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WATER-RESOURCES INVESTIGATIONS REPORT 98-4022
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Regional Water Table (1996) and Water-Table Changes in the Antelope Valley Ground-Water Basin, California

Introduction

Antelope Valley is located in the western part of the Mojave Desert in southern California, about 50 mi northeast of Los Angeles (fig. 1). Ground water historically has been the primary source of water in this region because of the scarcity of surface water. Water use in the valley has increased significantly since development began in the late 1800's. Ground-water pumping for agricultural uses peaked in the 1950's, possibly exceeding 400,000 acre-feet per year (acre-ft/yr) in 1953 (Snyder, 1955). Increased pumping costs from greater pumping lifts (greater depth to water because of declining ground-water levels) and increased electric power costs (Templin and others, 1995) resulted in a decrease in agricultural pumping in the early 1970's. By the early 1980's, ground-water pumping for urban use, which grew rapidly with urban development in the 1970's and 1980's, exceeded agricultural use. Since the late 1940's, ground-water pumping has exceeded estimated average annual recharge, 40,700 acre-ft/yr (Durbin, 1978), resulting in hundreds of feet of drawdown and more than 6 ft of land subsidence in some areas (Ikehara and Phillips, 1994). Since 1972, supplemental surface water has been imported from the California Water Project to help meet the demand for water in the Antelope Valley. To plan for future development in the Antelope Valley, an understanding of present ground-water conditions, and recent changes, is needed.

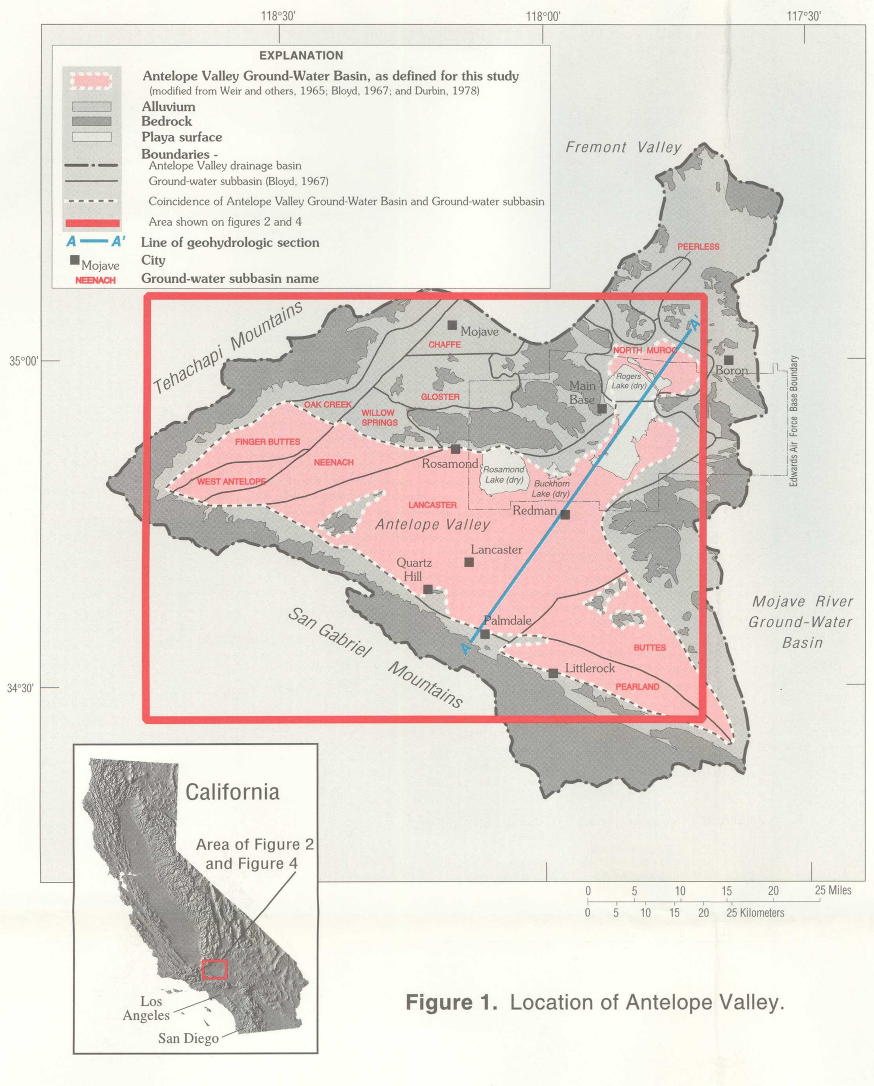

Figure 1. Location of Antelope Valley.

The U.S. Geological Survey (USGS), in cooperation with the Antelope Valley Water Group, studied and documented current (April 1996) ground-water conditions in the Antelope Valley Ground-Water Basin. Water-level data collected as part of ongoing monitoring programs were used to determine current and changing ground-water conditions. Past and present conditions were compared to document the effects of water-use and management practices on the ground-water system. This information can be used by local water managers to make informed decisions for the future.

Description of Antelope Valley

Antelope Valley is a triangular-shaped, topographically closed basin covering about 2,200 mi^2 (fig. 1). It is bounded on the northwest by the Tehachapi Mountains, on the north by the Fremont Valley, on the east by the Mojave River Ground-Water Basin, and on the south by the San Gabriel Mountains. The land-surface slopes from topographic highs along the surrounding mountains and low hills toward central topographic lows in the vicinity of the playa surfaces of Rosamond, Buckhorn, and Rogers Lakes (dry).

The climate of Antelope Valley is semi-arid to arid, characterized by low precipitation (less than 10 in. annually during the period 1928-91 in the interior) (Templin and others, 1995), low humidity, and temperatures that range from below 32^{0}F in the winter to above 100^{0}F in the summer (Londquist and others, 1993). Current land use, which has changed substantially from the historical predominance of agriculture, includes urban, military, industrial, and agricultural categories. Although the Antelope Valley is largely undeveloped, because of its proximity to Los Angeles, several communities expanded rapidly in the 1980's, increasing urban water use. Lancaster and Palmdale are the largest population centers in Antelope Valley, having had a combined population of about 33,000 in 1960 (Templin and others, 1995) compared with a combined population of 156,000 in 1990 (U.S. Department of Commerce, Bureau of the Census, 1990). Agricultural land use in 1996 is about 20 percent of the maximum levels in the 1950's and 1960's (D.L. Galloway, U.S. Geological Survey, written commun., 1996).

Geohydrology

The Antelope Valley drainage basin has been divided into 12 ground-water subbasins (fig. 1) by faults and consolidated rock and, in some instances, by arbitrary boundaries (Weir and others, 1965; Bloyd, 1967). As defined, the drainage basin consists of the Lancaster, Buttes, Pearland, Neenach, West Antelope, Finger Buttes, North Muroc, Oak Creek, Chaffe, Gloster, Willow Springs, and Peerless subbasins (fig. 1).

The Antelope Valley Ground-Water Basin, covers about 920 mi^2 and consists of the Buttes, Pearland, Lancaster, Neenach, West Antelope, Finger Buttes, and North Muroc subbasins as defined in Durbin (1978). In addition, the ground-water basin boundary was modified for this study on the basis of geophysical evidence (Mabey, 1960) and well-construction data that indicate the presence of consolidated, near-surface bedrock in the area near Rogers Lake (dry), in the North Muroc and the northeastern Lancaster subbasins, and in the area southeast of Palmdale in the Lancaster subbasin.

The Antelope Valley Ground-Water Basin occupies part of a structural depression created by downfaulting between the Garlock and the San Andreas Fault Zones (fig. 2). Consolidated rocks, which are essentially non-water bearing, generally crop out in the highlands that surround the ground-water basin and underlie and form the basin bottom. Consolidated rocks consist of igneous and metamorphic rocks of pre-Tertiary age and continental sedimentary rocks interbedded with volcanic flows of Tertiary age (Dibblee, 1967). Alluvial and lacustrine deposits form the matrix of the ground-water basin, which, in places, is as much as 5,000 ft thick (Benda and others, 1960; Mabey, 1960; R.C. Jachens, U.S. Geological Survey, written commun., 1991). The alluvium consists of unconsolidated to moderately indurated gravel, sand, silt, and clay (Pliocene to Holocene age) that become more indurated and less permeable with age and depth (Dutcher and Worts, 1963; Durbin, 1978). The lacustrine deposits, which form a confining unit (fig. 3), consist of low permeability fine-grained sand, silt, and clay of Pleistocene to Holocene age (Dutcher and Worts, 1963) deposited in a relatively large lake or marsh that, at times, covered large parts of the Antelope Valley (Dibblee, 1967). The fine-grained alluvial and lacustrine deposits have compacted in some areas, owing to ground-water withdrawals, resulting in land subsidence (Ikehara and Phillips, 1994).

Durbin (1978) divided the Lancaster subbasin, which is the largest and most heavily pumped subbasin in the Antelope Valley Ground-Water Basin, vertically into two hydrologic units: the semiconfined upper aquifer (known locally as the principal aquifer), and the confined deep aquifer. The two units are separated by fine-grained low-permeability deposits. The principal aquifer thins to the northeast as the fine-grained deposits approach the surface between Redman and Buckhorn Lake (Rewis, 1993). In the western part of the Lancaster subbasin, northwest of Quartz Hill, the aquifer system is not differentiated because the fine-grained deposits are not present. Figure 3 is a generalized geohydrologic section trending northeast from the Palmdale area.

Ground-water recharge in Antelope Valley is not well understood, but is thought to occur primarily as infiltration of water from ephemeral streams originating in the San Gabriel and the Tehachapi Mountains (Thompson, 1929; Snyder, 1955; Bloyd, 1967; and Durbin, 1978). Most recharge probably infiltrates into the ground-water system along the margins of the valley. Recharge from direct infiltration of precipitation is negligible (Durbin, 1978).

Before ground-water development, ground water flowed from the valley margins toward the topographic lows near Rosamond and Rogers Lakes (dry) (Durbin, 1978). Before 1915, there was an extensive area of flowing wells in the north-central part of the Lancaster subbasin (Johnson, 1911), indicating that the potentiometric surface (the surface to which water would rise in a tightly cased well) was higher than the land surface in this area. The wells ceased flowing soon after ground-water development began in the area. During the 1950's and 1960's, ground-water pumpage for irrigation (about 240,000 to 400,000 acre-ft/yr) (Templin and others, 1995), greatly exceeded estimated recharge (about 40,000 to 58,000 acre-ft/yr) (Templin and others, 1995), resulting in widespread declines in ground-water levels. Annual agricultural ground-water use decreased by about 92,000 acre-ft in the 1970's and decreased further in the 1980's. A rapid population growth in Antelope Valley in the late 1970's and 1980's caused a corresponding rise in urban ground-water use.

1996 Water Table

Water-level data from 188 wells were used to define the 1996 water-table surface and the direction of ground-water movement in the Antelope Valley ground-water basin. In areas where water-level data were sparse for 1996, the contours were defined on the basis of previous water-table maps (Londquist and others, 1993) and selected water levels for 1995 (seven wells, table 1). No contours were drawn for the Finger Buttes and West Antelope subbasins for 1996, because data were sparse (fig. 2). Water-level data were collected by the USGS from 172 wells in April 1996 as part of an annual monitoring program in cooperation with the Antelope Valley-East Kern Water Agency, and seven wells in July 1995 in the Palmdale area. Additional water-level data (April 1996) from nine wells were supplied by the Palmdale Water District (table 1). Water-level and well-construction data for each well shown on figure 2 are shown in table 1.

The water table is defined as the surface on which the fluid pressure in the pores of a porous medium is exactly atmospheric. The location of the surface is revealed by the level at which water stands in a shallow well open along its length and penetrating the surficial deposits just deep enough to encounter standing water in the bottom (Freeze and Cherry, 1979). The data collected as part of the project were used to draw water-table contours in figure 2 and are assumed to represent static conditions. It is important to note that there are factors that may violate this assumption. Water levels in the deeper wells probably do not accurately reflect conditions at the water table. Recent pumping of measured wells or pumping of nearby active wells will affect static conditions. For example, water-level data from production wells in the Palmdale Water District may not represent static conditions (D.D. LaMoreaux, Palmdale Water District, written commun., 1997). These data were collected in April to reflect the conditions before the summer pumping season. Local areas of perched water might exist (Johnson, 1911; Thompson, 1929; and Londquist and others, 1993) and water-level data from wells completed within a perched water body do not represent the regional water table.

Ground-Water Movement

Ground water flows from areas of higher to areas of lower water-table altitude and perpendicular to contours of equal water level (see red arrows, fig. 2). In general, ground water moves east from the Finger Buttes, West Antelope, and Neenach subbasins toward the Lancaster subbasin and northwest from the Buttes and Pearland subbasins toward the Lancaster subbasin (fig. 2). The lowest water levels in the valley are near the Lancaster and Palmdale urban areas in the Lancaster subbasin. Another area of low water levels centers around the primary ground-water production wells for Edwards Air Force Base (fig. 1), near the southern edge of Rogers Lake.

The geologic structure of Antelope Valley controls, to varying degrees, the ground-water flow between subbasins. Some faults have been assumed to be effective barriers to ground-water flow in previous investigations (Bloyd, 1967; Durbin, 1978). This includes the fault between the Pearland and Buttes subbasins and the Neenach Fault between the Lancaster and Neenach subbasins. South of Rogers Lake, the surfacing of the confining unit or a previously unidentified fault is shown (figs. 2, 4) as an unnamed hydrologic boundary (D.L. Rewis, U.S. Geological Survey, written commun., 1997). Water levels on the north side of this barrier are about 65 ft lower than water levels on the south side of the barrier (fig. 2). The barrier effect of faults is probably caused by compaction and deformation of water-bearing deposits immediately adjacent to the faults and cementation of the fault zone by mineral deposits from ground water (Dutcher and Garrett, 1963; Londquist and Martin, 1991). Because of the sparse distribution of monitoring wells near faults, contours near faults were drawn to best fit available data (1996) and, at the same time, to follow the flow patterns shown on previous water-table maps (Bloyd, 1967; Durbin, 1978; Londquist and others, 1993).

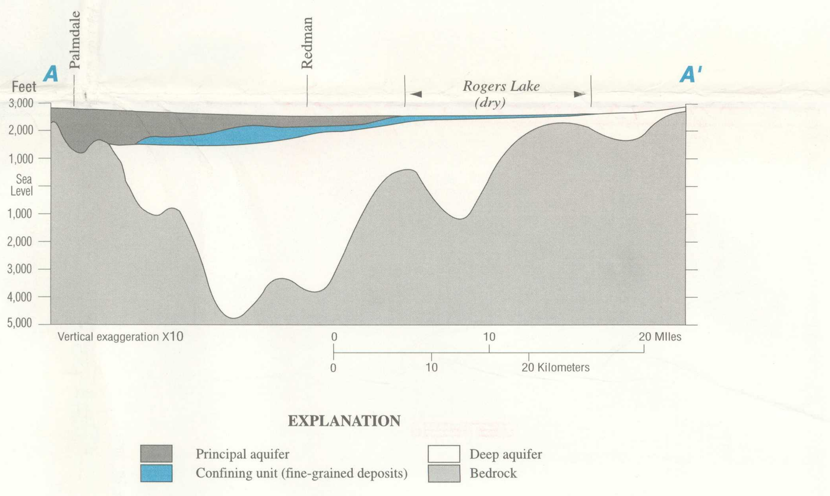

Figure 3. Generalized geohydrologic section of Antelope Valley. Line of section shown on figure 1. (Modified from Ikehara and Phillips, 1994, fig. 3).

Water-Level Changes

Historical water-level data were compared with data collected during this study to determine water-table change in the Antelope Valley (fig. 4). Historical water-level changes are represented in hydrographs showing water levels from 1950 to 1996 at selected wells. Regional water-level changes were determined by comparing 1996 ground-water levels with ground-water levels from April and May 1983 (fig. 4, table 1).

Hydrographs that show the water-level data for 20 wells were selected, on the basis of length of historical data, to show long-term water-level trends in the Antelope Valley (fig. 4). In general, the hydrographs show declining water levels from the 1950's through the 1960's, when agricultural ground-water use in the valley peaked. With the exception of declining water levels near urban areas (7N/12W-19R1 and 7N/12W-22K1) and rising water levels near former agricultural areas, most of the water levels have remained relatively unchanged, although some have risen by as much as 50 ft from the 1970's to 1996 as a result of decreased agricultural pumping. The largest water-level rises are shown in the hydrographs for well 7N/14W-13A1 in the southwestern part of the Lancaster subbasin and well 7N/10W-19D1 in the eastern part of the subbasin (fig. 4).

A water-level change map was developed by comparing ground-water levels from April 1983 with ground-water levels from April 1996 (fig. 4), a period representing increased urban development and associated water use. The year 1983 was selected on the basis of the relatively large number of water-level measurements in common with the 1996 water-level measurements. Water-level changes in these wells were contoured, and shaded to show the areal distribution of water-level change in the Antelope Valley. The water-table change map shows four primary areas

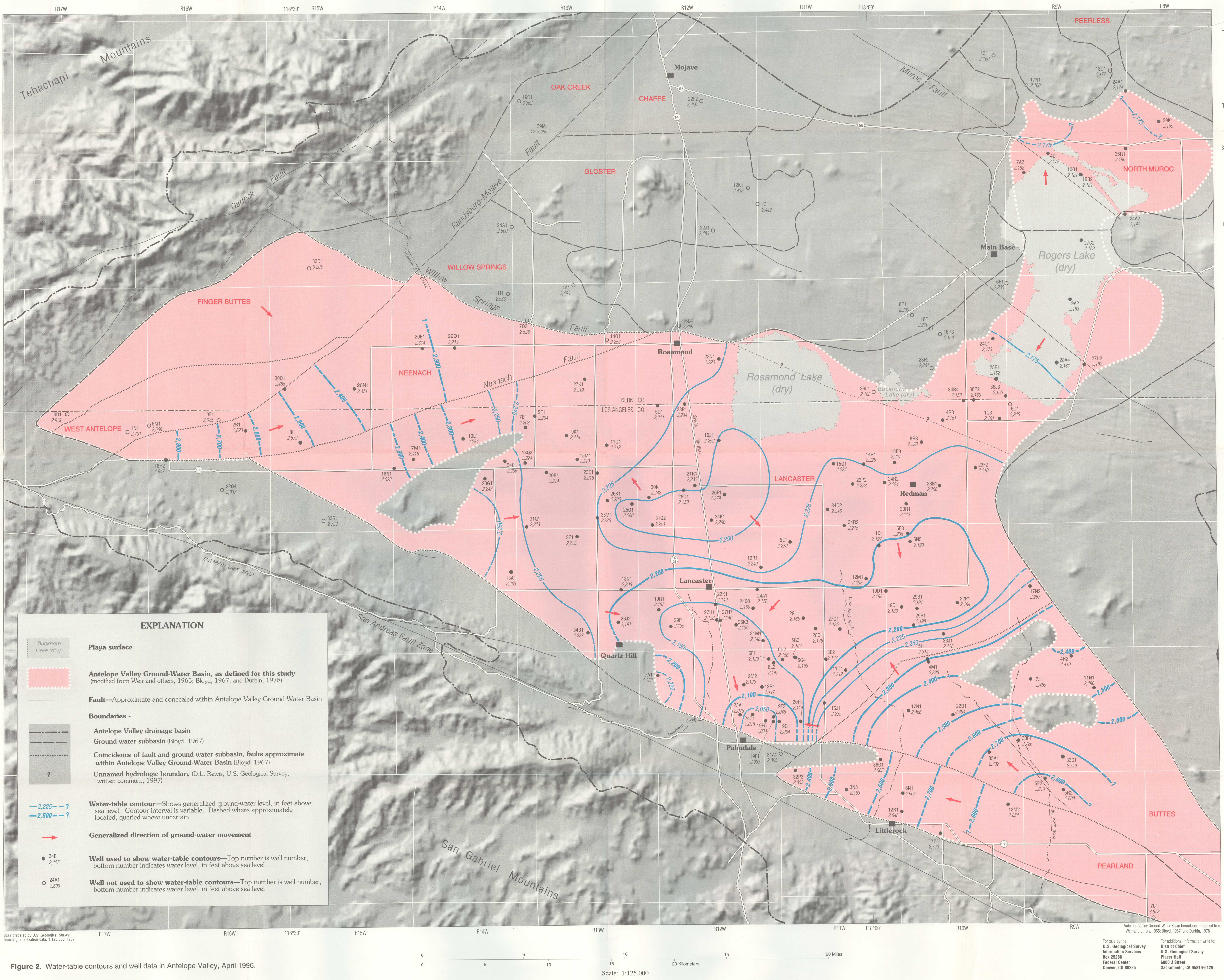

Figure 2. Water-table contours and well data in Antelope Valley, April 1996.

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