Ground-Water-Level Monitoring, Basin Boundaries, and Potentiometric Surfaces of the Aquifer System at Edwards Air Force Base, California, 1992

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CONVERSION FACTORS

Multiply	By	To obtain
acre-feet (acre-ft)	1,233	cubic meter
foot (ft)	0.3048	meter
gallon (gal)	3.785	liter
inch (in.)	2.54	centimeter
inch per year (in/yr)	2.54	centimeter per year
mile (mi)	1.609	kilometer
square mile (mi^2)	2.590	square kilometer

In this report, units of measurement for recharge and pumpage are given in acre-feet and gallons. Acre-feet can be converted to gallons by multiplying by 3.259×10^5. Raw data were reported by Edwards Air Force Base in thousand gallons.

Vertical Datum

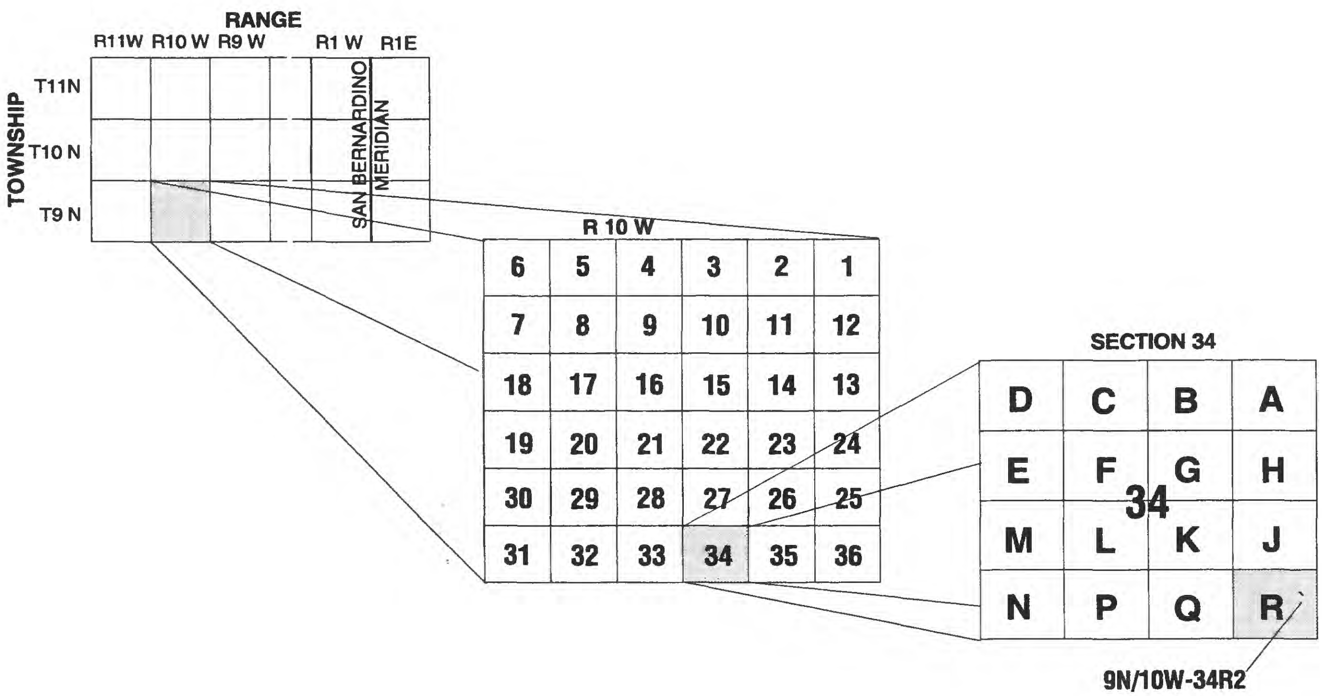
Sea level: In this report "sea level" refers to the National Geodetic Vertical Datum of 1929—a geodetic datum derived from a general adjustment of the first-order level nets of the United States and Canada, formerly called Sea Level Datum of 1929.

Acronyms

EAFB Edwards Air Force Base
GPS Global Positioning System
USGS U.S. Geological Survey

Well-Numbering System

Wells are identified and numbered according to their location in the rectangular system for subdivision of public lands. For example, in well number 009N010W34R002S, the identification number consists of the township number, north or south; the range number, east or west; and the section number. Each section is further divided into sixteen 40-acre tracts lettered consecutively (except I and O), beginning with "A" in the northeast corner of the section and progressing in a sinusoidal manner to "R" in the southeast corner. Within each 40-acre tract, wells are sequentially numbered in the order that they are inventoried. The final letter refers to the base line and meridian. In California, there are three base lines and meridians: Humbolt (H), Mount Diablo (M), and San Bernardino (S). Because all wells in the study area are referenced to the San Bernardino base line and meridian (S), the final letter will be omitted. In this report, well numbers are abbreviated and written 9N/10W-34R2. Wells in the same township and range may be referred to only by their section designation, -34R2. The following diagram shows how the number for well 9N/10W-34R2 is derived.



Ground-Water-Level Monitoring, Basin Boundaries, and Potentiometric Surfaces of the Aquifer System at Edwards Air Force Base, California, 1992

By Diane L. Rewis

Abstract

A ground-water-level monitoring program was implemented at Edwards Air Force Base, California, from January through December 1992 to monitor spatial and temporal changes in potentiometric surfaces that largely are affected by ground-water pumping. Potentiometric-surface maps are needed to determine the correlation between declining ground-water levels and the distribution of land subsidence. The monitoring program focused on areas of the base where pumping has occurred, especially near Rogers Lake, and involved three phases of data collection: (1) well canvassing and selection, (2) geodetic surveys, and (3) monthly ground-water-level measurements. Construction and historical water-level data were compiled for 118 wells and piezometers on or near the base, and monthly ground-water-level measurements were made in 82 wells and piezometers on the base.

The compiled water-level data were used in conjunction with previously collected geologic data to identify three types of no-flow boundaries in the aquifer system: structural boundaries, a principal-aquifer boundary, and ground-water divides. Heads were computed from ground-water-level measurements and land-surface altitudes and then were used to map seasonal potentiometric surfaces for the principal and deep aquifers underlying the base. Pumping has created a regional depression in the potentiometric surface of the deep aquifer in the South Track, South Base, and Branch Park well-field area. A 15-foot decline in the potentiometric surface from April to September 1992 and 20- to 30-foot drawdowns in the three production wells in the South Track well field caused locally unconfined conditions in the deep aquifer.

INTRODUCTION

Land subsidence, resulting from aquifer-system compaction caused by declining ground-water levels, and the associated playa-surface deformation of Rogers Lake affect the strategic and economic operations at Edwards Air Force Base (EAFB), Antelope Valley, California (fig. 1). Deformation of the playa surface by land subsidence at Rogers Lake has caused sinklike depressions, fissures, and desiccation cracks that adversely affect the use of the playa as a runway (Blodgett and Williams, 1992; Londquist and others, 1993). The playa is used by the U.S. Department of the Air Force and the National Aeronautics and Space Administration for test aircraft and space shuttle landings.

A ground-water-level monitoring program was developed and maintained by the U.S. Geological Survey (USGS) in cooperation with the U.S. Department of the Air Force, Edwards Air Force Base, Air Force Flight Test Center during 1992 as part of a comprehensive investigation of land subsidence and aquifer-system compaction at EAFB. The objective of the comprehensive investigation is to determine the hydrologic factors related to land subsidence at EAFB and playa-surface deformation (Blodgett and Williams, 1992; Londquist and others, 1993). The data collected during this study and interpretations of these data will be needed in future work to determine

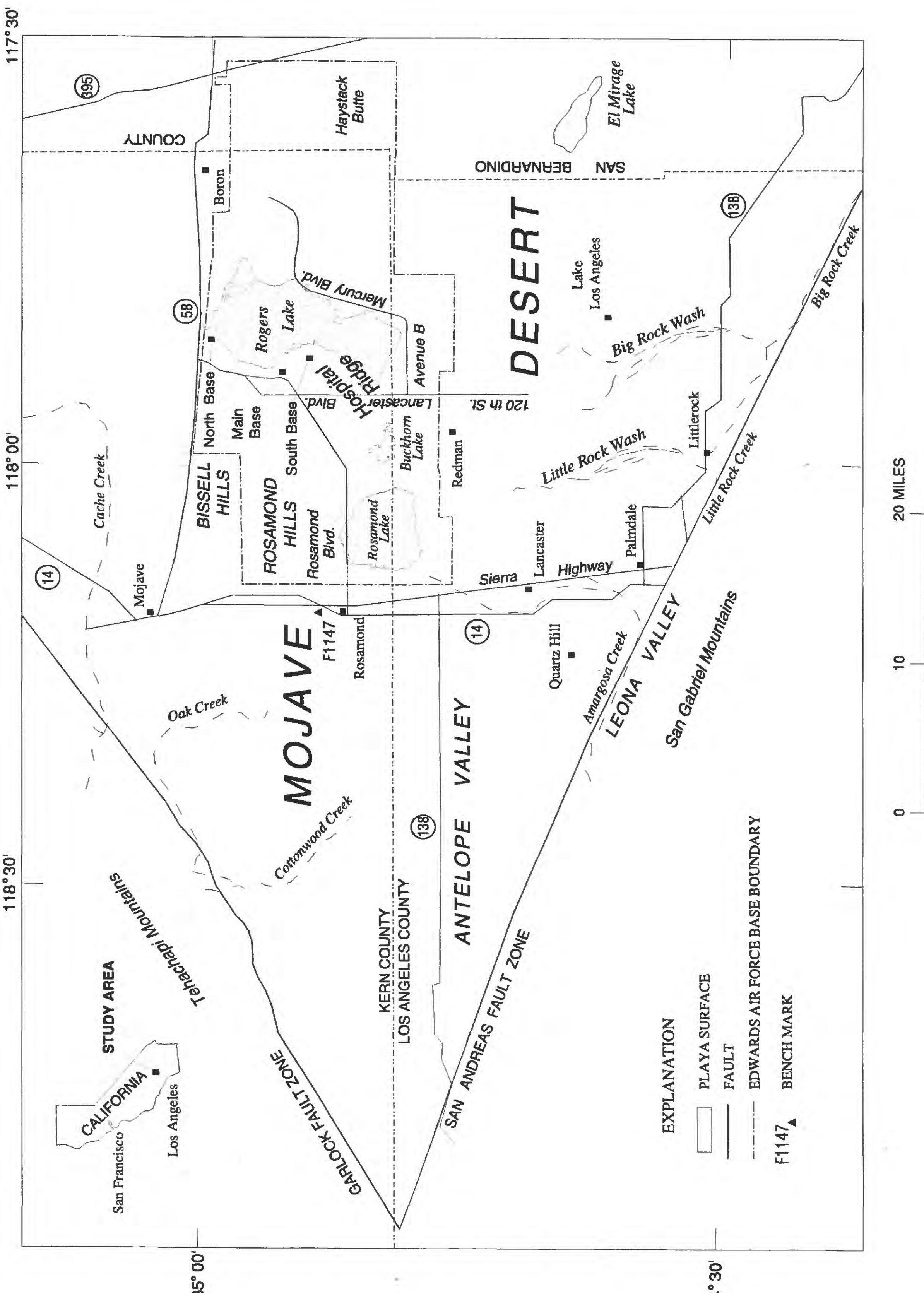


Figure 1. Location of study area.

relations between declining ground-water levels and the distribution of land subsidence.

The ground-water-level monitoring program was implemented to monitor spatial and temporal changes in the potentiometric surfaces of the aquifer system. These changes are caused primarily by ground-water pumping. The program focused on areas of the base where ground-water pumping occurs, especially near Rogers Lake and areas that might be developed for future ground-water supply. This program establishes a baseline for future ground-water-level monitoring and aquifer restoration programs.

Description of Study Area

Edwards Air Force Base is about 60 mi northeast of Los Angeles, in Antelope Valley, California. Antelope Valley is bounded by the Garlock Fault Zone and the Tehachapi Mountains to the west and northwest, the San Andreas Fault Zone and the San Gabriel Mountains to the south and southwest, and low bedrock hills to the east and north (fig. 2). Antelope Valley is in the rain shadow of the San Gabriel and Tehachapi Mountains. The climate at EAFB is arid with an average annual precipitation of 4.96 in. (period of record, 1942-92) (Donald Cameron, Range Staff Meteorologist, Air Force Flight Test Center, Edwards Air Force Base, written commun., 1993). Total precipitation in 1992 at the base was 12.07 in., 7.11 in. above average. The boundary of EAFB encompasses about 470 mi^2 of arkosic alluvium, low sand dunes, and playa surfaces surrounded by exposed bedrock hills (fig. 2).

Purpose and Scope

This report describes the ground-water-level monitoring program and presents interpretations of the ground-water-basin boundaries and seasonal potentiometric surfaces derived from the data collected during this monitoring program. Well-construction and historical water-level data were compiled for 118 wells and piezometers on and near the base. Monthly water-level measurements were made in 82 wells and piezometers on the base from January through December 1992. Land-surface altitudes for most of the monitored wells and piezometers were surveyed using differential leveling and Global Positioning System (GPS) surveying; some land-surface altitudes were derived from topographic maps. Hydraulic heads were computed from land-surface altitudes and water-level measurements. Monthly pumpage data were computed and tabulated from daily pumpage logs. These data are presented in data tables, hydrographs, bar graphs, and potentiometric-surface maps in this report.

Acknowledgments

The author would like to thank the many individuals and offices at EAFB that supported and contributed to this work. The Office of Programs and Plans Management at the Air Force Flight Test Center authorized security clearance into sensitive areas on EAFB and coordinated our activities on the base. The Civil Engineering office provided construction and pumpage data for production wells and access to pumphouses. The Base Operations office authorized access to Rogers Lake and provided meteorological data for EAFB. The Phillips Laboratory Civil Engineering office provided construction and pumpage data for production wells and escort into that facility.

HYDROGEOLOGIC SETTING

Antelope Valley is a closed alluvial basin filled with 5,000 to 10,000 ft of sediment (Durbin, 1978). Twelve ground-water subbasins have been identified in the Antelope Valley (fig. 2) (Bloyd, 1967). The aquifer system at EAFB is part of two ground-water subbasins, the Lancaster subbasin and the North Muroc subbasin (fig. 3) (Bloyd, 1967; Londquist and others, 1993). The aquifer system in the Lancaster subbasin is divided into two aquifers, the unconfined principal aquifer which overlies the partly confined, deep aquifer (fig. 4). These two aquifers are separated by a southwestward-dipping confining unit consisting of blue or greenish-gray, fine- to very fine-grained lacustrine deposits of locally variable thickness. The confining unit is shallow along the southern shore of Rogers Lake where it is overlain by thin playa deposits. The aquifer in the North Muroc subbasin is unconfined. For a more thorough description of the areal extent of the confining unit, the reader is referred to Durbin (1978). Lithologies of these aquifers are described by Londquist and others (1993) and Rewis (1993).

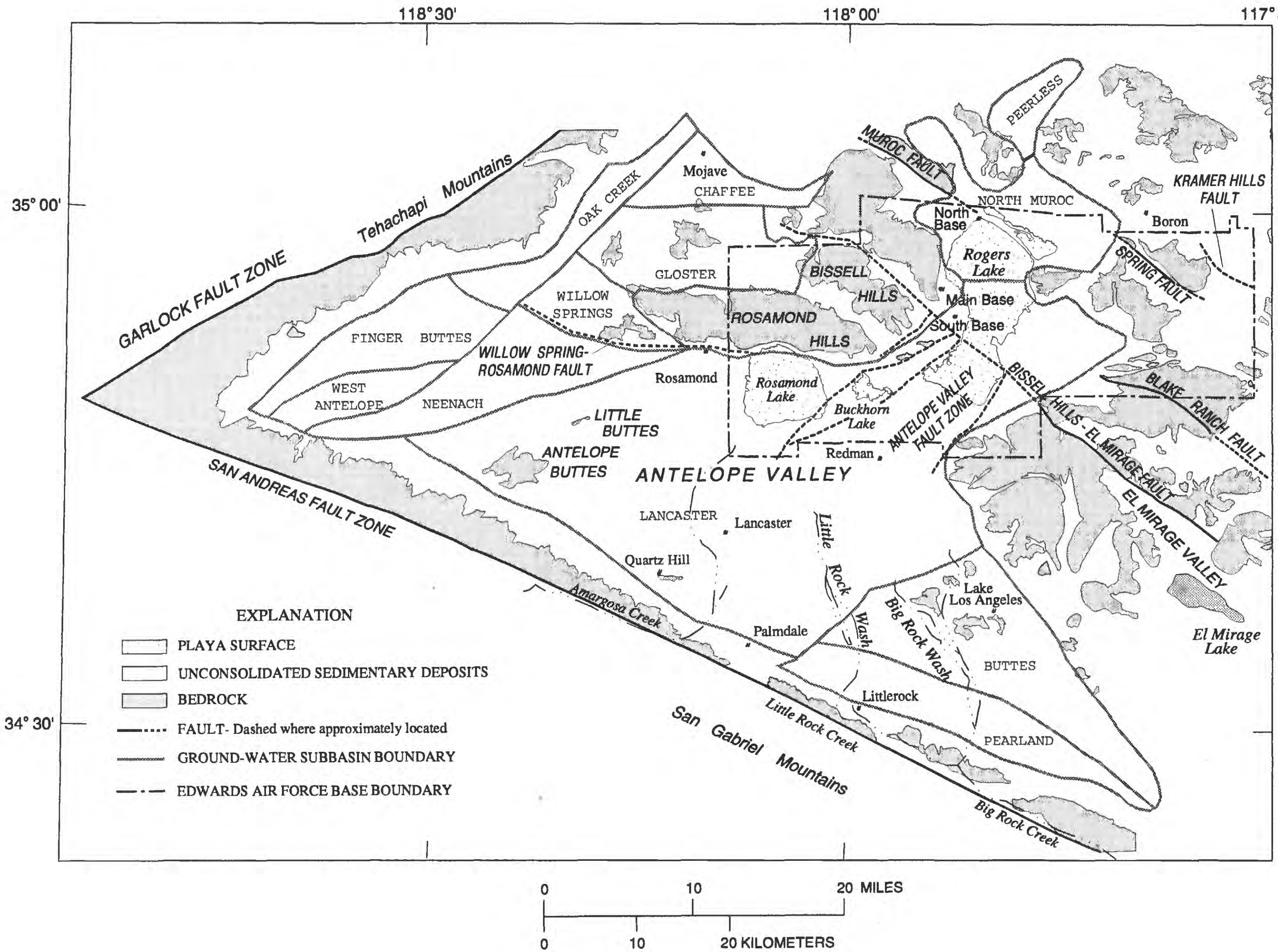


Figure 2. General geology and location of ground-water subbasins in the Antelope Valley, California. (Base map modified from Dibblee, 1960; Bloyd, 1967; Londquist and others, 1993; and Gary Dixon (U.S. Geological Survey, written commun., 1993.)

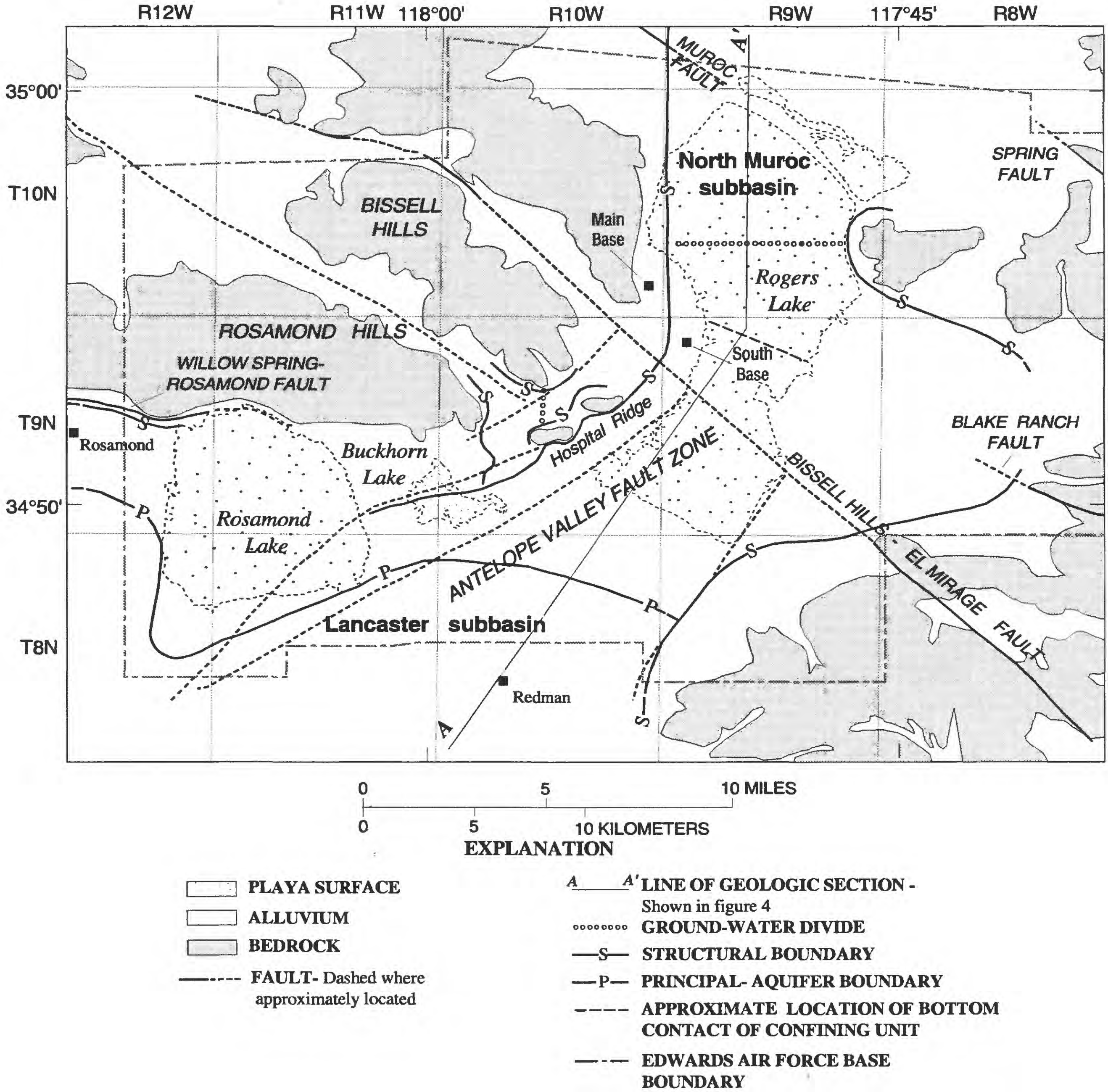


Figure 3. General geology and ground-water basin boundaries at Edwards Air Force Base, California, and geologic section *A-A'*. (Base map modified from Dibblee, 1960; Bloyd, 1967; Londquist and others, 1993; and Gary Dixon (U.S. Geological Survey, written commun., 1993).

To map potentiometric surfaces and ground-water flow at EAFB, boundary conditions for the aquifer system had to be identified. Three types of no-flow boundaries were identified: (1) structural boundaries, (2) the principal-aquifer boundary, and (3) ground-water divides (fig. 3). These boundaries are discussed more fully in the "Basin Boundary" section of this report. Each of these no-flow boundaries represents a specified-flux boundary where the flux across the boundary is equal to zero ("flux" refers to the volume of fluid crossing a unit cross-sectional surface area per unit time) (Franke and others, 1987). Some of these boundaries may coincide with faults recently identified in this part of Antelope Valley (fig. 3).

For simplicity, structural boundaries and ground-water divides are assumed to be fixed boundaries for the period of this study. In reality, the ground-water divides and, to a lesser extent, the structural and

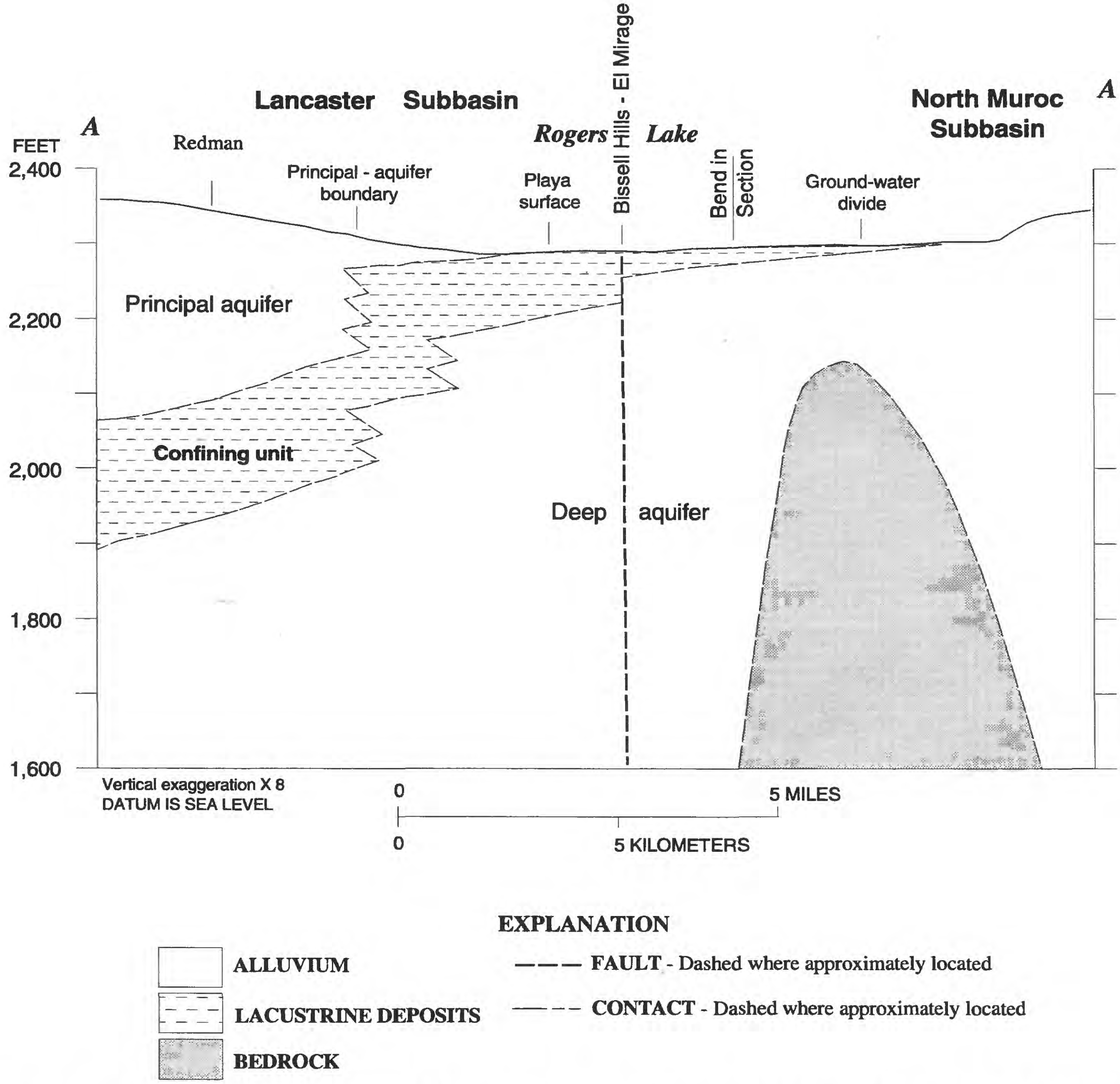


Figure 4. Geologic section *A-A'* showing the principal aquifer boundary and the ground-water divide between the Lancaster and North Muroc subbasins, Edwards Air Force Base, California.

principal-aquifer boundaries are time dependent and will migrate laterally with fluctuating ground-water levels.

Between Hospital Ridge and Rosamond and Bissell Hills lies a small, isolated, unnamed subbasin that previously has been included within the Lancaster subbasin boundary (Bloyd, 1967; Duell, 1987). The boundaries of the aquifer system in this area are not well defined. For purposes of this report, this small subbasin is considered separate from the Lancaster subbasin.

Average annual recharge to the aquifer system in Antelope Valley was estimated by Durbin (1978) to be 40,700 acre-ft, or 13,300 million gal. The principal source of recharge to the aquifer system in the Lancaster subbasin is infiltration of rainfall runoff through the alluvial fans of Big Rock, Little Rock, and Amargosa Creeks (fig. 1). Durbin (1978) reported that measured average annual runoff was 23,600 acre-ft, or 7.7

billion gal, for the Big Rock Creek and Little Rock Creek drainage basins; he assumed that 100 percent of the runoff was recharge to the aquifer system. Snyder (1955) reported an annual runoff estimate of 3,584 acre-ft, or 1.2 billion gal, for the Leona Valley-Amargosa Creek area.

Recharge to the North Muroc subbasin prior to development of the valley occurred as underflow from the Lancaster subbasin (Durbin, 1978). Because of pumping from the principal and deep aquifers, ground-water levels have declined in the Lancaster subbasin to the point where ground water no longer flows into the North Muroc subbasin (Durbin, 1978; Londquist and others, 1993). Ground-water-level data compiled for this study and presented in this report identify a ground-water divide hydraulically separating these two subbasins.

Recharge to the subbasins from infiltration in the bedrock hills on the eastern and northwestern parts of EAFB is minimal because average annual precipitation is less than 5 in/yr, and average annual pan evaporation is high, about 114 in/yr (Bloyd, 1967). A small amount of runoff may infiltrate the alluvium along the base of the bedrock hills and the coarse-grained sediments along intermittent stream channels. Some direct recharge to the aquifer system within the valley from storm runoff was observed. This storm runoff inundated the playas and infiltrated the subsurface through giant desiccation cracks and fissures in the playa surface. The volume of this recharge is difficult to determine, but probably is small because the vertical pathways become plugged with low permeability sediments washed in from the surface. Most of the water that reaches the playa probably evaporates.

GROUND-WATER-LEVEL MONITORING PROGRAM

The ground-water-level monitoring program involved three phases of data collection: (1) well canvassing and selection, (2) geodetic surveys to determine vertical datum for each well, and (3) monthly water-level measurements. Ground-water levels in 82 wells and piezometers on EAFB (fig. 5) were measured monthly from January through December 1992. These included 48 piezometers that were installed by the USGS at 15 sites, 10 production wells in 7 well fields, 15 abandoned wells monitored by the USGS annually and semiannually as part of the Antelope Valley-East Kern Water Agency ground-water-monitoring program, and 9 other abandoned homestead, irrigation, and production wells (table 1). Pumpage data were tabulated from daily records for the 10 production wells that were monitored at EAFB for this program and for 4 other production wells (9N/9W-14P2, -14Q1, 9N/10W-34P3, and 10N/9W-5B1) that were not monitored for this program. These wells are included in table 1. Monthly pumpage totals were compared with water levels measured in the wells and piezometers in the base well fields.

Land-surface altitude, date of construction, and original ground-water-level data were compiled for 36 wells on and near the base that were not monitored for this program (table 1; fig. 5). Lithologic data for these wells were used to determine the position and extent of aquifer-system boundaries.

Well Selection and Well Data

Selection of wells used in the ground-water-level monitoring program was based on (1) measurable ground-water levels, (2) accessibility of the wells, (3) proximity to the base well fields and Rogers Lake, (4) proximity to other suitable wells to avoid redundancy, and (5) the position of the screened or perforated interval in the well. The wells were differentiated in table 1 as being completed within the deep aquifer, the principal aquifer, and the confining unit in the Lancaster subbasin; within the unconfined aquifer of the small, unnamed subbasin; near the ground-water divide on Rogers Lake; or within the unconfined aquifer in the North Muroc subbasin.

The USGS piezometers generally are single or nested, small, 2- to 3-inch diameter wells with 10- to 40-foot screens at isolated intervals in the borehole (table 1) (Londquist and others, 1993; Rewis, 1993). Piezometer 9N/10W-16F1 is 6.75 in. in diameter and is uncased and open to the bedrock formation in the interval from 275 to 458 ft below land surface. The most shallow piezometers in the Lancaster subbasin are screened within the confining lacustrine unit and range from about 30 to 150 ft below land surface. The deeper piezometers are screened in the deep or confined aquifer ranging from about 80 to 1,010 ft below land surface. The tops of the screened or perforated intervals for most of the production and abandoned wells range from 96 to 300 ft below land surface and

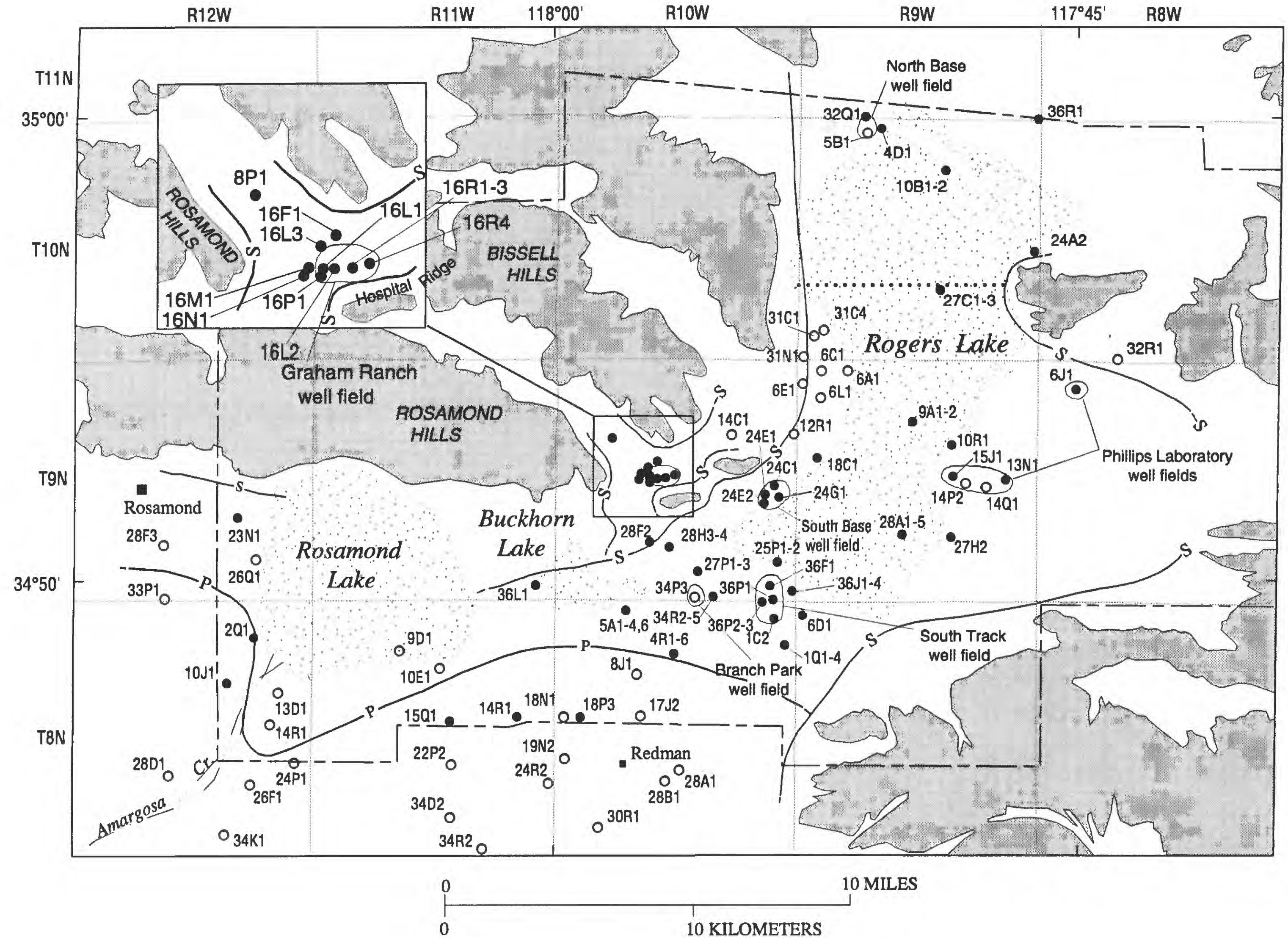


Figure 5. Locations of wells and piezometers on Edwards Air Force Base, California. (Base map modified from Dibblee, 1960; Bloyd, 1967; and Londquist and others, 1993.)

EXPLANATION FOR FIGURE 5

PLAYA SURFACE

ALLUVIUM

BEDROCK

—S— STRUCTURAL BOUNDARY

—P— PRINCIPAL-AQUIFER BOUNDARY

— — — EDWARDS AIR FORCE BASE BOUNDARY

·········· GROUND-WATER DIVIDE

27H2● WELL OR PIEZOMETER AND NUMBER- For which water-level measurements were made

6L1○ WELL AND NUMBER-Not monitored for the Antelope Valley-East Kern Water Ageney

generally are screened to the bottom of the well (table 1).

Land-Surface Altitudes

Prior to this study, land-surface altitudes of wells on EAFB generally were not surveyed because of the remoteness of the well fields and homesteads. Land-surface altitudes were estimated from topographic maps with accuracies of about plus or minus one-half the contour interval of the map.

The accuracy of the land-surface altitude at a well is dependent on the method and precision standards used. Three methods were used to establish land-surface altitudes for the monitored wells and piezometers: third-order differential leveling; GPS surveying (J.C. Blodgett and M.E. Ikehara, U.S. Geological Survey, written commun., 1993); and estimates from USGS topographic quadrangle maps.

Spirit leveling surveys were made to 25 well and piezometer sites from bench marks along adjusted level lines that originated from bench mark F1147 (fig. 1). Bench mark F1147 was surveyed using first-order accuracy by the National Geodetic Survey in 1961 (U.S. Department of Commerce, 1966). Accuracy of the spirit leveling surveys at EAFB was plus or minus one-hundredth of a foot. Twenty-one stations, or sites, were measured using static and pseudo-kinematic GPS surveys. The average standard error for vertical components of the GPS surveys was about 0.1 ft. Because of adjustments along the level lines and the accuracy of the GPS surveys, land-surface altitudes derived from leveling and GPS surveys were rounded to the nearest tenth of a foot (table 1).

Land-surface altitudes for wells 8N/12W-2Q1, 9N/8W-6J1, and 9N/9W-13N1 (see fig. 5 for well locations) were estimated from 7.5-minute quadrangle maps of Rosamond Lake, Rogers Lake North, and Rogers Lake South. Accuracies of land-surface altitudes for these wells were assumed to be plus or minus one-half the contour interval, 2.5 ft, 5 ft, and 10 ft, respectively.

Ground-Water Levels and Hydraulic Heads

Ground-water levels were measured to one-hundredth of a foot using a 300-foot calibrated steel measuring tape. Monthly ground-water levels in the wells and piezometers monitored for this study are listed in table 2 by well number and aquifer-system unit. Water levels generally ranged from about 95 to 130 ft below land surface in the North Muroc subbasin, 70 to 200 ft below land surface in the deep aquifer in the Lancaster subbasin, 35 to 95 ft below land surface in the principal aquifer in the Lancaster subbasin, and 100 to 125 ft below land surface in or near the Graham Ranch well field (table 2).

Hydraulic heads, or heads, were computed using ground-water levels and land-surface altitudes given in table 2. Head is the height of water in a well or piezometer referenced from an established datum, which for this report is sea level. Heads generally ranged from about 2,170 to 2,195 ft above sea level in the North Muroc subbasin; 2,150 to 2,200 ft above sea level in the deep aquifer in the Lancaster subbasin; 2,225 to 2,250 ft above sea level in the principal aquifer in the Lancaster subbasin; and 2,200 to 2,215 ft above sea level in the Graham Ranch well field. Heads in wells and piezometers completed in the confining unit ranged from about 2,210 to 2,275 ft above sea level.

Seasonal fluctuations of hydraulic heads for USGS piezometers on or near the base well fields and on Rogers Lake are shown in figure 6. Seasonal fluctuations for heads in piezometers screened in the deep

Table 1. Well-construction data and historic water-level data for wells and piezometers on and near Edwards Air Force Base, California

[State well No.: See well-numbering system on page V. See figure 5 for well locations. Altitude of land surface in feet above sea level rounded to the nearest tenth of a foot. Land-surface altitude, date of construction, and original ground-water-level data for wells not monitored for this study were compiled from Dutcher and others (1962). Type of well: AB, abandoned production or irrigation wells; AVEK, abandoned well monitored annually or semiannually by the U.S. Geological Survey for the Antelope Valley-East Kern Water Agency; D, destroyed; NPOT, production well for non-potable use; PIEZ, piezometer installed by the U.S. Geological Survey; POT, production well for potable use. Well depth, depth to water, and screened interval in feet below land surface. Casing in inches. --, data not available]

State well No.	Base well identification No.	Altitude of land surface	Type of well	Date of construction	Well depth		Casing diameter	Screened interval	Earliest recorded depth to water	
					Original	Current (1992)			Date	Measurement
Completed in the deep aquifer in the Lancaster subbasin										
8N/10W-1C2	S-6	2,293.8	POT	1984	700	--	16	300 - 690	10/84	146
-1Q1		2,301.8	PIEZ	1990	1,023	1,023	2	980 - 1,010	5/90	147.37
-1Q2		2,301.7	PIEZ	1990	645	645	3	605 - 635	5/90	146.87
-1Q3		2,301.7	PIEZ	1990	475	475	2	430 - 460	5/90	145.46
-4R1		2,301.4	PIEZ	1991	980	980	2	920 - 960	7/91	146.40
-4R2		2,301.4	PIEZ	1991	750	750	2	700 - 740	7/91	145.17
-4R3		2,301.4	PIEZ	1991	546	546	2	496 - 536	7/91	143.36
-4R4		2,301.4	PIEZ	1991	250	250	2	220 - 240	7/91	135.11
-5A1		2,287.3	PIEZ	1989	947	947	2	897 - 927	1/90	129.65
-5A2		2,287.3	PIEZ	1991	560	560	2	530 - 550	7/91	127.02
-5A3		2,287.3	PIEZ	1991	390	390	2	360 - 380	7/91	127.11
-5A4		2,287.3	PIEZ	1991	274	274	2	246 - 266	7/91	121.99
-30R1[1]		2,361	AVEK	1950	1,064	1,064	16	650 - 1,064	2/73	157.00
8N/11W-9D1[1]		2,276	D	1952	5,576	--	--	--	--	--
-10E1[1]		2,289	AB	--	612	--	8	550 - 612	5/51	36.47
8N/12W-13D1[1]		2,283	AB	1949	451	--	8	300 - 451	11/52	20.39
-14R1[1]		2,291	AB	1949	404	--	12	254 - 404	11/51	28.34
9N/8W-6J1	MW-3	2,394	POT	1961	363	--	14	147 - 363	6/61	145.7
9N/9W-6A1[1]		2,275	AB	1943	199	--	14	76 - 184	--	--
-6C1[1]		2,287	AB	1942	117	--	14	38 - 101	1/48	39.8
-6E1[1]		2,290	AB	1942	112	--	14	35 - 96	1/48	41.3
-6L1[1]		2,282	AB	1940	147	--	14	33 - 130	1/48	43.4
-9A1		2,271.2	PIEZ	1991	345	345	2	320 - 340	7/91	85.36
-9A2		2,271.2	PIEZ	1991	175	175	2	160 - 170	7/91	84.76
-10R1		2,281.5	AVEK	1937	106	97.9	9.5	--	10/51	18.14
-13N1	Well D	2,350.2	POT	--	555	--	12	178 - 533	8/62	104.0
-14P2[1]	Well B	2,296	POT	1963	500	--	12	--	8/62	53.0
-14Q1[1]	Well C	2,320	POT	--	--	--	12	--	--	--
-15J1	Well A	2,282.8	POT	--	534	--	14	155 - 505	8/62	42
-18C1	S-1	2,280.1	AB	1944	360	221	14	250 - 310	1/48	10.6
-27H2		2,279.8	AVEK	1957	200	170.8	8	100 - 200	7/57	22.76
-28A1		2,271.1	PIEZ	1991	755	755	2	735 - 745	6/91	93.47
-28A2		2,271.1	PIEZ	1991	524	524	2	494 - 514	6/91	95.09

Footnote at end of table.

Table 1. Well-construction data and historic water-level data for wells and piezometers on and near Edwards Air Force Base, California--*Continued*

State well No.	Base well identification No.	Altitude of land surface	Type of well	Date of construction	Well depth		Casing diameter	Screened interval	Earliest recorded depth to water	
					Original	Current (1992)			Date	Measurement
Completed in the deep aquifer in the Lancaster subbasin--*Continued*										
9N/9W-28A3		2,271.1	PIEZ	1991	350	350	2	320 - 340	6/91	89.07
-28A4		2,271.1	PIEZ	1991	220	220	2	195 - 215	6/91	87.80
9N/10W-12R1[1]		2,280.7	AB	1994	180	180	16	--	1/48	11.1
-14C1[1]		2,288	AB	1942	113	--	12	40 - 82	1/42	23.7
-24C1	S-9	2,283.0	AVEK	1951	750	733	14	156 - 733	7/52	24.65
-24E1	S-11	2,271.9	AB	1958	650	--	16	280 - 650	3/58	29.38
-24E2	S-3	2,271.1	POT	1974	590	579	14	220 - 590	5/74	116
-24G1	S-2	2,277.9	POT	1951	738	--	14	238 - 738	10/51	24.20
-25P1		2,269.5	PIEZ	1991	480	480	2	450 - 470	11/91	110.72
-25P2		2,269.5	PIEZ	1991	130	130	2	100 - 120	11/91	71.60
-27P1		2,278.6	PIEZ	1992	560	560	3	530 - 550	9/92	127.65
-27P2		2,278.6	PIEZ	1992	410	410	2	380 - 400	9/92	130.09
-27P3		2,278.8	PIEZ	1992	220	220	2	200 - 220	9/92	121.55
-28F2		2,293.9	AVEK	1953	140.8	140.8	10	--	7/57	44.55
-28H3		2,288.6	PIEZ	1992	500	500	2	475 - 495	9/92	125.94
-28H4		2,288.6	PIEZ	1992	305	305	2	275 - 295	9/92	131.92
-34P3[1]	C-1	2,295	NPOT	1958	350	--	8	--	--	--
-34R2		2,290.4	PIEZ	1989	838	838	2	788 - 808	1/91	133.81
-34R3		2,290.0	PIEZ	1989	520	520	2	480 - 510	1/91	132.80
-34R4		2,290.0	PIEZ	1989	250	250	2	210 - 240	1/91	132.08
-36F1	S-4	2,285.6	POT	1974	672	--	14	216 - 662	--	--
-36J1		2,283.0	PIEZ	1991	900	900	2	870 - 890	7/91	127.70
-36J2		2,283.0	PIEZ	1991	529	529	2	503 - 523	7/91	131.92
-36J3		2,283.0	PIEZ	1991	237	237	2	212 - 232	7/91	125.31
-36P1	S-5	2,288.3	POT	1974	667	--	16	223 - 655	--	--
-36P2		2,290.9	PIEZ	1991	465	465	2	435 - 455	11/91	135.35
9N/11W-36L1		2,289.2	AVEK	--	127.1	127.1	12	--	1/56	30.86
9N/12W-23N1		2,292.4	AVEK	1948	266.7	263.9	12	--	3/51	17.41
-26Q1[1]		2,286	AB	1945	300	--	12	102 - 300	3/47	flowing
-28F3[1]		2,324	AB	1951	150	150	8	--	8/51	32.00
10N/8W-32R1[1]		2,450	AB	1948	148	--	--	--	--	--
10N/9W-31C1[1]		2,280	AB	--	177	--	10	--	1/51	41.45
-31C4[1]		2,280	AB	1926	128	--	16	48 - 114	1/52	44.72
-31N1[1]		2,294	AB	1948	83	--	6	43 - 83	11/51	46.31

Footnote at end of table.

Table 1. Well-construction data and historic water-level data for wells and piezometers on and near Edwards Air Force Base, California--*Continued*

State well No.	Base well identification No.	Altitude of land surface	Type of well	Date of construction	Well depth: Original	Well depth: Current (1992)	Casing diameter	Screened interval	Earliest recorded depth to water: Date	Earliest recorded depth to water: Measurement
Completed in the principal aquifer in the Lancaster subbasin										
8N/10W-8J1[1]		2,315	AB	1951	648	--	12	--	11/51	63.83
-17J2[1]		2,327	AB	--	206	--	12	110 - 206	3/60	61.40
-18N1[1]		2,324	AB	1919	275	--	9	48 - 275	3/49	41.7
-18P3		2,322.5	AB	--	--	113.2	14	--	--	--
-19N2[1]		2,377	AB	1945	788	--	14	312 - 788	--	--
-28A1[1]		2,359	AB	1945	288	--	12	102 - 186	--	--
-28B1[1]		2,358	AVEK	1932	215	--	16	--	1/51	66.75
8N/11W-14R1		2,313.7	AVEK	1949	186	164.9	12	--	5/60	93.11
-15Q1		2,304.3	AVEK	1952	179.2	177.8	12	--	11/52	77.98
-22P2[1]		2,323	AVEK	--	202	--	12	--	12/78	109.75
-24R2[1]		2,337	AVEK	1946	270	132.2	12	120 - 270	5/51	124.86
-34D2[1]		2,340	AVEK	--	250	250	12	--	9/51	145.8
-34R2[1]		2,358	AVEK	--	260	--	12	--	11/51	147.71
8N/12W-2Q1		2,283.8	AVEK	--	260	72.7	6	--	5/51	flowing
-10J1		2,288.8	AVEK	--	91	85	6	30 - 91	3/60	13.67
-24P1[1]		2,307	AB	1923	723	--	18	--	--	--
-26F1[1]		2,303	AVEK	--	123	123	6	--	1/51	14.27
-28D1[1]		2,308	AVEK	--	316	316	12	48 - 316	4/51	11.89
-34K1[1]		2,316	AVEK	--	144	144	--	--	--	--
9N/12W-33P1[1]		2,310	AVEK	--	146	146	12	--	--	--
Completed within the confining lacustrine unit in the Lancaster subbasin										
8N/9W-6D1		2,287.2	AVEK	1950	200	135.6	8	--	3/59	26.90
8N/10W-1Q4		2,301.7	PIEZ	1990	130	130	2	85 - 115	5/90	51.98
-4R5		2,301.4	PIEZ	1991	150	150	2	135 - 150	10/91	89.54
-4R6		2,301.4	PIEZ	1991	100	100	2	80 - 100	10/91	59.56
-5A6		2,287.3	PIEZ	1991	55	55	2	30 - 50	7/91	28.02
9N/9W-28A5		2,271.1	PIEZ	1991	65	65	3	40 - 60	6/91	40.30
9N/10W-34R5		2,290.5	PIEZ	1991	90	90	2	60 - 80	10/91	17.90
-36J4		2,283.0	PIEZ	1991	95	95	2	70 - 90	7/91	21.90
-36P3		2,291.2	PIEZ	1991	120	120	2	90 - 110	11/91	27.88
Completed in the small, unconfined, unnamed subbasin										
9N/10W-8P1		2,370.5	AVEK	--	137	132.6	6	--	10/51	82.45
-16F1		2,320.7	PIEZ	1991	458	458	6.75	275 - 458	1/92	111.53

Footnote at end of table.

Table 1. Well-construction data and historic water-level data for wells and piezometers on and near Edwards Air Force Base, California--*Continued*

State well No.	Base well identification No.	Altitude of land surface	Type of well	Date of construction	Well depth		Casing diameter	Screened interval	Earliest recorded depth to water	
					Original	Current (1992)			Date	Measurement
Completed in the small, unconfined, unnamed subbasin--*Continued*										
9N/10W-16L1		2,319.5	AB	1948	500	--	14	--	10/51	125.20
-16L2		2,319.0	AB	1949	723	--	14	--	10/51	96.82
-16L3		2,318.7	AB	1989	270	270	16	50 - 260	1/90	111.50
-16M1		2,324.0	AB	1938	140.7	140.5	16	--	2/51	103.52
-16N1		2,325.8	AB	1946	396	376	14	96 - 396	5/54	99.39
-16P1	C-3	2,320.2	NPOT	1949	532	--	14	96 - 528	4/52	99.06
-16R1		2,312.9	PIEZ	1989	840	840	2	800 - 830	3/90	100.67
-16R2		2,312.8	PIEZ	1989	584	584	2	494 - 564	3/90	101.19
-16R3		2,312.8	PIEZ	1989	360	360	2	300 - 340	3/90	101.59
-16R4	C-4	2,308.4	NPOT	1990	700	700	16	290 - 690	4/90	110
Completed near the ground-water divide on Rogers Lake										
10N/9W-27C1		2,272.4	PIEZ	1991	222	222	2	207 - 217	7/91	79.59
-27C2		2,272.4	PIEZ	1991	160	160	2	130 - 150	7/91	78.39
-27C3		2,272.4	PIEZ	1991	80	80	2	55 - 75	7/91	70.29
Completed in the unconfined aquifer in the North Muroc subbasin										
10N/9W-4D1		2,304.2	AVEK	1957	502	456.2	12	144 - 433	3/57	95.02
-5B1[1]	N-2	2,278.0	POT	1964	500	--	16	100 - 500	6/64	75.99
-10B1		2,278.6	PIEZ	1991	312	312	2	285 - 302	10/91	95.42
-10B2		2,278.6	PIEZ	1991	150	150	2	117 - 137	10/91	95.10
-24A2		2,290.6	AVEK	1953	--	278.7	14	--	5/54	72.56
11N/9W-32Q1	N-1	2,302.9	AB	1957	450	--	16	234 - 450	10/57	93.61
-36R1		2,311.9	AVEK	1953	298	254.1	10	100 - 132	5/54	98.25

[1] Wells not monitored for this study.

Table 2. Ground-water levels for wells and piezometers on Edwards Air Force Base, California, 1992

[Water level, in feet below land surface. Altitude: altitude of land surface in feet above sea level. Depth: depth to water in feet below land surface]

Date	Water Level	Date	Water level	Date	Water level	Date	Water level
Completed in deep aquifer in the Lancaster subbasin							
8N/10W-1C2. Altitude, 2,293.8; depth, 700							
1-09-92	131.30	4-07-92	130.81	8-06-92	144.35	11-07-92	135.62
2-03-92	130.47	6-16-92	143.73	9-09-92	144.73	12-17-92	132.23
3-10-92	134.90	7-08-92	140.40	10-07-92	144.92		
8N/10W-1Q1. Altitude, 2,301.8; depth, 1,023							
1-08-92	144.42	4-04-92	142.46	7-13-92	145.71	10-29-92	147.86
1-13-92	144.36	5-05-92	142.63	8-05-92	146.62	12-14-92	145.31
2-03-92	143.56	6-09-92	144.89	9-09-92	147.79		
2-24-92	142.85	6-10-92	144.93	9-14-92	147.79		
3-10-92	142.60	7-07-92	145.59	10-05-92	147.82		
8N/10W-1Q2. Altitude, 2,301.7; depth, 645							
1-08-92	137.55	4-04-92	137.12	7-13-92	145.43	10-05-92	146.47
1-13-92	137.61	5-05-92	142.42	7-14-92	145.56	10-29-92	143.66
2-03-92	136.95	6-09-92	145.87	8-05-92	146.18	12-14-92	138.26
2-24-92	137.08	6-11-92	144.48	9-09-92	146.63		
3-10-92	137.13	7-07-92	145.29	9-14-92	146.34		
8N/10W-1Q3. Altitude, 2,301.7; depth, 475							
1-07-92	136.92	4-04-92	136.52	8-05-92	145.28	11-07-92	141.87
1-13-92	136.99	5-05-92	141.21	9-09-92	145.71	12-14-92	137.66
2-03-92	136.39	6-09-92	144.40	9-14-92	145.42		
2-24-92	136.23	7-07-92	144.35	10-05-92	145.65		
3-10-92	136.20	7-13-92	144.56	10-29-92	143.11		
8N/10W-4R1. Altitude, 2,301.4; depth, 980							
1-09-92	146.71	4-05-92	143.66	7-08-92	144.39	10-05-92	146.93
2-03-92	145.83	5-07-92	143.44	8-11-92	145.36	11-08-92	147.26
3-09-92	144.43	6-16-92	144.31	9-09-92	146.28	12-14-92	146.56
8N/10W-4R2. Altitude, 2,301.4; depth, 750							
1-09-92	143.00	4-05-92	140.27	7-08-92	143.36	10-05-92	146.06
2-03-92	142.00	5-07-92	140.89	8-11-92	144.60	11-08-92	145.64
3-10-92	140.59	6-16-92	143.14	9-09-92	145.70	12-14-92	143.41
8N/10W-4R3. Altitude, 2,301.4; depth, 546							
1-09-92	140.59	4-05-92	138.74	7-08-92	141.78	10-05-92	143.89
2-03-92	139.74	5-07-92	139.70	8-11-92	142.88	11-08-92	142.93
3-09-92	138.53	6-16-92	141.43	9-09-92	143.67	12-14-92	140.56
8N/10W-4R4. Altitude, 2,301.4; depth, 250							
1-09-92	133.66	4-05-92	132.04	7-08-92	133.81	10-05-92	135.51
2-03-92	132.96	5-07-92	132.64	8-11-92	134.68	11-08-92	135.13
3-09-92	132.00	6-16-92	133.58	9-09-92	135.28	12-14-92	133.65

Table 2. Ground-water levels for wells and piezometers on Edwards Air Force Base, California, 1992--*Continued*

Date	Water level	Date	Water level	Date	Water level	Date	Water level
Completed in the deep aquifer in the Lancaster subbasin--*Continued*							
8N/10W-5A1. Altitude, 2,287.3; depth 947							
1-09-92	127.23	3-31-92	125.72	7-08-92	125.21	10-05-92	126.38
2-03-92	126.79	5-08-92	125.48	8-11-92	125.73	11-08-92	126.61
3-09-92	126.18	6-16-92	125.72	9-09-92	126.16	12-14-92	126.37
8N/10W-5A2. Altitude, 2,287.3; depth, 560							
1-09-92	126.44	3-31-92	124.60	7-08-92	125.56	10-05-92	126.95
2-03-92	125.80	5-08-92	124.75	8-11-92	126.18	11-08-92	126.94
3-09-92	124.93	6-16-92	125.52	9-09-92	126.74	12-14-92	126.06
8N/10W-5A3. Altitude, 2,287.3; depth, 390							
1-09-92	126.39	3-31-92	124.50	7-08-92	125.68	10-05-92	127.19
2-03-92	125.70	5-08-92	124.75	8-11-92	126.37	11-08-92	127.10
3-09-92	124.80	6-16-92	125.62	9-09-92	126.96	12-14-92	126.06
8N/10W-5A4. Altitude, 2,287.3; depth 274							
1-09-92	126.41	3-31-92	124.48	7-08-92	125.82	10-05-92	127.37
2-03-92	125.70	5-08-92	124.80	8-11-92	126.53	11-08-92	127.22
3-09-92	124.77	6-16-92	125.70	9-09-92	127.14	12-14-92	126.10
9N/8W-6J1. Altitude, 2,394; depth, 363							
2-06-92	202.76	6-17-92	204.37	9-09-92	204.39	12-17-92	204.09
3-13-92	204.06	7-09-92	204.31	10-08-92	204.86		
5-09-92	203.30	8-08-92	203.91	11-07-92	227.54[1]		
9N/9W-9A1. Altitude, 2,271.2; depth, 345							
2-05-92	88.40	5-11-92	86.36	8-06-92	86.30	11-07-92	86.41
3-11-92	86.38	6-17-92	86.50	9-09-92	86.46	12-16-92	86.22
4-05-92	86.52	7-07-92	86.30	10-06-92	86.56		
9N/9W-9A2. Altitude, 2,271.2; depth, 175							
2-05-92	81.99	5-11-92	82.19	8-06-92	83.89	11-07-92	84.22
3-11-92	82.41	6-17-92	82.74	9-09-92	83.98	12-16-92	84.06
4-05-92	81.88	7-07-92	83.63	10-06-92	84.21		
9N/9W-10R1. Altitude, 2,281.5; depth 97.9							
2-05-92	94.58	5-11-92	94.98	8-06-92	95.28	11-07-92	95.49
3-11-92	94.75	6-17-92	95.04	9-09-92	95.52	12-16-92	95.72
4-05-92	94.76	7-07-92	95.15	10-06-92	95.50		
9N/9W-13N1. Altitude, 2,350.2; depth, 555							
2-05-92	161.39	6-17-92	161.77	9-10-92	162.35	12-17-92	162.64
3-13-92	161.63	7-09-92	162.10	10-08-92	162.43		
5-09-92	161.54	8-08-92	162.06	11-07-92	162.33		
9N/9W-15J1. Altitude, 2,282.8; depth, 534							
2-06-92	97.03	5-09-92	97.11	8-08-92	97.82	11-07-92	98.20
3-11-92	96.07	6-17-92	96.80	9-10-92	98.10	12-17-92	97.94
4-07-92	97.36	7-09-92	97.84	10-08-92	98.09		

Footnote at end of table.

Date	Water level	Date	Water level	Date	Water level	Date	Water level
Completed in the deep aquifer in the Lancaster subbasin--*Continued*							
9N/9W-18C1. Altitude, 2,280.1; depth, 221							
2-04-92	101.42	5-07-92	101.29	8-10-92	102.05	11-08-92	102.08
3-10-92	101.28	6-16-92	101.66	9-09-92	102.22	12-15-92	101.81
4-05-02	101.11	7-08-12	101.75	10-07-92	101.78		
9N/9W-27H2. Altitude, 2,279.8; depth, 170.8							
3-11-92	93.50	6-17-92	93.87	9-09-92	94.21	12-16-92	94.51
4-05-92	93.52	7-09-92	94.06	10-06-92	94.28		
5-09-92	93.55	8-08-92	94.17	11-07-92	94.39		
9N/9W-28A1. Altitude, 2,271.1; depth 755							
1-10-92	92.49	4-05-92	92.18	7-29-92	94.94	10-28-92	94.81
1-17-92	92.39	5-05-92	93.36	8-06-92	94.98	12-17-92	93.02
2-05-92	92.24	6-09-92	94.44	9-09-92	95.23		
3-09-92	92.01	7-07-92	94.39	9-14-92	95.03		
3-11-92	92.11	7-13-92	94.57	10-06-92	95.34		
9N/9W-28A2. Altitude, 2,271.1; depth, 524							
1-10-92	91.32	4-05-92	91.07	7-30-92	93.49	10-06-92	93.89
1-17-92	91.22	5-05-92	92.14	8-06-92	93.54	10-28-92	93.39
2-05-92	91.08	6-09-92	93.10	8-11-92	93.54	11-07-92	93.02
3-09-92	90.93	7-07-92	93.02	9-09-92	93.81	12-16-92	92.00
3-11-92	91.01	7-13-92	93.20	9-14-92	93.65		
9N/9W-28A3. Altitude, 2,271.1; depth, 350							
1-17-92	88.40	4-05-92	88.34	7-13-92	89.59	9-14-92	89.97
2-05-92	88.35	5-05-92	88.86	7-30-92	89.84	10-06-92	90.16
3-09-92	88.28	6-09-92	89.46	8-06-92	89.84	10-28-92	89.95
3-11-92	88.32	7-07-92	89.50	9-09-92	90.07	12-17-92	89.14
9N/9W-28A4. Altitude, 2,271.1; depth, 220							
1-17-92	87.26	5-05-92	87.84	8-06-92	88.76	11-07-92	88.86
2-05-92	87.50	6-09-92	88.33	9-09-92	88.96	12-16-92	88.37
3-09-92	87.34	7-07-92	88.42	9-14-92	88.87		
3-11-92	87.46	7-13-92	88.52	10-06-92	89.07		
4-05-92	87.44	7-30-92	88.72	10-28-92	88.92		
9N/10W-24C1. Altitude, 2,283.0; depth, 733							
1-10-92	116.99	4-05-92	115.87	7-08-92	117.80	10-07-92	118.94
2-04-92	116.41	5-07-92	115.80	8-10-92	118.49	11-08-92	116.35
3-10-92	116.21	6-16-92	117.25	9-09-92	118.59	12-17-92	116.62
9N/10W-24E1. Altitude, 2,271.9; depth, 650							
2-04-92	109.37	5-07-92	110.10	8-10-92	135.44	11-08-92	133.52
3-10-92	108.93	6-16-92	133.60	9-09-92	128.06	12-17-92	110.32
4-05-92	111.26	7-08-92	130.14	10-07-92	126.28		

Table 2. Ground-water levels for wells and piezometers on Edwards Air Force Base, California, 1992--*Continued*

Date	Water level	Date	Water level	Date	Water level	Date	Water level
Completed in the deep aquifer in the Lancaster subbasin--*Continued*							
9N/10W-24E2. Altitude, 2,271.1; depth, 579							
5-07-92	112.30	10-07-92	182.42[1]	11-08-92	237.21[1]	12-17-92	109.45
9N/10W-24G1. Altitude, 2,277.9; depth, 738							
2-04-92	162.12[1]	7-08-95	161.83[1]	9-09-92	161.91[1]	12-17-92	117.36
5-07-92	172.18[1]	8-10-92	161.85[1]	11-08-92	112.05		
9N/10W-25P1. Altitude, 2,269.5; depth, 480							
1-09-92	106.07	5-09-92	109.07	8-06-92	114.77	10-07-92	114.91
2-03-92	105.47	6-16-92	114.28	9-09-92	115.11	10-30-92	111.61
4-07-92	105.62	7-08-92	114.45	9-18-92	113.29	12-15-92	106.67
9N/10W-25P2. Altitude, 2,269.5; depth, 130							
1-09-92	69.91	5-09-92	70.79	8-06-92	71.77	10-07-92	72.26
2-03-92	70.07	6-16-92	71.97	9-09-92	72.11	10-30-92	72.02
4-07-92	70.06	7-08-92	71.32	9-18-92	72.28	12-15-92	71.57
9N/10W-27P1. Altitude, 2,278.6; depth, 560							
9-07-92	127.65	10-05-92	127.99	11-09-92	128.17	12-16-92	128.23
9N/10W-27P2. Altitude, 2,278.6; depth, 410							
9-07-92	130.09	10-05-92	130.12	11-09-92	129.67	12-16-92	128.10
9N/10W-27P3. Altitude, 2,278.8; depth, 220							
9-07-92	121.55	10-05-92	121.83	11-09-92	121.31	12-16-92	120.22
9N/10W-28F2. Altitude, 2,293.9; depth, 140.8							
1-09-92	90.55	4-04-92	90.56	7-07-92	90.52	10-05-92	90.84
2-04-92	90.49	5-11-92	90.65	8-10-92	90.71	11-08-92	90.81
3-10-92	90.63	6-16-92	90.73	9-07-92	90.78	12-15-92	90.89
9N/10W-28H3. Altitude, 2,288.6; depth, 500							
9-07-92	125.94	10-05-92	128.15	11-08-92	127.78	12-16-92	127.32
9N/10W-28H4. Altitude, 2,288.6; depth, 305							
9-07-92	131.92	10-05-92	133.10	11-09-92	133.25		
9N/10W-34R2. Altitude, 2,290.4; depth, 838							
2-03-92	132.00	6-16-92	134.92	9-17-92	136.93	12-14-92	133.40
3-09-92	130.90	7-08-92	134.98	10-05-92	137.20		
4-05-92	130.86	8-11-92	136.22	10-29-92	136.84		
5-08-92	132.36	9-07-92	137.02	11-08-92	136.11		
9N/10W-34R3. Altitude, 2,290.0; depth, 520							
1-10-92	132.14	5-08-92	134.10	9-07-92	136.77	12-15-92	132.05
2-03-92	131.03	6-16-92	134.82	9-17-92	136.42		
3-09-92	130.36	7-08-92	135.25	10-05-92	136.98		
4-05-92	130.66	8-11-92	136.31	10-29-92	135.78		

Footnote at end of table.

Date	Water level	Date	Water level	Date	Water level	Date	Water level
Completed in the deep aquifer in the Lancaster subbasin--*Continued*							
9N/10W-34R4. Altitude, 2,290.0; depth, 250							
2-03-92	130.43	6-16-92	134.20	9-17-92	136.21	12-14-92	131.62
3-09-92	129.73	7-08-92	134.66	10-05-92	136.69		
4-05-92	130.42	8-11-92	135.99	10-29-92	135.47		
5-08-92	132.63	9-07-92	136.46	11-08-92	134.76		
9N/10W-36F1. Altitude, 2,825.6; depth, 672							
1-09-92	122.36	4-07-92	122.27	8-06-92	151.68[1]	11-07-92	126.74
2-03-92	141.85	5-09-92	126.15	9-09-92	133.50	12-17-92	125.44
3-10-92	124.22	6-16-92	152.50[1]	10-07-92	133.91		
9N/10W-36J1. Altitude, 2,283.0; depth, 900							
1-09-92	122.28	5-09-92	122.72	7-31-92	128.30	10-05-92	128.74
2-04-92	121.30	6-16-92	126.48	8-06-92	128.65	10-30-92	128.40
3-10-92	120.57	7-08-92	127.17	9-09-92	129.60	12-15-92	123.52
4-07-92	120.64	7-16-92	127.32	9-16-92	129.35		
9N/10W-36J2. Altitude, 2,283.0, depth, 529							
1-09-92	119.43	5-09-92	124.12	7-31-92	132.88	10-05-92	131.55
2-04-92	119.10	6-16-92	131.73	8-06-92	131.81	10-30-92	125.07
3-10-92	121.96	7-08-92	130.35	9-09-92	131.79	12-15-92	120.02
4-07-92	119.35	7-16-92	131.23	9-16-92	129.82		
9N/10W-36J3. Altitude, 2,283.0; depth, 237							
1-09-92	116.54	5-09-92	118.91	8-06-92	124.44	11-07-92	120.33
2-04-92	116.49	6-16-92	124.67	9-09-92	124.60	12-16-92	117.25
3-10-92	116.59	7-08-92	125.11	9-16-92	125.30		
4-07-92	116.82	7-31-92	125.64	10-07-92	124.68		
9N/10W-36P1. Altitude, 2,288.3; depth, 667							
1-09-92	126.41	5-09-92	134.05	8-06-92	167.73[1]	11-07-92	130.16
2-03-92	125.32	6-16-92	167.90[1]	9-09-92	170.35[1]	12-17-92	127.51
4-07-92	125.47	7-08-92	137.27	10-07-92	169.82[1]		
9N/10W-36P2. Altitude, 2,290.9; depth, 465							
1-09-92	128.34	5-09-92	136.92	7-29-92	143.50	10-07-92	139.42
2-03-92	127.22	6-16-92	142.81	8-06-92	142.21	10-30-92	133.37
3-10-92	132.42	7-08-92	138.10	9-09-92	141.80	12-15-92	128.16
4-07-92	127.48	7-15-92	138.63	9-15-92	142.17		
9N/11W-36L1. Altitude, 2,289.2; depth, 127.1							
4-06-92	92.19	7-08-92	100.23	10-05-92	99.88		
5-11-92	101.47	8-05-92	94.97	11-08-92	101.54		
6-17-92	100.11	9-07-92	99.99	12-15-92	93.13		

Footnote at end of table.

Table 2. Ground-water levels for wells and piezometers on Edwards Air Force Base, California, 1992--*Continued*

Date	Water level	Date	Water level	Date	Water level	Date	Water level
Completed in the deep aquifer in the Lancaster subbasin--*Continued*							
9N/12W-23N1. Altitude, 2,292.4; depth 263.9							
3-12-92	72.69	5-06-92	72.56	8-05-92	72.77	11-08-92	73.15
4-06-92	72.64	6-17-92	72.65	9-09-92	72.94	12-14-92	73.35
4-16-92	72.61	7-08-92	72.65	10-05-92	73.08		
Completed in the principal aquifer in the Lancaster subbasin							
8N/10W-18P3. Altitude, 2,322.5; depth, 113.2							
2-07-92	93.28	5-06-92	93.46	8-05-92	93.57	11-08-92	93.62
3-12-92	93.39	6-17-92	93.54	9-09-92	93.62	12-14-92	93.70
3-31-92	93.42	7-08-92	93.57	10-05-92	93.69		
8N/11W-14R1. Altitude, 2,313.7; depth, 164.9							
3-12-92	86.41	6-17-92	86.48	9-09-92	86.59	12-14-92	86.70
4-04-92	86.29	7-08-92	86.70	10-05-92	86.72		
5-06-92	86.48	8-05-92	86.53	11-08-92	86.52		
8N/11W-15Q1. Altitude, 2,304.3; depth, 177.8							
3-12-92	78.55	6-17-92	78.62	9-09-92	78.61	12-14-92	78.69
4-04-92	78.43	7-08-92	78.65	10-05-92	78.69		
5-06-92	78.54	8-05-92	78.56	11-08-92	78.55		
8N/12W-2Q1. Altitude, 2,283.8; depth, 72.7							
4-06-92	49.00	7-08-92	49.68	9-09-92	50.78	11-08-92	52.13
5-06-92	48.94	8-05-92	50.30	10-05-92	51.29	12-14-92	52.06
6-17-92	49.26						
8N/12W-10J1. Altitude, 2,288.8; depth, 85							
3-11-92	36.43	5-06-92	36.42	8-05-92	36.88	11-08-92	37.13
4-06-92	36.33	6-17-92	36.42	9-09-92	36.92	12-14-92	37.15
4-13-92	36.48	7-08-92	36.81	10-05-92	37.03		
Completed within the confining lacustrine unit in the Lancaster subbasin							
8N/9W-6D1. Altitude, 2,287.2; depth, 135.6							
1-09-92	40.73	4-07-92	39.82	7-08-92	42.61	10-05-92	42.25
2-04-92	40.83	5-09-92	40.23	8-06-92	42.44	11-07-92	41.80
3-10-92	39.96	6-16-92	40.61	9-09-92	42.05	12-16-92	41.22
8N/10W-1Q4. Altitude, 2,301.7; depth, 130							
1-07-92	52.94	4-04-92	53.14	8-05-92	53.32	11-07-92	53.50
1-13-92	53.02	5-05-92	53.19	9-09-92	53.41	12-14-92	53.56
2-03-92	53.02	6-09-92	53.28	9-14-92	53.43		
2-24-92	53.07	7-07-92	53.16	10-05-92	53.44		
3-10-92	53.10	7-13-92	53.22	10-29-92	53.47		
8N/10W-4R5. Altitude, 2,301.4; depth, 150							
1-09-92	89.17	4-05-92	88.87	7-08-92	89.11	10-05-92	89.58
2-03-92	89.11	5-07-92	89.01	8-11-92	89.25	11-08-92	89.67
3-09-92	88.93	6-16-92	89.14	9-09-92	89.42	12-14-92	89.57

Table 2. Ground-water levels for wells and piezometers on Edwards Air Force Base, California, 1992--*Continued*

Date	Water level	Date	Water level	Date	Water level	Date	Water level
Completed within the confining lacustrine unit in the Lancaster subbasin--*Continued*							
8N/10W-4R6. Altitude, 2,301.4; depth, 100							
1-09-92	59.41	4-05-92	59.47	7-08-92	58.35	10-05-92	58.45
2-03-92	59.49	5-07-92	59.52	8-11-92	58.43	11-08-92	58.46
3-09-92	59.49	6-16-92	59.45	9-09-92	58.44	12-14-92	58.47
8N/10W-5A6. Altitude, 2,287.3; depth, 55							
1-09-92	28.36	3-31-92	28.38	7-08-92	28.49	10-05-92	28.64
2-03-92	28.36	5-08-92	28.39	8-11-92	28.56	11-08-92	28.66
3-09-92	28.36	6-16-92	28.46	9-09-92	28.62	12-14-92	28.66
9N/9W-28A5. Altitude, 2,271.1; depth, 65							
1-10-92	35.27	3-11-92	40.35	7-13-92	40.67	10-06-92	40.84
1-17-92	37.65	4-02-92	40.45	7-30-92	40.69	10-28-92	40.67
2-05-92	39.69	5-05-92	40.43	8-11-92	40.70	12-17-92	40.04
2-21-92	40.24	6-09-92	40.60	9-09-92	40.74		
3-09-92	40.25	7-07-92	40.69	9-14-92	40.60		
9N/10W-34R5. Altitude, 2,290.5; depth, 90							
1-10-92	17.45	5-08-92	17.92	9-07-92	18.33	12-15-92	17.58
2-03-92	17.41	6-16-92	17.85	9-17-92	18.26		
3-09-92	17.49	7-08-92	17.99	10-05-92	18.28		
4-05-92	17.70	8-11-92	18.21	10-29-92	18.04		
9N/10W-36J4. Altitude, 2,283.0; depth, 95							
1-09-92	22.09	5-09-92	21.80	8-06-92	21.46	11-07-92	21.63
2-04-92	21.84	6-16-92	21.70	9-09-92	21.53	12-16-92	21.81
3-10-92	21.77	7-08-92	21.57	9-16-92	21.53		
4-07-92	21.70	7-31-92	21.47	10-07-92	21.57		
9N/10W-36P3. Altitude, 2,291.2; depth, 120							
1-09-92	27.53	5-09-92	27.01	7-29-92	27.37	10-07-92	27.27
2-03-92	27.55	6-16-92	27.14	8-06-92	27.37	10-30-92	27.31
3-10-92	27.06	7-08-92	27.36	9-09-92	27.31	12-15-92	27.19
4-07-92	27.00	7-15-92	27.35	9-15-92	27.30		
Completed in the small, unconfined, unnamed subbasin							
9N/10W-8P1. Altitude, 2,370.5; depth, 132.6							
1-09-92	81.58	4-05-92	81.47	7-08-92	81.54	10-06-92	81.45
2-04-92	81.53	5-11-92	81.53	8-10-92	81.42	11-07-92	81.46
3-10-92	81.56	6-17-92	81.50	9-08-92	81.50	12-15-92	81.41
9N/10W-16F1. Altitude, 2,320.7; depth, 458							
1-08-92	111.53	4-05-92	111.33	7-07-92	110.40	10-06-92	110.92
2-04-92	111.49	5-11-92	111.30	8-10-92	110.98	11-08-92	110.80
3-10-92	111.40	6-16-92	111.16	9-07-92	111.02	12-15-92	110.74
9N/10W-16L1. Altitude, 2,319.5; depth, 500							
1-08-92	117.66	4-05-92	116.29	7-07-92	118.49	10-06-92	116.95
2-04-92	116.98	5-11-92	121.00	8-10-92	117.74	11-08-92	116.37
3-10-92	116.61	6-17-92	121.11	9-08-92	117.70	12-14-92	116.20

Table 2. Ground-water levels for wells and piezometers on Edwards Air Force Base, California, 1992--*Continued*

Date	Water level	Date	Water level	Date	Water level	Date	Water level
Completed in the small, unconfined, unnamed subbasin--*Continued*							
9N/10W-16L2. Altitude, 2,319.0; depth, 732							
1-08-92	113.40	4-05-92	112.16	7-07-92	113.65	10-06-92	112.96
2-04-92	112.87	5-11-92	112.43	8-10-92	113.08	11-08-92	112.90
3-10-92	112.42	6-16-92	113.46	9-07-92	113.06	12-14-92	112.92
9N/10W-16L3. Altitude, 2,318.7; depth, 270							
1-07-92	113.06	4-05-92	112.84	7-07-92	111.53	10-06-92	112.64
2-04-92	113.06	5-11-92	112.85	8-10-92	112.07	11-08-92	112.72
3-10-92	112.91	6-16-92	112.87	9-07-92	112.58	12-14-92	112.69
9N/10W-16M1. Altitude, 2,324.0; depth, 140.5							
1-09-92	120.25	4-05-92	120.33	7-07-92	120.45	10-06-92	120.58
2-04-92	120.29	5-11-92	120.35	8-10-92	120.50	11-08-92	120.58
3-10-92	120.33	6-16-92	120.40	9-07-92	120.58	12-15-92	120.60
9N/10W-16N1. Altitude, 2,325.8; depth, 376							
1-08-92	122.04	4-05-92	122.06	7-07-92	122.22	10-06-92	122.29
2-04-92	122.07	5-11-92	122.11	8-10-92	122.21	11-08-92	122.25
3-10-92	122.07	6-16-92	122.12	9-07-92	122.29	12-15-92	122.32
9N/10W-16P1. Altitude, 2,320.2; depth, 532							
1-08-92	118.07	4-05-92	116.88	7-07-92	118.75	10-06-92	117.48
2-04-92	117.50	5-11-92	121.33	8-10-92	118.17	11-08-92	116.96
3-10-92	117.16	6-16-92	121.00	9-07-92	118.11	12-15-92	116.81
9N/10W-16R1. Altitude, 2,312.9; depth, 840							
1-08-92	100.45	3-30-92	100.40	7-14-92	100.00	10-06-92	103.73
1-28-92	100.46	5-05-92	100.66	8-10-92	101.79	10-29-92	103.26
2-04-92	100.48	6-16-92	100.69	9-07-92	103.55	11-08-92	103.11
3-10-92	100.47	7-07-92	99.71	9-15-92	103.53	12-15-92	102.94
9N/10W-16R2. Altitude, 2,312.8; depth 584							
1-08-92	101.41	3-30-92	101.48	7-14-92	101.56	10-06-92	104.68
1-28-92	101.44	5-05-92	101.59	8-10-92	103.45	10-29-92	104.19
2-04-92	101.48	6-11-92	101.62	9-07-92	104.98	12-15-92	104.14
3-10-92	101.53	7-07-92	101.46	9-15-92	104.74		
9N/10W-16R3. Altitude, 2,312.8; depth, 360							
1-08-92	101.69	3-30-92	101.77	7-14-92	102.25	10-06-92	104.29
1-28-92	101.68	5-05-92	101.84	8-10-92	103.28	10-29-92	104.19
2-04-92	101.77	6-16-92	101.86	9-07-92	104.47	11-08-92	104.16
3-10-92	101.77	7-07-92	102.27	9-15-92	104.53	12-15-92	104.32
9N/10W-16R4. Altitude, 2,308.4; depth, 700							
2-04-92	99.74	5-11-92	99.91	8-10-92	136.69[1]	11-08-92	103.03
3-10-92	99.80	6-16-92	99.91	9-07-92	132.89[1]	12-15-92	103.10
4-05-92	99.85	7-07-92	116.09[1]	10-06-92	102.79		

Footnote at end of table.

Table 2. Ground-water levels for wells and piezometers on Edwards Air Force Base, California, 1992--*Continued*

Date	Water level	Date	Water level	Date	Water level	Date	Water level
Completed near the ground-water divide on Rogers Lake							
10N/9W-27C1. Altitude, 2,272.4, depth 222							
2-05-92	79.03	5-11-82	79.30	8-07-92	79.50	11-07-92	79.76
3-11-92	80.18	6-17-92	79.42	9-09-92	79.60	12-16-92	79.89
4-05-92	79.14	7-07-92	79.35	10-06-92	79.69		
10N/9W-27C2. Altitude, 2,272.4; depth, 160							
2-05-92	78.90	5-11-92	79.18	8-06-92	79.36	11-07-92	79.61
3-11-92	79.07	6-17-92	79.28	9-09-92	79.45	12-16-92	79.78
4-05-92	79.11	7-07-92	79.23	10-06-92	79.61		
10N/9W-27C3. Altitude, 2,272.4; depth, 80							
2-05-92	74.38	5-11-92	74.42	8-07-92	74.45	11-07-92	74.40
3-11-92	75.39	6-17-92	74.42	9-09-92	74.51	12-16-92	74.41
4-05-92	74.44	7-07-92	74.44	10-06-92	74.49		
Completed in the unconfined aquifer in the North Muroc subbasin							
10N/9W-4D1. Altitude, 2,304.2; depth, 456.2							
2-06-92	127.11	5-09-92	127.66	8-07-92	129.12	11-07-92	128.61
3-11-92	126.88	6-17-92	128.20	9-10-92	129.54	12-16-92	128.19
4-05-92	127.20	7-09-92	128.75	10-06-92	129.43		
10N/9W-10B1. Altitude, 2,278.6; depth, 312							
1-08-92	95.70	4-05-92	95.80	7-09-92	95.91	10-06-92	96.06
2-05-92	95.69	5-09-92	95.80	8-07-92	95.95	11-07-92	96.11
3-11-92	95.72	6-17-92	95.88	9-10-92	96.06	12-17-92	96.18
10N/9W-10B2. Altitude, 2,278.6; depth, 150							
1-08-92	95.52	4-05-92	95.61	7-09-92	95.72	10-06-92	95.88
2-05-92	95.48	5-09-92	95.60	8-07-92	95.77	11-07-92	95.91
3-11-92	95.51	6-17-92	95.67	9-10-92	95.88	12-17-92	96.01
10N/9W-24A2. Altitude, 2,290.6; depth, 278.7							
1-08-92	94.51	4-05-92	94.63	7-09-92	94.78	10-06-92	95.04
2-05-92	94.49	5-09-92	94.65	8-07-92	94.85	11-07-92	94.98
3-11-92	94.54	6-17-92	94.73	9-10-92	94.99	12-16-92	95.24
11N/9W-32Q1. Altitude, 2,302.9; depth, 450							
1-07-92	127.25	4-05-92	127.72	7-09-92	130.06	10-06-92	130.46
2-06-92	127.35	5-09-92	128.27	8-07-92	130.64	11-07-92	129.00
3-11-92	126.88	6-17-92	128.95	9-10-92	130.99	12-16-92	128.44
11N/9W-36R1. Altitude, 2,311.9; depth, 254.1							
2-06-92	121.80	5-09-92	121.98	8-07-92	122.05	11-07-92	122.20
3-11-92	121.82	6-17-92	121.98	9-10-92	122.19	12-17-92	122.27
4-04-92	121.98	7-09-92	122.06	10-06-92	122.18		

[1] Pumping level (or well pumping).

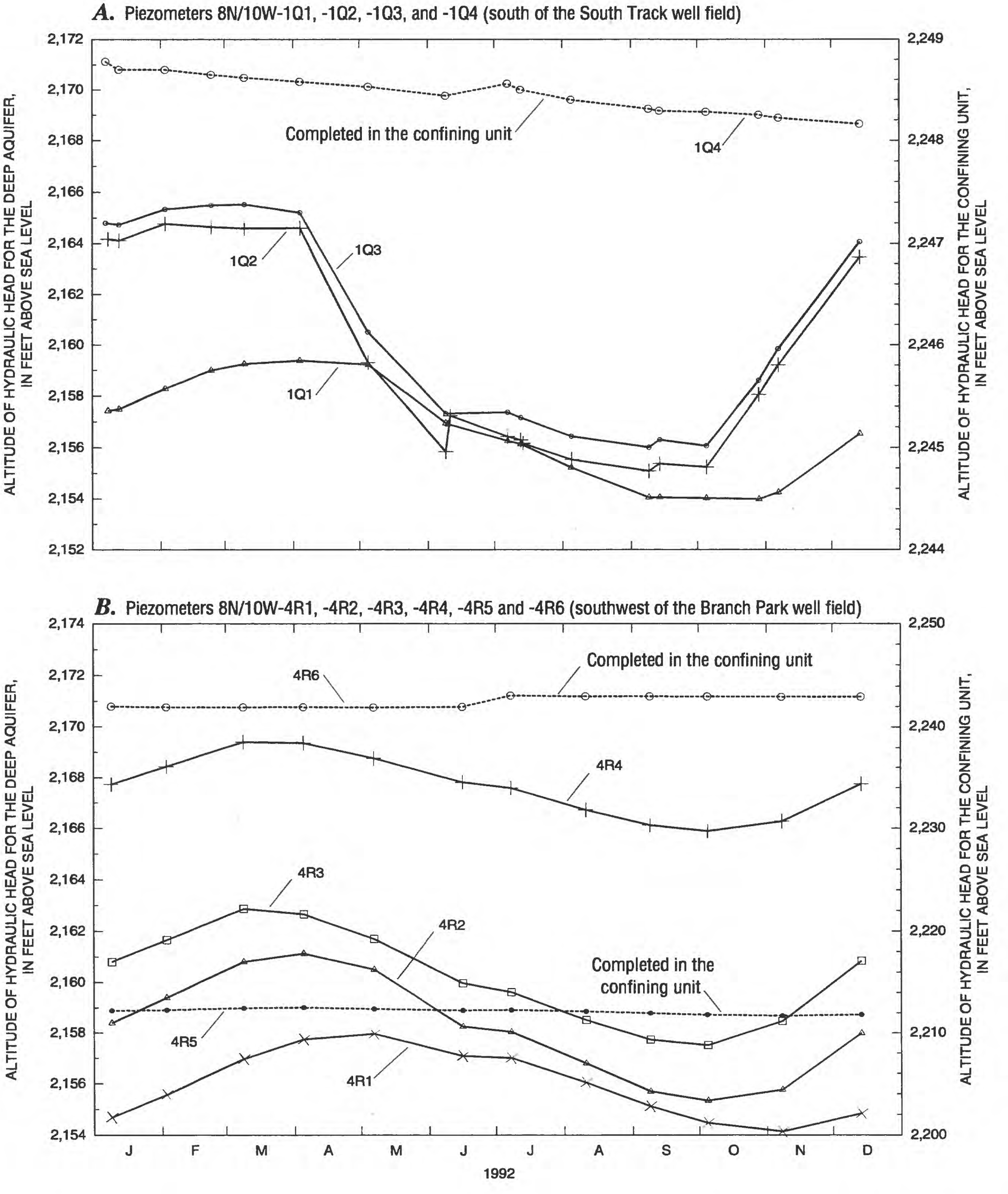


Figure 6. Hydraulic heads for U.S. Geological Survey piezometers on Edwards Air Force Base, California, 1992. (Screened in the deep aquifer of the Lancaster subbasin except where indicated. See figure 5 for piezometer locations.)

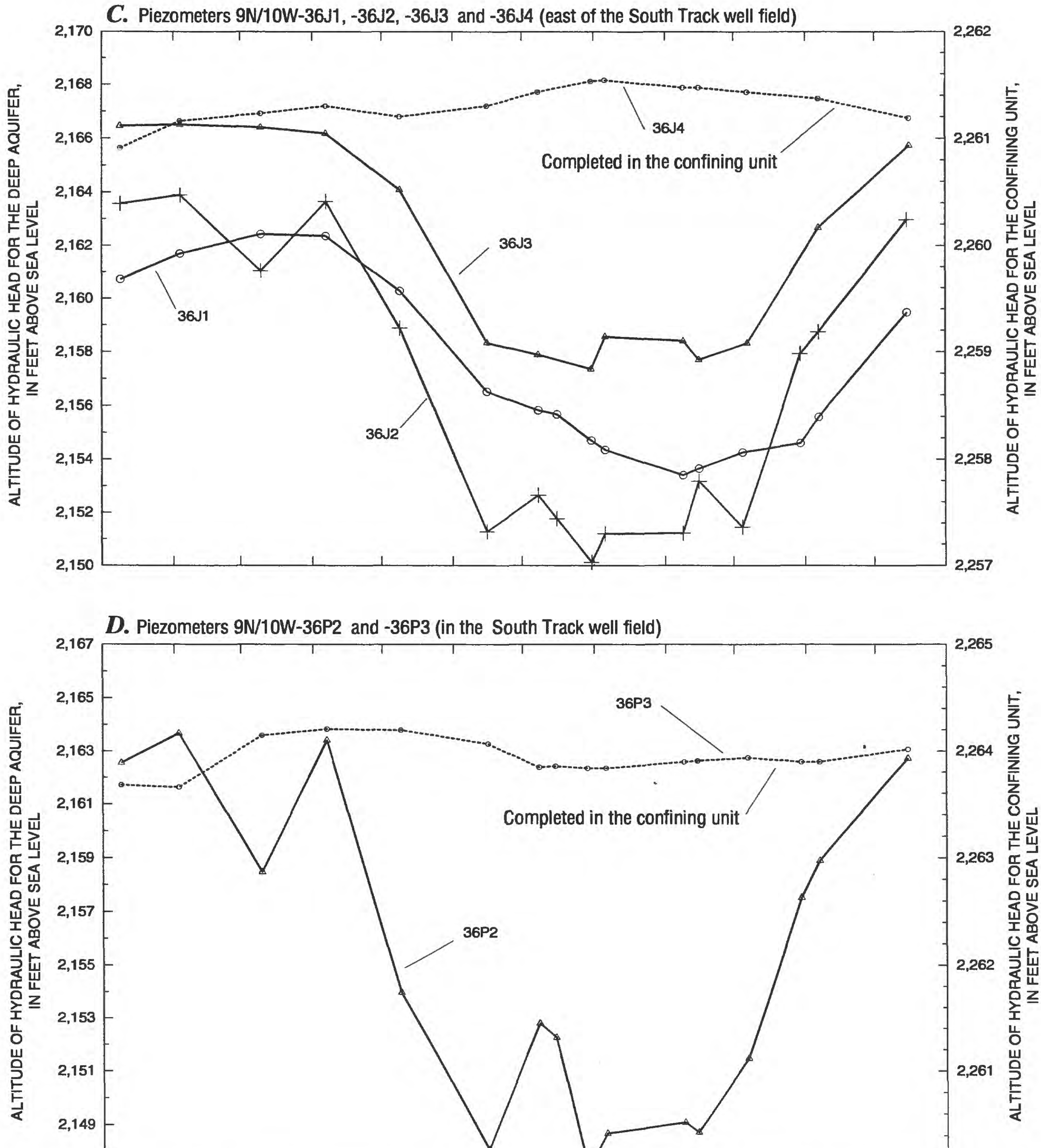


Figure 6. Hydraulic heads for U.S. Geological Survey piezometers on Edwards Air Force Base, California, 1992--*Continued.*

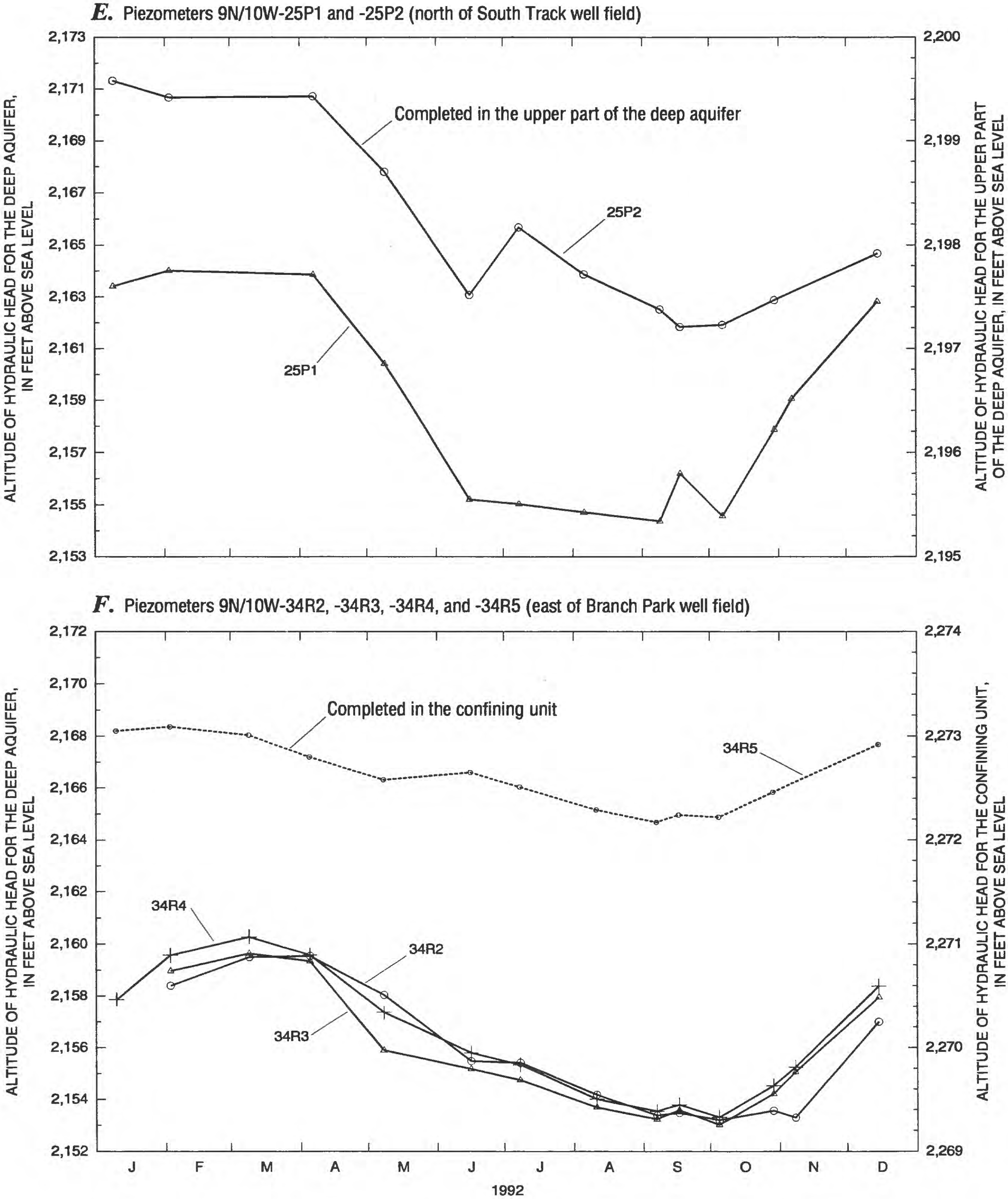
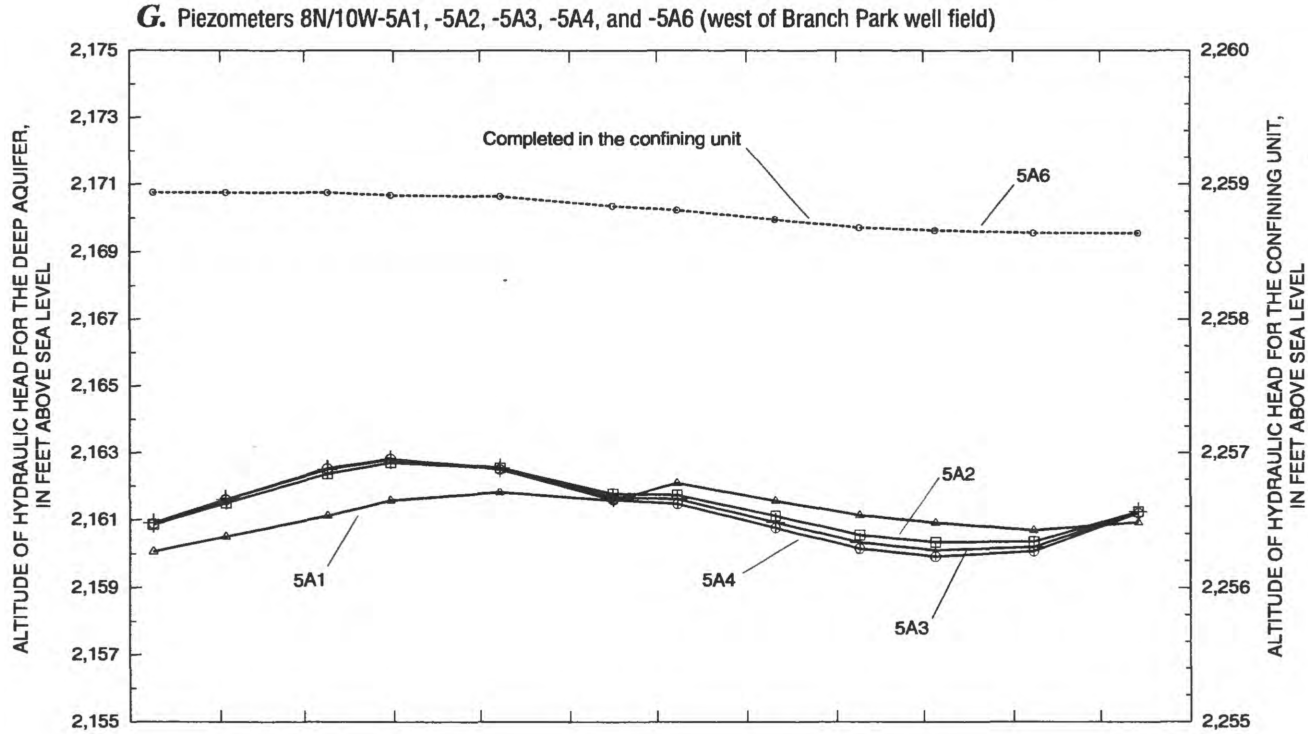


Figure 6. Hydraulic heads for U.S. Geological Survey piezometers on Edwards Air Force Base, California, 1992--*Continued.*



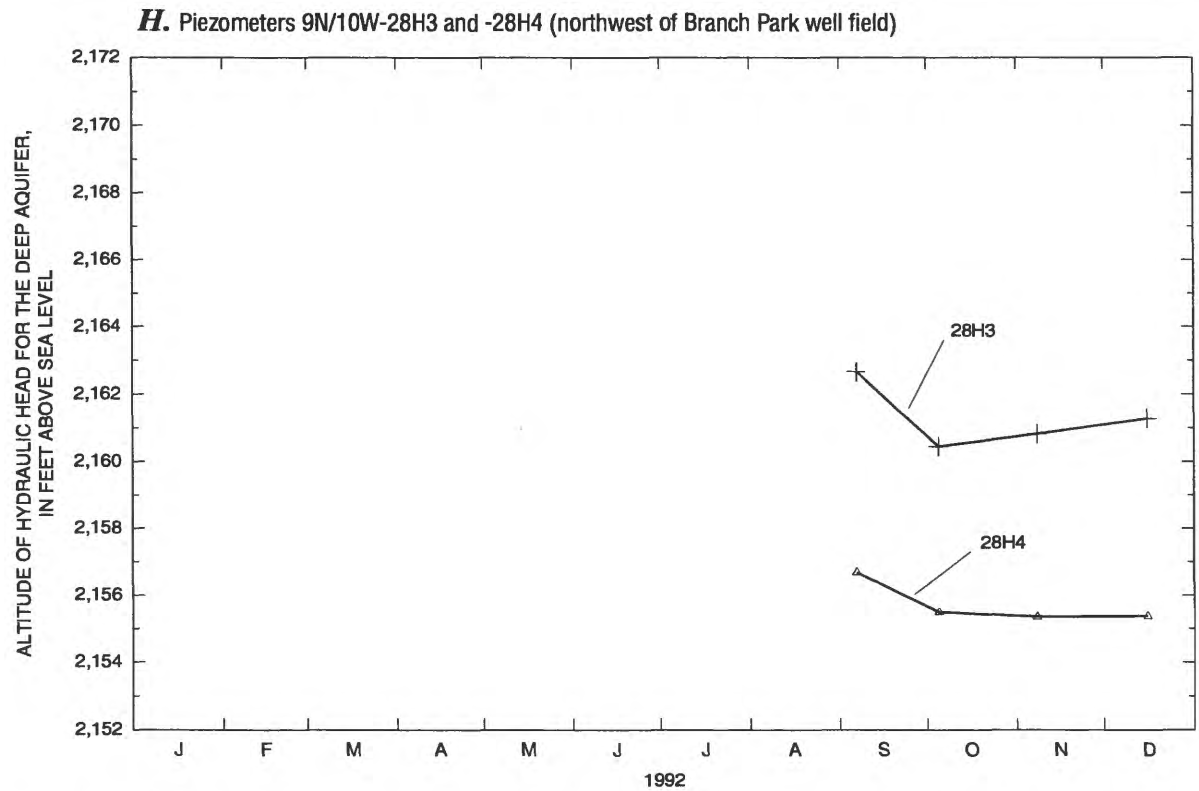


Figure 6. Hydraulic heads for U.S. Geological Survey piezometers on Edwards Air Force Base, California, 1992--*Continued.*

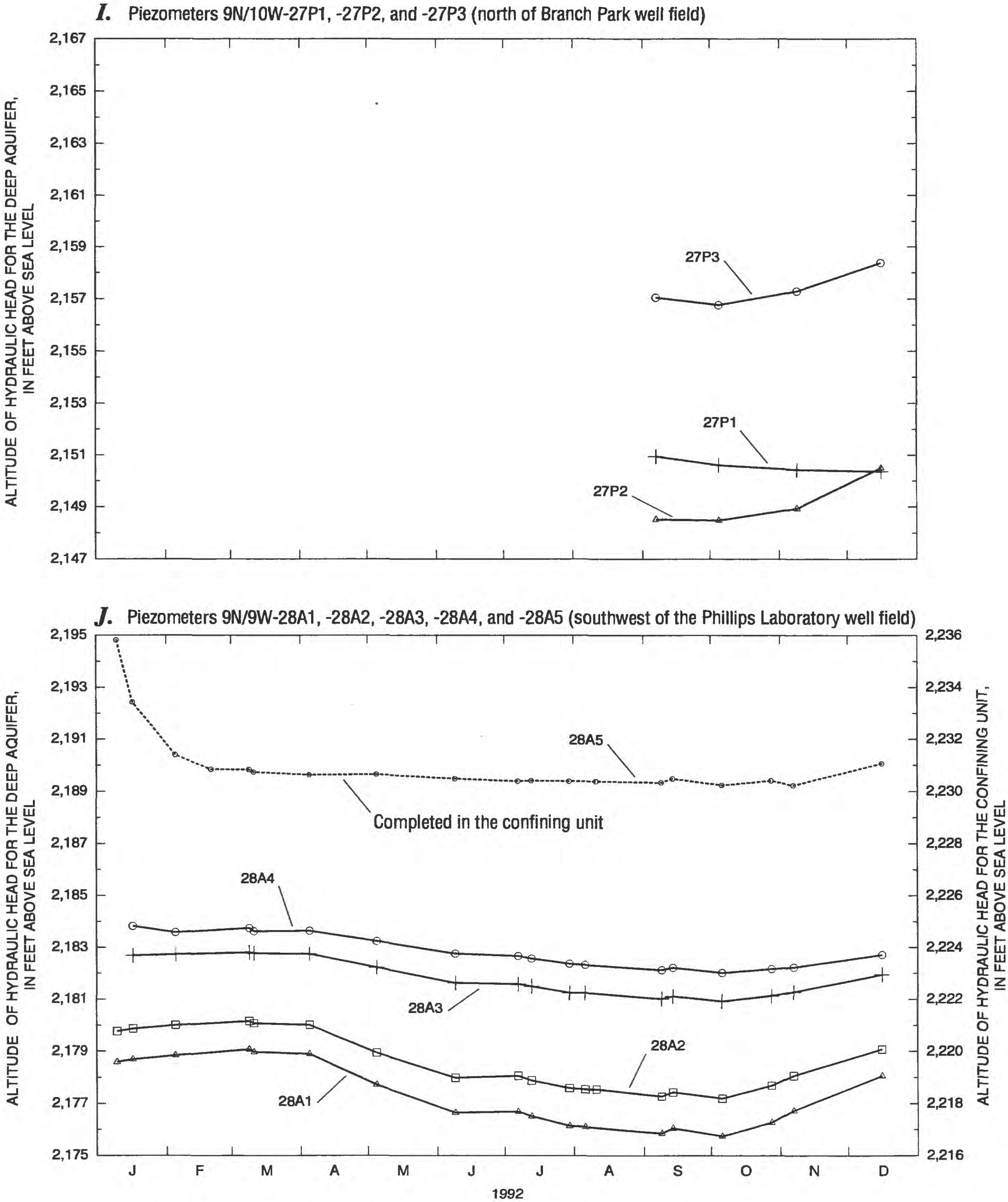
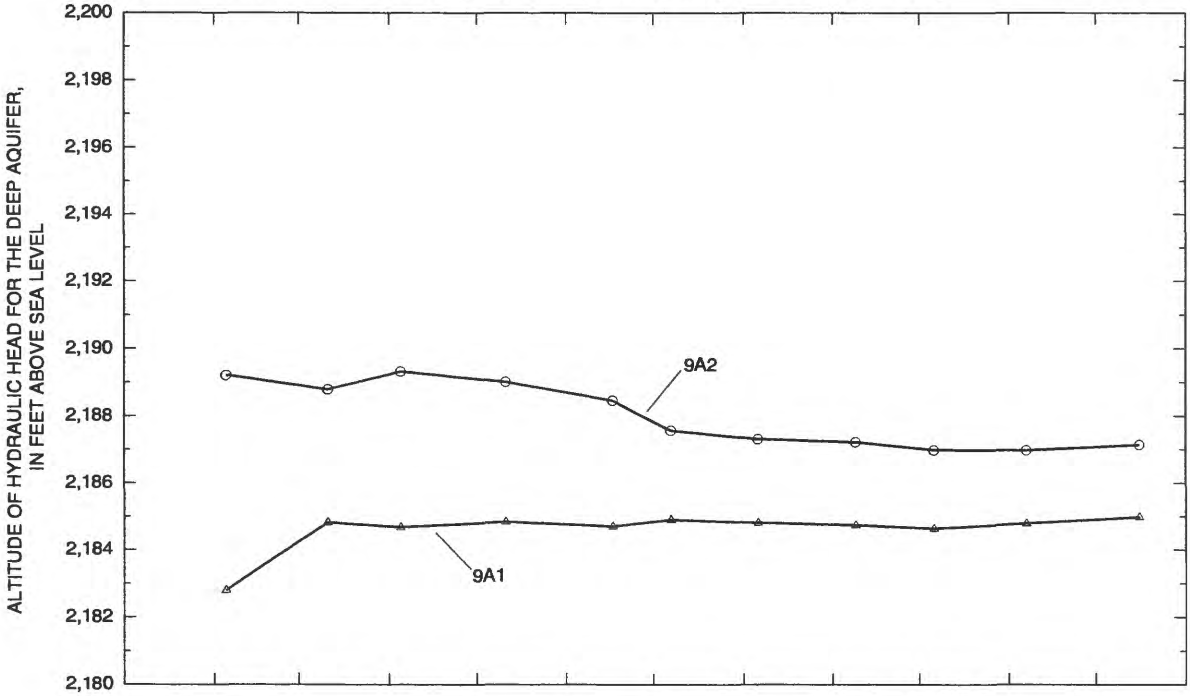


Figure 6. Hydraulic heads for U.S. Geological Survey piezometers on Edwards Air Force Base, California, 1992--*Continued.*

K. Piezometers 9N/9W-9A1 and -9A2 (northwest of the Phillips Laboratory well field)



L. Piezometers 10N/9W-27C1,-27C2, and -27C3 (north of the Phillips Laboratory well field near the ground-water divide)

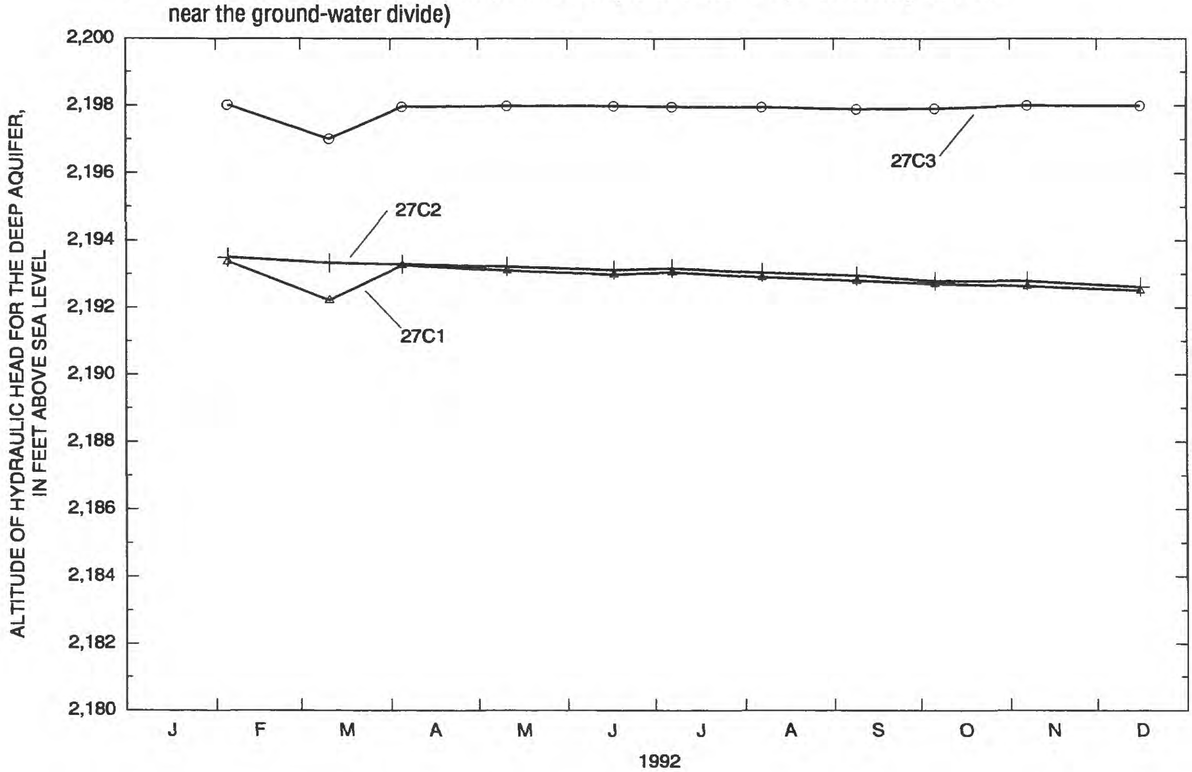
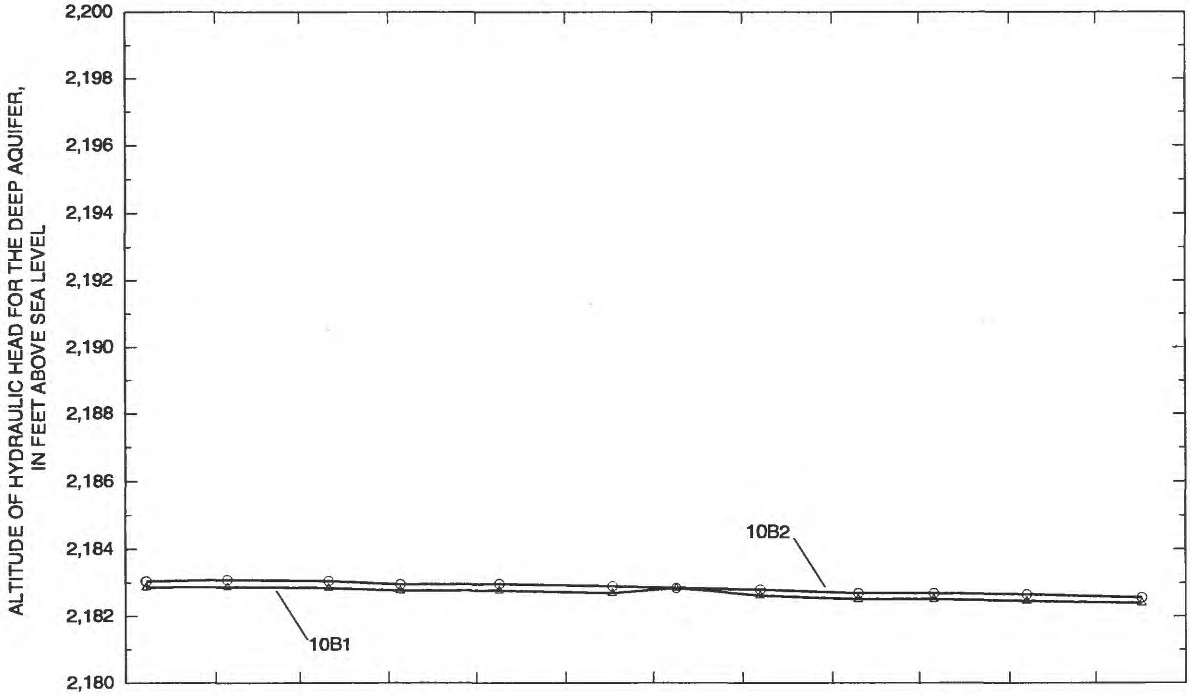


Figure 6. Hydraulic heads for U.S. Geological Survey piezometers on Edwards Air Force Base, California, 1992--*Continued.*

M. Piezometers 10N/9W-10B1 and -10B2 (southeast of the North Base well field)



N. Piezometers 9N/10W-16F1 (north of Graham Ranch well field) and 9N/10W-16R1, -16R2, and -16R3 (in the Graham Ranch well field)

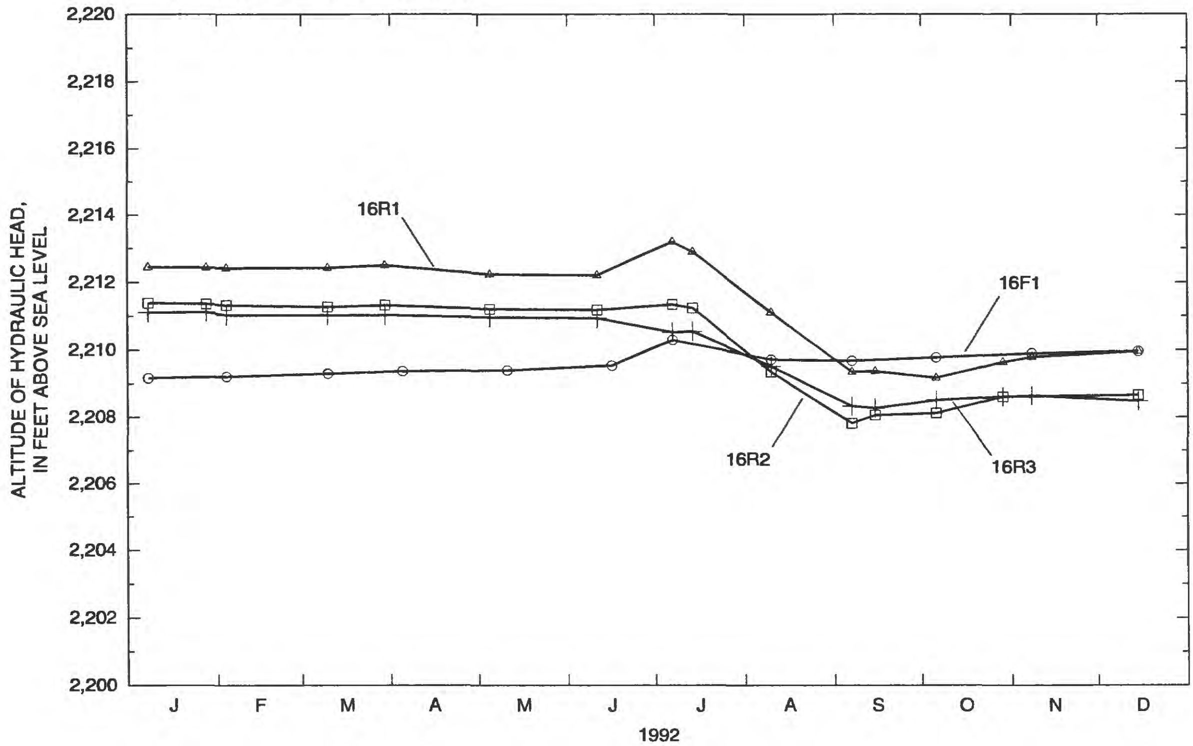


Figure 6. Hydraulic heads for U.S. Geological Survey piezometers on Edwards Air Force Base, California, 1992--*Continued.*

aquifer near the South Track well field (fig. 5) range from about 5 to 15 ft between spring recovery and late summer drawdown levels (figs. 6*A* through 6*N*). Heads in piezometers 8N/10W-1Q1 through -1Q3 and -4R1 through -4R4, 9N/10W-36J1 through -36J3, -36P2, and -34R2 through -34R4 (figs. 6*A*, 6*B*, 6*C*, 6*D*, and 6*F*) are higher than the lower contact of the confining unit (Londquist and others, 1993; Rewis, 1993) indicating confined, nonflowing artesian conditions west, south, and east of the South Track well field. Heads in piezometers 9N/10W-25P1 and -25P2 and 9N/9W-28A1 through -28A4 (figs. 6*E* and 6*J*) are lower than the lower contact of the confining unit indicating unconfined aquifer conditions north of the well field.

On the basis of ground-water-level, lithologic, water-quality, and borehole-resistivity data for piezometer 8N/10W-1Q1, Londquist and others (1993, p. 66) suggest that there is a poor hydraulic connection between the upper and lower confined zones of the deep aquifer at that site. This poor connection may be due to consolidation of the deeper alluvium. Heads in piezometers 8N/10W-4R1, 9N/10W-36J1, 9N/10W-34R2, and 9N/10W-5A1 (figs. 6*B*, 6*C*, 6*F*, and 6*G*) which are completed below 1,500 ft above sea level in the deep aquifer have similar delays in response to seasonal recharge and discharge stresses as for piezometer 8N/10W-1Q1 (fig. 6*A*). This similarity indicates that these piezometers may be completed in the lower confined zone.

Piezometers 8N/10W-4R5, -4R6, -5A6, 9N/9W-28A5, 9N/10W-34R5, -36J4, and -36P3 were completed in the confining unit (table 1, figs. 6*B*-6*D*, 6*F*, 6*G*, and 6*J*). Heads in piezometers 8N/10W-4R5, -4R6, and 9N/9W-28A5 indicate little or no head change from April to September (figs. 6*B* and 6*J*). Heads in piezometers 8N/10W-1Q4, -5A6, 9N/10W-34R5, and -36P3 declined about 0.3, 0.2, 0.6, and 0.3 ft, respectively, from April to September (table 2, figs. 6*A*, 6*G*, 6*F*, and 6*D*). Except for piezometer 8N/10W-1Q4 (fig. 6*A*), these declines correspond to declines in heads in the piezometers completed in the deep aquifer at these sites. Head in piezometer 9N/10W-36J4 increased about 0.2 ft from April to September (table 2, fig. 6*C*). The cause for this increase in head is not known, but may be due to underflow from a nearby dry wash or possibly leakage from water-supply lines in the area.

Piezometer 8N/10W-1Q4 was completed partly in the confining unit and partly in the overlying alluvium (tables 1 and 4) (Londquist and others, 1993). Hydraulic head in this piezometer was about 2,249 ft above sea level in January 1992 and is representative of the hydraulic head in the principal aquifer (fig. 6*A*; table 2). The occurrence of the thin (approximately 40-foot thick) principal aquifer at this site indicates a possibility that the principal aquifer extends into the South Track well-field area. About 3 mi west of well 8N/10W-1Q4 at wells 8N/10W-4R1 through -4R6, the top of the confining unit is about 20 ft higher than the hydraulic head in well -1Q4 (Londquist and others, 1993; Rewis, 1993) indicating a discontinuity of the principal aquifer in this part of the Lancaster subbasin.

The June 28, 1992, Landers and Big Bear earthquakes caused a static strain step (compressional) at EAFB as interpreted from hourly ground-water-level data recorded for piezometers 8N/10W-1Q2, 9N/9W-28A5, and 9N/10W-16R2 (D.L. Galloway, U.S. Geological Survey, written commun., 1992; Galloway, 1993; E. Roeloffs, U.S. Geological Survey, written commun., 1994). This strain step resulted in a volume compression of the aquifer materials, which caused an abrupt rise in hydraulic heads throughout the aquifer system. Heads recovered to near their pre-earthquake levels in the subsequent days or weeks. In some cases, strong pumping influences in the aquifer overwhelmed the aquifer response to the static strain step. The rise in heads between June and July recorded for piezometers 8N/10W-1Q4, 8N/10W-4R6, 9N/10W-25P2, 8N/10W-5A1, 9N/9W-9A1, -28A1, -28A2, 10N/9W-27C1, -27C2, 9N/10W-16F1, -16R1, and -16R2 (figs. 6*A*, 6*B*, 6*E*, 6*G*, 6*J*, 6*K*, 6*L*, and 6*N*) may reflect the same abrupt rise and subsequent decline response as those reported by Galloway (1993) and E. Roeloffs (U.S. Geological Survey, written commun., 1994).

Pumpage and Hydraulic Heads in Production Well Fields

Seven production well fields (fig. 5) provide potable and nonpotable water at EAFB. South Track, South Base, and North Base well fields provide potable water to the main facilities of the base. Branch Park and Graham Ranch well fields provide nonpotable water for landscape and recreational uses. The two Phillips Laboratory well fields supply potable ground water for potable and nonpotable uses for that facility.

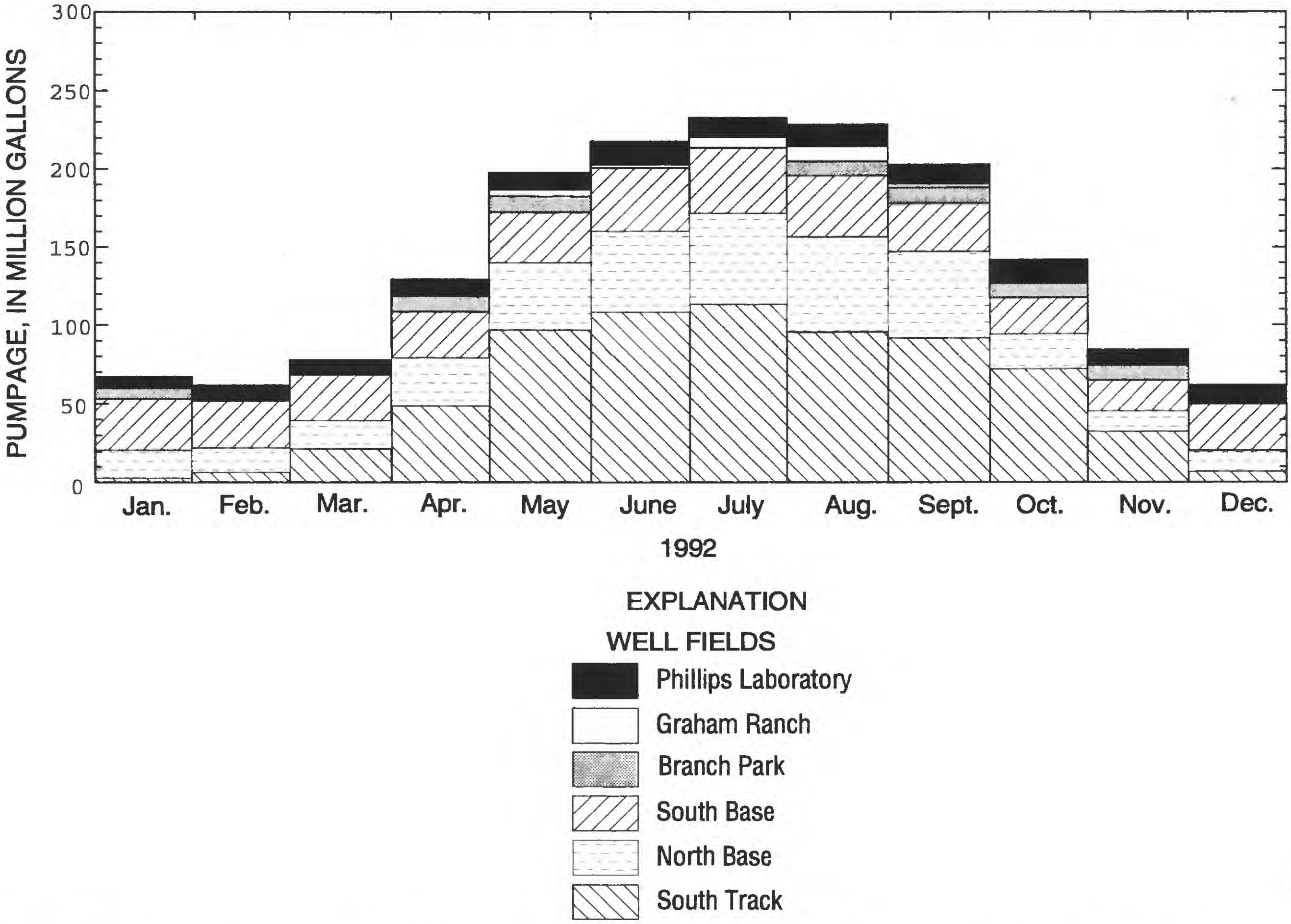


Figure 7. Total monthly pumpage at Edwards Air Force Base, California. (See table 3 for pumpage values.)

The production wells in the South Track, South Base, Branch Park, and Phillips Laboratory well fields yield water from the deep aquifer of the Lancaster subbasin, and the production wells in the North Base well field yield water from the unconfined aquifer of the North Muroc subbasin. Production wells in the Graham Ranch well field yield water from an unconfined aquifer in a small isolated subbasin. Total base pumpage for EAFB in 1992 was about 1,700 million gal, or 5,225 acre-ft (table 3) (Ronald Johnson, Edwards Air Force Base, written commun., 1993; C. Singletary, Superintendent of Water and Waste, Civil Engineering, Phillips Laboratory, Edwards Air Force Base, written commun., 1993). Figure 7 is a bar graph that illustrates the seasonal fluctuations of monthly pumpage totals for the well fields presented in table 3.

South Track Well Field

Total pumpage for 1992 for the South Track well field was about 697.3 million gal, 2,140 acre-ft (table 3). Hydrographs for wells and selected piezometers in and near the South Track well field and total monthly pumpage for wells 8N/10W-1C2 (S-6), 9N/10W-36F1 (S-4), and -36P1 (S-5) are shown in figure 8. During winter and early spring recovery, pumpage was low and hydraulic heads were about 2,164 to 2,166 ft above sea level. From April to May, pumpage doubled and heads began to decline (fig. 8). Pumping was nearly continuous from May into October. From April to September, heads declined about 9 ft in piezometers 8N/10W-1Q3 and 9N/10W-25P1 and about 10 ft in wells 9N/10W-36F1 and 8N/10W-1C2. Draw-

Table 3. Monthly and annual pumpage data from production wells on Edwards Air Force Base, California, 1992

[State well No.: See well-numbering system in text. See figure 5 for locations of wells. n/o, pump not operational; Mgal,

State well No.	Base well identification No.	Pumpage, in million gallons					
		January	February	March	April	May	June
South Track well field							
8N/10W-1C2	S-6	1.017	2.343	3.671	8.716	41.609	6.925
9N/10W-36F1	S-4	.415	3.988	5.064	30.782	10.589	42.034
-36P1	S-5	1.336	0	12.723	9.277	44.751	59.458
	Total	2.768	6.331	21.458	48.775	96.949	108.417
North Base well field							
10N/9W-5B1	N-2	17.573	15.469	17.596	30.111	42.917	51.553
	Total	17.573	15.469	17.596	30.111	42.917	51.553
South Base well field							
9N/10W-24E2	S-3	0	0	0	0.908	3.013	13.340
-24G1	S-2	32.627	29.952	29.464	28.629	29.394	27.366
	Total	32.627	29.952	29.464	29.537	32.407	40.706
Branch Park well field							
9N/10W-34P3	C-1	6.925	0	0	10.121	10.212	1.886
	Total	6.925	0	0	10.121	10.212	1.886
Graham Ranch well field							
9N/10W-16P1	C-3	0.057	0.063	0.019	0.328	4.249	0.992
-16R4	C-4	n/o	n/o	n/o	n/o	n/o	n/o
	Total	0.057	0.063	0.019	0.328	4.249	0.992
Phillips Laboratory well fields							
9N/9W-14P2	Well B	2.442	1.123	2.758	2.628	2.457	4.748
-15J1	Well A	1.176	3.784	1.603	3.058	2.233	2.748
-13N1	Well D	n/o	n/o	n/o	n/o	.421	.278
-14Q1	Well C	1.981	2.771	2.448	2.423	2.473	3.170
9N/8W-6J1	MW-3	1.516	2.180	2.196	2.535	3.378	3.145
	Total	7.115	9.858	9.005	10.644	10.962	14.089
Monthly base total, million gallons....................................		67.065	61.673	77.542	129.516	197.696	217.643
Monthly base total, acre-feet..		205.8	189.2	237.9	397.4	606.6	667.8

[1]Flowmeter not operational, pumpage estimated using number of hours operated at 1,700 gallons per minute.

million gallons; acre-ft, acre-foot]

Pumpage, in million gallons--*Continued*						Annual well and well field totals (Mgal)	Annual well field total (acre-ft)
July	August	September	October	November	December		
0	0.00	2.542	4.920	2.023	4.358	78.124	
56.054	53.576	31.404	19.377	5.303	2.615	261.201	
57.330	42.073[1]	57.907[1]	47.868	25.214[1]	n/o	357.937	
113.384	95.649	91.853	72.165	32.540	6.973	697.262	2,139.6
58.116	60.812	55.149	21.988	12.757	13.140	397.181	
58.116	60.812	55.149	21.988	12.757	13.140	397.181	1,218.7
14.092	11.434	5.119	10.289	7.831	1.876	67.902	
27.841	28.048	25.883	13.133	11.629	27.819	311.785	
41.933	39.482	31.002	23.422	19.460	29.695	379.687	1,165.0
0.00	8.869[1]	10.060	9.359	9.394	0.741	67.567	
0.00	8.869	10.060	9.359	9.394	0.741	67.567	207.3
n/o	n/o	0	0.075	0	0	5.783	
7.074	9.712	2.468	0	.825	.362	20.441	
7.074	9.712	2.468	0.075	0.825	0.362	26.224	80.5
3.018	2.784	2.035	2.210	1.346	1.494	29.043	
1.136	3.121	2.371	3.770	1.984	2.590	29.574	
2.797	3.719	3.295	3.725	2.162	2.881	33.529	
4.432	2.984	3.500	2.801	1.940	2.762	19.118	
.758	1.314	1.241	2.406	1.751	.925	23.661	
12.141	13.922	12.442	14.912	9.183	10.652	134.925	414.0
232.648	228.446	202.974	141.921	84.159	61.563	1,702.846	
713.9	701.0	622.8	435.5	258.2	188.9	5,255.1	

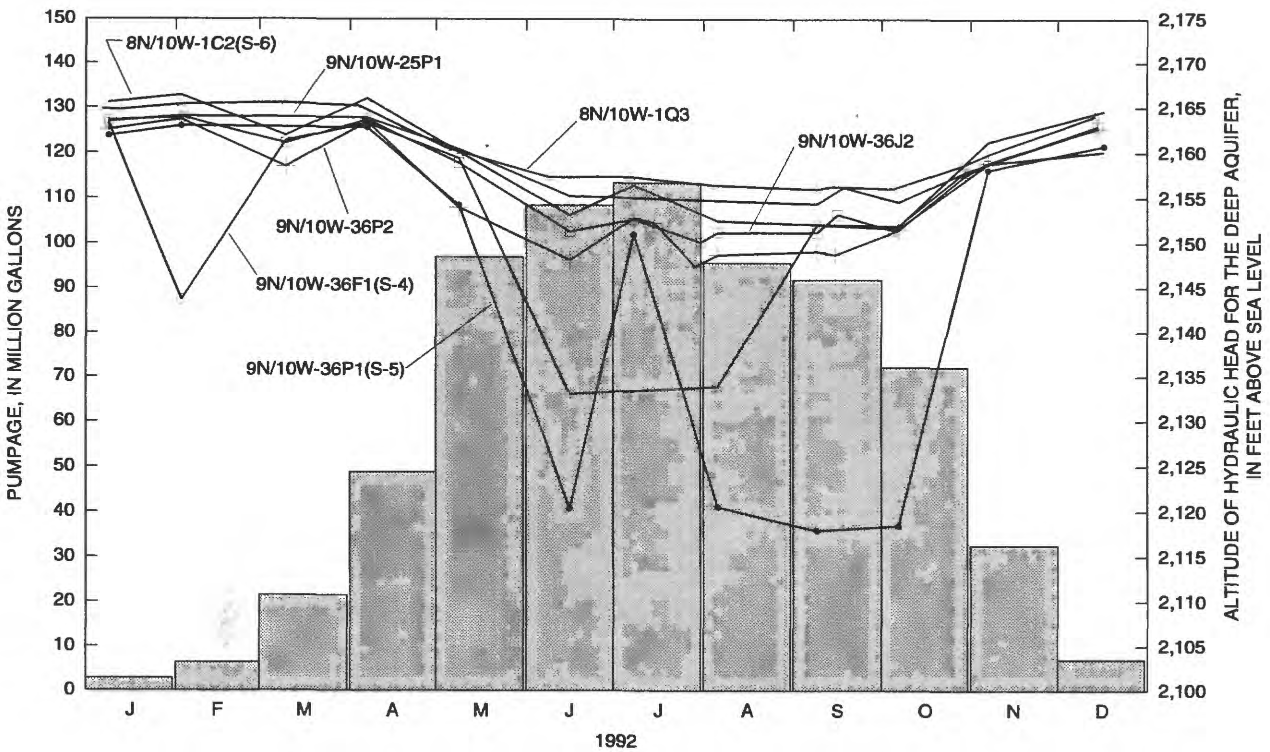


Figure 8. Monthly pumpage from and hydraulic heads in wells and selected piezometers in and near the South Track well field, Edwards Air Force Base, California.

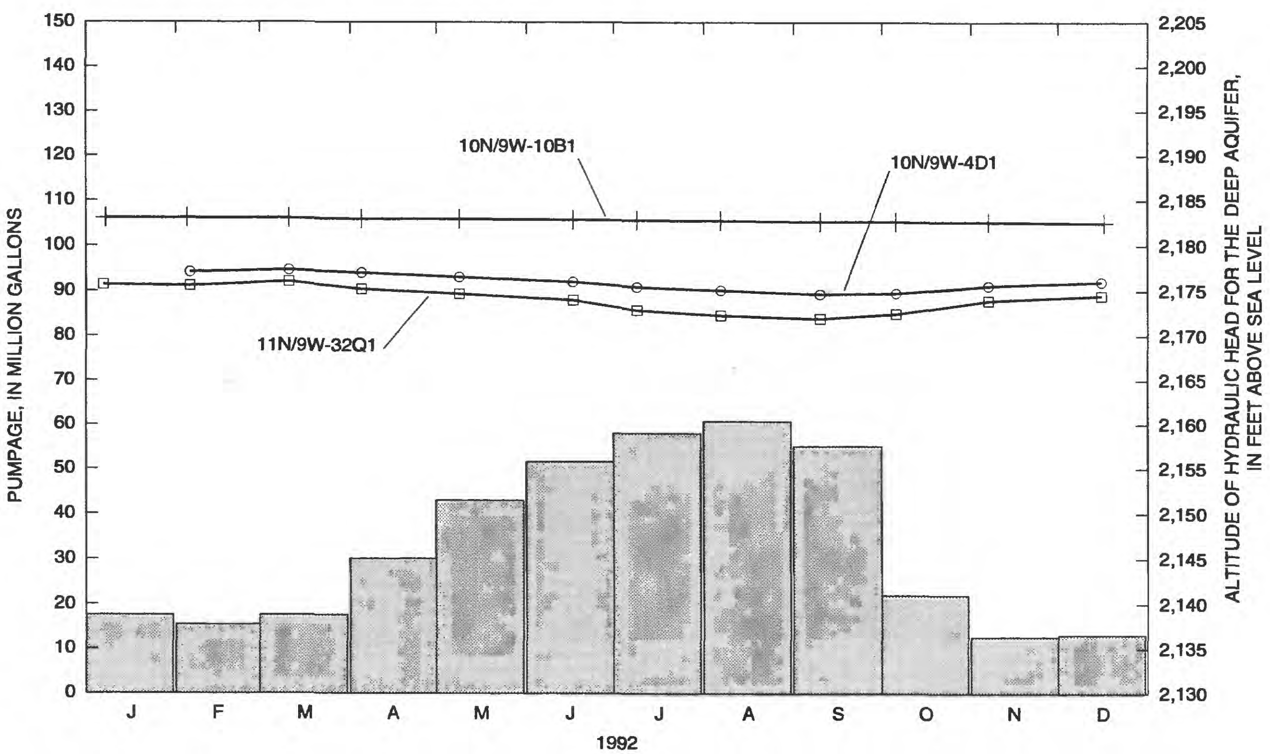


Figure 9. Monthly pumpage from and hydraulic heads in wells and selected piezometers in and near the North Base well field, Edwards Air Force Base, California.

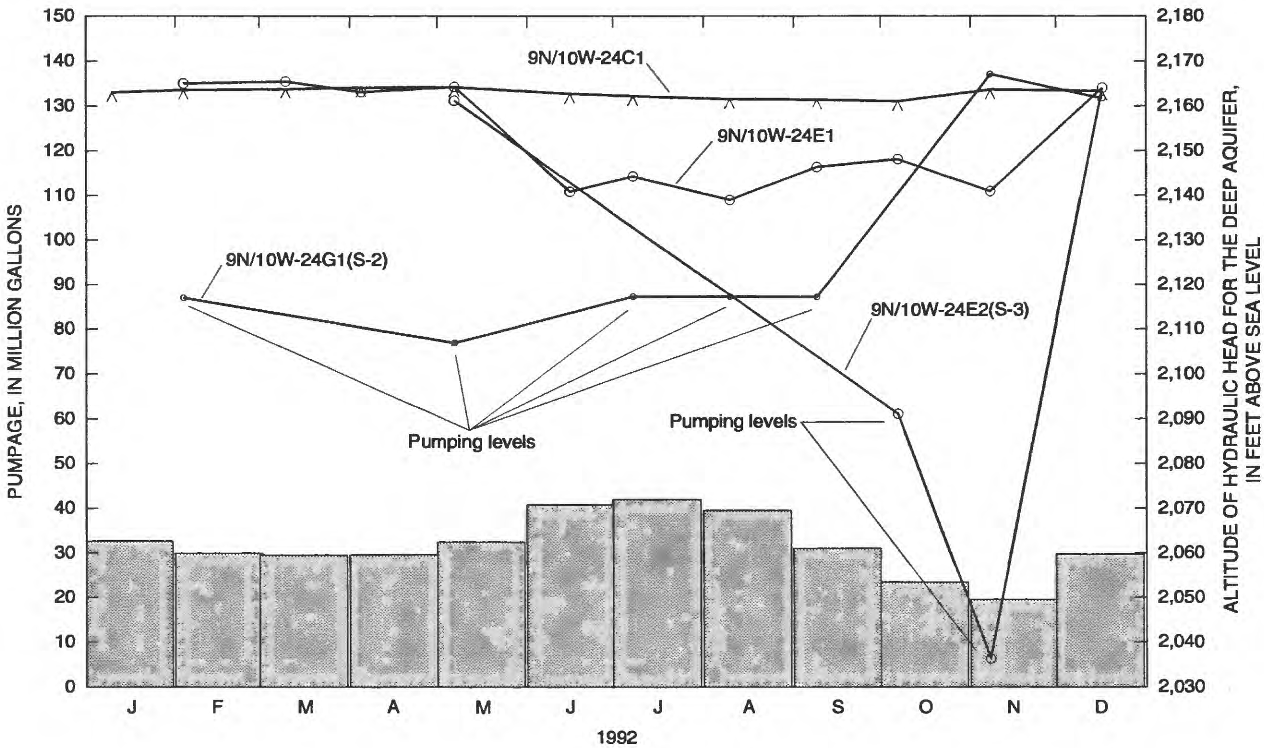


Figure 10. Monthly pumpage from and hydraulic heads in wells in the South Base well field, Edwards Air Force Base, California.

downs were about 20 ft and 30 ft in wells 9N/10W-36F1 and 9N/10W-36P1, respectively. Recovery began in late October, and by early December, heads recovered to about 2,160 to 2,165 ft above sea level.

North Base Well Field

About 397.2 million gal, or 1,219 acre-ft, was pumped from well 10N/9W-5B1 in the North Base well field (fig. 5) in 1992 (table 3). From April to September 1992, hydraulic heads declined about 2 ft in well 10N/9W-4D1 to the east of well 10N/9W-5B1 and about 3 ft in well 11N/9W-32Q1 to the north of well 10N/9W-5B1 (fig. 9). By December, well 10N/9W-4D1 had recovered 1.3 ft and well 11N/9W-32Q1 had recovered 2.2 ft. Heads in piezometer 10N/9W-10B1, about 2.2 mi southeast of well 10N/9W-5B1, declined steadily about half a foot during an 11-month period (January 8 to December 17, 1992).

South Base Well Field

Total annual pumpage for the South Base well field (fig. 5) in 1992 was about 379.7 million gal, 1,165 acre-ft (table 3), with an average monthly total of about 31.6 million gal, 97 acre-ft. The hydrograph for well 9N/10W-24C1 (fig. 10) shows that hydraulic heads ranged from about 2,164 to 2,167 ft above sea level. The altitude scale in figure 10 is two times that of figures 8 and 9. Drawdowns ranged about 50 to 60 ft for well 9N/10W-24G1 (S-2) and about 70 to 130 ft for 9N/10W-24E2 (S-3). Well 9N/10W-24E1 is about 750 ft north of well 9N/10W-24E2 (fig. 5). The 10-foot drop in head in well 9N/10W-24E1 when well -24E2 (S-3) was being pumped indicates that -24E1 is in the cone of depression of -24E2. Large drawdowns in both production wells may be due to low transmissivities (Londquist and others, 1993, tables 7 and 8) in this area or may indicate loss of storage in the aquifer because of dewatering and compaction of the interbedded, fine-grained layers. Large drawdowns allow an increase in oxidation or corrosion of the steel well casing when it is exposed to air, which could lead to collapse or shearing of the well casing. Such corrosion may have contributed to the collapse of well 9N/9W-18C1 (S-1) in 1991. The cement pump pad for well 9N/10W-24E2 was cracked and the cement foundation

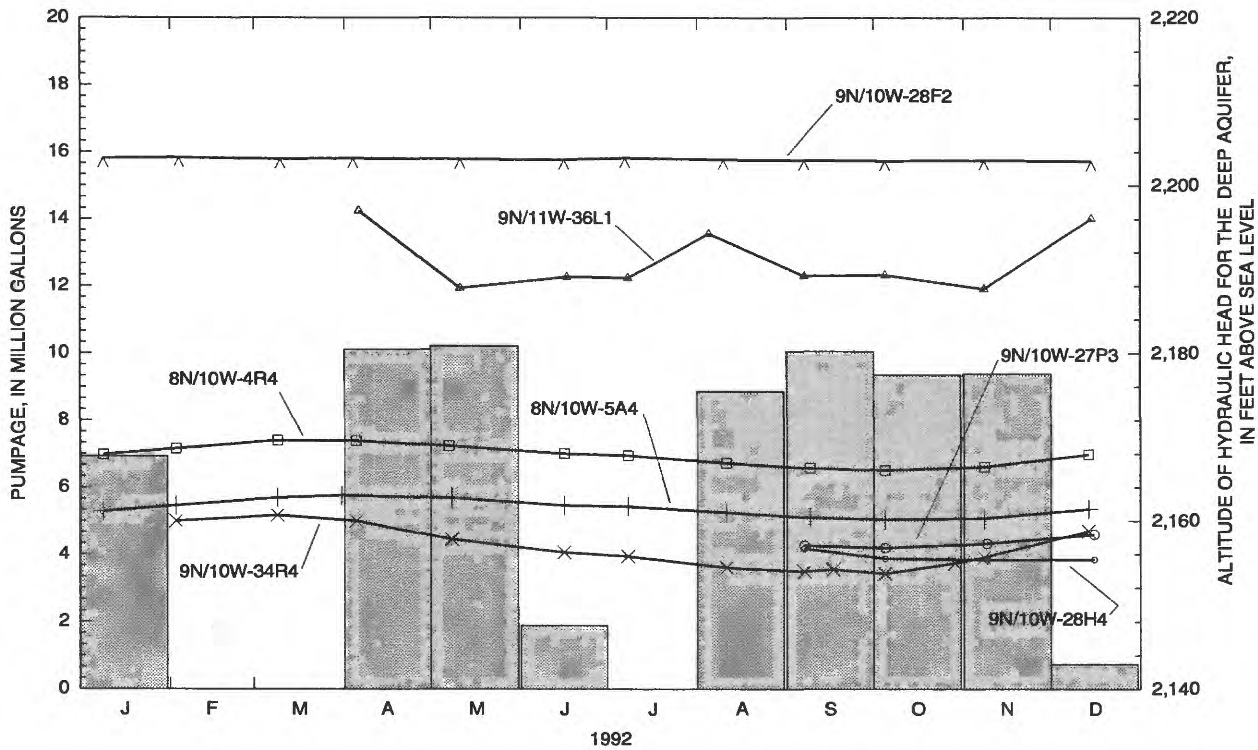


Figure 11. Monthly pumpage from and hydraulic heads in wells and selected piezometers in and near the Branch Park well field, Edwards Air Force Base, California.

had broken away from the bottom of the pad about 1 to 2 in., which indicates land subsidence and surface deformation have occurred around this well.

Branch Park Well Field

The Branch Park well field is about 1.5 mi west of the South Track well field (fig. 5). About 67.6 million gal, or 207 acre-ft, of ground water was pumped from well 9N/10W-34P3 (C-1) (table 3). The pumpage scale in figure 11 is one-fifth the pumpage scale in figures 8, 9, and 10. Hydraulic head in piezometer 9N/10W-34R4 declined about 7 ft from 2,160 to 2,153 ft above sea level between March and October 1992, then started to recover in late October even though well 9N/10W-34P3 continued to be pumped through November. This fluctuation reflects the influences of the combined pumping stresses occurring in the South Track and Branch Park well fields. Head in well 9N/10W-28F2, about 2 mi to the northwest of the Branch Park well field, was about 2,203 ft above sea level and about 40 to 50 ft higher than heads in piezometers 8N/10W-5A4 and 9N/10W-34R4. Head in well 9N/10W-28F2 did not respond to seasonal pumping stresses (fig. 11). These observations could be explained if well 9N/10W-28F2 were isolated from the aquifer system of the Lancaster subbasin.

Well 9N/11W-36L1, about 4 mi west of the Branch Park well field, is believed to be completed in the deep aquifer. The cause of the erratic ground-water-level fluctuations in this well is unknown (fig. 11). Falling water was heard when water levels were more than 100 ft below land surface, but no sound was heard when water levels were less than 95 ft below surface, which may indicate a perched aquifer in this area. This well may act as a conduit that hydraulically connects the perched and deep aquifers.

Graham Ranch Well Field

About 26.2 million gal, 80 acre-ft, were pumped from wells 9N/10W-16P1 (C-3) and -16R4 (C-4) in the Graham Ranch well field (fig. 5) in 1992 (table 3). Hydraulic heads ranged from about 2,200 to 2,210 ft above sea level (fig. 12). The altitude and pumpage scales in figure 12 are the same scales as those used in figure 11. About 0.3 million gal in April and about 4.2 million gal in May 1992 was pumped from well 9N/

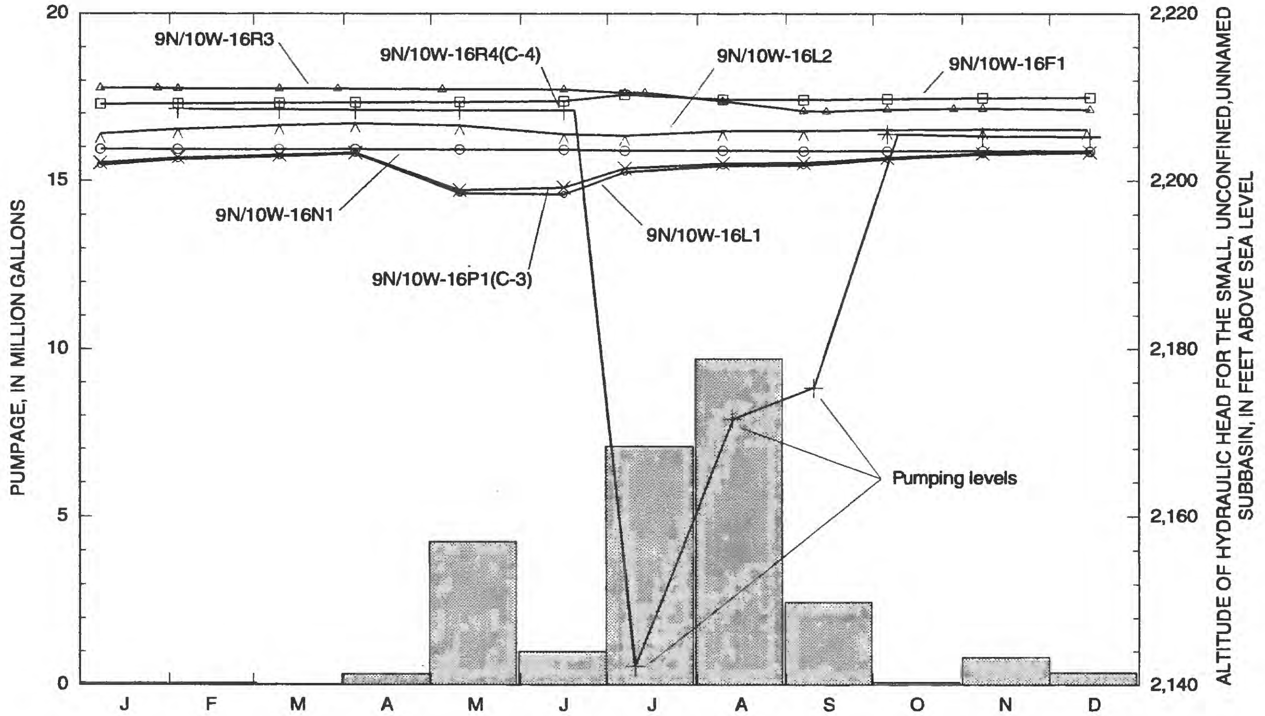


Figure 12. Monthly pumpage from and hydraulic heads in wells and selected piezometers in and near the Graham Ranch well field, Edwards Air Force Base, California.

10W-16P1 (C-3); the heads in wells 9N/10W-16P1 and -16L1 declined about 4.5 ft. Pumping from well 9N/10W-16P1 was ceased on June 30, 1992, and head was slow to recover to prepumping levels. Well 9N/10W-16R4 (C-4), 0.75 mi east of 9N/10W-16P1, was put into production July 1, 1992 (Ronald Johnson, Edwards Air Force Base, written commun., 1992). Drawdowns in well 9N/10W-16R4 ranged from 30 to 65 ft, and recovery in October 1992 was about 3 ft lower than prepumping levels.

Phillips Laboratory Well Fields

The Phillips Laboratory well fields are east of Rogers Lake (fig. 5). Two of the four production wells near the eastern shore of Rogers Lake were monitored, and one production well about 3.5 mi to the northeast was monitored. These well fields produced about 134.9 million gal, or 414 acre-ft, in 1992 (table 3). The pumpage scale in figure 13 is the same scale as the scale used for figures 11 and 12. Hydraulic heads ranged from about 2,182 to 2,191 ft above sea level (fig. 13). The altitude scale in figure 13 is three-fifths the scale used in figures 8, 9, 11, and 12.

Hydraulic heads in well 9N/8W-6J1 declined about 1 ft from January to December 1992; drawdown was about 23 ft. Heads in the wells and piezometers in and near the Phillips Laboratory well fields declined about 1 to 2 ft from January to December. Heads in piezometer 9N/9W-9A2 and production well 9N/9W-15J1 (Well A) declined about 1 ft between June and July (fig. 13) after production well 9N/9W-13N1 (Well D) began being pumped heavily at the end of June (table 3) (C. Singletary, Superintendent of Water and Waste, Civil Engineering, Phillips Laboratory, Edwards Air Force Base, written commun., 1993). This pumping had no influence on heads in wells 9N/9W-10R1 and -27H1 (fig. 13), about 1 mi north and 1.5 mi south of the well field, respectively. The heads in piezometers 9N/9W-9A1 (fig. 6*K*) and 9N/9W-28A1 through -28A4 (fig. 6*J*) also did not respond to

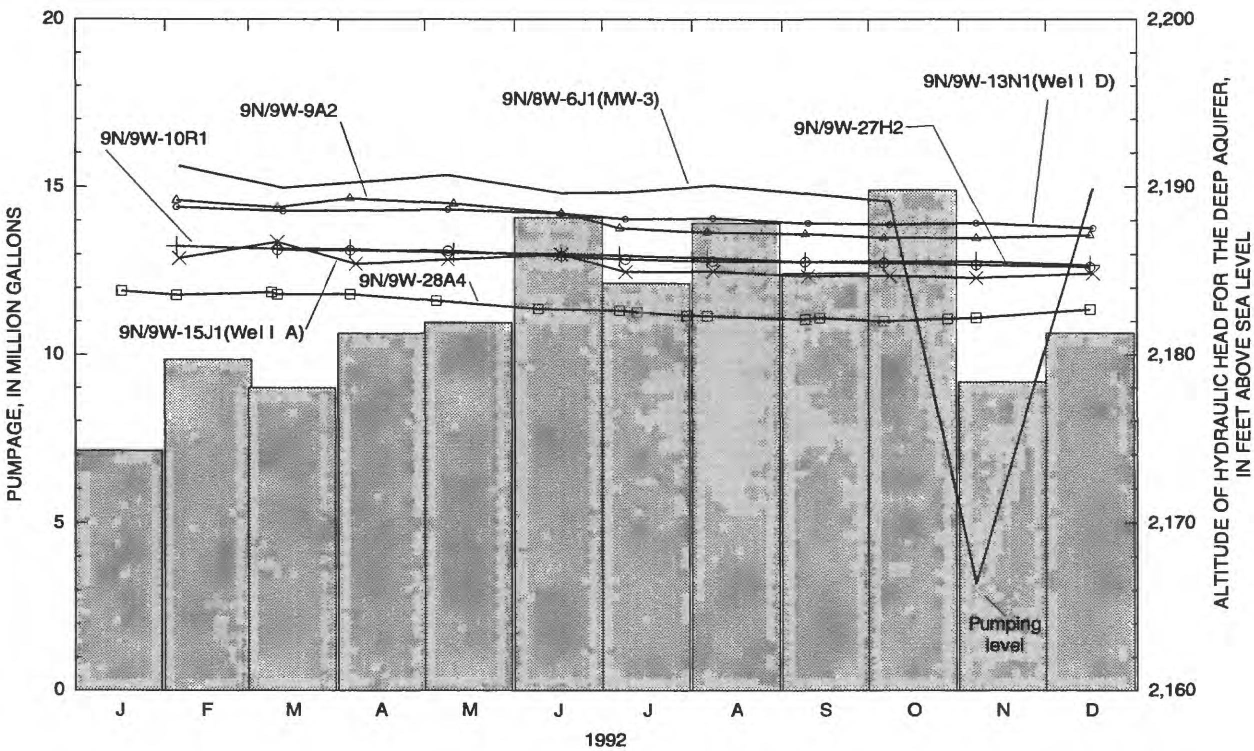


Figure 13. Monthly pumpage from and hydraulic heads in wells and selected piezometers in and near the Phillips Laboratory well fields, Edwards Air Force Base, California.

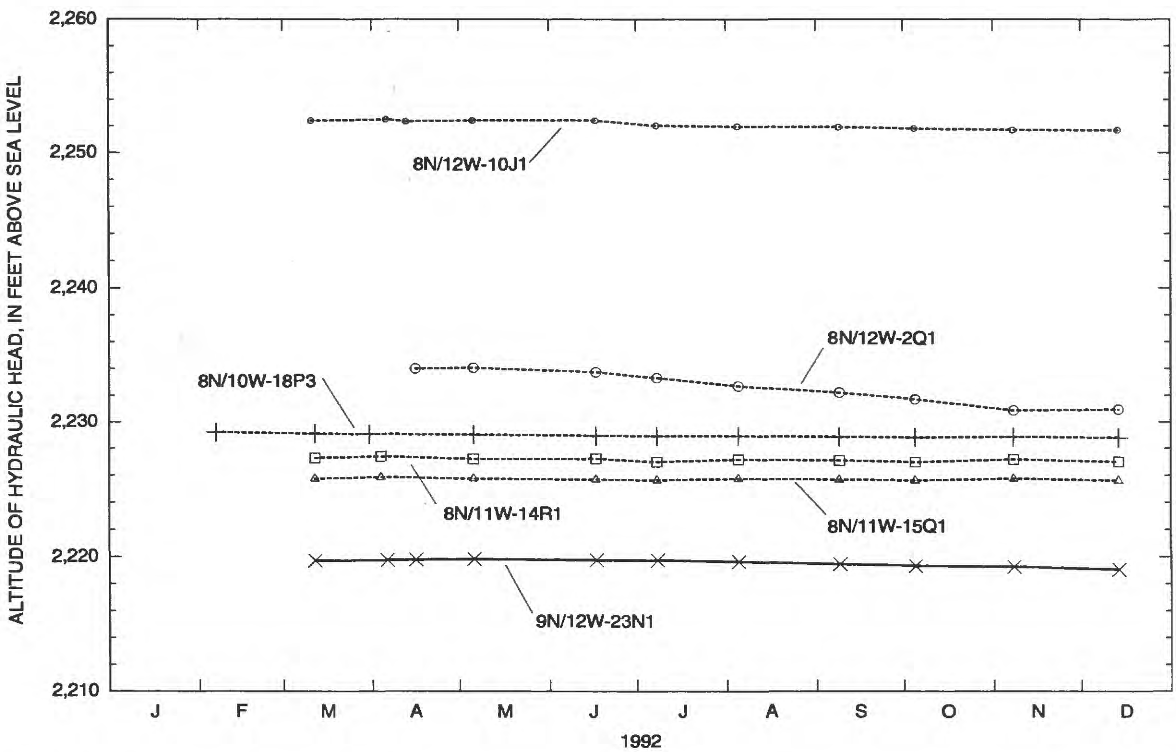


Figure 14. Hydraulic heads in wells south and west of Buckhorn and Rosamond Lakes, Edwards Air Force Base, California.

the increase in pumping. Piezometer 9N/9W-9A2 and well 9N/9W-15J1 seem to be hydraulically connected to well 9N/9W-13N1, and wells 9N/9W-10R1 and -27H2 and piezometers 9N/9W-9A1 and -28A1 do not seem to be connected. This hydraulic connection between the production wells and piezometer 9N/9W-9A2 may be through channelized, unconsolidated, coarse-grained gravel with high transmissivity, while wells 9N/9W-10R1 and -27H1 may be completed in poorly to moderately consolidated, fine-grained sediments that have lower transmissivities. Further study is needed to understand the variability in transmissivities in this area.

Hydraulic Heads in Wells Southeast and West of Rosamond Lake

Wells 8N/10-18P3, 8N/11W-14R1, -15Q1, 8N/12N-2Q1, and -10J1 (fig. 5) are completed in the principal aquifer (table 1). Hydraulic heads in wells 8N/10W-18P3, 8N/11W-14R1 and -15Q1, and 8N/12W-10J1 (fig. 14) remained relatively static from February and March 1992 through December 1992. Head in well 8N/12W-2Q1 declined about 3 ft from April to November (table 2).

Well 9N/12W-23N1 is near the northwest shore of Rosamond Lake (fig. 5). The location and depth to water of this well suggest that it is completed in the deep aquifer (tables 1 and 2). Heads in this well declined about 0.66 ft between March and December 1992 (table 2, fig. 14). Figure 14 shows heads in well 9N/12W-23N1 relative to those in wells 8N/12W-2Q1 and -10J1, 3 and 3.5 mi south, respectively, which are completed in the principal aquifer. Historical records indicate that heads in well 9N/12W-23N1 were similar to heads in wells 8N/12W-2Q1 and -10J1 in the late 1950's and early 1960's. The rate of head decline in wells 8N/12W-2Q1 and -10J1 slowed in the early 1970's and then leveled off in the early 1980's (Londquist and others, 1993, fig. 17). This leveling off corresponds to a decline in agricultural activities in the valley. Heads in well 9N/12W-23N1 continued to decline in the deep aquifer. In 1992, heads in well 9N/12W-23N1 were about 13 and 33 ft lower than those in wells 8N/12-2Q1 and -10J1, respectively (fig. 14). Lack of sufficient recharge, recharge capture, and increased pumping from the deep aquifer for public and industrial supply may explain the steady decline in heads in the deep aquifer. Continued monitoring and analysis of head levels in these wells may help determine the cause of the declining heads, as well as document short- and long-term changes in the aquifer system.

BASIN BOUNDARIES

Three types of no-flow boundaries have been identified for the aquifer system at EAFB: structural boundaries, a principal-aquifer boundary, and ground-water divides (fig. 3). A no-flow boundary is a specialized constant-flux boundary where flux is zero and is typified by a region across which ground water neither enters nor leaves the aquifer system. Structural boundaries are juxtaposed bedrock-alluvium or consolidated-unconsolidated alluvium. In the Lancaster subbasin near EAFB, flow in the deep aquifer is defined by structural boundaries and a ground-water divide. The principal-aquifer boundary is the contact between relatively thick, very fine-grained, low-permeability, lacustrine material of the confining unit and coarse-grained alluvium of the principal aquifer. The principal-aquifer boundary controls ground-water flow in the principal aquifer. The confining unit separates the principal and the deep aquifers of the Lancaster subbasin. Permeability contrasts across structural and principal-aquifer boundaries generally are greater than several orders of magnitude. A ground-water divide is a ridge of relatively high hydraulic heads in the aquifer along which hydraulic heads are equal and from which ground water flows in opposite directions. The ground-water divide controls ground-water flow in the deep aquifer between the Lancaster and North Muroc subbasins. Boundary conditions were determined using surface and borehole geophysical data, lithologic logs, and ground-water-level data. Table 4 lists the altitudes of the confining-unit interval and bedrock-alluvium contacts of the wells used in this study.

Structural Boundaries

The structural boundaries to the south and southeast of Rogers Lake and north of the Phillips Laboratory well fields (fig. 5) are bedrock-alluvium contacts. These boundaries were defined using isostatic residual gravity data (John Mariano, U.S. Geological Survey, written commun., 1991). Lithologic logs for wells 10N/8W-32R1 and 9N/8W-6J1 show

Table 4. Altitudes of confining-unit interval and bedrock-alluvium contacts for wells on and near Edwards Air Force Base, California

[State well No.: See well-numbering diagram on page V. See figure 5 for location of wells. Altitude of confining-unit interval and bedrock-alluvium contact in feet above sea level. (U.S. Army Corp of Engineers, 1961; Dutcher and others, 1962; Dutcher and Worts, 1963; Londquist and others, 1993; Rewis, 1993]

State well No.	Altitude of confining-unit interval	Altitude of bedrock-alluvium contact
8N/9W-6D1	2,137 - 2,247	
8N/10W-1Q1	2,052 - 2,212	
-1Q2	2,052 - 2,212	
-1Q3	2,052 - 2,212	
-1Q4	2,052 - 2,212	
-4R1	2,071 - 2,261	
-4R2	2,071 - 2,261	
-4R3	2,071 - 2,261	
-4R4	2,071 - 2,261	
-8J1[1]	1,991 - 2,100	
-17J2[1]	([2]) - 2,129	
-18N1[1]	([2]) - 2,059	
-19N2[1]	1,927 - 2,072	
-28A1[1]	([2]) - 2,083	
-30R1[1]	1,706 - 2,104	
8N/11W-9D1[1]	1,976 - 2,176	
-10E1[1]	1,937 - 2,274	
-22P2[1]	([2]) - 2,115	
8N/12W-13D1[1]	1,887 - 2,283	
-14R1[1]	1,911 - 2,291	
-24P1[1]	1,646 - 2,234	
9N/8W-6J1		2,024
9N/9W-6C1[1]		2.179
-6E1[1]		2,208
-6L1[1]		2,151
-9A1	2,196 - 2,271	
-9A2	2,196 - 2,271	
-28A1	2,186 - 2,271	
-28A2	2,186 - 2,271	
-28A3	2,186 - 2,271	
-28A4	2,186 - 2,271	
9N/10W-12R1[1]		2,032
-14C1[1]	2,218 - 2,204	2,204
-16F1		2,190
-16L3		2,073
-16N1		1,936
-24C1	2,193 - 2,238	
-24E1	1,788 - 1,822	
-25P1	2,169 - 2,269	
-27P1	2,239 - 2,278	
-27P2	2,239 - 2,278	
-28H3	2,277 - 2,288	2,025
-28H4	2,277 - 2,288	2,025
-34P3[1]	2,150 - 2,295	
-34R2	2,145 - 2,190	
-34R3	2,145 - 2,190	
-34R4	2,145 - 2,190	
-36J1	2,143 - 2,233	
-36J2	2,143 - 2,233	
-36J3	2,143 - 2,233	
-36P2	2,135 - 2,270	
9N/12W-26Q1[1]	2,171 - 2,284	
-28F3[1]	2,254 - 2,324	
10N/8W-32R1[1]		2,336
10N/9W-4D1	([2]) - 1,867	
-27C1	2,242 - 2,272	2,082
-27C2	2,242 - 2,272	2,082
-27C3	2,242 - 2,272	2,082
-31C1[1]		2,118
-31C4[1]		2,155
-31N1[1]		2,212

[1]Wells not monitored for this study.

[2]Altitude of lower contact unknown.

bedrock altitudes of 2,336 and 2,024 ft above sea level, respectively (table 4). The difference in land-surface altitude between these two wells is about 56 ft (table 1); the difference in bedrock altitude is about 312 ft. This difference indicates a structural boundary, probably a fault, between these wells.

Isostatic residual gravity data also were used to define the structural boundary south of the Rosamond and Bissell Hills (fig. 3) (John Mariano, U.S. Geological Survey, written commun., 1991). This boundary strikes southwest-northeast from the eastern shore of Rosamond Lake to Buckhorn Lake and coincides with the northwestern boundary of the Antelope Valley Fault Zone defined by Gary Dixon (U.S. Geological Survey, written commun., 1993) (fig. 3). This boundary juxtaposes younger, more permeable alluvium on the south against older, less permeable alluvium on the north. Dibblee (1960) describes this older alluvium as a fanglomerate of early Pleistocene age.

The structural boundary extends across Buckhorn Lake and along the southeastern edge of Hospital Ridge and juxtaposes the granitic bedrock of Hospital Ridge against younger alluvium of the basin (Dibblee, 1960). Monthly heads in well 9N/10W-28F2 (fig. 11) were similar to heads in wells 9N/10W-16N1 and -16M1 (fig. 12) to the north, near the Graham Ranch well field, but were about 45 to 50 ft higher than those in piezometers 8N/10W-5A4, 9N/10W-27P3, -28H4 and -34R4 to the south and east (fig. 11), indicating well 9N/10W-28F2 is north of the structural boundary.

From Hospital Ridge, the structural boundary strikes northward (fig. 3), crosses the buried Bissell Hills-El Mirage Fault (Gary Dixon, U.S. Geological Survey, written commun., 1993) and then parallels exposed bedrock west of Rogers Lake. Lithologic logs indicate that the altitudes of the bedrock-alluvium contact in wells 9N/9W-6E1 and 10N/9W-31N1 are about 2,200 and 2,212 ft above sea level, respectively (table 4). The altitudes of the bedrock-alluvium contact for wells 9N/9W-6C1 and -6L1, 9N/10W-12R1, and 10N/9W-31C1 are about 2,179, 2,151, 2,032, and 2,118 ft above sea level, respectively. Wells 9N/9W-6A1 and 10N/9W-31C4 did not penetrate bedrock. The structural boundary is interpreted to be between wells 10N/9W-31N1 and 9N/9W-6C1, between wells 9N/9W-6E1 and -6L1, west of well 10N/9W-31C1, and northwest of well 9N/10W-12R1. The position of the structural boundary west and northwest of the North Base well field is unknown because of a lack of data.

Principal-Aquifer Boundary

The principal aquifer is defined primarily by the principal-aquifer boundary. This boundary is the contact between the principal aquifer and the underlying fine-grained confining unit (fig. 4) and part of a structural boundary. The confining unit is assumed to be relatively impermeable both laterally and vertically in relation to the aquifers. Ground-water-level data (table 2) and lithologic data (table 4) were used to determine the position of the principal-aquifer boundary (fig. 3). Wells 8N/10-8J1 and -18P3; 8N/11W-14R1 and -15Q1; 8N/12W-2Q1, -10J1, -24P1, -26F1, and -28D1; and 9N/12W-33P1, south and southwest of Rosamond and Buckhorn Lakes, were completed in the principal aquifer above or several feet into the confining unit and south of the principal-aquifer boundary. The deep aquifer is confined in this region. The confining unit is at or near land surface in wells or piezometers 8N/10W-4R1, 8N/11W-10E1, 8N/12W-13D1 and -14R1, and 9N/12W-26Q1 and -28F3. The altitude of the confining-unit interval in well 8N/10W-8J1 south of the principal-aquifer boundary was 1,991 to 2,100 ft above sea level; in piezometer 8N/10W-4R1 north of the principal-aquifer boundary, the altitude of the confining-unit interval was 2,071 to 2,261 ft above sea level (table 4). The bottom contact of the confining unit comes to the surface near the south-central part of Rogers Lake (fig. 3). North of the South Track well field, the deep aquifer of the Lancaster subbasin is considered unconfined.

Ground-Water Divide

A ground-water divide, oriented east-west across the north-central part of Rogers Lake (fig. 3), separates the Lancaster and North Muroc subbasins and prevents ground water from flowing northward into, or southward out of, the North Muroc subbasin. The location of this divide may not be static, but probably migrates north and south over time in response to seasonal and long-term changes in ground-water levels in the Lancaster and North Muroc subbasins. Heads in piezometers 10N/9W-27C1 and -27C2 were about 2,193 ft above sea level, about 5 to 9 ft higher than heads in piezometers 9N/9W-9A1 and -9A2 to the south and about 10 to 11 ft higher than heads in piezometers 10N/9W-10B1 and -10B2 to the north (fig. 6*K*-6*M*).

The ground-water divide corresponds to a bedrock ridge of unknown extent and depth buried under relatively thin alluvium and playa sediments (L.C. Dutcher, U.S. Geological Survey, written commun., 1959; Bloyd, 1967). Quartz monzonite is exposed at the playa surface of Rogers Lake in the southeast corner of T. 10 N., R. 9 W. (sec. 20) (Dibblee, 1960, pl. 8). The borehole for piezometers 10N/9W-27C1 through -27C3, about 1.5 mi east-southeast of the quartz monzonite outcrop, penetrated granitic bedrock at 190 ft below the playa surface (Rewis, 1993). Drill cuttings from depths greater than 190 ft below land surface were very fine- to very coarse-grained, very angular fragments of feldspar and quartz (Rewis, 1993). Interpretation of refraction data collected during a seismic survey near piezometers 10N/9W-27C1 through -27C3 indicated a near horizontal alluvium-bedrock contact about 200 ft below land surface (David Berger, U.S. Geological Survey, written commun., 1992). This alluvium-bedrock contact, a slow drilling rate, and borehole resistivity values greater than 150 ohm-meters (Rewis, 1993) corroborate the existence of a buried ridge and help to determine the lateral extent and depth of the ridge.

Contrary to the evidence mentioned above, an interpretation of data collected during a direct current resistivity survey on Rogers Lake near the ground-water divide indicates that the depth to high-resistivity bedrock materials is about 2,300 to 2,900 ft below land surface (Zhody and Bisdorf, 1991). This resistivity data suggests that the bedrock outcrop and the material encountered during drilling may be large granitic boulders in the alluvium, but does not explain the distinct and extensive seismic-velocity contrast at 200 ft below land surface. This contrast may result because the material below 200 ft is fractured, highly weathered, altered or saturated bedrock. The exposed bedrock in the surrounding area is extensively faulted and highly weathered, and there are volcanic and hydrothermal alterations of sediments and bedrock to the north of Rogers Lake, which could account for the lower resistivites of the material at depths.

The Graham Ranch well field (fig. 5) is south of the Bissell Hills and northwest of Hospital Ridge. Bloyd (1967) and Duell (1986) considered this area to be part of the deep aquifer in the Lancaster subbasin. The Graham Ranch well field is separated topographically from Rogers Lake by the exposed bedrock of Hospital Ridge. Land-surface altitudes in this well field are about 40 to 50 ft higher than the playa surface of Rogers Lake. The aquifer in the Graham Ranch well field is unconfined and probably is isolated from the deep and principal aquifers. Hydraulic heads are higher than those in the deep aquifer and lower than those in the principal aquifer. Heads range from about 2,200 to 2,215 ft above sea level (fig. 12). The boundaries of this basin are irregularly shaped bedrock-alluvium contacts. The altitudes of the bedrock-alluvium contact in wells 9N/10W-16F1, -16L3, and -16N1 are 2,190, 2,073, and 1,936 ft above sea level, respectively (table 4). Wells 9N/10W-16P1, -16L2, -16R1, and -16R4 were drilled deeper (table 1) (Dutcher and others, 1962; Londquist and others, 1993), not penetrating bedrock. The absence of bedrock in these four wells indicates the presence of a small, possibly narrow, down-dropped basin, or graben, with a minimum of 460 ft of normal slip. This graben may be the result of the release of extensional stresses related to the Antelope Valley Fault Zone (fig. 2).

The Antelope Valley Fault Zone is a zone of left lateral strike slip faulting, with oblique dip-slip down to the southwest (Gary Dixon, U.S. Geological Survey, written commun., 1993). For the depth and configuration of this basin, the reader is referred to Londquist and others (1993). Gravity and surface-resistivity data (Zhody and Bisdorf, 1990; J. Mariano, R.C., Joahens, and R.L. Morin, U.S. Geological Survey, written commun., 1991) indicate that there may be a hydraulic connection to the deep aquifer between the bedrock ridges, possibly through buried drainage channels, although this has yet to be verified (Londquist and others, 1993).

Water levels were used to identify a small north-south trending ground-water divide in the Graham Ranch well field near piezometers 9N/10W-16R1 through -16R3. The borehole for the piezometers was drilled to 960 ft below land surface and did not penetrate bedrock (Londquist and others, 1993). This ground-water divide is caused by two pumping centers around EAFB production wells 9N/10W-16P1 (C-3) and 9N/10W-16R4 (C-4).

SEASONAL POTENTIOMETRIC SURFACES

A potentiometric surface is defined as an imaginary surface represented by hydraulic heads in wells and piezometers completed in an aquifer. For a confined aquifer, the potentiometric surface is above the base of a confining unit and is represented by the level to which water would rise in an open well penetrating the confined aquifer. For an unconfined aquifer, the potentiometric surface is the water table where ground-water pressures generally are the same as atmospheric pressure. For the purposes of this study, the heads of perched aquifers were not used to define the potentiometric surfaces because the water is trapped above the true water table by a lens of material with low permeability.

The purpose of mapping potentiometric surfaces is to provide a visual interpretation of the areal extent and generalized ground-water-flow paths of the aquifer system. Hydraulic heads in EAFB production wells, abandoned wells, and one piezometer from each of the USGS piezometer sites were used to contour the potentiometric surfaces (figs. 15 through 18, at back of report). Table 5 lists the hydraulic heads and changes in head used in this interpretation. The head values were rounded to the nearest tenth of a foot.

Several factors were used in the determination of the potentiometric surfaces of the aquifer system at EAFB. Pumping centers on the base were identified. Domestic and public supply wells in and near the town of Rosamond (fig. 2) and agricultural irrigation wells south of Redman also were considered because of their influence on the ground-water-flow paths and changes to the potentiometric surfaces. To project contours south and west of the base boundary (figs. 15 through 18), hydraulic heads were calculated for the principal and deep aquifers using spring ground-water-level measurements (tables 2 and 5) for wells monitored by the USGS as part of the Antelope Valley-East Kern Water Agency ground-water-monitoring program.

Changes in the Potentiometric Surfaces

Changes in the potentiometric surfaces of the aquifer system at EAFB were relatively small in 1992. Hydraulic head contours for spring 1992 ranged from about 2,160 to 2,220 ft above sea level in the deep aquifer and 2,200 to 2,280 ft above sea level in the principal aquifer in the Lancaster subbasin; 2,180 to 2,190 ft above sea level in the North Muroc subbasin; and 2,210 to 2,290 ft above sea level in the Graham Ranch well-field area (figs. 3 and 15-18). Figure 19 shows contours for changes in hydraulic head for spring to late summer 1992 for wells completed in the deep aquifer (table 5). Changes in head for five wells completed in the principal aquifer (not illustrated) were less than 2 ft (table 5). Figure 20 is generalized geologic cross sections showing hydraulic heads in selected wells and piezometers for sections shown on figure 15.

Deep Aquifer

In the areas between and adjacent to the South Track, South Base, and Branch Park well fields, the potentiometric surface of the deep aquifer for spring 1992 ranged from 2,160 to 2,180 ft above sea level forming a shallow regional ground-water depression (fig. 15). This depression is oriented along a southwest-northeast trending axis similar to the trend of maximum measured subsidence reported by Londquist and others (1993, fig. 21).

In spring 1992, the deep aquifer was confined in the South Track well field. A small, shallow, local ground-water depression formed around well 9N/10W-34P3 in the Branch Park well field in response to pumping (table 3, figs. 15 and 20). In May, the South Track well field began pumping almost continuously. Between April and September, the potentiometric surface had declined about 10 ft in the South Track well field, about 3 ft in the South Base well field, and about 8 ft in the Branch Park well field (table 5, fig. 19). Because of a 10-foot decline in the potentiometric surface in the South Track well field by late summer and 20- to 30-foot drawdowns in production wells 8N/10W-1C2 and 9N/10W-36F1 and -36P1 (table 5, fig. 8), water-levels dropped below the bottom of the confining unit, which resulted in the deep aquifer becoming locally unconfined near the wells (figs. 8 and 20). The configuration of the potentiometric surface of the deep aquifer south and southwest of EAFB is unknown (figs. 15 and 16).

Change in hydraulic heads from spring to late summer in and near the Phillips Laboratory and North Base well fields were 0 to 2 ft and 2 to 3 ft, respectively (fig. 19). Heads near the ground-water divide

Table 5. Hydraulic heads and change in hydraulic heads for selected wells and piezometers used to plot the potentiometric surfaces of the aquifer system at Edwards Air Force Base, California, 1992

[State well No.: See well-numbering system on page V. See figures 15 through 18 for locations of wells. Hydraulic head, in feet, computed from land-surface altitude and depth to water (table 2), rounded to nearest tenth of a foot. Div., at the ground-water divide; ft, foot; do., ditto; --, data not available]

State well No.	Subbasin	Hydraulic head, spring		Hydraulic head, late summer		Change in hydraulic head (ft)
		Date	Head	Date	Head	
Completed in deep aquifer						
8N/10W-1C2	Lancaster	4-07-92	2,163.0	9-09-92	2,149.1	13.9
-1Q3	do.	4-04-92	2,165.2	9-09-92	2,156.0	9.2
-4R4	do.	4-05-92	2,169.4	9-09-92	2,166.1	3.3
-5A4	do.	3-31-92	2,162.8	9-09-92	2,160.2	2.6
-30R1[1]	do.	4-14-92	2,217.4	--	--	--[2]
9N/8W-6J1	do.	3-31-92	2,190.0	9-09-92	2,190.0	0
9N/9W-9A2	do.	4-05-92	2,189.3	9-09-92	2,187.2	2.1
-10R1	do.	4-05-92	2,186.7	9-09-92	2,186.0	.7
-13N1	do.	3-13-92	2,188.6	9-10-92	2,187.9	.7
-15J1	do.	4-07-92	2,185.4	9-10-92	2,184.7	.7
-18C1	do.	4-05-92	2,179.0	9-09-92	2,177.8	1.2
-27H2	do.	4-05-92	2,186.3	9-09-92	2,185.6	.7
-28A4	do.	4-05-92	2,183.7	9-09-92	2,182.1	1.6
9N/10W-24C1	Lancaster	4-05-92	2,167.1	9-09-92	2,164.4	2.7
-24E1	do.	4-05-92	2,160.3	9-09-92	2,143.5[3]	16.8
-25P1	do.	4-07-92	2,163.9	9-09-92	2,154.4	9.5
-27P3	do.	--[4]	--[4]	9-07-92	2,157.0	--[2]
-28F2	do.	4-04-92	2,203.3	9-07-92	2,203.1	.2
-28H4	do.	--[4]	--[4]	9-07-92	2,156.7	--[2]
-34R4	do.	4-05-92	2,159.6	9-07-92	2,153.5	6.1
-36F1	do.	4-07-92	2,163.3	9-09-92	2,152.1	11.2
-36J2	do.	4-07-92	2,163.6	9-09-92	2,151.2	12.4
-36P1	do.	4-07-92	2,162.8	9-09-92	--[5]	--[2]
-36P2	do.	4-07-92	2,163.4	9-09-92	2,149.1	14.3
9N/11W-36L1	do.	4-06-92	2,197.0	9-07-92	2,189.2	7.8
9N/12W-23N1	do.	4-06-92	2,219.8	9-09-92	2,219.5	.3
10N/9W-4D1	North Muroc	4-05-92	2,177.0	9-10-92	2,174.7	2.3
-10B1	do.	4-05-92	2,182.8	9-10-93	2,182.5	.3
-24A2	do.	4-05-92	2,196.0	9-10-92	2,195.6	.4
-27C2	Div.	4-05-92	2,193.3	9-09-92	2,193.0	.3
11N/9W-32Q1	North Muroc	4-05-92	2,175.2	9-10-92	2,171.9	3.3
-36R1	do.	4-04-92	2,189.9	9-10-92	2,189.8	.1

Footnotes at end of table.

Table 5. Hydraulic heads and change in hydraulic heads for selected wells and piezometers used to plot the potentiometric surfaces of the aquifer system at Edwards Air Force Base, California, 1992--*Continued*

State well No.	Subbasin	Hydraulic head, spring		Hydraulic head, late summer		Change in hydraulic head (ft)
		Date	Head	Date	Head	
Completed in principal aquifer						
8N/10W-18P3	Lancaster	3-31-92	2,229.1	9-09-92	2,228.9	0.2
-28B1[1]	do.	4-15-92	2,206.9	--	--	--[2]
8N/11W-14R1	do.	4-04-92	2,227.4	9-09-92	2,227.1	.3
-15Q1	do.	4-04-92	2,225.9	9-09-92	2,225.7	.2
-22P2[1]	do.	4-14-92	2,223.2	--	--	--[2]
-24R2[1]	do.	4-14-92	2,227.4	--	--	--[2]
-34D2[1]	do.	4-15-92	2,217.4	--	--	--[2]
-34R2[1]	do.	4-15-92	2,226.8	--	--	--[2]
8N/12W-2Q1	do.	4-06-92	2,234.8	9-09-92	2,232.0	2.8
-10J1	do.	4-06-92	2,252.5	9-09-92	2,251.9	.6
-26F1[1]	do.	4-13-92	2,279.5	--	--	--[2]
-28D1[1]	do.	4-13-92	2,248.9	--	--	--[2]
-34K1[1]	do.	4-13-92	2,259.5	--	--	--[2]
9N/12W-33P1[1]	do.	4-16-92	2,235.4	--	--	--[2]
Completed in the unconfined aquifer						
9N/10W-8P1	Unnamed	4-05-92	2,289.0	9-08-92	2,289.0	0
-16F1	do.	4-05-92	2,209.4	9-07-92	2,209.7	-.3
-16L1	do.	4-05-92	2,203.2	9-08-92	2,201.8	1.4
-16L2	do.	4-05-92	2,206.8	9-07-92	2,205.9	.9
-16L3	do.	4-05-92	2,205.9	9-07-92	2,206.1	-.2
-16M1	do.	4-05-92	2,203.7	9-07-92	2,203.4	.3
-16N1	do.	4-05-92	2,203.7	9-07-92	2,203.5	.2
-16P1	do.	4-05-92	2,203.3	9-07-92	2,202.1	1.2
-16R3	do.	3-30-92	2,211.0	9-07-92	2,208.3	2.7
-16R4	do.	4-05-92	2,208.5	10-06-92	2,205.6	2.9

[1]Wells monitored annually for Antelope Valley-East KErn Water Agency (Johnson and Fong-Frydendal, 1993).
[2]Not able to calculate.
[3]Influenced by pumping from well 9N/10W-24E2.
[4]Drilled in August 1992.
[5]Well pumping.

across Rogers Lake did not measurably change (fig. 19).

In the Graham Ranch well field, hydraulic heads in production wells 9N/10W-16P1 and -16R4 declined 1 and 3 ft, respectively, from spring to late summer (table 5, fig. 19). The north-south, 2,210-foot potentiometric contours that defined the ground-water divide in the spring (fig. 15) merged and were plotted northeast of the well field in late summer (fig. 16).

Principal Aquifer

The potentiometric surface of the principal aquifer near wells 8N/10W-18P3 and 8N/11W-14R1 and -15Q1 was relatively flat (figs. 17 and 18), whereas the slope of the potentiometric surface steepened toward a regional ground-water depression south of Redman (Londquist and others, 1993, fig. 5). Heads in wells 8N/10W-18P3 and 8N/11W-14R1 and -15Q1 changed less than 0.5 ft between April and September (table 5). The potentiometric-surface contours of the principal aquifer southwest of Rosamond Lake ranged from about 2,220 to 2,280 ft above sea level (figs. 17 and 18). Because ground-water levels for wells south of the base were not available, the potentiometric surface of the principal aquifer for late summer is inferred.

Ground-Water Flow

Ground water flows from areas of high hydraulic head to areas of low hydraulic head. Flow may be vertical as well as horizontal. Hydraulic gradient is the ratio of the difference in hydraulic head between two wells and the distance between the wells. Vertical hydraulic gradient is the ratio of the difference in head in nested or clustered wells and the difference in altitude of the midpoint of the screened interval.

Four subregional ground-water-flow directions were identified in the deep aquifer: (1) north and northeast from the Lancaster subbasin to the Branch Park and South Track well fields; (2) south and southwest from the central part of Rogers Lake to the South Base and South Track well fields; (3) west from the alluvial fan upslope (east) of the Phillips Laboratory well fields to Rogers Lake; and (4) north from a ground-water divide in the north-central part of Rogers Lake to the North Base well field (figs. 15 and 16). The spring and late summer hydraulic gradients for these four flow directions are listed in table 6.

Table 6. Hydraulic gradients for four subregional ground-water-flow directions in the deep aquifer at Edwards Air Force Base, California, 1992

Flow direction	Hydraulic gradients, in feet	
	Spring	Late summer
8N/10W-4R4 to 9N/10W-34R4	0.0012	0.0016
9N/9W-28A4 to 9N/10W-36J2	.0011	.0017
9N/9W-13N1 to 9N/9W-15J1	.0005	.0005
10N/9W-10B1 to 10N/9W-4D1	.0006	.0008

Hydraulic heads in the piezometers completed in the deep aquifer (figs. 6*A*, 6*B*, 6*C*, 6*F*, 6*G*, 6*J*, and 6*K*) indicate that the vertical gradient generally is downward from the upper confined zone to the lower confined zone. During the summer pumping season, heads in piezometers near the South Track well field (figs. 6*C*, 6*F*, and 6*G*) indicate that the vertical gradient had reversed at these sites causing upward flow from the lower confined zone to the upper confined zone. This may cause hard, saline type water (Londquist and others, 1993) to move upward from the lower confined zone to the upper confined zone.

EXPLANATION FOR FIGURE 19

PLAYA SURFACE

ALLUVIUM

BEDROCK

·········· GROUND-WATER DIVIDE

— S — STRUCTURAL BOUNDARY

— - — EDWARDS AIR FORCE BASE BOUNDARY

— 4 — LINE OF EQUAL HEAD DECLINE-Spring to late summer 1992. Interval 1 foot. Dashed where approximate

24E1 WELL OR PIEZOMETER AND NUMBER-With hydraulic head changes for the deep aquifer

30R1 ○ WELL OR PIEZOMETER AND NUMBER-Not monitored for this study

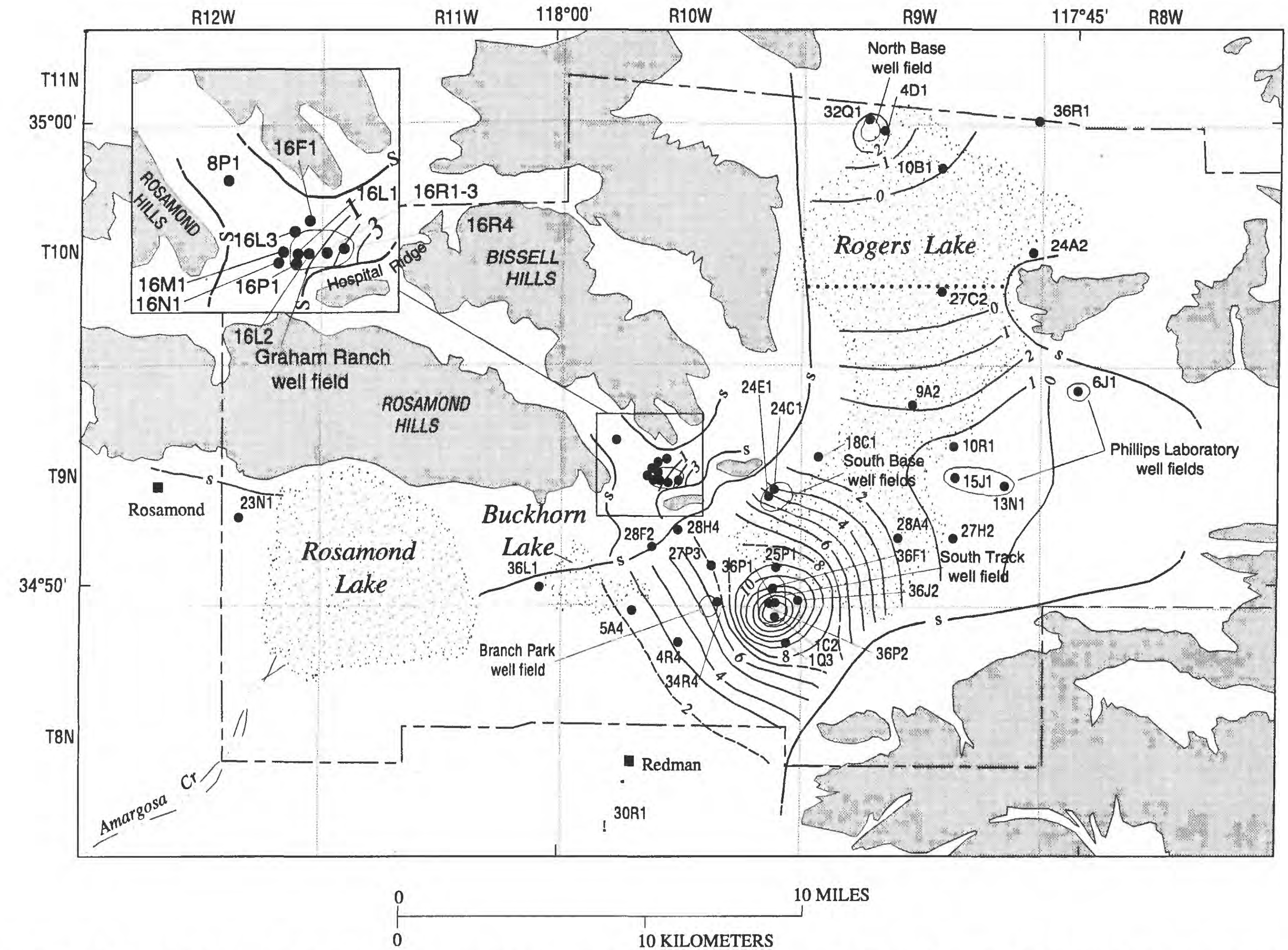


Figure 19. Change in hydraulic head in wells and piezometers completed in the deep aquifer, Edwards Air Force Base, California, spring to late summer 1992. (Base map modified from Dibblee, 1960; Bloyd, 1967; and Londquist and others, 1993.)

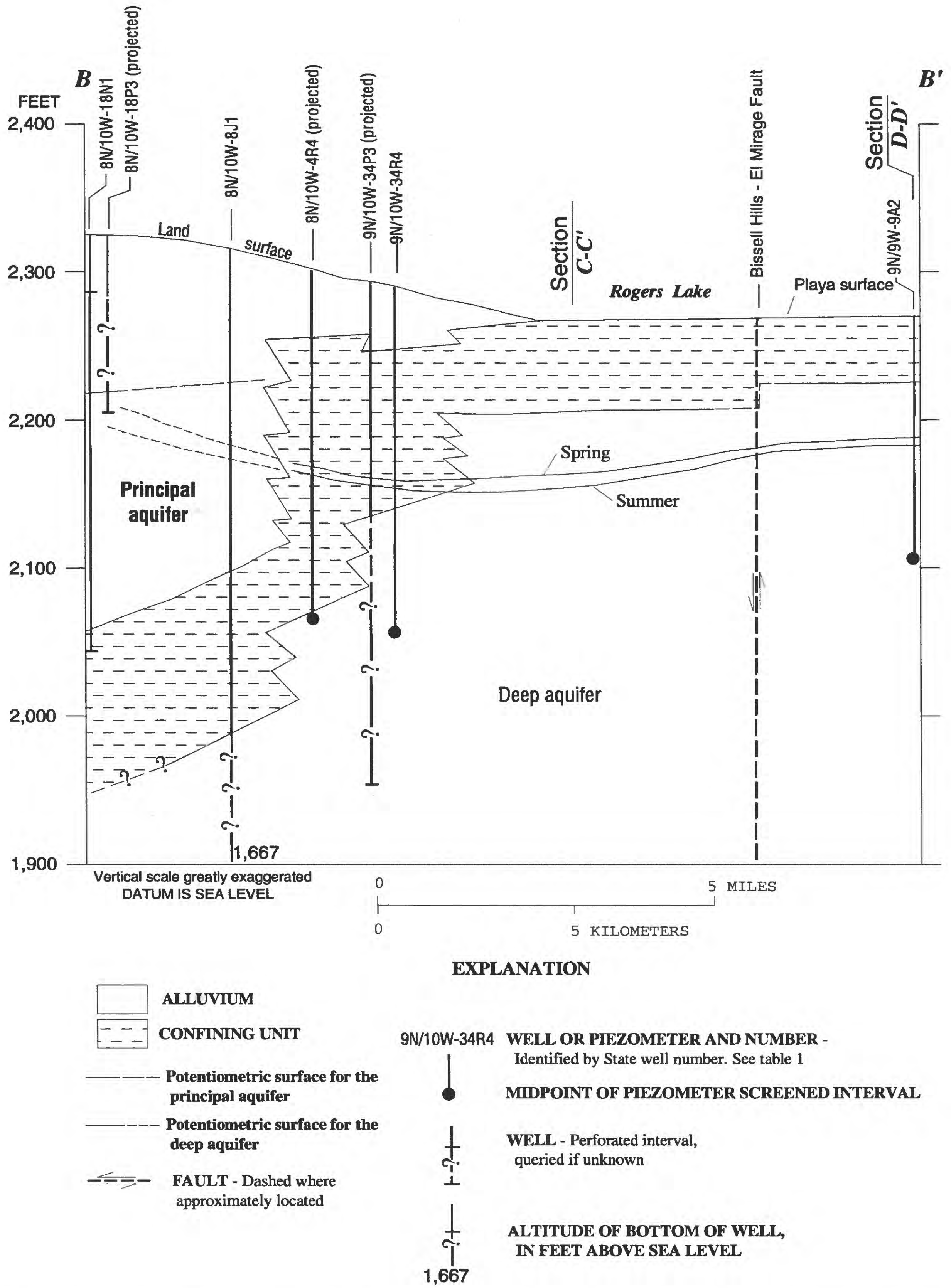


Figure 20. Hydraulic-head profiles for geologic sections *B-B'*, *C-C'* and *D-D'*, Edwards Air Force Base, California.

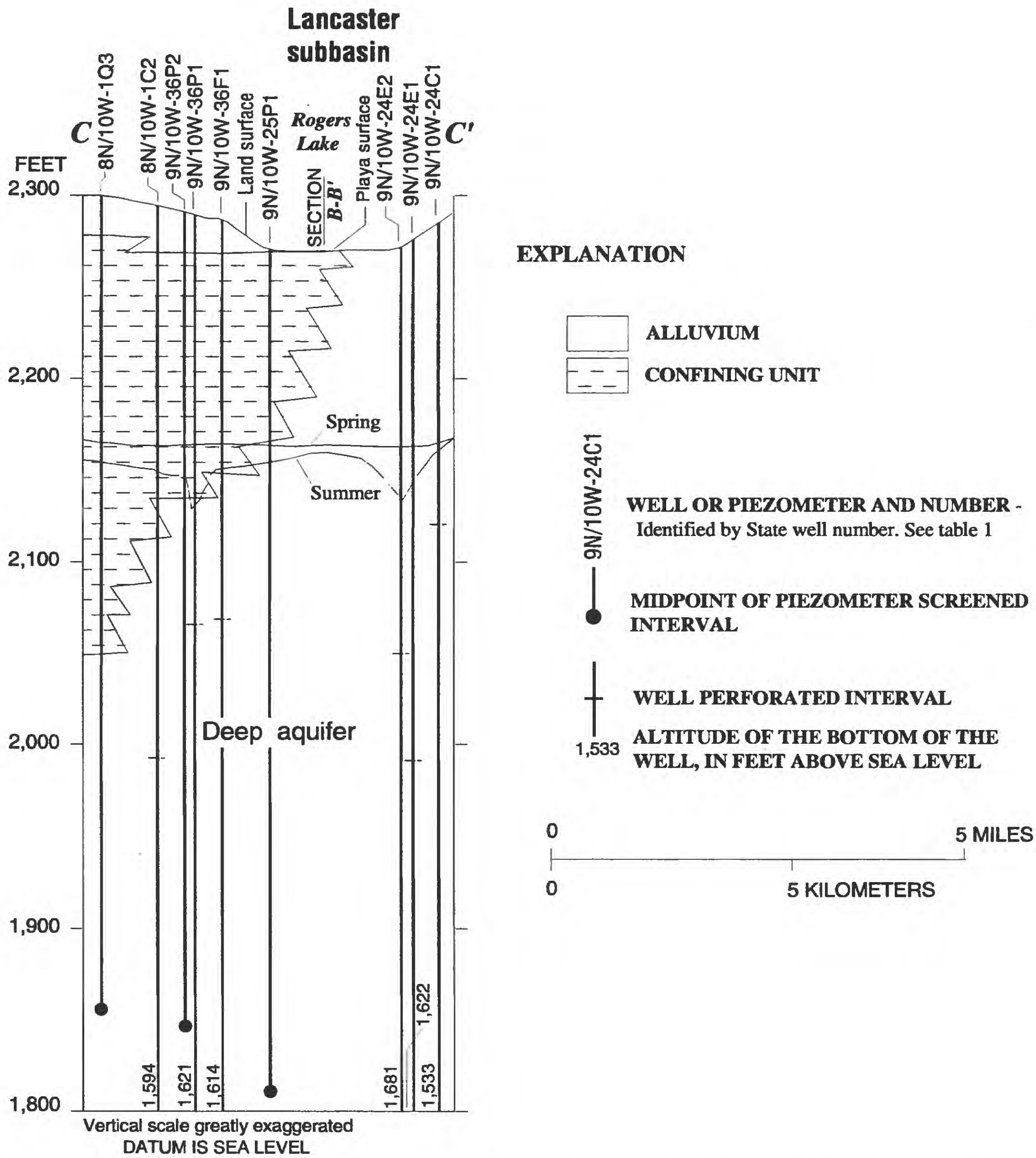


Figure 20. Hydraulic-head profiles for geologic sections *B-B'*, *C-C'* and *D-D'*, Edwards Air Force Base, California--*Continued.*

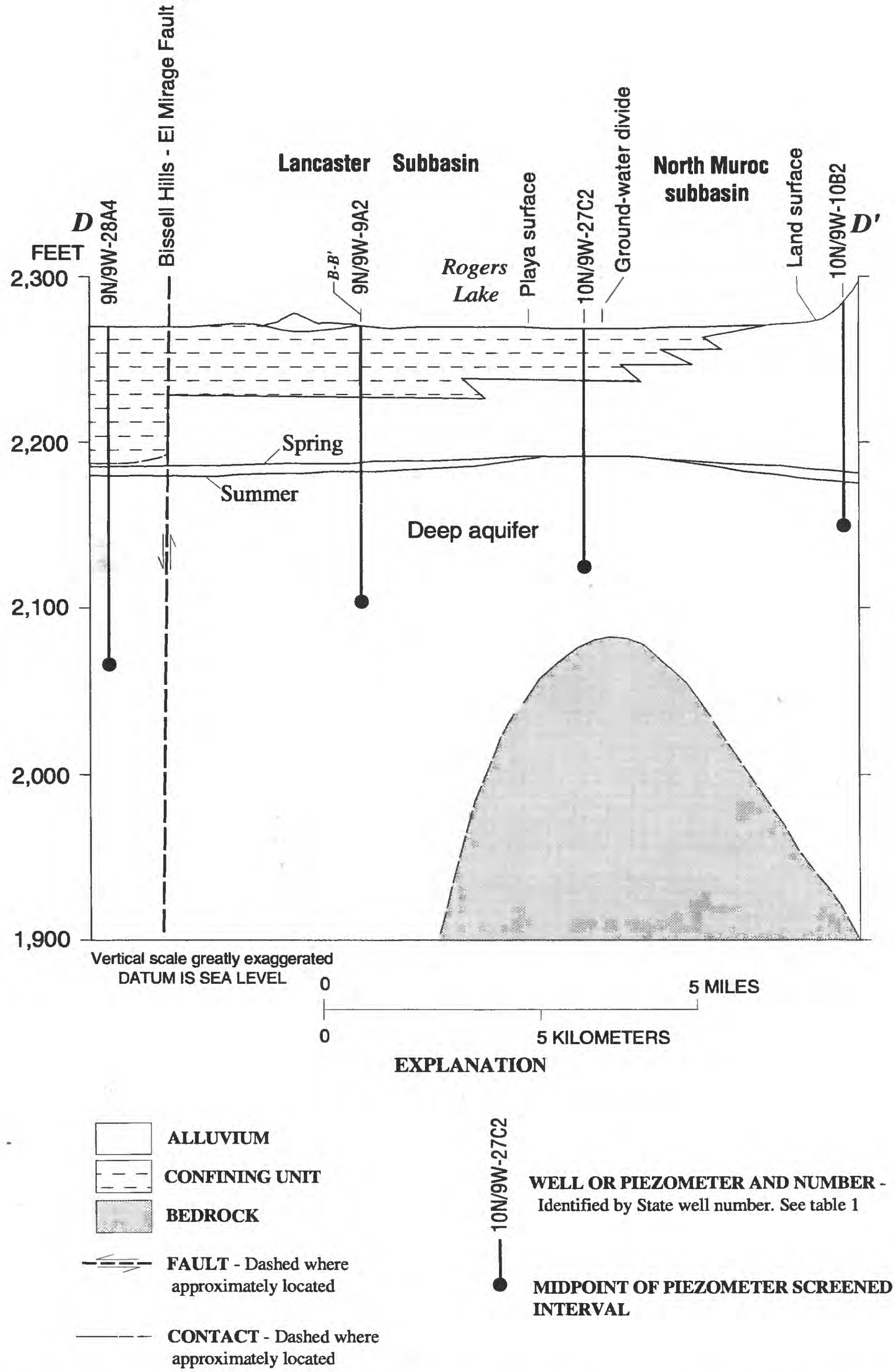


Figure 20. Hydraulic-head profiles for geologic sections *B-B'*, *C-C'* and *D-D'*, Edwards Air Force Base, California--*Continued.*

Johnson (1911) reported that alkali deposition on the playa surface of Rogers Lake possibly was due to ground-water evaporation. Historical evidence of artesian flow in wells completed in the deep aquifer in this area indicated an upward vertical gradient from the deep aquifer through the confining unit (Johnson, 1911). According to historical records for the late 1950's, well 8N/9W-6D1, completed in the confining unit, and wells 9N/9W-27H1 and 9N/10W-24C1, completed in the deep aquifer, had similar water levels—about 20 to 25 ft below land surface (Londquist and others, 1993)—indicating equilibrium between heads in the deep aquifer and heads in the confining unit. In 1992, hydraulic heads in the piezometers completed in the confining unit were higher than those completed in the confined aquifer, indicating that the vertical gradient is now downward from the confining unit to the deep aquifer. Because the vertical gradient between the confining unit and deep aquifer is downward, the confining unit is being dewatered. This dewatering is causing compaction of fine-grained sediments, which, in turn, results in land-surface deformation.

Hydraulic heads in the confining unit south of the principal-aquifer boundary are not known. Further study in this area is needed to determine the vertical gradients between the deep aquifer and the confining unit and between the confining unit and the principal aquifer.

In the area of the Graham Ranch well field, ground water flows toward the pumping centers of production wells 9N/10W-16P1 and -16R4 (figs. 15 and 16). Higher hydraulic heads in the deepest piezometer, 9N/10W-16R1 (fig. 6*N*), and lower hydraulic head in the shallowest piezometer, 9N/10W-16R3, indicate that the vertical hydraulic gradient is upward. Near well 9N/12W-23N1, ground water probably flows westward away from Rosamond Lake (figs. 15 and 16).

In the principal aquifer, ground water flows south and southeastward, away from EAFB and radially from the ground-water mound identified southwest of Rosamond Lake (figs. 17 and 18). The ground-water mound is at the terminus of Amargosa Creek (figs. 17 and 18) where the Los Angeles Sanitation District maintains lagoons that contain treated wastewater that is discharged from their sanitation facilities west of Sierra Highway (fig. 1). This ground-water mound may indicate that surface-water runoff and treated wastewater recharges the principal aquifer at that location. Spring water levels in wells 8N/12W-2Q1, -10J1, -26F1, -28D1, and -34K1 indicate ground water flows south and westward from this mound. Water levels in wells 8N/12W-2Q1 and -10J1 declined less than 2 ft from April to September (table 5, fig. 14), indicating that the principal aquifer may respond to seasonal recharge fluctuations and increased pumping west and southwest of Rosamond during the summer months. Public and private supply wells in this area, which may be screened above and below the confining unit, could affect heads and ground-water flow in both the principal and deep aquifers.

SUMMARY AND CONCLUSIONS

A ground-water-level monitoring program was implemented at Edwards Air Force Base (EAFB), Antelope Valley, California, to monitor spatial and temporal changes in the potentiometric surfaces of the aquifer system that are affected by ground-water pumping. Potentiometric-surface maps are needed to determine the correlation between declining ground-water levels and the distribution of land subsidence. The ground-water-level monitoring program focused on areas of EAFB where ground-water pumping occurs, especially near Rogers Lake. Well-construction, historical water-level, and lithologic data were compiled for 118 wells and piezometers on and near the base, and monthly measurements of ground-water levels were made for 82 wells and piezometers on the base from January to December 1992.

The ground-water-level monitoring program involved three phases of data collection: (1) well canvassing and selection, (2) geodetic surveying to determine vertical datum for each well, and (3) monthly measurements of ground-water levels. Selection of wells used in this monitoring program was based on (1) measurable ground-water levels, (2) accessibility of the wells, (3) proximity to the EAFB well fields and Rogers Lake, (4) proximity to other suitable wells to avoid redundancy, and (5) the position of the screened or perforated interval in the well.

Ground-water levels generally ranged from about 95 to 130 ft below land surface in wells and piezometers in the North Muroc subbasin, 70 to 200 feet below land surface in the deep aquifer in the Lancaster subbasin, 35 to 95 feet below land surface in the principal aquifer in the Lancaster subbasin, and 100 to 125 feet below land surface in or near the Graham Ranch well field. Total hydraulic heads, or heads, were computed using these ground-water levels and land-surface altitudes. Heads generally ranged from about 2,170 to 2,195 feet above sea level in the North Muroc subbasin, 2,150 to 2,200 feet above sea level in the deep aquifer in the Lancaster subbasin, 2,225 to 2,250 feet above sea level in the principal aquifer in the Lancaster subbasin, and 2,200 to 2,215 feet above sea level in the Graham Ranch well field. Heads in wells and piezometers completed in the confining unit ranged from about 2,210 to 2,275 feet above sea level.

Heads for the piezometers completed in the deep aquifer, west, south, east, and in the South Track well field, which were higher than the lower contact of the confining unit, indicate confined, nonflowing, artesian conditions. Heads in piezometers completed in the deep aquifer north of the South Track well field which were lower than the lower contact of the confining unit, indicate locally unconfined aquifer conditions.

Heads in the piezometers completed below 1,500 feet above sea level indicate a delay in response to seasonal recharge and discharge stresses in the aquifer, which, in turn, indicates a poor hydraulic connection between the upper and lower confined zones. This poor hydraulic connection probably is due to the consolidation of the deeper alluvium.

Total pumpage for 1992 from seven well fields on EAFB was about 1,700 million gallons or 5,225 acre-feet. Total pumpage of about 697.3 million gallons, 2,140 acre-feet, from the EAFB production wells in the South Track well field caused heads to decline about 9 to 10 feet. Drawdowns in these wells ranged from about 20 to 30 feet. About 397.2 million gallons, 1,219 acre-feet, was pumped from the North Base well field, lowering heads about 2 to 3 feet. About 379.7 million gallons, 1,165 acre-feet, was pumped from the South Base well field. Large drawdowns of 50 to 130 feet in the South Base wells may indicate low transmissivity, possibly a result of dewatering and compaction of the fine-grained layers.

Boundaries of the aquifer system were determined using surface and borehole geophysical data, lithologic logs, and ground-water-level data. Three types of no-flow boundaries were identified: structural boundaries, a principal-aquifer boundary, and ground-water divides.

Structural boundaries to the south and southeast of Rogers Lake and north of the Phillips Laboratory well field are bedrock-alluvium contacts. Another structural boundary south of the Rosamond and Bissell Hills, striking southwest-northeast from the eastern shore of Rosamond Lake to Buckhorn Lake, is a permeable/less permeable alluvium contact that coincides with the northwestern boundary of the Antelope Valley Fault Zone. The boundary extends across Buckhorn Lake, becomes a bedrock-alluvium boundary along the southeastern edge of Hospital Ridge, then strikes northward, crosses the buried Bissell Hills-El Mirage Fault, and parallels exposed bedrock west of Rogers Lake. The boundary probably continues northward west of the North Base well field, but, because of insufficient data, its position is not known.

Ground-water-level and lithologic data were used to determine the position of the principal-aquifer boundary. The confining unit is at or near land surface in wells or piezometers north of the boundary. South of the boundary, wells generally are completed in the principal aquifer; the deep aquifer is confined. The lateral, northeastern extent of the confining unit is in the south-central part of Rogers Lake. North of the South Track well field, the deep aquifer is unconfined. A ground-water divide strikes east-west across the north-central part of Rogers Lake. The divide separates the Lancaster and North Muroc subbasins and prevents ground water from flowing between the two subbasins. The boundaries of the unconfined aquifer in the Graham Ranch well field are irregularly shaped bedrock-alluvium contacts. A ground-water divide separates the EAFB production wells in this small subbasin.

Hydraulic heads of base production wells, abandoned wells, and one piezometer from each of the USGS piezometer sites were used to contour seasonal potentiometric surfaces of the aquifer system at EAFB. Mapping of the potentiometric surfaces was done to provide a visual interpretation of the areal extent and generalized ground-water-flow paths of the aquifer system. Changes in the potentiometric surfaces of the aquifer system at EAFB were relatively small, with heads ranging from about 2,160 to 2,220 feet above sea level in the deep aquifer and about 2,200 to 2,280 feet above sea level in the principal aquifer in the Lancaster subbasin; about 2,180 to 2,190 feet above sea level in the North Muroc subbasin; and about 2,210 to 2,290 feet in the Graham Ranch well-field area.

The potentiometric surface of the deep aquifer for spring 1992 ranged from 2,160 to 2,180 feet above sea level forming a regional ground-water depression in the areas between, and adjacent to, the South Track, South Base, and Branch Park well fields. By late summer, the potentiometric surface had declined about 10 feet in the South Track well field, about 3 feet in the South Base well field, and about 8 feet in the Branch Park well field. A 10-foot decline in the potentiometric surface and 20- to 30-foot drawdowns in the EAFB production wells caused local, unconfined conditions in the deep aquifer in the South Track well field. The potentiometric surfaces near the Phillips Laboratory and North Base well fields declined about 0 to 3 feet between spring and late summer. The potentiometric surface near the ground-water divide across Rogers Lake did not change measurably. The potentiometric surface in and near the Graham Ranch well field declined 1 to 3 feet.

The potentiometric surface of the principal aquifer near wells along the southern boundary of the base were relatively flat, whereas the slope of the potentio-metric surface steepened toward a regional ground-water depression south of Redman. The potentiometric-surface contours of the principal aquifer southwest of Rosamond Lake ranged from about 2,220 to 2,280 feet above sea level, forming a ground-water mound beneath the terminus of Amargosa Creek where surface-water runoff and treated wastewater discharge probably recharge the principal aquifer. The principal aquifer in this area may respond to both seasonal recharge fluctuations and increased pumping in the Rosamond area during the summer months. The configuration of the potentiometric surface of the deep aquifer south and west of EAFB is unknown.

Four major ground-water-flow directions were identified in the deep aquifer: (1) north and northeast from the Lancaster subbasin to the Branch Park and South Track well fields; (2) south and southwest from the central part of Rogers Lake toward the South Base and South Track well fields; (3) west from the Phillips Laboratory well fields to Rogers Lake, and (4) north from a ground-water divide in the north-central part of Rogers Lake to the North Base well field. Ground-water flow in the area of the Graham Ranch well field is toward the EAFB production wells. Ground-water flow in the principal aquifer is south and southeastward away from EAFB and radially from the ground-water mound southwest of Rosamond Lake. Ground-water flow near well 9N/12W-23N1 probably is westward away from Rosamond Lake.

Vertical head differences in piezometers constructed in the Lancaster and North Muroc subbasins indicate that vertical ground-water flow generally is downward from the upper confined zone into the lower confined zone. In the summer months, increased pumping in the South Track well field caused flow to reverse in the deep aquifer and to move upward from the lower confined zone into the upper confined zone. Vertical head differences in piezometers in the Graham Ranch well field indicate flow is upward.

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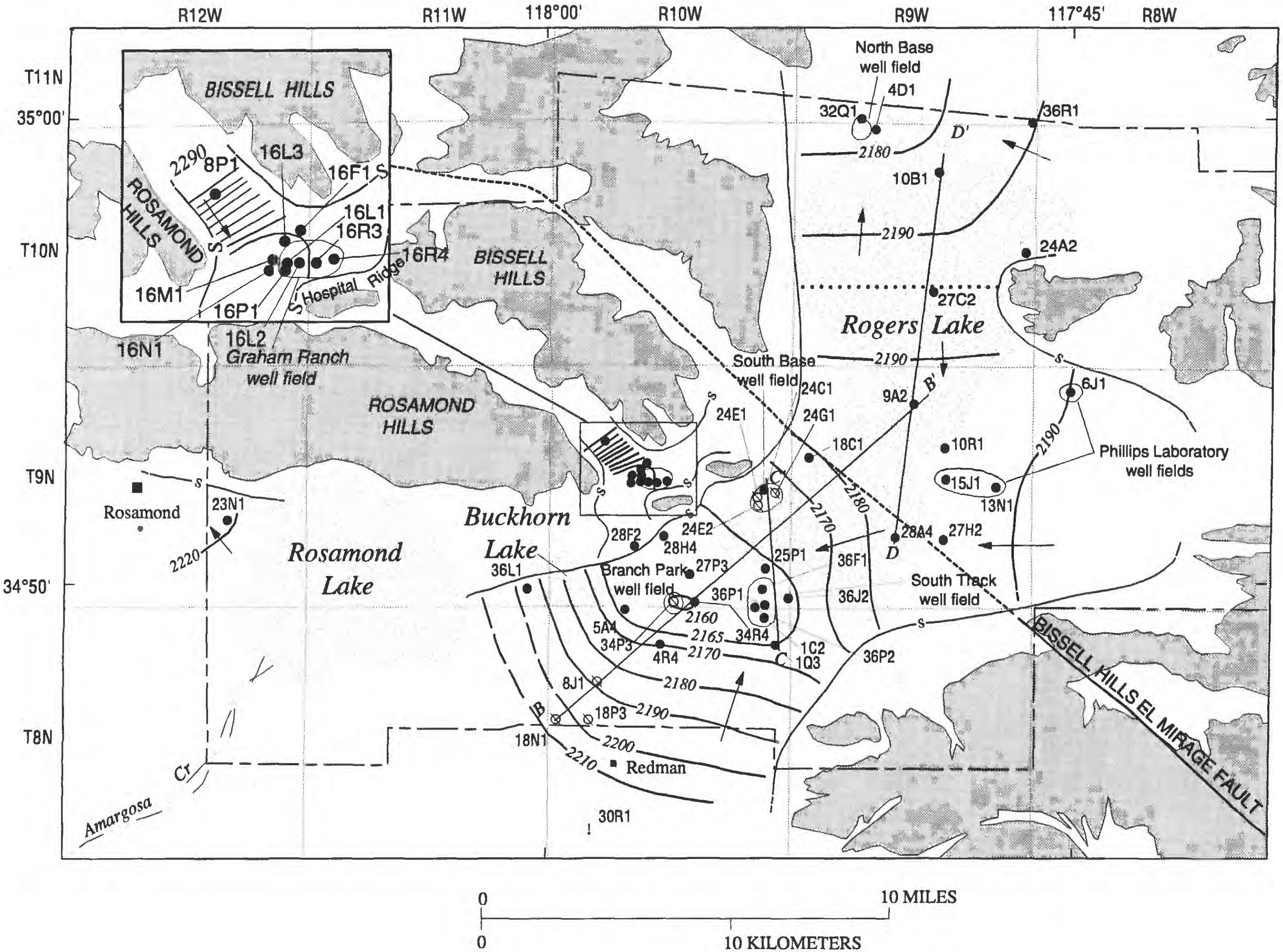

Figure 15. Potentiometric surface of the deep aquifer, Edwards Air Force Base, California, spring 1992. (Base map modified from Dibblee, 1960; Bloyd, 1967; and Londquist and others, 1993.)

EXPLANATION FOR FIGURE 15

	PLAYA SURFACE
	ALLUVIUM
	BEDROCK
B *B'*	LINE OF GEOLOGIC SECTION- Shown in figure 20
	DIRECTION OF GROUND-WATER FLOW
	GROUND-WATER DIVIDE
—S—	STRUCTURAL BOUNDARY
	EDWARDS AIR FORCE BASE BOUNDARY
	FAULT- Dashed where approximately located
2190	POTENTIOMETRIC CONTOUR-Shows altitude at which water would have stood in tightly cased wells, spring 1992. Contour interval variable. Dashed where approximately located. Datum is sea level
24E1	WELL OR PIEZOMETER AND NUMBER- For which water-level measurements were made
30R1	WELL OR PIEZOMETER AND NUMBER- Monitored for the Antelope Valley-East Kern Water Agency, not for this study
8J1	WELL OR PIEZOMETER AND NUMBER- Not monitored for the study but used to obtain lithologic data

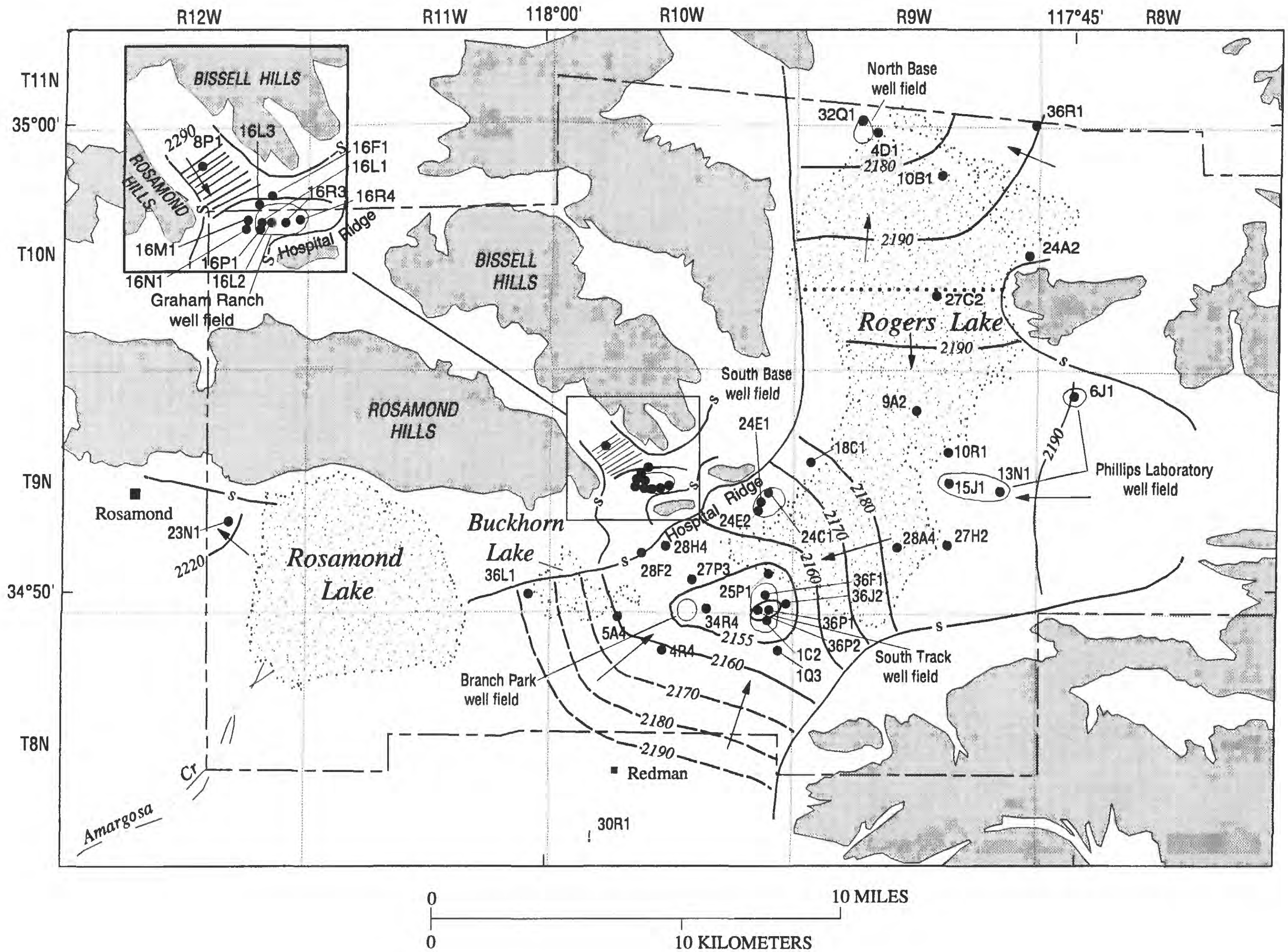

Figure 16. Potentiometric surface of the deep aquifer, Edwards Air Force Base, California, late summer 1992. (Base map modified from Dibblee, 1960; Bloyd, 1967; and Londquist and others, 1993.)

EXPLANATION FOR FIGURE 16

PLAYA SURFACE

ALLUVIUM

BEDROCK

DIRECTION OF GROUND-WATER FLOW

GROUND-WATER DIVIDE

—S— STRUCTURAL BOUNDARY

EDWARDS AIR FORCE BASE BOUNDARY

2190 POTENTIOMETRIC CONTOUR-Shows altitude at which water would have stood in tightly cased wells, late summer 1992. Contour interval variable. Dashed where approximately located. Datum is sea level

24E1 WELL OR PIEZOMETER AND NUMBER-For which water-level measurements were made

30R1 WELL OR PIEZOMETER AND NUMBER-Monitored for the Antelope Valley-East Kern Water Agency, not for this study

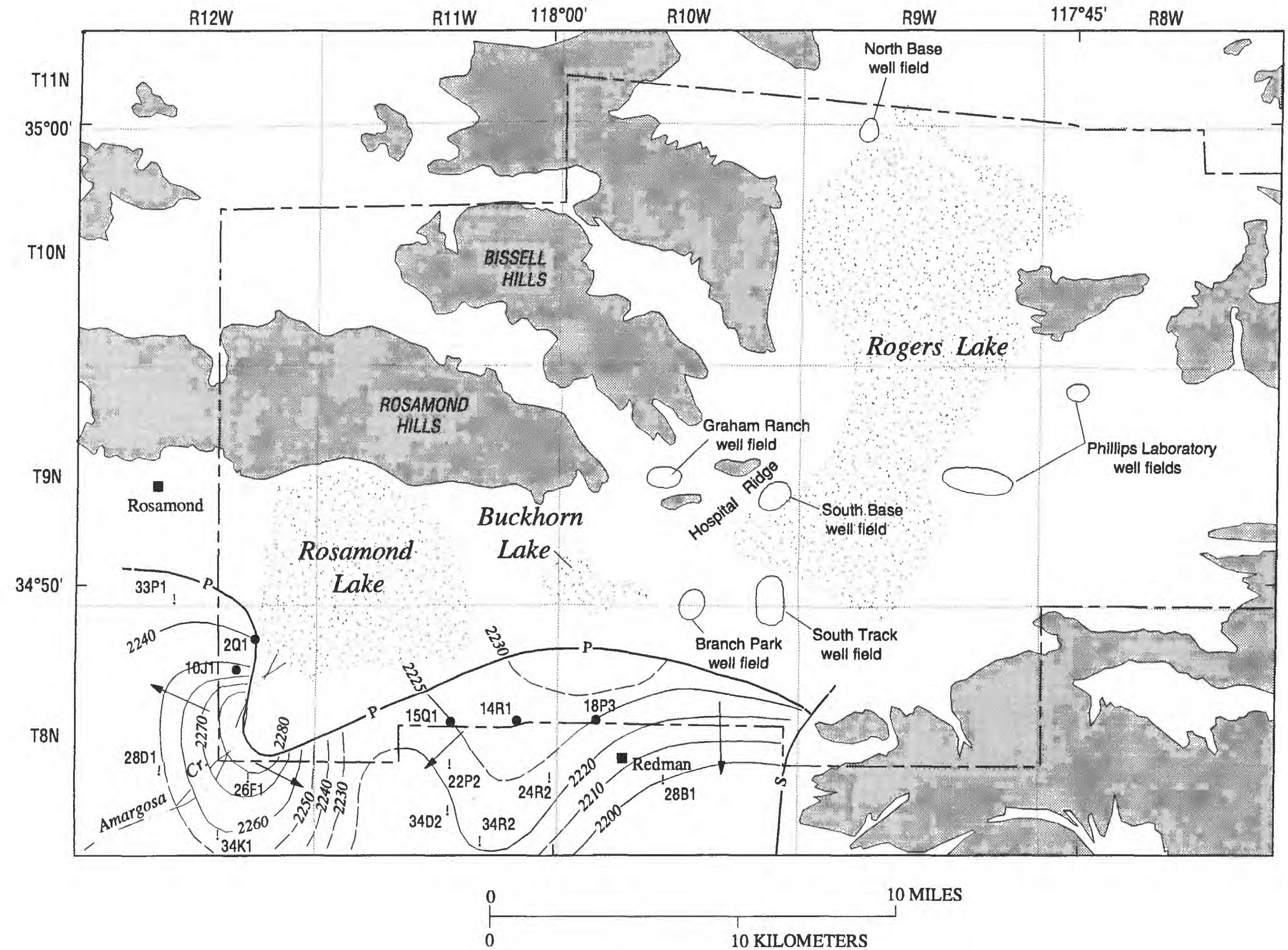

Figure 17. Potentiometric surface of the principal aquifer, Edwards Air Force Base, California, spring 1992. (Base map modified from Dibblee, 1960; Bloyd, 1967; and Londquist and others, 1993.)

EXPLANATION FOR FIGURE 17

(stippled box)	PLAYA SURFACE
(blank box)	ALLUVIUM
(shaded box)	BEDROCK
←——	DIRECTION OF GROUND-WATER FLOW
—S—	STRUCTURAL BOUNDARY
—P—	PRINCIPAL-AQUIFER BOUNDARY
— - —	EDWARDS AIR FORCE BASE BOUNDARY
2240 ——	POTENTIOMETRIC CONTOUR-Shows altitude at which water would have stood in tightly cased wells, spring 1992. Contour interval variable. Dashed where approximately located. Datum is sea level
18P3 `	WELL OR PIEZOMETER AND NUMBER-For which water-level measurements were made
34D2 o	WELL OR PIEZOMETER AND NUMBER-Monitored for the Antelope Valley-East Kern Water Ageney, not for this study

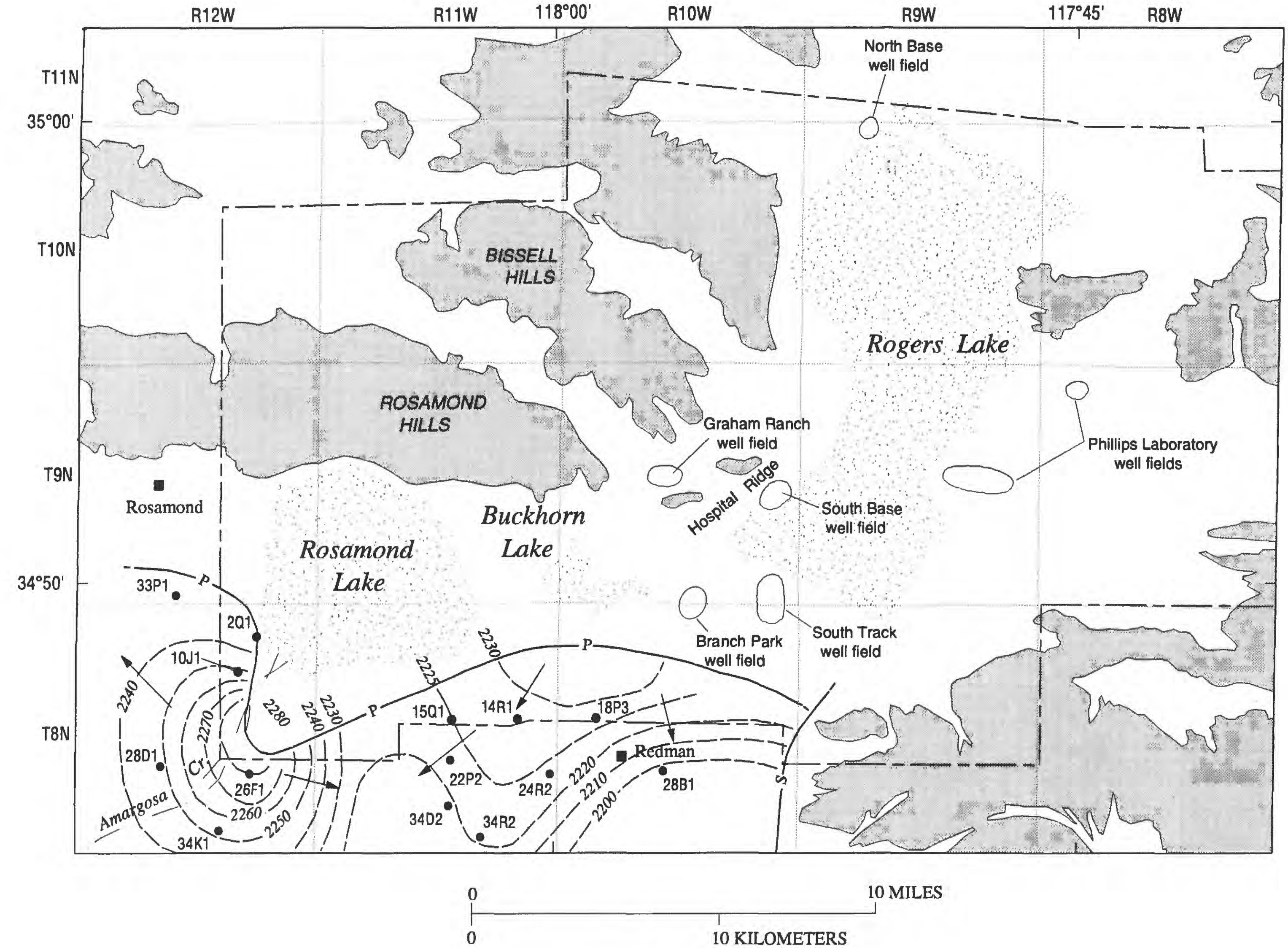

Figure 18. Potentiometric surface of the principal aquifer, Edwards Air Force Base, California, late summer 1992. (Base map modified from Dibblee, 1960; Bloyd, 1967; and Londquist and others, 1993.)

EXPLANATION FOR FIGURE 18

PLAYA SURFACE

ALLUVIUM

BEDROCK

← DIRECTION OF GROUND-WATER FLOW

—S— STRUCTURAL BOUNDARY

—P— PRINCIPAL-AQUIFER BOUNDARY

— – — EDWARDS AIR FORCE BASE BOUNDARY

2240 ——— POTENTIOMETRIC CONTOUR-Shows altitude at which water would have stood in tightly cased wells, late summer 1992. Contour interval variable. Dashed where approximately located. Datum is sea level

14R1 WELL OR PIEZOMETER AND NUMBER-For which water-level measurements were made

34D2 o WELL OR PIEZOMETER AND NUMBER-Monitored for the Antelope Valley-East Kern Water Agency, not for this study