Canoa Ranch Groundwater Evaluation

Hydrologic Evaluation of the Occurrence and Nature of Groundwater, and Water Level Trends and Water Balance Related to Future Water Resource Use in the Canoa Ranch Area, Upper Santa Cruz Basin, Pima County, Arizona

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Executive Summary

The Water Resources Division of the Pima County Regional Flood Control District has conducted a hydrologic evaluation of the Canoa Ranch and vicinity, with a focus on the historical and current water balance and how it has affected local groundwater- level conditions, and the potential impacts on the hydro- and meso-riparian vegetation of the Ranch. Numerous data sources were evaluated during the study, including the U.S. Geological Survey (USGS), Arizona Department of Water Resources (ADWR), Pima County, Pima Association of Governments, and consulting reports.

The Canoa Ranch hydrologic study area is centered along the Santa Cruz River (SCR) from the Santa Cruz/Pima County Line in Pima County, Arizona to about 7.5 miles downstream along the River (Figure 1-1). Large portions of the study area along the SCR (4,800 acres) are owned by Pima County as part of the old Canoa Ranch; Elephant Head Road from the South to Santa Rita Springs Development and the Farmers Investment Company (FICO) on the north; from Interstate 19 on the west to the floodplain pediments on the east. The historic Canoa Ranch is undergoing building restoration and is slated for riparian restoration in some targeted areas. Several of the larger tributaries to the SCR include Agua Caliente Canyon Wash, Madera Canyon Wash and Florida Canyon Wash draining the Santa Rita Mountains from the east; Sopori Wash just south of the County Line; Old Junction Wash and Demetrie Wash draining the Sierrita Mountains from the west. Flows on the SCR are intermittent to ephemeral in this area due to discharge of effluent the Nogales International Wastewater Treatment Facility, and periodic rainfall-runoff and snow melt events.

The upper SCR is ephemeral to intermittent, and the associated aquifer system is generally unconfined to depths of at least 1,000 ft. The groundwater moves beneath the Canoa Ranch Study Area in a north-northeastward direction. The hydraulic properties of the sediments within the Study Area vary between layers and proximity to the Santa Cruz River Channel. The sedimentary units underlying the Canoa study area are interconnected and from the ground surface downward in descending order are the recent surficial alluvial deposits, Fort Lowell Formation or basin fill, Tinaja Beds and the Pantano Formation. The surficial deposits in the last 16 years have been de-watered, although some evidence of perched water has been observed in wells in the southeastern portion of the Ranch. The aquifer is highly responsive to recharge from surficial flood events and is replenished by mountain front recharge from the Santa Rita and Sierrita Mountains and stream flow recharge.

Freeport McMoran Mine owns the Water rights to over 22,000 AF/yr, and pumps groundwater from large extraction wells spaced along the floodplain of the SCR on the Pima County Canoa Ranch property (Figure 1-1). The six pumping mine wells on Canoa Ranch have Grandfathered Water Rights to pump 22,800 AF/yr (Poster-Frost, 2006).Other wells include ranch and municipal wells in the vicinity. Pumping amounts in the study area ranged from a low of 14,074 AF in 1992 to a peak of 24,989 AF in 2010. The average pumpage from 1984-2010 is 19,606 AF/yr. Of that amount approximately 83% is from the six mining extraction wells on Canoa Ranch.

Depth to groundwater in the Study Area varies from greater than 250 feet below land surface (bls) in the eastern and western portions of the study area to less than 50 feet bls near Elephant Head Road and the Santa Cruz River (Figure 3-4). Moving north along the floodplain of the Santa Cruz River, depth to water gradually increases to 70 feet south of the Canoa Ranch Headquarters to 125 feet bls within the headquarters and to approximately 150 feet bls at the northern boundary of Canoa Ranch. Water levels quickly increase in depth to over 200 feet bls west of I-19 and the Headquarters. South of Elephant Head Road and Canoa Ranch, water levels are 50 feet or less along the floodplain of the SCR and increase gradually to 70 feet and 90 feet bls near I-19 and the Pima/Santa Cruz County Line.

In contrast, two previous area reports depict mapped ground-water levels in the mid-1990s on Canoa Ranch to be significantly shallower. Water levels were as shallow as 50 feet bls along the floodplain of the SCR as far north as the Canoa Ranch Headquarters, and at the northern Canoa Ranch boundary were less than 100 feet bls (Environmental Resource Consultants, 1996; Errol L. Montgomery and Associates, Inc. 1998).

Historic water levels have been predominantly impacted by recharge from larger flood flow events and the advent of large volume groundwater pumping by mine extraction wells on the Ranch since the early 1970s. From 1995-2011, ground-water levels in the Study Area have declined an average 3 ft/yr, with Canoa Ranch supply and monitor wells declining over 5 ft/yr over that period. From 1981-2011, water levels rose significantly and then dropped precipitously after 1994 for an average decline of 0.3 ft/yr. The large flood flows of 1983-84 and 1993 triggered a large water-level recovery effect. Subsequently, except for impacts from year 2000 flood flows, recharge on the SCR has been low.

Comparing rainfall records over time substantiates three distinct climate trends near the Study Area. The time periods 1962-1977, 1978-1994 and 1995-2011 were chosen to illustrate differences in average annual rainfall for these periods. Average annual rainfall for the 1995-2011 period is very similar to the 1962-1977 period for the available gages at Tumacacori and the Florida Canyon Station. Although these stations are higher in altitude than most of the study area in the basin, they show the relative differences against the 1978-1994 period for these two stations. The 1978-1994 rainfall averages for these two stations are 25-30% higher than for the other two time periods. The flood flow records and resulting water level changes in area wells confirm these trends. Only recently (1995-2011) have additional rain gages been added at or near the Santa Cruz River and within or very close to Canoa Ranch.

Several water-level hydrographs which include available pumping and stream-flow records illustrate differences in the climatic periods and the capacity of stream flow within the SCR to recharge the aquifer. The precipitation-driven climatic periods have contributed to both substantial ground-water recoveries and substantial ground-water declines (Figures 2-3 to 2-5 and 3-6 to 3-10). Information presented on the hydrographs confirm that ground-water level decline due to the large pumping beginning in the 1970s can only be offset by large flood flows along the SCR similar to the 1978-94 period. The large water-level declines experienced since 1995 will continue unless a sustained wetter climatic period occurs, a supplemental source of water is introduced, or groundwater pumping is significantly reduced.

The future outlook for available water resources and groundwater-level recovery on Canoa Ranch is mixed. The cyclic trend of climate suggests the Canoa Ranch area could potentially transition into a wet period, based on relatively dry years from 1960-1976, wet years from 1977-1994, and dry years from 1995-2012. However, because of potential anthropomorphic influences, this general area has been predicted to produce less runoff by the middle of the 21st Century, based on several climate models (Milly, et al, 2008). In addition, improvements at the Nogales International Wastewater Facility in 2012 has resulted in reduction in nutrient discharge, and in turn, improved infiltration farther upstream of the Canoa Ranch area. Groundwater underflow to the Ranch may increase due to population increase with increasing wastewater facility discharges and subsequent recharge. Barring additional ground-water withdrawals, the water balance may not differ much from previous time when nutrient levels inhibited infiltration closer to Nogales. However, discharge from the wastewater facility may diminish by as much as 3-5 mgd (20-25%) due to the new Los Alisos Treatment Plant discharging outside the SCR Basin. Finally, the Freeport McMoran Canoa Ranch industrial mine well field is scheduled from 2014-2025 to pump 24% of the earlier 1984-2010 average pumpage, or as little as 3450-4000AF/yr. From 2025-2042 (the end of the current mine plan of operation) pumping would increase to 44% of the 1984-2010 average. The additional pumping the mine needs will be shifted to a new well field about 5-7 miles downgradient of Canoa Ranch to control a sulfate plume in the area. The resulting reduction due to mine ground-water pumping in the Canoa Ranch area will help to reduce the large annual water-level declines. Recovery to the shallow groundwater levels of the mid-1990s may only occur if a wet weather cycle recurs.

By contrast, potential groundwater usage due to incorporating all of the recommendations of the 2006 Canoa Ranch Water Master Plan (Westland Resources, Inc., 2008) would require about 164 AF/yr, as follows:

- Restoration 49 AF
- Aquatic ecosystems 30 AF
- Pasture/horses 75 AF
- Headquarters/entry Landscaping 10 AF

Continued water-level monitoring is required to document changes in ground-water levels in the Canoa Ranch area. Installation of soil moisture probes in suspected perched water areas with hydro-riparian vegetation will provide valuable information regarding long term viability of meso- and hydro- riparian vegetation during long term drought conditions.

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Canoa Ranch Groundwater Evaluation

Hydrologic Evaluation of the Occurrence and Nature of Groundwater, Water Level Trends and Water Balance Related to Future Water Resource Use in the Canoa Ranch Area, Upper Santa Cruz Basin, and Pima County, Arizona

1.0 Introduction and Background

The Canoa Ranch Area includes the land in southern Pima County near the Santa Cruz County line along the floodplain and terraces of the Santa Cruz River (SCR), and is a significant regional location for water resources management, flood control and public recreation. Pima County purchased the 4,800 acre Canoa Ranch in 2001, and it is a focal point for flood control, environmental enhancement/restoration, recreational development and recharge activities (Poster Frost Associates, Inc., 2006). An understanding of the water withdrawals and water rights, sub-surface water levels, flow and recharge dynamics and what influences these parameters is essential for future resource planning efforts in this area.

1.1 Purpose and Scope

The purpose of this project is to perform a baseline hydrologic evaluation of current and historic water-level conditions, recharge and pumping influence and changes, and monitoring opportunities in the vicinity of the Canoa Ranch Area. Both Canoa Ranch and the overall hydrologic study area are shown in Figure 1-1.

1.2 Methodology

Available documents regarding this project were collected and reviewed by Pima County Regional Flood Control District (RFCD) staff. Sources of information regarding the Canoa Ranch Area include the Pima County and Regional Flood Control District web sites and libraries. Some of the more important reports reviewed include:

- The Canoa Ranch Master Plan (Poster-Frost Associates, Inc., 2006)
- The Pima County CAP White Paper (Fox, Chavez, Postillion, 2007)
- Assessment of Hydrogeology in Sahuarita-Green Valley Area (Montgomery and Associates, 1998)
- PAG Upper Santa Cruz Mines Task Force Reports and update (1983a, 1983b, 2002)
- PAG Shallow Groundwater Area Report (2012)

Several data sources were available to review and assess available well measurements and water levels in the study area:

- The Arizona Department of Water Resources (ADWR) Groundwater Site Inventory (GWSI) is the most comprehensive database available for historical water levels. However, data was lacking for some portions of the area.

- The ADWR Well Registry was also reviewed to assess the number, location and type of wells in the vicinity.
- The Pima County MapGuide overlay for wells also identifies wells in the area. Monitor well data from Canoa Ranch was available
- The Pima County Regional Wastewater Reclamation Department (RWRD)
- Pima County Natural Resources Parks and Recreation (PCNRP&R)
- U.S. Geological Survey (USGS) for surface water flows and groundwater level data.

Additional water resources data were collected from the following sources:

- Pumping data were collected from ADWR for non-exempt wells in the area to assess temporal trends and evaluate their impacts on water levels.
- Treated effluent release data to the SCR from the Nogales Wastewater Treatment Facility
- Natural stream flow event data from the USGS was evaluated to determine their roles related to local ground water levels.
- National Climatic Data Center precipitation data
- Pima County Regional Flood Control ALERT flow and precipitation data.

2.0 Hydrologic and Hydrogeologic Setting

2.1 Subsurface Geology

The Canoa Ranch hydrologic study area (Study Area) is centered along the Santa Cruz River about one mile north of the Santa Cruz/Pima County Line in Pima County, Arizona **(Figure 2-1, Site Map)**. Large portions of the area along the Santa Cruz River (4,800 acres) are owned by Pima County and is described in detail as running from Elephant Head Road from the South to Santa Rita Springs Development and the Farmers Investment Company (FICO) on the north, Interstate 19 on the west and the floodplain pediments on the east (Poster Frost, 2006). The hydrologic study area for this report begins in the vicinity of Pima/Santa Cruz County Line and runs along the corridor of the Santa Cruz River floodplain northeasterly to just South of Florida Canyon Wash. The western site boundary is about one-mile west of Interstate-19 Highway (I-19), and the eastern boundary is as far as 2-miles east of the Santa Cruz River at the southern portion of the study area. Several of the larger tributaries to the Santa Cruz River include Agua Caliente Canyon Wash, Madera Canyon Wash and Florida Canyon Wash draining the Santa Rita Mountains from the east; Sopori Wash just south of the County Line; Old Junction Wash and Demetrie Wash draining the Sierrita Mountains from the west. Flows on the Santa Cruz River are intermittent in this area due to discharge of effluent at the Nogales International Wastewater Treatment facilities. For purposes of this report Canoa Ranch is a portion of the hydrologic Study Area and encompasses the Canoa Ranch property owned by Pima County described in other reports and documents (Poster Frost Associates, Inc., 2006).

Several reports and studies provide significant descriptions of the hydrogeology of the Study Area. Davidson (1973) describes the hydrogeology with detailed lithology at the Tucson Basin and Upper Santa Cruz Basin as far south as the Santa Cruz County line, and provided underflow calculations within the study area with which to compare current inflow estimates. Postillion and Schmidt (1983a) presented a more local and detailed description of the hydrogeology in a report on nitrates in the Study Area and north of the Study Area. Anderson (1988) of the United States Geological Survey (USGS)

provided additional detail of subsurface geology in a subsidence report, with one cross-section bisecting the Study Area north to south. Halpenny and Halpenny (1988) along with Anderson (1987) helped to distinguish and compare the different ages of alluvium near the land surface. Osterkamp (1973) describes grain-size distributions spatially between the Sierrita and Santa Rita Mountains and provides background recharge estimates for the Study Area. More recent studies summarized the Canoa Ranch and lands farther north as part of a Green Valley/Sahuarita area Central Arizona Project (CAP) water recharge feasibility study (E.L. Montgomery, 1998). Hydro Geo Chem, Inc (2009) uses estimates of aquifer properties and natural recharge from several older models (Mason and Bota, 2006; Hanson and Benedict, 1994; E.L. Montgomery, 2007) in their numerical model to assess the extent of sulfate contamination and use as a tool to mitigate the sulfate plume for Freeport McMoran Sierrita Mine northwest of the Canoa Ranch area.

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The sedimentary units underlying the Study Area are interconnected and from the ground surface downward in descending order are the recent surficial alluvial deposits, Fort Lowell Formation or basin fill, Tinaja Beds and the Pantano Formation. The recent surficial alluvial sand and gravel deposits along the Santa Cruz River floodplain in the Study Area vary from 30-60 feet (Anderson, 1988; Montgomery, 1998). The surficial deposits provide the mostly permeable sands and gravels that percolate storm water along the floodplain of the Santa Cruz River. These deposits were mostly saturated in the mid-1980s to mid- 1990s. However, in the last 16 years the surficial deposits have been dewatered in the Study Area due to reduced flows on the Santa Cruz River, less overall rainfall contributing to mountain front and stream-flow recharge, and continued large pumping withdrawals.

The Fort Lowell formation (Qf) unconformably underlies the recent alluvium and is approximately 130-180 feet thick in the Study Area. The Qf consists primarily of interbedded unconsolidated sand, clayey sand, gravel and sandy to gravely clay (Anderson, 1987).

The Fort Lowell unit is mostly saturated near the southern portion of Canoa Ranch and becomes less saturated moving northward. This formation still comprises a significant source of groundwater for the area and, along with the surficial deposits, is the primary recharge media for storm water, snow melt runoff and for some periods treated effluent from the Nogales Wastewater Treatment Facility. However, both the Fort Lowell formation and surficial deposits comprised a much larger portion of the shallow groundwater that dominated the area prior to the mid-1990s.

Underlying the Fort Lowell formation in the Study Area are the upper Tinaja beds, which generally consist of unconsolidated to semi-consolidated and/or moderately cemented, sand to clay and clayey sand and gravel. This unit varies from 70 feet in the northern portion of Canoa Ranch to 120 feet thick near Elephant Head Road (Anderson, 1987). The Upper Tinaja unit is a primary water-bearing unit in the Study Area and is still completely saturated.

Anderson (1988) indicates middle Tinaja Beds are absent in the Study Area. The lower Tinaja beds underlie the upper Tinaja beds and consist of gravel and conglomerate to clay silt and mudstone (Anderson, 1987).

The thickness of Tinaja sediments varies from the 800 to over 1000 feet in the Study Area. The sediments within the upper Tinaja beds are generally unconsolidated. However, consolidation and cementation within the Tinaja beds typically increase with depth, and intervals of greater consolidation and

cementation encountered at greater depths yield less water to wells than those intervals above them. Since sediments from both the Fort Lowell formation and the upper portion of the Upper Tinaja beds are relatively permeable, the Fort Lowell-Upper Tinaja contact is usually insignificant hydrologically with regard to the movement of groundwater (Anderson, 1987). The lower Fort Lowell Formation and Tinaja Beds provide most of the saturated sediments for potable, agricultural and industrial water use.

The Pantano Formation underlies the Tinaja formations and is described as silty and pebbly sandstone, mudstone, and gypsiferous mudstone to moderately cemented gravel (Anderson, 1988; Davidson, 1973). It can also contain mega-breccia, tuff beds and interbedded volcanic flows. Hydrologically it is a very poor water releasing material and is generally unproductive for water supply.

The Santa Rita Mountains and Sierrita Mountains and basement rock east and west of the Study Area consist of fractured granitic and volcanic rock that is very unproductive for yielding water from larger municipal wells. This basement material is as shallow as 400 feet bls in areas west and east of the Santa Cruz River.

The aquifer system is generally unconfined to depths of at least 1,000 ft. The groundwater moves beneath the Study Area in a north-northeastward direction. The hydraulic properties of the sediments within the Study Area vary mostly between units or strata and proximity to the Santa Cruz River channel.

Specific yield values obtained from Travers and Mock (1984) were derived based on the DWR Driller's Log Program that assigned representative specific yield values to the various compositions of sediment types found in the area. Specific yield is the ratio of the volume of water drained or released over the total material volume and reflects the capacity of the aquifer to yield water to a pumping well. Specific yields were highest (0.10-0.12) within one mile south and southeast of the Canoa Ranch East boundary. Within the entire Study Area, specific yield values ranged from 0.05 to 0.12, with an average of 0.09 (Travers and Mock, 1984).

Transmissivity values for the entire Study Area average approximately 76,000 gallons/day/foot (gpd/ft). Transmissivity is a function of hydraulic conductivity and the ease of water to move through pore spaces or fractures, and is the saturated aquifer thickness times the saturated hydraulic conductivity. The southern, central and northern portion of Canoa Ranch along the SCR have transmissivity values of 59,000, 82,000, and 96,000 gpd/ft, respectively, while west of I-19 values are 55,000, 45,000, and 55,000 gpd/ft respectively. Transmissivity values range from 31,000 gpd/ft in the northern portion of Canoa Ranch West of I-19 to 168,000 gpd/ft in the northwest portion of Green Valley (Travers and Mock, 1984). The southern, central, and northern portions of the Green Valley Water Company service area have Transmissivity values of 75,000, 65,000, and 134,000 gpd/ft, respectively. The alluvial fans from Madera Canyon Wash area to the east of the Study Area also contain some of the higher Transmissivity values (86,000-136,000 gpd/ft). The Transmissivity values across the entire Study Area generally increase toward the Santa Cruz River channel as shown by modeling estimates (Travers and Mock, 1984).

2.2 Sources of Recharge for the Study Area

In the Upper Santa Cruz Basin, subsurface water movement (underflow) comes primarily from the south of the Study Area and, to a much lesser degree, from the southwest at the southern edge of the Sierrita Mountains. Given Transmissivity values for the Study Area derived from the finite difference model by Travers and Mock (1984), a seven mile west-east trending section and a water level gradient in 1995 of 50 feet per mile, underflow into the Study Area from the south was calculated to be approximately 27,000 AF/yr (Environmental Resource Consultants, 1996). Recent estimates of underflow into the Canoa Ranch area from the Santa Cruz AMA were 22,000AF/yr (Mason and Bota 2006). The values of underflow into the Study Area will change as water-level gradients change in response to groundwater pumping changes and a drier climate over the last 17 years.

While most small washes, arroyos and non-cemented channels also contribute to groundwater recharge, only the dominant rivers and washes are considered recharge contributors from stream flow in this groundwater evaluation. For the reach of the Santa Cruz River beginning at the Pima County-Santa Cruz County border and extending up to the Continental stream flow gaging station, Osterkamp (1973) estimated the average annual riverbed recharge to be approximately 3,200 AF/yr. This is based upon approximately 300 AF/mile of recharge to the river. However, Osterkamp's estimates of river recharge, on the average, significantly increased in total flow from 15,300 AF/yr. for the period 1960-1972 to 32,750 AF/yr. for the period 1972-1986 (1986-91 incomplete record). Therefore, estimates of river recharge were doubled to 600 AF/mile or 6,400 AF/yr from 1972-1986. Currently, river recharge has lessened due to significantly reduced flood flows on the Santa Cruz River and is probably now more in line with the earlier estimates of 300-400 AF/mile.

Additionally, Osterkamp estimated mountain front recharge. His map estimates mountain front recharge along the eastern flank of the Sierrita Mountains as well as the western flank of the Santa Rita Mountains at 300 AF/mile. Given a total of approximately 20 miles of mountain front surrounding the Study Area, the total mountain front recharge is estimated at 6,000 AF/yr.

2.3 Water Wells, Use and Pumping

Figure 2-2 shows the wells within the study area. The referenced well numbers can be cross referenced in Appendix A to view other information such as well owner, State registration number (Wells 55), well type and Groundwater Site Inventory identification. Wells with recent water level data in the area are mostly owned by Pima County, Farmers Investment Company (north of Canoa Ranch) and index wells measured by ADWR. Many of these are production wells which provide water for potable use or agricultural irrigation. Pima County has several monitoring wells on Canoa Ranch. Coverage for water levels is sufficient except in the area north, east and southeast of the Canoa Ranch Headquarters. Most of the wells east and southeast of the headquarters are owned by Freeport McMoran and access to their data is more difficult to obtain for public agencies. Six pumping wells now owned by Freeport McMoran on Canoa Ranch have Grandfathered Water Rights to pump 22,800 AF/yr (Poster-Frost,

2006). Other wells in the area include private stock wells, domestic wells from Green Valley domestic Water Improvement District and some agricultural wells.

Figure 2-3 shows total pumping from non-exempt wells from near the Santa Cruz County Line to north of Canoa Ranch since 1984, juxtaposed with total annual flow at Continental and the SCR since 1980, and water levels for a Canoa Ranch well (ADWR #55-623123) located just east of the SCR 1½ miles south of the Canoa Ranch headquarters and 1.9-miles north of Elephant Head Road and the SCR, just west of the Union Pacific Rail Road (D 19 13 21BAA). Pumping amounts ranged from a low of 14,074 AF in 1992 to a peak in 2008 of 24,989 AF. The average pumpage from 1984-2010 is 19,606 AF/yr. Of that amount approximately 83% is from the six mining extraction wells on Canoa Ranch. Although reporting was not mandatory before 1984 for exempt wells, documentation of mining wells in Canoa Ranch indicate groundwater pumping started around 1970, with extraction of about 12,000 - 20,000 AF/yr used for processing at the Sierrita Mine over the years by several companies.

As shown on **Figure 2-3**, the key variables affecting water levels in the Canoa area appear to be flood flows and pumping. The constant effect of pumping, averaging about 19,600 AF/yr since 1984 in this area, causes water levels to decline, unless the intermittent effluent and snow melt base flows (6-7 cubic feet per second annual average are supplemented with larger magnitude cumulative storm water runoff. Significant cumulative flood flows over 30,000AF annually from 1964-67, 1977-79, 1983-84, and in 1993 coincided with significant water-level recoveries for this well 6-months to a year later.

Groundwater pumping was similar in magnitude from the mid-1970s to 1980 as the Duval Sierrita Mine pumped from 12,000-20,000AF/yr within the Canoa Well Field beginning in the early 1970s. Prior to the early 1970s, less groundwater was pumped and the effects of a drier period had less impact on water levels. The introduction of high volume pumping by the six mining wells on Canoa Ranch in the early 1970s changed the water balance significantly. Only large flood flows corresponding to wetter periods, in conjunction with reduced groundwater pumping, will sustain similar shallow water levels as were maintained in the 1950s and1960s. Recent water-level declines from diminished flood flows 1995 to present may be exacerbated by the projected removal of a portion of the effluent base flow to the SCR in late 2012 from the new Alisos Nogales Treatment Facility, which will discharge up to 5 mgd into another disconnected basin in northern Mexico.

The flood flow- recharge phenomenon is further confirmed in the area of pumping from near the Santa Cruz County Line to north of Canoa Ranch. As shown in **Figure 2-4** pumping was highest in this region in 2008 at near 25,000 AF/yr, and has averaged near 24,000 AF since 2005. Average pumping in this area was almost 20,000 AF/yr over the 1984-2011 record. However, the flood years of 1998-2000, 2005 and 2007-8 of over 20,000AF/yr at the upstream Tubac and SCR gage (Figure 3-8) helped reverse the water level declines for a few years within a nearby Canoa well at Elephant Head Road and the SCR (D-19-13-29BCC), after which water elevations continued to drop. This phenomenon will be explained in more detail in section 3-3.

Over 105 exempt wells are found within the hydrologic study area, primarily used for domestic purposes by public and private entities. These wells are only permitted to withdraw a maximum of 35 gallons per minute. Since the owners are not required to report water withdrawals to the ADWR, pumping volumes from these wells can only be estimated. In their report on groundwater withdrawals in shallow groundwater areas, Pima Association of Governments (2012) assumed that the annual withdrawal from exempt wells was one acre-foot per year based on discussions with ADWR. Using the one acre-foot per year figure, pumping from these wells is insignificant compared to the overall pumping by the non-exempt wells in the Study Area and was not used in the analysis described above. However, the identification of the exempt wells and an additional 8 monitoring wells is provided as a means to show the potential for filling gaps in water level data for this area.

3.0 Groundwater Level Evaluation

3.1 Current Water Level Conditions

The most recent comprehensive water-level data for the Study Area is from December 2011 through December 2012. Water levels from numerous wells in the vicinity were collected from several sources:

- The Arizona Department of Water Resources (ADWR) Groundwater Site Inventory (GWSI) was accessed for numerous wells.
- Monitor well data from the Pima County Regional Wastewater Reclamation Department (RWRD) and Pima County Natural Resources Parks and Recreation were collected with comprehensive water-level data for the Canoa area.
- PCRFCD Field measurements in December 2012

Additional water-level data from the same sources for previous years were used to supplement the data for the 2010-2011 period as needed. Late winter/ early spring data were plotted as most of the intense pumping was in the summer months.

Figure 3-1 shows water-level elevations for the period of December, 2010 through December, 2011. Near the Pima - Santa Cruz County Line, the direction of groundwater movement is northeasterly to northerly with an elevation of 3000 feet above mean sea level (amsl). At the northern edge of Canoa Ranch, groundwater movement is more northerly near with an elevation of 2750 feet amsl. In large part, groundwater movement in the Canoa Ranch area parallels the alignment of the SCR floodplain.

The slope, or gradient, of the water table surface varies through the study area. In the southern portion of the area between the County Line and Elephant Head Road, the slope averages about 40 feet/mile (0.008 ft/ft). Near the confluence of several larger tributary streams from the Sierrita and Santa Rita Mountains with the Santa Cruz River north of Elephant Head Road, the water table surface flattens to about 27 feet/mile (0.005 ft/ft). But further north, the slope of the water table increases significantly to almost 100 feet/mile (0.019 ft/ft) from the Canoa Ranch headquarters to over one mile north of it. More pumping is experienced in this area, including two large-volume mine supply wells, golf course and municipal supply wells west of I-19, and FICO agricultural wells to the north. The changing gradient of the water table

along north-south cross section A – A' slope is illustrated on **Figure 3-2,** with elevation and slope data provided for years 1995 and 2010. The significant lowering of the groundwater table over this 15-yr period is clearly evident. **Figure 3-3** shows an east-west cross section of the water table approximately one and one half miles south of the Canoa Ranch Headquarters. The drop in groundwater elevations over the 15-yr period is more pronounced in proximity to the SCR floodplain.

Depth to groundwater in the Canoa study area varies from less than 50 feet bls near Elephant Head Road and the Santa Cruz River **(Figure 3-4)** to greater than 250 feet below land surface (bls) in the eastern and western portions of the study area (as the surface topography rises from the SCR floodplain)**.** Near I-19 and the Pima/Santa Cruz County Line, south of Elephant Head Road, water levels are 50 feet or less along the floodplain of the SCR and increase gradually to 70 feet and 90 feet bls with distance to the west and east of the floodplain. Moving south to north along the floodplain of the Santa Cruz River, depth to water gradually increases to 70 feet south of the Canoa Ranch Headquarters, 100 feet bls within the headquarters, and approximately 150 feet bls at the northern boundary of Canoa Ranch. To the west of I-19 and the Canoa Ranch Headquarters, water levels quickly increase to over 200 feet bls.

In contrast, two previous reports in the mid-1990s depict water levels on Canoa Ranch to be significantly shallower (E.L. Montgomery and Associates, Inc. 1998; Environmental Resource Consultants, 1996). Water levels were as shallow as 50 feet along the floodplain of the SCR as far north as the Canoa Ranch Headquarters, some 50 feet higher than the present. Similarly, water levels at the northern Canoa Ranch boundary were less than 100 feet bls.

3.2 Historical Water Levels

The most reliable and complete source record of water level data began in the late 1970s to early 1980s and has continued through 2012. Thus, our analysis evaluated water–level changes over two time periods: the overall approximate 30-35 year period (1977 – 2012), and the period from 1995-2010 for comparison. The span of 1995-2012 has been a period of considerable dryness and drought. **Figure 3-5** is a map of hydrographs geographically spread across for the Study Area for comparison. Some of these hydrographs are listed later in larger view for discussion.

A summary of the two contrasting periods of record for wells in the Study Area for approximately 35-years (1977-2012) and 17-years (1995-2012), when available, is provided in **Table 3-1**. With very large flood flows of record in 1983 (100-year flood), 1993 (50-year flood) and 2000 (20-year flood), overall rate change for 11 representative wells in the area declined slightly, with an average drop of -0.38 ft/yr. for the average 33 year period. This illustrates the cyclic nature of the climate in this area and the resulting fluctuation in water levels, especially with a backdrop of large amounts of groundwater pumping.

Table 3-1
Water Level Changes Within and Adjacent to the Canoa Ranch Study Area

Wells55- Registry	Well Location	35 Year Record Change	17 Year Record Change
627932	D-20-13-06 CBA (Henson Farms)	1977-2012 (35 yr.) -4.5 ft., -0.13 ft./yr.	1995-2012 (17 yr.) -27.2 ft., -1.60 ft./yr.
626066	D-19-13-34 DBD (Underdown, 1st Well)		1995-2010 (15 yr.) -26.6 ft., -1.77 ft./yr.
801309	D-19-13-33 AAA (Ocotillo Community)		1995-2010 (15 yr.) -24.1 ft., -1.61 ft./yr.
626063	D-19-13-32 ABC (Rancho Sonado, LLC)	1982-2010 (28 yr.) -5.6 ft., -0.20 ft./yr.	1995-2010 (15 yr.) -28.4 ft., -1.89 ft./yr.
314435111025601 (GWSI)	D-19-13-30 DCA (Samuel Gonzalez)	1982-2010 (28 yr.) +0.15 ft., +0.005 ft./yr.	1995-2010 (15 yr.) -32.0 ft., -2.13 ft./yr.
623122	D-19-13-29 BCC (PCNRPR Canoa #6)	1977-2012 (35 yr.) +5.14 ft., +0.15 ft./yr.	1995-2012 (17 yr.) -50.14 ft., -2.95 ft./yr.
623123	D-19-13-21 BAA (PCNRPR Canoa #16)	1977-2012 (35 yr.) +0.19 ft., +0.005 ft./yr.	1995-2012 (17 yr.) -89.41 ft., -5.26 ft./yr.
623117	D-19-13-09 CAA (PCNRPR Canoa Entry)	Dec 1977- Jan 2012 (34 yr.) -1.10 ft., -0.03 ft./yr.	1995-2012 (17 yr.) -87.0 ft., -5.11 ft./yr.
314827111015801 (GWSI)	D-19-13-05 ACA (Casa Colina)	1979-2012 (33 yr.) -39.0 ft., -1.18 ft./yr.	1995-2012 (17 yr.) -53.5 ft., -3.15 ft./yr.
624022	D-19-13-03 ADC (FICO E-15)	1977-2012 (35 yr.) -2.40 ft., -0.07 ft./yr.	1995-2012 (17 yr.) -47.5 ft., -2.79 ft./yr.
624018	D-18-13-35 CBA (FICO E-11A)	1977- 2010 (35 yr.) -22.3 ft., -0.64 ft./yr.	1995-2010 (17 yr.) -54.7 ft., -3.21 ft./yr.
624025	D-18-13-34 DBC (FICO W-11)	1977-2010 (33 yr.) -24.5 ft., -0.74 ft./yr.	1995-2010 (17 yr.) -57.6 ft., -3.39 ft./yr.
624026	D-18-13-27 ADA (FICO W-12)	1977-2010 (33 yr.) -43.8 ft., -1.33 ft./yr.	1995-2010 (17 yr.) -56.6 ft., -3.33 ft./yr.
		Avg. # Yrs; Chg/yr **33.1 yr.; -0.38 ft./yr.**	**Avg. #Yrs; Chg/yr** **16.4 yr.; -2.94 ft./yr.**

By contrast, during the drier 1995-2012 period, average water levels for 13 representative wells dropped an average of 2.94 ft/yr for the average 16.4 year period. For wells directly on the Canoa Ranch property, including wells at the ranch headquarters and wells between the Santa Cruz River and the Union Pacific Railroad tracks to the east, declines in some wells since 1995 have been greater than 5 feet/year. This alarming downward trend has resulted in a significant reduction of shallow groundwater in the area (SGA), defined as a depth of less than 50 feet (PAG, 2000, Pima County, 2002). This continued water-level decline means the combination of drought conditions and groundwater pumping in the area (described in Section 2-3, average of 21,000 AF/yr) exceeds the ability of the aquifer in the area to maintain water levels. Consequently, some kind of additional groundwater replenishment is needed to restore or maintain water levels in this area. Without more significant rainfall with accompanying larger flood flows and associated groundwater recharge from these events, water levels will continue to decline at a rate which is detrimental to present and future users of groundwater in the Canoa Ranch area. The SGA has shrunk from 3.7 square miles in 2002 for the Study Area (as delineated on Pima County MapGuide /PAG, 2000) to 0.67square miles (Figure 3-4).

One of the longest and most complete water level records is for a Pima County owned well near the SCR and the Union Pacific Railroad tracks, approximately 1.9 miles north-northeast of Elephant Head Road (D19-13-21BAA; ADWR Registration #55-623123) near the downstream end of the confluence of the Agua Caliente Canyon Wash and the SCR **(Figure 2-3)**. This well exhibits large fluctuations in water levels over the period 1960-2012, underscoring the ability of the aquifer to quickly accept recharge of large amounts of water when available, but also yielding large amounts of groundwater for removal in short periods. After the two largest floods of records in 1983 and 1993; and to a lesser extent the 2000 wetter period, water levels recovered 16-40 feet within 1-2 years after each event, suggesting the permeable sands and gravels (surficial alluvial deposits and underlying Ft. Lowell Formation) in this area are very responsive to large recharging flows. Despite these large flood events and subsequent volumes of recharged treated effluent discharged from the Nogales International Wastewater Treatment Facility, water levels experienced a gradual overall decline over the periods of record (1960-2012) of 1.0 feet per year, a 0.005 ft/yr recovery from 1977-2012 and a dramatic 5.3 ft/yr decline from 1995-2012. Apart from 2000, the last 17 years has seen significantly less rainfall and flood flows in this area, not seen since the period 1968-1976.

Table 3-2 displays rainfall averages for the available rain gages near the Study Area. The time periods 1962-1977, 1978-1994 and 1995-2011 were chosen to illustrate differences in average annual rainfall for these periods. Rainfall averages for the 1995-2011 period is very similar to the 1962-1977 period for the available gages at Tumacacori and the Florida Canyon Station. Although these stations are higher in altitude than most of the study area in the basin, they show the relative differences against the 1978-1994 period for these two stations. The 1978-1994 rainfall averages for these two stations are 25-30% higher than for the other two time periods, with some 4 to 6 inches more of annual rainfall. The flood flow records and resulting water level changes in area wells confirm these trends. Only recently (1995-2011)

have additional rain gages been added near the Santa Cruz River and within or very close to Canoa Ranch.

Table 3-2
Rainfall Data for Three Climatic Periods in the Canoa Ranch Vicinity

Date Range	Average Annual Rainfall at Green Valley NCDC Coop #23668 (inches)	Average Annual Rainfall at SRER NCDC Coop #27593 & ALERT #6390 (Florida Canyon Station) (inches)	Average Annual Rainfall at Elephant Head Butte ALERT #6350 (inches)	Average Annual Rainfall at Elephant Head Road ALERT #6060 (inches)	Average Annual Rainfall at Tumacacori NCDC Coop #28865 (inches)
1962-1977	----	20.78	----	----	14.81
1978-1994	----	26.31	----	----	19.13
1995-2011	12.50[a]	19.04[b]	11.85	9.20	14.54

[a] 8 of 18 years were not used in the average due to incomplete data (missing days or months)

[b] Pima County Regional Flood Control District ALERT data from 2006-2011 used to calculate average due to incomplete data (missing days or months) from immediately adjacent National Climatic Data Center (NCDC) Santa Rita Experimental Range station (SRER, Florida Canyon Station, altitude 4400 ft amsl)

3.3 Influence of Flood Flows and Cumulative Annual River Flows on Water Levels

As discussed, there appears to be a direct correlation between the annual volume of flow in the SCR channel and groundwater levels measured in the Study Area from 1960 to 2012.[1] This physical hydrologic condition is clearly demonstrated by a comparison of annual runoff volume versus depth to water and groundwater elevation, as shown at these well locations in **Figures 3-6 through 3-9:**

- Figure 3-6 Entrance to Canoa Ranch
- Figure 3-7 West of SCR and 1.9 miles northeast of Elephant head Road
- Figure 3-8 SCR and Elephant Head Road
- Figure 3-9 South of Elephant Head Road
- Figure 3-10 North of Camino de Rondo

Four major trends are dominant on the figures:

- A relatively moderate period of flood and base flow appeared to maintain a relative stable period and water levels were above 60 feet in the early 1960s until around 1968. With it, concomitant larger flows dominated, peaking over 40,000 AF total flow in 1967.

- Beginning in 1968, total annual flow on the SCR was typically below 10,000AF/yr. Water levels fell at a significant rate of 4 feet/year by 1978, lowering water levels near the SCR to 80-

[1] Annual runoff volumes were not available from 1985 through 1991 for the USGS stream gauge at Continental Bridge and 2001-2002 at the Tubac Bridge.

100 feet bls. Also during this period, around 1970, the mines initiated significant pumping of groundwater in the study area.

- Beginning in 1977, three years of large flood flows on the SCR averaging over 50,000AF/yr resulted in significant water level recoveries. This trend continued with dramatic increases in water levels and maintained recovery after the high volume years of 1983 and 1993, which were characterized by two of the largest floods on record for the SCR.

- A downward trend in water levels began in 1996 and has continued through 2011. In some wells, subtle increases in water level occurred during the relatively high volume year of 2000, which had larger storm water runoff events. The difference of approximately 60,000 AF between the total annual flow at the Tubac SCR gaging station, approximately eight miles south of the Pima County line, and the Continental Bridge Station, approximately ten miles north of the Pima County line, illustrates the large capacity of the SCR to recharge storm flows along the Canoa Ranch floodplain. In between the high volume surface flow years, water levels experienced significant declines throughout the Study Area, despite a typical effluent dominated base flow reaching Elephant Head Road of 5-8 cfs over the last two decades.

A discussion of the major flood flows and their impacts on water levels illustrates the capacity of the SCR to recover when provided a source of water.

3.3.1 1977-1979

The Study Area experienced large volumes of flow (40,000 - 61,000 acre-feet at the SCR and Continental Road) during three successive years from 1977 through 1979. The majority of this flow occurred as the result of heavy rainfall and associated flooding along the Santa Cruz River.

Roughly 88% (46,400 acre-feet) of the annual flow recorded in 1977 (52,700 acre-feet) occurred as the result of Tropical Storm Heather. On October 6-10, heavy and prolonged rainfall in the extreme southern portions of the State, including the SCR basin, caused heavy destruction all along the SCR from Nogales to Marana (NWS, 2013). The official storm report from Nogales indicated 8.3 inches of rainfall, but unofficial amounts up to 12 inches were received in various parts of the community (Durrenberger & Ingram, 1978). A peak discharge of 26,500 cfs was recorded at the Continental Road bridge on October 9, 1977 (USGS, 1978).

Almost 80% of the total annual flow in 1978 (61,030 acre-feet) occurred during the months of March, November and December. Although primarily concentrated in the northern portion of the watershed, heavy rainfall occurred throughout the SCR basin from March 4-20 (NWS, 2013). The flow volume recorded at Continental Road bridge for the month of March was 8,100 acre-feet (USGS, 1979). Later in the year, from December 17-20, heavy precipitation combined with saturated conditions (7,920 acre-feet of discharge at SCR and Continental Road in November (USGS, 1980)) caused almost every major river in Arizona to overflow its banks, including the SCR near Green Valley (NWS, 2013). Total flow for the month of December at SCR and Continental Road was 32,550 acre-feet, with a peak discharge of 16,000 cfs occurring on December 18.

Saturation of the river channel and continued wet weather in January 1979 produced a total monthly discharge of 34,750 acre-feet at the Continental Road bridge. This was over 82 percent of the total flow recorded at the gage for the entire 1979 Calendar Year (USGS, 2011).

Due to the high annual flows, fairly significant increases in groundwater levels are noted along the SCR within the Canoa Ranch Area over this time period and beyond to the onset of the flood of 1983. From early 1977 to 1980-81, water levels in wells from Elephant Head Road to Camino de Rondo (north end of Canoa Ranch) rose 17-22 feet (**Figures 3-6, 3-8 and 3-10**).

3.3.2 1983-1984

In 1983, the annual flow volume in the SCR at Continental Road was just over 117,000 acre-feet (USGS, 2011). The majority of this volume was due to flooding along the river channel as a result from heavy rainfall (as much as 11 inches) occurring over Pima County from September 27 to October 3 caused by tropical storm Octave. The peak flow was 45,000 cfs at the Continental Road gage (Roeske et. al.,1989). After this flood event, water levels increased as much as 47 feet within a few years in wells close to the SCR north of Elephant Head Road near Canoa Ranch headquarters **(Figures 3-6, 3-7)**

3.3.3 1993

A very large volume of annual flow was also recorded in 1993 (almost 90,000 acre-feet at Continental Bridge gage), mainly due to flooding caused by moderate to heavy rains throughout Pima County mixed with snow melt from January 5th through January 19th with a recorded peak of approximately 32,000 cfs (PCDOT/FCD, 1993). After this flood event, groundwater levels within the Study Area increased in wells by almost 15 feet within the vicinity of Canoa Ranch. Water levels were at their shallowest for the period of record in 1995, ranging from 11.5 feet at Rancho Sonado south of Elephant Head Road, to 35 feet at Elephant Head Road to 13.5 feet north of Elephant Head Road near the SCR, to about 50 feet near the Canoa Ranch entrance. (Figures 3-6 through 3-9)

3.3.4 2000

One other year experienced higher annual volumes of note, which positively influenced groundwater levels to a lesser extent. Over 71,000 AF of flow from October-December 2000 (~86 percent of annual flow) was gaged at the SCR Tubac Bridge. The flow was initiated by storm activity in mid-October. There were no base flows on the SCR at Continental before or after the storm runoff events, which lasted from October 9-November 18 (four separate peak flows recorded). December 2000 flow at Tubac was 5,600 AF, but at Continental gage flow was zero. Initial flood flows at Continental Road in October were about 33% of the total at Tubac, while flows in November at Continental were 46% that at Tubac. This data indicates that the SCR had recharged a very large amount of flood flow over the 18 miles between Tubac Bridge and Continental Bridge. The USGS gage at Elephant Head Road was operational from 2004-2010, so estimates of recharge on Canoa Ranch would be based upon that percentage of river on the Ranch between the operational gages. The difference between the annual flow at Tubac (83,150 AF) and Continental (25,720 AF) was 57,430 AF, strongly suggests that this stretch allows for tremendous amounts of recharge when large flows are generated (Figure 3-8). After examining Tubac Bridge flood flows and Continental Bridge flood flow data for 1996-2011, the

amount of storm-flow recharge for 2000 was significantly larger at 3,040 AF/mi/yr from Tubac to Continental Bridge than for the other years, estimated at 250 AF/mi/yr.

3.3.5 Groundwater Level Declines and Recoveries

The average annual stream volume in the Santa Cruz River at Continental Road Bridge gage from 1978 through 1994 was 35,527 acre-feet. Water levels on Canoa Ranch recovered during this time period 50-90 feet. During 1995-2011 the average flow for the same gage was 4,261 AF/yr. Water levels generally declined from 50 feet to 90 feet during this time span on Canoa Ranch. The highest groundwater level recoveries in the area occurred during the two years with very large flood flows in the Santa Cruz River, 1983 and 1993. These flood flows not only provided natural groundwater recharge to the area, they also scoured out the channel bottom, thus exposing coarser grained materials and increasing in-channel recharge of subsequent smaller storm water events and effluent discharges from the upstream Nogales wastewater treatment plant.

In the last ten years, moderate flood events initiated primarily south of the County line and higher than normal cumulative annual flows in 2005, 2007 and 2008 at the Tubac gage (20,000-25,000 AF/yr), approximately 10 miles upstream of Elephant Head, and Elephant Head gage (12,000-17,000 AF/yr) helped produce a temporary cessation of water-level decline in wells near the SCR (Figures 3-7; 3-8), but was not as effective in the Canoa Ranch Headquarters well due to interception pumping of recharged water from mine supply wells (Figure 3-6). These water-level stabilization events were temporary; declining rates of about 5 ft/yr have been the norm for the last 16 years.

4.0 Future Recharge and Water Balance Scenarios

Based upon a review of available information from historical water levels, flood flows and groundwater pumping, it appears the Canoa Ranch area along the SCR and floodplain is underlain by appreciable subsurface sandy and gravelly sediments which are capable of quickly recharging large amounts of treated effluent, stormwater and other sources of water. Current pumping regimes in the area lower water levels and increase storage capacity within the aquifer, providing additional volume for the recharge of water.

Surplus effluent is currently available based upon the amount generated south of Canoa Ranch at the Arivaca Junction Wastewater Treatment Facility. However, the facility is about one mile south of Canoa Ranch (Elephant Head Rd) and a mechanism to transport about 40-50 AF/yr of effluent has not been constructed.

Recent improvements at the Nogales International Wastewater Facility have resulted in reduction in nutrient discharge and in turn improved infiltration farther upstream of the Canoa Ranch area. Underflow to the Ranch may increase and, barring additional groundwater withdrawals, the water balance may not differ much from the current condition. However, overall downstream discharge from the facility may diminish by 3-5 mgd, or 25-30% of discharge, due to the new Los Alisos Treatment Plant, which will discharge outside the SCR Basin (SACF, 2012). Previous documented base flow over the last two decades have ranged from 5-8 cfs from historical USGS gaging records at the Elephant Head Road Bridge gage, at the southern boundary of Canoa Ranch and Elephant Head Bridge (USGS, 2004-2010). Most of the base flow has been winter flow and dominated by effluent. Although the amount of effluent

dominated base flow is low (700-1,000 AF/yr), it provided a contribution along the SCR that will now be mostly unavailable. The 2005-2009 Elephant Head Road Bridge flow data allowed for estimates of effluent recharge during that period. Using average base flow, which was effluent dominated we estimated historic recharge of effluent north of Elephant Head Road at 720 AF/mi/yr. South of Elephant Head Road the estimate was more like 425 AF/mi/yr.

Proposals for extending pipelines to move Central Arizona Project (CAP) Water further south near the SCR alignment have been developed by Community Water Company (CWC) and Farmers Investment Company (FICO). The infrastructure costs have been limiting, but progress has been made by the Upper Santa Cruz Providers and Users Group (USCPUG) to potentially broker an agreement to extend a water line. Conceptual plans have been developed to design off-channel recharge basins as far south as the northern portions of Canoa Ranch. More feasibility studies will be needed to evaluate all potential recharge sites in the Green Valley area. (Bernal, 2008).

The activity that may have the largest impact on water levels over the next three decades on Canoa Ranch may be the planned change in pumping regime by the six on-site Canoa Ranch industrial mining wells owned by Freeport McMoran, which provide processing water for the company's Sierrita copper and molybdenum mine (approximately five miles northwest and downgradient of Canoa Ranch). Table 4-1 details the planned pumping rates for the Canoa well field, as dictated by the current Arizona Department of Environmental Quality (ADEQ) Mitigation Order Work Plan, to the end of the current mine plan of operation or through 2042. This plan is subject to change dependent on various conditions, which include but are not limited to pumping performance, changes to Mitigation Order, and changes to mine plan (Beck, 2013).

The projected reductions in Canoa Ranch Well field are significant. Beginning in 2014, pumping in the Canoa Ranch well field will diminish to approximately 24% of the earlier 1984-2010 average pumpage, or as little as 3450 AF/yr until 2020. From 2021-2025 pumping will be at 4,420 AF/yr or 27% of the earlier 1984-2010 average. From 2025-2042 (the end of the current mine plan of operation) pumping would increase to 44% of the 1984-2010 average. The additional mitigation order pumping the mine needs will be shifted to a new well field about 5-7 miles downgradient of Canoa Ranch to control a sulfate plume downgradient of the Sierrita tailings pond in the area (HydroGeochem, Inc. and Clear Creek Associates, P.L.C., 2010). The resulting reduction due to mine groundwater pumping in the Canoa Ranch area will help to reduce the large annual water-level declines. Recovery to the shallow groundwater levels of the mid-1990s may only occur if a wet weather cycle recurs.

Table 4-1
Planned Sierrita Mine Pumping (AF/yr)

	2013	2014 to 2020	2021 to 2025	2026 to 2030	2031 to 2035	2036 to 2042
Total Mitigation Order Pumping	8,969	23,145	22,175	20,867	20,141	17,240
Total Canoa Well-field Pumping	17,726	3,450	4,420	5,728	6,154	9,355
Total Sierrita Pumping	26,595	26,595	26,595	26,595	26,595	26,595

Source: Beck, 2013

By contrast, potential groundwater usage due to incorporating all of the recommendations of the 2006 Canoa Ranch Water Master Plan (Westland Resources, Inc, 2008) would require about 165 AF/yr, as follows:

- Restoration 50 AF
- Aquatic ecosystems 30 AF
- Pasture/horses 75 AF
- Headquarters/entry Landscaping 10 AF

5.0 Key Findings

The Canoa Ranch hydrologic study area is bisected by the intermittent Santa Cruz River and several large tributaries from the Santa Rita and Sierrita Mountains. Many factors influence the periodic rise or ongoing fall of subsurface water levels, including climatic conditions, annual SCR runoff volumes, recharge of surface waters to the groundwater aquifer, and groundwater pumping. In addition, surface flow and recharge of treated effluent along the Santa Cruz River influences the maintenance of shallow water levels and riparian habitat in Canoa Ranch and upstream areas.

Based upon the information presented and discussed above, the following are key evaluation findings:

- Sedimentary units in the hydrologic evaluation area include from the surface to bedrock: Surficial deposits, Fort Lowell Formation, Tinaja Beds, Pantano Formation, and the Santa Rita and Sierrita Mountains basement bedrock. The surficial deposits and upper Fort Lowell Formation consist of permeable sands and gravels, which accommodate rapid recharge of storm water and effluent via the SCR, tributary channels and potential surface impoundments. The lower Fort Lowell Formation and Tinaja Beds provide most of the saturated sediments, pumped for potable, agricultural and industrial water use.

- Current sources of recharge fluids in the Canoa Ranch Area include storm water flowing in the Santa Cruz River and tributary watercourses from the Santa Rita and Sierrita Mountains, mountain front recharge from the Santa Rita and Sierrita mountains, and treated effluent from the

Nogales International Wastewater Treatment Facilities released into the Santa Cruz River.

- Ground-water pumping in the hydrologic study area has been considerable over the last 40 years, averaging 19,606 AF/yr over the documented period of 1984 - 2011. Pumping amounts ranged from a low of 14,074 AF in 1992 to a peak of 24,990 AF in 2010. Of that amount approximately 83% is attributed to Freeport McMoran Mine and the six mining extraction wells on Canoa Ranch. Based on records of mining production, undocumented mining well pumping in Canoa Ranch has probably been similar during the period of the early 1970s to 1984.

- Water levels are shallowest at the Santa Cruz River and south of Elephant Head Road to the County line with a narrow band of depth-to-groundwater contours of 50 feet bls and less along the Santa Cruz River corridor. At the Canoa Ranch Headquarters area, water levels increase to 90-100 feet bls. Near the northern Canoa Ranch boundary water levels are 130 feet bls and increase in depth farther north. In the area west of I-19, to the west of the Canoa Ranch Headquarters, depth to water quickly increases to over 200 feet bls and over 250 feet bls at the study area boundary in response to rising surface topography. East of Canoa Ranch depth to water increases to over 200 feet bls near the pediments of the Santa Rita Mountains, also in response to rising surface topography.

- Canoa Ranch ground-water levels appear to fluctuate the most in the area closest to the Santa Cruz River. Annual flow in the Santa Cruz River appears to be directly correlated with water-level recovery or decline, especially within wells close to the River.

- The direction of groundwater movement is northeasterly, roughly parallel to the alignment of the Santa Cruz River. Near the confluence of several larger tributary streams from the Sierrita and Santa Rita Mountains with the Santa Cruz River south of the Canoa Ranch Headquarters, the water table slope is shallowest and flattest at about 27 feet/mile (0.005 ft/ft). The water table slope increases significantly to about 100 feet/mile near the Canoa Ranch Headquarters.

- Water levels in the Canoa Ranch area have fluctuated, at times dramatically, over the last 42-44 years based upon dramatic changes to the three PCNRPR wells on Fig 3-5 since the beginning of mine supply well pumping around 1970. Two distinct periods of sharp water level decline have been documented over the study period of record: 1968 -1977 (50 – 80 ft) and 1995- present (60 – 90 ft).

- Overall, water levels within the project boundary have had an average decline of approximately 0.4 ft/yr over the most recent 33-years based upon the eleven wells with available record. Over the last 16 years the average water level decline was approximately 3 ft/yr based upon thirteen wells with available records for the period.

- Despite overall water level declines for both the last 33-year and 16-year periods, water levels in numerous wells recovered from 20-25 feet within one year after the large floods of record in 1983 and 1993 (and to a lesser extent in 2000). However, these water level recoveries were not sustained due to subsequent years of lesser flood flows and ongoing industrial, agricultural and municipal well pumping.

- Future projected reduction in discharge of treated effluent from the Nogales Wastewater Treatment Facility may increase current water level declines in the Canoa Ranch area. It is uncertain if future flood events could reverse this projected water-level decline trend due to loss of effluent and reduced storm-flow recharge.

- Future recharge volumes and variable pumping rates will affect groundwater levels in the Canoa area. The Canoa Ranch area hosts subsurface alluvial units capable of quickly recharging large amounts of treated effluent, storm water and other sources of water. Current pumping regimes in the area diminish water levels, resulting in increased storage capacity within the groundwater aquifer system for subsequent recharge of surface water through the extremely permeable alluvium of Santa Cruz River channel and floodplain.

- Well pumping from the mine supply wells on Canoa Ranch is anticipated to decrease in a few years from about 17,725AF/yr in 2013 to about 3450 AF/yr in 2014-2020. Subsequent anticipated pumping includes 4420 AF/yr for the period of 2021-2025, followed by a gradual increase in pumping to 9355 AF/yr by 2042, at the end of the current mine plan of operation. These changes in pumping for mine water needs are based upon a shift by Freeport McMoran to pump from interceptor wells to control a sulfate plume several miles downgradient from Canoa Ranch (Beck, 2012; HydroGeochem, Inc.,2007). Planned reduction in mine groundwater pumping may reduce the current water-level decline rate for Canoa Ranch wells of 5 ft/yr. However, additional cumulative SCR flows exceeding 20,000 AF/yr annually at Canoa Ranch may also be needed to allow for substantial water level recoveries.

- Generally, current water level data for the Canoa hydrologic study area are considered adequate, except for a lack of available public water-level data north-northeast of Canoa Ranch Headquarters and immediately east of Canoa Ranch. The lack of well coverage and access to a number of existing wells is problematic and represents a gap in annual groundwater data for this area, thereby limiting our understanding of groundwater occurrence and changing conditions in Canoa Ranch.

- Evidence of perched water conditions (cascading water) was apparent in two wells separated by a distance of about 3,000 feet, east of the Santa Cruz River, west of the Union Pacific Railroad tracks and about 1-2 miles north of Elephant Head Road. The presence of cottonwoods and willows in an area west of these wells along the SCR suggests the possibility of a larger area of perched water.

6.0 Recommendations

Based on the findings from this groundwater evaluation of Canoa Ranch, the following recommendations are provided for consideration and further evaluation:

- Evaluate recharge opportunities in the Canoa Ranch area in order to:
    1) Sustain the existing riparian corridor adjacent to the Santa Cruz River
    2) Stabilize groundwater levels

- Formalize a groundwater level monitoring program in accordance with Pima County's plans for long-term restoration of Canoa Ranch.
    1) Perform quarterly groundwater monitoring
    2) Obtain permission from Freeport McMoran Mining Company to access their six pumping wells in Canoa Ranch as part of the groundwater monitoring program
    3) Update groundwater conditions maps for the ranch

- Update the current ADWR Upper Santa Cruz Basin model using the data from the 2013 water level monitoring program and this report.
    1) With the updated model, perform a sensitivity analysis using different recharge and pumping scenarios for groundwater replenishment or extraction in the Canoa Ranch area
    2) Identify the range of overall recharge / pumping conditions necessary to maintain adequate shallow water levels along the SCR
    3) Identify opportunities for selective mine ground-water pumping scenarios from the six Canoa Ranch wells which might influence groundwater conditions spatially across the ranch property and enhance the ownership goals of Pima County. Perform this analysis for the next three decades of reduced water pumping.

- Further evaluate constructed multi-purpose recharge of CAP water in the northern portion of Canoa Ranch, from the headquarters area to the north property line:
    1) To maintain and/or recover water levels in this part of the ranch

- Evaluate diversion of treated effluent from the Arivaca Treatment Facility:
    1) To the old pond at Canoa Ranch Headquarters for multi-purpose recharge and riparian restoration
    2) To just north of Elephant Head Road
    3) To the suspected perched groundwater zone discussed below

- Investigate the suspected perched groundwater area to better understand the relationship between the shallow groundwater zone and the enhanced riparian environment observed nearby:
    1) Install shallow piezometers and/or soil moisture sensors in the target area
    2) Monitor groundwater conditions quarterly and following moderate - large flow events
    3) Evaluate seasonal groundwater occurrence and conditions

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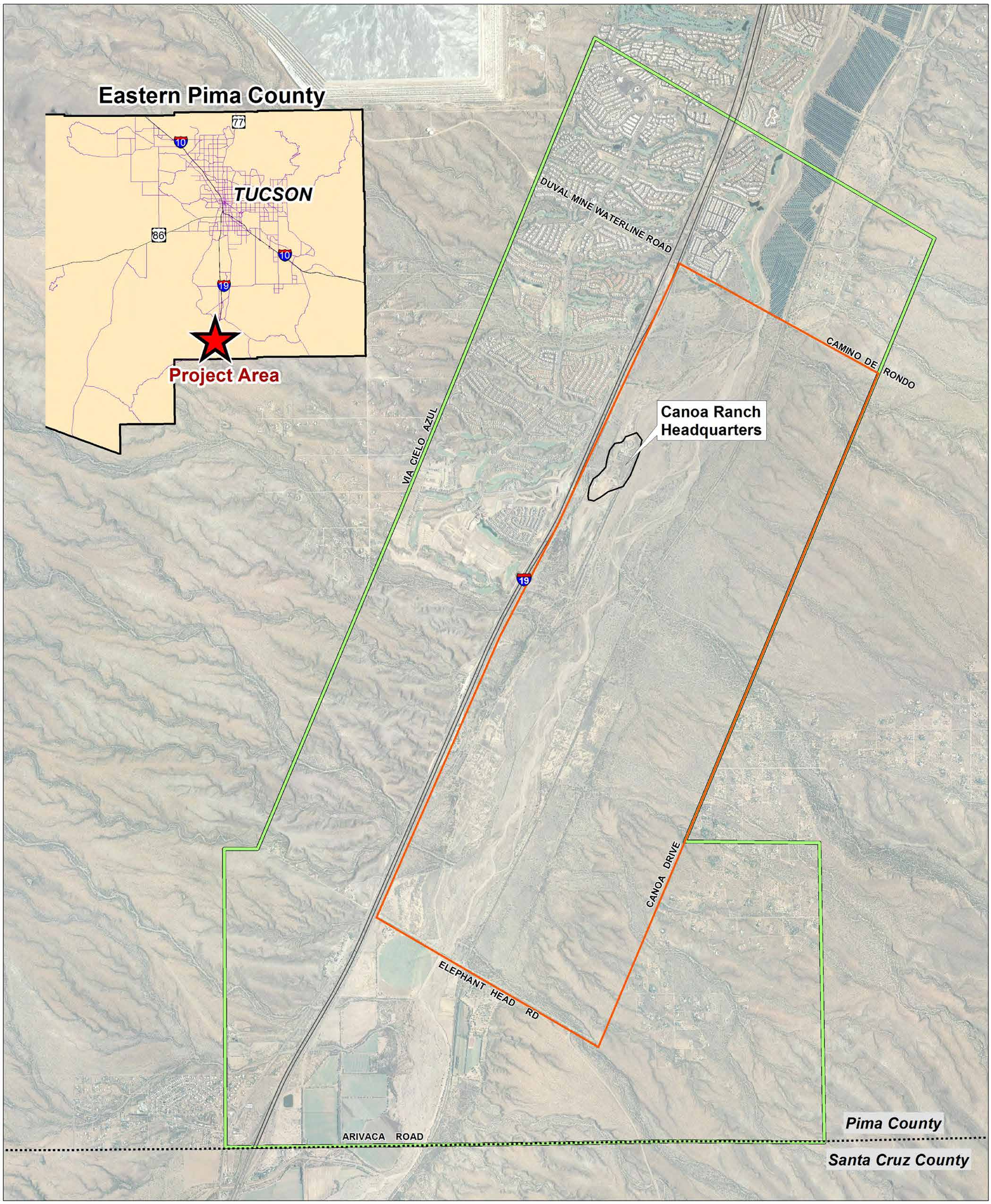
FIGURES



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Canoa Ranch Hydrologic Study
Figure 1-1 Vicinity Map

N W E S

Pima County Canoa Ranch
Project Boundary
County Limits

1 inch = 1,000 feet

0 1,000 2,000 4,000 6,000 8,000 Feet

Date: 1/31/2013

THE SEAL OF PIMA COUNTY ARIZONA

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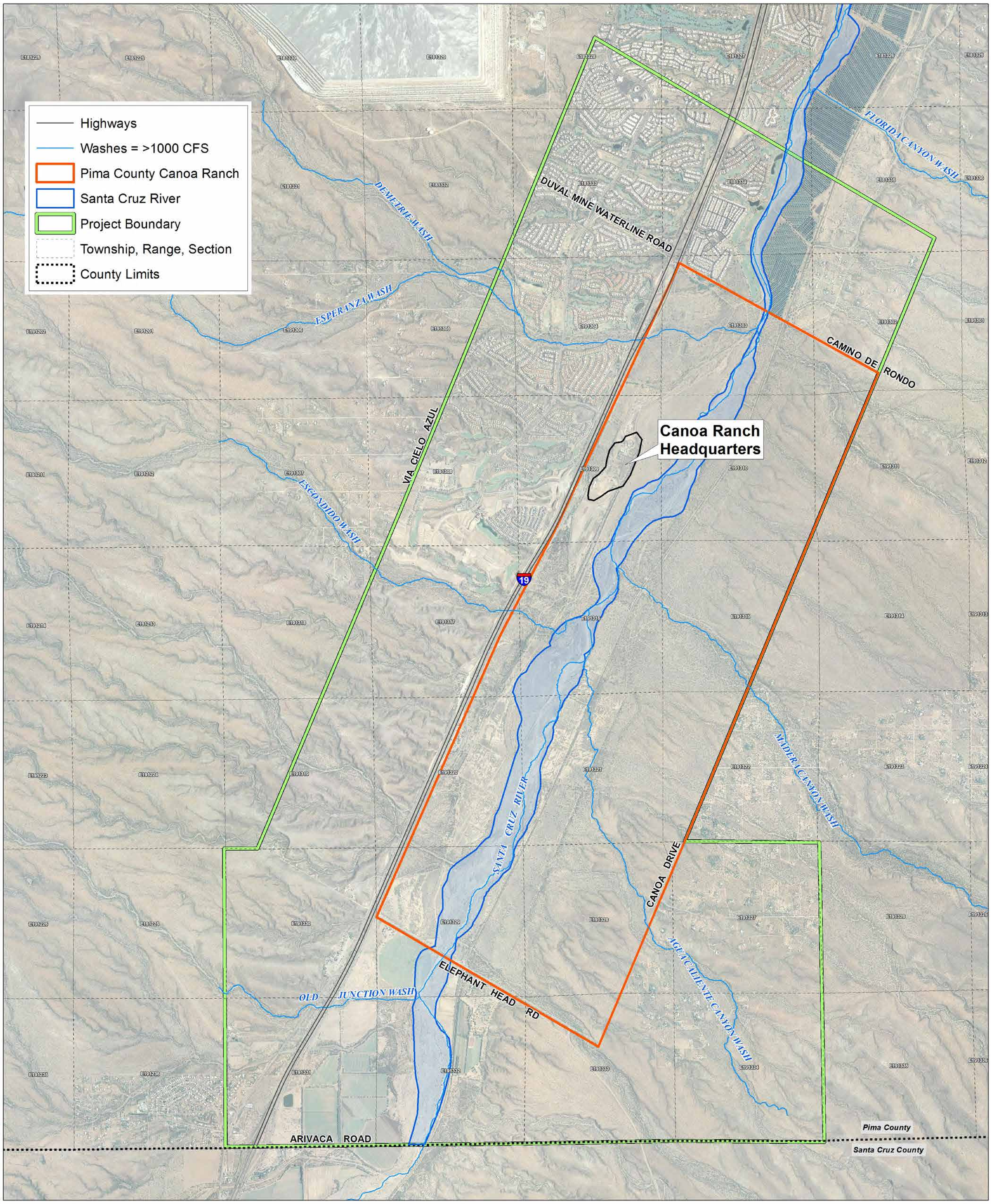

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Canoa Ranch Hydrologic Study
Figure 2-1 Hydrologic Evaluation Area

N W E S

PIMA
SANTA CRUZ

1 inch = 1,000 feet

0 1,000 2,000 4,000 6,000 8,000 Feet

Date: 1/31/2013

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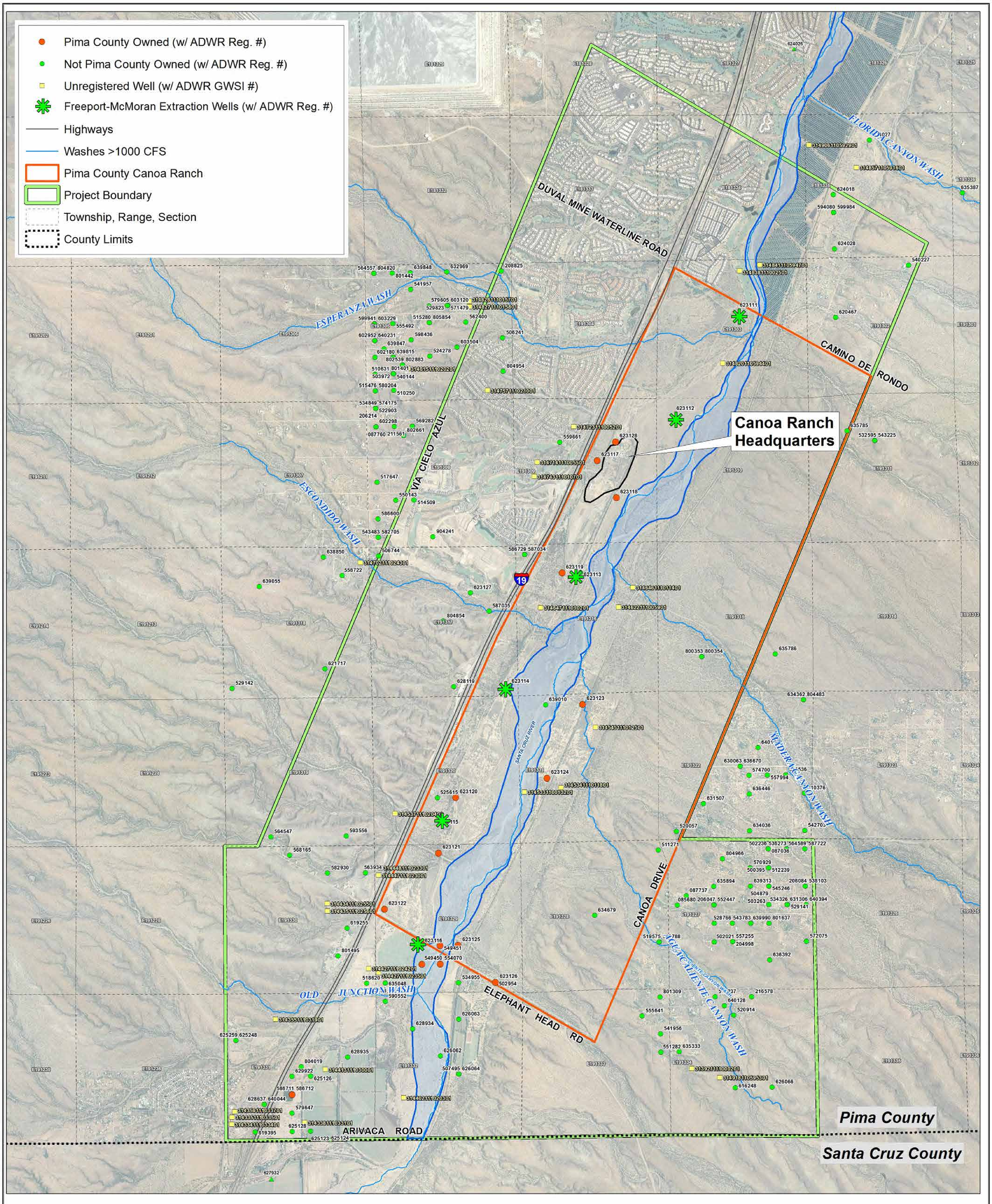

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Canoa Ranch Hydrologic Study
Figure 2-2 Water Wells in Study Area
(not all wells field verified)

N W E S

PIMA
SANTA CRUZ

1 inch = 1,000 feet

0 1,000 2,000 4,000 6,000 8,000 Feet

Date: 1/31/2013

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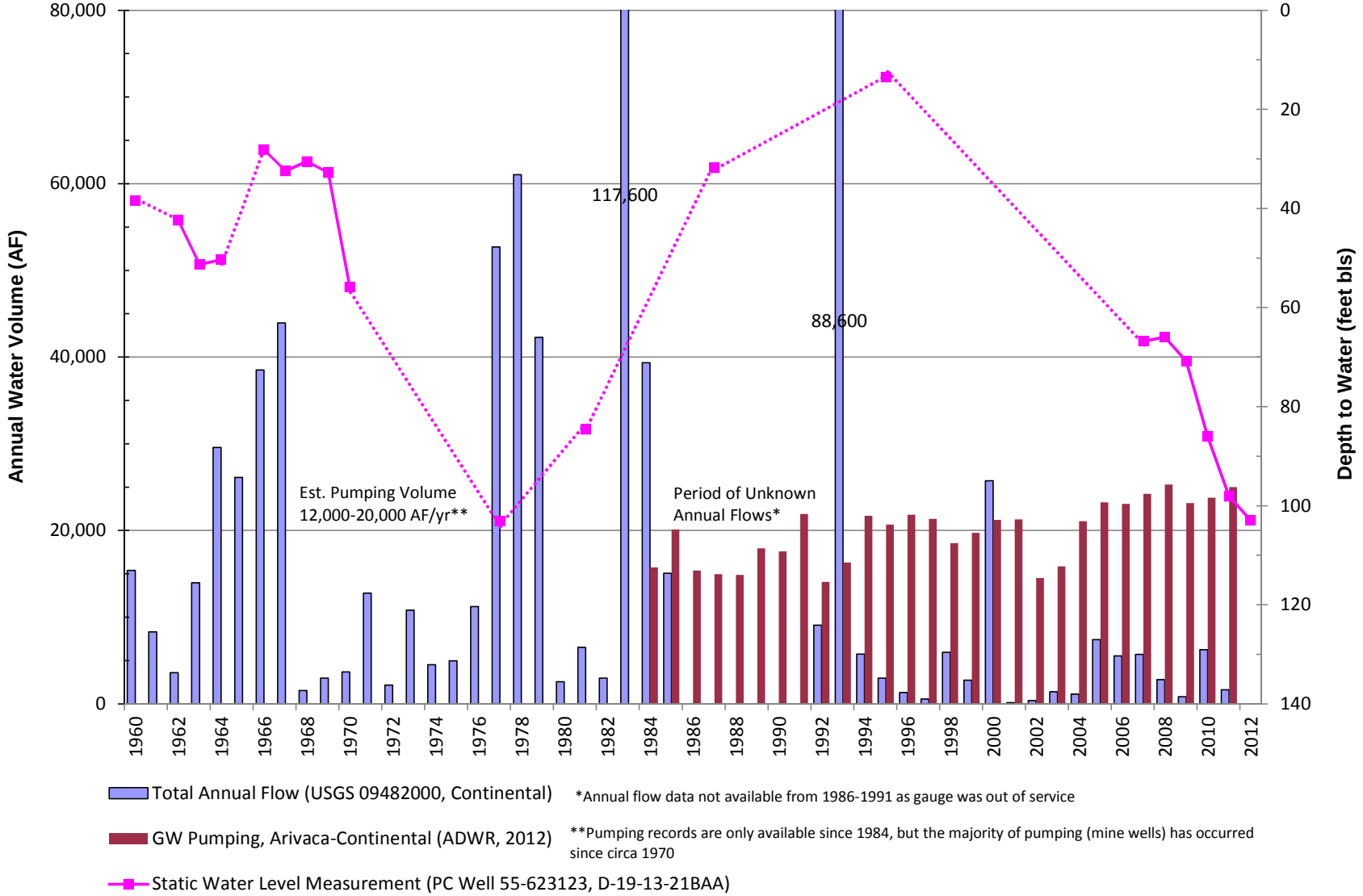
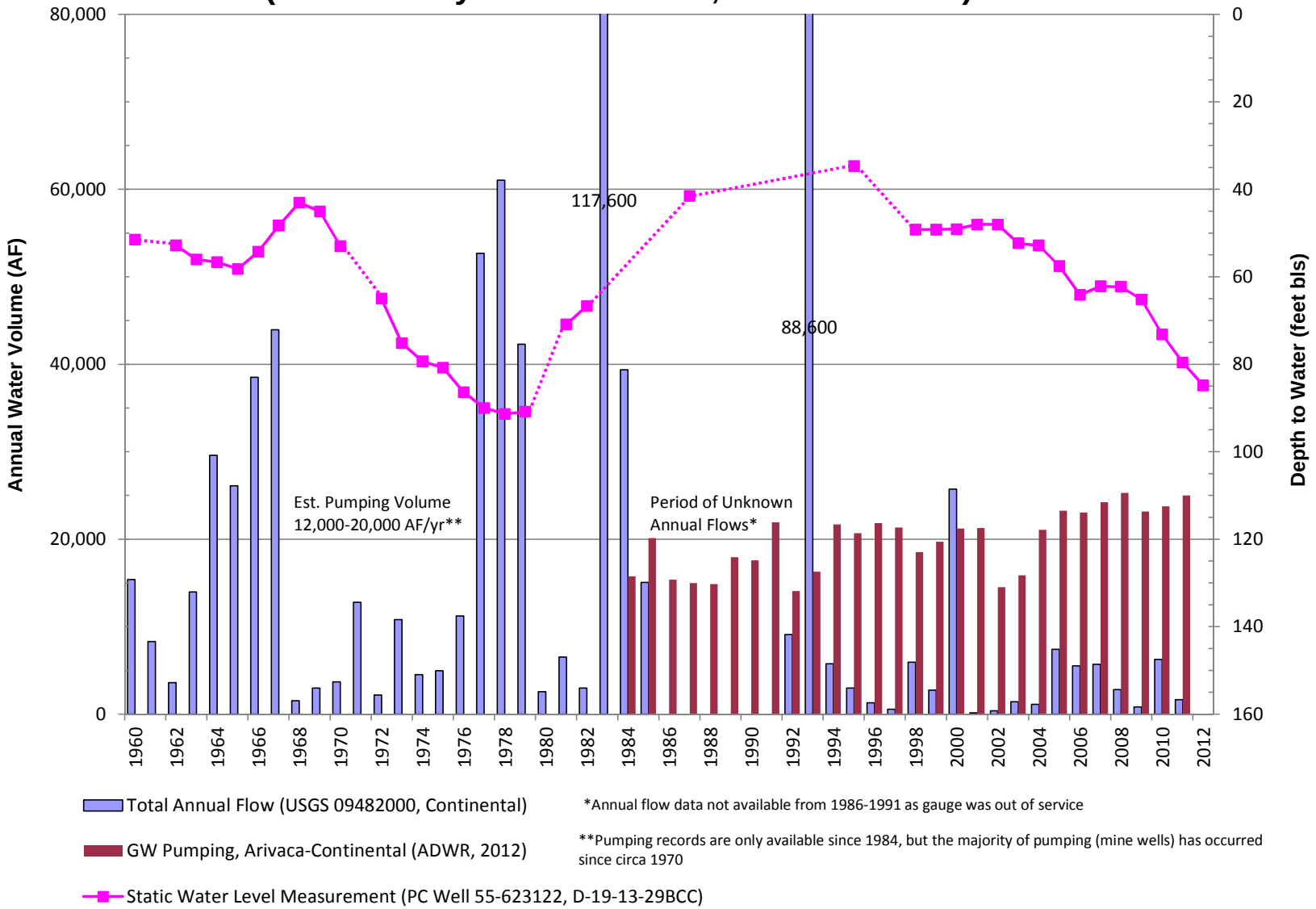
Figure 2-3
Annual Runoff Volume at Continental Bridge vs. Depth to Water in a Well near SCR, 1.5 miles South of Canoa Ranch Headquarters (Pima County Well 55-623123, D-19-13-21BAA)



*Annual flow data not available from 1986-1991 as gauge was out of service

**Pumping records are only available since 1984, but the majority of pumping (mine wells) has occurred since circa 1970

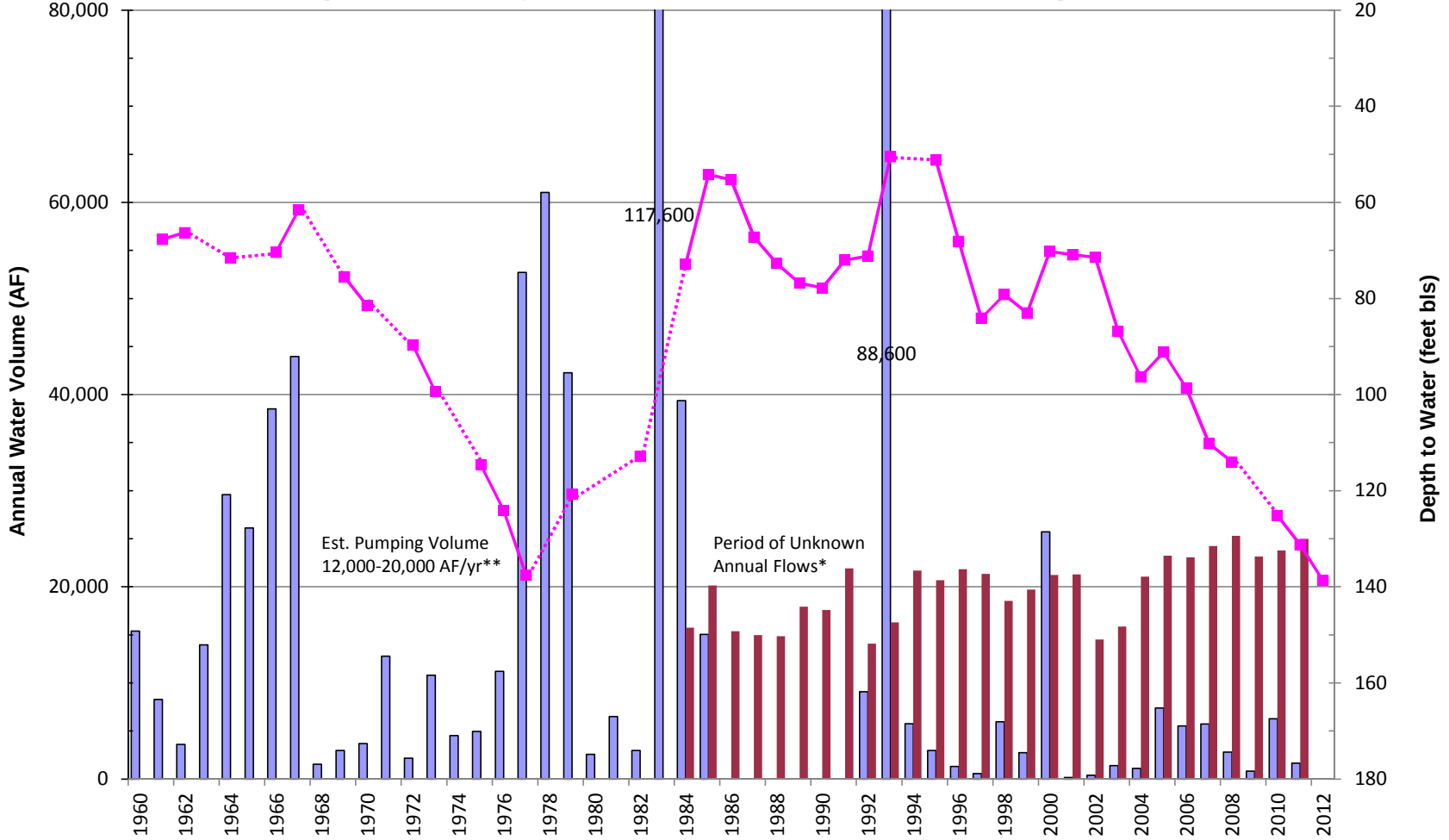
Figure 2-4
Annual Runoff Volume at Continental Bridge vs. Depth to Water in a Well at Elephant Head Road and I-19 (Pima County Well 55-623122, D-19-13-29BCC)



*Annual flow data not available from 1986-1991 as gauge was out of service

**Pumping records are only available since 1984, but the majority of pumping (mine wells) has occurred since circa 1970

Figure 2-5
Annual Runoff Volume at Continental Bridge vs. Depth to Water in a Well Near the Entrance to Canoa Ranch (Pima County Well 55-623117, D-19-13-09ACC)



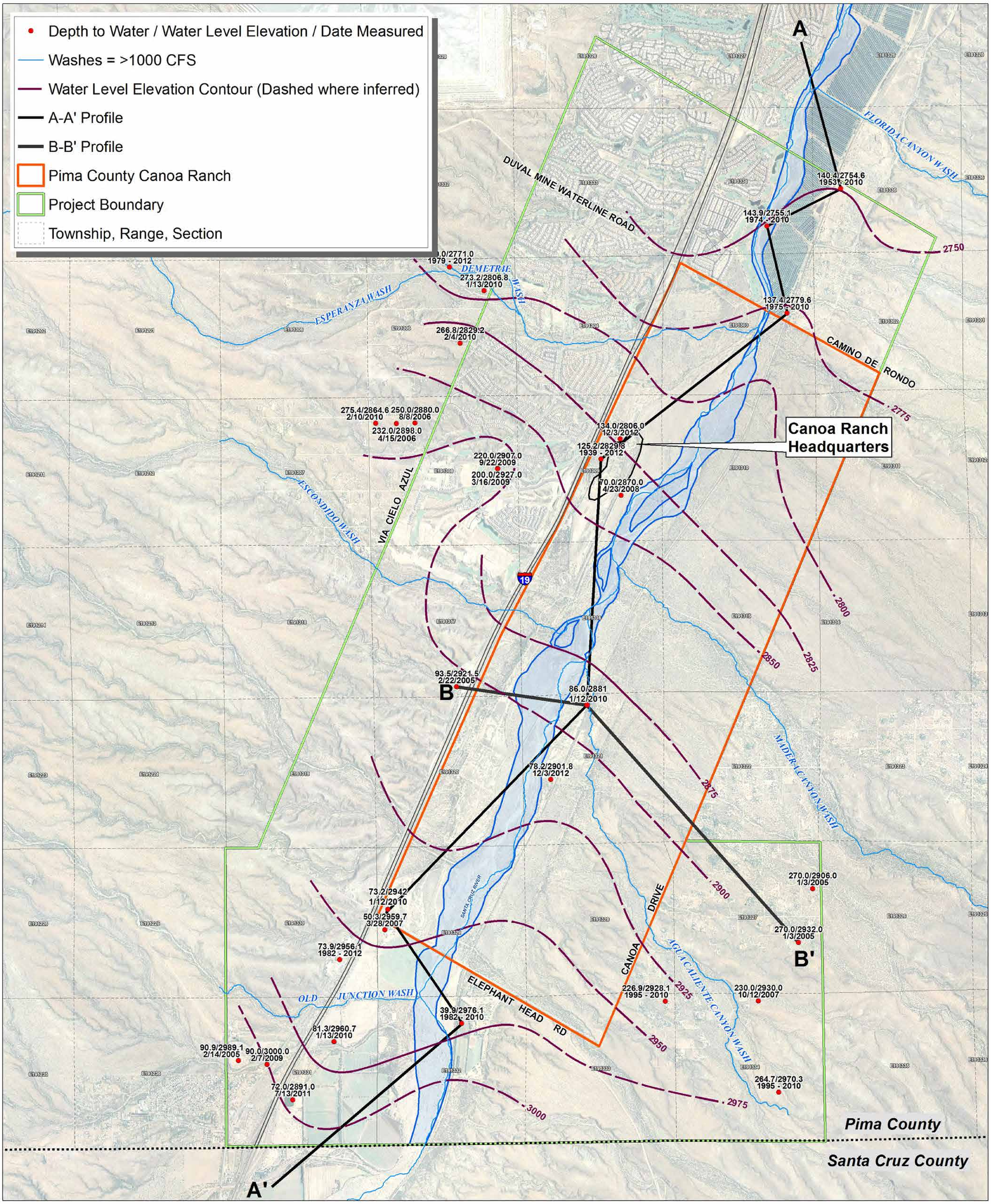
Total Annual Flow (USGS 09482000, Continental)

GW Pumping, Arivaca-Continental (ADWR, 2012)

Static Water Level Measurement (PC Well 55-623117, D-19-13-09ACC)

*Annual flow data not available from 1986-1991 as gauge was out of service

**Pumping records are only available since 1984, but the majority of pumping (mine wells) has occurred since circa 1970



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Canoa Ranch Hydrologic Study
Figure 3-1 Growndwater Elevation Map 2010

1 inch = 1,000 feet

0 1,000 2,000 4,000 6,000 8,000 Feet

Date: 12/20/2012

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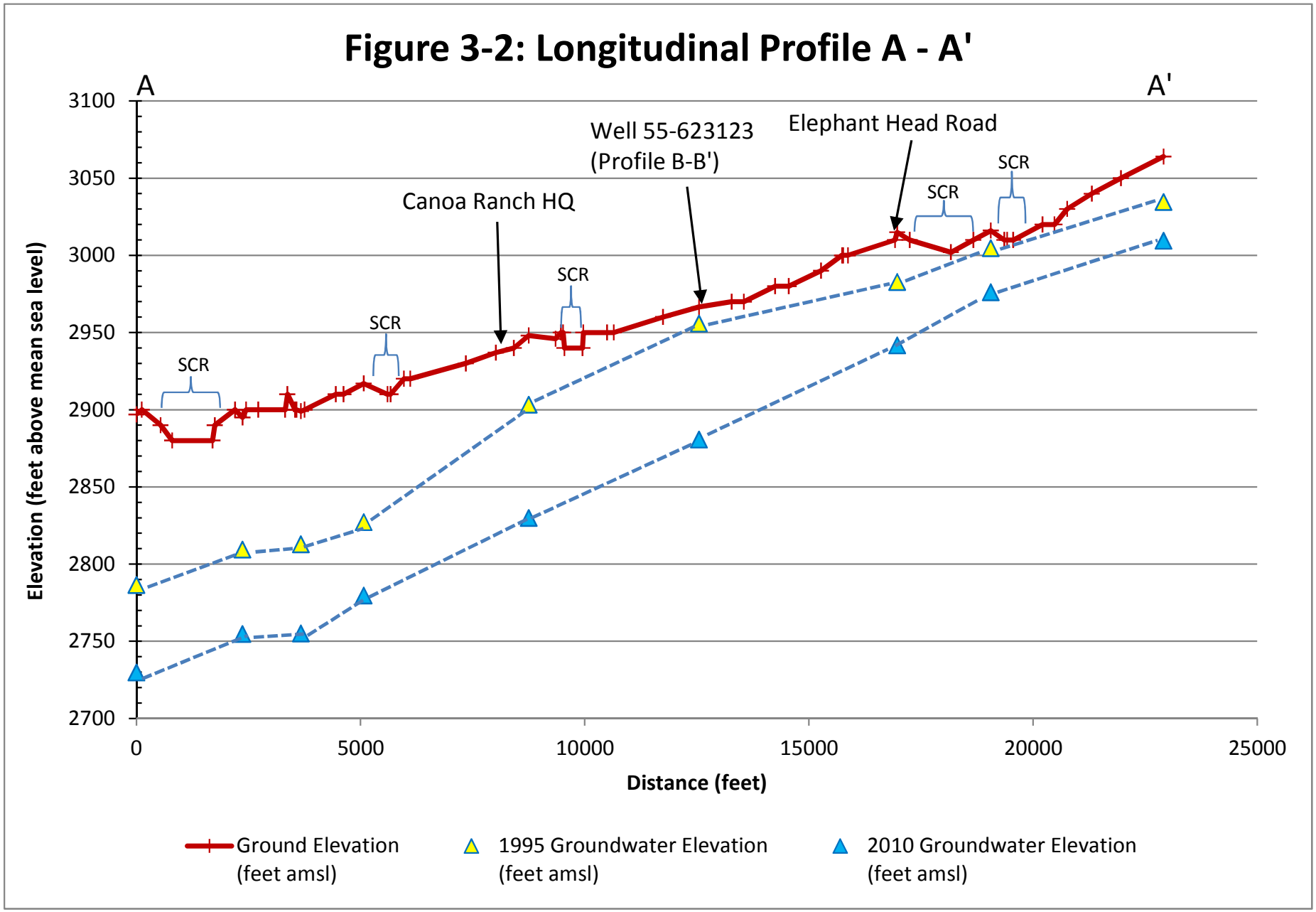


Figure 3-2: Longitudinal Profile A - A'
A
A'
Well 55-623123
(Profile B-B')
Elephant Head Road
Canoa Ranch HQ
SCR
SCR
SCR
SCR
SCR
Elevation (feet above mean sea level)
3100
3050
3000
2950
2900
2850
2800
2750
2700
0
5000
10000
15000
20000
25000
Distance (feet)
Ground Elevation (feet amsl)
1995 Groundwater Elevation (feet amsl)
2010 Groundwater Elevation (feet amsl)

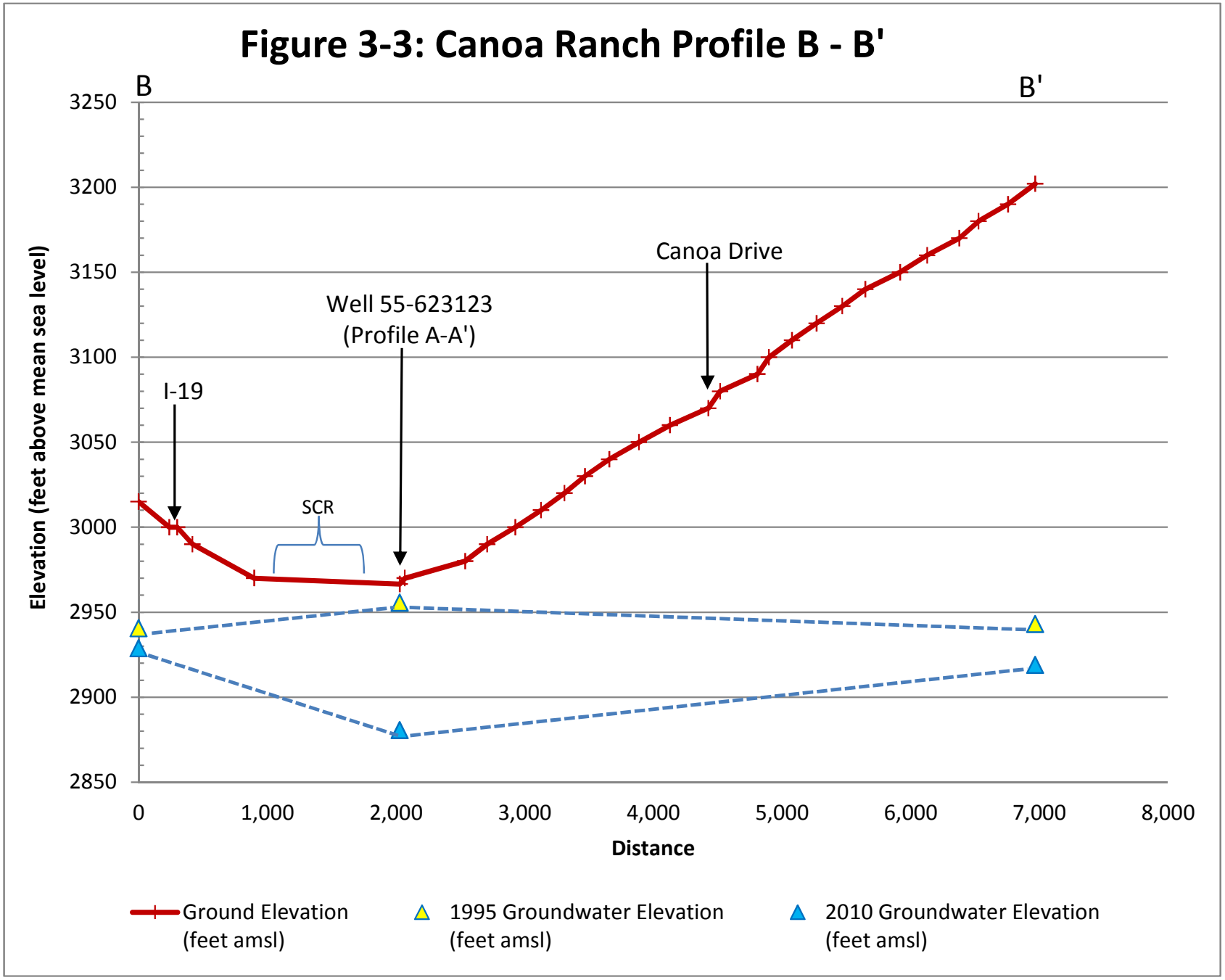
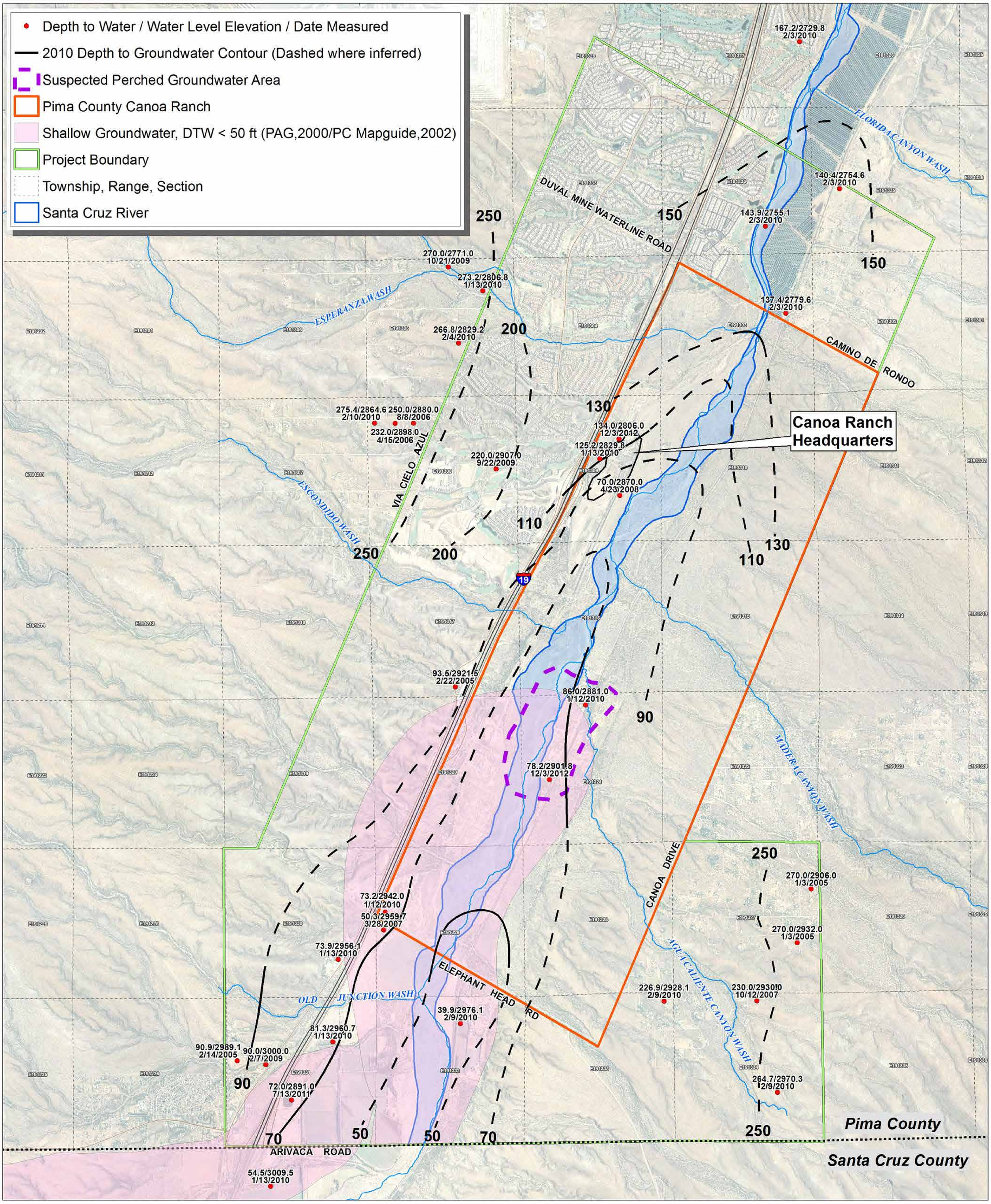


Figure 3-3: Canoa Ranch Profile B - B'
B
B'
3250
3200
3150
3100
3050
3000
2950
2900
2850
Elevation (feet above mean sea level)
Canoa Drive
Well 55-623123
(Profile A-A')
I-19
SCR
0
1,000
2,000
3,000
4,000
5,000
6,000
7,000
8,000
Distance
Ground Elevation
(feet amsl)
1995 Groundwater Elevation
(feet amsl)
2010 Groundwater Elevation
(feet amsl)



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Canoa Ranch Hydrologic Study
Figure 3-4 Depth to Groundwater Map 2010
(Includes 2005-2012 Data, Trend Accounted For)

N W E S

PIMA
SANTA CRUZ

1 inch = 1,000 feet

0 1,000 2,000 4,000 6,000 8,000 Feet

Date: 12/20/2012

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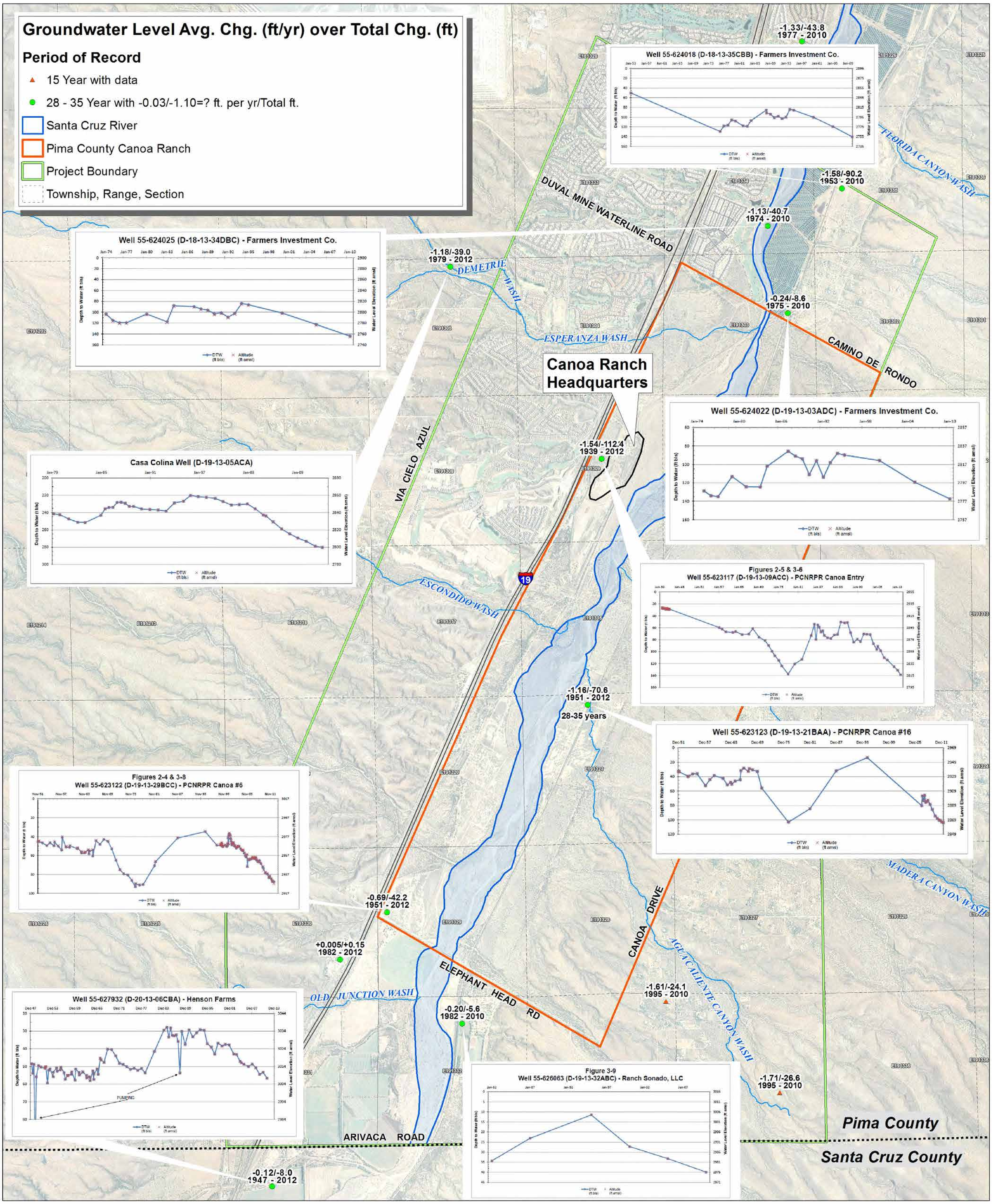

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Canoa Ranch Hydrologic Study
Figure 3-5 Map of Water Level Hydrographs

N W E S

PIMA
SANTA CRUZ

1 inch = 1,000 feet

0 1,000 2,000 4,000 6,000 8,000 Feet

Date: 1/31/2013

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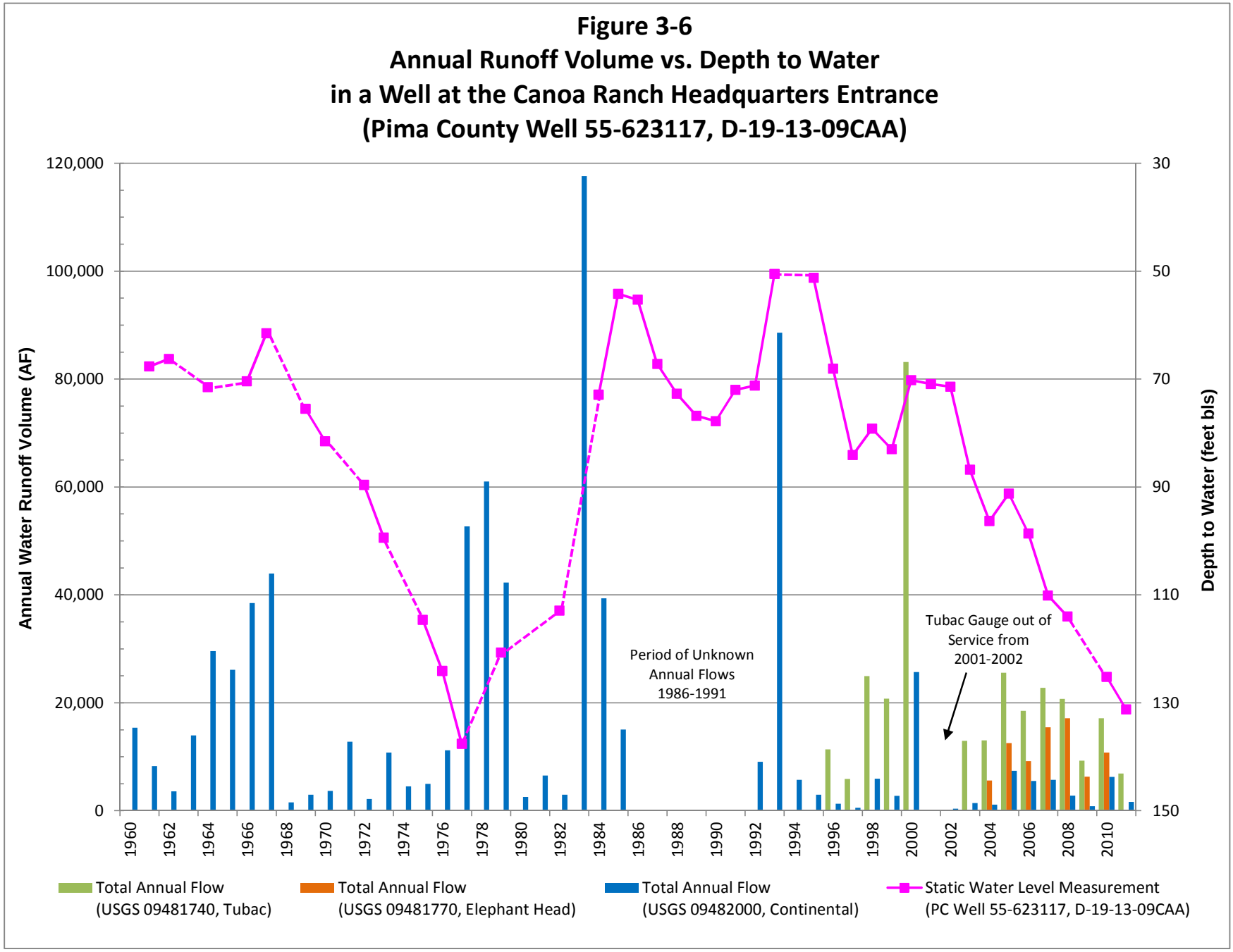
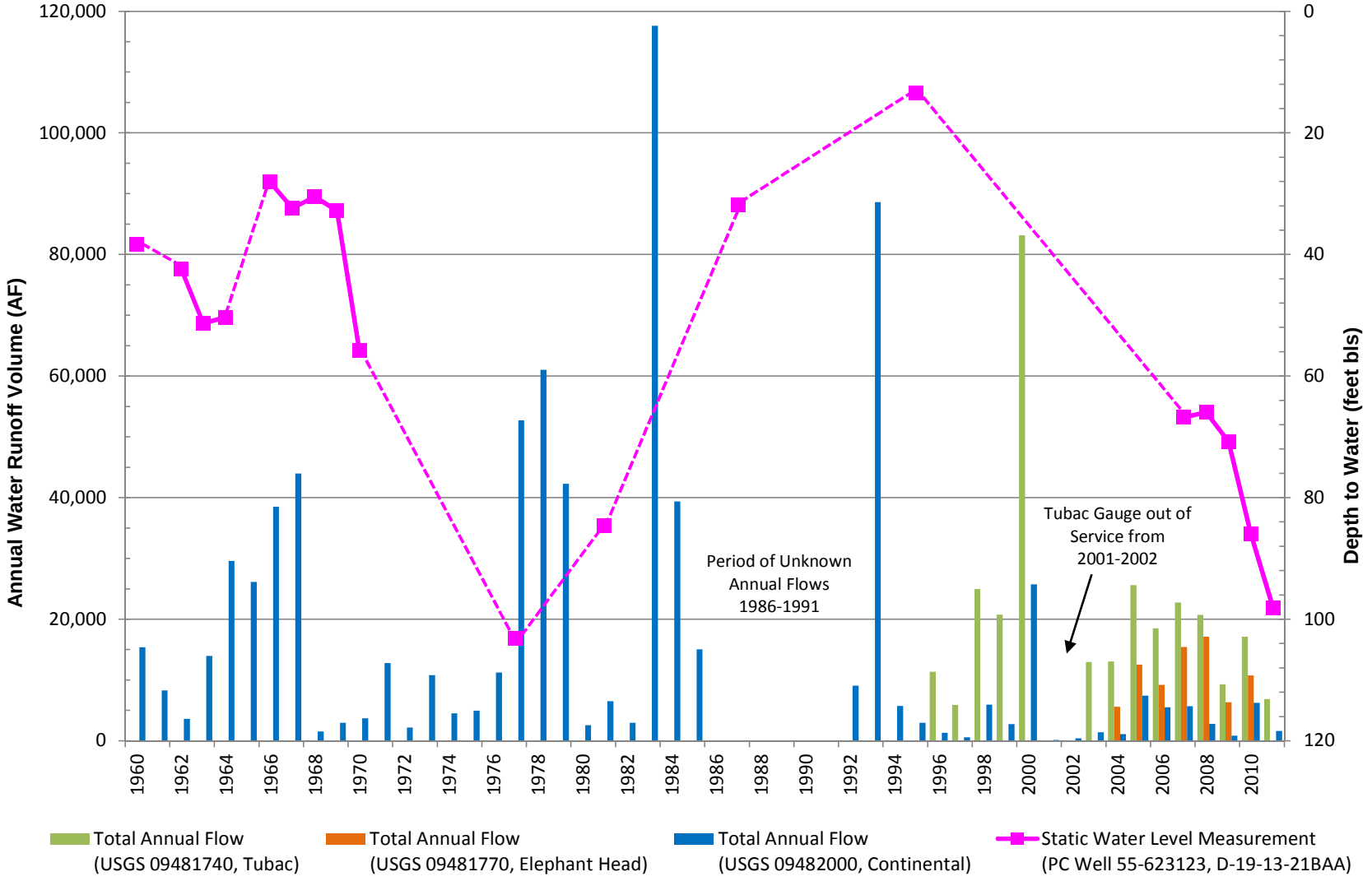


Figure 3-6
Annual Runoff Volume vs. Depth to Water
in a Well at the Canoa Ranch Headquarters Entrance
(Pima County Well 55-623117, D-19-13-09CAA)
Annual Water Runoff Volume (AF)
Depth to Water (feet bls)
120,000
100,000
80,000
60,000
40,000
20,000
0
30
50
70
90
110
130
150
1960
1962
1964
1966
1968
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
Period of Unknown Annual Flows 1986-1991
Tubac Gauge out of Service from 2001-2002
Total Annual Flow (USGS 09481740, Tubac)
Total Annual Flow (USGS 09481770, Elephant Head)
Total Annual Flow (USGS 09482000, Continental)
Static Water Level Measurement (PC Well 55-623117, D-19-13-09CAA)

Figure 3-7
Annual Runoff Volume vs. Depth to Water
in a Well near SCR 1.5 Miles South of Canoa Ranch Headquarters
(Pima County Well 55-623123, D-19-13-21BAA)



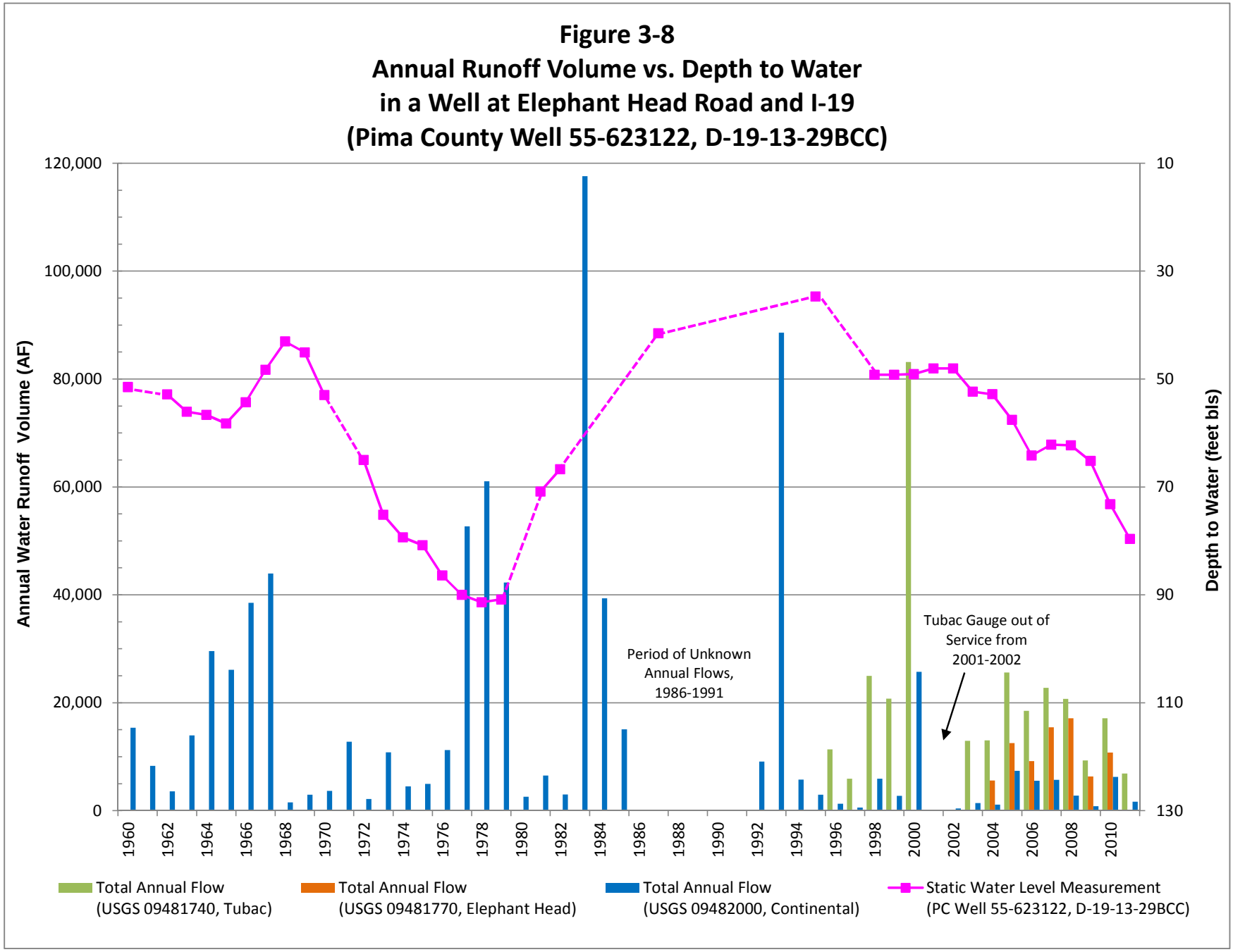


Figure 3-8
Annual Runoff Volume vs. Depth to Water
in a Well at Elephant Head Road and I-19
(Pima County Well 55-623122, D-19-13-29BCC)
Annual Water Runoff Volume (AF)
Depth to Water (feet bls)
120,000
100,000
80,000
60,000
40,000
20,000
0
10
30
50
70
90
110
130
1960
1962
1964
1966
1968
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
Period of Unknown Annual Flows, 1986-1991
Tubac Gauge out of Service from 2001-2002
Total Annual Flow (USGS 09481740, Tubac)
Total Annual Flow (USGS 09481770, Elephant Head)
Total Annual Flow (USGS 09482000, Continental)
Static Water Level Measurement (PC Well 55-623122, D-19-13-29BCC)

Figure 3-9
Annual Runoff Volume vs. Depth to Water in a Well at Rancho Sonado, ~1000 feet East of SCR and ~0.5 Miles South of Elephant Head Road Bridge (Rancho Sonado Well 55-626063, D19-13-32ABC)

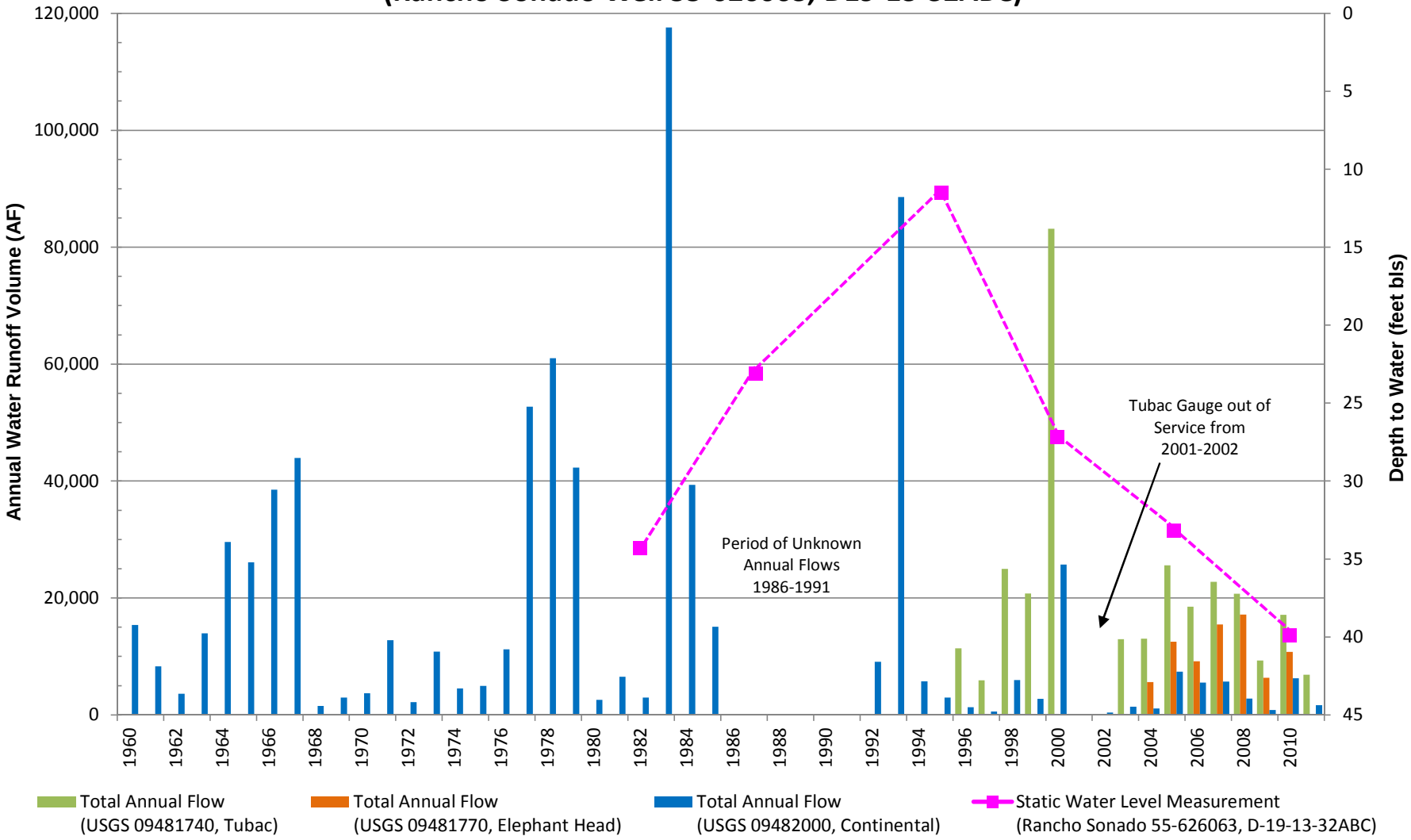
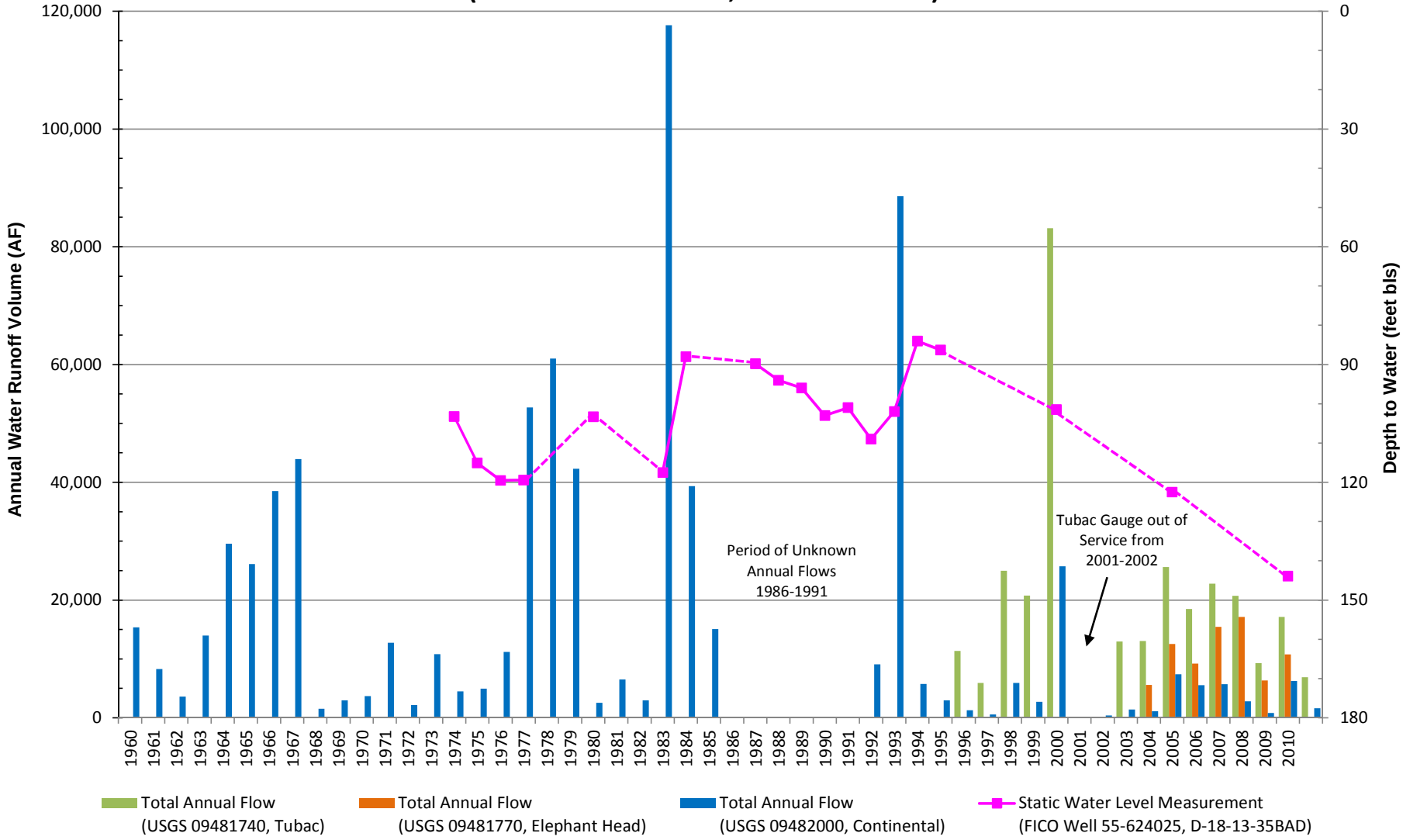


Figure 3-10
Annual Runoff Volume vs. Depth to Water in a Well at Farmers Investment Corporation, along SCR ~0.5 Miles North of Camino De Rondo (FICO Well 55-624025, D-18-13-35BAD)



APPENDIX A

Appendix A. Well Records by Cadastral Location (T-R-S) in the Canoa Ranch Area: South-North

Wells 55	GWSI	Owner's Well ID	Owner (Manager)	Cadastral (T-R-S)	Period of Record	Records (#)	DTW	Water Level Elevation	Date	MP Elev. (ft MSL)	Well Type	Pumping Records	Comments
624026	314958110593801	W-12	FARMERS INVESTMENT COMPANY	D-18013027ADA	1977-2010	7	167.2	2729.8	2/3/2010	2897	NON-EXEMPT	YES	
909828			ARIZONA DEPARTMENT OF WATER RESOURCES	D18013034000	?	?	?	?	?		OTHER	NO	NOA 11/14/2008
	313921111000201		?	D18013034ABC	1939	1	29.0	2884.0	10/9/1939	2913	NON-EXEMPT		
	314918110595301	W-2	FICO	D18013034AC	1939-1981	4	136.0	2750.0	12/21/1981	2885	NON-EXEMPT		
624025	314858110595701	W-11 (FICO)	FARMERS INVESTMENT,	D18013034DBC	1977-2010	6	143.9	2755.1	2/3/2010	2899	NON-EXEMPT	YES	ASLD #35-26757
624027	314923110590801	NP-1 (FICO)	FARMERS WATER CO,	D18013035BAD	1968	1	90.0		2/1/1968	2880	NON-EXEMPT	NO	WL taken on well drilling date
624027	314924110591001	NP-1 (FICO)	FARMERS WATER CO,	D18013035BAD	1987	1	102.3	2804.7	12/1/1987	2907	NON-EXEMPT	NO	Well was destroyed
624018	314859111003601	E11A	FARMERS INVESTMENT COMPANY	D18013035CBA	1953-2010	9	140.4	2754.6	2/3/2010	2895	NON-EXEMPT	YES	ASLD #35-40364
	314906110592901	Well E-11	FICO	D18013035CBB	1987	1	84.3	2810.7	12/1/1987	2895	NON-EXEMPT	NO	Well destroyed
594080			GARY WIDNER	D18013035CBD	?	?	?	?	?		EXEMPT	NO	Application Withdrawn 8/7/2003
599984			GARY WIDNER	D18013035CBD	?	?	?	?	?		EXEMPT	NO	Drilling Authority issued 8/26/2003
624028	314842110592801	NP-2 (FICO)	FARMERS WATER CO,	D18013035CCD	?	?	?	?	?	2930	NON-EXEMPT	YES	Registration of Existing Well 6/10/1982
	314857110591601	Well NP-2	FICO	D18013035CDB	1987	1	90.9	2822.1	12/1/1987	2913	NON-EXEMPT		
635387	314913110583401	Amado	SANTA RITA RANCH INC,	D18013036CBB	1948-2005	36	187.1	2789.9	2/24/2005	2977	EXEMPT	NO	UA #2552
908479			SANTA RITA RANCH	D18013036DDD	2008	1	299.0	2763.0	4/3/2008	3062	EXEMPT	NO	Elevation measured using GPS hand-held unit
540227			SHEARER,,J A	D19013002ABA	1994	1	145.0		1/10/1994		EXEMPT	NO	
620467			DOMINGUEZ,J R	D19013002BCD	1975	1	275.0		5/5/1975		EXEMPT	NO	
	314841110594701	C-2	FICO	D19013003ABA	1952-1987	13	48.7	2861.3	12/1/1987	2910	NON-EXEMPT		
623111	314820111000901		FREEPORT-MCMORAN SIERRITA INC.	D19013003ACC	1977-1996	5	139.1	2777.0	7/15/1996	2916	NON-EXEMPT	YES	No. 1 Deep/Canoa Field (Cyprus Sierrita); D5-2 (Duval)
624022	314821110594501	E-15	FARMERS INVESTMENT COMPANY	D19013003ADC	1977-2010	9	137.4	2779.6	2/3/2010	2917	NON-EXEMPT	YES	ASLD #35-30224
	314820110594401	E-1	FICO	D19013003ADC	1939-1995	1	29.7	2887.3	10/3/1939	2917	NON-EXEMPT		Obstruction 1/9/1995
	314838111002501	W-1	FICO	D19013003BBA	1939-1977	84	138.5	2790.5	1/7/1977	2929	NON-EXEMPT		
909829			ARIZONA DEPARTMENT OF WATER RESOURCES	D19013004000	?	?	?	?	?		OTHER	NO	Well NOA 11/14/2008
603503			GREEN VALLEY WATER,	D19013004BCB	1982	1	154.0		2/1/1982		NON-EXEMPT	YES	Well Abandoned 3/29/1994
208825			GREEN VALLEY WATER COMPANY	D19013005AAA	2003	1	222.0		3/17/2003		NON-EXEMPT	YES	Permission Authorization for Water Level Measurement 1/7/2010
	314828111015701		HUGGETT, MISS	D19013005ACA	1948-2000	43	227.6	2852.0	2/28/2000	3080	EXEMPT		Obstruction 2/23/2005
	314827111015801		CASA COLINA	D19013005ACA	1979-2012	38	280.4	2799.6	1/11/2012	3080	EXEMPT		Pumping 2/22/2011, Recently Pumped 1/11/2012
603120			RAYMOND & CARRIE FEIND	D19013005ACB	1975	1	235.0		1/1/1975		EXEMPT	NO	
529823			ORMSBY, CINDY,L	D19013005ACB	1990	1	217.0		12/14/1990		EXEMPT	NO	
571479			JUAN R DOMINGUEZ	D19013005ACB	?	?	?	?	?		EXEMPT	NO	NOI to drill, deepen, replace or modify 11/16/1998
562400			KENNETH & JEANNIE WELSH	D19013005ACD	1997	1	215.0		9/5/1997		EXEMPT	NO	
639848			HARR,W L	D19013005BAB	1982	1	400.0		5/25/1982		EXEMPT	NO	Water depth approximated by registrant
541957			CARL AND PATRICIA` JOSEPH	D19013005BAC	1994	1	255.0		3/3/1994		EXEMPT	NO	
632969			A. H. GATTERER	D19013005BBA	2009	1	270.0		10/21/2009	3041	EXEMPT	NO	MP Elevation using hand-held GPS unit

Appendix A. Well Records by Cadastral Location (T-R-S) in the Canoa Ranch Area: South-North

Wells 55	GWSI	Owner's Well ID	Owner (Manager)	Cadastral (T-R-S)	Period of Record	Records (#)	DTW	Water Level Elevation	Date	MP Elev. (ft MSL)	Well Type	Pumping Records	Comments
801442	314837111022401		JURS, LAURIE,	D19013005BBA	1972	1	230.0		10/1/1972	3090	NON-EXEMPT	YES	
804820			ROBERT & B BARNES	D19013005BBB	1987	1	245.0		7/20/1987		EXEMPT	NO	WL provided by registrant
564557			JAMES & ENOLA JOHNSTONE	D19013005BBB	1999	1	249.0		11/14/1999		EXEMPT	NO	
603229			JARVIS, DAVID,	D19013005BCC	1978	1	295.0		6/18/1978		EXEMPT	NO	
599941			STEVE & ELLEN CARPENTER	D19013005BCC	2004	1	262.0		4/20/2004		EXEMPT	NO	
555492			MCNEELY, STEPHAN,R	D19013005BCD	1996	1	262.0		3/22/1996		EXEMPT	NO	
518511			CRUZ, JOSE,D	D19013005BDA	?	?	?	?	?		EXEMPT	NO	Well cancelled
515280			CHABOYA, CHRIS,C	D19013005BDD	1986	1	260.0		12/30/1986		EXEMPT	NO	
805854			ARLEN UUSITALO	D19013005BDD	1978	1	230.0		1/1/1978		NON-EXEMPT	NO	
802883			L T OBRIEN	D19013005C00	1972	1	252.0		6/14/1972		EXEMPT	NO	
802539			OBRIEN, LOUIS,T	D19013005C00	1972	1	252.0		6/14/1972		EXEMPT	NO	
598436			VITO & DONNA ARDITO	D19013005CAB	2003	1	145.0		7/12/2003		EXEMPT	NO	
524278			CRUZ, JOSE,D	D19013005CAD	1989	1	246.0		8/18/1989		EXEMPT	NO	
639847			MONTANA VISTA WATER,	D19013005CB0	1970	1	250.0		3/15/1970		EXEMPT	NO	
640231			COSTELLO,M E	D19013005CBB	1977	1	268.0		2/4/1977		EXEMPT	NO	
602952	314821111023701		SPAFFORD,J C	D19013005CBB	1977	1	300.0		10/19/1977	3149	NON-EXEMPT	YES	ASLD #35-48752
602180			SAGERS,C	D19013005CBC	1977	1	305.0		10/4/1977		EXEMPT	NO	
539659			NEWKIRK, JOHN,A	D19013005CBD	1993	1	274.0		7/16/1993		EXEMPT	NO	
639815			LOZANO,F V	D19013005CBD	1975	1	260.0		1/1/1975		EXEMPT	NO	
540144			WOODWARD, KENNETH,	D19013005CCA	1993	1	235.0		9/8/1993		EXEMPT	NO	
503972			MONTANA VISTA WATER,	D19013005CCA	1982	1	289.0		9/20/1982		EXEMPT	NO	
801401			DORIS L. & GEORGE M. STOECKEL	D19013005CCA	1979	1	165.0		4/1/1979		NON-EXEMPT	YES	
510631			SCHNITZLER,R	D19013005CCB	1985	1	270.0		4/10/1985		EXEMPT	NO	
515476			HARRY E JAMISON	D19013005CCC	1986	1	285.0		11/15/1986		EXEMPT	NO	
580204			ROGER BURIAN	D19013005CCC	2000	1	250.0		4/22/2000		EXEMPT	NO	
510250			PROVENCAL,R J	D19013005CCD	?	?	?	?	?		EXEMPT	NO	Well cancelled; no Imaged Record
	314757111021001		?	D19013005CDD	1972	1	252.0	2848.0	6/1/1972	3100			
506241			CHABOYA, CHRIS,	D19013005DAA	?	?	?	?	?		EXEMPT	NO	Well cancelled; no Imaged Record
	314815111020201		LOZANO	D19013005DBC	1987-1995	2	234.2	2865.8	1/11/1995	3100	EXEMPT		
603504	314809111015701		GREEN VALLEY MUNICIPAL PROPERTY CORPORATION	D19013005DBD	2000-2010	3	266.8	2829.2	2/4/2010	3096	NON-EXEMPT	YES	Aquifer test 2/7/67
804954			CHABOYA, EDMUNDO,C	D19013005DDA	1971	1	250.0		6/10/1971		NON-EXEMPT	NO	
910394			CAROLYN FOX	D19013008ADD	2009	1	200.0		3/16/2009	3127	EXEMPT	NO	MP Elevation using hand-held GPS unit
910447			RICHARD SLATER	D19013008ADD	2009	1	220.0		9/22/2009	3127	EXEMPT	NO	MP Elevation using hand-held GPS unit
802661			JACK NICHOLS	D19013008B00	1978	1	170.0		9/18/1978		EXEMPT	NO	
212266			JEAN HUTCHINGS	D19013008BAC	2006	1	250.0	2880.0	8/8/2006	3130	EXEMPT	NO	Permission Authorization for Water Level Measurement 1/7/2010
569282			GENE ANAYA	D19013008BAC	1998	1	210.0		9/9/1998		EXEMPT	NO	
212249			MICHAEL EMMETT COOK	D19013008BAC	2006	1	290.0		7/21/2006		EXEMPT	NO	Permission Authorization for Water Level Measurement 12/31/2009
206214			THEODORE & MARTHA E GONZALEZ	D19013008BBB	2004	1	300.0		1/12/2004		EXEMPT	NO	
522903			MAPELSDEN, THOMAS,R	D19013008BBB	1988	1	230.0		12/8/1988		EXEMPT	NO	

Appendix A. Well Records by Cadastral Location (T-R-S) in the Canoa Ranch Area: South-North

Wells 55	GWSI	Owner's Well ID	Owner (Manager)	Cadastral (T-R-S)	Period of Record	Records (#)	DTW	Water Level Elevation	Date	MP Elev. (ft MSL)	Well Type	Pumping Records	Comments
534849			ALVAREZ, FRANCES,	D19013008BBB	1992	1	167.0		7/21/1992		EXEMPT	NO	
574175			VICTOR CHAVEZ	D19013008BBB	1999	1	222.0		6/30/1999		EXEMPT	NO	
87760	314752111023201		MAXANT,	D19013008BBC	1987-2010	5	275.4	2864.6	2/10/2010	3140	EXEMPT	NO	
602298			ANTHONY AND JUNE LINDBERG MARTIRES	D19013008BBC	1967	1	240.0		7/1/1967		EXEMPT	NO	
211561			RAYMOND L & KAREN K BELL	D19013008BBD	2006	1	232.0		4/15/2006		EXEMPT	NO	
514509	314725111023201		HENRY, ROBERT,	D19013008CAC	1987-1995	2	206.8	2916.2	1/11/1995	3123	EXEMPT	NO	
517647			SKINNER, ARTHUR,	D19013008CBB	?	?	?	?	?		EXEMPT	NO	Well cancelled; no Imaged Record
550143			MEYER, HERMAN,R	D19013008CBD	1995	1	190.0		6/28/1995		EXEMPT	NO	
586600			ROBERT D OTANEZ	D19013008CCB	2001	1	209.0		6/11/2001		EXEMPT	NO	
582705			ANNA JIMENEZ	D19013008CCC	2000	1	190.0		9/6/2000		EXEMPT	NO	
543483			CONNELL, TIMOTHY,J	D19013008CCC	1994	1	203.0		5/20/1994		EXEMPT	NO	
904241			PAUL D. OR JANA L. KEMP	D19013008CDD	2006	1	380.0		4/24/2006		EXEMPT	NO	
	314743111010701		?	D19013009ABC	1953	1	54.1	2921.0	1/1/1953	2975	NON-EXEMPT		
623128			PIMA COUNTY	D19013009ACA	2012	1	134	2806	12/3/2012	2940	NON-EXEMPT	YES	NOI to deepen well 7/25/2012
623117	314728111011101		PIMA COUNTY NATURAL RESOURCES, PARKS AND RECREATION DEPT.	D19013009CAA	1939-2012	65	141.4	2813.6	12/3/2012	2955	EXEMPT	YES	Registration Number is estimated based on data collected by Pima County; number is subject to change by ADWR based on their inquiry
	314723111005201		?	D19013009DAB	1952	1	45.7	2884.3	2/1/1952	2930	NON-EXEMPT		
623118			PIMA COUNTY NATURAL RESOURCES, PARKS AND RECREATION DEPT.	D19013009DBD	?	?	?	?	?		EXEMPT	YES	Well pump removed and well capped 5/13/1987
	314714111005501	M-2	DUVAL SIERRITA	D19013009DCB	1981	1	105.2	2832.8	12/7/1981	2938	NON-EXEMPT		
623112	314740111003701		FREEPORT-MCMORAN SIERRITA INC.	D19013010BCB	1977-1996	3	148.2	2781.0	7/15/1996	2929	NON-EXEMPT	YES	No. 2 Deep/Canoa Field (Cyprus Sierrita); S5-2 (Duval)
635785			MARCO,J D	D19013011B00	?	?	?	?	?		EXEMPT	NO	Well data is unknown 6/10/1982
532595			STEINMAN, DONALD,	D19013011BDA	1991	1	155.0		9/1/1991		EXEMPT	NO	
543225			FREELAND, J ZACHERY,	D19013011BDA	?	?	?	?	?		EXEMPT	NO	NOI 3/28/1994
800353			JACK GORETCKI	D19013015C00	1955	1	240.0		1/1/1955		EXEMPT	NO	
800354			SANTA RITA RANCH INC	D19013015C00	1941	1	230.0		1/1/1941		EXEMPT	NO	
635786			MARCO,J D	D19013015D00	?	?	?	?	?		EXEMPT	NO	Well data is unknown 6/10/1982
	314647111010201		?	D19013016ACB	?	?	?	?	?	2960	NON-EXEMPT		
623119			PIMA COUNTY NATURAL RESOURCES, PARKS AND RECREATION DEPT.	D19013016BAC	?	?	?	?	?		EXEMPT	NO	Well capped 5/13/1987
623113	314645111011301		FREEPORT-MCMORAN SIERRITA INC.	D19013016BAD	1977-1996	4	131.5	2819.0	7/15/1996	2950	NON-EXEMPT	YES	No. 3 Deep/Canoa Field (Cyprus Sierrita); S-3 (Duval)
586729			GREEN VALLEY MUNICIPAL PROPERTY CORPORATION	D19013016BBB	2002	1	107.0		5/3/2002		NON-EXEMPT	YES	
	314646111011401		?	D19013016BDA	1939-1941	16	8.8	2941.3	12/30/1941	2950	NON-EXEMPT		
	314622111005901		?	D19013016DCA	1952	1	31.8	2936.2	1/23/1952	2968	NON-EXEMPT		
623127	314646111015701		FAIRFIELD CANOA RNCH,	D19013017ACA	1987-1995	2	86.2	2925.8	1/9/1995	3012	EXEMPT	NO	Obstruction 2/22/2005
506744			WALKEY,D L	D19013017BBB	1984	1	195.0		1/29/1984		EXEMPT	NO	
628119	314614111020001		ADOT,	D19013017DCC	1987-2005	4	93.5	2921.5	2/22/2005	3007	EXEMPT	NO	Rest Area Well

Appendix A. Well Records by Cadastral Location (T-R-S) in the Canoa Ranch Area: South-North

Wells 55	GWSI	Owner's Well ID	Owner (Manager)	Cadastral (T-R-S)	Period of Record	Records (#)	DTW	Water Level Elevation	Date	MP Elev. (ft MSL)	Well Type	Pumping Records	Comments
623114	314610111014301		FREEPORT-MCMORAN SIERRITA INC.	D19013017DDD	1977-1995	3	83.6	2894.4	1/11/1995	2978	NON-EXEMPT	YES	No. 4 Deep/Canoa Field (Cyprus Sierrita); S-4 (Duval)
	314702111024301		?	D19013018AAA	1987	1	153.2	2948.8	12/2/1987	3102	EXEMPT		
558722			COOLEY, VERN,	D19013018AAC	1996	1	161.0		10/10/1996		EXEMPT	NO	
638850			GANT, LONNY,	D19013018ABA	1982	1	200.0		4/27/1982		EXEMPT	NO	WL provided by registrant
639055			SIMPSON,S M	D19013018B00	1982	1	216.0		6/11/1982		EXEMPT	NO	WL provided by registrant
529142			SIMMONS/WALSH,	D19013018CCC	1990	1	250.0		9/6/1990		EXEMPT	NO	
621717			TREWITT,A D	D19013018DCA	1979	1	280.0		11/12/1979		EXEMPT	NO	
582930			MAX ELLIOT	D19013019ABD	2000	1	120.0		9/27/2000		EXEMPT	NO	
219937			MAX ELLIOT	D19013019ABD	?	?	?	?	?		EXEMPT	NO	Drilling Authority issued 11/17/2011
568165			DOMINIC M. & KIMBERLY G. CURRIERI	D19013019BAA	1998	1	150.0		9/10/1998		EXEMPT	NO	
911507			AARON FREDERICK	D19013019BAB	?	?	?	?	?		EXEMPT	NO	NOI 12/10/2009
564547			JAMES B. HYMER	D19013019CDC	1997	1	200.0		12/3/1997		EXEMPT	NO	
593556			CHARLES A. & MARILYN L. SCHALL	D19013019DDC	2002	1	123.0		9/12/2002		EXEMPT	NO	
	314537111020401		?	D19013020ACC	1952-1966	14	39.8	2944.2	1/11/1966	2984	NON-EXEMPT		
525615			SOUTHWEST GAS CORP,	D19013020CAD	?	?	?	?	?		OTHER	NO	WL not provided in Well Driller Report 1/15/1990
623115	314525111021001		FREEPORT-MCMORAN SIERRITA INC.	D19013020CDA	1981-1996	2	180.8	2809.0	7/15/1996	2990	NON-EXEMPT	YES	Well Pumping 7/15/1996; No. 5 Deep Well (Cyprus Sierrita); S-5 Canoa (Duval)
623120	314534111020301	Canoa 11	PIMA COUNTY NATURAL RESOURCES, PARKS AND RECREATION DEPT.	D19013020DBC	1981-1995	2	18.0	2970.0	1/11/1995	2988	EXEMPT	NO	M-4 (Duval)
623123	314606111011301	Canoa 16	PIMA COUNTY NATURAL RESOURCES, PARKS AND RECREATION DEPT.	D19013021BAA	1951-2012	42	103.3	2863.3	12/3/2012	2966.59	EXEMPT	NO	Canoa Ranch BI (ADWR); ASLD #35-32459/60; UA #2589; M-7 (Duval)
639010			ALEGRIA,F M	D19013021BBA	1977	1	110.0		1/1/1977		EXEMPT	NO	
	314534111011801		?	D19013021CAC	1939-1956	4	30.5	2959.5	1/1/1956	2990	NON-EXEMPT		
623124			PIMA COUNTY NATURAL RESOURCES, PARKS AND RECREATION DEPT.	D19013021CBA	2008-2012	2	78.2	2901.8	12/3/2012	2980	EXEMPT	NO	Well Capped 5/15/1987
	314545111012501	M-8	SIERRITA DUVAL	D19013021CBA	1981-1995	3	11.9	2964.1	1/9/1995	2976	NON-EXEMPT		
	314533110013201		?	D19013021CBC	1954-1967	8	32.1	2939.9	3/27/1967	2972			
636670			HITCHINER,G G	D19013022000	?	?	?	?	?		EXEMPT	NO	WL not provided by registrant 6/14/1982
630063			SHAFFER,R	D19013022000	1977	1	170.0		1/1/1977		EXEMPT	NO	
804483			ROWLEY, MARIANNE,	D19013022AAA	1980	1	150.0		1/1/1980		EXEMPT	NO	Well drilled prior to 1980
634362			TERRY L REIN	D19013022AAA	1978	1	180.0		2/26/1978		EXEMPT	NO	
640140			DONALD R & PAULINE A SAMPSON	D19013022AC0	1982	1	179.0		7/8/1982		EXEMPT	NO	WL provided by registrant
631507			SALAZAR ET ALS,	D19013022C00	1979	1	184.0		6/1/1979		EXEMPT	NO	
520057			YOUNG, EDWIN,L	D19013022CCC	1988	1	175.0		2/25/1988		EXEMPT	NO	
564536			ENRIQUE ULLOA	D19013022DAB	1997	1	160.0		12/24/1997		EXEMPT	NO	
210376			RONALD ASHLAND	D19013022DAD	?	?	?	?	?		EXEMPT	NO	NOI Packets sent 12/21/2005
557994			RODRIQUEZ, RUBEN,L	D19013022DBA	1996	1	205.0		9/18/1996		EXEMPT	NO	
574700			RICHARD W MYERS	D19013022DBB	1999	1	520.0		7/1/1999		EXEMPT	NO	

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Wells 55	GWSI	Owner's Well ID	Owner (Manager)	Cadastral (T-R-S)	Period of Record	Records (#)	DTW	Water Level Elevation	Date	MP Elev. (ft MSL)	Well Type	Pumping Records	Comments
636446			ALVAREZ JR ET AL,A A	D19013022DBC	1976	1	175.0		12/1/1976		EXEMPT	NO	
634036			KEITH R JOHNSON	D19013022DCC	?	?	?	?	?		EXEMPT	NO	WL not provided in registration 5/11/1982
542703			SCOTT A MEINTEL	D19013022DDD	1994	1	245.0		4/4/1994		EXEMPT	NO	
587722			DIANA WINTER	D19013027AAA	2001	1	278.0		8/18/2001		EXEMPT	NO	
564589			DARRELL G COLLINS	D19013027AAB	1997	1	340.0		10/21/1997		EXEMPT	NO	
536273			HOBACK, DANIEL,	D19013027AAB	1993	1	257.0		3/14/1993		EXEMPT	NO	
87036			THUON,A J	D19013027ABA	?	?	?	?	?		EXEMPT	NO	Well cancelled; no Imaged Record
502236			THUON,A J	D19013027ABA	1982	1	245.0		5/14/1982		EXEMPT	NO	
570929			SCOTT LABROSSE	D19013027ABC	1998	1	236.0		11/2/1998		EXEMPT	NO	
512239			GARCIA, MANUEL,F	D19013027ABD	1985	1	250.0		11/25/1985		EXEMPT	NO	
500395			LINDA KOHANOV	D19013027ABD	?	?	?	?	?		EXEMPT	NO	WL not provided in Change of Well Ownership 8/11/2010
545246			VELASQUEZ, MANUEL,	D19013027ACA	1994	1	245.0		8/26/1994		EXEMPT	NO	
503264			COPENHAVER,	D19013027ACA	?	?	?	?	?		EXEMPT	NO	Well cancelled; no Imaged Record
504879			VALASQUEZ,M	D19013027ACA	?	?	?	?	?		EXEMPT	NO	Well cancelled; no Imaged Record
639313			DE LA CRUZ, MAXIMO,	D19013027ACB	1977	1	250.0		3/1/1977		EXEMPT	NO	
503263			HILL,H	D19013027ACD	1982	1	275.0		7/15/1982		EXEMPT	NO	
538103			MILLER, VIRGIL,L	D19013027ADA	1993	1	270.0		5/5/1993		EXEMPT	NO	
206084			PHIL JAUREQUI	D19013027ADA	2005	1	270.0	2906.0	1/3/2005	3176	EXEMPT	NO	MP Elevation using hand-held GPS unit
529141			STIEGLEITER, DENNIS,	D19013027ADC	?	?	?	?	?		EXEMPT	NO	Well cancelled; no Imaged Record
534326			STIEGLEITER, DENNIS,	D19013027ADC	1992	1	288.0		7/24/1992		EXEMPT	NO	
631306			KAREN POMROY	D19013027ADC	1976	1	270.0		12/20/1976		EXEMPT	NO	
640394			LINDEMAN,V C	D19013027ADD	1976	1	240.0		9/15/1976		EXEMPT	NO	
804966	314514111001601		STEVEN & CATHERINE BURGER	D19013027BA0	1987	1	192.4	2919.6	12/2/1987	3112	EXEMPT	NO	
87737			GILMARTIN - WENDLE,	D19013027BC0	1981	1	120.0		5/30/1981		EXEMPT	NO	
85680			WILLIAMS,M F	D19013027BCC	1980	1	190.0		9/29/1980		EXEMPT	NO	
635894			HACKETT,E L	D19013027BDB	1976	1	260.0		12/1/1976		EXEMPT	NO	WL measurement and date of measurement are approximate
552447			KOTELMAN ET AL,	D19013027BDC	1996	1	220.0		1/4/1996		EXEMPT	NO	
206047			JAMES L & NANCY J WILLIAMS	D19013027BDC	2005	1	270.0	2860.0	1/6/2005	3130	EXEMPT	NO	Questionable depth to water measurement based on surrounding data
543783			FERGUSON, RAYMOND,H	D19013027CAA	1994	1	236.0		6/30/1994		EXEMPT	NO	
528766			SANDRA A OCHOA	D19013027CAB	1990	1	121.0		8/8/1990		EXEMPT	NO	
502021			LEE,R N	D19013027CAC	1982	1	220.0		4/16/1982		EXEMPT	NO	
557255			CLEWETT, GEORGE,	D19013027CAD	1996	1	235.0		6/10/1996		EXEMPT	NO	
204998			MARSHA S MENDELSOHN	D19013027DAC	2005	1	270.0	2932.0	1/3/2005	3202	EXEMPT	NO	MP Elevation using hand-held GPS unit
572075			KEITH MOORE	D19013027DAD	1998	1	292.0		11/18/1998		EXEMPT	NO	
801637			THE DOVE WAY WELL ASSOCIATION INC	D19013027DBA	1976	1	276.0		1/1/1976		EXEMPT	NO	Estimated date of well completion 1976
639990			WHITAKER,C L	D19013027DBB	?	?	?	?	?		EXEMPT	NO	WL measurement not provided with registration 6/21/1982
636392			HARRISJR,E P	D19013027DCA	?	?	?	?	?		EXEMPT	NO	WL measurement not provided with registration 6/14/1982
634679	314608111000201		BENNING ET AL,	D19013028000	1987-1995	2	136.4	2901.6	1/9/1995	3038	EXEMPT	NO	

Appendix A. Well Records by Cadastral Location (T-R-S) in the Canoa Ranch Area: South-North

Wells 55	GWSI	Owner's Well ID	Owner (Manager)	Cadastral (T-R-S)	Period of Record	Records (#)	DTW	Water Level Elevation	Date	MP Elev. (ft MSL)	Well Type	Pumping Records	Comments
511271			VILLALOBOS,F	D19013028AAA	1985	1	175.0		7/20/1985		EXEMPT	NO	WL provided in driller's log
563788			GEORGE B. GUNDERSON	D19013028DAD	1997	1	156.0		9/20/1997		EXEMPT	NO	
519575			VEACH, GEORGE,H	D19013028DAD	1988	1	170.0		7/10/1988		EXEMPT	NO	WL provided with well test
623121			PIMA COUNTY NATURAL RESOURCES, PARKS AND RECREATION DEPT.	D19013029BAA	?	?	?	?	?		EXEMPT	NO	WL measurement not provided with registration 6/9/1982
623122	314454111023701	Canoa #6	PIMA COUNTY NATURAL RESOURCES, PARKS AND RECREATION DEPT.	D19013029BCC	1951-2012	114	87.7	2929.7	5/22/2012	3014.8	EXEMPT	NO	Elephant Head Bridge, SE (ADWR); UA #2594; M-6 (Duval)
623116	314446111022801		FREEPORT-MCMORAN SIERRITA INC.	D19013029CAC	1977-1996	6	164.7	2837.3	7/16/1996	3002	NON-EXEMPT	YES	Pumping 7/16/1996; Deep Well No. 6 (Cyprus Sierrita); S-6 (Duval)
549451			PIMA CNTY DOT & FCD,	D19013029CAD	1995	1	3.5		5/31/1995		MONITOR	NO	
	314447111023001		AMADO, GUS	D19013029CBB	?	?	?	?	?	3010	EXEMPT	NO	Dry 3/28/2007; old windmill site (depth = 37 ft.)
	314448111023301		AMADO, GUS	D19013029CBB	2007	1	50.3	2959.7	3/28/2007	3010	EXEMPT	NO	
635048			GUSTAVO A & BEVERLY J AMADO	D19013029CCC	1957	1	51.0		9/1/1957		EXEMPT	NO	
623888	314426111023401		STEWART TITLE & TRUST #2725	D19013029CCC	1966	1	36.0	2989.0	3/10/1966	3025	NON-EXEMPT	YES	
	314427111023501		?	D19013029CCC	1952-1957	5	41.0	2984.0	1/31/1957	3025	NON-EXEMPT		
554070			PIMA COUNTY DEPT OF,T R	D19013029CDA	?	?	?	?	?		NON-EXEMPT	YES	Well constructed for temporary dewatering (Permit #59-553675) in 1996
549450			PIMA CNTY DOT &FCD,	D19013029CDB	?	?	?	?	?		MONITOR	NO	Well cancelled; no Imaged Record
623125			PIMA COUNTY NATURAL RESOURCES, PARKS AND RECREATION DEPT.	D19013029DBC	?	?	?	?	?		EXEMPT	NO	WL measurement not provided with well registration 6/9/1982
534955			PREVATT, TOM,	D19013029DCC	1992	1	24.0		5/22/1992		EXEMPT	NO	
623126	314436111015001	M-10	PIMA COUNTY NATURAL RESOURCES, PARKS AND RECREATION DEPT.	D19013029DDC	1987-1995	2	44.2	2965.9	1/10/1995	3010	EXEMPT	NO	
502954			RANCHO SONADO LLC	D19013029DDC	1982	1	70.0		6/19/1982		EXEMPT	NO	
563934			ARMANDO SALCIDO	D19013030AAD	1997	1	140.0		10/9/1997		EXEMPT	NO	
619255			MANUEL B. & CARMELA C. VERDUGO	D19013030DCA	?	?	?	?	?		EXEMPT	NO	WL measurement not provided with registration 6/14/1982
518620			FELIPE JAUREQUI	D19013030DCA	1987	1	60.0		8/23/1987		EXEMPT	NO	
801495			H. MAC WARD, JR.	D19013030DCA	1973	1	85.0		10/8/1973		EXEMPT	NO	
	314435111025601		GONZALEZ, SAMUEL	D19013030DCA	1982-2010	32	73.9	2956.1	1/13/2010	3030	EXEMPT		Dry at 75 ft. 1/18/2011; also dry Summer 2009
	314434111025501		HALF-WAY STATION	D19013030DCA	1967	1	75.0	2955.0	5/1/1967	3030	EXEMPT		Located 30 ft. SE of GWSI 314435111025601
	314427111024201		?	D19013030DDD						3025			
804019			SALCIDO, AGUSTINA,P	D19013031000	1968	1	125.0		10/1/1968		EXEMPT	NO	
	314413111030001		PARKER, DAVE	D19013031ABD	1997-2012	96	89.2	2952.8	9/12/2012	3042	NON-EXEMPT		No measurements taken when pumping
628935	314402111025101		LAURINDA OSWALD	D19013031ADC	1961-1964	6	56.2	2976.8	11/12/1964	3033	NON-EXEMPT	YES	UA #2068
625259	314411111033401		MARLEY CATTLE CO,	D19013031BCB	1944	1	550.0		1/1/1944	3090	EXEMPT	NO	WL provided when well was drilled, sometime in 1944

Appendix A. Well Records by Cadastral Location (T-R-S) in the Canoa Ranch Area: South-North

Wells 55	GWSI	Owner's Well ID	Owner (Manager)	Cadastral (T-R-S)	Period of Record	Records (#)	DTW	Water Level Elevation	Date	MP Elev. (ft MSL)	Well Type	Pumping Records	Comments
625248	314406111033701		MARLEY CATTLE CO,	D19013031BCB	1999-2000	2	109.1	2980.9	2/22/2000	3090	NON-EXEMPT	NO	
	314359111033701		?	D19013031BCC	1952-2005	15?	90.9	2989.1	2/14/2005	3084	NON-EXEMPT		
809479			MARLEY CATTLE COMPANY	D19013031BCD	2009	1	90.0		2/7/2009		EXEMPT	NO	WL estimated on Late Registration of Well
640044			BULLHEAD AUTO INDUST,	D19013031C00	?	?	?	?	?		EXEMPT	NO	WL measurement not provided with well registration 6/23/1982
628637			SHALLENBERGER,M	D19013031C00	?	?	?	?	?		NON-EXEMPT	NO	WL measurement not provided with well registration 6/14/1982
629922			SCHWEISSINGER,R	D19013031CAA	1979	1	76.0		9/1/1979		EXEMPT	NO	
	314355111031901		?	D19013031CAB	?	?	?	?	?	3060	EXEMPT		
913454			PIMA COUNTY RWRD	D19013031CAD	2011	1	72.0	2988.0	7/13/2011	3060	MONITOR	NO	MP Elevation using hand-held GPS unit
586711			PIMA COUNTY WASTEWATER	D19013031CAD	?	?	?	?	?		MONITOR	NO	WL estimated at 75 feet on schematic diagram with NOI 4/25/2001
586712			PIMA COUNTY WASTEWATER	D19013031CAD	?	?	?	?	?		OTHER	NO	WL measurement not provided with NOI 4/25/2001
	314334111033401		?	D19013031CCC	1939	1	47.9	3027.1	10/10/1939	3075	EXEMPT	NO	Windmill
	314335111033501		?	D19013031CCC	?	?	?	?	?	3075	NON-EXEMPT		
619395			GREEN,S O	D19013031CCD	?	?	?	?	?		EXEMPT	NO	WL measurement not provided with registration 6/14/1982
	314338111033101		KINSLEY	D19013031CCD	1998-2003	2	65.1	3004.9	7/17/2003	3070	EXEMPT		Pump and column pipe have been removed 7/17/2003
625128			MIDDLETON RANCH CO,	D19013031CDD	?	?	?	?	?		EXEMPT	NO	WL measurement not provided with registration 6/14/1982
625126	314411111031001		MIDDLETON RANCH CO,	D19013031DBB	2003	3	64.4	2977.6	5/14/2003	3042	NON-EXEMPT	YES	
625123	314334111030601		MIDDLETON RANCH CO,	D19013031DCC	1941-1995	37	28.7	3021.3	1/10/1995	3050	NON-EXEMPT	YES	Well No. 1 (Oswald Cattle Co.); UA #2602; Foreign Material (oil) 1/10/1995
625125	314335111025001		MIDDLETON RANCH CO,	D19013031DDC	1951-1968	18	23.0	3019.0	11/19/1968	3042	NON-EXEMPT	YES	UA #2603
625124	314342111025401		MIDDLETON RANCH CO,	D19013031DDC	1952-1966	12	45.5	2995.5	1/10/1966	3041	NON-EXEMPT	YES	
626063	314416111015901		Rancho Sonado, LLC	D19013032ABC	1982-2010	6	39.9	2976.1	2/9/2010	3016	NON-EXEMPT	YES	
	314402111020301		?	D19013032ACC	1944	1	26.0	2994.0	1/1/1944	3020	NON-EXEMPT		
628934			LAURINDA OSWALD	D19013032B00	1945	1	35.0		1/1/1945		NON-EXEMPT	NO	WL measurement taken at time of well drilling Year 1945
590552			DAVID AND MARTY PARKER	D19013032BBB	2003	1	33.0		4/3/2003		EXEMPT	NO	WL provided on completion report
626062			UNDERDOWN,R L	D19013032BDD	1942	1	30.0		1/1/1942		NON-EXEMPT	NO	Well abandoned
507495	314357111020301		Rancho Sonado, LLC	D19013032DBB	1987-1998	5	21.1	2998.0	11/17/1998	3019	NON-EXEMPT	YES	
626064			Rancho Sonado, LLC	D19013032DBB	1909	1	30.0		1/1/1909		NON-EXEMPT	NO	WL measurement provided on registration 6/14/1982
801309	314421111003701		OCOTILLO COMMUNITY,	D19013033AAA	1995-2010	4	226.9	2928.1	2/9/2010	3155	NON-EXEMPT	YES	
555641			BRACAMONTE, WALTER,H	D19013033AAC	1996	1	205.0		4/8/1996		EXEMPT	NO	
541956			SADER, DAVID,P	D19013033ADA	1994	1	203.0		1/26/1994		EXEMPT	NO	
551282			DAVID COLLINS	D19013033ADD	1996	1	217.0		5/22/1996		EXEMPT	NO	
216578			JOHN BENCK	D19013034ABB	2007	1	230.0		10/12/2007	3160	EXEMPT	NO	MP Elevation using hand-held GPS unit
640128			ORTIZ, CARL,	D19013034BA0	1980	1	200.0		3/1/1980		EXEMPT	NO	WL measurement estimated on registration 7/16/1982

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Wells 55	GWSI	Owner's Well ID	Owner (Manager)	Cadastral (T-R-S)	Period of Record	Records (#)	DTW	Water Level Elevation	Date	MP Elev. (ft MSL)	Well Type	Pumping Records	Comments
513237			LUNA, JESSE , SR,M	D19013034BAB	?	?	?	?	?		EXEMPT	NO	Well cancelled; no Imaged Record
520914			WARRINER, GARY,	D19013034BAD	1988	1	255.0		5/13/1988		EXEMPT	NO	WL measurement provided on well driller's report
635333			HADDEN, JAMES,R	D19013034BCC	1974	1	140.0		9/15/1974		EXEMPT	NO	
616248			AZ STATE LAND DEPT,	D19013034CAD	1965	1	273.0		5/27/1965		EXEMPT	NO	
626066	314353111001201	First Well	UNDERDOWN,R L	D19013034DBD	1995-2010	4	264.7	2970.3	2/9/2010	3235	EXEMPT	NO	ASLD #55-616248
627932	314303111032801	UA 2650	Henson Farms	D20013006CD	1947-2012	91	56.7	3007.3	1/11/2012	3064	NON-EXEMPT	YES	