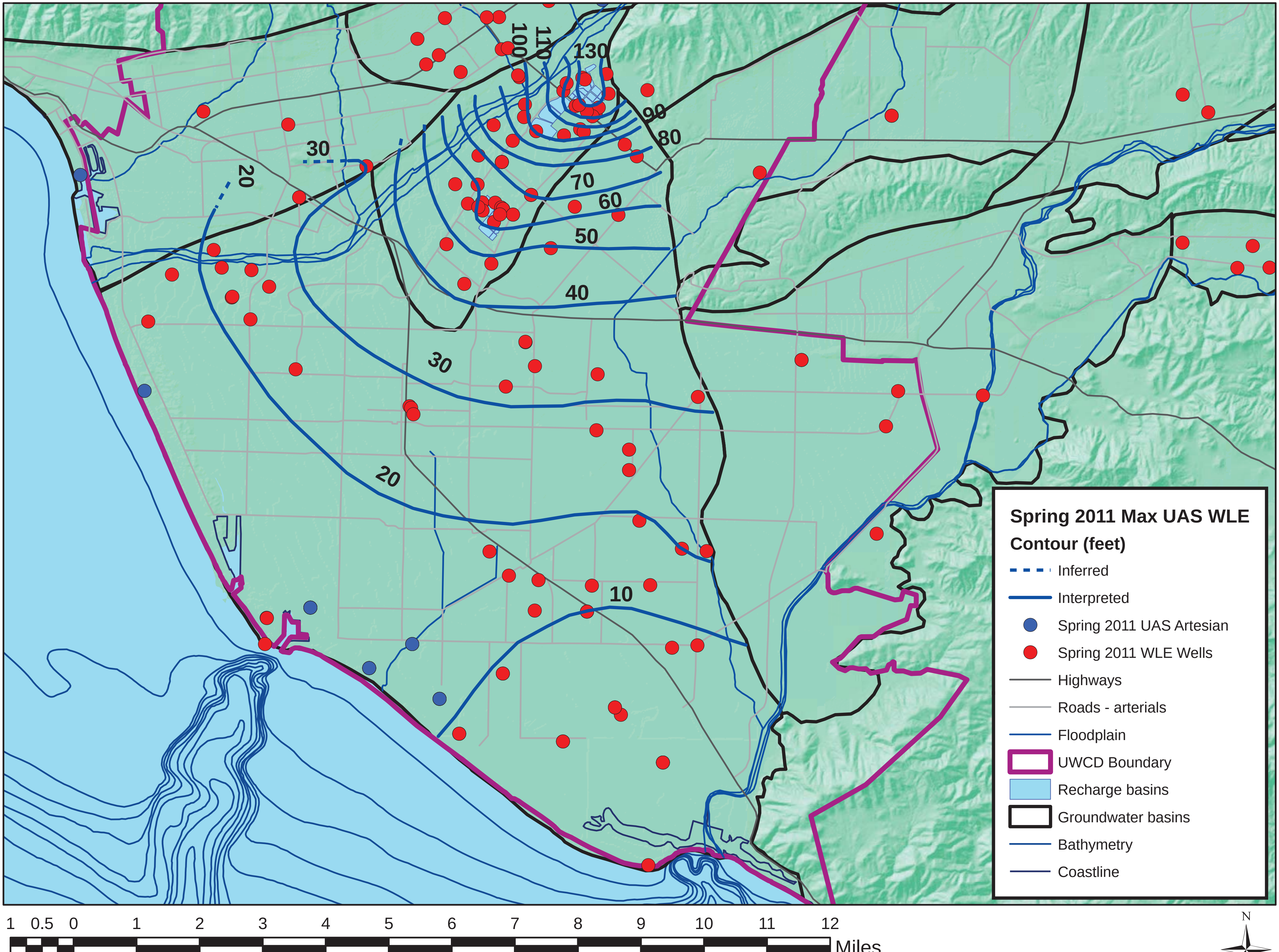


Figure 4.3-22. Oxnard Forebay-Oxnard Plain Upper Aquifer System (UAS) groundwater elevations for spring 2011

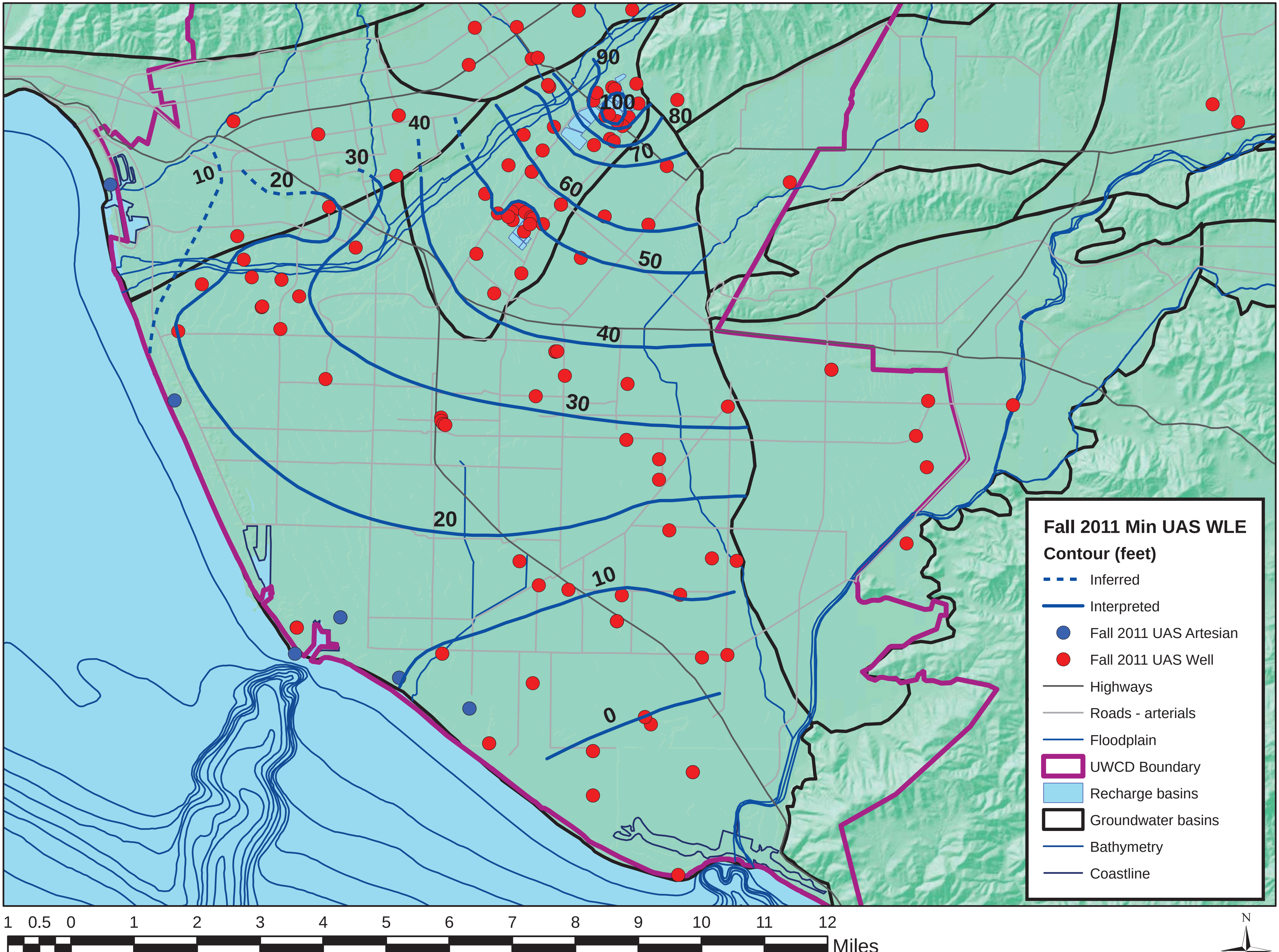


Figure 4.3-23. Oxnard Forebay-Oxnard Plain Upper Aquifer System (UAS) groundwater elevations for fall 2011

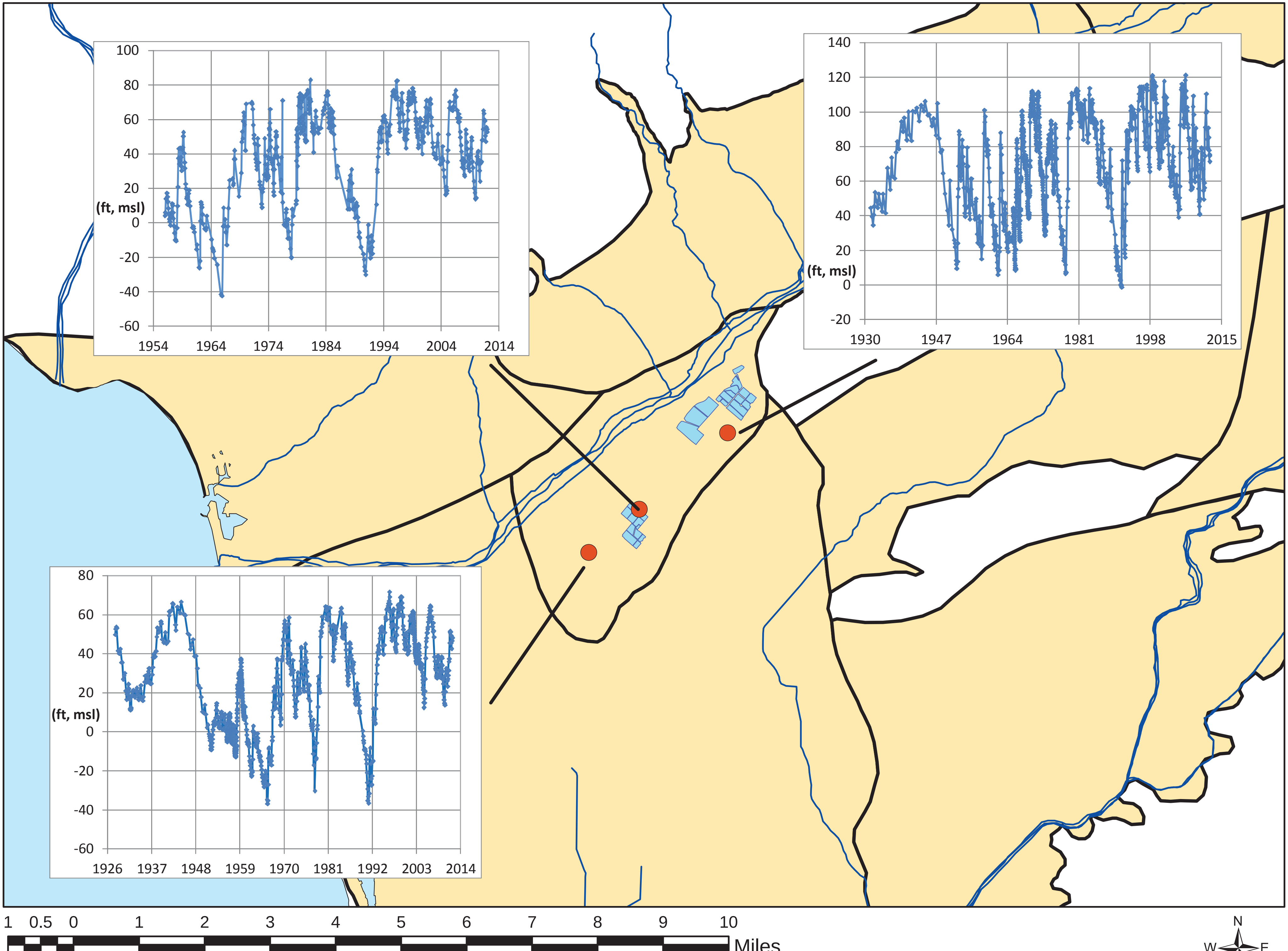


Figure 4.3-24. Oxnard Forebay Upper Aquifer System (UAS) groundwater elevation hydrographs, selected wells

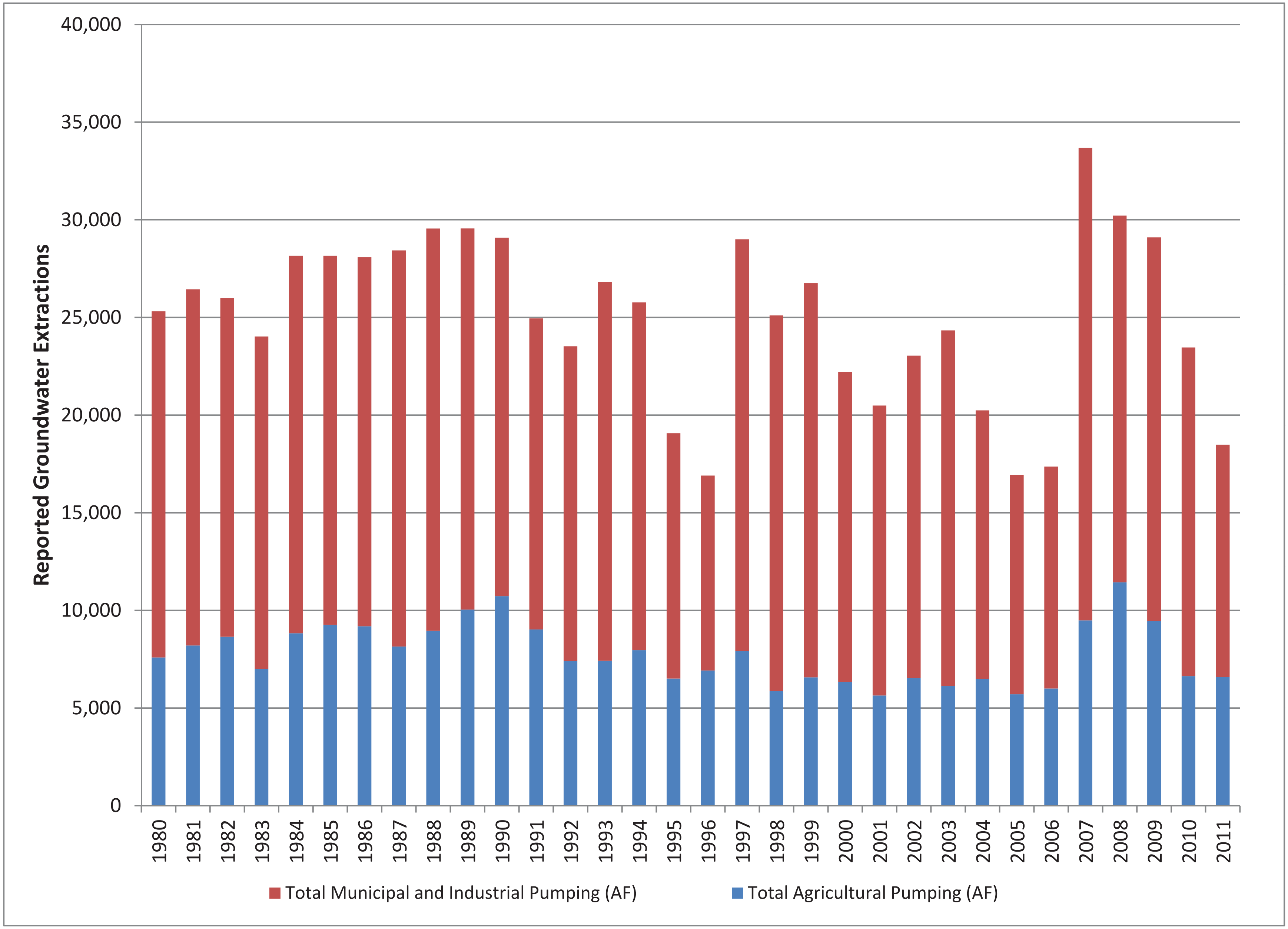


Figure 4.3-25. Historical reported groundwater extractions for the Oxnard Forebay

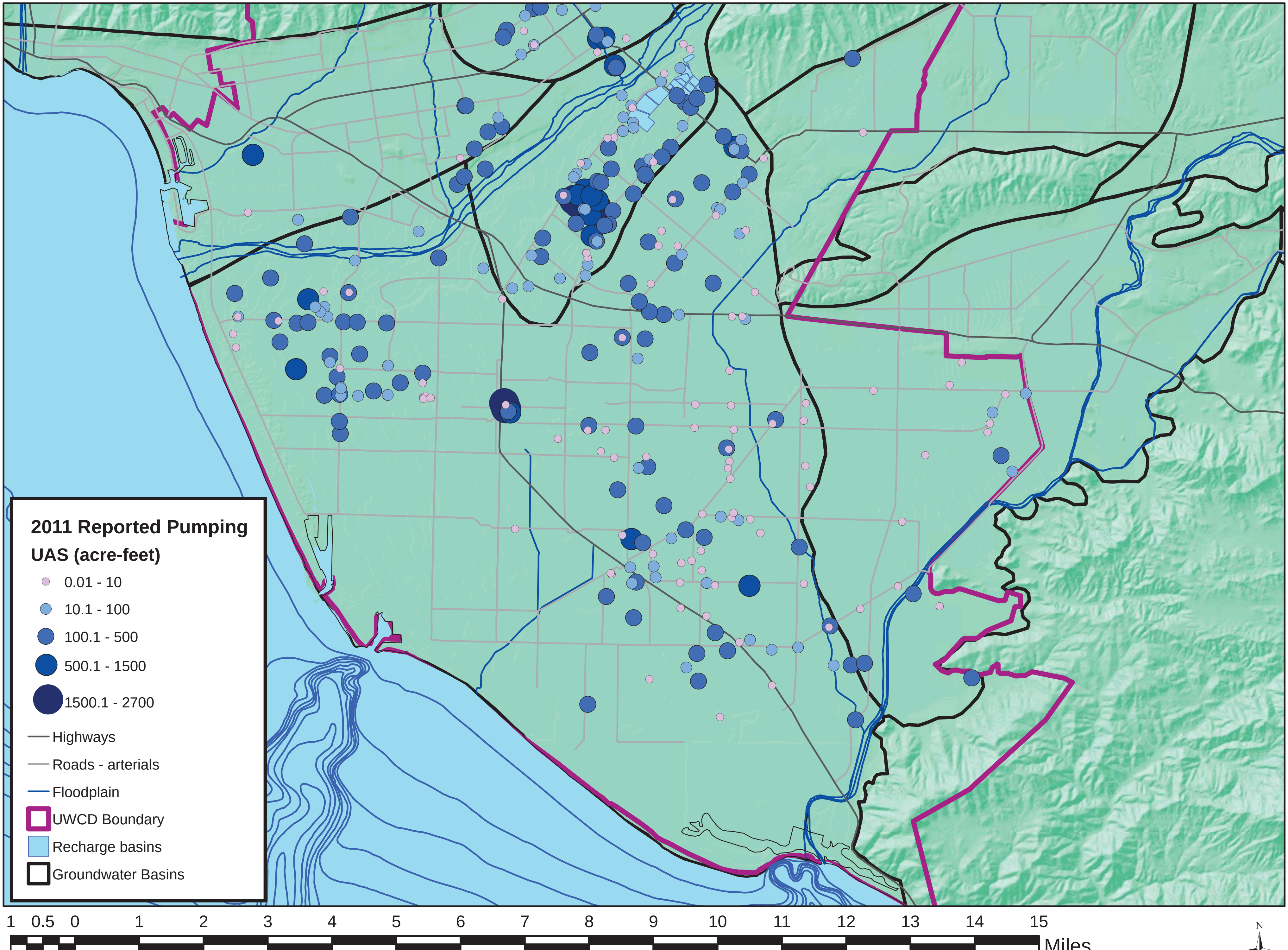


Figure 4.3-26. Reported Oxnard Forebay- Oxnard Plain Reported Upper Aquifer System (UAS) Pumping for 2011

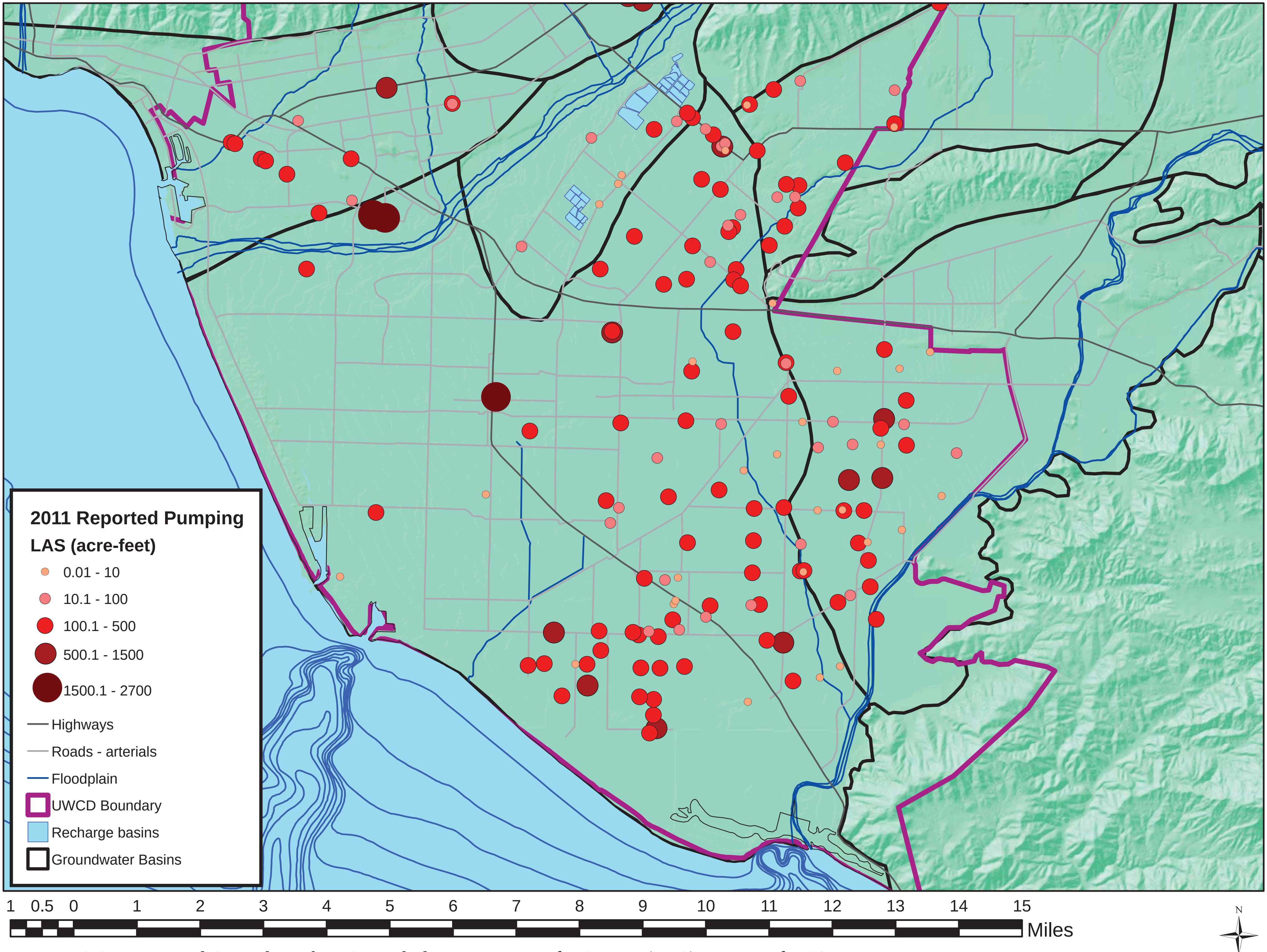


Figure 4.3-27. Reported Oxnard Forebay-Oxnard Plain Lower Aquifer System (LAS) Pumping for 2011

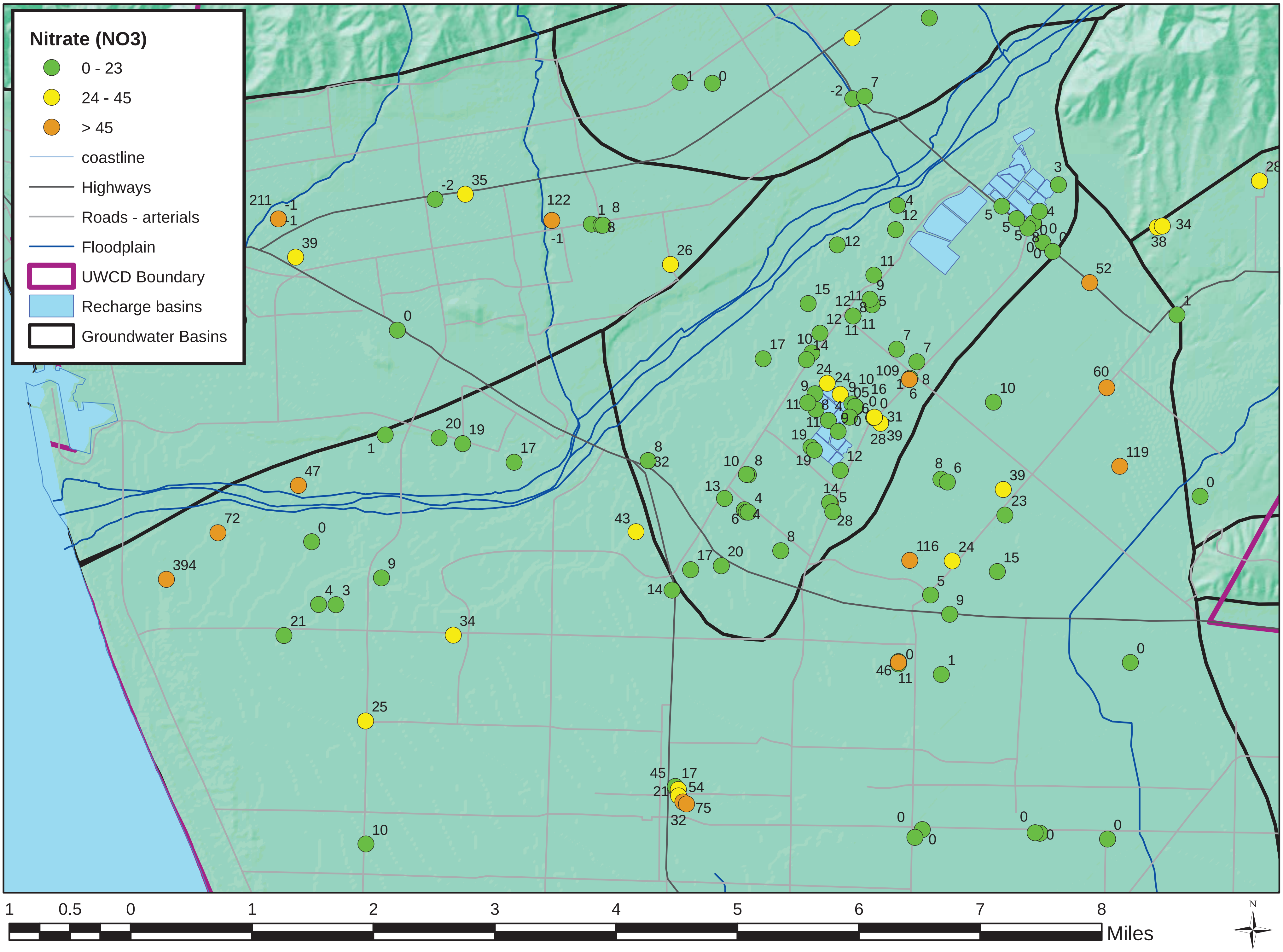


Figure 4.3-28. Maximum recorded nitrate (NO3) in Oxnard Forebay-Oxnard Plain wells, 2011

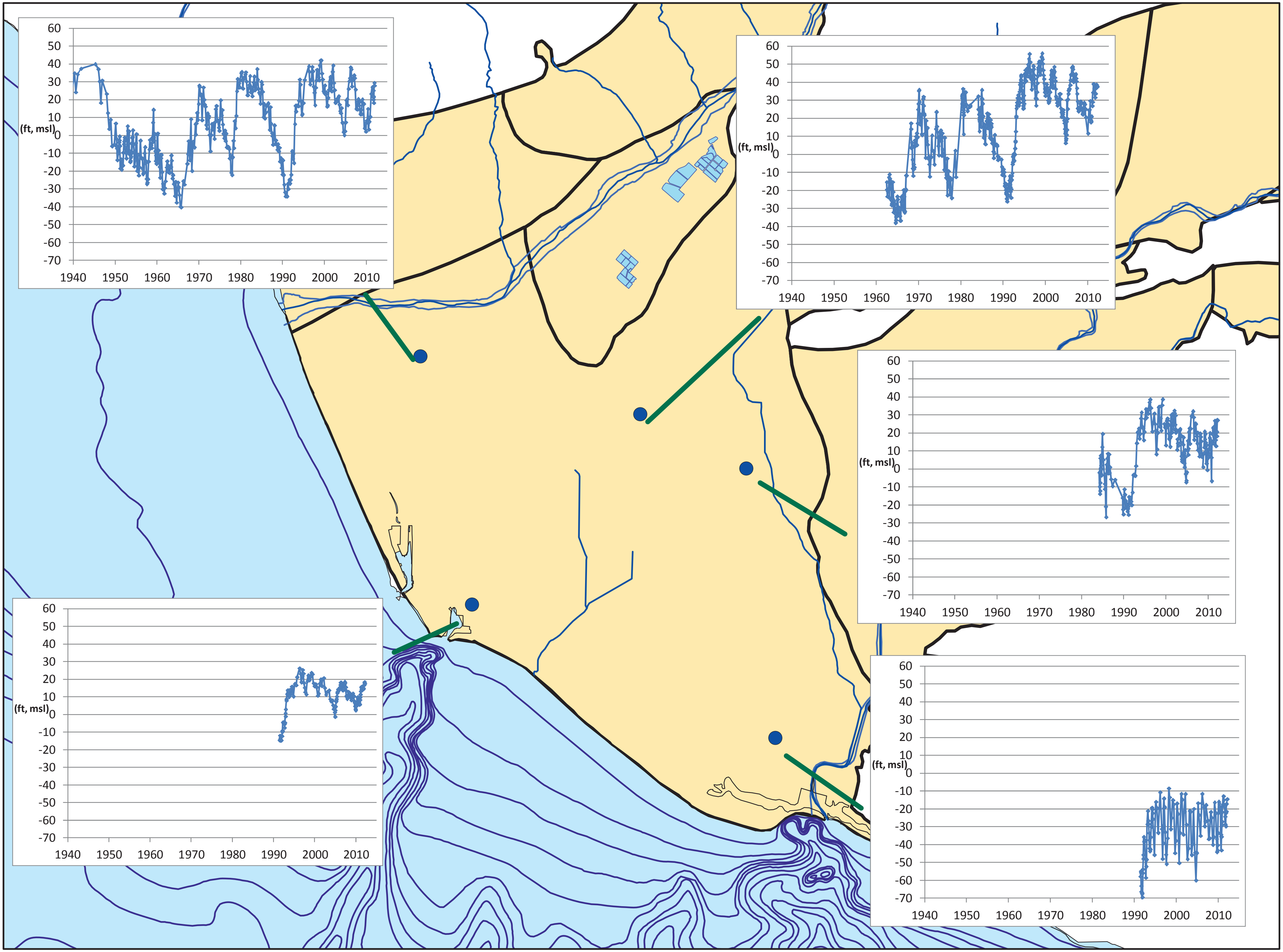


Figure 4.3-29. Oxnard Plain Upper Aquifer System (UAS) groundwater elevation hydrographs, selected wells

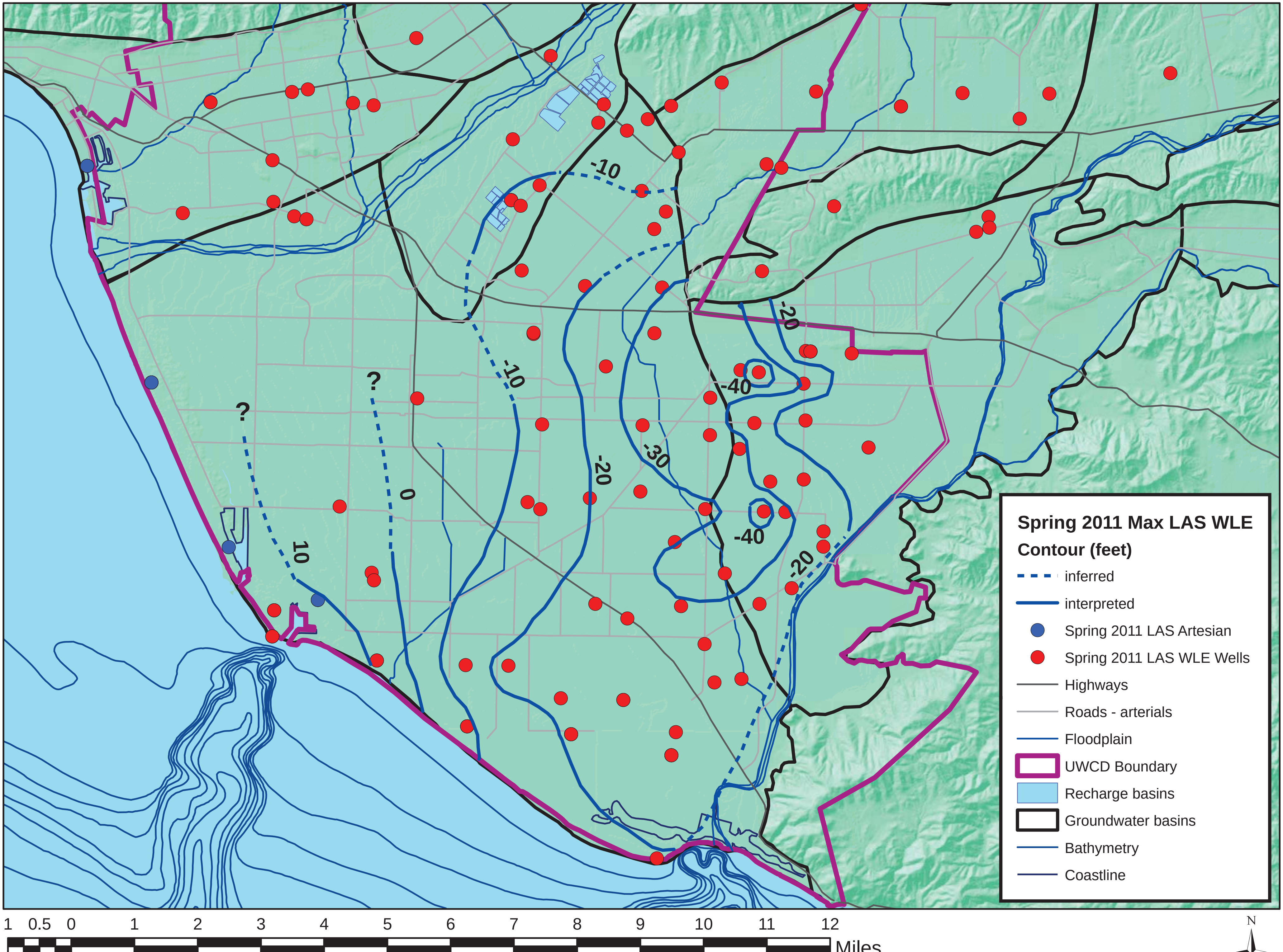


Figure 4.3-30. Oxnard Forebay-Oxnard Plain Lower Aquifer System (LAS) groundwater elevations for spring 2011

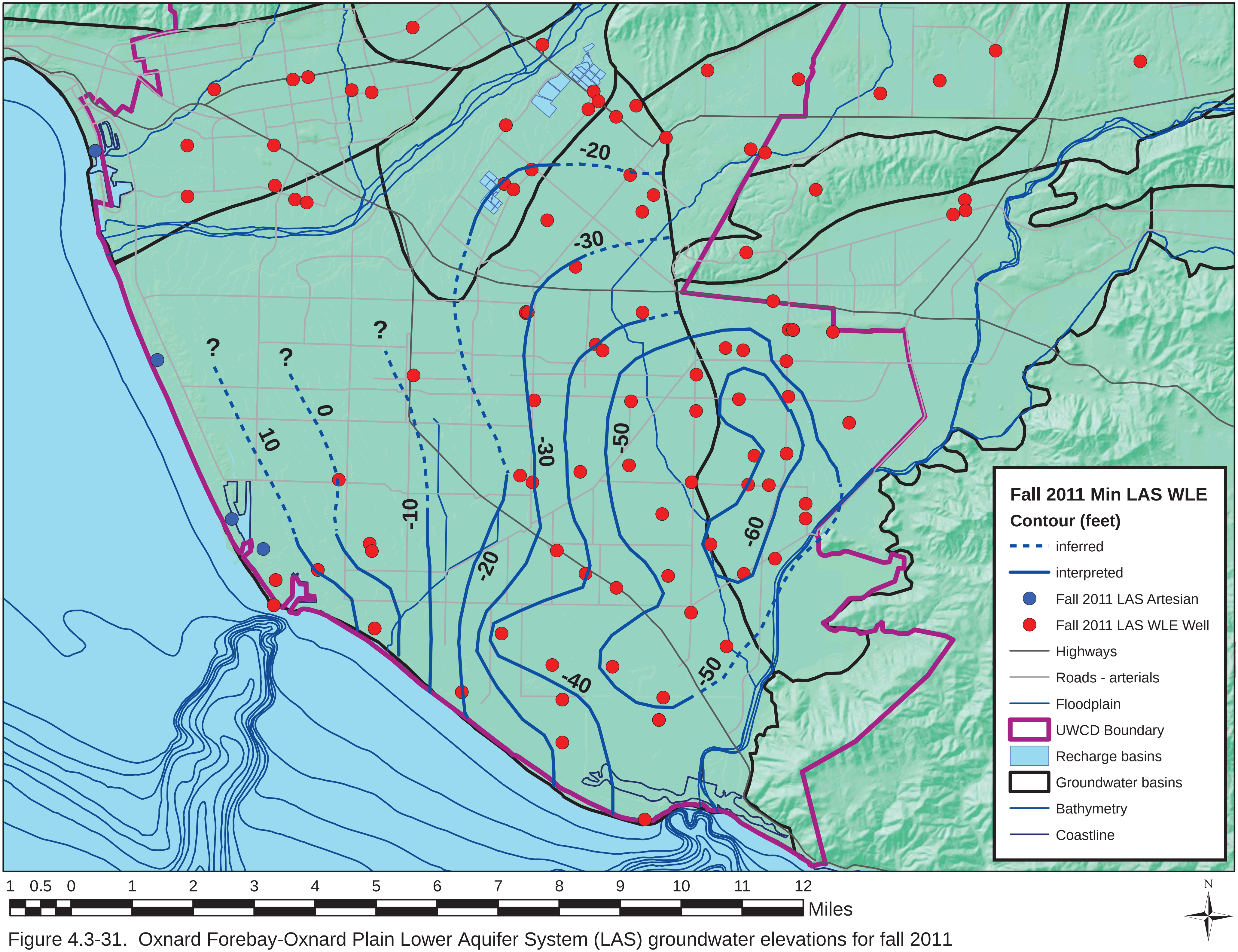


Figure 4.3-31. Oxnard Forebay-Oxnard Plain Lower Aquifer System (LAS) groundwater elevations for fall 2011

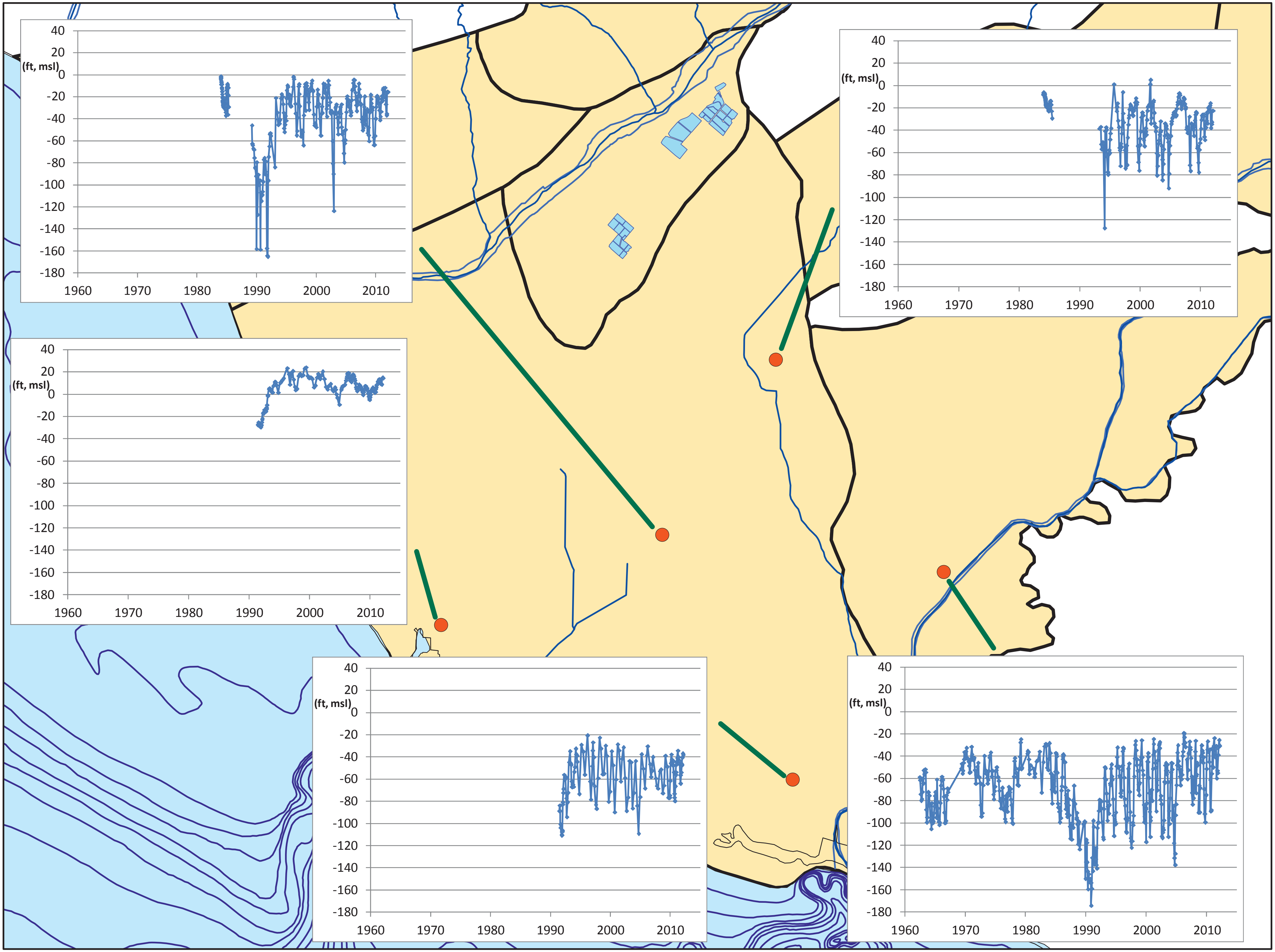


Figure 4.3-32. Oxnard Plain Lower Aquifer System (LAS) groundwater elevation hydrographs, selected wells

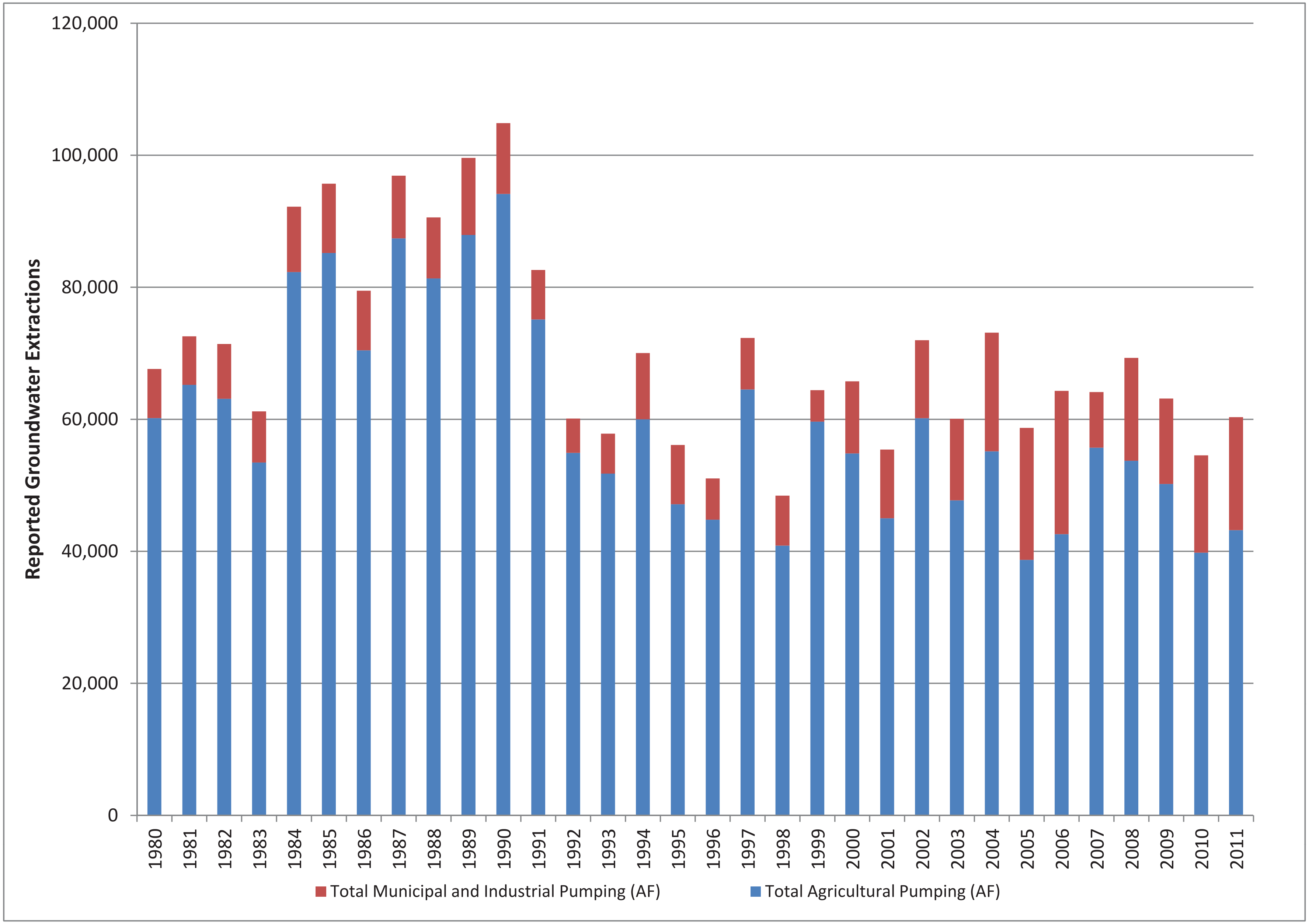


Figure 4.3-33. Historical reported groundwater extractions for the Oxnard Plain and portions of Pleasant Valley and the West Las Posas Basin

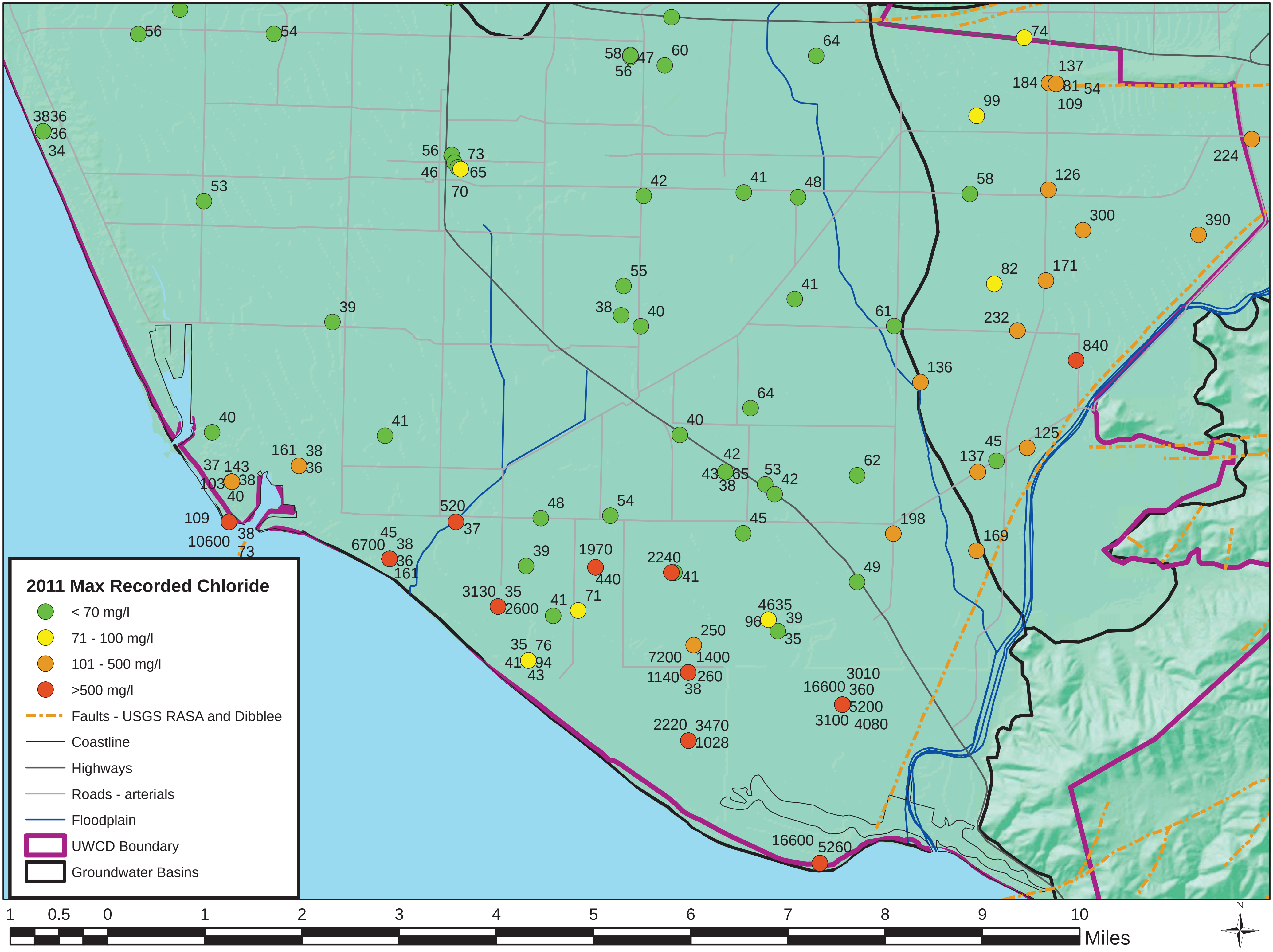


Figure 4.3-34. Maximum recorded chloride for Oxnard Plain and Pleasant Valley Basin wells, 2011

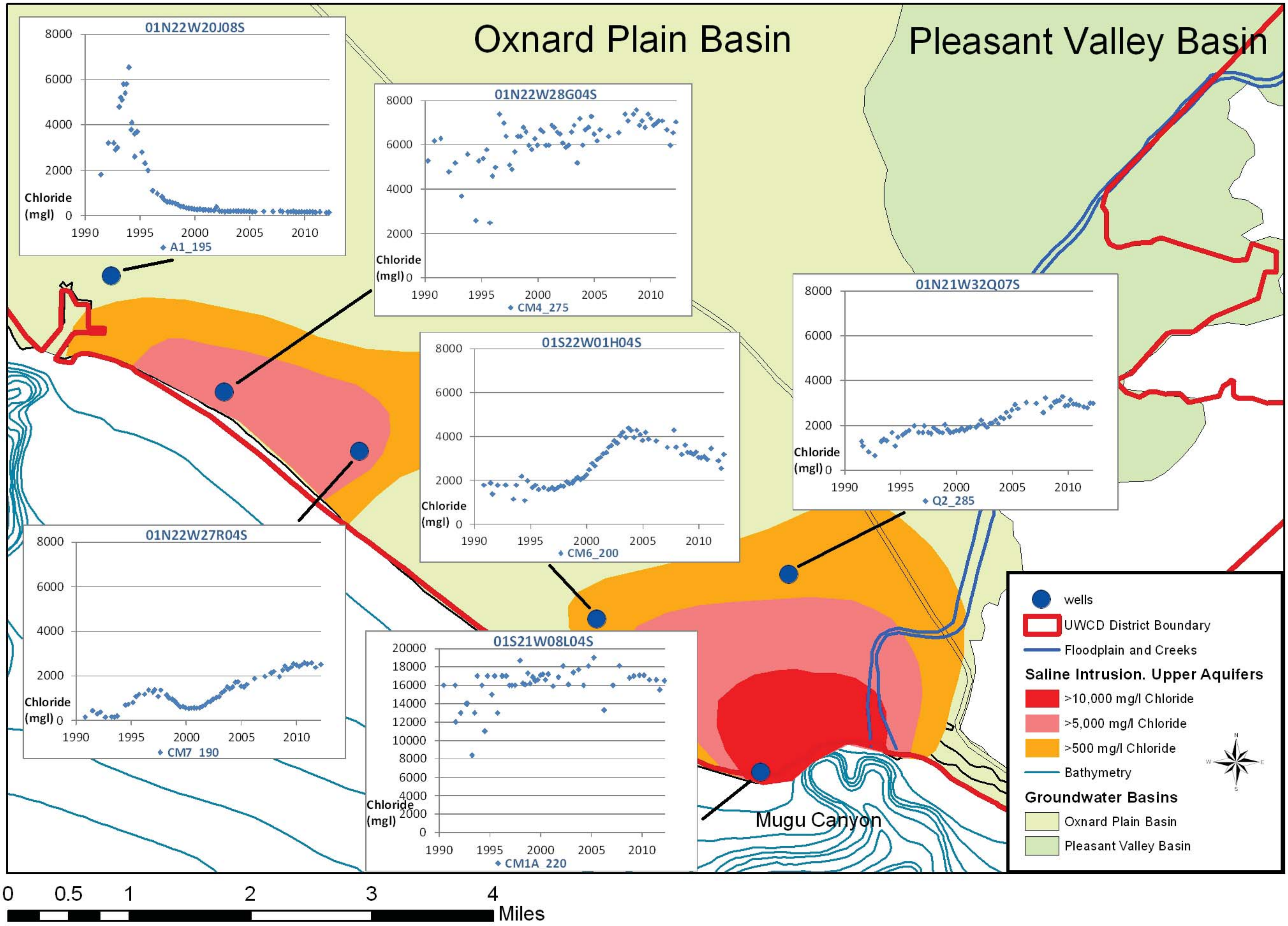


Figure 4.3-35. Chloride time series for selected Upper Aquifer System (UAS) wells, southern Oxnard Plain

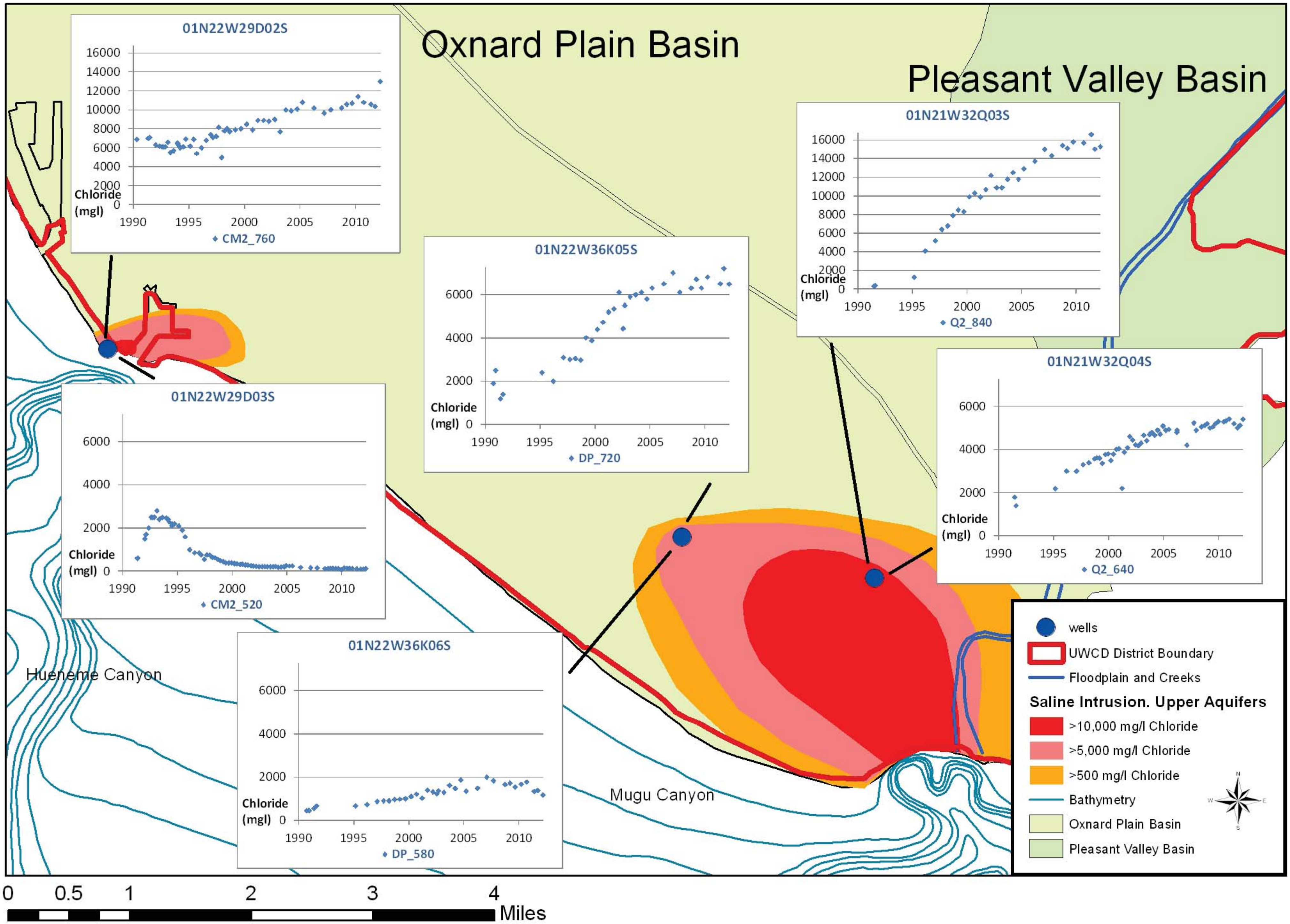


Figure 4.3-36. Chloride time series for selected Lower Aquifer System (LAS) wells, southern Oxnard Plain

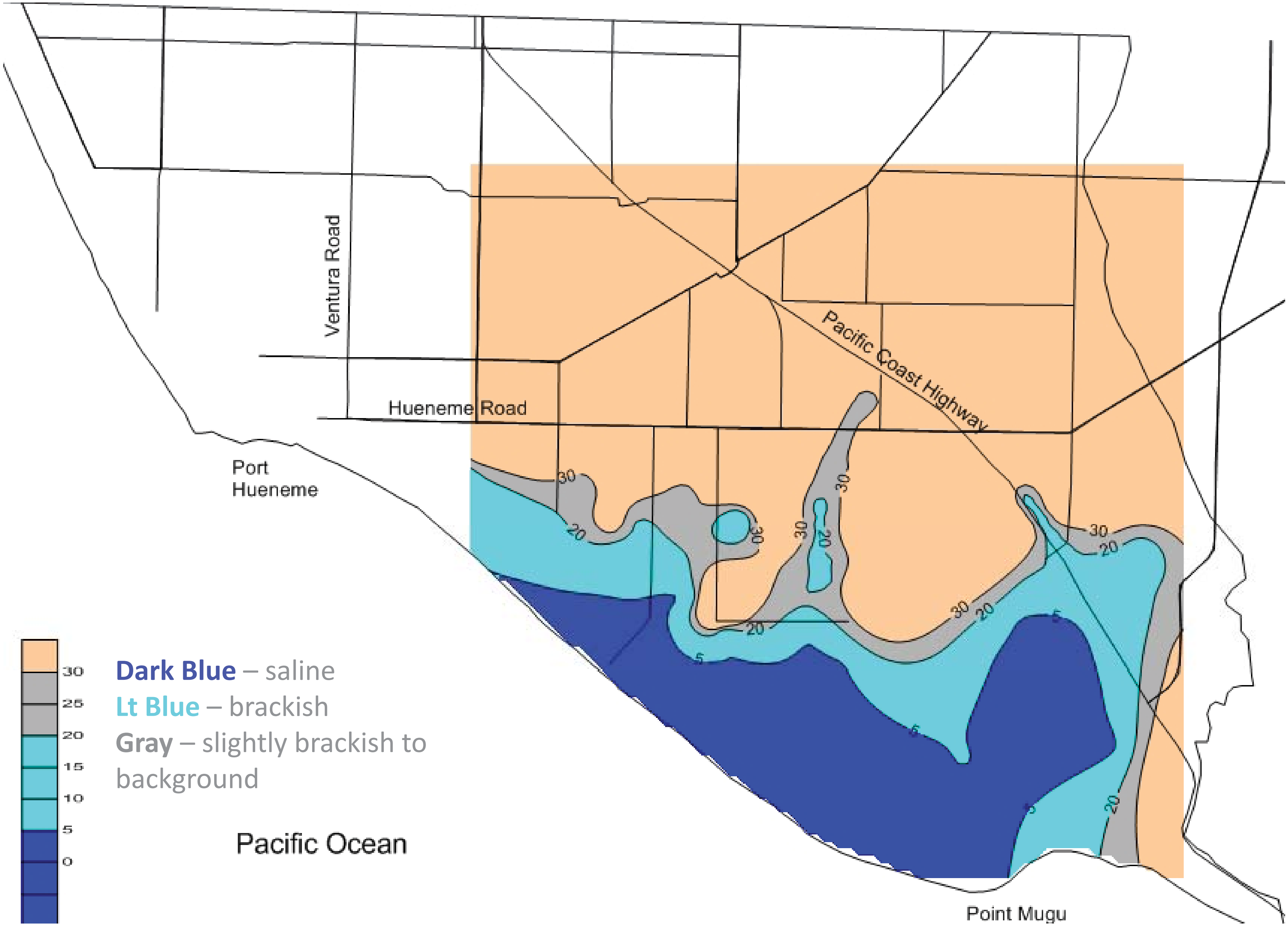


Figure 4.3-37. Geophysical survey (TDEM) of deep Upper Aquifer System (UAS) salinity, southern Oxnard Plain

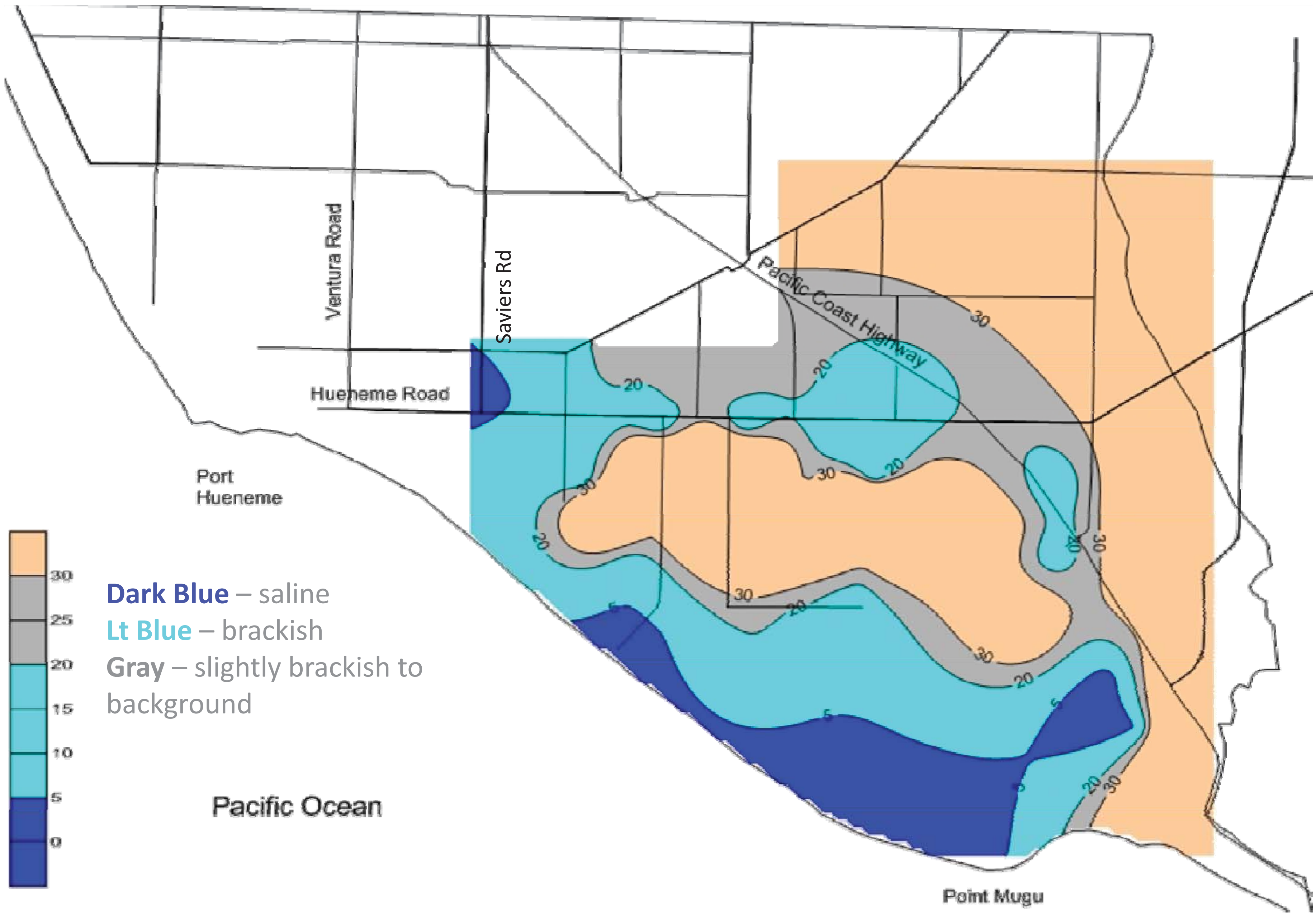


Figure 4.3-38. Geophysical survey (TDEM) of shallow Lower Aquifer System (LAS) salinity, southern Oxnard Plain

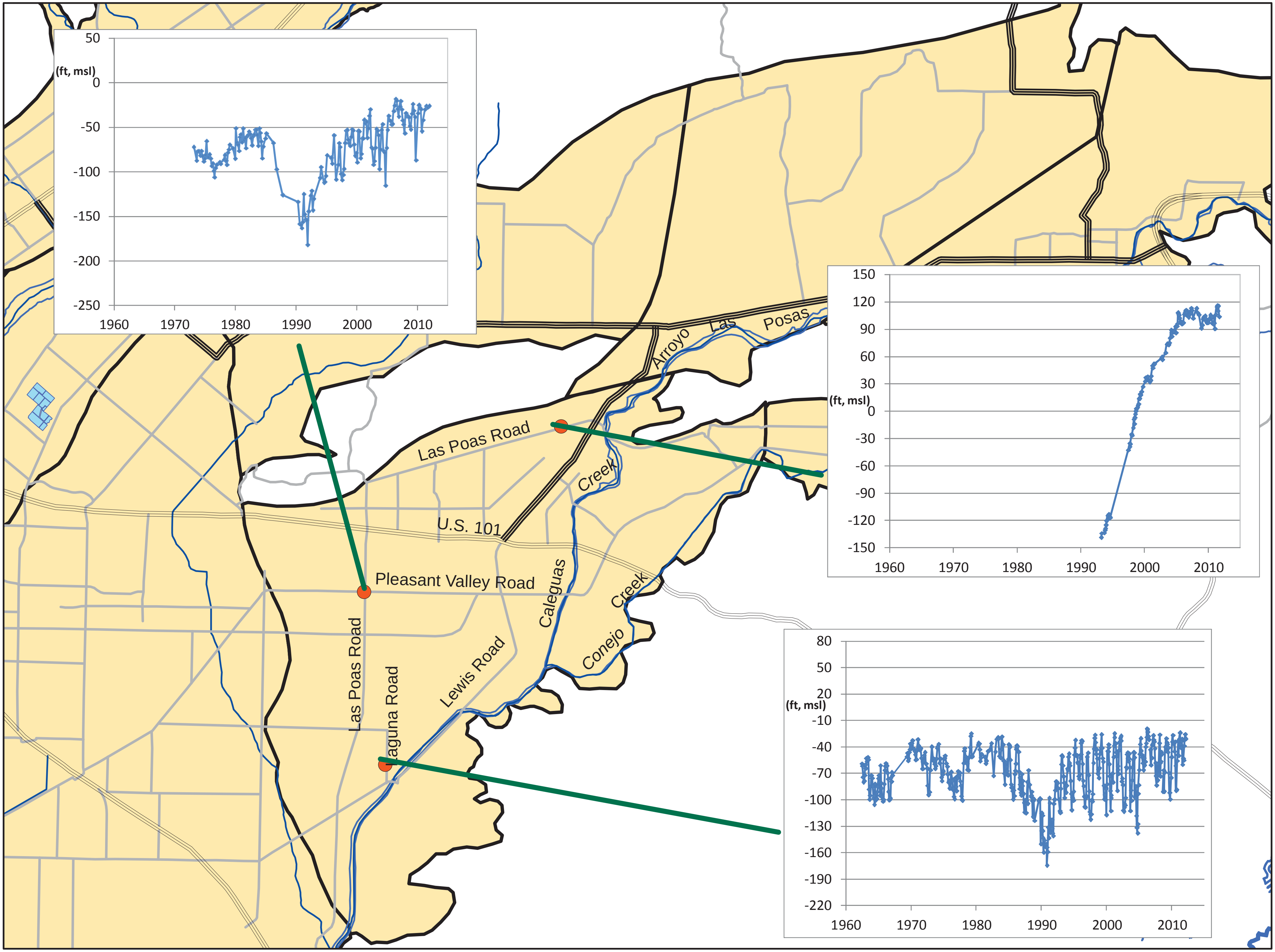


Figure 4.3-39. Pleasant Valley Basin Lower Aquifer System (LAS) groundwater elevation hydrographs, selected wells

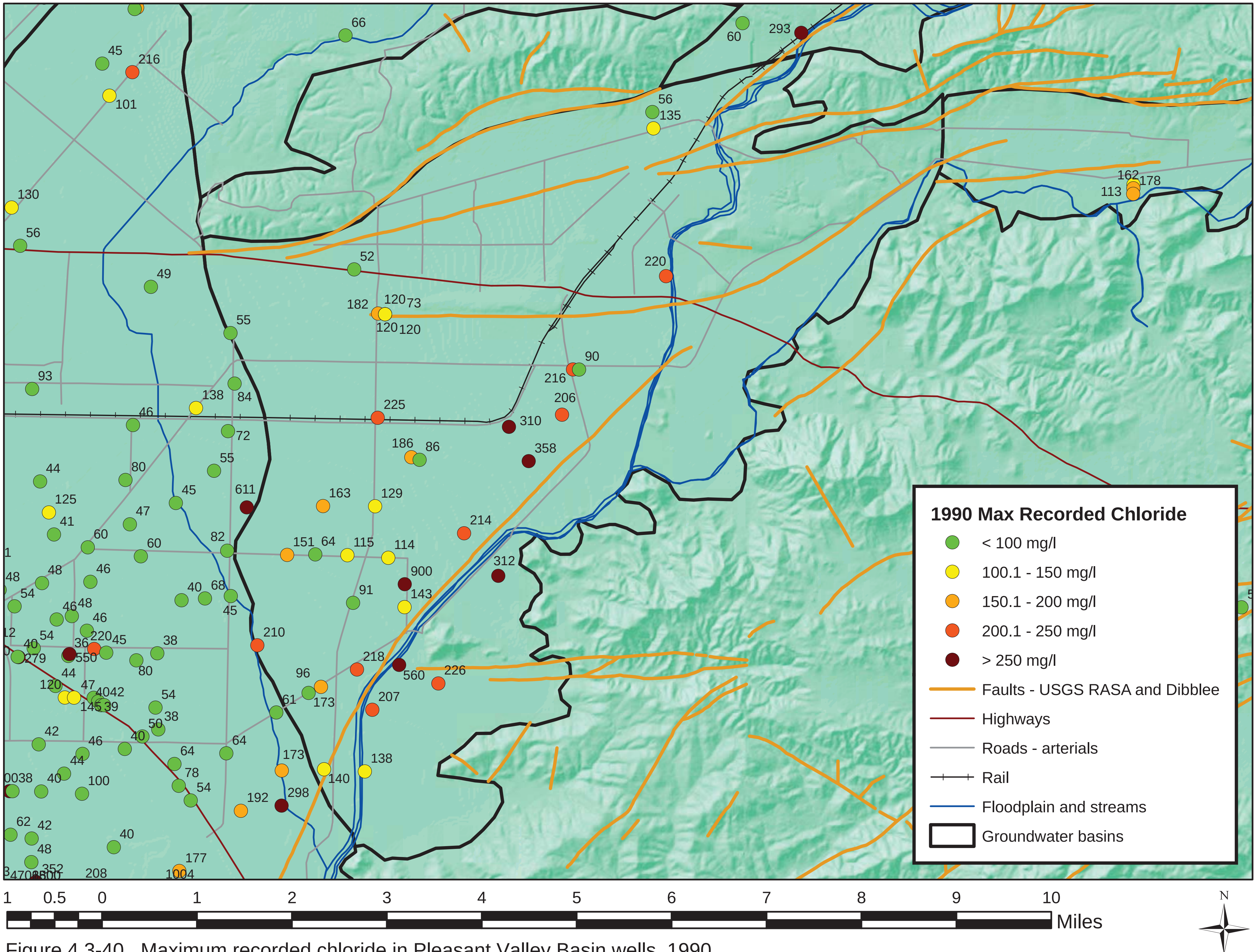


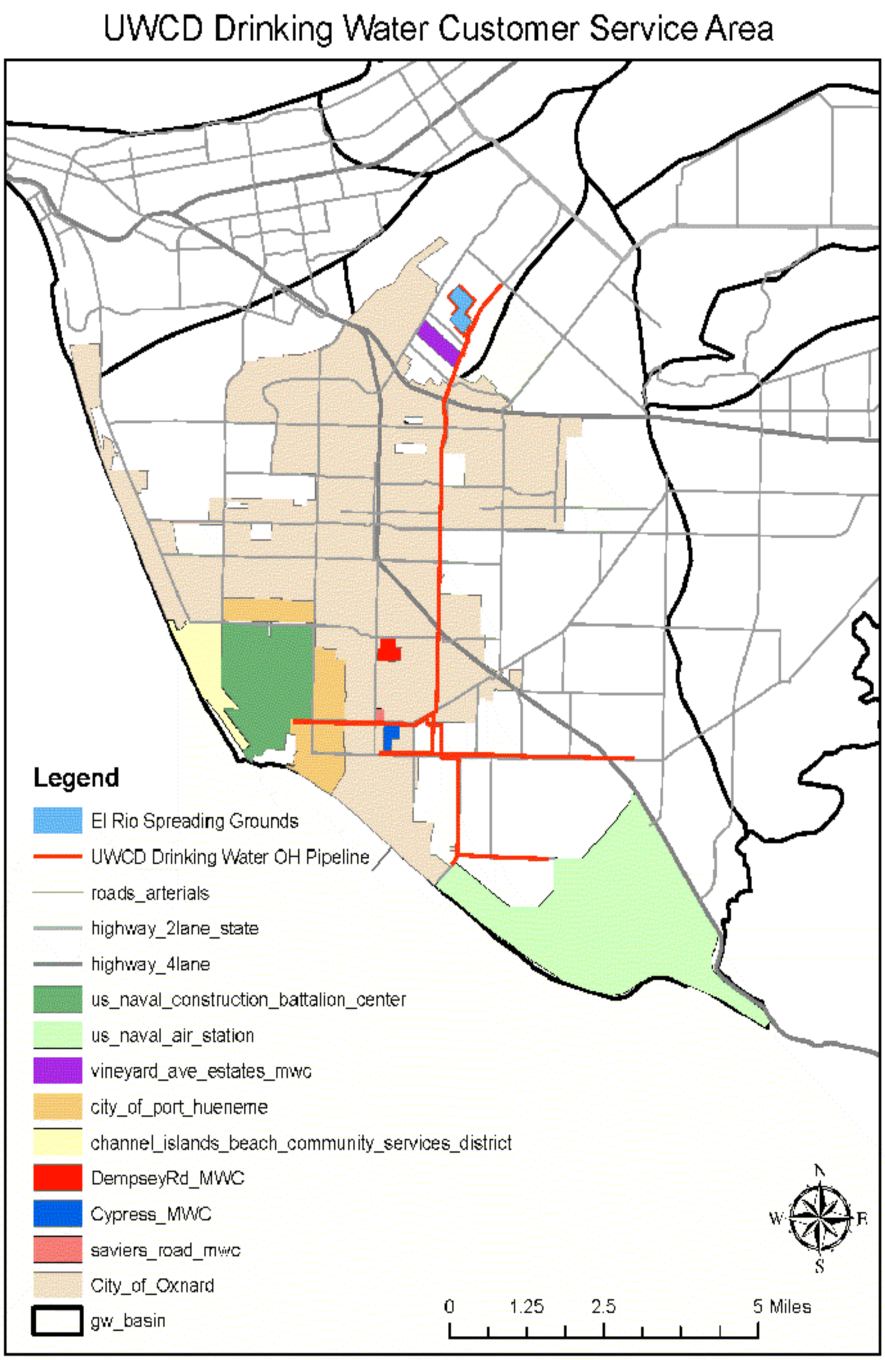
Figure 4.3-40. Maximum recorded chloride in Pleasant Valley Basin wells, 1990

8 APPENDIX A. 2011 CONSUMER CONFIDENCE REPORT, O-H SYSTEM

United Water Conservation District

Oxnard-Hueneme Water Delivery System

2011 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 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 cities of Oxnard and Port Hueneme, two Naval bases, and several smaller water companies. Those 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 California Department of Public Health prescribes regulations that limit the amount of certain contaminants in public drinking water. We treat our water to meet these health regulations. The Department'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 litre

ppb: parts per billion, or micrograms per litre

ND: none detected

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

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 2011.

Contaminants Detected in 2011

Chemical	State MCL MRDL	State DLR	PHG MCLG MRDLG	Units	Range	Avg	Date	Major Sources in Drinking Water
Primary Standards - Clarity								
Delivered water turbidity	TT	N/A	N/A	NTU	0.14 - 0.04	0.07	2011	Well corrosion byproducts. Microscopic soil particles.
Primary Standards - Radioactivity Contaminants								
Gross Alpha	15	3	NA	pCi/L	6.68 - 4.30	5.29	2011	Decay of natural and man-made deposits.
Uranium	20	1	0.43	pCi/L	8.41 - 4.63	6.64	2011	Erosion of natural deposits.
Radon	N/A	100	NA	pCi/L	364 - 129	273.25	2011	Decay of natural deposits.
Primary Standards - Inorganic Contaminants								
Arsenic	10	2	0.04	ppb	3 - ND	1.5	2011	Erosion of natural deposits.
Fluoride	2	0.1	1	ppm	0.8 - 0.7	0.75	2011	Erosion of natural deposits.
Nitrate (as NO_3)	45	2	45	ppm	9.5 - 4.7	6.72	2011	Leaching from fertilizers and septic systems.
Selenium	50	5	30	ppb	9 - 5	7	2011	Erosion of natural deposits. Discharge from mines, runoff from livestock lots.
Primary Standards - Disinfection								
Chloramine Residual (as Cl_2)	4	4	4	ppm	2.4 - 1.3	1.91	2011	Drinking water disinfectant added for treatment.
Total Haloacetic Acids	60	NA	NA	ppb	6 - 1	4.06	2011	By-product of drinking water disinfection.
Dibromoacetic Acid	N/A	2	NA	ppb	6 - 4	5.45	2011	By-product of drinking water disinfection.
Monobromoacetic Acid	none	1		ppb	1 - 1	1	2011	By-product of drinking water disinfection.
Trichloeoacetictic Acid	none	1		ppb	1 - 1	1	2011	By-product of drinking water disinfection.
Primary Standards - Disinfection By-Products								
Total Trihalomethanes	80	N/A	1.8	ppb	49.8 - 19.8	30.3	2011	By-product of drinking water disinfection.
Bromodichloromethane	N/A	1	NA	ppb	6.2 - 3.3	4.5	2011	By-product of drinking water disinfection.
Bromoform	N/A	1	NA	ppb	23.7 - 7.8	12.5	2011	By-product of drinking water disinfection.
Chloroform	N/A	1	NA	ppb	1.3 - 0.6	1	2011	By-product of drinking water disinfection.
Dibromochloromethane	N/A	1	NA	ppb	19.1 - 8.0	12.4	2011	By-product of drinking water disinfection.
Microbiological Contaminants								
Total Coliform bacteria	Systems that collect <40 samples/month: no more than 1 positive		0	Absense/ Presence/ 100ml	Absent	Absent	2011	Naturally present in the environment.
Fecal Coliform bacteria and E.*coli*	A routine and repeat sample are total coli-form positive, and one of these is fecal or E.coli positive		0	Absense/ Presence/ 100ml	Absent	Absent	2011	Human and animal fecal waste.
Secondary Standards								
Sodium	N/A	N/A	N/A	ppm	79 - 71	75	2011	Leaching from natural mineral deposits.
Sulfate	500	0.5	N/A	ppm	420 - 308	374.31	2011	Runoff/leaching from natural deposits.
Total Dissolved Solids, TDS	1,000	NA	N/A	ppm	900 - 670	803.85	2011	Leaching from natural mineral deposits.
Total Hardness	N/A	N/A	N/A	ppm	467 - 400	433.5	2011	Leaching from natural mineral deposits.
Total Organic Carbon (TOC)	N/A	0.3	N/A	ppb	1.3 - 0.8	1.03	2011	Naturally present in the environment.
Unregulated Chemicals								
Boron	N/A	100	N/A	ppb	600 - 500	550	2011	Erosion of natural deposits.

Water Quality Data

The table on page 3 lists all of the drinking water contaminants that we detected during the 2011 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.

Total Dissolved Solids and Sulfate

Total Dissolved Solids, or TDS, is a measure of the total mineral content of the water. TDS and sulfate 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 2011 and was submitted to the Department of Health Services.

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 45 ppm is a health risk for infants of less than six months of age. High 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. High nitrate levels may also affect the ability of the blood to carry oxygen in some individuals, such as pregnant women and those with certain specific enzyme deficiencies. Nitrate levels may rise quickly because of rainfall or agricultural activity and groundwater movement. If you are caring for an infant, or are pregnant, you should ask advice from your doctor, or choose to use bottled water for drinking and for mixing formula and juice for your baby.

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

Para información en español llámenos al (805) 525-4431.