Geohydrology and Water Quality of Marine Corps Logistics Base, Nebo and Yermo Annexes, near Barstow, California

By Jill N. Densmore, Brett F. Cox, and Steven M. Crawford

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CONVERSION FACTORS, VERTICAL DATUM, AND WELL-NUMBERING SYSTEM

Multiply	By	To obtain
acre-foot (acre-ft)	0.4047	square hectometer
acre-foot (acre-ft)	1,233	cubic meter
acre-foot per year (acre-ft/yr)	0.001233	cubic hectometer per year
cubic foot (ft^3)	0.02832	cubic meter
foot (ft)	0.3048	meter
foot per day (ft/d)	0.3048	meter per day
foot squared per day (ft^2)	0.09290	meter squared per day
inch (in.)	25.4	millimeter
mile (mi)	1.609	kilometer
square mile (mi^2)	2.590	square kilometer

Temperature is given in degrees Fahrenheit (°F), which can be converted to degrees Celsius (°C) by the following equation:

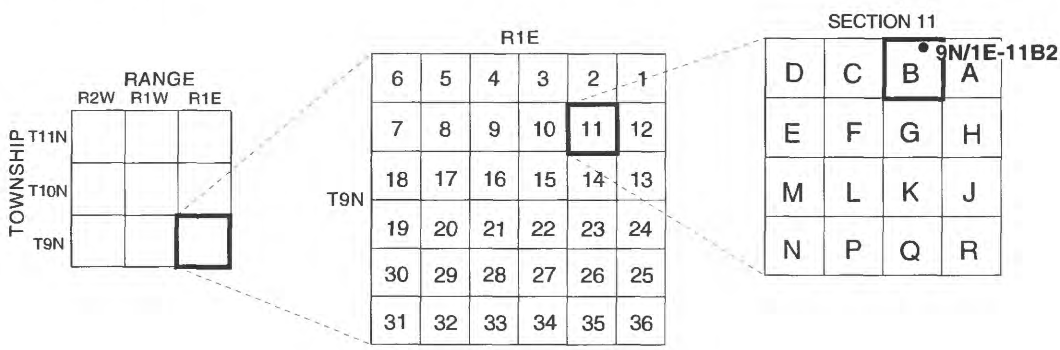
$$°C=5/9\ (°F-32).$$

VERTICAL DATUM

Sea Level: In this report, "sea level" refers to the National Geodetic 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.

Well-Numbering System

Wells are identified and numbered according to their location in the rectangular system for the subdivision of public lands. Identification consists of the township number, north or south; the range number, east or west; and the section number. Each section is 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 the 40-acre tract, wells are sequentially numbered in the order they are inventoried. The final letter refers to the base line and meridian. In California, there are three base lines and meridians; Humboldt (H), Mount Diablo (M), and San Bernardino (S). All wells in the study area are referenced to the San Bernardino base line and meridian (S) Well numbers consist of 15 characters and follow the format 009N001E11B002S. In this report, well numbers are abbreviated and written 9N/1E-11B2. Wells in the same township and range are referred to only by their section designation, 11B2. The following diagram shows how the number for well 9N/1E-11B2 is derived.



Well-numbering diagram

Geohydrology and Water Quality of Marine Corps Logistics Base, Nebo and Yermo Annexes, near Barstow, California

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Abstract

Because ground water is the only dependable source of water in the Barstow area, a thorough understanding of the relationship between the geology and hydrology of this area is needed to make informed ground-water management and remediation decisions. This report summarizes geologic and hydrologic studies done during 1992–95 at the Marine Corps Logistics Base, Nebo and Yermo Annexes, near Barstow, California. The geologic investigation dealt with the stratigraphy and geologic history of the area and determined the location of faults that cross the Marine Corps Logistics Base, Nebo Annex. Two of these faults coincide with significant ground-water barriers. Geologic and hydrologic data collected for this study were used to define two main aquifer systems in this area. The Mojave River aquifer is contained within the sand and gravel of the Mojave River alluvium, and the regional aquifer lies in the bordering alluvial-fan deposits and older alluvium. Water-level data showed that recharge occurs extensively in the Mojave River aquifer but occurs only in small areas of the regional aquifer. Dissolved-solids concentrations showed that ground-water degradation exists in the Mojave River aquifer near the Nebo Annex and extends at least 1 mile downgradient of the Nebo golf course in the younger Mojave River alluvium. Nitrogen concentrations show that more than one source is causing the observed degradation in the Mojave River aquifer. Oxygen-18, deuterium, tritium, and carbon-14 data indicate that the Mojave River and regional aquifers have different sources of recharge and that recent recharge occurs in the Mojave River aquifer but is more limited in the regional aquifer.

INTRODUCTION

Ground water is the only dependable source of water in the Barstow area. Because the potential for contamination of this water supply is high, a thorough understanding of the relationship between the geology and hydrology of this area is needed to make wise ground-water management and remediation decisions. Ground-water degradation in the river deposits near Barstow was reported as early as 1910 (Hughes, 1975). In the early 1970's, recharge from municipal sewage, industrial wastewater, and irrigation-return flow was identified as the source of ground-water degradation near Barstow and the Nebo Annex. In 1992, the U.S. Geological Survey (USGS) began a study of the relationship between the Mojave River, the main drainage in this area, and the two main aquifers, the Mojave River and regional aquifers. This work is part of the Regional Aquifer-System Analysis program, a hydrologic investigation by the U.S. Geological Survey to study ground-water basins in southern California. Companion geologic studies were sponsored by the U.S. Geological Survey National Geologic Mapping Program. Funding for this study was provided jointly by the U.S. Geological Survey, the U.S. Department of Navy, and the Mojave Water Agency.

Purpose and Scope

The purpose of this study is to define the relationship between the Mojave River, and the Mojave River aquifer and regional aquifer in the Marine Corps

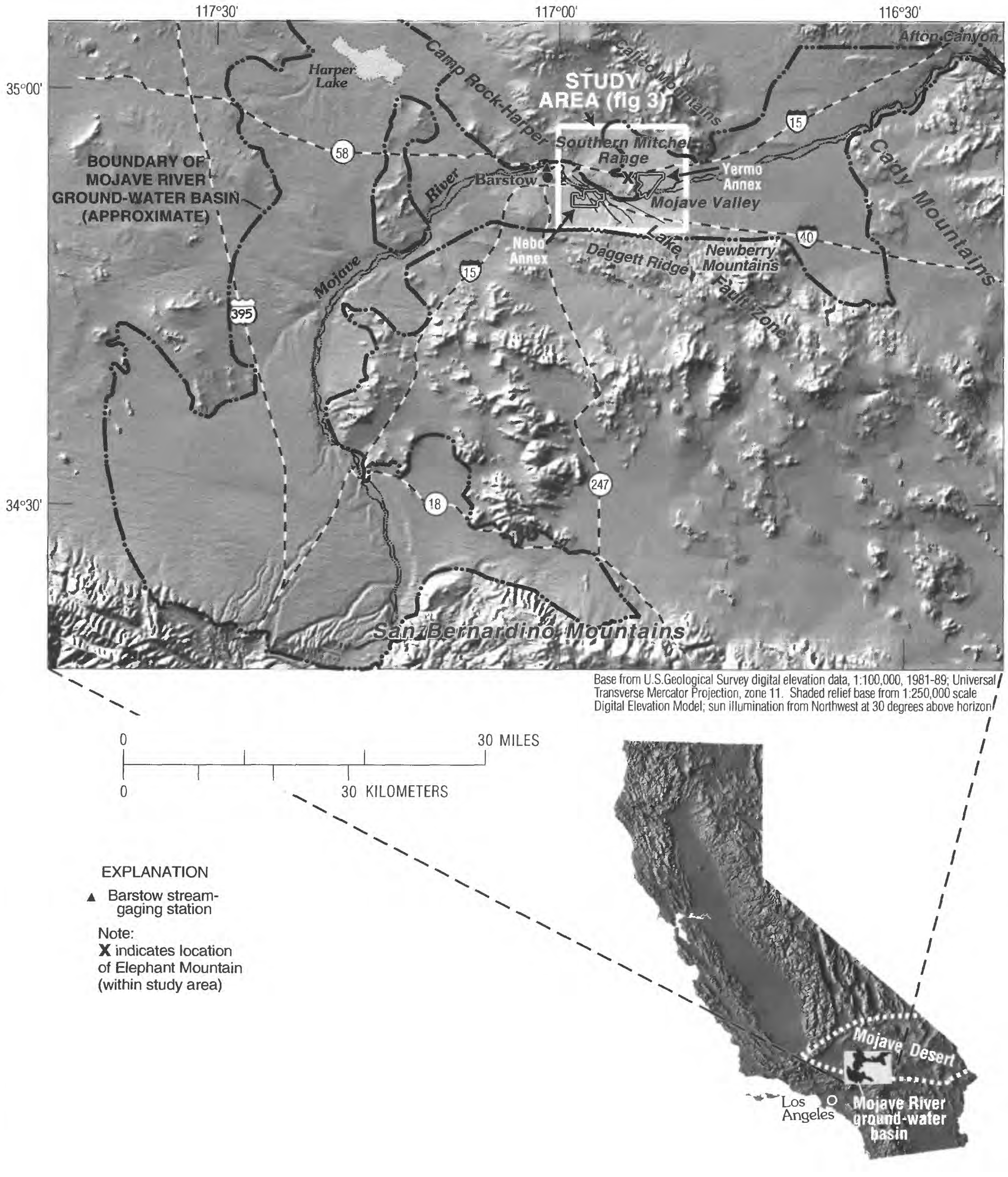


Figure 1. Location of study area, Marine Corps Logistics Base, Nebo and Yermo Annexes, near Barstow, California.

Logistics Base area east of Barstow, California (fig. 1). This was accomplished by evaluating new geologic and hydrologic data collected during 1992–95, along with existing data. This report describes the data and interpretations of geologic and hydrologic studies done by the USGS during 1992–95 at the Marine Corps Logistics Base, Nebo and Yermo Annexes.

The geologic setting at the Nebo and Yermo Annexes was determined by mapping the surficial geology and by trenching one of the five main faults in the study area. Areal geologic mapping of the study area is described in two reports by Cox and Wilshire (1993; 1994). Geologic field work was concentrated in hilly areas surrounding the Nebo Annex, where rock units and geologic structures are well exposed. Geologic data for the low-lying areas and for areas disturbed by construction or by agriculture were obtained mainly from aerial photographs. A conceptual model of the subsurface geology was produced by analyzing cuttings and geophysical data from several boreholes (these data are given in the appendix). Additional subsurface information was obtained from a direct-current resistivity survey (Zohdy and Bisdorf, 1994).

The hydrologic conditions at the Nebo and Yermo Annexes were determined by measuring water levels and collecting water-quality samples from eight new multiple-well monitoring sites installed on the Marine Corps Logistics Base property and from numerous pre-existing wells (table 1, at back of report). Oxygen-18, deuterium, tritium, and carbon-14 data were collected to determine the source, movement, and relative age of the ground water in the study area.

Location and General Features

The Marine Corps Logistics Base is east of the city of Barstow, approximately 100 mi northeast of Los Angeles in the Mojave Desert region of southern California (fig. 1). The base consists of the Nebo and

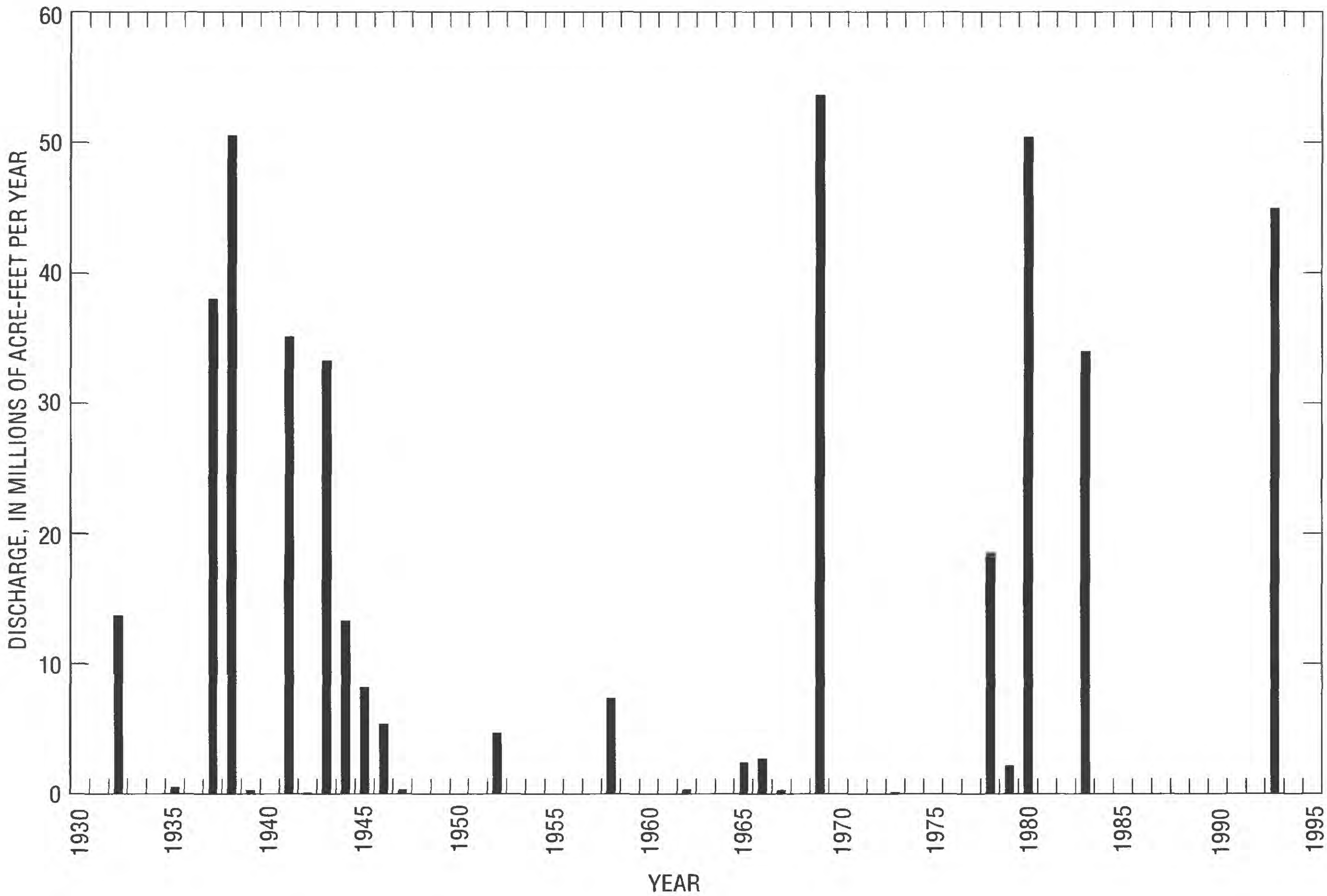


Figure 2. Annual discharges of the Mojave River at the Barstow gage, California.

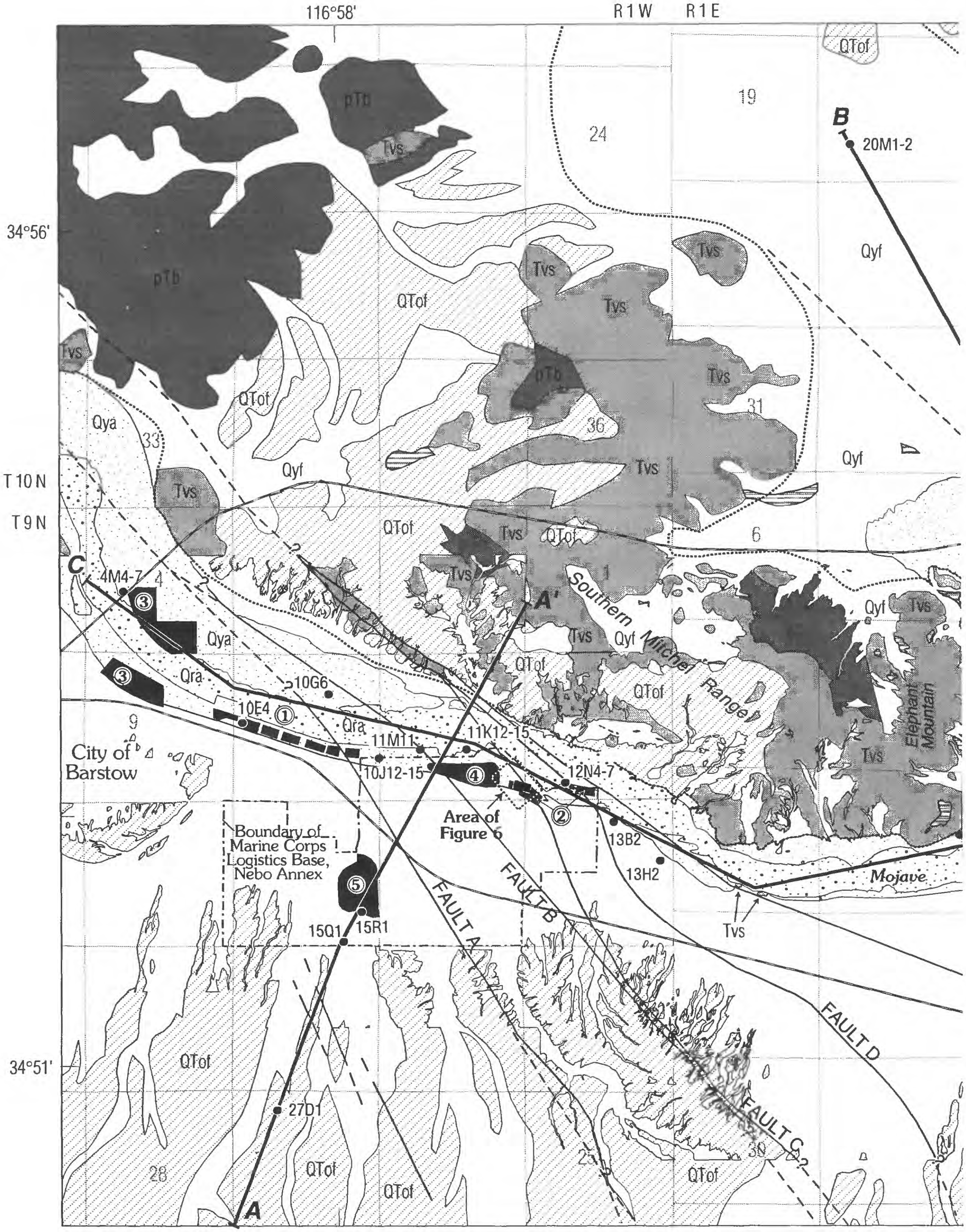
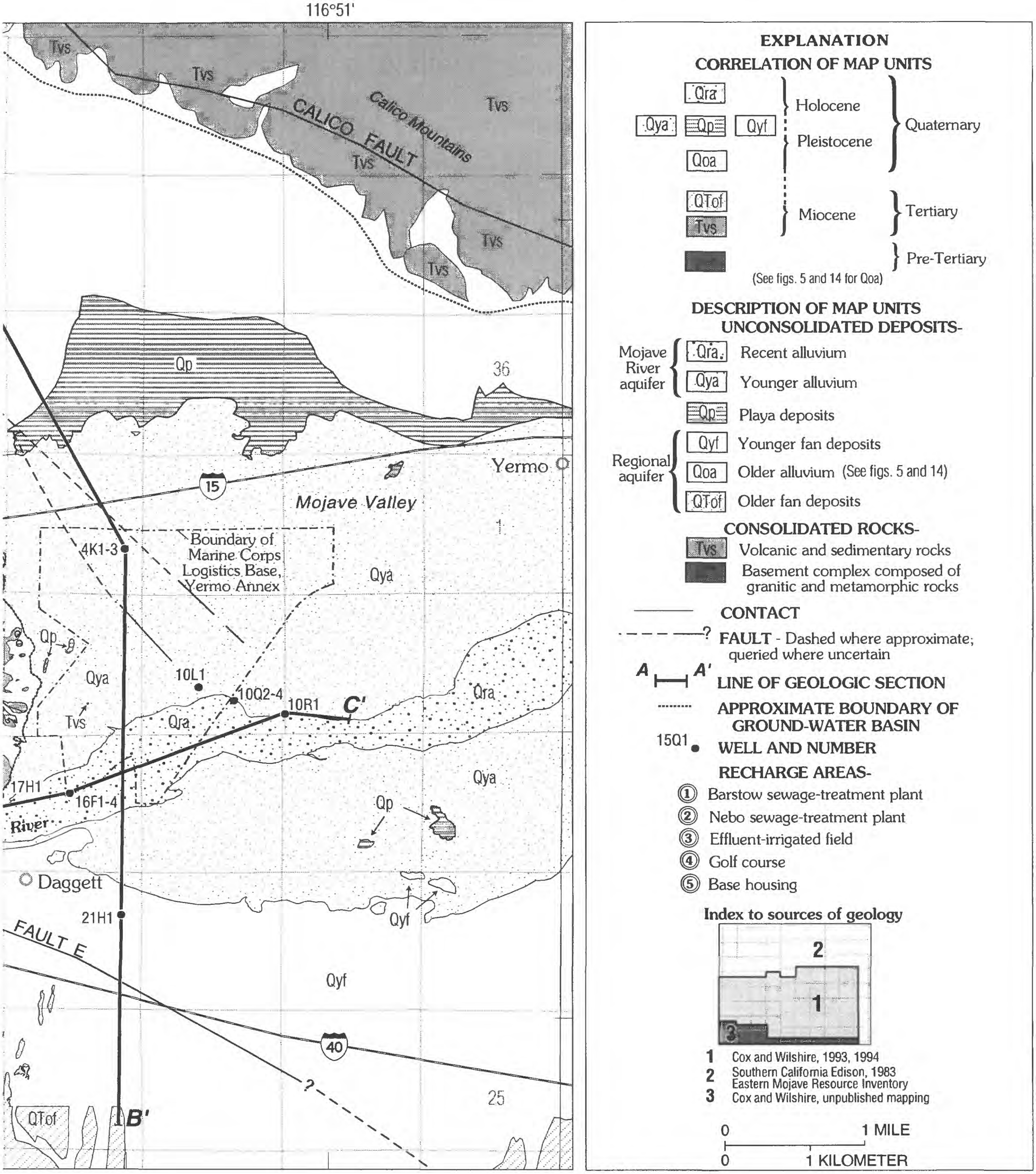


Figure 3. Generalized surficial geology and locations of geologic sections and wells used for these sections, in the vicinity of



the Marine Corps Logistics Base, Nebo and Yermo Annexes, near Barstow, California.

Yermo Annexes. The Nebo Annex covers an area of about 2 mi^2 and is about 2 mi east of Barstow, along the south side of the Mojave River channel. The Yermo Annex covers an area of about 3 mi^2 and is about 5 mi east of the Nebo Annex. The study area of this report covers a northeastern segment of the Mojave River ground-water basin that underlies both annexes of the Marine Corps Logistics Base. The study area spans a 10-mi reach of the Mojave River extending from Interstate 15 to about 2 mi east of the Yermo Annex. The eastern part of the study area, including the Yermo Annex, lies within Mojave Valley, a broad depression that is bounded by Elephant Mountain to the west, the Calico Mountains to the north, the Newberry Mountains to the south, and extends east to Afton Canyon and the Cady Mountains.

The climate in the study area is typical of the deserts of the southwestern United States. During the summer months, daytime high temperatures generally range from 100°F to 110°F, with occasional highs greater than 125°F. Winter daytime high temperatures generally range from the high 40's to the mid-60's, and winter lows below freezing are not uncommon. The potential evaporation is probably greater than 70 inches per year (Miller, 1969), which far exceeds the average precipitation of about 4 inches per year (50-year mean precipitation, Department of Water Resources, 1967).

The Mojave River is the main drainage in the study area (fig. 1). The river bed is dry in the study area except during major storms at its headwaters in the San Bernardino Mountains (fig. 1), about 50 mi upstream. Such storms produce floodwaters in the river channel. The direction of flow in the study area is from west to east. Figure 2 shows the annual discharge of the Mojave River at Barstow, California, for 1930–95. For this period, flow occurred less than 10 percent of the time and usually only for short periods. Peak flows of more than 50 million acre-ft/yr have occurred only three times during the period of record. Prior to ground-water development in this area, the Mojave River flowed continuously at fault C (fig. 3), which is part of the Camp Rock-Harper Lake (CR-HL) fault system (mapped by Cox and Wilshire, 1993), where ground water was forced to the surface. However, since the advent of ground-water pumping along the river, ground-water levels have declined and the Mojave River flows at fault C only after there has been sustained surface flows through this reach of the river in response to recharge to the ground-water system.

The concentration of dissolved material in the floodflows in the Mojave River increases slightly as it flows downstream. The change is generally from excellent quality [80 milligrams per liter (mg/L)] in the headwaters area to good quality (150 mg/L) in the downstream areas (Miller, 1969).

Previous Studies

Many geohydrologic investigations have been completed in the study area over the past 20 years. Ground-water conditions at the Marine Corps Logistics Base between 1967 and 1971 are documented in six water-resource data reports by the USGS (Koehler and Banta, 1969; Koehler, 1969, 1970, 1971, 1972; Miller, 1969). These reports provide historical water-level and water-quality measurements that were used to determine ground-water movement and water-quality trends. In 1972, a series of studies was completed that identified and characterized ground-water degradation to the Mojave River aquifer in the Barstow area (Hughes, 1975), and a digital water-quality model of the area was produced (Robson, 1974). Investigators concluded that the degradation of the ground water resulted from local municipal and industrial waste disposal and that the water supply for the U.S. Marine Corps Logistic Base, Nebo Annex, downgradient from Barstow, was in jeopardy. As a result of the ground-water degradation, pumping from the Nebo Annex production wells was discontinued. Recent work has been done by Jacobs Engineering Group Inc. (1992) to document and address soil and ground-water contamination at the Nebo and Yermo Annexes. This work included the installation and operation of ground-water extraction wells to clean up contaminated sites and provided recent water-level measurements and water-quality samples. Densmore and others (1994) have shown that the natural ground water in the alluvial deposits of the regional aquifer is of poor quality (dissolved-solids concentrations in excess of 2,000 mg/L) and that the hydraulic head is sufficiently high to discharge poor-quality water to the river deposits. This naturally occurring poor-quality water may be an additional source of degradation to the river deposits.

Acknowledgments

The authors thank Boyle Engineering for providing data pertaining to three monitoring well sites near Nebo Annex; Jacobs Engineering for providing data pertaining to numerous monitoring well sites at Yermo Annex; the personnel at Marine Corps Logistics Base for providing all available data from base production wells and for funding the sampling efforts necessary for this study; and Mojave Water Agency for providing additional funding to complete this report.

GEOHYDROLOGY

The geohydrologic framework of the Marine Corps Logistics Base area was defined by mapping the surficial geology (fig. 3) and by collecting geologic and hydrologic data from existing and newly drilled wells. Table 1 lists the State well number, local well name, and well-construction data for all wells used in this report and for which data were available.

During March 1992 and July 1993, 28 piezometers were installed at 8 multiple-well monitoring sites to update and refine the understanding of the ground-water hydrology of the Marine Corps Logistics Base area. Four of these sites (9N/1W-10J12-15, -11K12-15, -12L2-5, and -12N4-7) are on the Nebo Annex and the other four sites (9N/1E-4K1-3, -10Q2-4, -16F1-4, and 10N/1E-20M1-2) are on or near the Yermo Annex (fig. 3). Piezometers are small-diameter wells that generally are perforated or screened over a small interval, thereby enabling one to collect depth-dependent data that can be used to determine various conditions, such as hydraulic head, water quality, and hydraulic properties. A typical multiple-well monitoring site consists of two to four 2-inch diameter polyvinyl chloride (PVC) piezometers installed at different depths in the same borehole. The actual design of the multiple-well monitoring site was determined by examining the drill cuttings collected from each hole during drilling and by examining the geophysical logs for each borehole. The lithologic logs of the drill cuttings and the geophysical logs from each borehole are given in the appendix.

Geologic Setting

The surficial geology of the Marine Corps Logistics Base area has been mapped in detail by McCulloh (1965), Dibblee (1970), and Cox and Wilshire (1993, 1994). The geologic analysis presented in this report summarizes these reports, with an emphasis on the water-bearing characteristics of the stratigraphic units and the structural features that affect ground-water movement. Figure 3 shows the major geologic units and Quaternary faults in the study area.

The Nebo Annex lies within the Camp Rock-Harper Lake fault zone in a narrow valley along the Mojave River basin, which is bounded on the south by younger and older alluvial fan deposits, and on the north by the southern Mitchel Range (figs. 1 and 3). The Yermo Annex lies north of the river in the western part of Mojave Valley, a broad alluvial plain that is bounded on the west by the southern Mitchel Range, on the south by the Newberry Mountains, and on the north by the Calico Mountains (figs. 1 and 3).

Stratigraphic Units

Rocks and sediments in the study area consist of six generalized stratigraphic units, which are grouped as follows: (1) a basement complex of pre-Tertiary granitic and metamorphic rocks, (2) Tertiary continental volcanic and sedimentary rocks, (3) Tertiary-Quaternary older and younger alluvial-fan deposits, (4) Quaternary older alluvium, (5) Quaternary playa deposits, and (6) Quaternary younger and recent Mojave River alluvium (figs. 4 and 5). These units are discussed in order of age, which differs slightly from the order listed above. The subsurface stratigraphy (figs. 4 and 5) was inferred from surficial geology, borehole data (in appendix), and from an areal resistivity survey of the Marine Corps Logistics Base and vicinity (Zohdy and Bisdorf, 1994).

The pre-Tertiary basement complex (geoelectric basement, Zohdy and Bisdorf, 1994) does not crop out and has not been penetrated by boreholes at the Marine Corps Logistics Base. For this report, the basement complex refers to an assemblage of granitic and metamorphic rocks of pre-Tertiary age (fig. 3 pTb). Except for small quantities of water in the fractures and weathered zones in this unit, the basement complex is considered non-water bearing. On the basis of measurements of electrical resistivity at the ground surface, the geoelectric basement lies at minimum depths of about 2,000-3,500 feet beneath the Nebo Annex (fig. 4 pTb) and 1,100-3,200 feet beneath the Yermo Annex (fig. 5 pTb).

Undifferentiated continental volcanic and sedimentary rocks of Tertiary age (Tvs) overlie the basement complex throughout most of the study area (figs.

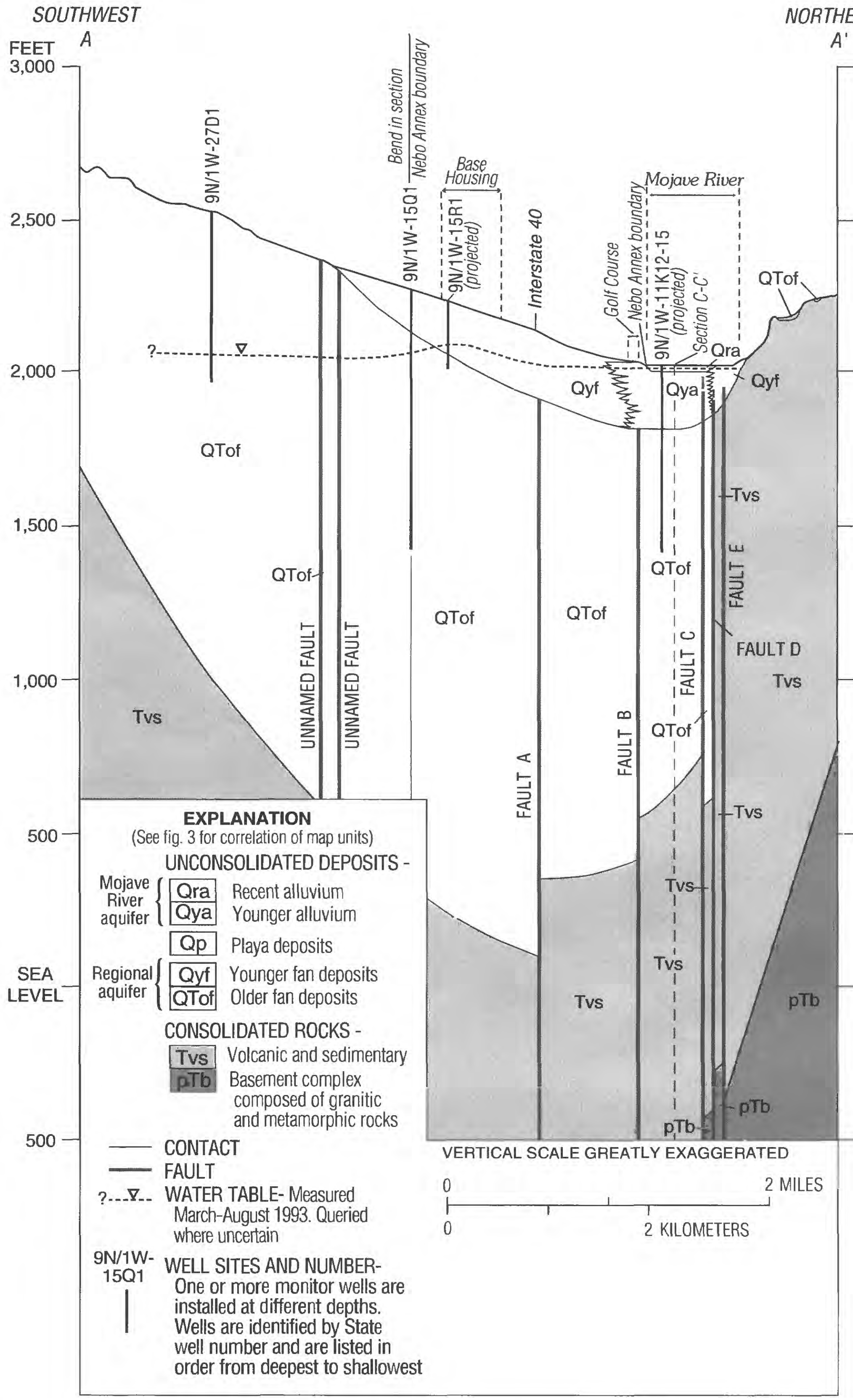


Figure 4. Generalized geologic section *A-A´* across Nebo Annex and vicinity of the Marine Corps Logistics Base, near Barstow, California. Location of faults A-E based on mapping of Cox and Wilshire (1993). (Location of section is shown on figure 3.)

4, and 5; see fig. 3 for correlation of map units). These rocks include a heterogeneous lower sequence of early Miocene-age volcanic intrusions, flows, and pyroclastic rocks interbedded with sandstone, limestone, conglomerate, and avalanche breccia. The lower assemblage is intruded by rhyodacite plugs that form Elephant Mountain (Cox and Wilshire, 1993) and is unconformably overlain by fluvial and lacustrine sedimentary deposits of early to middle Miocene age. In general, the Tertiary rocks contain some water-bearing units but yield only small quantities of mostly poor-quality water to wells. On the basis of the electrical

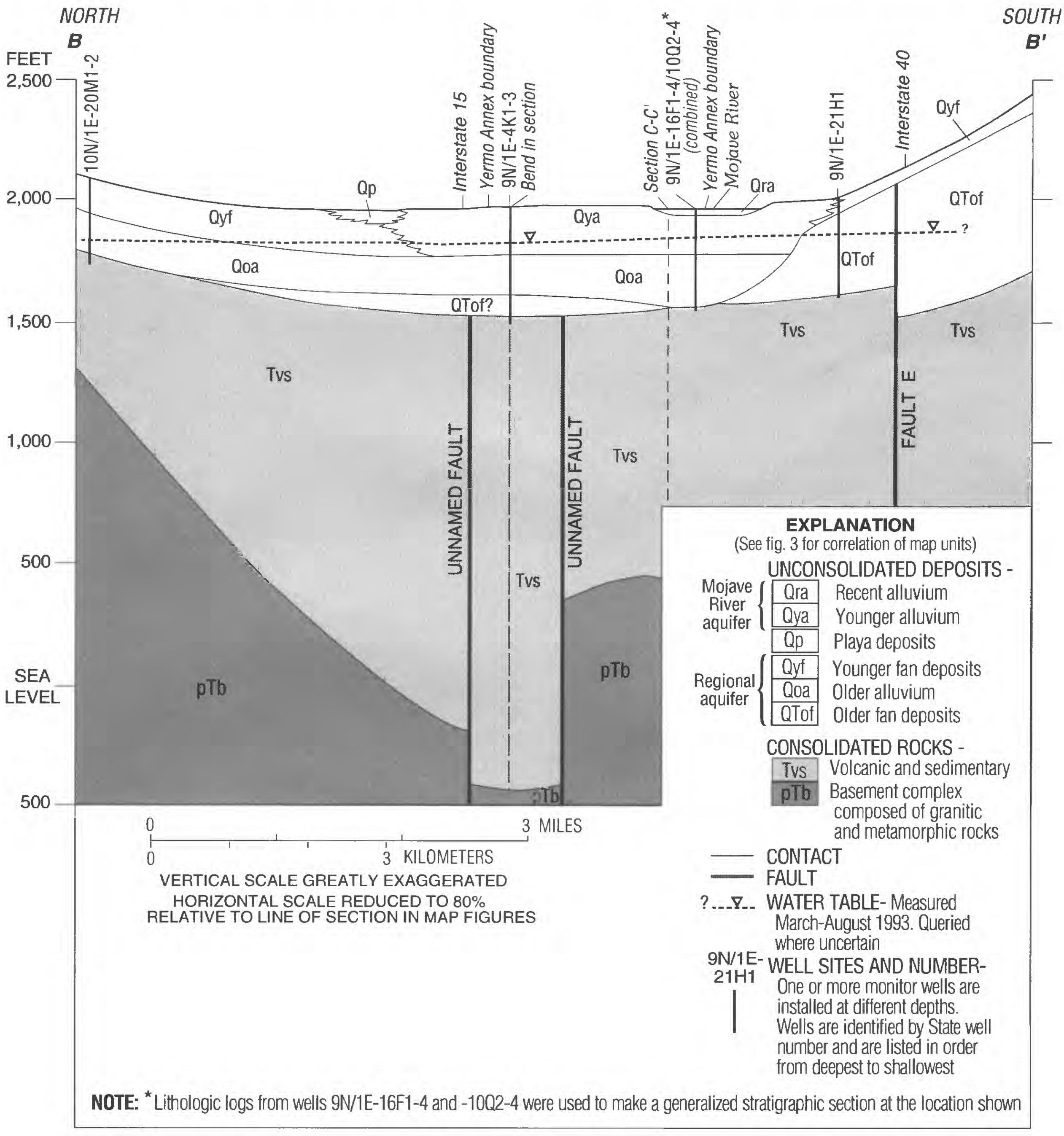


Figure 5. Generalized geologic section *B-B'* across Yermo Annex and vicinity of the Marine Corps Logistics Base, near Barstow, California. Location of fault E is based on mapping of Cox and Wilshire (1994). (Location of section is shown on figure 3.)

resistivity survey (Zohdy and Bisdorf, 1994), the depth to the Tertiary rocks in the Nebo Annex area ranges from about 1,500 to 2,000 ft below land surface. These rocks are penetrated by only one well near the north side of the Mojave River channel (fig. 3, well 9N/1W -12L5 of monitoring site 9N/1W-12L2-5; in appendix). North of the Nebo Annex and north of the Camp Rock-Harper Lake fault zone, these rocks are exposed at land surface. In the Yermo Annex area, several boreholes penetrate these rocks, which range in depth from 0 to 100 ft near the western boundary of the base to more than 500 ft near the eastern boundary.

Alluvial-fan deposits overlie the Tertiary volcanic and sedimentary rocks. These deposits are divided into two stratigraphic units (figs. 4, and 5; see fig. 3 for correlation of map units): (1) older fan deposits (QTof, poorly dated, possibly of late Miocene to early Pleistocene age) and (2) younger fan deposits (Qyf, Pleistocene to Holocene). As a group, the fan deposits consist of poorly sorted sand and gravel containing angular detritus derived from neighboring mountains and abundant fragments of Tertiary and pre-Tertiary volcanic rocks. The fan deposits are typically finer grained downslope toward the basin axis, grading from boulder and cobble gravel near the mountain fronts to silty, pebbly sand near the toes of the fans. The alluvial-fan deposits are much less permeable than the adjacent and overlying Mojave River alluvium.

The older fan deposits (QTof) crop out extensively south of the Mojave River, forming a belt of coalescing alluvial fans on the north flank of the Newberry Mountains and Daggett Ridge. In contrast to the younger fan deposits, the older fan deposits are deeply eroded, are locally arched and faulted, and yield relatively low electrical resistivities in the boreholes (5-25 ohm-m in saturated alluvium; see monitoring sites 9N/1W-10J12-15, -11K12-15, and -12N4-7 in appendix). The electrical resistivity survey (Zohdy and Bisdorf, 1994) suggests the older fan deposits may be as much as 1,500 to 2,000 ft thick beneath the Nebo Annex. They thin abruptly northward across the Mojave River near both the Nebo and Yermo Annexes, reflecting, in part, the original subsurface geometry of the old fans and the effects of post-depositional faulting and erosion. A 90-ft thick interval of muddy sediments penetrated by a borehole at the Yermo Annex (figs. 3 and 5, well 9N/1E-4K1-3; in appendix, 355-445 ft depth) is tentatively inferred to consist of playa deposits that accumulated at the foot of the old fans.

The older alluvium unit (Qoa) is about 150-250 ft thick and is found only in boreholes near the Yermo Annex (fig. 5), where it overlies the older fan deposits (QTof), and is itself overlain by the younger alluvium unit (Qya) and younger fan deposits (Qyf). The older alluvium terminates a short distance south of the Mojave River channel, where it likely rests in buttress unconformity against older fan deposits. Beneath the Mojave River and Yermo Annex, where the older alluvium is penetrated by boreholes, the upper half of the older alluvium unit closely resembles the overlying younger alluvium (Qya) in composition, texture, and facies relations. Both units consist of granitic pebble gravel and coarse arkosic sand near the Mojave River (sites 9N/1E-10Q2-4 and -16F1-4; in appendix), but they are finer grained northward, grading into silty sand with sparse gravel lenses near the northern boundary of the Yermo Annex (site 9N/1E-4K1-3; in appendix). Beyond these similarities, the older alluvium is significantly more consolidated and less permeable than the younger alluvium. Moreover, deposits in the lower half of the older alluvium unit beneath the Yermo Annex and deposits throughout the entire thickness of the unit beneath more northerly parts of Mojave Valley (site 10N/1E-20M1-2, 135 to 300 ft depth; in appendix), are compositionally heterogeneous, containing abundant sandy and pebbly detritus of Tertiary and pre-Tertiary age volcanic rocks intermixed with granitic debris. These heterogeneous sediments are compositionally and texturally similar to the younger fan deposits (Qyf) but are distinguished by greater consolidation and lower spontaneous potential, as indicated by borehole caliper and electrical logs.

By comparing the deposits in the upper half of the older alluvium unit lying beneath the Yermo Annex and the adjacent Mojave River deposits, it appears that the older alluvium formed in much the same manner as the overlying younger alluvium unit, implying deposition by an ancestral Mojave River. By contrast, the compositionally heterogeneous deposits of older alluvium north of the Yermo Annex probably were deposited on alluvial fans that intertongued southward into the old river deposits. Other paleontologic and sedimentologic evidence supporting the existence of an early Mojave River system is found in Pleistocene lacustrine sediments of the Lake Manix Formation, which crop out along the Mojave River about 15 to 20 mi northeast of the Yermo Annex. This lacustrine sequence, dated at about 500,000 to 14,000 years, seems to require a voluminous inflow of fresh water that was likely fed by an ancestral Mojave River (Jefferson, 1994). The older alluvium unit near the Yermo Annex is not dated, but it might reasonably be correlated with the lower to middle parts of the Lake Manix Formation, which would imply that the older alluvium is middle to late Pleistocene in age. The older alluvium is not present at the land surface or in boreholes near the Nebo Annex (fig. 4), and it probably was never deposited there. The ancestral Mojave River apparently was eroding a channel through the older fan deposits near the Nebo Annex at the same time that it deposited the older alluvium near the Yermo Annex. Detritus that eroded from the older fan deposits during this local incision of the ancestral river channel probably was redeposited downstream in western Mojave Valley, which probably accounts for the compositional heterogeneity of the lower half of the older alluvium unit near the Yermo Annex.

Younger fan deposits (Qyf) are of variable thickness and overlie the older fan deposits south of the Nebo and Yermo Annexes and the older alluvium north of the Yermo Annex. The younger fan deposits intertongue northward, toward the river channel, with younger alluvium of the Mojave River (Qya) (figs. 4 and 5). Particle grain size decreases downslope toward the toes of the younger fans, where the deposits are very silty and consequently less permeable than the adjacent relatively well-sorted river deposits.

Locally, north of the Yermo Annex, a narrow body of late Pleistocene to Holocene age silt and clay (Qp; fig. 5) was deposited in a playa nestled between the toes of the younger fans (Qyf) and the neighboring younger alluvium (Qya) of Mojave Valley. These deposits are less permeable than the adjacent and underlying younger alluvial-fan deposits and younger alluvium. The playa deposits are very localized in the Yermo Annex area and are above the water table.

The Mojave River alluvium is divided into two superposed stratigraphic units (figs. 3, 4, and 5; see fig. 3 for correlation of map units): (1) younger alluvium (Qya, Pleistocene to Holocene age) and (2) recent alluvium (Qra, Holocene age). These units overlie the older alluvium and consist of unconsolidated to slightly consolidated, moderately to well-sorted, coarse sand and gravel. Both units contain abundant subangular to rounded detritus of granitic rocks derived from the headwaters of the Mojave River in the western San Bernardino Mountains, about 50 mi upstream (fig. 1). These units also contain lesser amounts of angular volcanic detritus from tributary streams that drain nearby mountains of the central and southern Mojave Desert. The recent alluvium is highly permeable, whereas the younger alluvium is slightly less permeable. The younger alluvium is confined to a narrow corridor less than 1 mi wide near the Nebo Annex, but it expands abruptly eastward in Mojave Valley, forming an alluvial plain several miles wide near the Yermo Annex. It forms a continuous layer about 200 ft thick that extends the full length of the study area (figs. 4 and 5). The younger alluvium interfingers to the north and south with the unit of younger fan deposits (Qyf). Radiocarbon ages from several localities in western Mojave Valley indicate that the uppermost 10 ft of the younger alluvium is late Pleistocene to early Holocene, about 12,200-7,350 years in age (Reynolds and Reynolds, 1985, 1991). The recent alluvium generally is less than 30 ft thick and follows the modern channel of the Mojave River, which skirts the north edge of the Nebo Annex and south edge of the Yermo Annex (fig. 3). The floor of the Mojave River channel and the flanking low stream terraces have become incised as much as 15 to 25 ft into the underlying younger alluvium during Holocene time (Cox and Wilshire, 1994).

Geologic History and Structure

The central Mojave Desert has undergone two major periods of deformation: a period of crustal rifting in the early Miocene and a period of crustal shortening and strike-slip faulting from the late Miocene to the present (Cox and Wilshire, 1993). During the period of rifting, the crust was pulled apart by large-scale displacement on a gently dipping master shear zone, termed the Waterman Hills detachment fault (Walker and others, 1990). This fault is exposed in the hills north of Barstow and probably extends southeastward beneath the southern Mitchel Range and the neighboring Nebo and Yermo Annexes, where it lies at depths greater than those illustrated on the geologic sections (figs. 4 and 5). Thick bodies of sedimentary and volcanic strata accumulated in tectonic depressions within the rift zone. These strata were folded, faulted, and rotated in the later stages of rifting and are now exposed in the southern Mitchel Range and other nearby ranges. Early Miocene tilting accounts for the relatively steeply dipping lower boundary of the Tertiary rocks (fig. 4 and 5). These deformed strata were eroded and then intruded by the plugs and the domes of rhyodacite that form Elephant Mountain. Although the early Miocene deformation was extensive, the resulting structural features have little geohydrologic significance because the affected Tertiary and pre-Tertiary rocks are essentially non-water bearing.

During the second period of deformation, north-south shortening in the Mojave Desert region produced east-west trending arches and basins and northwest-trending, right-lateral, strike-slip faults. The western Mojave Valley and the adjoining smaller alluvial basins, bordered by the Newberry Mountains, Daggett Ridge, Mitchel Range, and the Calico Mountains, formed during this period of deformation. From late Miocene to early Pleistocene, the alluvial basins near the Nebo and Yermo Annexes were filled exclusively with locally derived sediments, such as alluvial-fan deposits and playa deposits that make up the older fan deposits described in this report (QTof, figs. 4 and 5). Much of the rock detritus in the older fan deposits was eroded from an uplifted bedrock arch immediately south of the study area, in the Newberry Mountains and Daggett Ridge (fig. 1)

The east-west trend of the old alluvial basins east of Barstow helped to determine the future path of the Mojave River and its associated ground-water basin. The river developed its present course eastward from Barstow to Mojave Valley during the Pleistocene, about 500,000 years ago, forging a route across the floors of the pre-existing alluvial basins. The river flowed into ancient Lake Manix, which occupied the eastern part of Mojave Valley (Jefferson, 1994). In the western part of the valley, river deposits, composed of granitic sand and gravel derived from the mountains south of the Mojave Desert, accumulated amid the alluvial-fan deposits derived from the basin margins. The earliest river deposits (termed the older alluvium in this report) were restricted to Mojave Valley. Eventually, the depositional tract expanded upstream toward Barstow, and the younger river deposits (termed younger alluvium in this report) were deposited across the future sites of both the Nebo and the Yermo Annexes. About 14,000 years ago, a low sill at the east end of Lake Manix was eroded, draining the lake and allowing the Mojave River to lengthen its channel eastward through Afton Canyon (Meek, 1989). The accumulation of river deposits in the western Mojave Valley ended shortly thereafter, during the Holocene, when the Mojave River incised its modern channel into the younger alluvium. Most recently, a thin layer of recent alluvium has accumulated on the flanking stream terraces and on the floor of the active channel as the river continues to erode its channel.

The northwest trending Camp Rock-Harper Lake fault zone, which cuts through the Nebo Annex area (fig. 1), evolved during the ongoing late Miocene to present period of crustal shortening. This fault zone extends from about 30 mi southeast of Nebo Annex to just east of Harper Lake, about 15 mi northwest of Nebo Annex (fig. 1). Five northwest-trending, right-lateral, strike-slip strands of the Camp Rock-Harper Lake fault zone cross the Nebo Annex (faults A-E, fig. 3). Two of these faults, B and C, pass beneath heavily developed parts of the Nebo Annex. The estimated aggregate lateral displacement on faults B and C is about 1.5 mi (Cox and Wilshire, 1993). Fault C has special significance because it forms a ground-water barrier where it crosses the aquifer within the Mojave River deposits and because it is a potential source of earthquake hazards (Cox and Wilshire, 1993). Fault C has also been called the Waterman fault by previous investigators, but it should not be confused with the similarly named Waterman Hills detachment fault.

Other, apparently older, northwest-trending faults underlie the Yermo Annex and vicinity. Aeromagnetic data (U.S. Geological Survey, 1987) and an electrical resistivity survey (Zohdy and Bisdorf, 1994) suggest that two faults pass beneath the Yermo Annex, converging about 1 mi northwest of the base boundary (figs. 3 and 5). These faults lack scarps or other surficial evidence of Holocene activity. Other northwest-trending faults (not shown on figs. 3 and 5) were identified directly west of the Yermo Annex on the basis of topographic lineaments that coincide with jogs in the crest of Elephant Mountain (Cox and Wilshire, 1994). Both of these groups of faults in the Yermo area displace Miocene strata and underlying pre-Tertiary basement rocks, but the faults do not seem to disturb the thick Pleistocene to Holocene alluvium and fan deposits of the western Mojave Valley, nor do they have any obvious influence on ground-water flow or quality.

In 1993–94, a fault-trenching study was done at the Nebo Annex across fault C in the Camp Rock-Harper Lake fault zone. The trenching was done (1) to chart the geometry of subsurface deformational structures across fault C, (2) to estimate the frequency of past movements along the fault, and (3) to investigate possible structural causes of the observed ground-water barrier.

The trench site is on the south side of the Mojave River directly east of the Marine Corps Logistics Base golf course (fig. 6). This site was selected for trenching because of a northwest-trending lineament observed on

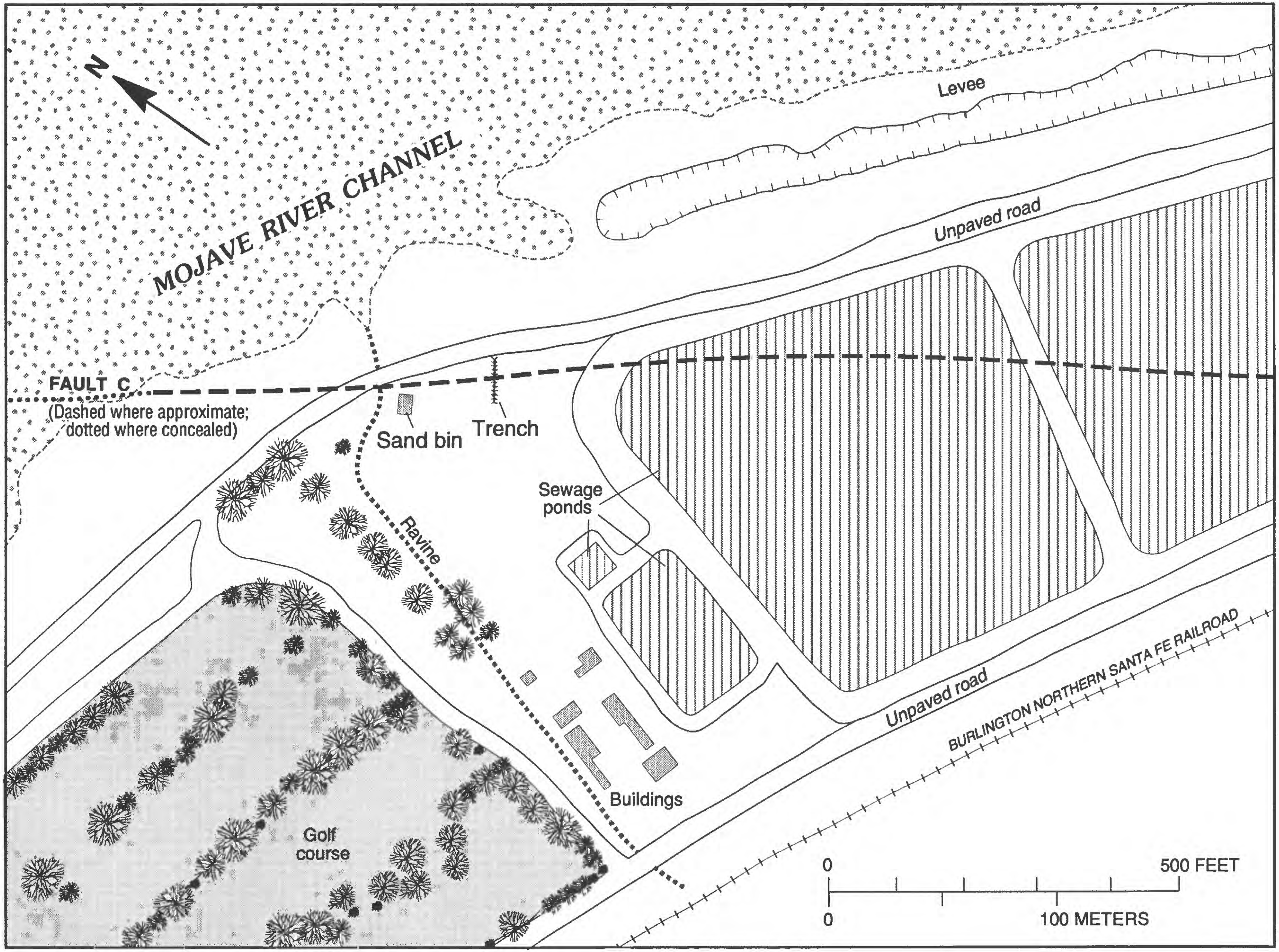


Figure 6. Location of trench across fault C at Marine Corps Logistics Base, Nebo Annex, near Barstow, California. (See figure 3 for location.)

aerial photographs taken in the mid 1940's (Cox and Wilshire, 1993). The lineament, which consists of a topographic break and parallel line of vegetation, was obliterated by military construction activities around 1950. The topographic expression of the lineament was best developed several hundred feet southeast of the trench site, where it consisted of a low northeast-facing scarp cutting Holocene or late Pleistocene alluvial-fan deposits. That part of the lineament is now covered by sewage ponds and therefore is not accessible for study. Accordingly, the trench was sited near the northwest end of the lineament, in an area used in recent years for dumping grass and tree clippings. In this area, the lineament on the photo is less distinct, consisting of a faint line bordered on its southwest side by a 100-ft wide zone of gently arched ground.

The trench was excavated on a true bearing of 035 degrees to a length of about 126 ft and to a depth of about 7 to 13 ft. The northeastern fifth of the trench was about 3 ft wide with vertical walls supported by hydraulic shoring. The rest of the trench was unshored, with walls beveled for safety, to a maximum width of about 25 ft at the top.

The main stratigraphic and structural features exposed in the trench are illustrated in a generalized diagram of the northwest wall of the trench (fig. 7). Much of the trench wall consists of a well-layered sequence of fluvial sediments deposited by the Mojave River (units I-VI). These sediments form the uppermost strata of the unit of younger alluvium shown on generalized section A-A´ (Qya, fig. 4). Lower parts of this sequence consist mainly of sand and pebble gravel (units I, II, and IV) deposited in former channels of the river, whereas the upper parts consist mainly of silt and clay (units III, V, and VI) deposited in non-turbulent environments of a former river floodplain. The floodplain deposits are overlain by a thin layer of sand and pebble gravel (unit VII) deposited by tributary alluvial-fan streams that presently drain the uplands south of the Mojave River. This layer is part of the unit of younger fan deposits shown on section A-A´ (Qyf, fig. 4). Finally, at the top of the trench is a thin man-made layer consisting of garden refuse mixed with soil (unit VIII), which represents landfill operations of the past 50 years.

Deformational structures in the trench walls indicate that the shallow fluvial deposits were shortened repeatedly by folding and faulting during the accumulation of the sedimentary sequence. These structures also show that the southwest side of the fault zone generally was displaced upward and northwestward (right-lateral separation) relative to the northeast side. The earliest evidence of deformation is shown by the inclined gravel beds of unit I in the northeast half of the trench. These beds were tilted northeastward within a monoclinal fold and then were planed off by river erosion before unit II was deposited. Horizontal beds of unit I in the southwest half of the trench form the uplifted limb of the monocline.

During a second deformational event, strata of units II and III buckled to form a broad east-west trending structural depression that is exposed in the central region of the trench wall. A particularly impressive suite of structures is on the north limb of this depression, where sandy beds of unit II have shortened and thickened across several superimposed thrust faults and have arched into a prominent hump that also deflects the overlying silty and clayey deposits of unit III. The crestal region of the hump consists of structureless fine-grained sand that may have flowed as a liquefied mass during thrusting. During subsequent flooding, the structural depression was filled in by a channel-shaped body of coarse river sand (unit IV).

Two subsequent deformational events are represented by southwest-dipping, high-angle faults that cut stratigraphic units I-VI in the northeastern third of the trench (fig. 7). Observations of both walls of the trench suggest that these structures are oblique slip faults with right-lateral and reverse components of displacement. Stratigraphic truncations of individual fault planes suggest two events of high-angle faulting, one occurring between the deposition of units V and VI and the other between units VI and VII.

The alluvial-fan deposits near the top of the trench (unit VII) are not conspicuously faulted. However, inspection of old aerial photographs indicates that similar alluvial-fan deposits were cut by a low, northeast-facing fault scarp several hundred feet southeast of the trench site (Cox and Wilshire, 1993). Thus, a fifth event probably occurred during which the southwest side of the fault zone was uplifted, presumably in combination with right-lateral slip. However, this most recent deformational event did not produce any obvious structural effects at the site of the trench.

Fragments of detrital charcoal recovered from the walls of the trench are currently (1996) being dated by the radiocarbon method to determine the ages of the stratigraphic units and the deformational events. Preliminary results indicate that a bed of clayey silt near the middle of the exposed sequence (unit IIIB, fig. 7) is

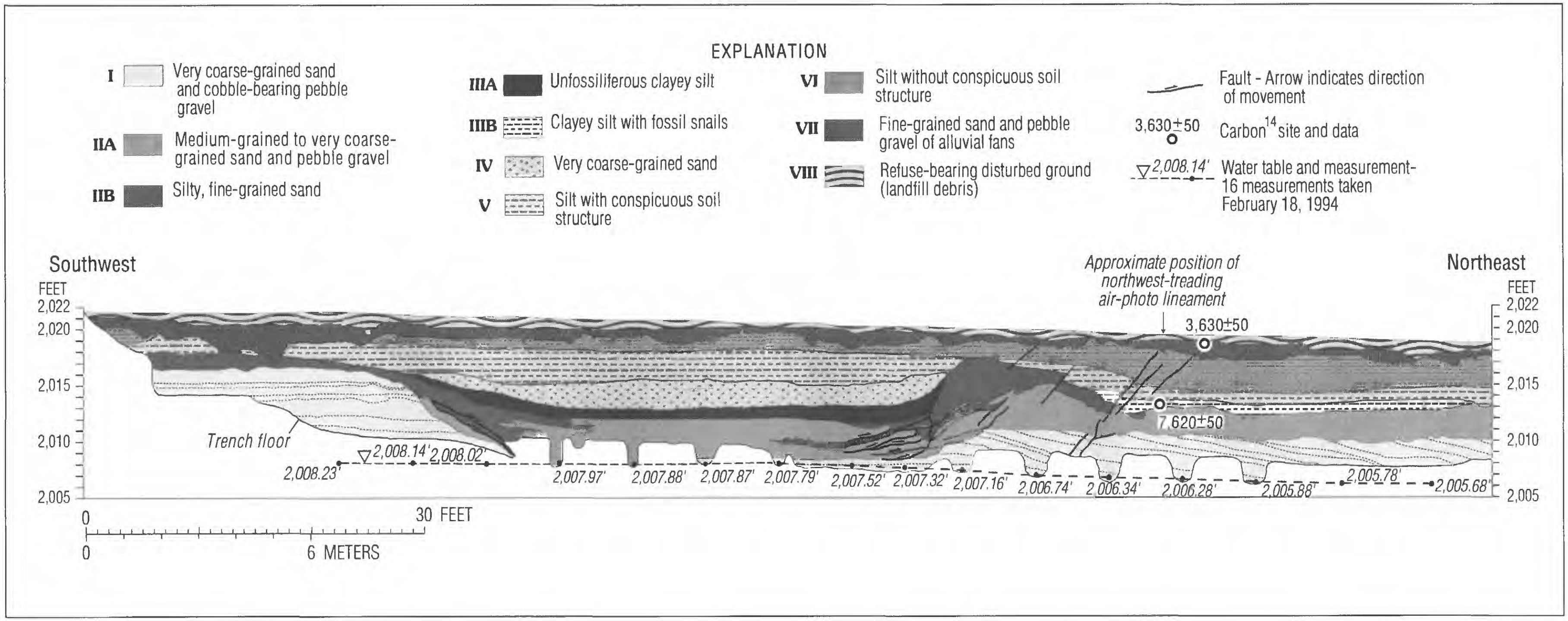


Figure 7. Generalized stratigraphy and structure of alluvial deposits in a trench at the Marine Corps Logistics Base, Nebo Annex, near Barstow, California. (Diagram shows northwest wall of the trench projected onto a vertical plane that parallels trench axis (true bearing 035 degrees.)

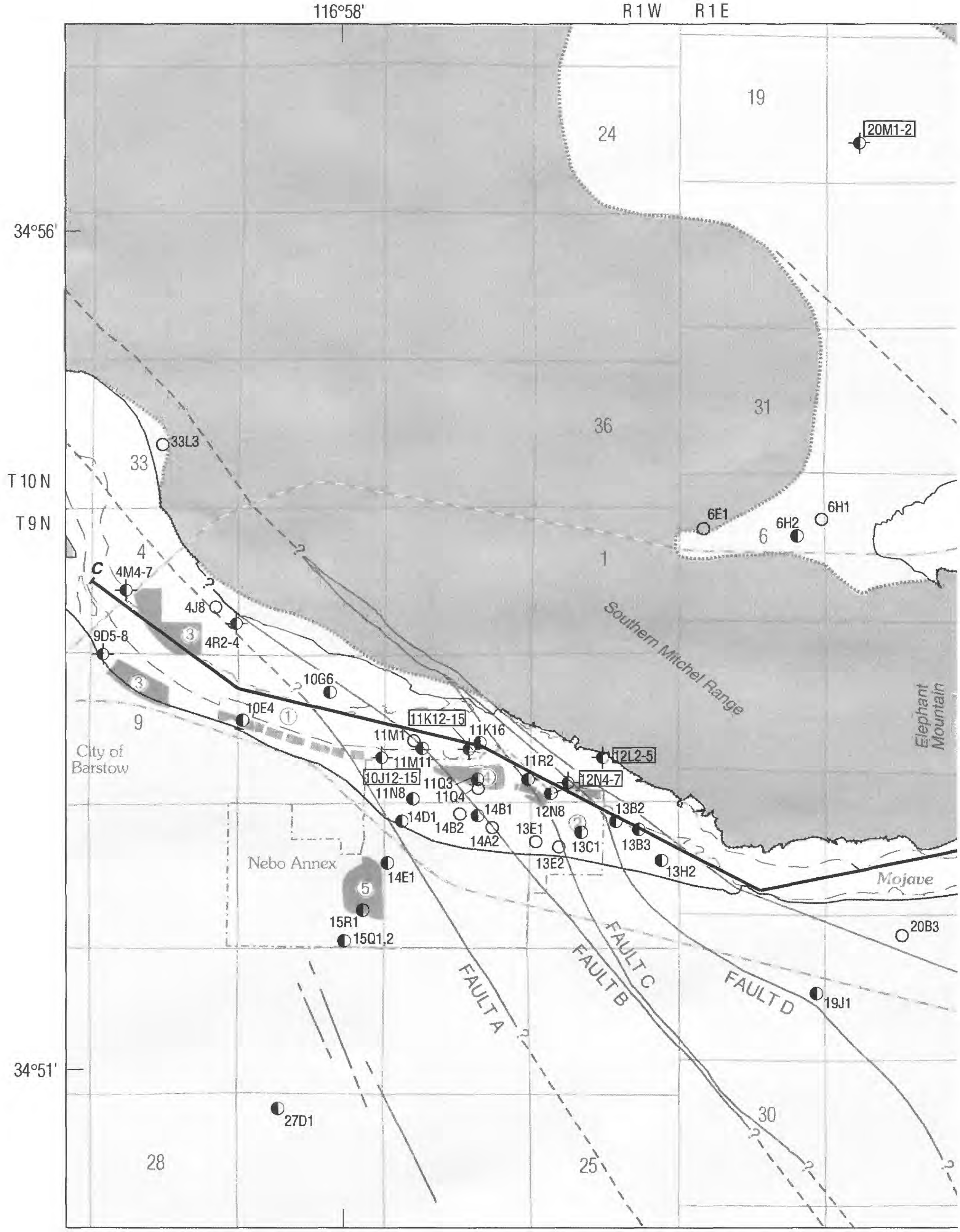
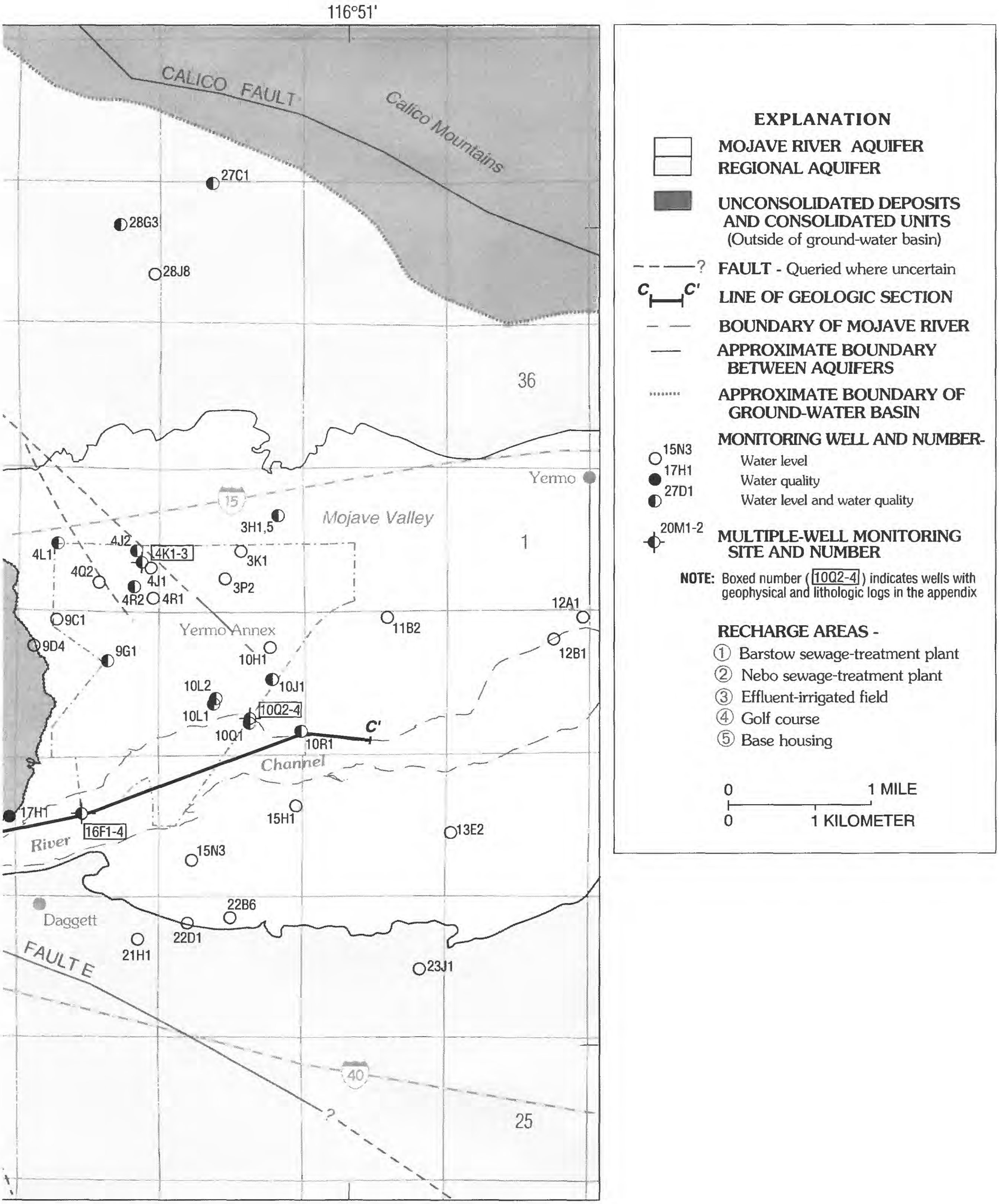


Figure 8. Location of well and multiple-well monitoring sites in the vicinity of the Marine Corps Logistics Base, Nebo and



Yermo Annexes, near Barstow, California.

7,620 ± 60 years old, and sandy alluvial-fan deposits near the top of the trench wall (unit VII, fig. 7) are 3,630 ± 50 years old. Inasmuch as four of the deformational events seem to post-date the deposition of unit IIIB, fault C apparently has moved four times in the past 7,620 years, or on average about once every 1,900 years during this period. Additional radiocarbon ages are being obtained to test these initial results.

To investigate the influence of the fault zone on local ground-water levels, pits were dug down to the water table at 6-ft intervals along the axis of the trench. The altitude of the water table, as measured on February 18, 1994, is plotted on the generalized trench log (fig. 7). These data show that the water table consistently slopes northeastward along the line of the trench. The gradient changes at two points, first steepening near the middle of the trench, then shallowing again near the north end. The first break in slope may mark the location of a ground-water barrier that passes beneath the midpoint of the trench. The barrier appears to correspond to what is locally the main dislocation surface of fault C. Formation of clay gouge by recurrent shearing along such a fault surface would lower the permeability of the alluvial sediments and impede the flow of ground water, thereby producing a step in the water table across the fault.

The master-fault plane, implied by the break in the water table, does not penetrate upward into strata exposed in the walls of the trench, which is consistent with the character of the lineament on the aerial photographs. The lineament deteriorates northwestward into a faint line near the trench site. Nevertheless, fault C can be traced beyond the trench site to the Mojave River, where it historically was marked by perennial springs but today is marked by a dense cluster of riparian vegetation. Presumably, a steeply dipping master-fault plane passes beneath the trench site at a shallow depth but has not broken cleanly upward to the ground surface in this particular area. Instead, recent movement of the master fault at depth have buckled the overlying shallow alluvium, producing the broad zone of folding and minor faulting observed in the walls of the trench.

Hydrologic Setting

The ground-water hydrology of this area is described in several reports (Koehler and Banta, 1969; Koehler, 1969, 1970, 1971, 1972; Miller, 1969; Hughes, 1975; Robson, 1974; Densmore and others, 1994). For this study, data were collected from existing and newly drilled wells to update and refine the understanding of the ground-water hydrology of the study area. Table 1 lists the well-construction data for all wells used in this report for which data were available.

Definition of the Aquifer System

Two aquifers have been identified within the study area, the Mojave River aquifer and the regional aquifer (fig. 8). The Mojave River aquifer as it is referred to in this paper has been referred to as the alluvial aquifer in previous reports (Robson, 1974; Densmore and others, 1994), and is the main aquifer in the study area. The Mojave River aquifer is approximately 1 mi wide in the Nebo area, widens to as much as 4 mi in the Yermo area, and is about 200 ft thick. This aquifer consists of recent and younger alluvium (fig. 3). Primarily, the recent alluvium underlies the present Mojave River channel (fig. 3) from land surface to a depth of approximately 30 ft, and it is more permeable than the younger alluvium. The younger alluvium extends across the entire width of the aquifer system (fig. 3) and underlies the recent alluvium. The hydraulic conductivity of the Mojave River aquifer was estimated from aquifer tests; it averages 150 ft/d (Robson, 1974). Most of the water from the production wells in the area is from the Mojave River aquifer. In some areas, the Mojave River aquifer is overlain by a veneer of younger fan deposits.

The regional aquifer, which underlies and surrounds the Mojave River aquifer throughout most of the study area, is more than 1,000 ft thick in some areas and consists of the younger and older fan deposits and older alluvium (fig. 4 and 5; see fig. 3 for correlation of map units). This aquifer system generally is less permeable than the Mojave River aquifer and generally is not tapped by wells except where the Mojave River aquifer is absent. The hydraulic conductivity of the regional aquifer was estimated by Robson (1974) to be 1.5 ft/d. Most of the ground water in storage in the study area is in the regional aquifer; however, yields from wells perforated in this aquifer generally are low.

The regional aquifer is underlain by a series of Tertiary rocks that generally are of very low permeability (figs. 4 and 5). Some water-bearing units are contained within these rocks; however, they yield only small quantities of mostly poor-quality water. The top of these rocks is considered the base of the ground-water system in the study area.

Recharge and Discharge

Recharge to the ground-water system occurs primarily from the infiltration of Mojave River floodflows, seepage of sewage effluent, irrigation-return flow, and ground-water underflow from basins upstream (table 2, at back of report). Because the precipitation in this area is low and the potential evaporation is high, little, if any, recharge occurs as a result of the direct infiltration of precipitation.

Infiltration of Mojave River floodflows in the Nebo area was about 1,615 acre-ft/yr during 1946–71 (Robson, 1974). Dividing the infiltration by the river's reach in the Robson's study gives a recharge estimate of 230 acre-ft/yr/mi. Assuming that this rate of recharge is representative for the study area, the estimated recharge by infiltration for the 10-mi reach in this study is 2,300 acre-ft/yr. Most of this recharge occurred during the 33 years in which flow occurred past Barstow (fig. 9). Mojave River floodflows are the major source of recharge in the study area.

Seepage of sewage effluent by direct percolation from the ponds at the Barstow and Nebo sewage-treatment plants (fig. 3) was estimated at 1,450 acre-ft/yr by Robson (1974) for the time period of 1946–71. This seepage made up about 28 percent of the total estimated recharge of 5,090 acre-ft/yr to the Nebo area during this period (Robson, 1974). From 1972 to 1994, average seepage of sewage effluent from the Barstow and Nebo sewage-treatment plants was estimated at about 2,170 acre-ft/yr (C. L. Stamos-Pfeiffer, U. S. Geological Survey, written commun., 1996) using total percolation numbers (John Brand, City of Barstow, written commun., 1993) and deducting evaporation estimated at 6.6 ft/yr for the Newberry Springs (east of the study area). Seepage from the ponds at the Yermo sewage-treatment plant was estimated at 90 acre-ft/yr

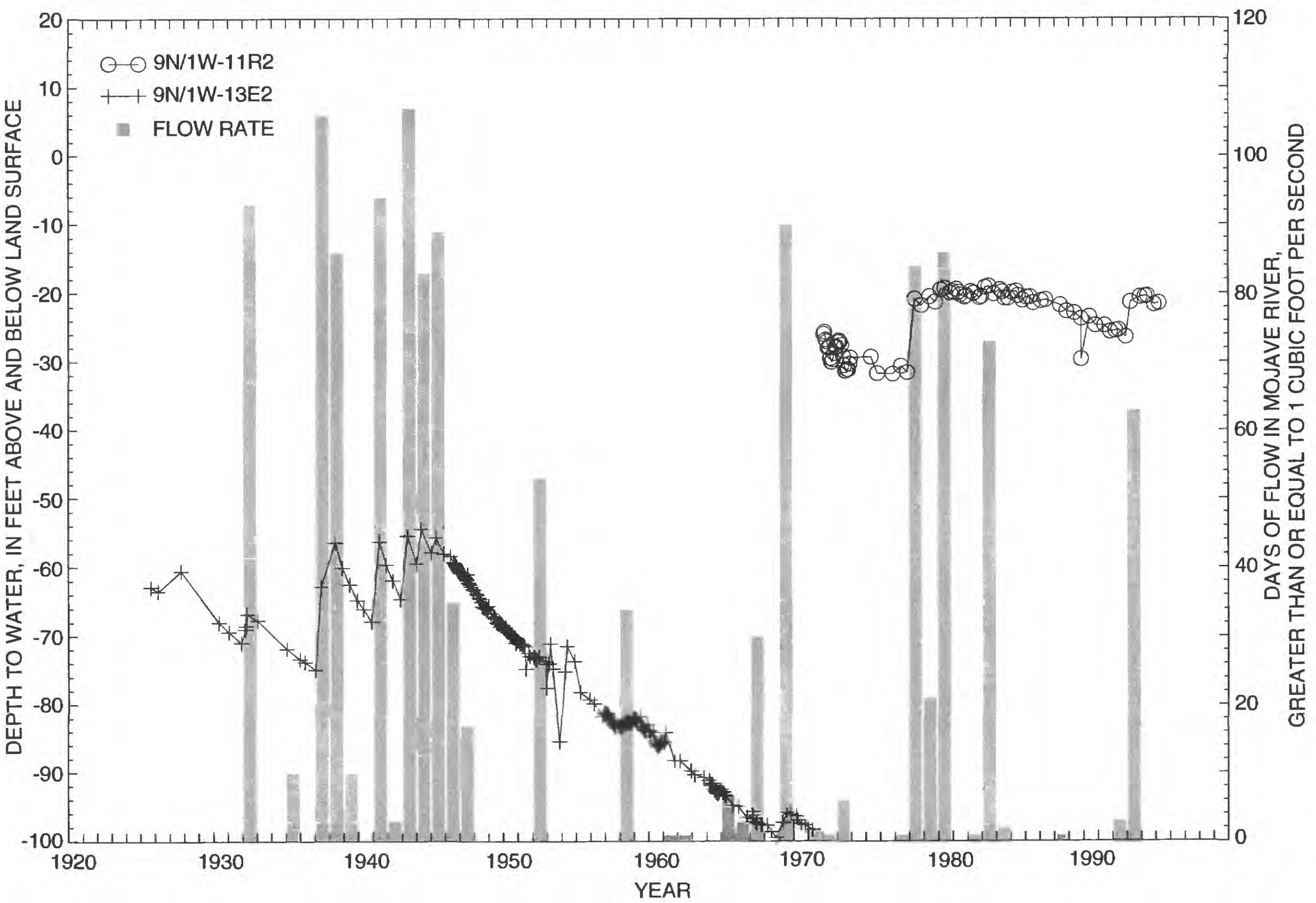


Figure 9. Comparison of ground-water levels at the Marine Corps Logistics Base, Nebo and Yermo Annexes, to days of flow in the Mojave River near Barstow, California. (No streamflow data are available prior to 1931 when data collection began.)

during 1961–95 (C. L. Stamos-Pfeiffer, U.S. Geological Survey, written commun., 1996). Thus, the current estimated seepage of sewage effluent in the study area is 2,260 acre-ft/yr (2,170 + 90 acre-ft/yr).

Percolation of irrigation-return flow from agricultural areas and from fields irrigated with Barstow and Nebo sewage effluent is another source of recharge to the ground-water system. The main agricultural areas lie west of Barstow, outside the study area shown in figure 3, and southeast of the Mojave River in Mojave Valley. A small agricultural area lies east of Barstow, north of the Barstow sewage-treatment plant. Alfalfa, the primary irrigated crop, requires large quantities of water. The quantity of recharge from irrigation-return flow in these areas varies from year to year, but the average annual recharge during 1946–1971 was estimated to be 830 acre-ft (Hughes, 1975) for the fields in the Barstow area. It is not known how much irrigation-return flow recharges the aquifer system from the agricultural areas southeast of the Mojave River in the Mojave Valley.

Sewage-effluent recharge to the Mojave River aquifer from irrigation of the Nebo Annex golf course between 1959 and 1972 was estimated at about 150 acre-ft/yr (Hughes, 1975). We assumed for this study that this irrigation resumed in the late 1970's after the base's water-supply wells were abandoned because of ground-water degradation. Since 1983, sewage effluent has been used to irrigate two areas approximately 0.5 mi upstream of the Barstow sewage plant (fig. 3). In 1992, the quantity of sewage effluent used to irrigate these fields was 950 acre-ft, about one-third of the 2,900 acre-ft of sewage outflow for that year (John Brand, City of Barstow, oral commun., 1993). By subtracting crop consumptive use of about 580 acre-ft/yr [6.3 ft/yr (consumptive use of alfalfa) x 92.54 acre (area of irrigated fields)] for alfalfa from the 950 acre-ft of effluent that was used for irrigation, it is estimated that about 370 acre-ft/yr of sewage effluent recharges the Mojave River aquifer. Thus, a conservative estimate of irrigation-return recharge is 1,350 acre-ft/yr (830 + 150 + 370 acre-ft/yr). Hughes (1975) determined that the percolation of sewage effluent and treated wastewater was the source of degradation of the water quality in the Mojave River aquifer.

Ground-water underflow (inflow) into the Barstow area beneath the Mojave River was estimated to be 1,100 acre-ft/yr in 1966 by Miller (1969) using the following form of Darcy's law.

$$Q = KIA \tag{1}$$

where

- Q is ground-water underflow (134,000 ft^3/d or 1,100 acre-ft/yr)
- K is average hydraulic conductivity of the saturated unconsolidated deposits (134 ft/d)
- I is hydraulic gradient estimated from water-level contours (0.002 ft/ft) and
- A is cross-sectional area (500,000 ft^2).

Robson (1974) also estimated that the annual recharge by ground-water underflow into the study area was about 1,100 acre-ft/yr during 1946–58 but he indicated that this value decreased to 800 acre-ft/yr during 1959–71, probably as a result of increased pumping upstream.

Discharge from the study area results primarily by ground-water pumping, subsurface outflow, and evapotranspiration (consumptive use by evaporation from native vegetation where the water table is less than 10 ft below land surface). Discharge by ground-water pumping from the Barstow area was estimated at only 5,070 acre-ft/yr during 1946–71 (Robson, 1974). Since 1971, ground-water pumping in this area has increased. Estimates of total pumpage during 1972–94 were about 13,700 acre-ft/yr in the study area, of which about 4,300 acre-ft/yr was extracted from the Nebo Annex area and about 9,400 acre-ft/yr was extracted from the Yermo Annex area (C. L. Stamos-Pfeiffer, U.S. Geological Survey, oral commun., 1996). About 30 percent of this extracted ground water returns to the ground-water system as irrigation-return flow (Hardt, 1971). Thus, the net amount of discharge from pumpage during 1972–94 was estimated at 9,570 acre-ft/yr.

Natural discharge occurs along the Mojave River by ground-water underflow (outflow) to the east of the study area. Annual outflow along the eastern boundary of the study area was estimated at 450 acre-ft/yr. These estimates were made using the following form of Darcy's law:

$$Q = TIW \quad (2)$$

where

Q is ground-water underflow (54,000 ft^3/d or 450 acre-ft/yr);

T is average transmissivity of the saturated unconsolidated deposits [3,300 ft^2/d (Hardt, 1971) in the Mojave River alluvium];

I is hydraulic gradient estimated from water-level contours (0.001 ft/ft); and

W is width of the cross-sectional area through which flow passes (3.1 mi or 16,368 ft).

Natural discharge by evapotranspiration from native vegetation along the Mojave River occurs primarily near the Nebo Annex upgradient of fault C, where the water table is shallowest. On the basis of vegetation coverage in the study area and the rates of water use for specific plant types (G. C. Lines, U.S. Geological Survey, written commun., 1996), evapotranspiration from native vegetation was estimated at about 1,000 acre-ft/yr.

The total annual recharge in the vicinity of the Marine Corps Logistics Base was estimated at 6,710 acre-ft/yr but varies annually depending on the amount of flow in the Mojave River during a particular year. The total annual discharge in this area was estimated at 11,020 acre-ft/yr. Recharge was greater than discharge in this area prior to ground-water development. Presently, discharge is greater than recharge in this area as indicated by declining ground-water levels.

Ground-Water Levels and Movement

Ground-water levels were measured periodically at about 85 sites (table 3, at back of report) in the study area during 1992–96. Water-level measurements were used to show changes in the water table and in the ground-water flow direction. Historical water levels (fig. 9) were used to show long-term trends. Water-level data for 1992–96 are given in table 3.

The direction of ground-water flow was determined by constructing a water-table contour map. Figure 10 shows the water-table contours for two periods: (1) between March 1992 and January 1993, before flooding of the Mojave River occurred, and (2) between February 1993 and August 1993, after flooding occurred. Arrows, which are at right angles to the contours, show the general direction of ground-water movement. Throughout the study area, the general direction of movement is downstream along the Mojave River, which is from west to east within the study area (fig. 10). The contours show ground water moving from the regional aquifer toward the Mojave River aquifer (fig. 10).

Water levels rose in the Mojave River aquifer in the vicinity of the Marine Corps Logistics Base following the 1993 flood of the Mojave River (fig. 11). Water levels rose about 10 to 20 ft in wells perforated in the Mojave River aquifer near the Nebo Annex (wells 9N/1W-4M7, -4R4, -11K15, and -12N7 in fig. 11) and about 1 to 15 ft in the Mojave River aquifer near the Yermo Annex (wells 9N/1E-3H5, -10L2, -11B2, and -15H1 in fig. 11). With the exception of a mound beneath base housing at the Nebo Annex, the water table was relatively unchanged in the regional aquifer system (fig. 10). This mound has formed in the regional aquifer as a result of irrigation-return flow from lawns in this area.

The difference in water-level altitude across the faults in the Nebo Annex area indicates that some of these faults act as barriers to ground-water flow in both aquifers and that ground water is being forced to the surface here. The water-level altitudes are higher upgradient of fault C than downgradient of this fault (fig. 10). In 1992, water-level altitudes were as much as 30 ft higher upgradient of fault C [about 2,010 ft in wells 9N/1W-11K12-15 (fig. 11)] than the water levels downgradient of fault C [about 1,980 ft in wells 9N/1W-12N4-7 (fig. 11)]. After the 1993 floods, upgradient water levels [about 2,015 ft in wells 9N/1W-11K12-15 (fig. 11)] were only about 20 ft higher than downgradient water levels [about 1,995 ft in wells 9N/1W-12N4-7 (fig. 11)]. About 10 ft of this difference in water-level altitudes is due to the difference in land-surface altitude between each site. The rise in water levels reflects the recharge of both aquifers after the 1993 flood (fig. 11). Fault E also appears to act as a barrier to ground-water flow. The water-level altitude declines sharply downgradient of fault E (fig. 10) suggesting that this fault may have a greater effect on ground-water flow than was previously believed.

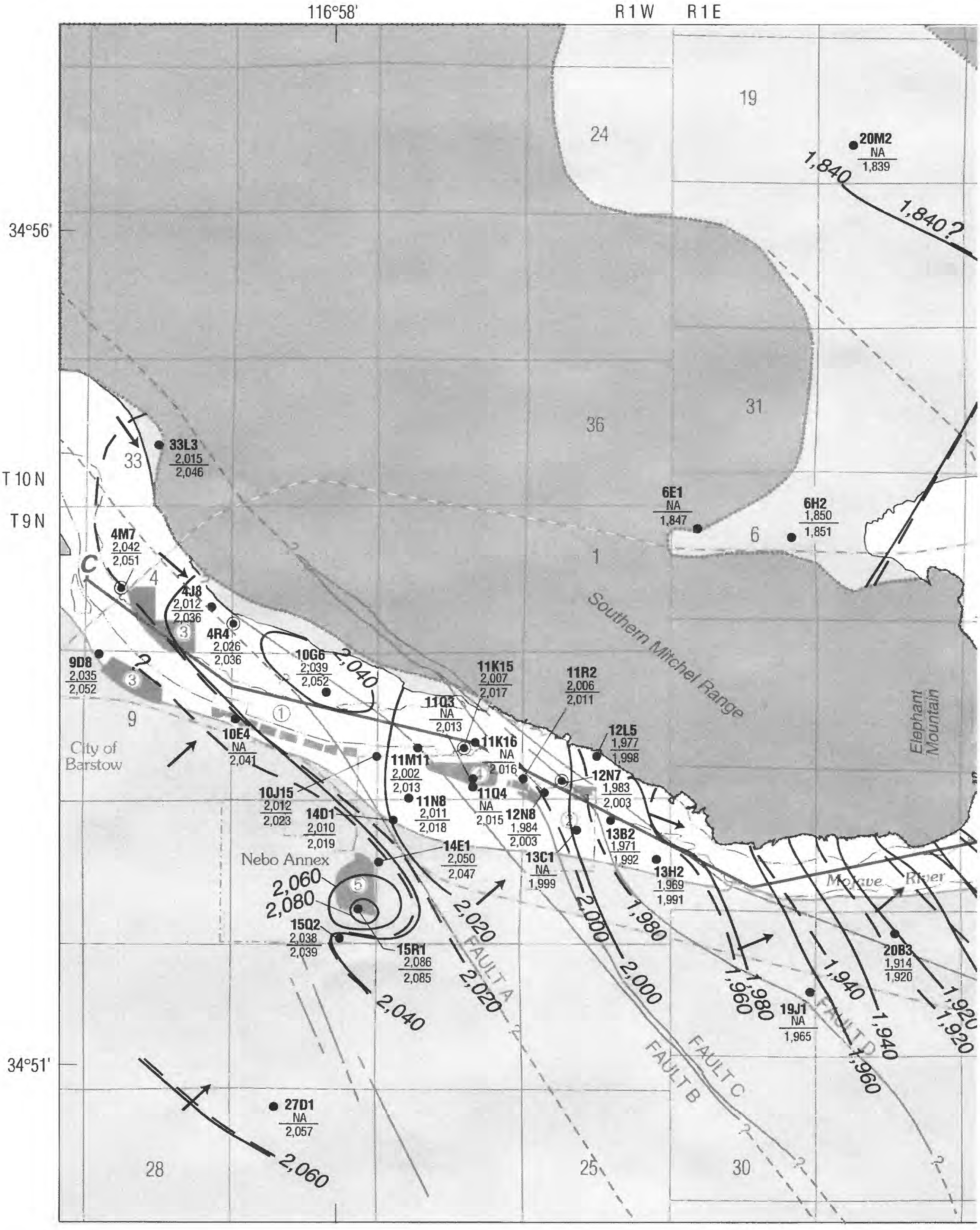
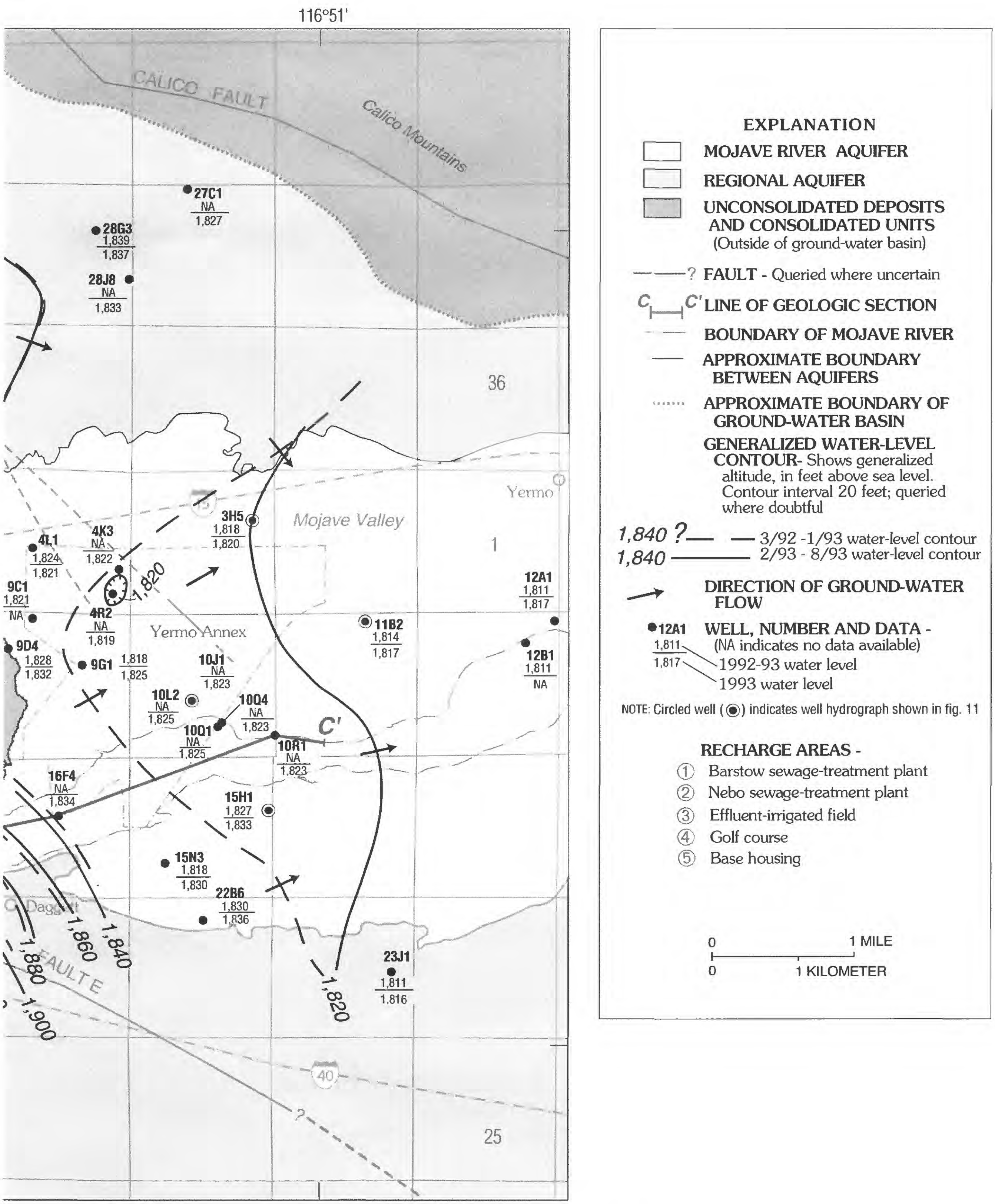


Figure 10. Generalized altitude of water table prior to and following the 1993 flood of the Mojave River at the Marine Corps



Logistics Base, Nebo and Yermo Annexes, near Barstow, California, 1992–93.

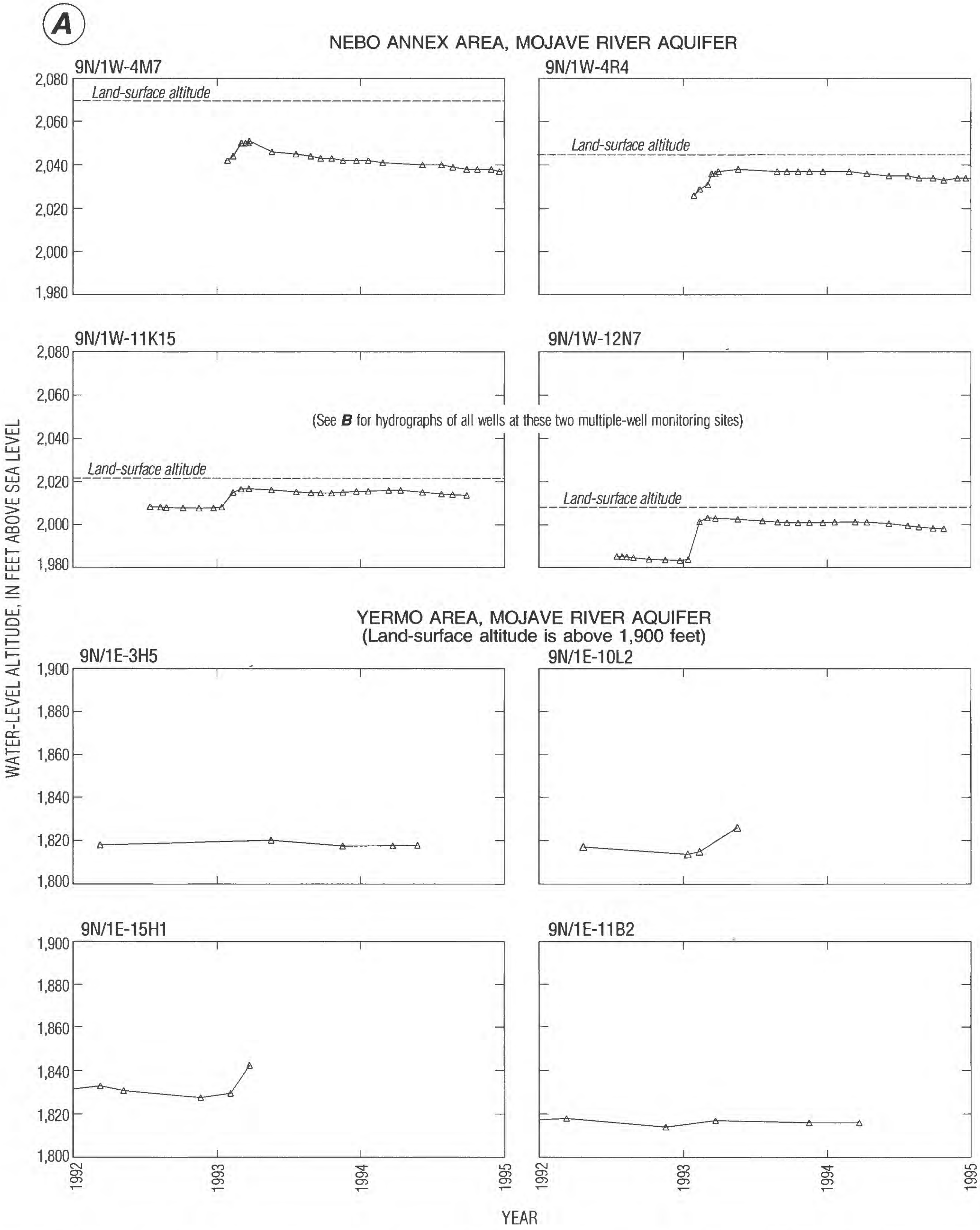


Figure 11. Hydrographs of selected wells in the vicinity of the Marine Corps Logistics Base, Nebo and Yermo Annexes, near Barstow, California. Hydrographs shown in *B* are detailed versions of multiple-well monitoring sites (9N/1W-11K12-15) and (9N/1W-12N4-7). They illustrate the impact that fault C has on water levels. (See figure 10 for location of wells.)

Water-Level Changes

Long-term changes in water levels can be determined by examining hydrographs of historical water levels for a specific well. Because very little continuous water-level data are available for wells in the Nebo and Yermo Annex area, composite hydrographs were constructed for wells perforated in the same intervals. In the Yermo area, water-level data for the regional aquifer were so limited that wells used to make the composite hydrographs were as much as 2 mi apart.

Water levels in the Mojave River aquifer near the Nebo Annex are very responsive to flow in the river. Between periods of flow, water levels in wells perforated in the Mojave River aquifer in the Nebo area (9N/1W-11R2 and -13E2) declined steadily and then rose abruptly in years of river flow (fig. 9). Prior to 1972, ground-water pumping from wells in the Barstow area and the Nebo Annex caused water levels to decline during periods with little or no flow in the Mojave River. After prolonged periods of flow, water levels in the

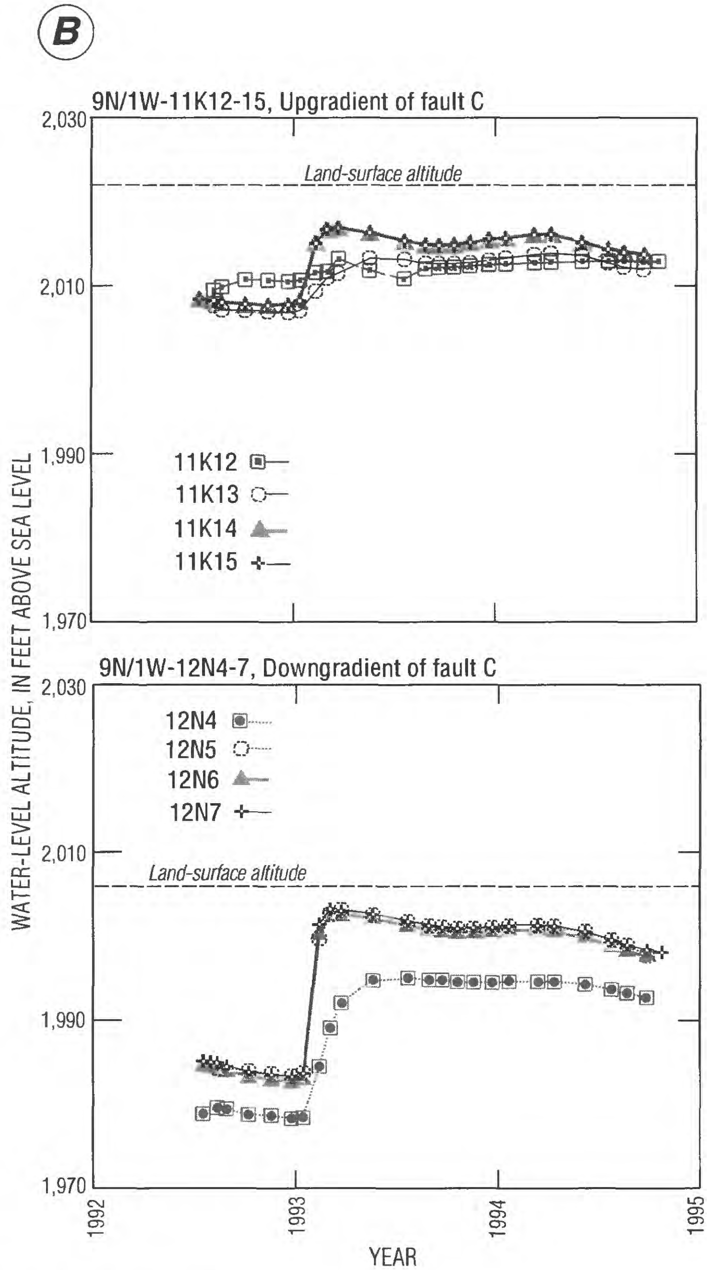


Figure 11. Continued.

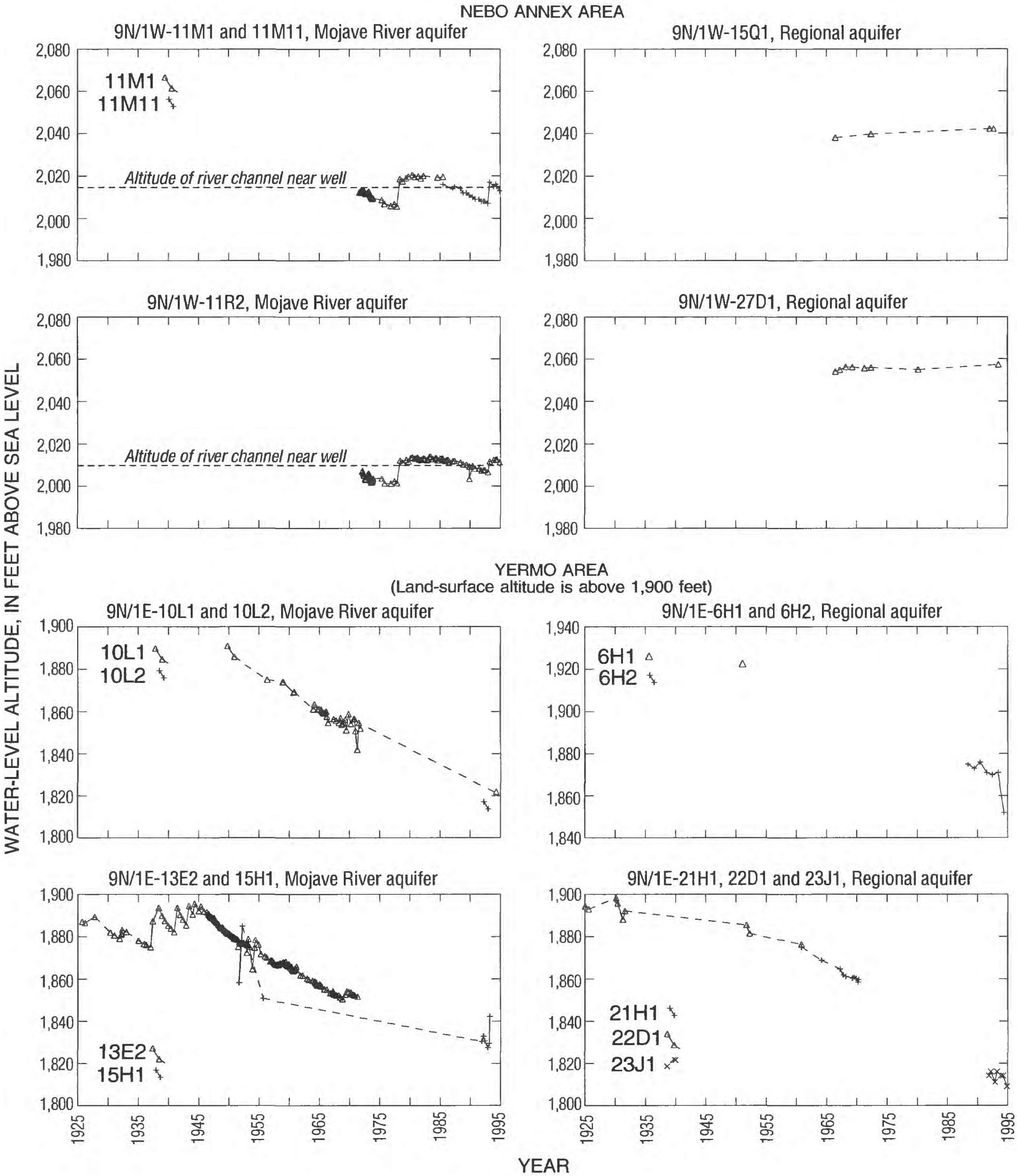


Figure 12. Hydrographs of selected wells in the vicinity of the Marine Corps Logistics Base, Nebo and Yermo Annexes, near Barstow, California. (See figure 8 for location of wells.)

Mojave River aquifer (wells 9N/1W-11M1, -11M11, and -11R2) in the Nebo area rose to the approximate altitude of the Mojave River channel bottom upgradient of fault C (fig. 12) indicating that potential recharge exceeds recharge capacity in this area of the Mojave River. In the regional aquifer, water levels in this area have risen slightly since about 1966 (wells 9N/1W -15Q1 and -27D1), the beginning of the period of record for wells in this area (fig. 12). This slight rise in water levels is probably due to the cessation of pumping at the Nebo Annex in the early 1970's.

Water levels in wells perforated in the Mojave River aquifer near the Yermo Annex (9N/1E-10L1, -10L2, -13E2, and -15H1) have declined about 65 to 80 ft during the last 50 years (fig. 12). This steady decline is probably due to pumping at the Yermo Annex and in the area south of the river. Water levels in this area respond to flow in the river, but the changes in water levels generally are not as dramatic as the changes in the Nebo Annex area. Well 9N/1E-15H1, perforated in the Mojave River aquifer near the Yermo Annex, had a 12-ft water-level rise after the flood in 1993. The composite hydrographs of wells completed in the regional aquifer near the Yermo Annex indicate a decline in water levels, possibly as much as 90 ft since the 1940's (fig. 12). Water levels in wells perforated in the regional aquifer near the Yermo Annex (9N/1E-6H1, -6H2, -21H1,- 22D1, and -23J1) have declined because of local pumping for domestic and municipal supply and because of the lack of recharge to this system.

GROUND-WATER QUALITY

Water-quality samples were collected from 66 wells perforated in the Mojave River and regional aquifers within the study area between January 1992 and October 1995 (table 4, at back of report; fig. 8). These samples were analyzed in the field for specific conductance, pH, temperature, and alkalinity and in the laboratory for major ions, trace elements, tritium, and the stable isotopes of oxygen-18 and deuterium (table 4). The 1992 sampling reflects conditions after 8 years of drought, with no recharge from floodwaters in the Mojave River; the 1993 sampling reflects conditions following a period of prolonged flow in the river. Because floodwaters flowed 20 to 45 mi past Barstow between January and March 1993 (G.C. Lines, U. S. Geological Survey, oral commun., 1994), recharge to the Mojave River aquifer was high in 1993 (fig 12). Potential sources of ground-water degradation, areal and vertical variations in the ground water quality, and the source and age of the ground water are described in the following sections.

Sources of Ground-Water Degradation

Degradation of ground water in the Mojave River aquifer near Barstow, California, is reported to have occurred as early as 1910 (Hughes, 1975). Potential sources of ground-water degradation to the Mojave River aquifer near Barstow include (1) municipal sewage effluent and industrial waste, (2) irrigation-return flow, and (3) naturally occurring, high-dissolved-solids water from underlying and surrounding older fan deposits of Tertiary age and sedimentary and volcanic rocks of Tertiary age. In this study, dissolved-solids concentrations were used to identify ground-water degradation.

Sewage effluent from the city of Barstow and the Nebo sewage-treatment plants is a major source of recharge to the study area. Since 1938, sewage-treatment plants operated by the city of Barstow have been releasing waste effluents to the river-channel deposits of the Mojave River (Hughes, 1975). The original plant was located south of the Mojave River (just west of the area shown in figure 3) and was in operation from 1938 to 1953. The original plant discharged domestic waste directly to the Mojave River deposits. The level of treatment of the waste before discharge is not known. In 1953, a replacement sewage-treatment plant was built about 0.5 mi downstream (not shown on figure 3). It was designed to provide primary and secondary treatment to the increasing volume of sewage from the growing city. The sewage effluent was disposed of by direct percolation to the river-channel deposits and by evaporation from oxidation ponds. In 1968, the plant currently in use, began operation; it is about 2.5 mi downstream from the second plant and about 1 mi upstream from the Nebo Annex (fig. 3). This current plant provides primary and secondary treatment to sewage and consists of a holding pond for mechanical aeration and six oxidation ponds. The sewage-treatment plant operated by the Marine Corps Logistics Base at Nebo Annex was built in 1942 and is approximately 1.5 mi downstream from the plant currently operated by the city of Barstow (fig. 3). The Nebo plant also provides primary and secondary treatment of the industrial and domestic waste, which is disposed of by evaporation and direct percolation to the river-channel deposits. The dissolved-solids concentra-

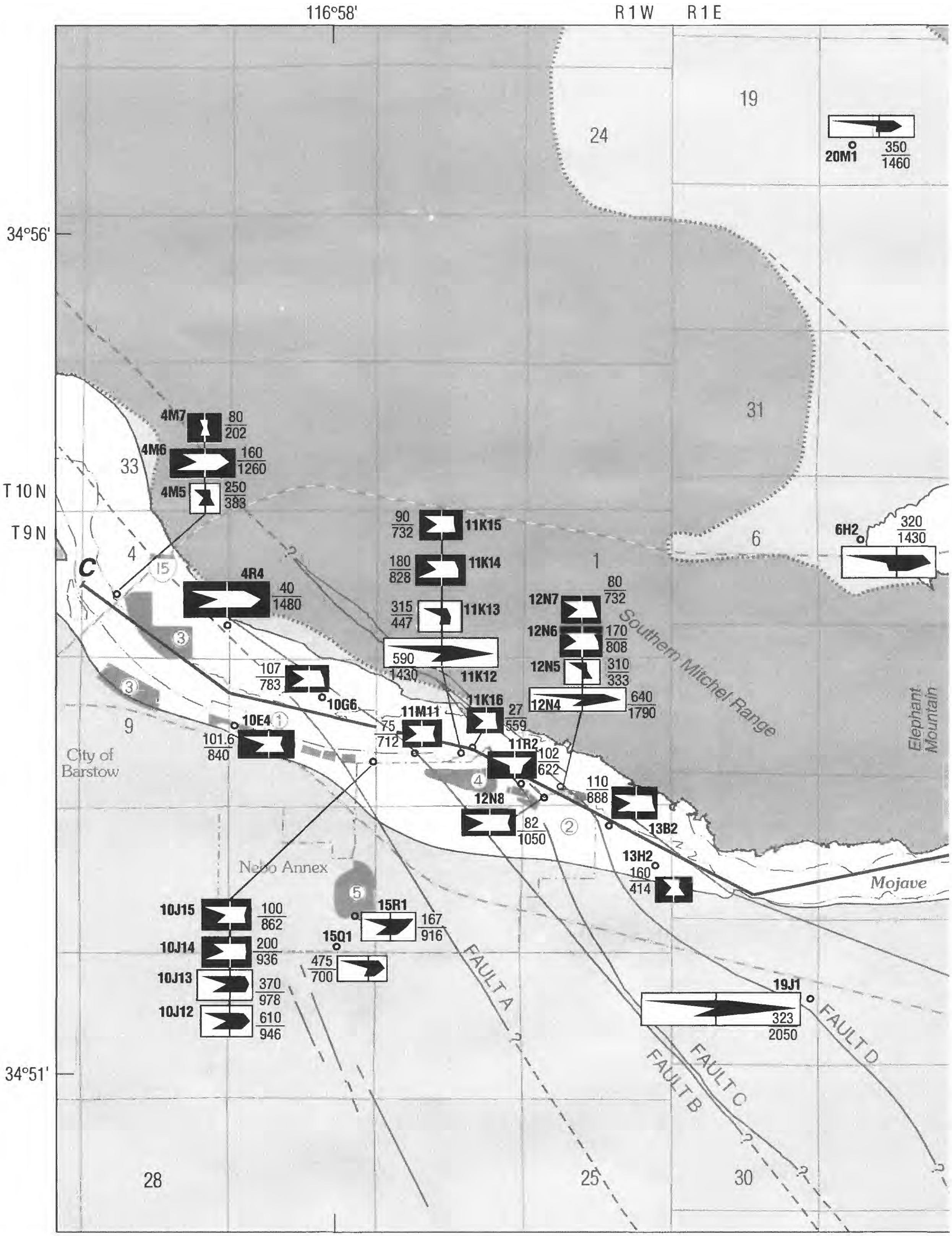
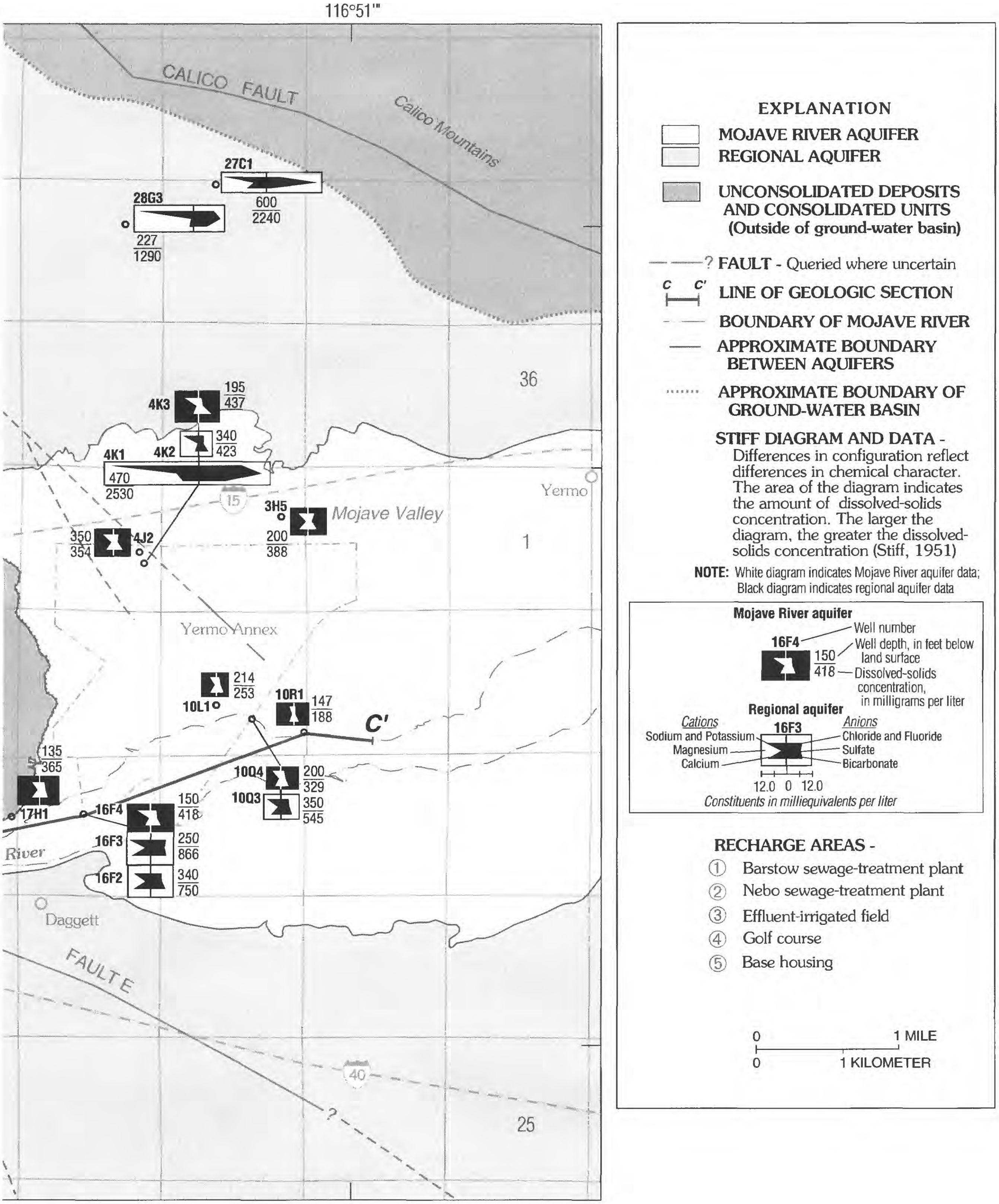


Figure 13. Distribution and concentrations of dissolved solids for selected wells in the vicinity of the Marine Corps Logistics



Base, Nebo and Yermo Annexes, near Barstow, California, 1992–94.

tion of sewage effluent from the city of Barstow plant is about 850 mg/L, and the dissolved-solids concentration of sewage effluent from the Nebo plant is about 1,000 mg/L (Hughes, 1975).

Industrial-waste discharge to the Mojave River began as early as 1910 when the Atchison, Topeka, and Santa Fe Railway built a drain system from the shop and yards to the river channel, near the city of Barstow's original sewage-treatment plant. Waste effluent from this source included fuel oils, solvents, radiator coolants containing chromium, emulsified oil, and synthetic detergents (Hughes, 1975). The railroad modified its waste treatment and discharge from 1959 to 1968 to conform to effluent standards established by the California Water Resources Control Board and the city of Barstow. The quantity and quality of industrial waste from the Atchison, Topeka, and Santa Fe facilities varied greatly, and dissolved-solids concentration ranged from 311 to 2,700 mg/L (Hughes, 1975). The contribution of waste from this source continued until 1968 when most of the railway waste was conveyed to the current city sewage-treatment plant.

Irrigation-return flow is also a source of degradation of the ground water in the study area. The main agricultural areas lie west of Barstow, outside the area shown in figure 3, and southeast of the Mojave River in Mojave Valley. Because of evaporation, leaching of minerals, and introduction of fertilizer salts, dissolved-solids concentration in the irrigation-return water can be more than twice the concentration of the applied water (Hughes, 1975). Some of the irrigation water is treated effluent from the sewage-treatment facilities. From 1953 to 1964, treated effluent from the city of Barstow's replacement sewage-treatment plant was used to irrigate fields about 0.5 mi downstream from the plant. Since 1983, treated effluent from the city of Barstow's current sewage-treatment plant has been used to irrigate fields about 0.5 mi upstream of the plant (fig. 3). Between 1959 and 1972, treated sewage effluent from the Nebo plant was used to irrigate the Nebo Annex golf course (fig. 3). It is assumed that irrigation with sewage effluent resumed after the production wells on the base were abandoned in the mid-1970's because of ground-water degradation. The dissolved-solids concentration of the irrigation-return water of the fields irrigated with sewage effluent was estimated to be 2,000 mg/L (Hughes, 1975).

Another potential source of degradation of the ground water is naturally occurring, high-dissolved-solids water from the underlying and surrounding older fan deposits of the regional-aquifer system and sedimentary and volcanic rocks. Because the deposits that make up the regional aquifer are less permeable than those of the Mojave River aquifer, the contribution of water from the regional-aquifer system to the Mojave River aquifer and the effect from the underlying Tertiary-aged rocks on ground-water quality in the Mojave River ground-water basin was believed to be small (Robson, 1974; Hughes, 1975). However, the dissolved-solids concentrations of water from parts of the regional-aquifer system and from the underlying rocks of Tertiary-age are as much as 2,000 mg/L (Densmore and others, 1994).

Areal and Vertical Variations

The quality of ground water in the vicinity of the Marine Corps Logistics Base varied areally within individual water-bearing deposits. The chemical character of water from selected wells sampled during 1992–94 is shown on figure 13 using a method suggested by Stiff (1951). The water-quality diagrams depict the concentrations of major ions and indicate relative proportions of major ions. Analyses with similarly shaped diagrams represent ground water of similar chemical characteristics. Changes in the width of the diagrams indicate differences in the concentration of dissolved constituents. For wells perforated in the Mojave River aquifer, these diagrams are white outlined in black and for wells perforated in the regional aquifer, they are shaded black.

Samples from wells perforated in the Mojave River aquifer generally have lower dissolved-solids concentrations than samples from wells perforated in the regional aquifer, except in areas where the Mojave River aquifer has been degraded by the disposal of treated sewage effluent. Upgradient of the Nebo Annex, water in well 9N/1W-4M7 (fig. 13), which is perforated in the Mojave River aquifer that recently had been recharged by Mojave River floodflows, had a low dissolved-solids concentration (202 mg/L) and is similar to concentrations (about 150 mg/L) reported for floodflows in the river (Miller, 1969). Wells in the Nebo Annex area downstream of well 9N/1W-4M7 and perforated in the Mojave River aquifer have high dissolved-solids concentrations (559 to 1,480 mg/L) (fig. 13). These higher concentrations are attributed to the ground-water degradation of the Mojave River aquifer, which is reported to have occurred as early as 1910 (Hughes, 1975), and has been attributed to the recharge of municipal sewage effluent, industrial wastewater, and irrigation return to the Mojave River aquifer upgradient of the Nebo Annex (Hughes, 1975; Densmore and others, 1994). Dissolved-solids concentrations for sewage effluent at the city of Barstow plant presently are about 850 mg/L (table 5, at back of report). In the Yermo Annex area, water from wells perforated in the Mojave River aquifer has lower dissolved-solids concentrations (188 to 437 mg/L) than water from wells in the Nebo Annex area (fig. 13). Available data show that there is little effect of the sewage-treatment ponds at the Yermo Annex on ground-water quality downgradient of these ponds.

The vertical distribution and concentrations of dissolved solids for selected wells sampled between 1992 and 1994 are shown in figure 14. All wells in figure 14 are projected into the section except 9N/1E -16F1-4 and -10R1. Three plumes of degraded water with concentrations of dissolved solids in excess of 900 mg/L were identified in the Mojave River aquifer by Hughes (1975) on the basis of the 1972 dissolved-solids and nitrogen concentrations in the Nebo Annex area. Two of these plumes were located at the water table underlying the Barstow sewage-treatment ponds and the Nebo Annex golf course. A third plume was located at the base of the Mojave River aquifer and extended from the original sewage-treatment plant (site was west of area shown in figure 3) to an area beneath the current sewage-treatment plant (fig. 14). The water-table plume beneath the Barstow sewage-treatment ponds was attributed to percolation of sewage effluent from the ponds, and the water-table plume beneath the Nebo Annex golf course was attributed to irrigation-return flow from the effluent-irrigated golf course (Hughes, 1975). The source of the deep plume was attributed to percolation of effluent from the original and replacement sewage-treatment plants and from the railroad waste site (Hughes, 1975). Dissolved-solids concentrations were 500 to 700 mg/L at sites unaffected by the degraded water. On the basis of both hydrologic and chemical data, Hughes (1975) estimated the deep plume was moving at a rate of 1.0 to 1.5 ft/d. At this rate of movement, the deep plume would have moved downgradient 1.4 to 2.1 mi between 1972 and 1992.

The dissolved-solids concentrations of water from the younger alluvium increase dramatically from about 200 mg/L at well 9N/1W-4M7, which is immediately upgradient of effluent-irrigated fields to 840 mg/L at well 9N/1W-10E4, which is immediately downgradient of these fields (fig. 13). The dissolved-solids concentration for well 9N/1W-4M7 is similar to concentrations (150 mg/L) reported for floodflows in the Mojave River (Miller, 1969). Water from wells in the Nebo area perforated in the recent and younger alluvium underlying the effluent-irrigated fields and the sewage-treatment ponds ranged from 712 to 936 mg/L dissolved solids (fig. 14; table 4). Well 9N/1W -4M6 perforated at the base of the younger alluvium upgradient of these fields has 1,260 mg/L dissolved solids (figs. 13 and 14). Concentrations in water from wells beneath the effluent-irrigated fields are within the range of concentrations of sewage effluent that has been subjected to evapotranspiration and leaching of minerals.

The dissolved-solids concentrations of water in the Mojave River aquifer beneath the Nebo Annex (golf course and Nebo sewage-treatment ponds) have increased since 1972 (fig. 14). The concentrations in wells beneath the Nebo Annex (9N/1W-11K14-15, -12N6-7) generally are greater than 750 mg/L. These high concentrations extend to well 9N/1W-13B2 (fig. 13) which is at the eastern edge of the Nebo Annex. Water from well 9N/1W-13H2, which is less than 0.25 mi downgradient of well 9N/1W-13B2, has a lower dissolved-solids concentration than water from well 9N/1W-13B2, indicating that the plume of high dissolved-solids concentrations has not reached this well. Thus, the downgradient edge of the deep plume of high dissolved-solids concentration water extends at least 2 mi downgradient from its 1972 position (fig. 14), and the water-table plume extends about 1 mi downgradient (fig. 14). High dissolved-solids concentrations are also present in water from well 9N/1W -4M6 perforated at the base of the Mojave River aquifer (fig. 14). Well 9N/1W-4M6 is upgradient of areas of current sewage-effluent discharge and is overlain by a zone of low dissolved-solids concentration water (well 9N/1W-4M7) which probably represents river water. Well 9N/1W -4M6 is perforated in the zone of high dissolved-solids concentration water that Hughes identified in 1972 as the third plume (fig. 14). This plume was produced by percolation of effluent from abandoned sewage plants operated by the city of Barstow (west of study area). The 1992–94 distribution of dissolved-solids concentration supports Hughes' (1975) estimated rate of ground-water movement of 1.0 to 1.5 ft/d, a rate at which it would have taken the plume to reach fault C of the Waterman Fault system by 1992.

Nitrogen concentrations, also used to identify sources of degradation in 1972, were high in the parts of the Mojave River aquifer beneath the effluent-irrigated fields, the Barstow sewage-treatment ponds, and the Nebo sewage-treatment ponds. During this study, nitrogen concentrations in the Mojave River aquifer underlying and near the effluent-irrigated fields (wells 9N/1W-4R4, -10G6; table 4) and Barstow sewage-treatment ponds (well 9N/1W-10E4; table 4) exceeded 5 mg/L. Nitrogen concentrations in water from these wells ranged from 5.8 to 6.8 mg/L during 1993–94. About 0.5 mi downgradient of the sewage-

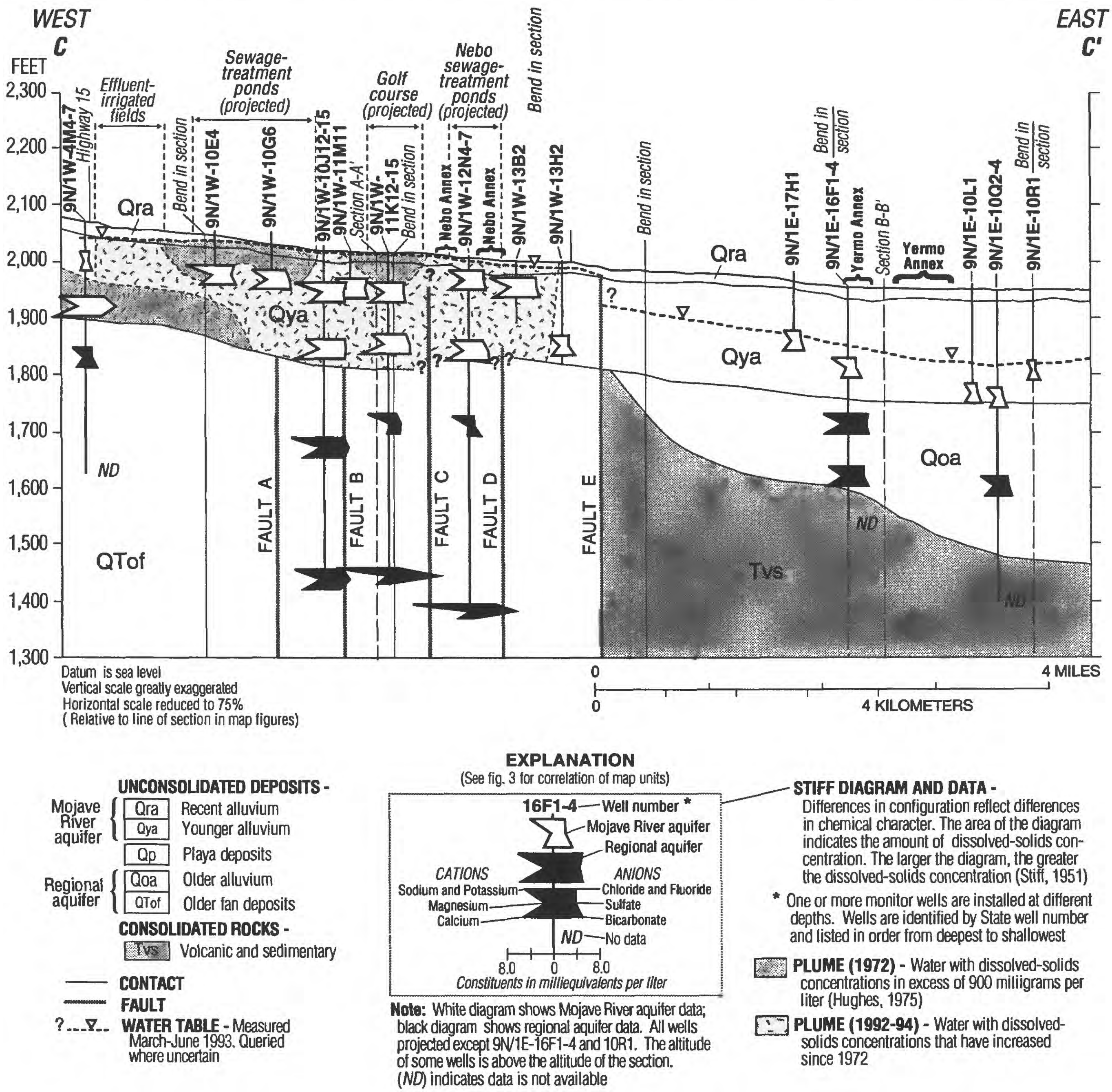


Figure 14. Geologic units and dissolved-solids concentrations in the vicinity of the Marine Corps Logistics Base, Nebo and Yermo Annexes, near Barstow, California, 1992–94. (Location of section is shown in figure 3; see table 4 for dissolved-solids concentrations.)

treatment ponds, nitrogen concentrations in water from wells 9N/1W-10J14, -11K14, and -12N6 perforated at the base of the Mojave River aquifer ranged from 5 to 2.4 mg/L (table 4). These concentrations are higher than the concentrations of 2 mg/L or less determined by Hughes (1972). This increase in the nitrogen concentrations in the Mojave River aquifer downgradient of the effluent-irrigated fields and sewage-treatment ponds since 1972 suggests that the increased use of sewage effluent for irrigation may be the source. In 1992, the city of Barstow used about 950 acre-ft of effluent to irrigate alfalfa near the sewage-treatment plant, and the Nebo Annex used about 150 acre-ft of effluent to irrigate the golf course. Nitrogen concentrations in wells 9N/1W-10J15, -11M11, and -11K15 in the upper part of the Mojave River aquifer downgradient of the Barstow sewage-treatment ponds were less than 3 mg/L (table 4). These concentrations are similar to 1972 concentrations described by Hughes (1975). Hughes attributed the low nitrogen concentrations to the effective reduction of nitrogen by biological activity in the ponds prior to percolation.

In the Yermo Annex area, the dissolved-solids concentrations were low in wells 9N/1E-17H1, -16F4, -10L1, -10Q4, and -10R1 perforated in the Mojave River aquifer. The dissolved-solids concentrations in water from these wells range from 188 to 418 mg/L (table 4).

Water from wells perforated in the regional aquifer in the vicinity of the Nebo and Yermo Annexes generally has high dissolved-solids concentrations (greater than 850 mg/L; fig. 13). Wells 9N/1W-4M5, -11K13, -12N5, and 9N/1E-4K2, and -10Q3 perforated in the shallowest part of the regional aquifer directly beneath the Mojave River have lower dissolved-solids concentrations than wells 9N/1W-10J12, -10J13, -11K12, -12N4, and 9N/1E-4K1 perforated deeper in the regional aquifer. Well 9N/1W-10Q3 contains water with about 545 mg/L dissolved solids. The low dissolved-solids concentration of water from the shallow regional aquifer suggests that the Mojave River recharged the regional aquifer deposits beneath the river channel prior to the onset of ground-water degradation in the overlying Mojave River aquifer. Very little change was observed in the dissolved-solids concentrations of water from the regional aquifer following the 1993 floods.

Dissolved-solids concentrations in wells 9N/1E -16F2, -16F3, and -10Q3 perforated in the older alluvium (Qoa) beneath the Yermo Annex are higher than dissolved-solids concentrations in wells 9N/1E-16F4 and -10Q4 perforated in the overlying Mojave River aquifer (fig. 14). Although the dissolved-solids concentrations in water from wells 9N/1E-16F2, -16F3, and -10Q3 are similar to the concentrations in the degraded water underlying the Nebo Annex, it is not likely that this water is being degraded by the same source (treated sewage) because the leading edge of the plume of degraded water from the Nebo Annex area is upgradient of well 9N/1W-13H2. The higher concentrations in these wells may have resulted from evaporation upstream, as indicated by the oxygen and deuterium isotopic data for these samples (table 4). The isotopic data indicate that this water has undergone some evaporation that may have resulted when the ground water was forced to land surface at fault C. The mineralogic composition of the deposits can also affect the water quality within the deposits; thus, the high dissolved-solids concentrations occurring in water from the older alluvium may be the result of dissolution of soluble minerals.

Long-Term Changes

The specific conductance data for wells with a long period of record (about 40 years) were examined (fig. 15) to determine if any water-quality changes have occurred over time. Specific conductance is the ability of a substance to conduct an electrical current and is an indicator of the presence of ions in the water. Water with low dissolved-solids concentrations (ions) has low specific-conductance values. As the dissolved-solids concentrations increase, the specific conductance increases. Specific conductance can be used to approximate dissolved-solids concentrations by multiplying the value of specific conductance by 0.75 (Hem, 1985). Previous studies have shown that ground-water quality in the river deposits southeast of Barstow has degraded steadily since the 1940's (Miller, 1969; Hughes, 1975).

Specific conductance increased between 1979 and 1982 in well 9N/1W-10E4 which is perforated in the Mojave River aquifer near the sewage-treatment plant at Barstow (fig. 15A). Since 1982, specific conductance values in this well have remained constant. Specific conductance increased in well 9N/1W-11M11, which is located about 0.4 mi downgradient of Barstow sewage-treatment plant (fig. 3), from 1985 until 1993 when floodflows recharged the Mojave River aquifer (fig. 15A). Between 1972 and 1977, specific conduc-

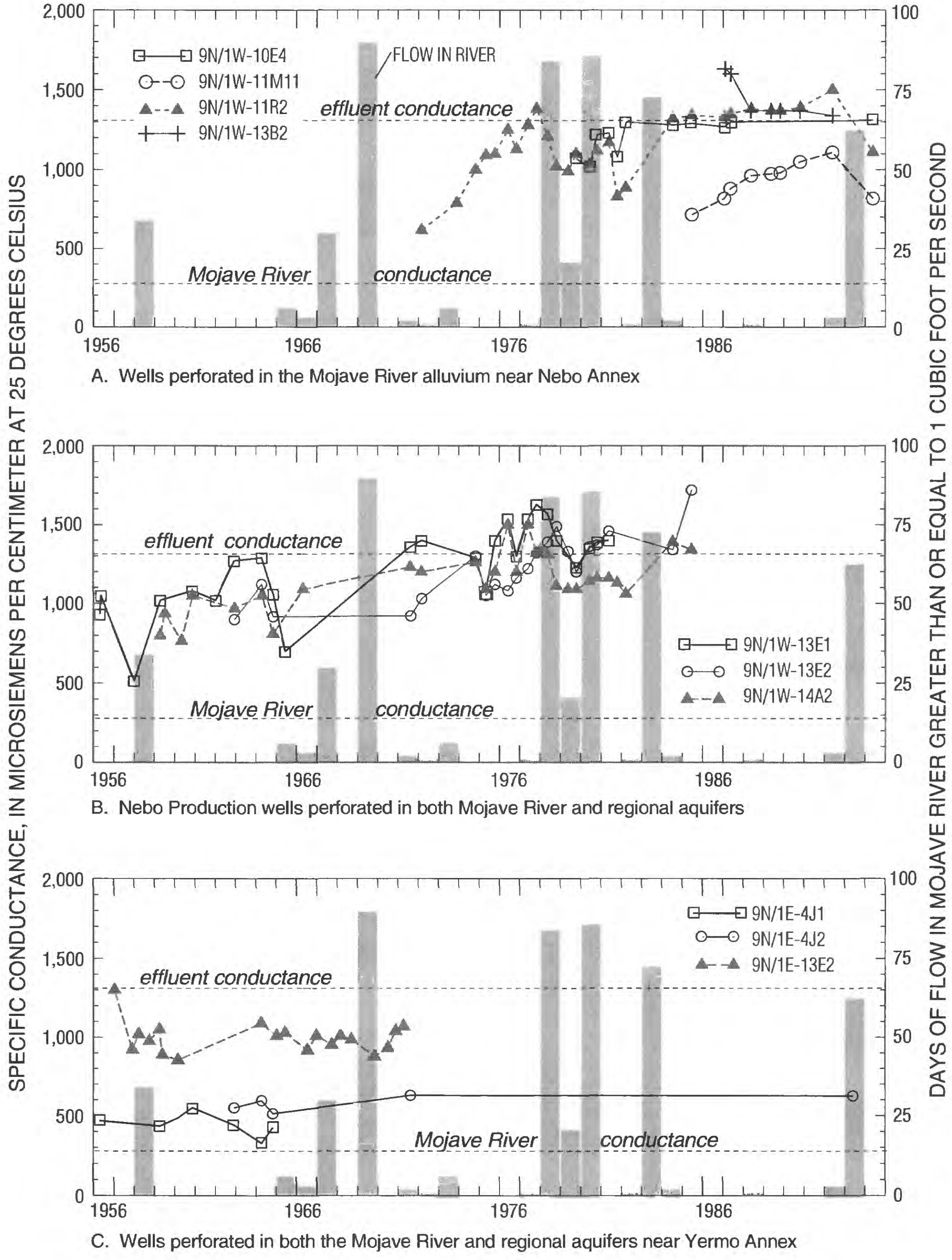


Figure 15. Specific conductance for selected wells and days of flow in the Mojave River, in the vicinity of the Marine Corps Logistics Base, Nebo and Yermo Annexes, near Barstow, California.

tance also increased in well 9N/1W-11R2 (fig. 15A) which is perforated in the Mojave River aquifer downgradient of the golf course at the Nebo Annex. This increase occurred when fields upgradient of the Nebo Annex were being irrigated with sewage effluent from the Barstow sewage-treatment plant and the base golf course was being irrigated with sewage effluent from the Nebo sewage-treatment plant. After periods of recharge in the late 1970's and early 1980's, specific conductance decreased in well 9N/1W-11R2 and then slowly increased until 1993 when the aquifer was recharged by floodflows. During 1986–87, specific conductance decreased in well 9N/1W-13B2, downgradient of Nebo's sewage-treatment plant (fig.15A), and remained constant from 1988 until the early 1990's. Although the quality of ground water from wells perforated in the Mojave River aquifer near Nebo Annex has continued to deteriorate since 1972, the water quality commonly improves after periods of floodflows because of a surge of recharge of low specific conductance water from the Mojave River.

Several Nebo production wells downstream of the Barstow sewage-treatment plant (9N/1W-13E1, -13E2, and -14A2) have shown an increase in specific conductance over the period of record (1956–85, fig. 15B). These production wells are perforated in both the Mojave River aquifer and the regional aquifer. During a study by Koehler (1970), a well flowmeter was used to measure the flow at various depths in a production well while it was being pumped at a constant rate. This well was constructed similarly to other production wells in the Nebo Annex. The flowmeter results indicated that most of the water enters the well above the depth of 200 feet, the approximate contact of the Mojave River aquifer and the regional aquifer. The flowmeter data suggest that the increase in specific conductance in the Nebo production wells is the result of water-quality degradation of the Mojave River aquifer. The Mojave River aquifer is the major source of water to these wells.

Limited historical water-quality data are available for wells in the vicinity of the Yermo Annex (fig. 15C). Wells 9N/1E-4J1 and -4J2, about 1.5 mi north of the Mojave River, are perforated in the younger alluvium. Specific conductance for these wells indicates that the water quality has remained relatively constant during the period of record (1956–94) and indicates relatively good quality water in this area, probably of Mojave River origin. Well 9N/1E-13E2, south of the Mojave River, is perforated in the regional aquifer system. Specific conductance is higher for this well than for wells north of the river. The limited data for this well show some decrease in specific conductance following floodflows in the Mojave River (fig. 15).

Source and Age of Ground Water

Oxygen-18, deuterium, tritium, and carbon-14 data were collected to determine the source, movement, and relative age of ground water in the Mojave River and regional aquifers. Water samples were collected from 56 wells, 35 wells drilled during this study and from 21 existing wells for analyses of the stable isotopes of oxygen-18 ($\delta^{18}O$) and deuterium (δD), tritium (^3H), and/or carbon-14 (^{14}C) (table 4). The $\delta^{18}O$ and δD data were used to determine the source and trace the movement of water in the Mojave River aquifer and in the surrounding regional aquifer. The ^3H and ^{14}C data were used to estimate the age (time of recharge) of ground water.

Oxygen-18 and Deuterium Isotopes

Oxygen-18 and deuterium are naturally occurring stable isotopes of oxygen and hydrogen. The ratios of the isotopes of oxygen [oxygen-18 (^{18}O):oxygen-16 (^{16}O)] and hydrogen [deuterium, D(^2H):hydrogen (^1H)] in ground water are indicators of its hydrologic history. The isotopic ratios are expressed in delta notation (δ) as per mil (parts per thousand) differences relative to the standard known as Vienna Standard Mean Ocean Water (VSMOW) (Gonfiantini, 1978). Higher (less negative) values of $\delta^{18}O$ and δD represent enrichment in the heavier isotope of oxygen and hydrogen, respectively; and lower (more negative) δ values represent enrichment in the lighter isotope (depletion in the heavier isotope). Because most of the world's precipitation is originally derived from evaporation of seawater, the $\delta^{18}O$ and δD composition of precipitation throughout the world is linearly correlated. This relation is known as the meteoric water line (Craig, 1961).

The $\delta^{18}O$ and δD composition of ground water, relative to the meteoric water line and relative to the isotopic composition of water from other sources, is an indicator of the source and movement of ground water. The isotopic composition of ocean water undergoes fractionation during the transfer from the ocean surface to the vapor phase. Further fractionation occurs as water vapor condenses from the atmosphere, leaving the remaining water vapor depleted in the heavier isotopes. Latitude, air temperature, and altitude also affect the fractionation of water vapor. The net result is that precipitation from a given storm becomes isotopically lighter as the storm moves inland, and precipitation that forms at lower temperatures is lighter than precipitation that forms at higher temperatures (Fournier and Thompson, 1980).

Evaporation also causes isotopic fractionation. When water is evaporated, the lighter isotopes of oxygen and hydrogen are preferentially partitioned into the vapor phase, causing the remaining water to be isotopically heavier. Aside from geothermal systems, further change in isotopic composition does not occur after the recharge water has reached the water table. Therefore, any subsequent changes in the isotopic composition of ground water along a flow line generally reflect only the mixing within the aquifer system or concentration by evaporation where the water table is very shallow and where ground water discharges at land surface.

The oxygen and hydrogen isotopes for water from wells perforated in the Mojave River aquifer range from -9.17 to -3.99 per mil $\delta^{18}O$ and from -65.5 to -41.1 per mil δD (fig. 16). These values are similar to values reported by Izbicki and others (1995) for the Mojave River aquifer. The primary sources of recharge to the Mojave River aquifer are floodflows in the Mojave River, resulting from precipitation in its headwaters in the San Bernardino Mountains, and to a lesser extent, sewage effluent, irrigation return, and ground-water underflow. Recharge from local precipitation is thought to be negligible. Samples of the Mojave River water and of local precipitation (Friedman and others, 1992) are isotopically lighter (values are more negative) than samples from the Mojave River aquifer.

The isotopic ratios of water from the Mojave River aquifer are shifted to the right of the meteoric water line indicating evaporation (fig. 16). Figure 17 suggests that water from the Mojave River aquifer in the Nebo Annex area has been subjected to more evaporation than water from the Mojave River aquifer in the Yermo Annex area (fig. 17). Data for water samples from the Mojave River aquifer near the Nebo Annex plot along a line that intersects the meteoric water line, near the average plotted for the river-water sample and has a slope of 4 (fig. 17A). A slope between 3 and 6 is indicative of water that has been affected by evaporation (International Atomic Energy Agency, 1981). Because ground water is more than 10 ft below land surface in most of the study area, evaporation from the water table is not the cause of the observed isotopic distribution.

In the Nebo Annex area, the Mojave River aquifer is affected by infiltration of sewage effluent and irrigation return (Densmore and others, 1994), which are affected by evaporation. Samples of the sewage effluent from the Barstow plant have an average isotope ratio of -60.3 per mil δD and -8.4 per mil $\delta^{18}O$. Data for these samples plot along the evaporation line (fig. 17A). The use of sewage effluent for irrigation results in further evaporation and makes the irrigation return even heavier isotopically. Most of the water samples from the Mojave River aquifer downgradient of the current Barstow sewage-treatment plant and the effluent-irrigated fields are isotopically heavier. The data for these samples plot farther to the right along the evaporation line than the data for water samples from the Barstow sewage-treatment ponds. The data for a water sample from the Mojave River aquifer upgradient of the current sewage effluent-irrigated fields (well 9N/1W-4M6) plots along the meteoric water line. The sample for this well does not seem to be affected by evaporation (fig. 17A). The source of poor-quality water sampled in this well is believed to be the deep plume that originated from the previous sewage-treatment plants. Data for samples from wells 9N/1W-10J14 and -11K14 downgradient of the 1972 extent of this plume and downgradient of the effluent-irrigated fields plot along the evaporation line. However, the isotopic data for these two wells indicate that the deep plume cannot be the sole source of the degraded water downgradient of Highway 15, but rather, that the downgradient water, which consists of Mojave River recharge, has been affected by migration of the deep plume and by current sewage disposal practices (ponds and irrigation). Additional data would be needed to determine the relative contributions from each of the sources.

The isotopic data indicate that degradation of the ground-water quality of the Mojave River aquifer by upward leakage from the regional aquifer is minimal. Only two wells in the Mojave River aquifer (9N/1W-9D7 and -9D8) are affected by leakage from the regional aquifer. The isotopic compositions for samples from these two wells plot between the isotopic composition for samples from the Mojave River aquifer and the regional aquifer (fig. 16). Water from these wells is isotopically lighter than water from other wells perforated in the Mojave River aquifer, which can result only by mixing isotopically heavy water from the

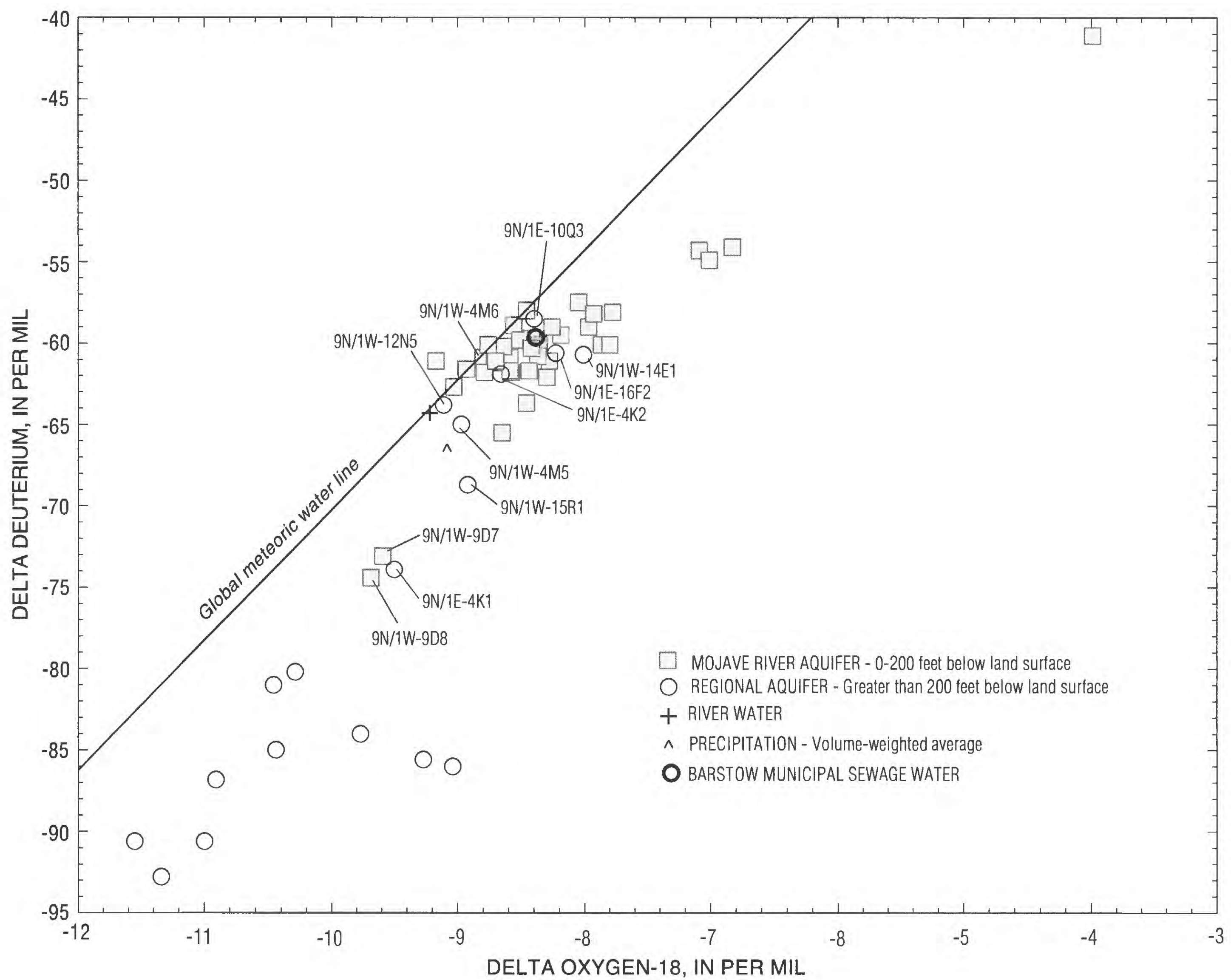


Figure 16. Stable-isotope ratios for samples of ground water, river water, precipitation, and municipal sewage in the vicinity of the Marine Corps Logistics Base, Nebo and Yermo Annexes, near Barstow, California.

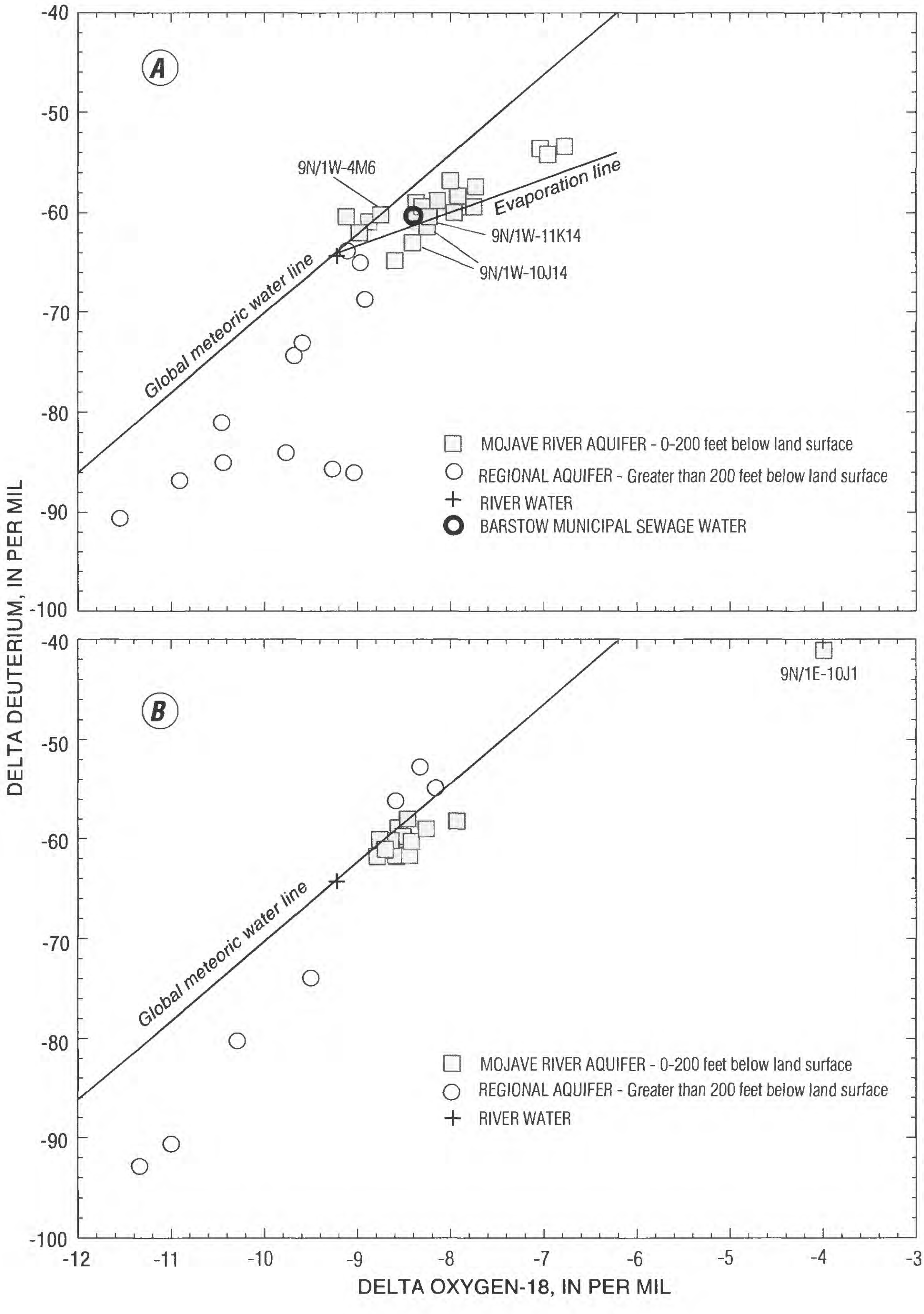


Figure 17. Stable-isotope ratios for samples of ground water *(A)* from the Nebo Annex, river water, and municipal sewage and *(B)* from the Yermo Annex and river water, Marine Corps Logistics Base, near Barstow, California.

Mojave River aquifer with isotopically light water from the regional aquifer.

In the regional aquifer in the Nebo Annex area, the only samples that are isotopically similar to present day Mojave River are samples from wells 9N/1W-12N5, -14E1, and -15R1. Water-level data for multiple-well monitoring site 9N/1W-12N4-7 downgradient of fault C, indicate the potential direction for ground-water movement was downward from the Mojave River aquifer to the underlying regional aquifer resulting in higher water levels in shallower wells (fig. 11). Upgradient of fault C, water-level data from multiple-well monitoring site 9N/1W-11K12-15 prior to the 1993 flooding, indicate the ground- water direction for potential movement was upward from the regional aquifer to the Mojave River aquifer resulting in higher water levels in the deeper wells (fig. 11). After the 1993 flooding, however, the potential direction of ground-water movement reversed until about the end of 1994 (fig. 11). The potential for upward movement of ground water from the regional aquifer to the Mojave River aquifer during periods of no flow in the Mojave River could explain why there is limited apparent recent recharge to the regional aquifer upgradient of fault C in the Nebo Annex area.

The isotopically heavier samples collected from wells 9N/1W-14E1 and -15R1 are probably the result of irrigation-return flows from landscaped areas of the base housing in the Nebo Annex. These areas are irrigated with ground water derived from wells perforated in the Mojave River aquifer. The ground-water mound beneath the base housing shown on figure 10 indicates local recharge.

Most of the data for the water samples from the Mojave River aquifer samples in the Yermo Annex area plot close to the meteoric water line, indicating that the water in these samples has not been affected by evaporation to the extent that the water in the samples from the Nebo Annex area have been affected (fig. 17B). Because the depth to the water table is greater than 100 ft below land surface and because no sewage effluent is being applied to fields downgradient and near the Yermo Annex, only floodflows are being affected by evaporation. However, water from well 9N/1E-10J1 is an exception. The isotopic composition of this well is heavy, indicating that water in this well is highly evaporated. This well is located near the sewage-treatment plant in the Yermo Annex, and water from this well contains sewage effluent that infiltrates the Mojave River aquifer from this plant.

The isotopic ratios for samples from the regional aquifer range from -11.55 to -8.23 per mil $\delta^{18}O$ and from -92.8 to -58.5 per mil δD and are significantly lighter (values are more negative) than the ratios for samples of Mojave River water and local precipitation (fig. 16). With some exceptions, samples from the regional aquifer are also significantly lighter (values are more negative) than samples from the Mojave River aquifer. Data for water in the regional aquifer are shifted to the right of the meteoric water line, indicating that most areas of the regional aquifer were not recharged by the present day flow in the Mojave River and may have been recharged under different climatic conditions than those occurring today.

Data for samples from wells 9N/1W-4M5, 9N/1E-4K1, -4K2, -10Q3, and -16F2 perforated in the regional aquifer plot among the sampling data for the isotopically heavier Mojave River aquifer. Well 9N/1W-4M5 is perforated in the top of the older alluvium upgradient of the Nebo Annex and wells 9N/1E-4K1, -4K2, -10Q3, and -16F2 are perforated in the older alluvium beneath the Yermo Annex. The isotopic data from these wells suggest that the Mojave River is the source of water to these wells.

Tritium and Carbon-14

Tritium (^3H) is a naturally occurring radioactive isotope of hydrogen with a half-life of 12.4 years. ^3H is measured in tritium units (Tu). Each tritium unit equals one atom of tritium in 10^{18} atoms of hydrogen. Approximately 800 kg of ^3H was released as a result of the atmospheric testing of nuclear weapons during 1952-62 (Michel, 1976). As a result, ^3H concentrations in precipitation and in ground water, which was recharged during that time, increased. Because ^3H is part of the water molecule and its concentrations are not significantly affected by reactions other than radioactive decay, ^3H is an excellent tracer of the movement of ground water and to determine the relative age of water on time scales ranging to about 40 years before present.

Carbon-14 (^{14}C) is a naturally occurring radioactive isotope of carbon that has a half-life of about 5,730 years. ^{14}C data are expressed as percent modern carbon by comparing ^{14}C activities to the specific activity of National Bureau of Standards oxalic acid (12.88 disintegrations per minute per gram of carbon in the year 1950 equals 100 percent modern carbon). ^{14}C, as well as ^3H, was produced by the atmospheric testing of nuclear weapons. As a result, ^{14}C activities can exceed

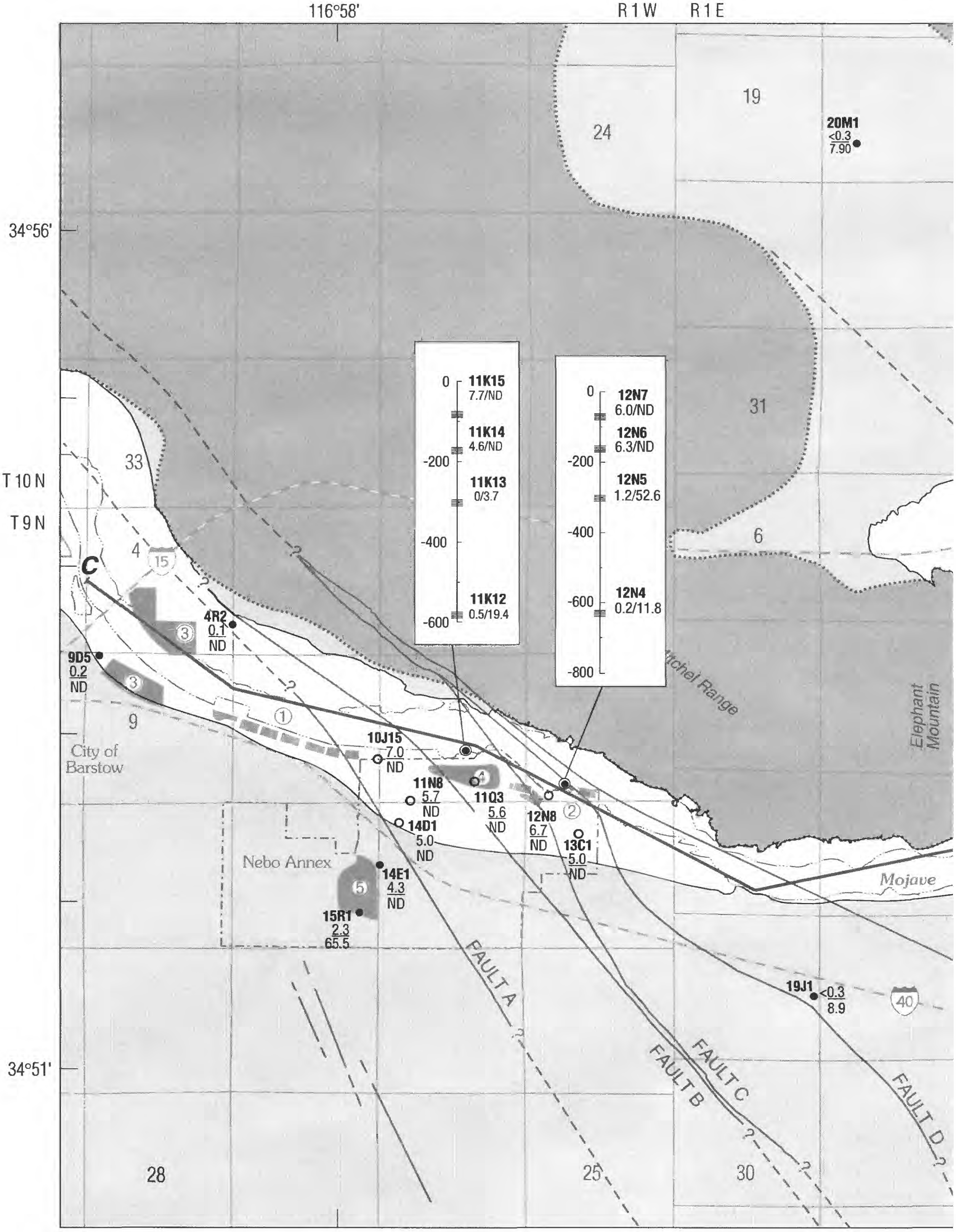
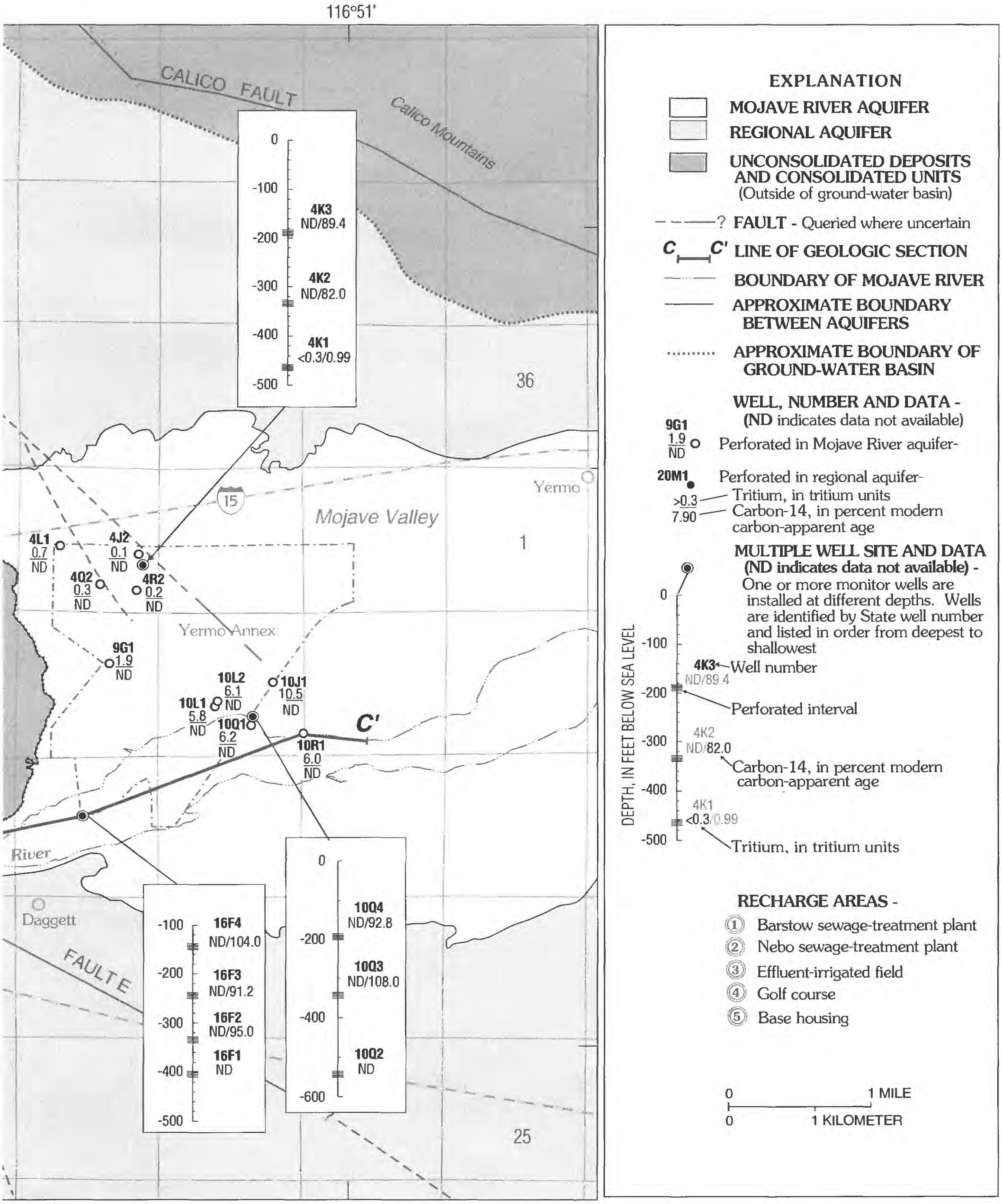


Figure 18. Tritium concentrations and carbon-14 data for selected wells in the vicinity of the Marine Corps Logistics Base,



Nebo and Yermo Annexes, near Barstow, California.

100 percent modern carbon in areas where ground water contains ^3H. ^{14}C is a tracer of movement and of relative age of water on time scales ranging from several hundred to more than 20,000 years before the present. Because ^{14}C is not part of the water molecule, ^{14}C activities are affected by chemical reactions between dissolved constituents and aquifer material, and relative ages must be corrected using ^{13}C data to evaluate chemical reactions that occur within an aquifer in order to determine the approximate age of the water. Uncorrected ^{14}C data are used in this report to give an apparent age. This apparent age can be as much as 10,000 years older than corrected ^{14}C age (Izbicki and others, 1995).

In this report, ground water with ^3H concentrations less than the detection limit of 0.3 Tu is interpreted as water recharged prior to 1952, and ground water with detectable levels of ^3H is interpreted as water recharged after 1952. Also, ground water with ^{14}C activities less than 90 percent modern carbon is interpreted as being recharged before 1952; ground water with ^{14}C activities greater than 90 percent modern carbon is interpreted as being recharged after 1952.

Water from wells containing measurable ^3H is present throughout most of the Mojave River aquifer and in some parts of the regional aquifer near the Mojave River in the area of the Nebo and Yermo Annexes (fig. 18). The ^3H data indicate that water in the Mojave River aquifer was recharged by the Mojave River after 1952 and that the water in regional aquifer throughout most of the study area was recharged prior to 1952. The geohydrology of the Nebo Annex area influences the depth and areal extent of river recharge infiltrating the aquifers. In the Nebo Annex area, the Mojave River is surrounded and underlain by low permeability, alluvial-fan deposits and consolidated, non-water-bearing Tertiary rocks that retard the movement of ground water between the two aquifers. Therefore, most wells perforated in the regional aquifer in the Nebo Annex area do not contain ^3H. However, some shallow wells underlying the Nebo Annex and perforated in the regional aquifer (9N/1W-14E1 and -15R1) contain water with measurable ^3H, indicating recent recharge. These wells are located in the area that has been recharged by irrigation of Mojave River water applied to lawns and other green areas in the base housing area. Water levels of wells in this area indicate mounding occurs as a result of local recharge (fig. 10). Well 9N/1W-12N5, downgradient of fault C, is perforated in the regional aquifer and contains water with measurable ^3H (fig. 18). The downward vertical gradient, downgradient of fault C, favors recharge in this part of the regional aquifer.

In the Yermo Annex area, most of the wells on the base contain water with ^3H. The isotopic data suggest that recent recharge from the Mojave River reaches wells as far as 1.5 mi north of the present river channel. Water from wells 9N/1E-4Q2 and -4L1, on the northwest corner of the base, contains measurable ^3H (0.3 to 0.7 Tu, respectively; fig. 18). Water in these wells may be the result of irrigation return and/or recharge from the Mojave River. The wider areal extent of recharge in this area is the result of the geologic differences between the Yermo and Nebo Annexes. In the Yermo Annex area, the Mojave River aquifer (Qya) covers a much broader area than in the Nebo Annex area (fig. 3). In addition, the Mojave River aquifer is underlain by permeable deposits of older alluvium (Qoa) in the Yermo Annex area that are not present at the Nebo Annex (fig. 14).

Measured ^{14}C activities ranged from 0.99 to 108 percent modern carbon in 15 wells in the study area (fig. 18). In the Nebo Annex, ^{14}C activities ranged from 3.7 to 65.5 percent modern carbon in six wells perforated in the regional aquifer. In four of the six samples, ^{14}C activities were less than 20 percent modern carbon, indicating that the regional aquifer is not readily recharged under current climatic conditions. The uncorrected ^{14}C data suggest that water in this part of the regional aquifer was recharged more than 14,000 years ago. However, for well 9N/1W-15R1, the ^{14}C activity was 65.5 percent modern carbon and ^3H was measurable. Water in this well is recharged irrigation-return water from the Mojave River that had been applied to lawns and other green areas in the base housing at the Nebo Annex. The mounding of water beneath the base housing indicates that recharge is occurring in this area (fig. 10). Because well 9N/1W-15R1 is located about 1 mi south of the active river channel, it is not likely that it is recharged by percolation of river water during floodflows. Well 9N/1W-12N5, downgradient of fault C, also had a higher ^{14}C activity (52.6 percent modern carbon). The higher ^{14}C activity and the presence of ^3H in well 9N/1W-12N5 indicates that relatively recent water from the Mojave River aquifer is mixing with older water from the regional aquifer in this part of the study area. The downward vertical hydraulic gradient downstream of fault C indicates the potential for ground-water recharge in this area. In general, ^{14}C decreases with depth in most of the wells in the Nebo Annex area, except in well 9N/1W-11K12. ^{14}C activity is higher in well 9N/1W-11K12 than in the well -11K13 directly above. The presence of higher ^{14}C and of ^{3}H in this well suggests that this well may be slightly underdeveloped and that the drilling fluid, which contained modern carbon, may have mixed with water from the regional aquifer, which has low amounts of modern carbon.

In the Yermo Annex area, ^{14}C activities ranged from 0.99 to 108 percent modern carbon. ^{14}C activities can exceed 100 percent modern carbon in areas that have been recently recharged with ^{14}C that was produced as a result of atmospheric testing of nuclear weapons between 1952 and 1962. ^{14}C activities in wells 9N/1E-16F2, -16F3, -16F4, -10Q3, and -10Q4 perforated in the Mojave River aquifer and in the underlying older alluvium of the regional aquifer along the Mojave River is greater than 90 percent modern carbon, indicating relatively recent recharge. Samples from wells 9N/1E-4K2 and -4K3, in the northern part of Yermo Annex, also had relatively high ^{14}C activities, indicating mixing with recent Mojave River recharge (fig. 18). The lowest ^{14}C activity (oldest water) in the Yermo Annex area was detected in well 9N/1E-4K1, which is perforated in the Tertiary volcanic and sedimentary rocks. The water sample for this well was the only sample analyzed for ^{14}C in water from the regional aquifer beneath the older alluvium in this area. The uncorrected ^{14}C data suggest that this part of the regional aquifer was recharged more than 40,000 years before present.

SUMMARY AND CONCLUSIONS

The Marine Corps Logistics Base is approximately 100 miles northeast of Los Angeles in the Mojave Desert region of southern California and consists of the Nebo and Yermo Annexes. The Nebo Annex, about 2 miles east of Barstow, lies within the Camp Rock-Harper Lake fault zone in a narrow valley bounded to the south by alluvial-fan deposits and to the north by consolidated Tertiary rocks. The Yermo Annex, which is east of the Nebo Annex, lies in the western part of the Mojave Valley and is bounded to the west, north, and south by consolidated Tertiary rocks. The Yermo Annex sits on alluvial sediments deposited by the Mojave River during Pleistocene to early Holocene time. The main drainage in this area is the Mojave River, which is normally dry throughout the 10-mile reach of the study area. Prior to development of ground water in this area, the river flowed at fault C of the Camp Rock-Harper Lake fault, but now it flows only after major storms that have produced floodwaters.

Six stratigraphic units (from oldest to youngest) have been identified from lithologic data as (1) pre-Tertiary granitic and metamorphic rocks, (2) Tertiary volcanic and sedimentary rocks, (3) older and younger alluvial-fan deposits, (4) older alluvium, (5) playa deposits, and (6) younger and recent Mojave River alluvium. The pre-Tertiary rocks form the basement complex, which consist of granitic and metamorphic rocks, are considered non-water bearing, and lie about 2,000-3,500 feet beneath the Nebo Annex and 1,100-3,200 feet beneath the Yermo Annex. The Tertiary rocks are consolidated, volcanic and sedimentary rocks that contain small amounts of poor-quality water. The alluvial-fan deposits are poorly sorted, weakly consolidated, silty sands and gravels. These deposits are less permeable than the adjacent and overlying Mojave River alluvium. They are divided into two stratigraphic units: (1) older fan deposits and (2) younger fan deposits. Older alluvium overlies the older fan deposits and underlies the younger alluvium, and is texturally and compositionally similar to the overlying younger and recent Mojave River alluvium. The older alluvium consists of unconsolidated to weakly consolidated, silty sands and gravels, and is more consolidated and less permeable than the younger and recent alluvium. The younger and recent Mojave River alluvium are unconsolidated, permeable, coarse sands and gravels that occur from land surface to about 200 feet below land surface.

The central Mojave Desert has undergone two major periods of deformation. The first was a period of rifting during which the crust was pulled apart by large-scale displacement on a gently dipping master shear zone. Sedimentary and volcanic strata accumulated in tectonic depressions within the rift zone and then were subsequently folded, faulted, and rotated. A period of erosion and volcanic intrusion followed. The second period of deformation involved north-south shortening in the Mojave Desert region which has produced east-west trending arches and basins and northwest-trending right-lateral strike-slip faults. Concurrent with crustal shortening, the alluvial basins near the Nebo and Yermo Annexes were filled with locally derived sediments, such as alluvial-fan deposits. During the late-Pleistocene, the Mojave River developed its present course eastward from Barstow to Mojave Valley. River deposits composed of granitic sand and gravel derived from mountains south of the Mojave Desert accumulated amid alluvial-fan deposits derived from the basin margins. The earliest river deposits were restricted to Mojave Valley until the depositional tract expanded upstream (westerly) toward Barstow, at which time, the younger alluvium were deposited across the future sites of both the Nebo and Yermo Annexes. The Mojave River lengthened its channel eastward after a low sill at Afton Canyon was eroded and historic Lake Manix was drained about 14,000 years ago. The buildup of river deposits in western Mojave Valley ended shortly thereafter, when the Mojave River incised its modern channel into the younger alluvium. Most recently, a thin layer of recent river deposits has accumulated on flanking stream terraces and on the floor of the active channel as the river continues to erode its channel.

Five northwest-trending, right-lateral strike-slip strands of the Camp Rock-Harper Lake fault zone cross the Nebo Annex. Fault C of the Camp Rock-Harper Lake fault zone has special significance because it forms a ground-water barrier where it intersects the Mojave River aquifer. Aeromagnetic data and an areal resistivity survey suggest that two faults pass beneath the Yermo Annex but these faults lack any surficial evidence of Holocene activity. Trenching across fault C of the Camp Rock-Harper Lake fault zone established the deformational structures across the fault and allowed for an estimation of the frequency of movement. The deformational structures in the trench walls indicate repeated buckling of strata by north-south compression during accumulation of the shallow fluvial sediments, followed by three events of high-angle faulting. Preliminary results of radiocarbon dating indicate that a clayey silt bed is 7,620 + 60 years old and sandy alluvial-fan deposits are 3,630 + 50 years old. Inasmuch as four deformational events seem to post-date the deposition of the clayey silt bed, fault C apparently has moved on average once every 1,900 years since 7,620 years before present.

The aquifer system in Nebo and Yermo Annex area consists of two aquifers, the Mojave River aquifer and the regional aquifer. The Mojave River aquifer lies within the younger and recent Mojave River alluvium, which extend to a depth of about 200 feet. It is about 1 mile wide in the Nebo Annex area and widens to about 4 miles in the Yermo Annex area. The Mojave River aquifer is underlain by the regional aquifer which consists of alluvial-fan deposits and older alluvium deposited by the ancestral Mojave River. The regional aquifer is less permeable than the Mojave River aquifer and contains most of the ground water in storage. The base of the ground-water system is considered to be the top of the underlying Tertiary rocks. The primary source of water supply is ground water because of the lack of any other reliable source. Mojave River floodwater is the primary source of natural recharge to the aquifer system (both the Mojave River and regional aquifers). In addition to the natural recharge of the Mojave River floods, a substantial amount of recharge to the Mojave River aquifer comes from the seepage of sewage effluent, the percolation of irrigation-return flow, and ground-water underflow. Recharge in the form of precipitation to this area is minimal. Discharge from the study area occurs by ground-water pumping, subsurface outflow, and evapotranspiration.

The general direction of ground-water movement is downstream along the Mojave River, from west to east within the study area. Water-level data indicate that natural recharge occurs in the Mojave River aquifer during major floods in the Mojave River. After the floods in 1993, water levels in the Mojave River aquifer rose about 10-20 feet near the Nebo Annex and about 1 to 15 feet near the Yermo Annex. The water table was relatively unchanged in the regional aquifer system except for a mound that has formed beneath the base housing at the Nebo Annex. This mound formed as a result of irrigation-return flow from the watering of lawns in this area. Faults in the Nebo Annex area act as barriers to ground-water flow and ground water is forced to the surface. Water levels in the regional aquifer have risen slightly in the Nebo Annex area and have decreased in the Yermo Annex area.

Ground-water degradation in the Mojave River aquifer is reported to have occurred as early as 1910. Potential sources of ground-water degradation to the Mojave River aquifer near Barstow include (1) municipal- and industrial-waste effluent and (2) irrigation-return flow. Presently, the degradation in the Mojave River aquifer extends from about 1 mile upgradient of the Nebo Annex to about 1 mile downgradient of the Nebo golf course. Water-quality data indicate that water in the Mojave River aquifer generally has lower dissolved-solids concentrations than water in the regional aquifer. Water from wells perforated in the Mojave River aquifer, located upgradient of the Nebo Annex and near the Yermo Annex, has lower dissolved-solids concentrations than water from wells in the degraded area near the Nebo Annex. Water in the regional aquifer generally has high dissolved-solids concentrations. However, a zone of low dissolved-solids content water in the upper part of the regional aquifer indicates that Mojave River water has recharged the regional aquifer directly beneath the Mojave River aquifer prior to the recent degradation of this aquifer. High dissolved-solids concentrations are present in water from the older alluvium beneath the Yermo Annex. Nitrogen concentrations were high in the parts of the Mojave River aquifer beneath the effluent-irrigated fields, the Barstow sewage-treatment ponds, and the Nebo sewage-treatment ponds. The increase in the nitrogen concentrations in the Mojave River aquifer downgradient of the effluent-irrigated fields and sewage-treatment ponds since 1972 suggests that the increased use of sewage effluent for irrigation may be the source.

Historical data indicate that specific-conductance values in water from both the Mojave River aquifer and the regional aquifer near the Nebo Annex have increased. Specific conductance in water from both aquifers near Yermo Annex show only a slight increase over time. Ground water that is low in dissolved solids, extends at least 1.5 mi north of the Mojave River in the younger alluvium underlying the Yermo Annex and to depths of 200-300 feet below land surface, suggesting that water from the Mojave River has recharged this area.

The isotopic data indicate that Mojave River floodflows are the main source of water recharging the Mojave River aquifer. Water in the Mojave River aquifer near the Nebo Annex has been subjected to more evaporation than water in the Mojave River aquifer near the Yermo Annex. Isotopic ratios indicate that water in the Mojave River aquifer near the Nebo Annex has been affected by the mixture and evaporation of river water and sewage effluent. Water in the regional aquifer is isotopically different from water in the Mojave River aquifer, indicating that the present Mojave River is probably not the source of regional aquifer water.

The tritium concentrations indicate that water in the Mojave River aquifer was recharged by the Mojave River after 1952 and that water in most of the regional aquifer was recharged prior to 1952. Recharge to the regional aquifer has occurred beneath the Nebo Annex housing area as a result of irrigation of Mojave River water on green areas and lawns. Recharge to the deposits underlying the Yermo Annex extends about 1.5 miles north of the present river channel. The wider areal extent of recharge at the Yermo Annex is due in part to the stratigraphic difference, consolidation, and cementation of the deposits, as well as the geometry of the basin. Uncorrected carbon-14 data indicate that water in the regional aquifer was recharged more than 14,000 years before the present in the Nebo Annex area. The oldest water (greater than 40,000 years old) was detected in the Tertiary volcanic and sedimentary rocks underlying the Yermo area.

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APPENDIX

Lithologic Logs

Lithologic logs were compiled from descriptions of drill cuttings collected at each borehole and from observations recorded during logging. The cuttings, collected at 20-ft intervals and at distinguishable changes in lithology, were described by rock type, texture, sorting, rounding, color, mineralogy, and any other significant features. Texture descriptions follow the National Research Council (National Research Council, 1947) grain-size classification. This classification allows for correlation of general grain-size terms (such as "sand") to size limits in millimeters or inches. Color, determined on moist samples, follows the numerical color designations in the Munsell Soil Color Charts (Munsell Color, 1975). Detailed lithologic descriptions for the boreholes are given in tables 6-13, at back of report.

Generalized lithologic columns for each site were compiled by grouping similar lithologic units determined from the detailed lithologic logs (figures 19A-H). Borehole geophysical logs were used to identify the depths of contacts between the lithologic units. The lithologic units were categorized using the nomenclature by Folk (1954, 1980) for 15 textural groups (figure 20).

Borehole Geophysics

Geophysical logs were made for the boreholes at each multiple-well monitoring site immediately following completion of drilling. The logs of the uncased boreholes, which were filled with drilling mud, include 16- and 64-inch normal resistivity, lateral (6-ft) resistivity, spontaneous potential, natural gamma, and caliper logs (figures 19A-H) and sonic logs for sites 9N/1W -10J12-15, -11K12-15, -12L2-5, and -12N4-7. The logs provide information on the character of the formations and on the presence and chemical characteristics of ground water. Data from the geophysical logs were used with the lithologic logs to determine the placement of the piezometers.

Resistivity devices measure the apparent resistivity of a volume of rock under the direct application of an electric current (Keys and MacCary, 1983). Geophysical logs are used to determine formation resistivity, formation porosity, and fluid resistivity. In general, low resistivity indicates fine-grained deposits such as silt, clay, and shale; whereas high resistivity indicates coarser materials such as sand and gravel.

Spontaneous-potential devices measure voltage differences between the borehole fluid and the surrounding rock (Keys and MacCary, 1983). Spontaneous potential logs are used mainly for correlating geologic units, determining bed thickness, and differentiating between non-porous and porous beds. This type of log usually has a baseline that corresponds to impermeable beds such as clay or shale. Deflections to the left of this baseline correspond to the positions of permeable strata if the formation water is less resistive (more saline) than the drilling mud. The opposite is true if the formation water is more resistive than the drilling mud.

Natural gamma logs measure the intensities of gamma-ray emissions resulting from the natural decay of potassium-40 and of the daughter products of uranium and thorium. The gamma logs are used primarily to define lithology indicators and for geologic correlation. Clay, feldspar-rich gravel, and granite generally emit higher intensity gamma rays (Driscoll, 1986). In the logs completed for this study, an increase in gamma intensity generally corresponds with an increase in granitic materials in the deposits.

Caliper devices measure the diameter of the borehole. The caliper log can be used to show the existence of cave-in in unconsolidated sand or the presence of swelling clay.

The sonic log measures the time it takes for a sonic pulse to travel between a transmitter and a receiver on a probe. The sonic log measurements indicate the degree of consolidation of the formation and is useful in the identification of lithologic layers with different densities.

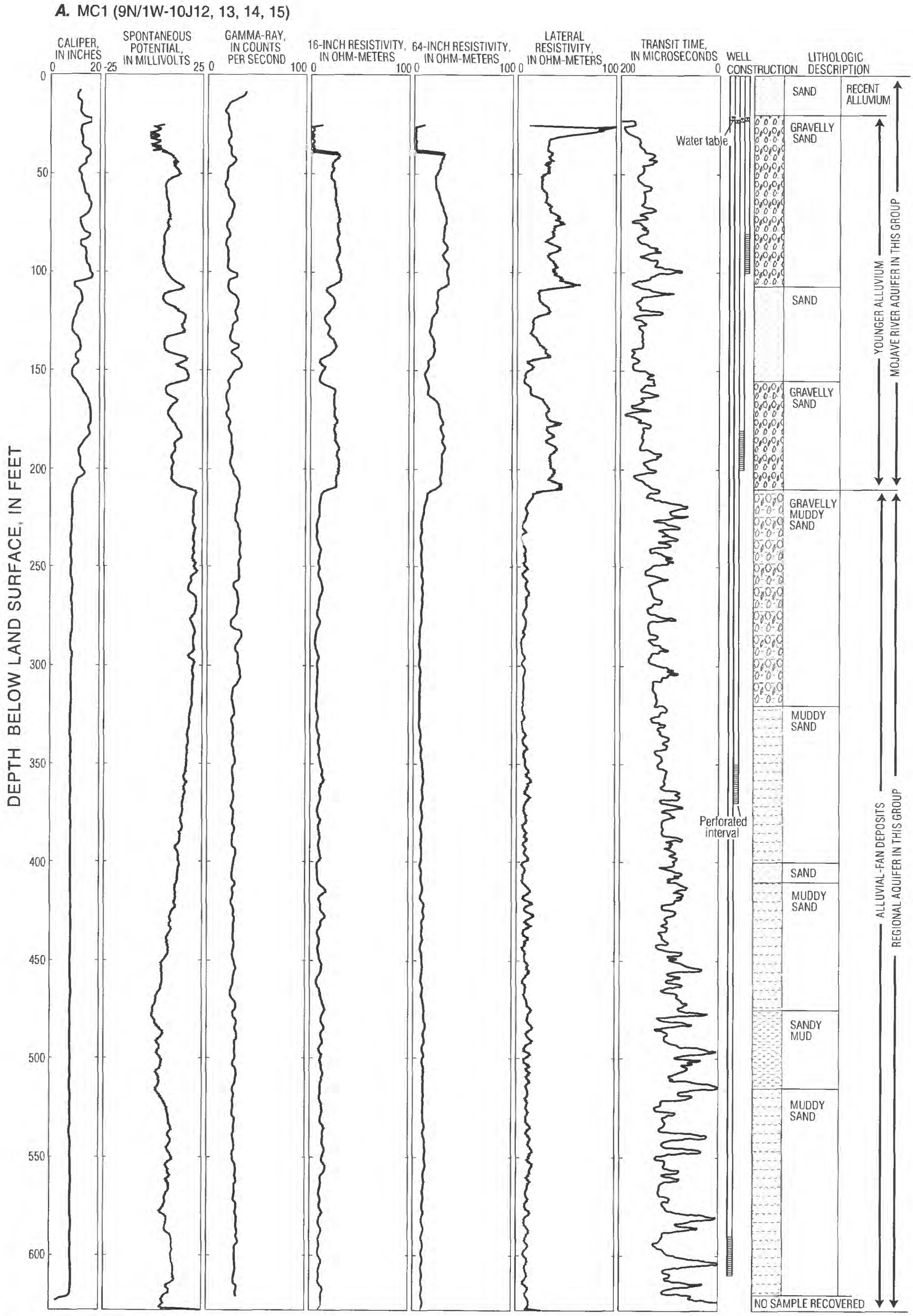

Figure 19. Geophysical and lithologic logs for boreholes of multiple-well monitoring sites in the vicinity of the Marine Corps Logistics Base, Nebo and Yermo Annexes, near Barstow, California. (See table 1 for well names and numbers.)

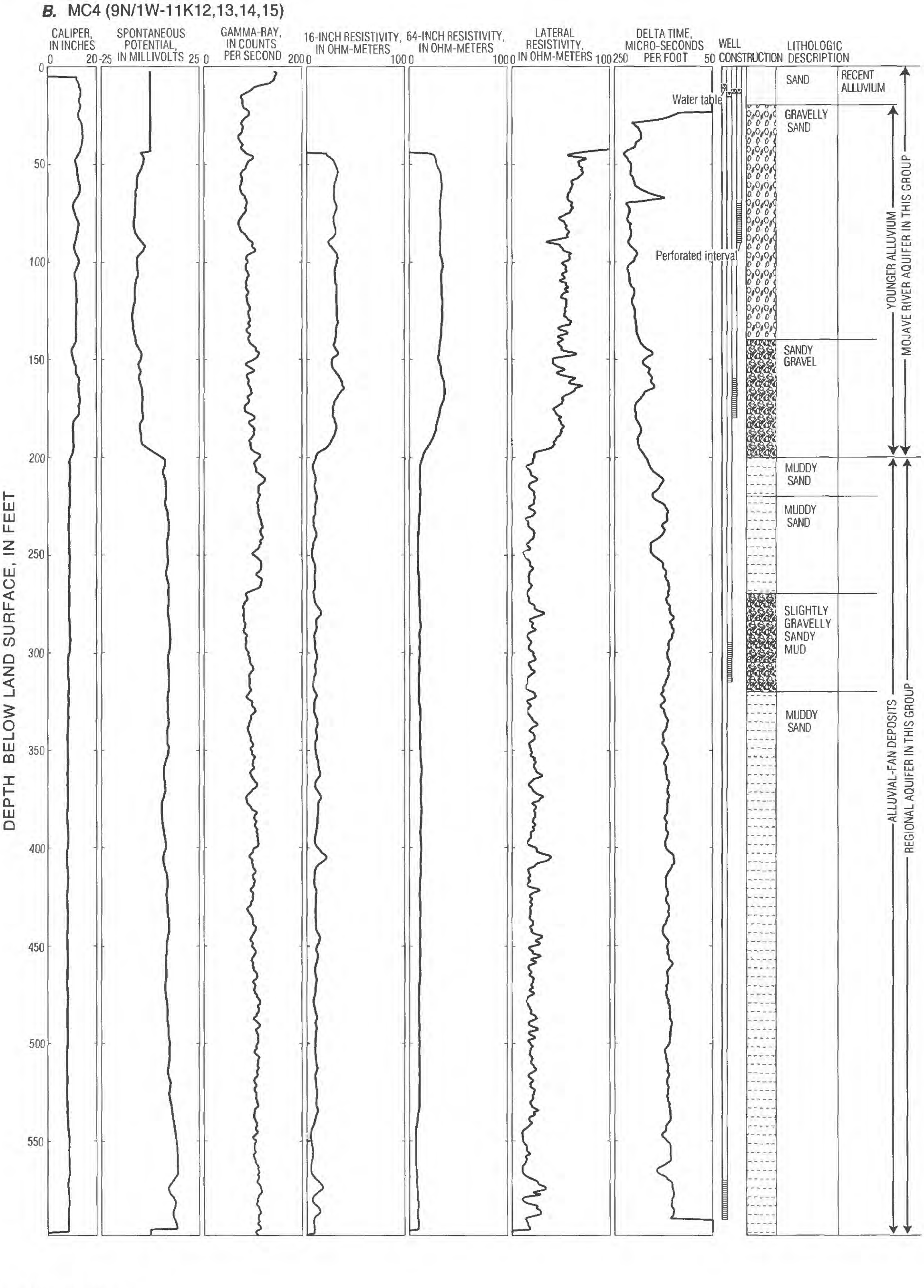

Figure 19. *Continued.*

C. MC2 (9N/1W-12L2,3,4,5)

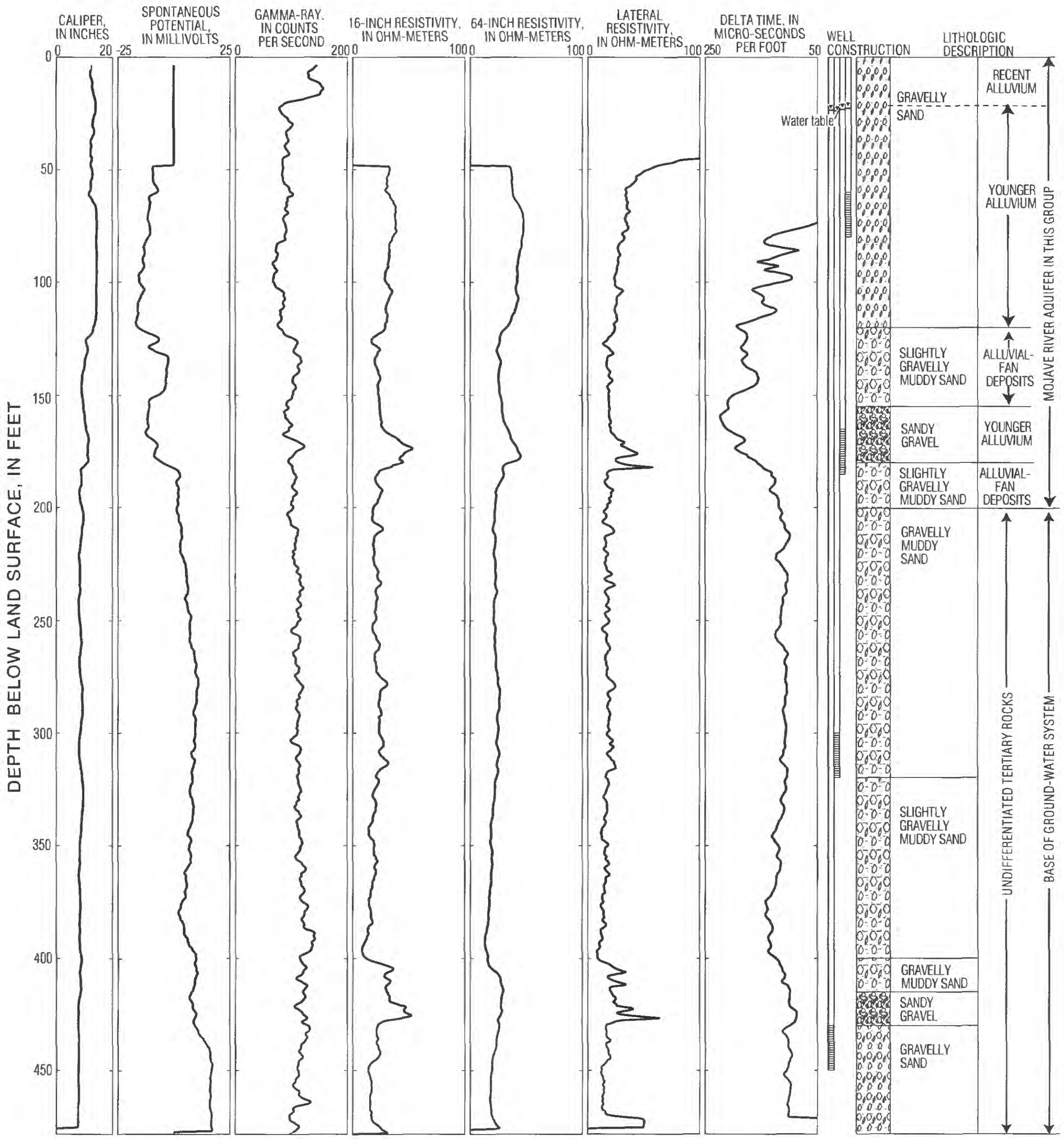

Figure 19. *Continued.*

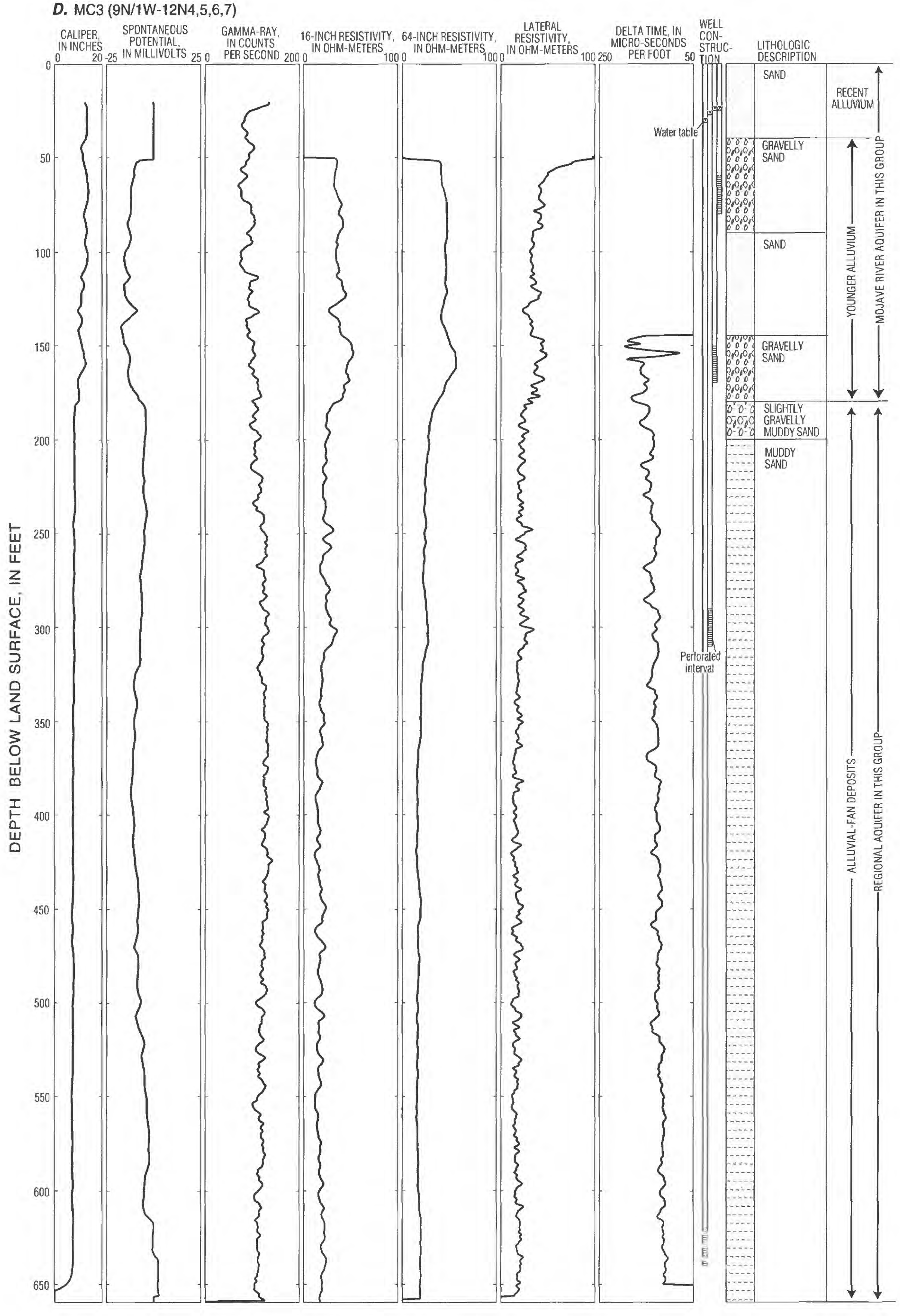

Figure 19. *Continued.*

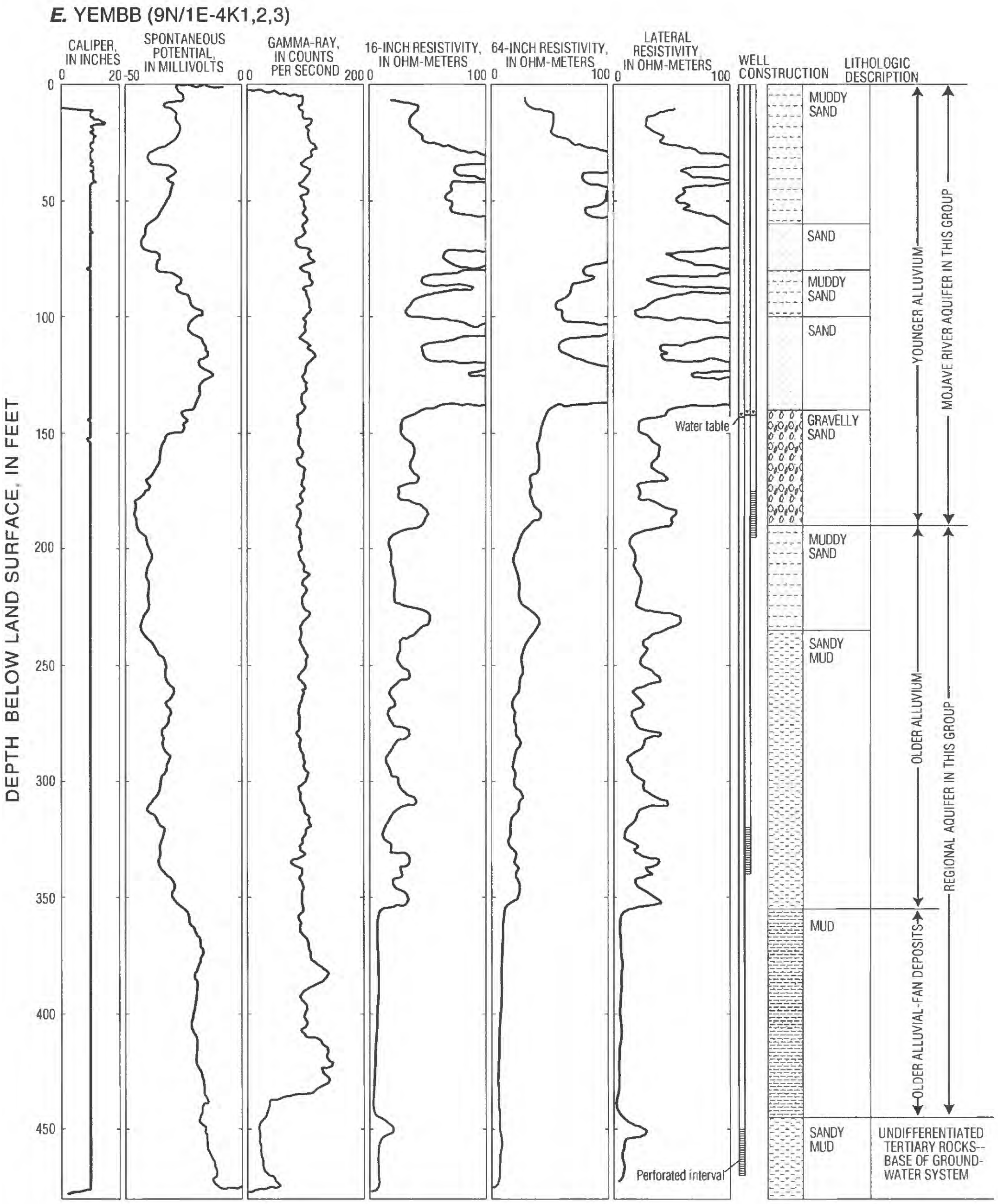

Figure 19. *Continued.*

F. YEMRR (9N/1E-10Q2,3,4)

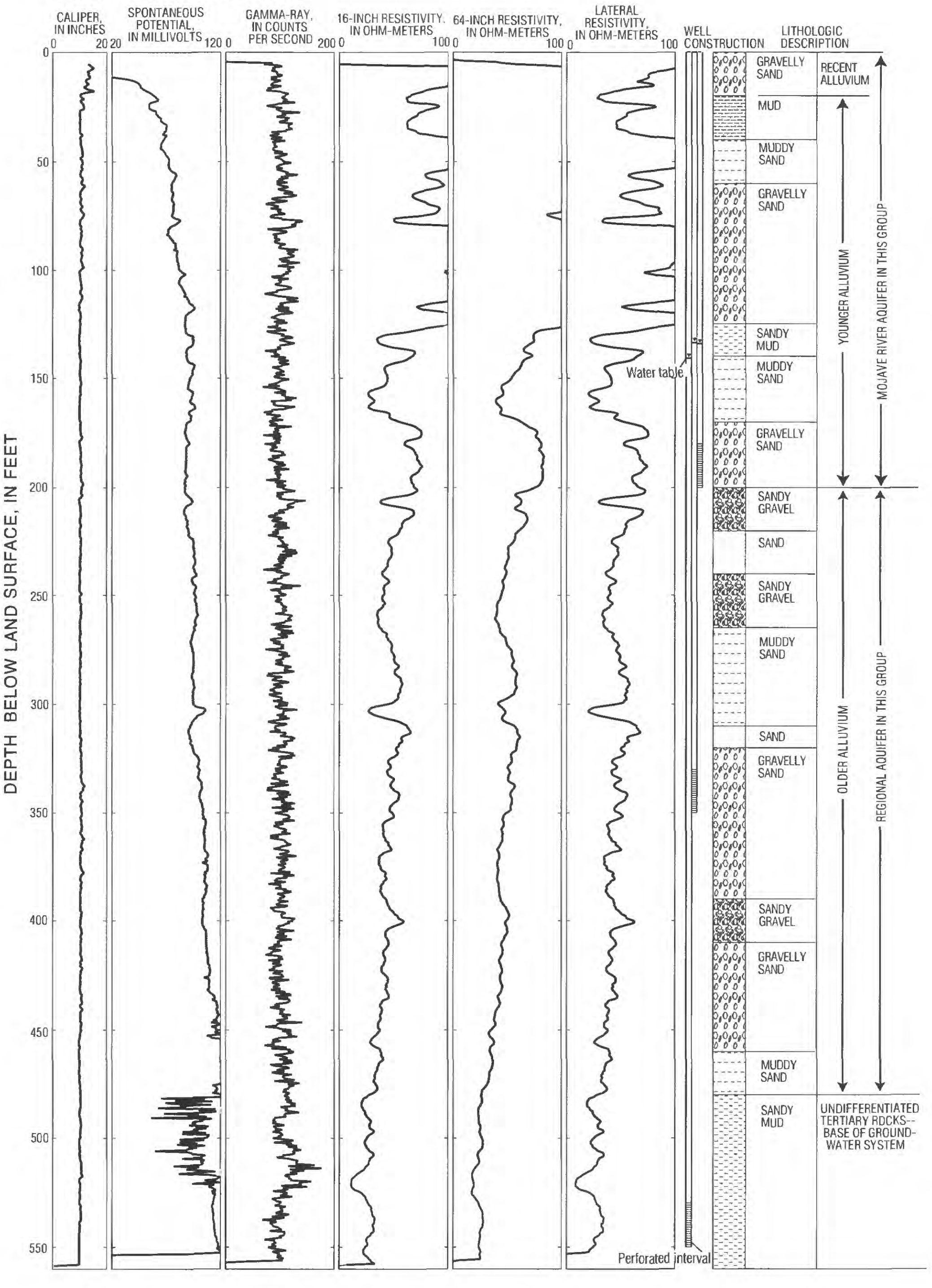

Figure 19. *Continued.*

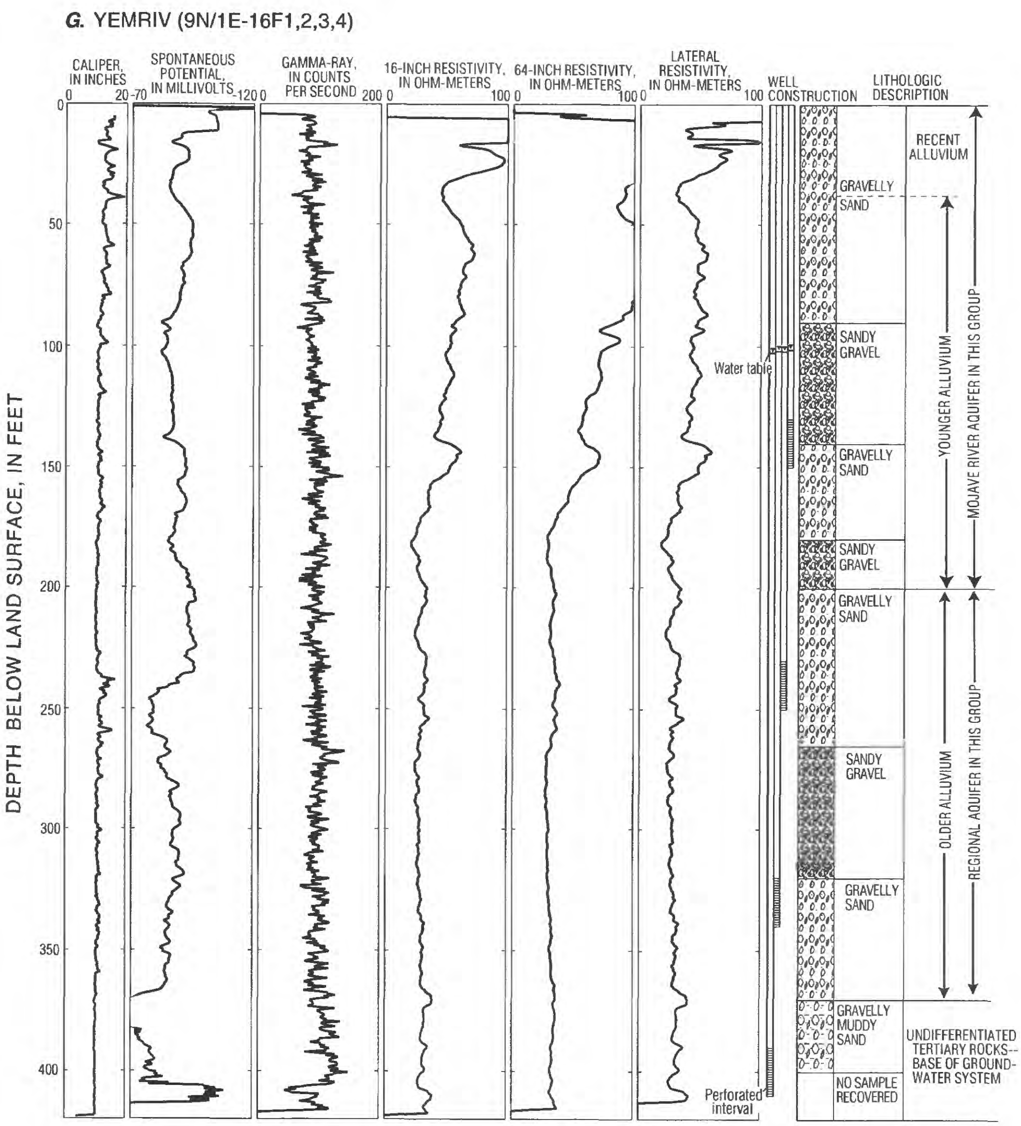

Figure 19. *Continued.*

H. CALFAN (10N/1E-20M1,2)

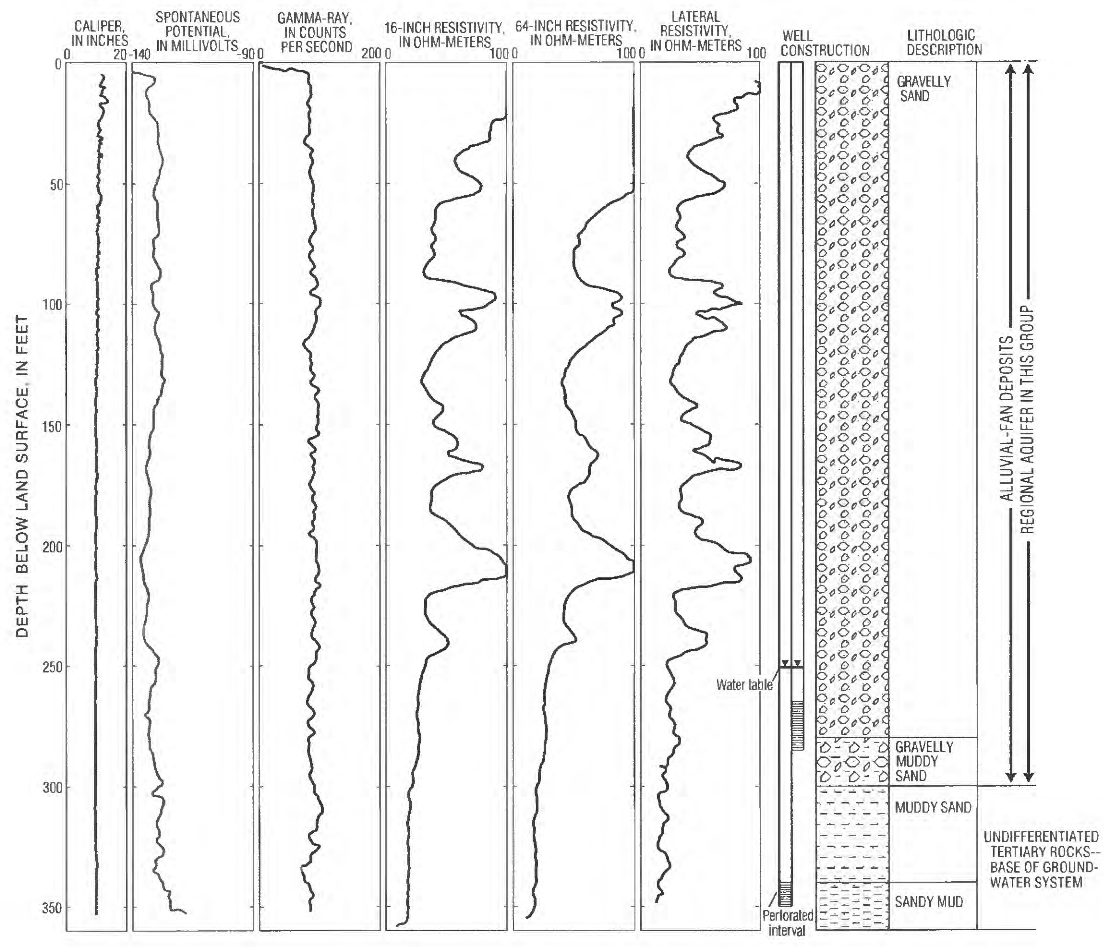

Figure 19. *Continued.*

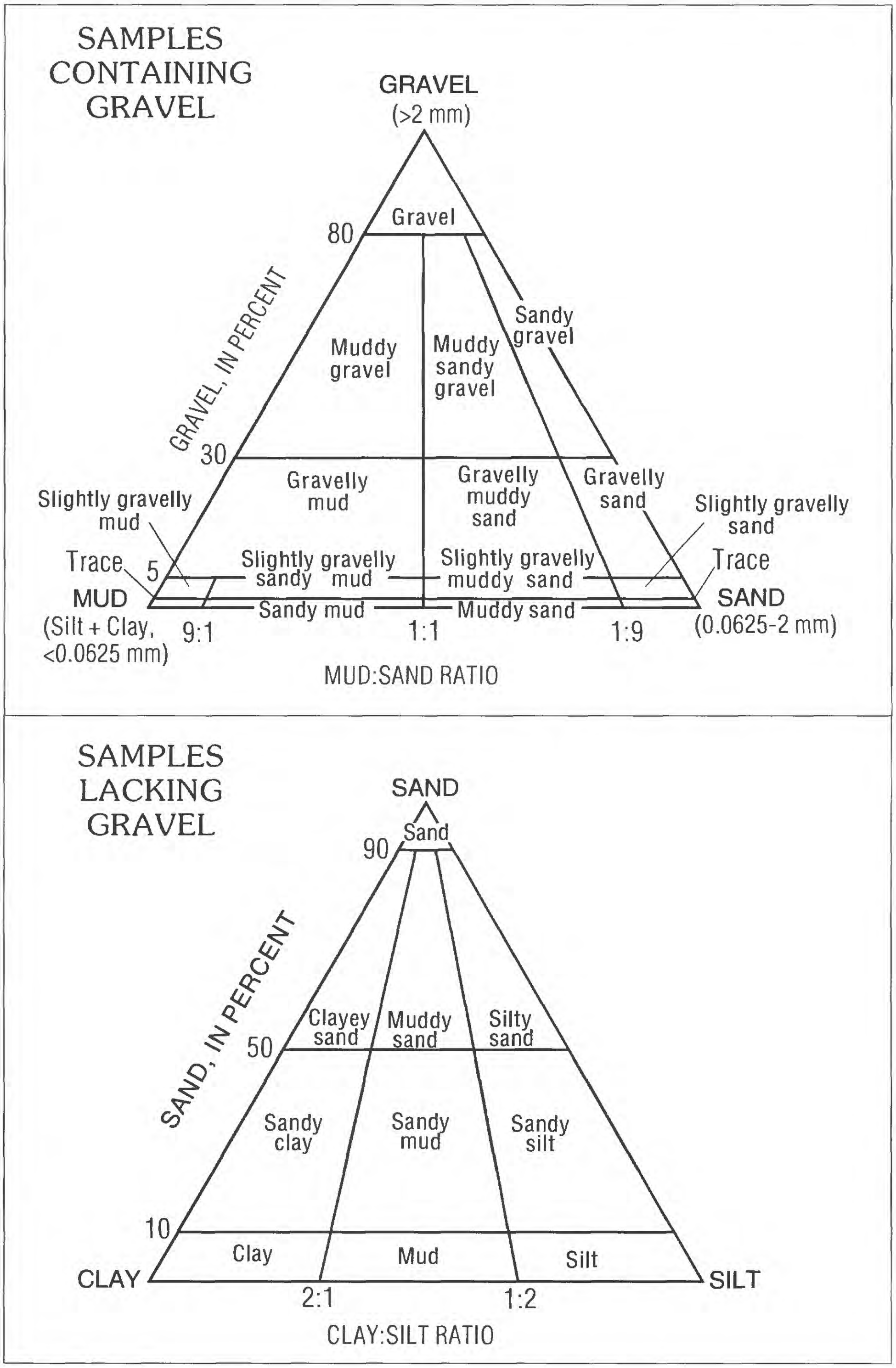

Figure 20. Rock-type nomenclature used for stratigraphic columns (fig. 19*A-H*). (From Folk, 1954, fig. 1.)

TABLES

Table 1. Well-construction data for wells in the vicinity of the Marine Corps Logistics Base, Nebo and Yermo Annexes, near Barstow, California

[State well No.: See Well-Numbering System in text. Altitude of land surface in feet above sea level. Depth drilled, depth of well, and top and bottom of open interval in feet below land surface. Well type: OBS, observation; WTR, water supply. --, no data]

State well No.	Local well name (where given)	Altitude of land surface	Well type	Depth drilled	Date of construction (where known)	Depth of well	Top of open interval	Bottom of open interval
9N/1E-3H1		1,948	OBS	137	06- -45	125	--	--
-3H5		1,950	OBS	209	12-10-88	200	100	200
-3K1	YEB-4	1,965	OBS	640	--	--	--	--
-3P2	YERMO #5	1,955	WTR	410	07- -69	400	160	400
-4J1	YERMO #1	1,965	WTR	296	- -42	296	142	260
-4J2	YERMO #4	1,964	WTR	475	- -60	350	60	--
-4K1[1]	YEMBB-470	1,965	OBS	480	06-09-93	470.0	450	470
-4K2[1]	YEMBB-340	1,965	OBS	480	06-09-93	340.0	320	340
-4K3[1]	YEMBB-195	1,965	OBS	480	06-09-93	195.0	175	195
-4L1	YWP-4	1,963.57	OBS	154	--	154	134	154
-4Q2	YPZ-3	1,927.26	OBS	166	--	166	146	166
-4R1	YERMO #2	1,963	WTR	174	- -42	--	--	--
-4R2	YS28-1	1,965.24	OBS	162	--	162	142	162
-6E1		2,099	OBS	--	--	480	--	--
-6H1	6H1	1,980	WTR	152	01-01-50	152	--	--
-6H2	6H2	1,980	WTR	320	05-24-76	320	--	--
-9C1	YWP3	1,975	OBS	--	--	--	149.8	168.9
-9D4		1,990	OBS	--	--	[2]249	--	--
-9G1	YWP-2	1,974.12	OBS	170	--	170	150	170
-10H1	10H1	1,960	OBS	453	06-18-68	441	431	441
-10J1	YS22-3	1,948.52	OBS	145	05-18-93	145	125	145
-10L1	YERMO #3	1,960	WTR	428	- -42	214	--	214
-10L2	YS23-3	1,956.22	OBS	160	--	160	140	160
-10Q1	Y5-1	1,959.45	OBS	160	--	160	140	160
-10Q2[1]	YEMRR-550	1,948	OBS	560	06-06-93	550.0	530	550
-10Q3[1]	YEMRR-350	1,948	OBS	560	06-06-93	350.0	330	350
-10Q4[1]	YEMRR-200	1,948	OBS	560	06-06-93	200.0	180	200
-10R1	Y10-1	1,944.08	OBS	147	--	147	127	147
-11B2		1,955	WTR	--	--	198	--	--
-12A1		1,915	OBS	--	--	--	--	--
-12B1		1,915	OBS	--	--	--	--	--
-13E2		1,950	OBS	174	--	--	--	--
-15H1		1,960	WTR	385	- -51	--	--	--
-15N3		1,970	OBS	--	--	--	--	--
-16F1[1]	YEMRIV-410	1,950	OBS	422	07-14-93	410.0	390	410
-16F2[1]	YEMRIV-340	1,950	OBS	422	07-14-93	340.0	320	340
-16F3[1]	YEMRIV-250	1,950	OBS	422	07-14-93	250.0	230	250

See footnotes at end of table.

Table 1. Well-construction data for wells in the vicinity of the Marine Corps Logistics Base, Nebo and Yermo Annexes, near Barstow, California—*Continued*

State well No.	Local well name (where given)	Altitude of land surface	Well type	Depth drilled	Date of construction (where known)	Depth of well	Top of open interval	Bottom of open interval
9N/1E-16F4[1]	YEMRIV-150	1,950	OBS	422	07-14-93	150.0	130	150
-17H1	17H1, DAGGETT #4	1,980	WTR	135	- -57	135	70	135
-19J1	19J1	2,144	OBS	755	05-17-66	323	180	186
							198	204
							212	218
							240	252
-20B3		2,040	OBS	--	--	--	--	--
-21H1	21H1	2,000	OBS	410	03-15-57	402	148	398
-22B6		1,975	OBS	--	--	200	--	--
-22D1	22D1	1,969	OBS	152	- -17	--	--	--
-23J1		1,980	OBS	--	--	--	--	--
9N/1W-4J8		2,050	OBS	--	--	- -	--	--
-4M4[1]	BARSTOW1-440	2,070	OBS	540	01-14-93	440	420	440
-4M5[1]	BARSTOW1-250	2,070	OBS	540	01-14-93	250	230	250
-4M6[1]	BARSTOW1-160	2,070	OBS	640	01-14-93	160	140	160
-4M7[1]	BARSTOW1-80	2,070	OBS	540	01-14-93	80	40	80
-4R2[1]	BARSTOW2-280	2,045	OBS	300	01-21-93	280	260	280
-4R3[1]	BARSTOW2-140	2,045	OBS	300	01-21-93	140	120	140
-4R4[1]	BARSTOW2-40	2,045	OBS	300	01-21-93	40	20	40
-9D5[1]	BARSTOW3-500	2,094	OBS	620	01-27-93	500	480	500
-9D6[1]	BARSTOW3-300	2,094	OBS	620	01-27-93	300	280	300
-9D7[1]	BARSTOW3-190	2,094	OBS	620	01-27-93	190	170	190
-9D8[1]	BARSTOW3-80	2,094	OBS	620	01-27-93	80	60	80
-10E4		2,060	OBS	102	07-17-79	101.6	99.6	101.6
-10G6		2,058	WTR	--	--	107	--	--
-10J12[1]	MC1-610	2,033.59	OBS	620	03-19-92	610	590	610
-10J13[1]	MC1-370	2,033.59	OBS	620	03-19-92	370	350	370
-10J14[1]	MC1-200	2,033.59	OBS	620	03-19-92	200	180	200
-10J15[1]	MC1-100	2,033.59	OBS	620	03-19-92	100	80	100
-11K12[1]	MC4-590	2,022.28	OBS	600	07-10-92	590	570	590
-11K13[1]	MC4-315	2,022.28	OBS	600	07-10-92	315	295	315
-11K14[1]	MC4-180	2,022.28	OBS	600	07-10-92	180	160	180
-11K15[1]	MC4-90	2,022.28	OBS	600	07-10-92	90	70	90
-11K16	US1-3	2,019.68	OBS	27	--	27	7	27
-11M1		2,033	OBS	53	- -71	51	49	51
-11M11		2,015	OBS	--	--	75	--	--
-11N8	NPZ-16	2,065.69	OBS	--	--	70	50	70
-11Q3	NPZ-18	2,034	OBS	--	--	41	21	41
-11Q4		2,042.94	OBS	--	--	--	30	50
-11R2		2,033	OBS	117	- -72	102	100	102

See footnotes at end of table.

Table 1. Well-construction data for wells in the vicinity of the Marine Corps Logistics Base, Nebo and Yermo Annexes, near Barstow, California—*Continued*

State well No.	Local well name (where given)	Altitude of land surface	Well type	Depth drilled	Date of construction (where known)	Depth of well	Top of open interval	Bottom of open interval
9N/1W-12L2[1]	MC2-450	2,002	OBS	481.5	06-17-92	450	430	450
-12L3[1]	MC2-320	2,002	OBS	480	06-17-92	320	300	320
-12L4[1]	MC2-185	2,002	OBS	480	06-17-92	185	165	185
-12L5[1]	MC2-80	2,002	OBS	480	06-17-92	80	60	80
-12N4[1]	MC3-640	2,010.24	OBS	660	06-29-92	640	620	640
-12N5[1]	MC3-310	2,010.24	OBS	660	06-29-92	310	290	310
-12N6[1]	MC3-170	2,010.24	OBS	660	06-28-92	170	150	170
-12N7[1]	MC3-80	2,010.24	OBS	660	06-28-92	80	60	80
-12N8	NPZ-4	2,015.94	OBS	--	--	82	62	82
-13B2		2,000	OBS	110	12-10-82	110	30	110
-13B3		1,995	OBS	66	02-06-87	60	45	50
-13C1	NPZ-5	2,026.35	OBS	58.5	--	--	38.5	58.5
-13E1	NEBO 4	2,071	OBS	348	- -54	348	48	348
-13E2	NEBO 5	2,060	OBS	450	- -60	440	65	440
-13H2		2,000	OBS	185	- -54	160	65	108
-14A2	NEBO 2	2,058	OBS	407	- -58	407	107	407
-14B1	NEBO 1	2,064	OBS	192	- -42	171	70	--
-14B2	NEBO 3	2,068	OBS	280	- -47	230	37	97
					--		130	230
-14D1	NPZ-10	2,093.13	OBS	--	--	90	70	90
-14E1	NPZ-12	2,161.64	OBS	--	--	123	103	123
-15Q1	15Q1	2,250	OBS	850	06-07-66	475	472	474
-15Q2	15Q2	2,250	OBS	290	06- -66	290	288	290
-15R1	NPZ-13	2,222.57	OBS	--	--	167	147	167
-27D1	27D1	2,480	OBS	568	06- -66	[3]508.3	546	548
10N/1E 20M1[1]	CALFAN-350	2,090	OBS	360	06-18-93	350.0	340	350
-20M2[1]	CALFAN-285	2,090	OBS	360	06-18-93	285.0	265	285
-27C1	--	2,085	WTR	700	07- -80	600	200	400
-28G3	--	1,985	WTR	227	10-10-86	227	127	227
-28J8	--	1,972	OBS	256	02-03-92	255	--	--
10N/1W-33L3	--	2,090	OBS	--	--	120	--	--

[1]Multiple-well monitoring site.

[2]Depth at which well was sounded in July 1994

[3]Depth at which well was sounded on June 24, 1993.

Table 2. Sources and estimates of average annual recharge and discharge in the vicinity of the Marine Corps Logistics Base, Nebo and Yermo Annexes, near Barstow, California

[acre-ft/yr, acre-foot per year]

Source	Estimate of average annual value, (acre-ft/yr)
Recharge	
Infiltration of Mojave River floodflows	[1]2,300
Seepage of sewage effluent	[2,3]2,260
Irrigation-return flow	[2,4]1,350
Ground-water underflow (inflow)	[5]800
Total.............	6,710
Discharge	
Ground-water pumpage	[3]9,570
Ground-water underflow (outflow)	[6]450
Evapotranspiration	[7]1,000
Total.............	11,020

[1]Calculated as acre-ft/yr per mile from recharge estimates of Robson (1974).

[2]John Brand (City of Barstow, written commun., 1993).

[3]C.L. Stamos-Pfeiffer (U.S. Geological Survey, written commun., 1996).

[4]Hughes (1975).

[5]Robson (1974).

[6]Estimate calculated using equation 2 in text.

[7]G.C. Lines (U.S. Geological Survey, written commun., 1996).

Table 3. Water-level data for selected wells in the vicinity of the Marine Corps Logistics Base, Nebo and Yermo Annexes, near Barstow, California, January 1992-September 1996

[State well No.: See Well-Numbering System in text. Site identification number is the latitude, longitude, and sequence number of the site. Altitude, feet above sea level. Measurement method (column M): A, airline; C, calibrated airline; R, reported; S, steel tape; T, electric tape; and V, calibrated electric tape. Site status (column S): F, flowing; O, obstruction; P, pumping; R, recently pumped; S, nearby pumping; T, nearby recently pumped; V, foreign substance; W, well destroyed; and Z, other]

Local Number 009N001E03H005S
Site id 345413116512902
Top of perforations 100
Bottom of perforations 200
Altitude 1950
About 1.5 miles west of Yermo. Drilled domestic well. Diameter 6 inches, depth 200 feet, perforated 100-200 feet. Altitude of land-surface datum 1,950 feet. Water-level records available 1989 to current year.

WATER LEVEL, IN FEET BELOW LAND-SURFACE DATUM

DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS
MAR 10, 1992	132.02	S	NOV 16, 1993	132.47	S	NOV 14, 1994	136.39	S			
MAY 27		P	MAR 23, 1994	132.40	S	MAY 09, 1995		O			
MAY 18, 1993	129.87	V	MAY 25	132.16	V	MAY 15, 1996		SO			

HIGHEST 129.87 MAY 18, 1993
LOWEST 136.39 NOV 14, 1994

Local Number 009N001E04K001S YEMBB-470
Site id 345356116523001
Top of perforations 450
Bottom of perforations 470
Altitude 1965

WATER LEVEL, IN FEET BELOW LAND-SURFACE DATUM

DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS
JUL 21, 1993	143.04	V	FEB 26, 1994	144.06	V	JAN 23, 1995	148.92	V	OCT 30, 1995	151.90	V
22	142.75	V	APR 16	144.67	V	FEB 27	149.25	VZ	NOV 27	152.57	V
AUG 27	143.53	V	JUN 07	145.88	V	MAR 27	149.02	V	DEC 18	152.21	V
28	143.35	V	JUL 25	146.85	V	APR 24	148.72	V	JAN 31, 1996	152.18	V
SEP 21	142.99	S	AUG 22	147.42	V	MAY 24	149.12	V	FEB 29	152.67	V
OCT 19	143.64	V	SEP 27	148.06	V	JUN 26	149.33	V	MAR 26	152.47	V
NOV 17	143.86	V	OCT 24	148.27	VS	JUL 24	149.79	V	APR 29	152.93	V
DEC 21	143.67	V	NOV 28	148.73	V	AUG 28	150.10	V			
JAN 06, 1994	143.98	V	DEC 19	148.87	V	SEP 25	151.67	V			

HIGHEST 142.75 JUL 22, 1993
LOWEST 152.93 APR 29, 1996

Local Number 009N001E04K002S YEMBB-340
Site id 345356116523002
Top of perforations 320
Bottom of perforations 340
Altitude 1965

WATER LEVEL, IN FEET BELOW LAND-SURFACE DATUM

DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS
JUL 21, 1993	142.00	V	FEB 26, 1994	144.38	V	JAN 23, 1995	149.16	V	OCT 30, 1995	153.29	V
22	142.15	V	APR 16	145.09	V	FEB 27	149.32	VZ	NOV 27	151.96	V
AUG 27	142.89	V	JUN 07	146.23	V	MAR 27	149.15	V	DEC 18	155.16	V
28	142.81	V	JUL 25	147.35	V	APR 24	150.65	V	JAN 31, 1996	155.15	V
SEP 21	143.11	S	AUG 22	147.97	V	MAY 24	152.62	V	FEB 29	153.15	V
OCT 19	143.82	V	SEP 27	148.64	V	JUN 26	149.54	V	MAR 26	152.22	V
NOV 17	144.07	V	OCT 24	151.23	VS	JUL 24	150.38	V	APR 29	152.90	V
DEC 21	144.13	V	NOV 28	149.20	V	AUG 28	150.60	V			
JAN 06, 1994	144.31	V	DEC 19	149.27	V	SEP 25	151.16	V			

HIGHEST 142.00 JUL 21, 1993
LOWEST 155.16 DEC 18, 1995

Table 3. Water-level data for selected wells in the vicinity of the Marine Corps Logistics Base, Nebo and Yermo Annexes, near Barstow, California, January 1992-September 1996—*Continued*

Local Number 009N001E04K003S YEMBB-195
Site id 345356116523003
Top of perforations 175
Bottom of perforations 195
Altitude 1965

WATER LEVEL, IN FEET BELOW LAND-SURFACE DATUM

DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS
JUL 21, 1993	142.14	VR	FEB 26, 1994	143.52	V	JAN 23, 1995	147.98	V	OCT 30, 1995	152.09	V
22	142.16	V	APR 16	144.03	V	FEB 27	148.21	VZ	NOV 27	150.57	V
AUG 27	142.49	V	JUN 07	144.71	V	MAR 27	148.16	V	DEC 18	153.09	V
28	142.50	V	JUL 25	145.47	V	APR 24	148.81	V	JAN 31, 1996	153.17	V
SEP 21	142.62	S	AUG 22	146.13	V	MAY 24	150.79	V	FEB 29	151.37	V
OCT 19	143.04	V	SEP 27	146.90	V	JUN 26	148.46	V	MAR 26	151.20	V
NOV 17	143.05	V	OCT 24	149.11	VS	JUL 24	148.82	V	APR 29	151.53	V
DEC 21	142.98	V	NOV 28	147.68	V	AUG 28	149.13	V			
JAN 06, 1994	143.48	V	DEC 19	147.87	V	SEP 25	149.72	V			

HIGHEST 142.16 JUL 22, 1993
LOWEST 153.17 JAN 31, 1996

Local Number 009N001E04L001S
Site id 345403116530701
Top of perforations 134
Bottom of perforations 154
Altitude 1963.57

WATER LEVEL, IN FEET BELOW LAND-SURFACE DATUM

DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS
MAR 03, 1992	139.52	R[1]	JAN 12, 1993	142.29	R[1]	FEB 11, 1993	142.55	R[1]	MAY 18, 1993	141.81	V

Local Number 009N001E04Q002S
Site id 345349116524901
Top of perforations 146
Bottom of perforations 166
Altitude 1927.26

WATER LEVEL, IN FEET BELOW LAND-SURFACE DATUM

DATE	WATER LEVEL	MS
MAY 20, 1993	146.27	V

Local Number 009N001E04R002S
Site id 345347116523301
Top of perforations 142
Bottom of perforations 162
Altitude 1965.24

WATER LEVEL, IN FEET BELOW LAND-SURFACE DATUM

DATE	WATER LEVEL	MS
MAY 20, 1993	146.26	V

[1]See footnote at end of table.

Table 3. Water-level data for selected wells in the vicinity of the Marine Corps Logistics Base, Nebo and Yermo Annexes, near Barstow, California, January 1992-September 1996—*Continued*

Local Number 009N001E06E001S
Site id 345413116552201
Top of perforations
Bottom of perforations
Altitude 2099

WATER LEVEL, IN FEET BELOW LAND-SURFACE DATUM

DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS
APR 22, 1993	251.85	S	APR 24, 1996	277.	V

HIGHEST 251.85 APR 22, 1993
LOWEST 277. APR 24, 1996

Local Number 009N001E06H002S
Site id 345410116544101
Top of perforations
Bottom of perforations
Altitude 1980
About 5 miles northeast of Barstow. Drilled domestic well. Diameter 6 inches, depth 320 feet. Altitude of land-surface datum 2,000 feet. Water-level records available 1988 to current year.

WATER LEVEL, IN FEET BELOW LAND-SURFACE DATUM

DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS
MAY 29, 1992	129.81	S	MAY 24, 1994	147.69	V	MAY 13, 1996	131.94	S			
MAY 18, 1993	128.60	VR	MAY 08, 1995	153.73	VP						

HIGHEST 129.81 MAY 29, 1992
LOWEST 147.69 MAY 24, 1994

Local Number 009N001E09C001S
Site id 345335/1165300
Top of perforations 149.8
Bottom of perforations 168.9
Altitide 1975

WATER LEVEL, IN FEET BELOW LAND-SURFACE DATUM

DATE	WATER LEVEL	MS
MAR 31, 1992	154.22	R[1]

Local Number 009N001E09D004S
Site id 345327116531601
Top of perforations
Bottom of perforations
Altitude 1990

WATER LEVEL, IN FEET BELOW LAND-SURFACE DATUM

DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS
NOV 20, 1991	156.46	S	NOV 17, 1992	161.82	S	NOV 16, 1993	157.79	S	NOV 14, 1994	160.35	S
MAR 10, 1992	156.95	S	MAR 23, 1993	159.44	S	MAR 23, 1994	158.20	S			

HIGHEST 156.46 NOV 20, 1991
LOWEST 161.82 NOV 17, 1992

[1]See footnote at end of table.

Table 3. Water-level data for selected wells in the vicinity of the Marine Corps Logistics Base, Nebo and Yermo Annexes, near Barstow, California, January 1992-September 1996—*Continued*

Local Number 009N001E09G001S
Site id 345320116524501
Top of perforations 150
Bottom of perforations 170
Altitude 1974.12

WATER LEVEL, IN FEET BELOW LAND-SURFACE DATUM

DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS
MAR 31, 1993	155.94	R[1]	MAY 20, 1993	149.45	V

Local Number 009N001E10J001S
Site id 345313116513201
Top of perforations 125
Bottom of perforations 145
Altitude 1948.52

WATER LEVEL, IN FEET BELOW LAND-SURFACE DATUM

DATE	WATER LEVEL	MS
MAY 18, 1993	125.96	V

Local Number 009N001E10L001S
Site id 345304116515801
Top of perforations
Bottom of perforations 214
Altitude 1960

WATER LEVEL, IN FEET BELOW LAND-SURFACE DATUM

DATE	WATER LEVEL	MS
JAN 11, 1994	137.75	V

Local Number 009N001E10L002S
Site id 345306116515701
Top of perforations 140
Bottom of perforations 160
Altitude 1956.22

WATER LEVEL, IN FEET BELOW LAND-SURFACE DATUM

DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS
APR 22, 1992	140.42	R[1]	JAN 12, 1993	143.78	R[1]	FEB 11, 1993	142.58	R[1]	MAY 18, 1993	130.35	V

Local Number 009N001E10Q001S
Site id 345257116514201
Top of perforations 140
Bottom of perforations 160
Altitude 1959.45

WATER LEVEL, IN FEET BELOW LAND-SURFACE DATUM

DATE	WATER LEVEL	MS
MAY 20, 1993	134.61	V

[1]See footnote at end of table.

Table 3. Water-level data for selected wells in the vicinity of the Marine Corps Logistics Base, Nebo and Yermo Annexes, near Barstow, California, January 1992-September 1996—*Continued*

Local Number 009N001E10Q002S YEMRR-550
Site id 345259116514201
Top of perforations 530
Bottom of perforations 550
Altitude 1948

WATER LEVEL, IN FEET BELOW LAND-SURFACE DATUM

DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS
AUG 03, 1993	147.94	V	APR 13, 1994	137.55	V	APR 24, 1995	140.39	V	DEC 18, 1995	143.10	V
26	140.94	V	JUN 07	142.42	V	MAY 24	140.46	V	JAN 31, 1996	143.21	V
SEP 21	138.22	V	JUL 25	140.17	V	JUN 26	140.93	V	FEB 29	143.22	V
OCT 19	136.84	V	OCT 24	141.29	V	JUL 24	141.35	V	MAR 26	143.29	V
NOV 17	136.66	V	NOV 28	141.42	V	AUG 28	142.02	V	APR 29	143.35	V
DEC 21	137.13	V	DEC 19	142.46	V	SEP 25	141.96	V			
JAN 10, 1994	136.31	V	JAN 23, 1995	142.24	V	OCT 30	142.76	V			
FEB 26	136.17	V	MAR 27	141.52	VZ	NOV 27	142.98	V			

HIGHEST 136.17 FEB 26, 1994
LOWEST 147.94 AUG 03, 1993

Local Number 009N001E10Q003S YEMRR-350
Site id 345259116514202
Top of perforations 330
Bottom of perforations 350
Altitude 1948

WATER LEVEL, IN FEET BELOW LAND-SURFACE DATUM

DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS
AUG 03, 1993	133.12	V	APR 13, 1994	136.94	V	APR 24, 1995	139.52	V	DEC 18, 1995	144.10	V
26	133.73	V	JUN 07	138.62	V	MAY 24	140.63	V	JAN 31, 1996	143.73	V
SEP 21	136.42	V	JUL 25	140.42	V	JUN 26	141.77	V	FEB 29	143.60	V
OCT 19	135.22	V	OCT 24	142.21	V	JUL 24	142.80	V	MAR 26	144.04	V
NOV 17	135.42	V	NOV 28	141.74	V	AUG 28	143.97	V	APR 29	145.16	V
DEC 21	135.35	V	DEC 19	142.29	V	SEP 25	144.24	V			
JAN 10, 1994	135.48	V	JAN 23, 1995	141.77	V	OCT 30	144.52	V			
FEB 26	135.55	V	MAR 27	140.30	VZ	NOV 27	144.30	V			

HIGHEST 133.12 AUG 03, 1993
LOWEST 145.16 APR 29, 1996

Local Number 009N001E10Q004S YEMRR-200
Site id 345259116514203
Top of perforations 180
Bottom of perforations 200
Altitude 1948

WATER LEVEL, IN FEET BELOW LAND-SURFACE DATUM

DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS
AUG 26, 1993	133.59	V	APR 13, 1994	136.83	V	MAR 27, 1995	140.32	VZ	OCT 30, 1995	144.54	V
SEP 21	134.37	V	JUN 07	141.02	V	APR 24	139.43	V	NOV 27	144.34	V
OCT 19	135.12	V	JUL 25	140.29	V	MAY 24	140.52	V	DEC 18	144.19	V
NOV 17	135.44	V	OCT 24	141.50	V	JUN 26	141.65	V	JAN 31, 1996	143.82	V
DEC 21	135.25	V	NOV 28	141.13	V	JUL 24	142.67	V	FEB 29	143.65	V
JAN 10, 1994	135.53	V	DEC 19	142.34	V	AUG 28	143.80	V	MAR 26	144.08	V
FEB 26	135.62	V	JAN 23, 1995	141.87	V	SEP 25	144.12	V	APR 29	145.03	V

HIGHEST 133.59 AUG 26, 1993
LOWEST 145.03 APR 29, 1996

Table 3. Water-level data for selected wells in the vicinity of the Marine Corps Logistics Base, Nebo and Yermo Annexes, near Barstow, California, January 1992-September 1996—*Continued*

Local Number 009N001E10R001S
Site id 345254116511901
Top of perforations 127
Bottom of perforations 147
Altitude 1944.08

WATER LEVEL, IN FEET BELOW LAND-SURFACE DATUM

DATE	WATER LEVEL	MS
MAY 20, 1993	121.25	V

Local Number 009N001E11B002S
Site id 345336116504101
Top of perforations
Bottom of perforations
Altitude 1955

WATER LEVEL, IN FEET BELOW LAND-SURFACE DATUM

DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS
MAR 10, 1992	137.10	S	MAR 23, 1993	138.05	S	MAR 23, 1994	139.20	S			
NOV 17	140.95	S	NOV 16	138.76	S						

HIGHEST 137.10 MAR 10, 1992
LOWEST 140.95 NOV 17, 1992

Local Number 009N001E12A001S
Site id 345336116491401
Top of perforations
Bottom of perforations
Altitude 1915

WATER LEVEL, IN FEET BELOW LAND-SURFACE DATUM

DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS
MAR 10, 1992	97.15	S	NOV 20, 1992	103.99	S	MAR 23, 1994	100.59	S	MAR 22, 1995	104.8	S
MAY 08	100.85	S	MAR 23, 1993	97.88	S	NOV 14	105.20	S			

HIGHEST 97.15 MAR 10, 1992
LOWEST 105.20 NOV 14, 1994

Local Number 009N001E12B001S
Site id 345328116492701
Top of perforations
Bottom of perforations
Altitude 1915

WATER LEVEL, IN FEET BELOW LAND-SURFACE DATUM

DATE	WATER LEVEL	MS
MAR 10, 1992	103.78	S

Table 3. Water-level data for selected wells in the vicinity of the Marine Corps Logistics Base, Nebo and Yermo Annexes, near Barstow, California, January 1992-September 1996—*Continued*

Local Number 009N001E15H001S
Site id 345230116512101
Top of perforations
Bottom of perforations
Altitude 1960.00

WATER LEVEL, IN FEET BELOW LAND-SURFACE DATUM

DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS
MAR 10, 1992	127.14	S	FEB 04, 1993	130.54	S	MAR 23, 1994	127.35	SS	MAR 26, 1996	134.92	V
MAY 08	129.32	S	MAR 24	117.75	S	NOV 15	133.75	SS			
NOV 20	132.54	S	NOV 16	126.53	S	MAR 22, 1995	134.75	S			

HIGHEST 117.75 MAR 24, 1993
LOWEST 134.92 MAR 26, 1996

Local Number 009N001E15N003S
Site id 345207116520801
Top of perforations
Bottom of perforations
Altitude 1970

WATER LEVEL, IN FEET BELOW LAND-SURFACE DATUM

DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS
MAR 10, 1992	146.52	S	NOV 16, 1993	140.70	S	MAR 22, 1995	159.87	S			
NOV 17	151.82	S	MAR 23, 1994	143.51	SS	NOV 08	164.81	V			
MAR 24, 1993	125.82	S	NOV 15	151.35	V	MAR 26, 1996	162.86	V			

HIGHEST 125.82 MAR 24, 1993
LOWEST 164.81 NOV 08, 1995

Local Number 009N001E16F001S YEMRIV-410
Site id 345224116525701
Top of perforations 390.0
Bottom of perforations 410.0
Altitude 1950

WATER LEVEL, IN FEET BELOW LAND-SURFACE DATUM

DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS
AUG 03, 1993	106.03	V	APR 14, 1994	116.66	V	FEB 27, 1995	124.53	VZ	NOV 27, 1995	126.19	V
04	105.28	V	JUN 02	120.63	V	MAR 27	115.79	VZ	DEC 18	126.18	V
28	105.69	V	JUL 25	123.48	V	APR 24	115.16	V	JAN 31, 1996	126.72	V
SEP 21	106.44	S	AUG 22	124.79	V	MAY 24	116.86	V	FEB 29	126.61	V
OCT 19	111.55	V	SEP 27	125.43	V	JUN 26	119.79	V	MAR 26	127.11	V
NOV 17	112.55	V	OCT 24	125.63	V	JUL 24	121.82	V	APR 29	128.24	V
DEC 21	113.98	V	NOV 28	125.70	V	AUG 28	123.50	V			
JAN 20, 1994	115.11	V	DEC 19	125.63	V	SEP 25	124.57	V			
MAR 13	117.05	V	JAN 23, 1995	125.52	V	OCT 29	126.16	V			

HIGHEST 105.28 AUG 04, 1993
LOWEST 126.24 APR 29, 1996

Local Number 009N001E16F002S YEMRIV-340
Site id 345224116525702
Top of perforations 320
Bottom of perforations 340
Altitude 1950

WATER LEVEL, IN FEET BELOW LAND-SURFACE DATUM

DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS
AUG 03, 1993	104.47	V	APR 14, 1994	118.36	V	FEB 27, 1995	124.22	VZ	NOV 27, 1995	125.99	V
04	105.13	V	JUN 07	121.31	V	MAR 27	115.59	VZ	DEC 18	126.11	V
28	106.02	V	JUL 25	123.03	V	APR 24	115.29	V	JAN 31, 1996	126.77	V
SEP 21	108.18	S	AUG 22	124.87	V	MAY 24	116.83	V	FEB 29	126.49	V
OCT 19	111.08	V	SEP 27	125.07	V	JUN 26	119.40	V	MAR 26	127.55	V
NOV 17	112.53	V	OCT 24	125.49	V	JUL 24	122.19	V	APR 29	127.90	V
DEC 21	113.96	V	NOV 28	125.65	V	AUG 28	123.26	V			
JAN 20, 1994	115.07	V	DEC 19	125.57	V	SEP 25	125.42	V			
MAR 13	117.38	V	JAN 23, 1995	125.49	V	OCT 29	126.05	V			

HIGHEST 104.47 AUG 03, 1993
LOWEST 127.90 APR 29, 1996

Local Number 009N001E16F003S YEMRIV-250
Site id 345224116525703
Top of perforations 230
Bottom of perforations 250
Altitude 1950

WATER LEVEL, IN FEET BELOW LAND-SURFACE DATUM

DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS
AUG 03, 1993	104.96	V	NOV 17, 1993	112.55	V	JUN 07, 1994	121.37	V	NOV 28, 1994	125.72	V
04	102.38	V	DEC 21	114.07	V	JUL 25	123.06	V	DEC 19	125.82	V
28	106.10	V	JAN 20, 1994	115.13	V	AUG 22	124.92	V	JAN 23, 1995	125.56	V
SEP 21	107.58	S	MAR 13	117.44	V	SEP 27	125.14	V	APR 29, 1996	127.99	V
OCT 19	111.80	V	APR 14	118.41	V	OCT 24	125.54	V			

HIGHEST 102.38 AUG 04, 1993
LOWEST 127.99 APR 29, 1996

Local Number 009N001E16F004S YEMRIV-150
Site id 345224116525704
Top of perforations 130
Bottom of perforations 150
Altitude 1950

WATER LEVEL, IN FEET BELOW LAND-SURFACE DATUM

DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS
AUG 03, 1993	101.16	V	APR 14, 1994	120.74	V	JAN 23, 1995	129.03	V	SEP 25, 1995	127.31	V
28	106.13	V	JUN 07	123.37	V	FEB 27	127.68	VZ	OCT 30	128.47	V
SEP 21	108.85	S	JUL 25	125.50	V	MAR 27	116.75	VZ	NOV 27	129.02	V
OCT 19	112.12	V	AUG 22	126.89	V	APR 24	115.31	V	DEC 18	129.31	V
NOV 17	114.28	V	SEP 27	127.97	V	MAY 24	118.30	V	JAN 31, 1996	129.58	V
DEC 21	116.08	V	OCT 24	128.68	V	JUN 26	121.42	V	FEB 29	129.71	V
JAN 20, 1994	117.53	V	NOV 28	129.09	V	JUL 24	122.69	V	MAR 26	130.01	V
MAR 13	119.18	V	DEC 19	129.11	V	AUG 28	125.98	V	APR 29	130.72	V

HIGHEST 101.16 AUG 03, 1993
LOWEST 130.72 APR 29, 1996

Table 3. Water-level data for selected wells in the vicinity of the Marine Corps Logistics Base, Nebo and Yermo Annexes, near Barstow, California, January 1992-September 1996—*Continued*

Local Number 009N001E19J001S
Site id 345126116543301
Top of perforations 180.0
198.0
212.0
240.0
Bottom of perforations 186.0
204.0
218.0
252.0
Altitude 2144.00
South of Daggett and Interstate 40. Drilled unused well. Diameter 8 inches, depth drilled 755 feet, concrete plug at 345 feet, depth measured 322.95 feet in 1993, perforated 180-186, 198-204, 212-218, 240-252 feet. Altitude of of land-surface datum 2,144 feet. Water-level records available 1966, 1993 to current year.

WATER LEVEL, IN FEET BELOW LAND-SURFACE DATUM

DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS
APR 04, 1992	181.19	S	MAY 18, 1993	179.10	V	MAY 08, 1995	178.04	S	MAY 14, 1996	177.45	S
APR 23, 1993	178.67	S	MAY 17, 1994	178.58	S	APR 22, 1996	181.50	S			

HIGHEST 177.45 MAY 14, 1996
LOWEST 181.50 APR 22, 1996

Local Number 009N001E20B003S
Site id 345147116535601
Top of perforations
Bottom of perforations
Altitude 2040

WATER LEVEL, IN FEET BELOW LAND-SURFACE DATUM

DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS
MAR 10, 1992	127.08	S	MAR 24, 1993	119.90	S	MAR 23, 1994	114.36	S			
NOV 17	126.40	S	NOV 16	113.40	S	NOV 14	116.02	S			

HIGHEST 113.40 NOV 16, 1993
LOWEST 127.08 MAR 10, 1992

Local Number 009N001E22B006S
Site id 345151116515201
Top of perforations
Bottom of perforations
Altitude 1975

WATER LEVEL, IN FEET BELOW LAND-SURFACE DATUM

DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS
MAR 10, 1992	139.19	S	NOV 17, 1992	145.18	SR	MAR 23, 1994	137.78	S	MAR 22, 1995	156.75	S
24	139.49	S	NOV 16, 1993	138.72	S	NOV 15	141.95	S	NOV 08	161.34	V
MAR 26, 1996	159.33	V									

HIGHEST 137.78 MAR 23, 1994
LOWEST 161.34 NOV 08, 1995

Local Number 009N001E23J001S
Site id 345127116502701
Top of perforations
Bottom of perforations
Altitude 1980

WATER LEVEL, IN FEET BELOW LAND-SURFACE DATUM

DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS
MAR 10, 1992	164.33	S	NOV 16, 1993	166.38	S	MAR 22, 1995	167.60	S			
NOV 17	169.02	S	MAR 23, 1994	165.83	SS	NOV 08	174.54	V			
MAR 24, 1993	164.40	S	NOV 15	170.84	S	MAR 26, 1996	171.21	V			

HIGHEST 164.33 MAR 10, 1992
LOWEST 174.54 NOV 08, 1995

Local Number 009N001W04J008S
Site id 345345116585401
Top of perforations
Bottom of perforations
Altitude 2050

WATER LEVEL, IN FEET BELOW LAND-SURFACE DATUM

DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS
MAR 11, 1992	35.63	S	MAR 23, 1993	14.10	S	NOV 15, 1994	19.30	S			
MAY 08	36.12	S	NOV 17	15.33	S	NOV 08, 1995	8.28	V			
NOV 20	37.92	S	MAR 24, 1994	16.40	S	MAR 26, 1996	9.62	V			

HIGHEST 8.28 NOV 08, 1995
LOWEST 37.92 NOV 20, 1992

Local Number 009N001W04M004S BARSTOW1-440
Site id 345351116593301
Top of perforations 420
Bottom of perforations 440
Altitude 2070

WATER LEVEL, IN FEET BELOW LAND-SURFACE DATUM

DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS
JAN 28, 1993	36.64	V	MAR 04, 1993	23.73	R	MAR 24, 1993		W			
FEB 11	31.26	V	14	22.80	S						

HIGHEST 22.80 MAR 14, 1993
LOWEST 36.64 JAN 28, 1993

Local Number 009N001W04M005S BARSTOW1-250
Site id 345351116593302
Top of perforations 230
Bottom of perforations 250
Altitude 2070

WATER LEVEL, IN FEET BELOW LAND-SURFACE DATUM

DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS
JAN 28, 1993	35.38	V	NOV 17, 1993	27.89	V	DEC 19, 1994	32.62	V	NOV 27, 1995	28.64	V
FEB 11	30.89	V	DEC 21	27.47	V	JAN 23, 1995	31.96	V	DEC 18	28.87	V
MAR 04	23.68	R	JAN 20, 1994	28.42	V	FEB 27	29.97	VZ	JAN 31, 1996	29.13	V
14	22.62	V	FEB 26	28.58	V	MAR 28	24.51	V	FEB 29	29.17	V
24	22.19	V	APR 12	29.11	V	APR 24	25.07	V	MAR 26	29.32	V
31	22.34	R	JUN 07	29.67	V	MAY 24	25.71	V	APR 29	28.82	V
MAY 20	23.92	V	JUL 25	30.46	V	JUN 26	26.30	V	MAY 30	29.45	V
JUL 20	25.24	V	AUG 22	31.01	V	JUL 24	26.88	V	JUL 02	30.34	V
AUG 27	26.12	V	SEP 27	31.63	V	AUG 28	27.47	V	30	31.12	V
SEP 21	26.73	V	OCT 24	32.01	V	SEP 25	27.83	V	AUG 20	31.55	V
OCT 19	27.52	V	NOV 28	32.42	V	OCT 30	28.12	V			

HIGHEST 22.19 MAR 24, 1993
LOWEST 35.38 JAN 28, 1993

Table 3. Water-level data for selected wells in the vicinity of the Marine Corps Logistics Base, Nebo and Yermo Annexes, near Barstow, California, January 1992-September 1996—*Continued*

Local Number 009N001W04M006S BARSTOW1-160
Site id 345351116593303
Top of perforations 140
Bottom of perforations 160
Altitude 2070

WATER LEVEL, IN FEET BELOW LAND-SURFACE DATUM

DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS
JAN 28, 1993	35.45	V	MAR 04, 1993	24.21	R	MAR 24, 1993	22.66	V	MAY 20, 1993	24.47	V
FEB 11	31.01	V	14	23.00	V	31	23.00	V	JUL 20	25.70	V
AUG 27, 1993	26.58	V	JUL 25, 1994	30.81	V	APR 24, 1995	25.51	V	JAN 31, 1996	29.52	V
SEP 21	27.17	V	AUG 22	31.32	V	MAY 24	26.16	V	FEB 29	29.49	V
OCT 19	27.97	V	SEP 27	31.97	V	JUN 26	26.73	V	MAR 26	29.65	V
NOV 17	28.30	V	OCT 24	32.35	V	JUL 24	27.31	V	APR 29	29.15	V
DEC 21	27.77	V	NOV 28	32.69	V	AUG 28	27.89	V	MAY 30	29.78	V
JAN 20, 1994	28.71	V	DEC 19	32.88	V	SEP 25	28.25	V	JUL 02	30.67	V
FEB 26	28.86	V	JAN 23, 1995	32.24	V	OCT 30	28.53	V	30	31.51	V
APR 12	29.47	V	FEB 27	30.33	VZ	NOV 27	29.03	V	AUG 20	31.85	V
JUN 07	30.02	V	MAR 28	24.95	V	DEC 18	29.27	V			

HIGHEST 22.66 MAR 24, 1993
LOWEST 35.45 JAN 28, 1993

Local Number 009N001W04M007S BARSTOW1-80
Site id 345351116593304
Top of perforations 40
Bottom of perforations 80
Altitude 2070

WATER LEVEL, IN FEET BELOW LAND-SURFACE DATUM

DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS
JAN 28, 1993	28.17	V	NOV 17, 1993	27.82	V	JAN 23, 1995	31.90	V	DEC 18, 1995	28.91	V
FEB 11	25.91	V	DEC 21	27.55	V	FEB 27	29.77	VZ	JAN 31, 1996	29.18	V
MAR 04	20.18	R	JAN 20, 1994	28.41	V	MAR 28	23.76	V	FEB 27	29.23	V
14	19.51	V	FEB 26	28.59	V	APR 24	24.57	V	MAR 26	29.32	V
21	19.81	V	JUN 07	29.63	V	MAY 24	25.47	V	APR 29	28.87	V
24	19.22	V	JUL 25	30.36	V	JUN 26	26.21	V	MAY 30	29.32	V
MAY 20	23.63	V	AUG 23	30.82	V	JUL 24	26.80	V	JUL 02	30.20	V
JUL 20	25.06	V	SEP 27	31.57	V	AUG 28	27.44	V	30	30.98	V
AUG 27	25.99	V	OCT 24	31.95	V	SEP 25	27.83	V	AUG 20	31.40	V
SEP 21	26.58	V	NOV 28	32.39	V	OCT 30	28.23	V			
OCT 19	27.50	V	DEC 19	32.57	V	NOV 27	28.66	V			

HIGHEST 19.22 MAR 24, 1993
LOWEST 32.57 DEC 19, 1994

Local Number 009N001W04R002S BARSTOW2-280
Site id 345339116584501
Top of perforations 260
Bottom of perforations 280
Altitude 2045

WATER LEVEL, IN FEET BELOW LAND-SURFACE DATUM

DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS
JAN 28, 1993	21.59	V	OCT 19, 1993	7.27	V	NOV 28, 1994	9.38	V	OCT 30, 1995	6.95	V
FEB 12	18.69	V	NOV 17	6.98	V	DEC 19	9.43	V	NOV 27	7.09	V
MAR 04	8.74	R	DEC 21	7.02	V	JAN 23, 1995	9.25	V	DEC 18	7.16	V
14	12.53	V	JAN 20, 1994	6.99	V	FEB 27	8.97	VZ	JAN 31, 1996	7.25	V
23	11.34	V	FEB 26	6.86	V	MAR 28	7.48	V	FEB 29	7.33	V
31	10.56	V	APR 12	7.33	V	APR 24	6.66	V	MAR 26	7.48	V
MAY 06	8.56	V	JUN 07	7.74	V	MAY 24	6.20	V	APR 29	7.37	V
20	8.16	V	JUL 25	8.45	V	JUN 26	6.20	V	MAY 30	7.54	V
JUL 20	7.96	V	AUG 22	8.90	V	JUL 24	6.47	V	JUL 02	8.07	V
AUG 27	6.95	V	SEP 27	9.18	V	AUG 28	6.77	V	30	8.53	V
SEP 21	6.84	V	OCT 24	9.14	V	SEP 25	6.95	V	AUG 20	8.87	V

HIGHEST 6.20 MAY 24, 1995 JUN 26, 1995
LOWEST 21.59 JAN 28, 1993

Table 3. Water-level data for selected wells in the vicinity of the Marine Corps Logistics Base, Nebo and Yermo Annexes, near Barstow, California, January 1992-September 1996—*Continued*

Local Number 009N001W04R003S BARSTOW2-140
Site id 345339116584502
Top of perforations 120
Bottom of perforations 140
Altitude 2045

WATER LEVEL, IN FEET BELOW LAND-SURFACE DATUM

DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS
JAN 28, 1993	19.60	V	DEC 21, 1993	8.06	V	JAN 23, 1995	10.58	V	DEC 18, 1995	8.90	V
FEB 12	13.84	V	JAN 20, 1994	8.11	V	FEB 27	10.08	VZ	JAN 31, 1996	9.03	V
MAR 04	10.83	R	FEB 26	8.17	V	MAR 28	7.89	V	FEB 29	8.96	V
14	8.21	V	APR 12	8.62	V	APR 24	7.12	V	MAR 26	10.10	V
23	7.91	V	JUN 07	9.90	V	MAY 24	7.11	V	APR 29	9.62	V
31	7.86	V	JUL 25	10.10	V	JUN 26	8.49	V	MAY 30	9.47	V
MAY 20	7.16	V	AUG 22	10.63	V	JUL 24	7.95	V	JUL 02	10.60	V
AUG 27	8.09	V	SEP 27	11.02	V	AUG 28	8.37	V	30	12.18	V
SEP 21	7.68	V	OCT 24	11.78	V	SEP 25	8.73	V	AUG 20	11.54	V
OCT 19	8.02	V	NOV 28	10.93	V	OCT 30	8.66	V			
NOV 17	8.05	V	DEC 19	11.01	V	NOV 27	8.91	V			

HIGHEST 7.11 MAY 24, 1995
LOWEST 19.60 JAN 28, 1993

Local Number 009N001W04R004S BARSTOW2-40
Site id 345339116584503
Top of perforations 20
Bottom of perforations 40
Altitude 2045

WATER LEVEL, IN FEET BELOW LAND-SURFACE DATUM

DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS
JAN 28, 1993	19.14	V	DEC 21, 1993	8.27	V	FEB 27, 1995	10.30	VZ	JAN 31, 1996	9.18	V
FEB 12	15.55	V	FEB 26, 1994	8.25	V	MAR 28	8.61	V	FEB 29	9.14	V
MAR 04	14.42	R	APR 12	8.80	V	APR 24	7.49	VV	MAR 26	9.98	V
14	9.27	V	JUN 07	9.60	V	MAY 24	7.33	V	APR 29	9.67	V
23	8.63	V	JUL 25	10.19	V	JUN 26	8.34	V	MAY 30	9.56	V
31	8.25	V	AUG 22	10.83	V	JUL 24	8.14	V	JUL 02	10.39	V
MAY 20	7.29	V	SEP 27	11.22	V	AUG 28	8.59	V	30	11.55	V
AUG 27	7.80	V	OCT 24	11.66	V	SEP 25	8.93	V	AUG 20	11.26	V
SEP 21	7.84	V	NOV 28	11.12	V	OCT 30	8.88	V			
OCT 19	8.25	V	DEC 19	11.13	V	NOV 27	9.05	V			
NOV 17	8.23	V	JAN 23, 1995	10.77	V	DEC 18	9.09	V			

HIGHEST 7.29 MAY 20, 1993
LOWEST 19.14 JAN 28, 1993

Local Number 009N001W09D005S BARSTOW3-500
Site id 345328116594301
Top of perforations 480
Bottom of perforations 500
Altitude 2094

WATER LEVEL, IN FEET BELOW LAND-SURFACE DATUM

DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS
JAN 28, 1993	33.26	V	OCT 19, 1993	22.98	V	NOV 28, 1994	21.61	V	OCT 30, 1995	18.85	V
FEB 11	22.49	V	NOV 18	22.48	V	DEC 19	21.57	V	NOV 27	18.84	V
MAR 04	20.84	R	DEC 21	22.22	V	JAN 23, 1995	21.28	V	DEC 18	18.78	V
21	22.65	V	JAN 20, 1994	22.07	V	FEB 27	21.31	VZ	JAN 31, 1996	18.62	V
23	20.84	V	FEB 26	21.45	V	MAR 28	20.75	V	FEB 29	18.67	V
31	22.00	V	MAR 13	21.81	V	APR 24	20.43	V	MAR 26	19.83	V
MAY 18	24.83	V	JUN 07	21.62	V	MAY 24	19.83	V	APR 29	20.00	V
20	25.00	V	JUL 25	21.54	V	JUN 26	19.19	V	MAY 30	19.96	V
JUL 20	22.44	V	AUG 22	21.25	V	JUL 24	19.31	V	JUL 02	19.96	V
AUG 22	22.32	V	SEP 27	21.23	V	AUG 28	19.22	V	30	20.08	V
SEP 20	22.35	V	OCT 24	21.13	V	SEP 25	19.00	V	AUG 20	20.02	V

HIGHEST 18.62 JAN 31, 1996
LOWEST 33.26 JAN 28, 1993

Table 3. Water-level data for selected wells in the vicinity of the Marine Corps Logistics Base, Nebo and Yermo Annexes, near Barstow, California, January 1992-September 1996—*Continued*

Local Number 009N001W09D006S BARSTOW3-300
Site id 345328116594302
Top of perforations 280
Bottom of perforations 300
Altitude 2094

WATER LEVEL, IN FEET BELOW LAND-SURFACE DATUM

DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS
FEB 11, 1993	31.54	V	NOV 18, 1993	27.76	V	JAN 23, 1995	28.25	V	DEC 18, 1995	27.26	V
MAR 04	32.23	R	DEC 21	27.73	V	FEB 27	28.14	VZ	JAN 31, 1996	27.28	V
21	28.99	V	JAN 20, 1994	27.65	V	MAR 28	27.39	V	FEB 29	27.41	V
23	28.89	V	FEB 26	27.37	V	APR 24	26.78	V	MAR 26	27.33	V
31	28.49	VV	JUN 07	27.89	V	MAY 24	26.70	V	APR 29	27.45	V
MAY 18	27.74	V	JUL 25	28.06	V	JUN 26	26.85	V	MAY 30	27.46	V
20	27.82	V	AUG 22	28.17	V	JUL 24	26.96	V	JUL 02	27.43	V
JUL 20	27.54	V	SEP 27	28.23	V	AUG 28	27.03	V	30	27.84	V
AUG 27	27.54	V	OCT 24	28.31	V	SEP 25	27.08	V	AUG 20	48.75	V
SEP 20	27.49	V	NOV 28	28.35	V	OCT 30	27.11	V			
OCT 19	27.83	V	DEC 19	28.41	V	NOV 27	27.24	V			

HIGHEST 26.70 MAY 24, 1995
LOWEST 48.75 AUG 20, 1996

Local Number 009N001W09D007S BARSTOW3-190
Site id 345328116594303
Top of perforations 170
Bottom of perforations 190
Altitude 2094

WATER LEVEL, IN FEET BELOW LAND-SURFACE DATUM

DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS
JAN 28, 1993	45.97	V	OCT 19, 1993	37.30	V	DEC 19, 1994	38.34	V	NOV 27, 1995	36.81	V
FEB 11	47.72	V	NOV 18	37.24	V	JAN 23, 1995	38.14	V	DEC 18	36.96	V
MAR 04	43.73	R	DEC 21	37.53	V	FEB 27	37.88	VZ	JAN 31, 1996	37.13	V
21	38.49	V	JAN 20, 1994	36.70	V	MAR 28	35.82	V	FEB 29	37.30	V
23	38.31	V	FEB 26	36.48	V	APR 24	35.39	V	MAR 26	37.53	V
31	37.75	V	JUN 07	37.49	V	MAY 24	35.70	V	APR 29	37.83	V
MAY 18	37.34	V	JUL 25	37.88	V	JUN 26	36.00	V	MAY 30	37.95	V
20	37.33	V	AUG 22	37.92	V	JUL 24	36.32	V	JUL 02	38.11	V
JUL 20	37.70	V	SEP 27	37.91	V	AUG 28	36.40	V	30	38.39	V
AUG 27	37.61	V	OCT 24	37.89	V	SEP 25	36.49	V	AUG 20	27.75	V
SEP 20	37.48	V	NOV 28	38.15	V	OCT 30	36.60	V			

HIGHEST 27.75 AUG 20, 1996
LOWEST 47.72 FEB 11, 1993

Local Number 009N001W09D008S BARSTOW3-80
Site id 345328116594304
Top of perforations 60
Bottom of perforations 80
Altitude 2094

WATER LEVEL, IN FEET BELOW LAND-SURFACE DATUM

DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS
JAN 28, 1993	58.85	V	OCT 19, 1993	45.05	V	JAN 23, 1995	48.63	V	DEC 18, 1995	46.93	V
FEB 11	54.17	V	NOV 18	45.43	V	FEB 27	47.55	VZ	JAN 31, 1996	47.05	V
MAR 04	46.67	R	DEC 21	45.29	V	MAR 28	42.55	V	FEB 29	46.02	V
18	41.92	V	JAN 20, 1994	45.89	V	APR 24	42.56	V	MAR 26	47.16	V
21	41.00	V	FEB 26	46.09	V	MAY 24	43.60	V	APR 29	47.26	V
23	40.58	V	JUL 25	47.19	V	JUN 26	46.46	V	MAY 30	47.43	V
31	40.36	V	AUG 22	48.04	V	JUL 24	45.01	V	JUL 02	47.92	V
MAY 20	42.01	V	SEP 27	48.39	V	AUG 28	45.59	V	30	48.47	V
JUL 20	43.36	V	OCT 24	48.64	V	SEP 25	45.99	V	AUG 20	38.43	V
AUG 27	43.98	V	NOV 28	49.11	V	OCT 30	46.42	V			
SEP 20	44.25	V	DEC 19	49.29	V	NOV 27	46.74	V			

HIGHEST 38.43 AUG 20, 1996
LOWEST 58.85 JAN 28, 1993

Local Number 009N001W10E004S
Site id 345304116584201
Top of perforations 99.60
Bottom of perforations 101.60
Altitude 2060.
In Barstow at sewage treatment facility. Drilled observation well in channel deposits. Diameter 2 inches, depth 101.6 feet, well point 99.6-101.6 feet. Altitude of land-surface datum 2,060 feet. Water-level records available 1979-87, 1993 to current year.

WATER LEVEL, IN FEET BELOW LAND-SURFACE DATUM

DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS
DEC 07, 1993	19.01	S	MAY 24, 1994	20.46	S	MAR 14, 1995	17.54	S	OCT 17, 1995	19.88	V
MAR 21, 1994	19.68	S	NOV 14	21.48	S	MAY 16	17.98	S	MAY 14, 1996	20.77	S

HIGHEST 17.54 MAR 14, 1995
LOWEST 21.48 NOV 14, 1994

Local Number 009N001W10G006S
Site id 345314116580401
Top of perforations
Bottom of perforations
Altitude 2058
About 1.5 miles southeast of Interstate 15 in the Mojave River. Drilled domestic well. Diameter 8 inches, depth 107 feet, perforated 75-105 feet. Altitude of land-surface datum 2,058 feet. Water-level records available 1987 to current year. Previously published in WDR-CA-89-5 as well 009N001W10G05S.

WATER LEVEL, IN FEET BELOW LAND-SURFACE DATUM

DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS
MAY 29, 1992	17.82	S	NOV 15, 1993	7.29	S	NOV 14, 1994	9.21	S	OCT 18, 1995	8.25	VR
NOV 24	19.06	S	MAR 22, 1994	6.60	S	MAR 14, 1995	7.75	S	MAY 14, 1996	7.89	S
MAR 22, 1993	5.68	S	MAY 24	7.56	S	MAY 12	6.22	S			

HIGHEST 5.68 MAR 22, 1993
LOWEST 19.06 NOV 24, 1992

Local Number 009N001W10J012S MC1-610
Site id 345251116574201
Top of perforations 590
Bottom of perforations 610
Altitude 2033.59

WATER LEVEL, IN FEET BELOW LAND-SURFACE DATUM

DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS
APR 29, 1992	21.28	V	MAR 03, 1993	14.81	V	APR 12, 1994	13.90	V	JUN 26, 1995	13.96	V
JUN 23	22.49	V	23	14.46	V	JUN 07	14.62	V	JUL 24	14.32	V
30	21.32	S	APR 29	13.92	V	JUL 25	15.09	V	AUG 28	14.60	V
JUL 01	21.43	S	MAY 02	13.94	V	AUG 23	15.29	V	SEP 25	14.71	V
AUG 10	20.65	V	19	14.69	V	SEP 26	15.56	V	OCT 30	14.68	V
11	20.85	S	JUL 21	15.14	V	OCT 24	15.56	V	NOV 27	14.38	V
SEP 08	20.98	V	AUG 28	14.99	V	NOV 28	15.41	V	DEC 18	14.20	V
OCT 06	21.37	V	SEP 21	15.28	V	DEC 19	15.32	V	JAN 31, 1996	13.84	V
NOV 16	20.92	V	OCT 19	14.89	V	JAN 23, 1995	14.57	V	FEB 29	13.81	V
DEC 23	21.48	V	NOV 17	14.70	V	FEB 27	14.09	VZ	MAR 26	13.71	V
JAN 13, 1993	21.16	V	DEC 21	14.70	V	MAR 28	13.28	V	APR 29	15.21	V
FEB 02	17.37	S	JAN 20, 1994	14.46	V	APR 24	13.52	V			
11	15.96	V	MAR 13	13.89	V	MAY 24	13.69	V			

HIGHEST 13.28 MAR 28, 1995
LOWEST 22.49 JUN 23, 1992

Table 3. Water-level data for selected wells in the vicinity of the Marine Corps Logistics Base, Nebo and Yermo Annexes, near Barstow, California, January 1992-September 1996—*Continued*

Local Number 009N001W10J013S MC1-370
Site id 345251116574202
Top of perforations 350
Bottom of perforations 370
Altitude 2033.59

WATER LEVEL, IN FEET BELOW LAND-SURFACE DATUM

DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS
APR 29, 1992	20.09	S	FEB 11, 1993	18.63	V	MAR 13, 1994	14.90	V	MAY 24, 1995	14.72	V
JUN 23	20.40	V	MAR 03	17.02	V	APR 12	14.87	V	JUN 26	14.82	V
30	22.27	S	23	16.75	V	JUN 07	15.35	V	JUL 24	15.07	V
JUL 01	22.12	S	APR 29	16.58	V	JUL 25	15.66	V	AUG 28	15.25	V
AUG 10	21.00	V	MAY 02	16.61	V	AUG 23	15.81	V	SEP 25	15.34	V
11	21.03	S	19	17.52	V	SEP 27	16.07	V	OCT 30	15.31	V
16	21.00	V	JUL 21	11.51	V	OCT 24	16.07	V	NOV 27	15.18	V
SEP 08	21.14	V	AUG 28	16.54	V	NOV 28	16.03	V	DEC 18	15.04	V
OCT 06	21.74	V	SEP 21	16.76	V	DEC 19	15.97	V	JAN 31, 1996	14.78	V
NOV 16	21.34	V	OCT 19	16.44	V	JAN 23, 1995	15.38	V	FEB 29	14.76	V
DEC 23	21.55	V	NOV 17	16.20	V	FEB 27	15.09	VZ	MAR 26	14.69	V
JAN 13, 1993	21.28	V	DEC 21	15.98	V	MAR 28	14.54	V	APR 29	14.17	V
FEB 02	20.33	S	JAN 20, 1994	15.42	V	APR 24	14.65	V			

HIGHEST 11.51 JUL 21, 1993
LOWEST 22.27 JUN 30, 1992

Local Number 009N001W10J014S MC1-200
Site id 345251116574203
Top of perforations 180
Bottom of perforations 200
Altitude 2033.59

WATER LEVEL, IN FEET BELOW LAND-SURFACE DATUM

DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS
APR 29, 1992	22.40	S	MAR 08, 1993	11.37	V	JUN 07, 1994	13.13	V	JUL 24, 1995	12.98	V
JUN 23	21.10	V	23	11.06	V	JUL 25	13.93	V	AUG 28	13.39	V
30	21.10	S	APR 29	11.26	V	AUG 22	13.89	V	SEP 25	13.30	V
JUL 01	21.13	S	MAY 19	11.67	V	SEP 26	14.59	V	OCT 30	13.28	V
AUG 10	21.45	V	JUL 21	12.61	V	OCT 24	14.62	V	NOV 27	13.04	V
11	21.44	S	AUG 28	13.28	V	NOV 28	14.30	V	DEC 16	12.79	V
SEP 06	21.80	V	SEP 21	13.27	V	DEC 19	13.76	V	JAN 31, 1996	12.28	V
OCT 06	22.03	V	OCT 19	13.31	V	JAN 23, 1995	13.04	V	FEB 29	12.21	V
NOV 16	22.03	V	NOV 17	12.93	V	FEB 27	12.28	VZ	MAR 26	12.11	V
DEC 23	21.82	V	DEC 21	12.72	V	MAR 28	11.02	V	APR 29	12.77	V
JAN 13, 1993	21.40	V	JAN 20, 1994	12.38	V	APR 24	11.52	V			
FEB 02	15.13	S	MAR 13	11.75	V	MAY 24	11.84	V			
11	13.35	V	APR 12	11.84	V	JUN 26	12.41	V			

HIGHEST 11.02 MAR 28, 1995
LOWEST 22.40 APR 29, 1992

Table 3. Water-level data for selected wells in the vicinity of the Marine Corps Logistics Base, Nebo and Yermo Annexes, near Barstow, California, January 1992-September 1996—*Continued*

Local Number 009N001W10J015S MC1-100
Site id 345251116574204
Top of perforations 80
Bottom of perforations 100
Altitude 2033.59

WATER LEVEL, IN FEET BELOW LAND-SURFACE DATUM

DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS
APR 29, 1992	20.42	V	FEB 02, 1993	14.68	S	JAN 20, 1994	12.05	V	MAY 24, 1995	11.48	V
MAY 08	20.0	S	11	13.10	V	MAR 13	11.29	V	JUN 26	12.06	V
JUN 29	22.18	V	MAR 03	10.95	V	APR 12	11.47	V	JUL 24	12.63	V
30	21.77	S	23	10.67	V	JUL 25	14.58	V	AUG 28	13.03	V
JUL 01	20.82	S	APR 29	10.87	V	AUG 22	14.25	V	SEP 25	13.64	V
AUG 10	21.05	S	MAY 02	10.88	V	SEP 27	14.25	V	OCT 30	13.60	V
11	21.13	S	19	11.27	V	OCT 24	14.27	V	NOV 27	12.69	V
SEP 08	21.52	V	JUL 21	12.73	V	NOV 28	13.98	V	DEC 18	12.42	V
OCT 06	21.74	V	AUG 28	12.91	V	DEC 19	14.12	V	JAN 31, 1996	11.89	V
NOV 16	21.77	V	SEP 21	13.00	V	JAN 23, 1995	12.65	V	FEB 29	11.75	V
20	21.74	S	OCT 19	12.95	V	FEB 27	11.91	VZ	MAR 26	11.60	V
DEC 23	21.52	V	NOV 17	13.50	V	MAR 28	10.61	V	APR 29	12.42	V
JAN 13, 1993	21.10	V	DEC 21	12.38	V	APR 24	11.15	V			

HIGHEST 10.61 MAR 28, 1995
LOWEST 22.18 JUN 29, 1992

Local Number 009N001W11K012S MC4-590
Site id 345254116570401
Top of perforations 570
Bottom of perforations 590
Altitude 2022.28

WATER LEVEL, IN FEET BELOW LAND-SURFACE DATUM

DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS
AUG 10, 1992	12.81	V	AUG 28, 1993	10.25	V	SEP 27, 1994	9.39	V	AUG 28, 1995	8.69	VS
25	12.44	V	SEP 21	10.09	V	OCT 24	9.37	V	SEP 25	8.65	V
OCT 06	11.57	V	OCT 19	10.07	V	NOV 28	9.40	V	OCT 30	8.58	V
NOV 16	11.61	V	NOV 17	9.92	V	DEC 19	9.36	V	NOV 27	8.59	V
DEC 23	11.79	V	DEC 21	9.77	V	JAN 23, 1995	9.06	V	DEC 18	8.48	V
JAN 13, 1993	11.61	V	JAN 20, 1994	9.68	V	FEB 27	8.92	VZ	JAN 31, 1996	8.33	V
FEB 11	10.71	V	MAR 13	9.55	V	MAR 28	8.81	V	FEB 29	8.37	V
MAR 03	10.56	V	APR 12	9.49	V	APR 24	8.79	V	MAR 26	8.29	V
23	9.03	V	JUN 07	9.40	V	MAY 24	8.67	V	APR 29	8.33	V
MAY 19	10.48	V	JUL 25	9.36	V	JUN 26	8.65	V			
JUL 21	11.43	V	AUG 22	9.37	V	JUL 24	8.69	V			

HIGHEST 8.29 MAR 26, 1996
LOWEST 12.81 AUG 10, 1992

Local Number 009N001W11K013S MC4-315
Site id 345254116570402
Top of perforations 295
Bottom of perforations 315
Altitude 2022.28

WATER LEVEL, IN FEET BELOW LAND-SURFACE DATUM

DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS
AUG 10, 1992	14.63	V	AUG 28, 1993	9.61	V	SEP 27, 1994	10.35	V	AUG 28, 1995	9.39	VS
25	15.13	V	SEP 21	9.66	V	OCT 24	10.39	V	SEP 25	9.51	V
OCT 06	15.20	V	OCT 19	9.63	V	NOV 28	10.17	V	OCT 30	9.53	V
NOV 16	15.30	V	NOV 17	9.52	V	DEC 19	10.05	V	NOV 27	9.36	V
DEC 23	15.42	V	DEC 21	9.25	V	JAN 23, 1995	9.60	V	DEC 18	9.42	V
JAN 13, 1993	15.20	V	JAN 20, 1994	8.97	V	FEB 27	9.11	VZ	JAN 31, 1996	8.90	V
FEB 11	12.92	V	MAR 13	8.57	V	MAR 28	8.58	V	FEB 29	8.71	V
MAR 03	11.38	V	APR 12	8.41	V	APR 24	8.39	V	MAR 26	8.58	V
23	10.80	V	JUN 07	8.65	V	MAY 24	8.41	V	APR 29	8.80	V
MAY 19	9.01	V	JUL 25	9.58	V	JUN 26	8.67	V			
JUL 21	9.13	V	AUG 22	10.04	V	JUL 24	9.04	V			

HIGHEST 8.39 APR 24, 1995
LOWEST 15.42 DEC 23, 1992

Table 3. Water-level data for selected wells in the vicinity of the Marine Corps Logistics Base, Nebo and Yermo Annexes, near Barstow, California, January 1992-September 1996—*Continued*

Local Number 009N001W11K014S MC4-180
Site id 345254116570403
Top of perforations 160
Bottom of perforations 180
Altitude 2022.28

WATER LEVEL, IN FEET BELOW LAND-SURFACE DATUM

DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS
JUL 15, 1992	13.81	V	JUL 21, 1993	6.92	V	AUG 22, 1994	8.23	V	JUL 24, 1995	7.14	V
AUG 10	14.02	V	AUG 28	7.35	V	SEP 27	8.50	V	AUG 28	7.61	VS
25	14.24	V	SEP 21	7.45	V	OCT 24	8.51	V	SEP 25	7.75	V
OCT 06	14.43	V	OCT 19	7.41	V	NOV 28	8.20	V	OCT 30	7.63	V
NOV 16	14.56	V	NOV 17	7.15	V	DEC 19	8.07	V	NOV 27	7.31	V
DEC 22	14.48	V	DEC 21	6.80	V	JAN 23, 1995	7.31	V	DEC 18	7.16	V
JAN 13, 1993	14.04	V	JAN 20, 1994	6.57	V	FEB 27	6.39	VZ	JAN 31, 1996	6.70	V
FEB 11	7.08	V	MAR 13	6.18	V	MAR 28	5.43	V	FEB 29	6.57	V
MAR 03	5.57	V	APR 12	6.16	V	APR 24	5.82	V	MAR 26	6.49	V
23	5.41	V	JUN 07	7.12	V	MAY 24	6.18	V	APR 29	6.88	V
MAY 19	5.95	V	JUL 25	7.90	V	JUN 26	6.67	V			

HIGHEST 5.41 MAR 23, 1993
LOWEST 14.56 NOV 16, 1992

Local Number 009N001W11K015S MC4-90
Site id 345254116570404
Top of perforations 70
Bottom of perforations 90
Altitude 2022.28

WATER LEVEL, IN FEET BELOW LAND-SURFACE DATUM

DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS
JUL 15, 1992	13.85	V	JUL 21, 1993	6.96	V	AUG 22, 1994	8.29	V	JUL 24, 1995	7.2	V
AUG 10	14.03	V	AUG 28	7.40	V	SEP 27	8.57	V	AUG 28	7.66	VS
25	14.26	V	SEP 21	7.50	V	OCT 24	8.57	V	SEP 25	8.81	V
OCT 06	14.45	V	OCT 19	7.52	V	NOV 28	8.25	V	OCT 30	7.68	V
NOV 16	14.57	V	NOV 17	7.18	V	DEC 19	8.12	V	NOV 27	7.37	V
DEC 23	14.50	V	DEC 21	6.72	V	JAN 23, 1995	7.36	V	DEC 18	7.23	V
JAN 13, 1993	14.06	V	JAN 20, 1994	6.65	V	FEB 27	6.44	VZ	JAN 31, 1996	6.77	V
FEB 11	7.24	V	MAR 13	6.24	V	MAR 28	5.49	V	FEB 29	6.62	V
MAR 03	5.63	V	APR 12	6.21	V	APR 24	5.87	V	MAR 26	6.55	V
23	5.46	V	JUN 07	7.15	V	MAY 24	6.23	V	APR 29	6.92	V
MAY 19	6.00	V	JUL 25	7.96	V	JUN 26	6.72	V			

HIGHEST 5.46 MAR 23, 1993
LOWEST 14.57 NOV 16, 1992

Local Number 009N001W11K016S
Site id 345256116565901
Top of perforations 7
Bottom of perforations 27
Altitude 2019.68

WATER LEVEL, IN FEET BELOW LAND-SURFACE DATUM

DATE	WATER LEVEL	MS
MAY 18, 1993	3.9	V

Local Number 009N001W11M011S
Site id 345254116572404
Top of perforations
Bottom of perforations
Altitude 2015
In Barstow on U.S. Marine Corps Base, west of golf course. Drilled domestic well. Diameter 4 inches, depth 75 feet, perforated 35-75 feet. Altitude of land-surface datum 2,015 feet. Water-level records available 1985 to current year.

WATER LEVEL, IN FEET BELOW LAND-SURFACE DATUM

DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS
MAR 11, 1992	11.14	S	NOV 24, 1992	12.40	S	NOV 15, 1993	4.29	S	MAY 24, 1994	3.87	S
MAY 27	11.16	S	MAR 22, 1993	2.23	S	MAR 21, 1994	3.15	S	NOV 14	5.58	S
MAR 14, 1995	1.04	S	MAY 18, 1995	3.16	V	OCT 17, 1995	4.91	V	MAY 14, 1996	4.27	S

HIGHEST 1.04 MAR 14, 1995
LOWEST 12.40 NOV 24, 1992

Local Number 009N001W11N008S
Site id 345236116572601
Top of perforations 50
Bottom of perforations 70
Altitude 2065.69

WATER LEVEL, IN FEET BELOW LAND-SURFACE DATUM

DATE	WATER LEVEL	MS
MAR 25, 1993	47.76	V

Local Number 009N001W11Q003S
Site id 345243116570001
Top of perforations 21
Bottom of perforations 41
Altitude 2034

WATER LEVEL, IN FEET BELOW LAND-SURFACE DATUM

DATE	WATER LEVEL	MS
MAR 24, 1993	20.91	V

Local Number 009N001W11Q004S
Site id 345240116570001
Top of perforations 30
Bottom of perforations 50
Altitude 2042.94

WATER LEVEL, IN FEET BELOW LAND-SURFACE DATUM

DATE	WATER LEVEL	MS
MAR 25, 1993	27.48	V

Table 3. Water-level data for selected wells in the vicinity of the Marine Corps Logistics Base, Nebo and Yermo Annexes, near Barstow, California, January 1992-September 1996—*Continued*

Local Number 009N001W11R002S
Site id 345243116563802
Top of perforations 100
Bottom of perforations 102
Altitude 2033
In Barstow on U.S. Marine Corps Base near golf course. Drilled observation water-table well. Diameter 2 inches, depth 102 feet, 97.90 feet in 1992, well point 100-102 feet. Altitude of land-surface datum 2,032.51 feet. Water-level records available 1972-73, 1975 to current year.

WATER LEVEL, IN FEET BELOW LAND-SURFACE DATUM

DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS
MAR 11, 1992	25.49	S	NOV 15, 1993	20.58	S	MAR 14, 1995	21.49	S	MAY 14, 1996	22.58	S
MAY 28	25.37	S	MAR 21, 1994	20.49	S	MAY 17	21.14	S			
NOV 24	26.40	S	MAY 23	20.43	S	18	91.92	VR			
MAR 22, 1993	21.32	S	NOV 14	21.68	S	OCT 17	23.55	V			

HIGHEST 20.43 MAY 23, 1994
LOWEST 26.40 NOV 24, 1992

Local Number 009N001W12L002S MC2-450
Site id 345251116560601
Top of perforations 430
Bottom of perforations 450
Altitude 2002

WATER LEVEL, IN FEET BELOW LAND-SURFACE DATUM

DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS
AUG 10, 1992	49.01	V	AUG 28, 1993	13.40	V	AUG 22, 1994	11.15	V	JUN 26, 1995	9.59	V
OCT 06	23.16	V	SEP 21	13.10	V	SEP 27	11.26	V	JUL 24	9.62	V
NOV 16	21.40	V	OCT 19	12.96	V	OCT 24	11.32	VS	AUG 28	9.68	V
DEC 23	21.10	V	NOV 17	12.68	V	NOV 28	11.43	V	DEC 18	9.95	V
JAN 13, 1993	63.43	V	DEC 21	12.55	V	DEC 19	11.44	V	JAN 31, 1996	9.91	V
FEB 02	32.50	S	JAN 20, 1994	12.06	V	JAN 23, 1995	11.23	V	FEB 29	9.90	V
MAR 26	18.50	V	MAR 13	11.60	V	FEB 27	10.90	VZ	MAR 26	9.89	V
MAY 19	15.43	V	APR 12	11.37	V	MAR 28	10.23	V	APR 29	10.00	VV
JUN 15	14.63	V	JUN 07	11.13	V	APR 24	9.90	V			
JUL 27	13.81	V	JUL 25	11.11	V	MAY 24	9.68	V			

HIGHEST 9.59 JUN 26, 1995
LOWEST 63.43 JAN 13, 1993

Local Number 009N001W12L003S MC2-320
Site id 345251116560602
Top of perforations 300
Bottom of perforations 320
Altitude 2002

WATER LEVEL, IN FEET BELOW LAND-SURFACE DATUM

DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS
JUN 30, 1992	23.76	S	JUL 27, 1993	7.67	V	AUG 22, 1994	9.04	V	JUL 24, 1995	7.31	V
JUL 14	22.34	S	AUG 28	7.75	V	SEP 27	9.59	V	AUG 28	7.84	V
AUG 10	22.49	V	SEP 21	9.11	V	OCT 24	9.93	VS	SEP 25	8.26	V
OCT 06	23.37	V	OCT 19	7.77	V	NOV 28	10.26	V	OCT 30	8.70	V
NOV 16	23.79	V	NOV 17	7.90	V	DEC 19	10.36	V	NOV 27	8.92	V
DEC 23	24.22	V	DEC 21	7.99	V	JAN 23, 1995	9.99	V	DEC 18	8.98	V
JAN 13, 1993	24.01	V	JAN 20, 1994	7.68	V	FEB 27	8.91	VZ	JAN 31, 1996	9.06	V
FEB 02	16.55	S	MAR 13	7.62	V	MAR 28	7.14	V	FEB 29	9.20	V
MAR 26	9.55	V	APR 12	7.67	V	APR 24	6.80	V	MAR 26	9.25	V
MAY 19	7.98	V	JUN 07	7.97	V	MAY 24	6.72	V	APR 29	9.52	V
JUN 15	7.68	V	JUL 25	8.59	V	JUN 26	6.93	V			

HIGHEST 6.72 MAY 24, 1995
LOWEST 24.22 DEC 23, 1992

Table 3. Water-level data for selected wells in the vicinity of the Marine Corps Logistics Base, Nebo and Yermo Annexes, near Barstow, California, January 1992-September 1996—*Continued*

Local Number 009N001W12L004S MC2-185
Site id 345251116560603
Top of perforations 165
Bottom of perforations 185
Altitude 2002

WATER LEVEL, IN FEET BELOW LAND-SURFACE DATUM

DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS
JUN 23, 1992	23.17	V	JUN 15, 1993	5.15	V	JUL 25, 1994	8.58	V	JUN 26, 1995	6.34	V
30	24.12	S	JUL 27	5.78	V	AUG 22	9.16	V	JUL 24	6.99	V
JUL 14	23.27	S	AUG 28	6.28	V	SEP 27	9.84	V	AUG 28	7.89	V
AUG 10	23.62	V	SEP 21	9.24	V	OCT 24	10.18	VS	SEP 25	8.49	V
OCT 06	24.52	V	OCT 19	6.72	V	NOV 28	10.45	V	OCT 30	8.95	V
NOV 16	24.98	V	NOV 17	6.75	V	DEC 19	10.52	V	NOV 27	9.09	V
DEC 23	25.29	V	DEC 21	6.89	V	JAN 23, 1995	9.71	V	DEC 18	9.08	V
JAN 13, 1993	25.01	V	JAN 20, 1994	6.73	V	FEB 27	7.75	VZ	JAN 31, 1996	9.10	V
FEB 02	10.35	S	MAR 13	6.78	V	MAR 28	5.12	V	FEB 29	9.22	V
MAR 26	4.57	V	APR 12	6.96	V	APR 24	5.33	V	MAR 26	9.25	V
MAY 19	4.85	V	JUN 07	7.57	V	MAY 24	5.73	V	APR 29	9.50	V

HIGHEST 4.57 MAR 26, 1993
LOWEST 25.29 DEC 23, 1992

Local Number 009N001W12L005S MC2-80
Site id 345251116560604
Top of perforations 60
Bottom of perforations 80
Altitude 2002

WATER LEVEL, IN FEET BELOW LAND-SURFACE DATUM

DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS
JUN 25, 1992	22.58	V	JUN 15, 1993	4.57	V	JUL 25, 1994	7.74	V	JUN 26, 1995	5.58	V
30	22.42	S	JUL 27	5.21	V	AUG 22	8.31	V	JUL 24	6.22	V
JUL 19	22.54	S	AUG 28	5.67	V	SEP 27	9.00	V	AUG 28	7.09	V
AUG 10	22.88	V	SEP 21	5.90	V	OCT 24	9.33	VS	SEP 25	7.70	V
OCT 06	22.88	V	OCT 19	6.04	V	NOV 28	9.60	V	OCT 30	8.15	V
NOV 16	24.27	V	NOV 17	6.08	V	DEC 19	9.67	V	NOV 27	8.28	V
DEC 23	24.58	V	DEC 21	6.01	V	JAN 23, 1995	8.87	V	DEC 18	8.27	V
JAN 13, 1993	24.30	V	JAN 20, 1994	6.01	V	FEB 27	6.98	VZ	JAN 31, 1996	8.29	V
FEB 02	8.31	S	MAR 13	6.04	V	MAR 28	4.32	V	FEB 29	8.37	V
MAR 26	3.82	V	APR 12	6.19	V	APR 24	4.60	V	MAR 26	8.39	V
MAY 19	4.27	V	JUN 07	6.74	V	MAY 24	5.01	V	APR 29	8.66	V

HIGHEST 3.82 MAR 26, 1993
LOWEST 24.58 DEC 23, 1992

Local Number 009N001W12N004S MC3-640
Site id 345242116562101
Top of perforations 620
Bottom of perforations 640
Altitude 2010.24

WATER LEVEL, IN FEET BELOW LAND-SURFACE DATUM

DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS
JUL 16, 1992	31.43	S	MAY 19, 1993	15.49	V	JUL 25, 1994	16.56	V	JUN 26, 1995	14.70	V
29	38.81	V	JUL 21	15.18	V	AUG 22	16.97	V	JUL 24	15.1	V
AUG 10	30.69	V	AUG 28	15.41	V	SEP 27	17.53	V	AUG 28	15.69	V
27	30.85	V	SEP 21	15.44	V	OCT 24	17.89	V	SEP 25	16.12	V
OCT 06	31.54	V	OCT 19	15.67	V	NOV 28	18.27	V	OCT 30	16.59	V
NOV 16	31.61	V	NOV 17	15.69	V	DEC 19	18.36	V	NOV 27	16.86	V
DEC 23	32.01	V	DEC 21	15.73	V	JAN 23, 1995	18.14	V	DEC 18	16.96	V
JAN 13, 1993	31.88	V	JAN 20, 1994	15.61	V	FEB 27	17.46	VZ	JAN 31, 1996	16.96	V
FEB 11	25.73	V	MAR 13	15.62	V	MAR 28	15.68	V	FEB 29	17.17	V
MAR 03	21.13	V	APR 12	15.65	V	APR 24	14.73	V	MAR 26	17.19	V
23	18.17	V	JUN 07	15.94	V	MAY 24	14.47	V	APR 29	17.48	V

HIGHEST 14.47 MAY 24, 1995
LOWEST 38.81 JUL 29, 1992

Table 3. Water-level data for selected wells in the vicinity of the Marine Corps Logistics Base, Nebo and Yermo Annexes, near Barstow, California, January 1992-September 1996—*Continued*

Local Number 009N001W12N005S MC3-310
Site id 345242116562102
Top of perforations 290
Bottom of perforations 310
Altitude 2010.24

WATER LEVEL, IN FEET BELOW LAND-SURFACE DATUM

DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS
JUL 16, 1992	34.48	S	MAY 19, 1993	7.68	V	JUL 25, 1994	10.66	V	JUN 26, 1995	8.73	V
29	34.20	V	JUL 21	8.47	V	AUG 22	11.25	V	JUL 24	9.33	V
AUG 10	25.96	V	AUG 28	8.97	V	SEP 27	12.51	V	AUG 28	10.14	V
27	35.03	V	SEP 21	9.12	V	OCT 24	12.11	V	SEP 25	10.67	V
OCT 06	26.26	V	OCT 19	9.29	V	NOV 28	12.23	V	OCT 30	10.99	V
NOV 16	26.58	V	NOV 17	9.28	V	DEC 19	12.26	V	NOV 27	11.01	V
DEC 23	26.85	V	DEC 21	9.17	V	JAN 23, 1995	11.35	V	DEC 18	10.95	V
JAN 13, 1993	26.48	V	JAN 20, 1994	8.98	V	FEB 27	9.72	VZ	JAN 31, 1996	10.82	V
FEB 11	10.50	V	MAR 13	8.90	V	MAR 28	7.71	V	FEB 29	10.84	V
MAR 03	7.64	V	APR 12	9.00	V	APR 24	7.84	V	MAR 26	10.83	V
23	7.06	V	JUN 07	9.62	V	MAY 24	8.18	V	APR 29	11.15	V

HIGHEST 7.06 MAR 23, 1993
LOWEST 35.03 AUG 27, 1992

Local Number 009N001W12N006S MC3-170
Site id 345242116562103
Top of perforations 150
Bottom of perforations 170
Altitude 2010.24

WATER LEVEL, IN FEET BELOW LAND-SURFACE DATUM

DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS
JUL 16, 1992	25.36	VR	MAY 19, 1993	7.77	V	JUL 25, 1994	11.06	V	JUN 26, 1995	9.04	V
29	25.58	V	JUL 21	8.71	V	AUG 22	11.62	V	JUL 24	9.67	V
AUG 10	25.67	V	AUG 28	9.21	V	SEP 27	12.31	V	AUG 28	10.52	V
27	26.06	V	SEP 21	9.42	V	OCT 24	12.52	V	SEP 25	11.07	V
OCT 06	26.77	V	OCT 19	9.56	V	NOV 28	12.66	V	OCT 30	11.41	V
NOV 16	27.04	V	NOV 17	9.58	V	DEC 19	12.65	V	NOV 27	11.43	V
DEC 23	27.31	V	DEC 21	9.38	V	JAN 23, 1995	11.70	V	DEC 18	11.35	V
JAN 13, 1993	26.90	V	JAN 20, 1994	9.20	V	FEB 27	9.99	VZ	JAN 31, 1996	11.22	V
FEB 11	9.76	V	MAR 13	9.21	V	MAR 28	7.90	V	FEB 29	11.21	V
MAR 03	7.42	V	APR 12	9.33	V	APR 24	7.86	V	MAR 26	11.21	V
23	7.47	V	JUN 07	9.97	V	MAY 24	8.47	V	APR 29	11.52	V

HIGHEST 7.42 MAR 03, 1993
LOWEST 27.31 DEC 23, 1992

Local Number 009N001W12N007S MC3-80
Site id 345242116562104
Top of perforations 60
Bottom of perforations 80
Altitude 2010.24

WATER LEVEL, IN FEET BELOW LAND-SURFACE DATUM

DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS
JUL 16, 1992	25.08	V	MAY 19, 1993	7.64	V	JUL 25, 1994	10.74	V	JUN 26, 1995	8.79	V
29	25.20	V	JUL 21	8.53	V	AUG 22	11.31	V	JUL 24	9.39	V
AUG 10	25.32	V	AUG 28	9.00	V	SEP 27	11.92	V	AUG 28	10.22	V
27	25.73	V	SEP 21	9.21	V	OCT 24	12.14	V	SEP 25	10.76	V
OCT 06	26.47	V	OCT 19	9.34	V	NOV 28	12.27	V	OCT 30	11.08	V
NOV 16	26.74	V	NOV 17	9.22	V	DEC 19	12.27	V	NOV 27	11.07	V
DEC 23	26.99	V	DEC 21	9.28	V	JAN 23, 1995	11.22	V	DEC 18	10.98	V
JAN 13, 1993	26.56	V	JAN 20, 1994	9.02	V	FEB 27	9.60	VZ	JAN 31, 1996	10.85	V
FEB 11	8.81	V	MAR 13	8.96	V	MAR 28	7.62	V	FEB 29	10.85	V
MAR 03	7.02	V	APR 12	9.08	V	APR 24	8.09	V	MAR 26	10.82	V
23	7.27	V	JUN 07	9.70	V	MAY 24	8.26	V	APR 29	11.13	V

HIGHEST 7.02 MAR 03, 1993
LOWEST 26.99 DEC 23, 1992

Table 3. Water-level data for selected wells in the vicinity of the Marine Corps Logistics Base, Nebo and Yermo Annexes, near Barstow, California, January 1992-September 1996—*Continued*

Local Number 009N001W12N008S
Site id 345238116562801
Top of perforations 62
Bottom of perforations 82
Altitude 2015.94

WATER LEVEL, IN FEET BELOW LAND-SURFACE DATUM

DATE	WATER LEVEL	MS
MAR 24, 1993	12.9	V

Local Number 009N001W13B002S
Site id 345228116560001
Top of perforations 30
Bottom of perforations 110
Altitude 2000
About 4 miles southeast of Barstow and 0.7 mile north of Interstate 40. Drilled domestic well. Diameter 8 inches, depth 110 feet, perforated 30-110 feet. Altitude of land-surface datum 2,000 feet. Water-level records available 1987 to current year.

WATER LEVEL, IN FEET BELOW LAND-SURFACE DATUM

DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS
MAR 10, 1992	25.94	S	NOV 24, 1992	28.78	S	MAR 22, 1994	10.45	S	NOV 14, 1994	14.02	S
MAY 27	26.50	S	MAY 17, 1993	8.07	S	MAY 17	10.97	SZ	MAR 14, 1995	9.76	S
MAY 11, 1995	9.07	S	OCT 18, 1995	12.38	V	MAY 15, 1996	13.58	S			

HIGHEST 8.07 MAY 17, 1993
LOWEST 28.78 NOV 24, 1992

Local Number 009N001W13B003S
Site id 345225116555001
Top of perforations 45
Bottom of perforations 50
Altitude 1995
About 4 miles southeast of Barstow, 0.5 mile northwest of intersection of National Trails Highway and Nebo Street, near bank of Mojave River channel. Drilled observation well in alluvium. Diameter 2 inches, depth 60 feet, perforated 45-50 feet. Altitude of land-surface datum 1,995 feet. Water-level records available 1987 to current year.

WATER LEVEL, IN FEET BELOW LAND-SURFACE DATUM

DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS
MAR 10, 1992	21.05	S	MAR 22, 1993	2.70	S	NOV 14, 1994	9.11	S	OCT 17, 1995	7.35	V
MAY 27	21.64	S	NOV 15	5.05	S	MAR 14, 1995	4.26	S	MAY 15, 1996	8.79	S
NOV 24	23.85	S	MAR 22, 1994	5.57	S	MAY 17	4.08	S			

HIGHEST 2.70 MAR 22, 1993
LOWEST 23.85 NOV 24, 1992

Local Number 009N001W13C001S
Site id 345224116561501
Top of perforations 38.5
Bottom of perforations 58.5
Altitude 2026.35

WATER LEVEL, IN FEET BELOW LAND-SURFACE DATUM

DATE	WATER LEVEL	MS
MAR 24, 1993	27.24	V

Local Number 009N001W13H002S
Site id 345214116554001
Top of perforations 65
Bottom of perforations 108
Altitude 2000
About 4 miles southeast of Barstow and 0.5 mile north of Interstate 40. Drilled domestic well. Diameter 8 inches, depth 160 feet, perforated 65-108 feet. Altitude of land-surface datum 2,000 feet. Water-level records available 1954, 1958, 1960, 1988 to current year.

WATER LEVEL, IN FEET BELOW LAND-SURFACE DATUM

DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS
MAR 10, 1992	28.43	S	MAR 22, 1993	9.07	S	MAY 17, 1994	13.20	SZ	MAY 15, 1996	16.02	S
MAY 27	29.15	S	NOV 15		P	MAY 11, 1995	9.75	S			
NOV 24	31.24	S	MAR 22, 1994	12.63	S	OCT 18	14.43	S			

HIGHEST 9.07 MAR 22, 1993
LOWEST 31.24 NOV 24, 1992

Local Number 009N001W14D001S
Site id 345228116573301
Top of perforations 70
Bottom of perforations 90
Altitude 2093.13

WATER LEVEL, IN FEET BELOW LAND-SURFACE DATUM

DATE	WATER LEVEL	MS
MAR 25, 1993	73.94	V

Local Number 009N001W14E001S
Site id 345213116574101
Top of perforations 103
Bottom of perforations 123
Altitude 2161.64

WATER LEVEL, IN FEET BELOW LAND-SURFACE DATUM

DATE	WATER LEVEL	MS
MAR 25, 1993	115.05	V

Local Number 009N001W15Q001S
Site id 345145116575801
Top of perforations 472
Bottom of perforations 474
Altitude 2250

WATER LEVEL, IN FEET BELOW LAND-SURFACE DATUM

DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS
JAN 14, 1992	207.86	S	AUG 25, 1992	207.88	S	JUN 24, 1993	208.58	S

HIGHEST 207.86 JAN 14, 1992
LOWEST 208.58 JUN 24, 1993

Table 3. Water-level data for selected wells in the vicinity of the Marine Corps Logistics Base, Nebo and Yermo Annexes, near Barstow, California, January 1992-September 1996—*Continued*

Local Number 009N001W15Q002S
Site id 345145116575802
Top of perforations 288
Bottom of perforations 290
Altitude 2250

WATER LEVEL, IN FEET BELOW LAND-SURFACE DATUM

DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS
JAN 14, 1992	210.72	S	AUG 25, 1992	211.57	S	JUN 24, 1993	211.45	S	APR 22, 1996	211.17	V

HIGHEST 210.72 JAN 14, 1992
LOWEST 211.57 AUG 25, 1992

Local Number 009N001W15R001S
Site id 345156116575001
Top of perforations 147
Bottom of perforations 167
Altitude 2222.57

WATER LEVEL, IN FEET BELOW LAND-SURFACE DATUM

DATE	WATER LEVEL	MS
MAR 25, 1993	137.66	V

Local Number 009N001W27D001S
Site id 345045116582701
Top of perforations 546
Bottom of perforations 548
Altitude 2480

WATER LEVEL, IN FEET BELOW LAND-SURFACE DATUM

DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS
JUN 24, 1993	422.75	S	MAY 02, 1996	422.02	V

HIGHEST 422.02 MAY 02, 1996
LOWEST 422.75 JUN 24, 1993

Local Number 010N001E20M001S CALFAN-350
Site id 345631116541401
Top of perforations 340
Bottom of perforations 350
Altitude 2090

WATER LEVEL, IN FEET BELOW LAND-SURFACE DATUM

DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS
JUL 21, 1993	250.82	V	JAN 25, 1994	251.61	V	JAN 23, 1995	253.26	V	SEP 25, 1995	254.32	V
AUG 02	250.99	V	APR 13	251.90	V	FEB 27	253.43	VZ	OCT 30	254.53	V
25	250.97	V	JUN 07	252.37	V	MAR 27	253.45	VZ	NOV 27	254.62	V
26	251.13	V	JUL 25	252.38	V	APR 24	253.64	V	DEC 18	254.78	V
28	251.09	V	AUG 22	252.61	V	MAY 24	253.76	V	JAN 31, 1996	254.88	V
SEP 23	251.37	V	SEP 27	252.72	V	JUN 05	253.89	V	FEB 29	255.03	V
OCT 19	251.30	V	OCT 24	252.88	V	26	253.92	V	MAR 26	255.20	V
NOV 17	251.34	V	NOV 28	253.07	V	JUL 24	254.02	V	APR 29	255.23	V
DEC 21	252.75	V	DEC 19	253.13	V	AUG 28	252.23	V			

HIGHEST 250.82 JUL 21, 1993
LOWEST 255.23 APR 29, 1996

Table 3. Water-level data for selected wells in the vicinity of the Marine Corps Logistics Base, Nebo and Yermo Annexes, near Barstow, California, January 1992-September 1996—*Continued*

Local Number 010N001E20M002S CALFAN-285
Site id 345631116541402
Top of perforations 265
Bottom of perforations 285
Altitude 2090

WATER LEVEL, IN FEET BELOW LAND-SURFACE DATUM

DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS
JUL 21, 1993	250.82	V	OCT 19, 1993	251.20	V	JUN 07, 1994	252.45	V	NOV 28, 1994	253.03	V
AUG 25	250.97	V	NOV 17	251.27	V	JUL 25	252.36	V	DEC 19	253.09	V
26	251.13	V	DEC 21	251.35	V	AUG 22	252.57	V	JAN 23, 1995	253.24	V
28	251.09	V	JAN 25, 1994	251.61	V	SEP 27	252.73	V	FEB 27	253.41	VZ
SEP 23	251.25	V	APR 13	251.88	V	OCT 24	252.85	V	MAR 27	253.44	VZ
APR 24, 1995	253.62	V	JUL 24, 1995	254.03	V	NOV 27, 1995	254.61	V	MAR 26, 1996	255.18	V
MAY 24	253.72	V	AUG 28	254.29	V	DEC 18	254.75	V	APR 29	255.21	S
JUN 05	253.93	V	SEP 25	254.29	V	JAN 31, 1996	254.86	V			
26	253.90	V	OCT 30	254.50	V	FEB 29	255.02	V			

HIGHEST 250.82 JUL 21, 1993
LOWEST 255.21 APR 29, 1996

Local Number 010N001E27C001S
Site id 345615116515801
Top of perforations 200
Bottom of perforations 400
Altitude 2085
About 12.5 miles northeast of Barstow. Drilled industrial well. Diameter 8 inches, depth 600 feet. Altitude of land-surface datum 2,085 feet. Water-level records available 1989 to current year.

WATER LEVEL, IN FEET BELOW LAND-SURFACE DATUM

DATE	WATER LEVEL	MS
JUN 21, 1993	257.7	VR

Local Number 010N001E28G003S
Site id 345600116523901
Top of perforations 127
Bottom of perforations 227
Altitude 1985
About 8 miles northeast of Barstow. Drilled domestic well. Diameter 6 inches, depth 227 feet, perforated 127-227 feet. Altitude of land-surface datum 1,985 feet. Water-level records available 1989 to current year.

WATER LEVEL, IN FEET BELOW LAND-SURFACE DATUM

DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS
MAY 29, 1992	145.68	S	MAY 17, 1994	149.54	SR	MAY 14, 1996	153.51	S			
MAY 18, 1993	147.75	S	MAY 09, 1995	151.44	V						

HIGHEST 145.68 MAY 29, 1992
LOWEST 153.51 MAY 14, 1996

Table 3. Water-level data for selected wells in the vicinity of the Marine Corps Logistics Base, Nebo and Yermo Annexes, near Barstow, California, January 1992-September 1996—*Continued*

Local Number 010N001E28J008S
Site id 345542116522401
Top of perforations
Bottom of perforations
Altitude 1972

WATER LEVEL, IN FEET BELOW LAND-SURFACE DATUM

DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS
APR 22, 1993	138.92	S	APR 24, 1996	131.50	S

HIGHEST	131.50	APR 24, 1996
LOWEST	138.92	APR 22, 1993

Local Number 010N001W33L003S
Site id 345443116591701
Top of perforations
Bottom of perforations
Altitude 2090

WATER LEVEL, IN FEET BELOW LAND-SURFACE DATUM

DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS
MAR 11, 1992	71.54	S	MAR 23, 1993	44.29	S	MAR 24, 1994	42.52	AS	MAR 26, 1996	42.88	V
NOV 17	74.59	S	NOV 17	41.15	S	NOV 15	47.12	S			

HIGHEST	41.15	NOV 17, 1993
LOWEST	74.59	NOV 17, 1992

[1]Water-level measurement provided by Jacobs Engineering Group, Inc.

Table 4. Water-quality data for selected wells in the vicinity of the Marine Corps Logistics Base, Nebo and Yermo Annexes, near Barstow, California, January 1992-October 1995

[State well No.: See Well-Numbering System in text; ft, foot; µS/cm, microsiemen per centimeter at 25 °C; °C, degree Celsius; mg/L, milligram per liter; µg/L, microgram per liter; TU, tritium units; <, actual value is less than value shown; --, no data]

State well No.	Local well name	Date of sampling	Water level below land surface (ft)	Depth of well, total (ft)	Specific conductance (µS/cm)	pH (standard units)	Temperature, water (°C)	Calcium, dissolved (mg/L)	Magnesium, dissolved (mg/L)	Sodium, dissolved (mg/L)
9N/1E-3H5		05-27-92	--	200	588	7.7	22.5	51	6.7	65
		05-25-94	132.16	200	638	7.8	22.5	55	7.3	67
-4J2	YERMO #4	06-02-93	--	350	625	7.7	23.0	45	7.1	76
-4K1	YEMBB-470	07-22-93	--	470	3,830	7.1	--	100	86	640
		08-12-93	--	470	--	--	--	--	--	--
-4K2	YEMBB-340	07-22-93	--	340	631	7.4	24.0	24	3.9	110
-4K3	YEMBB-195	07-22-93	--	195	652	7.2	23.5	31	7.0	100
-4L1	YWP-4	05-18-93	141.81	154	643	--	25.0	--	--	--
-4Q2		05-19-93	146.27	166	656	7.7	24.0	--	--	--
		05-20-93	146.27	166	656	7.7	24.0	--	--	--
-4R2	YS28-1	05-20-93	146.27	162	596	--	22.0	--	--	--
-6H2		05-29-92	129.81	320	2,150	7.9	25.0	52	9.4	380
		05-24-94	147.69	320	2,180	7.9	26.0	47	39	370
-9G1	YWP-2	05-20-93	149.45	170	722	--	24.5	--	--	--
-10J1	YS22-3	05-18-93	125.96	145	957	--	19.5	--	--	--
-10L1	YERMO #3	06-02-93	--	214	479	7.9	25.0	41	6.7	48
-10L2	YS23-3	05-18-93	130.35	160	443	--	20.0	--	--	--
-10Q1	Y5-1	05-20-93	134.61	160	599	--	19.0	--	--	--
-10Q3	YEMRR-350	08-03-93	133.12	350	832	7.2	24.0	63	12	100
-10Q4	YEMRR-200	08-03-93	--	200	516	7.2	21.0	37	7.4	62
		08-12-93	--	200	--	--	--	--	--	--
-10R1	Y10-1	05-20-93	121.25	147	314	7.4	19.0	27	5.2	29
-16F2	YEMRIV-340	08-04-93	104.47	340	1,120	7.4	22.0	110	20	120
-16F3	YEMRIV-250	08-04-93	101.94	250	1,290	7.3	21.0	120	21	150
-16F4	YEMRIV-150	08-03-93	101.16	150	676	7.3	20.5	38	7.8	100
-17H1	DAGGETT #4	06-02-93	--	135	599	7.6	18.5	53	9.7	58
		06-02-93	--	135	599	7.6	18.5	--	--	--
-19J1	19J1	09-02-92	--	323	2,770	8.3	28.0	140	1.5	510
9N/1W-4M5	BARSTOW1-250	03-31-93	22.34	250	613	7.8	20.0	44	6.9	78
-4M6	BARSTOW1-160	03-31-93	23.00	160	1,720	6.7	19.0	180	30	160
-4M7	BARSTOW1-80	03-31-93	19.81	80	333	7.3	11.5	26	5.2	33
-4R2	BARSTOW2-280	05-06-93	8.56	280	3,270	7.7	21.0	100	4.3	590
-4R3	BARSTOW2-140	03-31-93	7.86	140	519	7.7	21.0	33	6.1	72
-4R4	BARSTOW2-40	03-31-93	8.25	40	2,080	7.0	20.0	180	33	250

Table 4. Water-quality data for selected wells in the vicinity of the Marine Corps Logistics Base, Nebo and Yermo Annexes, near Barstow, California, January 1992-October 1995—*Continued*

State well No.	Date of sampling	Potassium, dissolved (mg/L)	Bicarbonate (mg/L)	Alkalinity (mg/L as $CaCO_3$)	Sulfate, dissolved (mg/L)	Chloride, dissolved (mg/L)	Fluoride, dissolved (mg/L)	Bromide, dissolved (mg/L)	Iodide, dissolved (mg/L)	Silica, dissolved (mg/L)
9N/1E-3H5	05-27-92	2.4	246	153	52	64	0.70	--	--	22
	05-25-94	2.3	181	153	61	74	.70	--	--	23
-4J2	06-02-93	2.7	--	154	69	60	.70	0.32	0.003	25
-4K1	07-22-93	11	--	359	960	490	.40	.92	.220	34
	08-12-93	--	--	--	--	160	--	.29	--	--
-4K2	07-22-93	3.0	--	154	75	56	.70	.13	.004	33
-4K3	07-22-93	2.9	--	155	72	--	.60	.52	.004	30
-4L1	05-18-93	--	--	--	--	63	--	.28	--	--
-4Q2	05-19-93	--	--	--	--	70	--	.34	--	--
	05-20-93	--	--	--	--	--	--	--	--	--
-4R2	05-20-93	--	--	--	--	63	--	.48	--	--
-6H2	05-29-92	7.9	219	176	480	270	2.5	--	--	48
	05-24-94	7.4	212	177	520	290	2.5	--	--	29
-9G1	05-20-93	--	--	--	--	66	--	.15	--	--
-10J1	05-18-93	--	--	--	--	110	--	.43	--	--
-10L1	06-02-93	3.0	--	116	62	31	.50	.10	.006	19
-10L2	05-18-93	--	--	--	--	26	--	.090	--	--
-10Q1	05-20-93	--	--	--	--	44	--	.13	--	--
-10Q3	08-03-93	3.4	--	174	130	81	.60	.17	.003	27
-10Q4	08-03-93	2.9	--	124	70	33	.50	.11	.002	25
	08-12-93	--	--	--	--	150	--	.36	--	--
-10R1	05-20-93	2.1	--	89	28	22	.60	.080	.003	25
-16F2	08-04-93	4.1	--	244	180	130	.50	.26	.014	25
-16F3	08-04-93	4.0	--	246	210	170	.50	.34	.013	27
-16F4	08-03-93	3.2	--	157	93	62	.60	.15	.006	25
-17H1	06-02-93	2.6	--	130	88	53	.60	.13	.004	25
	06-02-93	--	--	130	--	53	.60	.13	--	--
-19J1	09-02-92	6.1	--	48	1,200	110	4.0	.32	.055	18
9N/1W-4M5	03-31-93	2.6	--	145	77	52	.50	.10	.008	26
-4M6	03-31-93	4.6	--	180	360	160	.30	.45	.034	44
-4M7	03-31-93	1.6	--	85	38	31	.80	<.010	.039	16
-4R2	05-06-93	7.1	--	56	820	420	3.6	.34	.130	41
-4R3	03-31-93	2.7	--	167	46	42	.50	.10	.003	27
-4R4	03-31-93	4.9	--	352	490	180	.30	<.010	.390	27

Table 4. Water-quality data for selected wells in the vicinity of the Marine Corps Logistics Base, Nebo and Yermo Annexes, near Barstow, California, January 1992-October 1995—*Continued*

State well No.	Date of sampling	Solids, residue at 180 °C, dis-solved (mg/L)	Nitro-gen, nitrite, dis-solved (mg/L as N)	Nitrogen, NO_2+NO_3, dissolved (mg/L as N)	Nitro-gen, am-monia, dis-solved (mg/L as N)	Nitro-gen, am-monia + organic, dis-solved (mg/L as N)	Phos-porus, dis-solved (mg/L as P)	Phos-phorus ortho, dis-solved (mg/L as P)	Arsenic, dis-solved (µg/L)	Barium, dis-solved (µg/L)
9N/1E-3H5	05-27-92	352	<0.01	1.60	<0.010	--	--	0.040	1	--
	05-25-94	388	<.01	1.80	<.010	--	--	.040	--	--
-4J2	06-02-93	354	<.01	.530	<.010	<0.20	0.040	.020	2	73
-4K1	07-22-93	2,530	.03	.940	.070	.40	.780	3.30	4	100
	08-12-93	--	--	--	--	--	--	--	--	--
-4K2	07-22-93	423	.01	.430	.030	<.20	.660	3.70	26	12
-4K3	07-22-93	[1]437	.03	.100	.030	<.20	1.90	.900	16	24
-4L1	05-18-93	--	--	--	--	--	--	--	--	--
-4Q2	05-19-93	--	--	--	--	--	--	--	--	--
	05-20-93	--	--	--	--	--	--	--	--	--
-4R2	05-20-93	--	--	--	--	--	--	--	--	--
-6H2	05-29-92	1,380	<.01	.260	<.010	--	--	<.010	8	--
	05-24-94	1,430	<.01	.440	<.010	--	--	.010	--	--
-9G1	05-20-93	--	--	--	--	--	--	--	--	--
-10J1	05-18-93	--	--	--	--	--	--	--	--	--
-10L1	06-02-93	253	<.01	.770	.020	<.20	.020	<.010	<1	53
-10L2	05-18-93	--	--	--	--	--	--	--	--	--
-10Q1	05-20-93	--	--	--	--	--	--	--	--	--
-10Q3	08-03-93	545	.01	1.60	.030	<.20	4.60	1.70	13	71
-10Q4	08-03-93	329	<.01	2.10	.030	<.20	4.30	1.20	6	37
	08-12-93	--	--	--	--	--	--	--	--	--
-10R1	05-20-93	188	<.01	1.10	.020	<.20	.080	.070	1	38
-16F2	08-04-93	750	.01	1.90	.020	<.20	.050	.040	2	58
-16F3	08-04-93	866	.01	2.70	.020	<.20	.240	.150	2	71
-16F4	08-03-93	418	.05	1.40	.010	<.20	2.50	1.40	7	44
-17H1	06-02-93	365	<.01	1.10	.020	<.20	.060	.050	3	75
	06-02-93	--	--	--	--	--	--	--	2	74
-19J1	09-02-92	2,050	<.01	.900	.040	<.20	.020	<.010	18	<100
9N/1W-4M5	03-31-93	383	.01	.910	.010	<.20	.730	.750	13	81
-4M6	03-31-93	1,260	.02	3.70	<.010	<.20	.210	.230	3	55
-4M7	03-31-93	202	<.01	.650	<.010	<.20	.030	.040	2	31
-4R2	05-06-93	2,220	<.01	<.050	.040	<.20	2.40	1.40	45	<100
-4R3	03-31-93	310	.01	.480	.010	<.20	.410	.340	12	38
-4R4	03-31-93	1,480	<.01	5.80	.010	<.20	.120	.120	2	<100

See footnote at end of table.

Table 4. Water-quality data for selected wells in the vicinity of the Marine Corps Logistics Base, Nebo and Yermo Annexes, near Barstow, California, January 1992-October 1995—*Continued*

State well No.	Date of sampling	Boron, dissolved (µg/L)	Iron, dissolved (µg/L)	Manganese, dissolved (µg/L)	Strontium, dissolved (µg/L)	Tritium in water molecules (TU)	$^{13}C/^{12}C$ stable isotope ratio (per mil)	$^{2}H/^{1}H$ stable isotope ratio (per mil)	$^{18}O/^{16}O$ stable isotope ratio (per mil)	Carbon-14, percent modern
9N/1E-3H5	05-27-92	300	6	<1	--	--	--	--	--	--
	05-25-94	300	10	2	--	--	--	--	--	--
-4J2	06-02-93	850	3	<1	520	0.1	--	-61.1	-8.70	--
-4K1	07-22-93	8,200	30	10	10,000	<.3	0.10	-80.2	-10.29	0.99
	08-12-93	910	--	--	--	--	--	-73.9	-9.50	--
-4K2	07-22-93	1,400	150	71	550	--	-11.90	-61.9	-8.66	82.0
-4K3	07-22-93	390	310	53	520	--	-11.10	-60.2	-8.64	89.4
-4L1	05-18-93	1,200	--	--	--	.7	--	-61.7	-8.59	--
-4Q2	05-19-93	990	--	--	--	--	--	-61.8	-8.58	--
	05-20-93	--	--	--	--	.3	--	--	--	--
-4R2	05-20-93	290	--	--	--	.2	--	-60.1	-8.76	--
-6H2	05-29-92	4,900	<10	<10	--	--	--	--	--	--
	05-24-94	4,800	30	<10	--	--	--	--	--	--
-9G1	05-20-93	1,500	--	--	--	1.9	--	-61.2	-8.71	--
-10J1	05-18-93	2,500	--	--	--	10.5	--	-41.1	-3.99	--
-10L1	06-02-93	190	3	29	430	5.8	--	-60.3	-8.42	--
-10L2	05-18-93	180	--	--	--	6.1	--	-58.9	-8.56	--
-10Q1	05-20-93	140	--	--	--	6.2	--	-60.9	-8.59	--
-10Q3	08-03-93	280	58	43	850	--	-11.50	-58.5	-8.40	108.0
-10Q4	08-03-93	180	120	27	470	--	-11.00	-58.0	-8.46	92.8
	08-12-93	5,800	--	--	--	--	--	-61.7	-8.44	--
-10R1	05-20-93	100	<3	1	300	6.0	--	-59.8	-8.51	--
-16F2	08-04-93	400	<3	12	1,300	--	-12.40	-60.6	-8.23	95.0
-16F3	08-04-93	660	4	13	1,300	--	-12.90	-58.2	-7.93	91.2
-16F4	08-03-93	330	91	37	480	--	-11.80	-59.0	-8.26	104.0
-17H1	06-02-93	180	<3	<1	600	--	--	-61.8	-8.79	--
	06-02-93	180	<3	<1	580	--	--	--	--	--
-19J1	09-02-92	28,000	10	240	3,900	<.3	-18.40	-88.5	-10.50	8.9
9N/1W-4M5	03-31-93	170	38	2	510	.1	--	-65.0	-8.97	--
-4M6	03-31-93	2,400	<3	670	1,700	3.9	--	-60.9	-8.80	--
-4M7	03-31-93	100	<3	2	310	5.1	--	-61.1	-9.17	--
-4R2	05-06-93	12,000	50	100	2,800	.1	--	-85.6	-9.27	--
-4R3	03-31-93	190	6	3	400	.0	--	-61.6	-8.93	--
-4R4	03-31-93	720	<10	20	1,700	5.8	--	-57.5	-8.05	--

Table 4. Water-quality data for selected wells in the vicinity of the Marine Corps Logistics Base, Nebo and Yermo Annexes, near Barstow, California, January 1992-October 1995—*Continued*

State well No.	Local well name	Date of sampling	Water level below land surface (ft)	Depth of well, total (ft)	Specific conductance (µS/cm)	pH (standard units)	Temperature, water (°C)	Calcium, dissolved (mg/L)	Magnesium, dissolved (mg/L)	Sodium, dissolved (mg/L)
9N/1W-9D5	BARSTOW3-500	05-18-93	24.83	500	3,040	7.4	27.5	84	6.4	560
-9D6	BARSTOW3-300	05-18-93	27.74	300	2,590	8.0	24.5	54	6.2	490
-9D7	BARSTOW3-190	03-31-93	37.75	190	1,520	7.8	23.0	38	5.5	290
-9D8	BARSTOW3-80	03-31-93	40.36	80	1,670	7.6	22.0	40	5.8	320
-10E4		05-24-94	20.46	101.6	1,310	7.4	18.5	83	15	180
		05-16-95	17.98	101.6	1,370	7.2	17.5	79	15	180
		10-17-95	--	101.6	1,370	7.2	8.0	78	15	180
-10G6		05-17-93	--	107	1,210	7.3	19.5	110	20	130
		05-24-94	7.56	107	1,170	7.5	21.5	110	18	120
		05-12-95	6.22	107	1,210	7.3	16.5	110	19	120
		10-18-95	--	107	1,260	7.4	19.0	110	20	120
-10J12	MC1-610	07-01-92	21.43	610	2,010	7.2	23.0	77	11	300
		07-21-93	--	610	1,460	7.2	23.0	110	14	180
-10J13	MC1-370	07-01-92	22.12	370	2,390	6.9	21.5	45	5.2	430
		09-08-92	--	370	2,200	6.8	25.0	45	4.6	430
		07-14-93	16.46	370	1,510	7.2	24.0	110	14	200
-10J14	MC1-200	07-01-92	14.13	200	1,420	7.5	19.5	150	25	120
		07-14-93	12.38	200	1,450	7.3	21.0	160	24	120
-10J15	MC1-100	07-01-92	20.82	100	1,350	7.7	18.5	79	15	190
		07-14-93	12.01	100	1,400	7.3	22.0	82	15	180
-11K12	MC4-590	08-25-92	12.44	590	2,050	7.7	27.5	61	2.1	380
		07-15-93	10.24	590	2,070	8.2	27.5	66	1.5	390
-11K13	MC4-315	08-26-92	15.13	315	685	7.9	24.5	12	1.6	130
		06-03-93	9.03	315	707	8.0	23.5	15	1.5	130
-11K14	MC4-180	08-20-92	14.37	180	1,380	7.3	21.5	120	21	120
		06-03-93	6.15	180	1,350	7.3	20.5	150	22	110
-11K15	MC4-90	08-20-92	14.41	90	1,260	7.4	20.5	77	15	150
		07-16-93	6.71	90	1,170	7.2	19.5	100	17	120
-11K16		05-18-93	3.90	27	912	7.7	15.0	72	12	97
-11M11		05-27-92	11.16	75	1,110	7.2	19.5	110	20	98
		05-24-94	3.87	75	817	7.5	18.0	79	13	75
		05-18-95	3.16	75	821	7.4	19.0	67	12	72
		10-17-95	--	75	884	7.4	18.5	77	15	85
-11N8	NPZ-16	03-25-93	46.76	70	2,080	--	23.0	--	--	--
-11Q3	NPZ-18	03-24-93	19.41	41	2,400	--	22.0	--	--	--
-11R2		05-29-92	57.87	102	1,500	7.4	21.5	130	25	160
		05-23-94	20.43	102	1,110	8.2	24.0	26	19	160

Table 4. Water-quality data for selected wells in the vicinity of the Marine Corps Logistics Base, Nebo and Yermo Annexes, near Barstow, California, January 1992-October 1995—*Continued*

State well No.	Date of sampling	Potassium, dissolved (mg/L)	Bicarbonate (mg/L)	Alkalintiy (mg/L as $CaCO_3$)	Sulfate, dissolved (mg/L)	Chloride, dissolved (mg/L)	Fluoride, dissolved (mg/L)	Bromide, dissolved (mg/L)	Iodide, dissolved (mg/L)	Silica, dissolved (mg/L)
9N/1W-9D5	05-18-93	6.1	--	59	810	400	3.8	0.50	0.230	46
-9D6	05-18-93	5.0	--	71	730	300	5.6	.57	.055	36
-9D7	03-31-93	4.3	--	173	340	140	3.6	.42	.034	37
-9D8	03-31-93	4.4	--	177	370	160	3.4	.44	.053	39
-10E4	05-24-94	7.6	305	--	180	160	.30	--	--	29
	05-16-95	7.4	251	--	190	180	.30	--	--	28
	10-17-95	8.0	254	--	190	170	.20	--	--	31
-10G6	05-17-93	3.9	286	--	210	130	.40	--	--	23
	05-24-94	3.9	288	--	210	120	.50	--	--	24
	05-12-95	3.7	264	--	200	120	.50	--	--	22
	10-18-95	3.9	234	--	210	130	.40	--	--	24
-10J12	07-01-92	5.4	--	152	500	140	2.3	--	--	29
	07-21-93	4.0	--	184	300	150	.80	.41	.087	25
-10J13	07-01-92	6.0	--	88	730	120	1.9	.40	.690	29
	09-08-92	5.2	--	--	810	100	2.9	.31	.930	22
	07-14-93	5.4	--	239	280	160	.40	.35	.130	28
-10J14	07-01-92	4.8	--	245	240	160	.40	.40	.040	24
	07-14-93	4.5	--	237	240	170	.40	.41	.043	24
-10J15	07-01-92	4.6	--	238	210	160	.60	.39	.029	29
	07-14-93	4.2	--	235	210	180	.50	.41	.028	29
-11K12	08-25-92	3.7	--	37	820	110	.70	.36	.380	33
	07-15-93	3.5	--	32	780	98	4.4	.070	.280	32
-11K13	08-26-92	2.4	--	105	130	53	1.4	.22	.053	22
	06-03-93	3.8	--	121	130	51	1.4	.23	.064	23
-11K14	08-20-92	4.1	--	235	220	150	.40	.31	.031	16
	06-03-93	4.2	--	256	240	140	.40	.31	.036	25
-11K15	08-20-92	4.4	--	214	190	150	.50	.22	.032	27
	07-16-93	4.1	--	211	180	130	.50	.24	.027	25
-11K16	05-18-93	2.8	--	172	140	100	.50	.10	.013	14
-11M11	05-27-92	3.3	251	--	160	140	.50	--	--	23
	05-24-94	2.6	188	--	120	100	.40	--	--	23
	05-18-95	3.4	200	--	110	86	.50	--	--	22
	10-17-95	2.7	212	--	120	99	.50	--	--	23
-11N8	03-25-93	--	--	--	--	270	--	.50	--	--
-11Q3	03-24-93	--	--	--	--	330	--	.48	--	--
-11R2	05-29-92	4.5	354	--	200	200	.50	--	--	22
	05-23-94	4.1	124	--	130	190	.30	--	--	8.2

Table 4. Water-quality data for selected wells in the vicinity of the Marine Corps Logistics Base, Nebo and Yermo Annexes, near Barstow, California, January 1992-October 1995—*Continued*

State well No.	Date of sampling	Solids residue at 180 °C, dissolved (mg/L)	Nitrogen, nitrite, dissolved (mg/L as N)	Nitrogen, NO_2+NO_3, dissolved (mg/L)	Nitrogen, ammonia, dissolved (mg/L as N)	Nitrogen, ammonia + organic, dissolved (mg/L as N)	Phosphorus, dissolved (mg/L as P)	Phosphorus ortho, dissolved (mg/L as P)	Arsenic, dissolved (µg/L)	Barium, dissolved (µg/L)
9N/1W-9D5	05-18-93	2,040	0.01	0.170	0.020	<0.20	5.80	4.20	65	<100
-9D6	05-18-93	1,730	<.01	.350	.010	<.20	1.60	1.10	55	<100
-9D7	03-31-93	988	<.01	1.20	<.010	<.20	1.70	.610	28	14
-9D8	03-31-93	1,110	<.01	3.30	<.010	<.20	3.30	2.70	100	13
-10E4	05-24-94	840	<.01	6.50	.240	--	--	.700	--	--
	05-16-95	854	<.01	4.20	.280	--	--	.610	20	--
	10-17-95	850	<.01	14.0	.330	--	--	.650	20	--
-10G6	05-17-93	816	<.01	6.40	.010	--	--	.030	1	--
	05-24-94	783	.02	6.50	<.010	--	--	.030	--	--
	05-12-95	790	.10	5.90	<.015	--	--	.010	<1	--
	10-18-95	816	<.01	7.40	<.015	--	--	.020	1	--
-10J12	07-01-92	1,210	.10	2.50	.040	.30	18.0	11.0	54	18
	07-21-93	946	.04	3.50	.030	<.20	1.40	1.10	11	50
-10J13	07-01-92	1,540	.49	1.90	.040	<.20	27.0	19.0	90	<100
	09-08-92	1,550	.04	4.50	.050	<.20	11.0	8.20	<1	<100
	07-14-93	978	.09	3.30	.030	<.20	7.80	7.50	40	37
-10J14	07-01-92	934	<.01	5.00	.030	<.20	.570	.430	4	66
	07-14-93	936	<.01	5.00	.020	<.20	.080	.080	2	72
-10J15	07-01-92	858	<.01	.760	.030	<.20	1.00	.840	7	66
	07-14-93	862	<.01	1.00	.020	<.20	.170	.170	4	87
-11K12	08-25-92	1,400	.03	1.10	.010	<.20	4.00	2.10	68	<100
	07-15-93	1,430	.03	.900	.020	<.20	1.30	.760	53	<100
-11K13	08-26-92	427	<.01	2.80	<.010	<.20	2.00	.970	48	5
	06-03-93	447	<.01	2.70	.020	<.20	1.60	1.60	58	7
-11K14	08-20-92	856	.08	4.50	.030	<.20	1.80	1.10	5	55
	06-03-93	828	<.01	4.50	.010	<.20	.550	.530	3	72
-11K15	08-20-92	750	.25	1.60	.040	<.20	4.20	2.80	22	42
	07-16-93	732	<.01	2.90	.010	<.20	.690	.720	4	110
-11K16	05-18-93	559	<.01	.200	.010	<.20	.280	.260	4	94
-11M11	05-27-92	712	<.01	.470	.010	--	--	.080	2	--
	05-24-94	524	<.01	1.10	.010	--	--	.080	--	--
	05-18-95	505	<.01	.870	<.015	--	--	.060	2	--
	10-17-95	547	<.01	.930	.030	--	--	.060	1	--
-11N8	03-25-93	--	--	--	--	--	--	--	--	--
-11Q3	03-24-93	--	--	--	--	--	--	--	--	--
-11R2	05-29-92	942	.50	2.20	.130	--	--	<.010	<1	--
	05-23-94	622	<.01	<.050	<.010	--	--	<.010	--	--

Table 4. Water-quality data for selected wells in the vicinity of the Marine Corps Logistics Base, Nebo and Yermo Annexes, near Barstow, California, January 1992-October 1995—*Continued*

State well No.	Date of sampling	Boron, dissolved (µg/L)	Iron, dissolved (µg/L)	Manganese, dissolved (µg/L)	Strontium, dissolved (µg/L)	Tritium in water molecules (TU)	$^{13}C/^{12}C$ stable isotope ratio (per mil)	$^{2}H/^{1}H$ stable isotope ratio (per mil)	$^{18}O/^{16}O$ stable isotope ratio (per mil)	Carbon-14, percent modern
9N/1W-9D5	05-18-93	15,000	40	20	2,300	0.2	--	-86.0	-9.04	--
-9D6	05-18-93	13,000	10	10	1,600	.1	--	-84.0	-9.77	--
-9D7	03-31-93	5,300	69	7	1,000	.0	--	-74.4	-9.68	--
-9D8	03-31-93	4,900	58	4	1,000	1.6	--	-73.1	-9.59	--
-10E4	05-24-94	840	4	1,300	--	--	--	--	--	--
	05-16-95	--	<3	1,400	--	--	--	--	--	--
	10-17-95	--	<3	1,500	--	--	--	--	--	--
-10G6	05-17-93	580	<3	120	--	--	--	-59.5	-8.19	--
	05-24-94	560	6	140	--	--	--	--	--	--
	05-12-95	--	<3	150	--	--	--	--	--	--
	10-18-95	--	<3	130	--	--	--	--	--	--
-10J12	07-01-92	1,100	150	160	--	1.5	--	-74.5	-9.60	--
	07-21-93	130	16	140	1,300	--	-12.90	-65.5	-8.65	--
-10J13	07-01-92	2,000	960	360	--	.5	--	-84.5	-10.55	--
	09-08-92	1,900	240	150	1,500	--	--	-86.0	-10.75	11.5
	07-14-93	1,100	15	240	2,100	--	--	-63.7	-8.46	--
-10J14	07-01-92	570	<3	44	--	2.6	--	-62.5	-8.35	--
	07-14-93	640	<3	25	1,600	--	--	-62.1	-8.30	--
-10J15	07-01-92	810	5	270	--	7.0	--	-54.5	-7.30	--
	07-14-93	750	<3	390	980	--	--	-54.9	-7.01	--
-11K12	08-25-92	4,900	120	40	830	.5	--	-86.0	-10.90	19.4
	07-15-93	4,700	60	30	800	--	-17.40	-86.8	-10.91	--
-11K13	08-26-92	2,400	41	15	340	0	--	-91.5	-11.50	3.7
	06-03-93	2,600	22	4	410	.2	--	-90.6	-11.55	--
-11K14	08-20-92	650	31	29	1,300	5.9	--	-60.5	-8.10	--
	06-03-93	710	<3	15	1,400	4.6	--	-60.8	-8.37	--
-11K15	08-20-92	630	28	50	1,000	7.7	--	-58.0	-7.75	--
	07-16-93	690	<3	50	1,100	--	--	-59.0	-7.97	--
-11K16	05-18-93	280	6	170	860	--	--	-62.7	-9.03	--
-11M11	05-27-92	420	16	51	--	--	--	--	--	--
	05-24-94	350	4	3	--	--	--	--	--	--
	05-18-95	--	9	12	--	--	--	--	--	--
	10-17-95	--	<3	16	--	--	--	--	--	--
-11N8	03-25-93	1,700	--	--	--	5.7	--	-58.1	-7.78	--
-11Q3	03-24-93	1,700	--	--	--	5.6	--	-54.1	-6.83	--
-11R2	05-29-92	990	940	68	--	--	--	--	--	--
	05-23-94	420	7	4	--	--	--	--	--	--

Table 4. Water-quality data for selected wells in the vicinity of the Marine Corps Logistics Base, Nebo and Yermo Annexes, near Barstow, California, January 1992-October 1995—*Continued*

State well No.	Local well name	Date of sampling	Water level below land surface (ft)	Depth of well, total (ft)	Specific conductance (µS/cm)	pH (standard units)	Temperature, water (°C)	Calcium, dissolved (mg/L)	Magnesium, dissolved (mg/L)	Sodium, dissolved (mg/L)
9N/1W-12L3	MC2-320	06-30-92	23.80	320	3,250	7.5	23.5	150	5.3	620
		06-15-93	7.68	320	3,740	7.4	22.0	180	3.6	640
-12L4	MC2-185	06-30-92	24.12	185	1,340	7.3	21.5	140	25	150
		06-16-93	5.15	185	1,490	7.2	20.0	140	25	140
-12L5	MC2-80	06-30-92	22.42	80	1,340	7.4	20.5	140	19	150
		06-15-93	4.57	80	1,790	7.3	20.0	180	23	170
-12N4	MC3-640	07-30-92	38.81	640	2,730	7.7	22.5	86	5.5	490
		09-01-92	--	640	2,640	7.6	24.5	79	5.7	480
		03-03-93	21.13	640	2,620	8.2	19.0	88	5.0	490
-12N5	MC3-310	09-03-92	--	310	689	7.5	20.5	7.9	3.3	140
		03-03-93	7.61	310	523	8.2	21.5	9.7	2.6	100
-12N6	MC3-170	07-29-92	25.58	170	1,270	7.3	20.5	120	20	120
		03-03-93	7.42	170	1,200	7.3	20.0	120	22	110
-12N7	MC3-80	07-29-92	25.20	80	1,370	7.3	19.5	100	17	160
		03-03-93	7.02	80	1,130	7.4	20.0	93	16	130
-12N8	NPZ-4	03-24-93	12.90	82	1,670	7.3	21.0	140	24	180
-13B2		05-27-92	26.50	110	1,390	7.5	19.0	120	22	150
		05-17-94	10.97	110	1,380	7.7	18.5	120	22	160
		05-11-95	9.07	110	1,400	7.2	20.0	130	22	150
		10-18-95	--	110	189	7.6	19.0	130	22	150
-13B3		05-27-92	21.64	60	1,340	7.3	19.5	120	22	140
		05-17-95	4.08	60	1,480	7.3	20.0	130	24	160
		10-17-95	--	60	1,590	7.4	19.5	150	25	150
-13C1	NPZ-5	03-24-93	27.24	--	1,620	--	22.0	--	--	--
-13H2		05-27-92	29.15	160	690	7.6	21.5	55	8.8	76
		05-17-94	13.20	160	738	8.0	21.5	52	8.5	74
		05-11-95	9.75	160	696	7.4	20.5	54	9.0	79
		10-18-95	--	160	717	7.8	21.5	54	8.9	78
-14D1	NPZ-10	03-25-93	73.94	90	1,540	--	23.0	--	--	--
-14E1	NPZ-12	03-25-93	115.05	123	1,560	--	25.5	--	--	--
-15Q1	15Q1	09-01-92	--	475	--	--	--	27	2.9	200
-15R1	NPZ-13	03-25-93	137.66	167	1,530	7.6	24.5	93	15	190
10N/1E-20M1	CALFAN-350	08-02-93	250.99	350	2,150	7.7	--	29	12	480
		08-12-93	--	350	--	--	--	--	--	--
-27C1		05-29-92	--	600	3,000	7.6	27.0	170	65	430
-28G3		05-29-92	145.38	227	2,040	8.1	24.5	20	7.4	400
		05-17-94	149.54	227	2,000	8.2	22.5	21	6.8	390

Table 4. Water-quality data for selected wells in the vicinity of the Marine Corps Logistics Base, Nebo and Yermo Annexes, near Barstow, California, January 1992-October 1995—*Continued*

State well No.	Date of sampling	Potassium, dissolved (mg/L)	Bicarbonate (mg/L)	Alkalintiy (mg/L as $CaCO_3$)	Sulfate, dissolved (mg/L)	Chloride, dissolved (mg/L)	Fluoride, dissolved (mg/L)	Bromide, dissolved (mg/L)	Iodide, dissolved (mg/L)	Silica, dissolved (mg/L)
9N/1W-12L3	06-30-92	6.6	--	41	940	480	1.2	1.2	0.210	19
	06-15-93	4.7	--	23	1,100	540	1.1	.79	.170	14
-12L4	06-30-92	4.8	--	271	300	140	.60	.22	.026	25
	06-16-93	4.2	--	281	320	130	.60	.21	.024	25
-12L5	06-30-92	5.0	--	281	320	120	.60	.23	.020	18
	06-15-93	5.3	--	307	440	150	.80	.24	.013	18
-12N4	07-30-92	5.2	--	32	780	330	1.6	.23	1.4	22
	09-01-92	4.6	--	34	750	320	1.6	.090	.720	21
	03-03-93	5.0	--	39	760	310	1.3	.20	1.3	21
-12N5	09-03-92	2.9	--	163	90	56	1.0	.10	.016	31
	03-03-93	2.4	--	145	60	38	1.2	.070	.025	24
-12N6	07-29-92	4.3	--	255	210	130	.50	.21	.027	24
	03-03-93	3.9	--	254	230	120	.40	.19	.024	24
-12N7	07-29-92	4.1	--	260	200	150	.60	.25	.032	26
	03-03-93	3.6	--	241	190	110	.50	.20	.014	26
-12N8	03-24-93	4.1	--	316	260	220	.50	.35	.016	27
-13B2	05-27-92	3.5	325	--	210	180	.50	--	--	27
	05-17-94	3.5	356	--	240	170	.50	--	--	27
	05-11-95	3.4	308	--	240	160	.50	--	--	26
	10-18-95	3.4	217	--	240	160	.40	--	--	27
-13B3	05-27-92	3.3	348	--	200	160	.50	--	--	27
	05-17-95	3.3	354	--	240	180	.50	--	--	26
	10-17-95	3.5	349	--	250	190	.40	--	--	27
-13C1	03-24-93	--	--	--	--	200	--	.40	--	--
-13H2	05-27-92	2.8	207	--	79	66	.60	--	--	27
	05-17-94	2.7	205	--	78	61	.50	--	--	28
	05-11-95	2.7	195	--	76	61	.60	--	--	26
	10-18-95	2.6	217	--	80	66	.50	--	--	27
-14D1	03-25-93	--	--	--	--	200	--	.39	--	--
-14E1	03-25-93	--	--	--	--	210	--	.39	--	--
-15Q1	09-01-92	4.0	--	--	240	110	1.4	1.1	.100	13
-15R1	03-25-93	6.2	--	96	240	250	.50	.53	.046	31
10N/1E-20M1	08-02-93	8.3	--	262	490	230	2.3	.29	.061	56
	08-12-93	--	--	--	--	250	--	.29	--	--
-27C1	05-29-92	11	159	--	1,100	220	1.5	--	--	39
-28G3	05-29-92	5.1	273	--	380	220	3.4	--	--	56
	05-17-94	4.8	268	--	420	230	3.3	--	--	57

Table 4. Water-quality data for selected wells in the vicinity of the Marine Corps Logistics Base, Nebo and Yermo Annexes, near Barstow, California, January 1992-October 1995—*Continued*

State well No.	Date of sampling	Solids residue at 180 °C, dissolved (mg/L)	Nitrogen, nitrite, dissolved (mg/L as N)	Nitrogen, NO_2+NO_3, dissolved (mg/L)	Nitrogen, ammonia, dissolved (mg/L as N)	Nitrogen, ammonia + organic, dissolved (mg/L as N)	Phosphorus, dissolved (mg/L as P)	Phosphorus ortho, dissolved (mg/L as P)	Arsenic, dissolved (µg/L)	Barium, dissolved (µg/L)
9N/1W-12L3	06-30-92	2,370	0.13	0.300	0.070	0.30	7.00	4.00	28	<100
	06-15-93	2,520	<.01	<.050	.040	<.20	3.90	3.50	15	<100
-12L4	06-30-92	950	.04	1.50	.030	<.20	.440	.240	15	57
	06-16-93	994	<.01	1.50	.020	<.20	.030	.040	2	64
-12L5	06-30-92	968	.03	.640	.030	<.20	.330	.180	2	77
	06-15-93	1,230	<.01	.840	.020	<.20	.040	.050	2	110
-12N4	07-30-92	1,760	.02	.200	.060	<.20	3.40	1.10	31	<100
	09-01-92	1,820	.01	.230	.020	<.20	4.40	1.50	32	<100
	03-03-93	1,790	.01	.110	.030	<.20	.910	.560	28	<100
-12N5	09-03-92	459	.04	.690	.020	<.20	10.0	2.80	69	6
	03-03-93	333	.01	.180	<.010	<.20	2.70	2.10	68	9
-12N6	07-29-92	790	.05	2.70	.050	<.20	1.00	.550	6	74
	03-03-93	808	.02	2.40	<.010	<.20	.040	.040	2	94
-12N7	07-29-92	862	.03	3.10	.050	<.20	2.60	1.10	8	56
	03-03-93	732	.01	2.30	<.010	<.20	.600	.560	3	63
-12N8	03-24-93	1,050	<.01	2.30	.020	<.20	<.010	.020	2	65
-13B2	05-27-92	898	<.01	2.10	.010	--	--	.020	1	--
	05-17-94	888	<.01	.900	<.010	--	--	.010	--	--
	05-11-95	930	.05	2.00	.020	--	--	.010	1	--
	10-18-95	912	.04	1.70	<.015	--	--	.010	<1	--
-13B3	05-27-92	856	<.01	2.10	.020	--	--	.020	1	--
	05-17-95	970	.01	1.50	.030	--	--	.010	1	--
	10-17-95	988	<.01	1.40	<.015	--	--	.020	1	--
-13C1	03-24-93	--	--	--	--	--	--	--	--	--
-13H2	05-27-92	416	<.01	.750	.010	--	--	<.010	4	--
	05-17-94	414	<.01	.760	<.010	--	--	.020	--	--
	05-11-95	419	<.01	.760	<.015	--	--	<.010	4	--
	10-18-95	432	<.01	.840	<.015	--	--	<.010	4	--
-14D1	03-25-93	--	--	--	--	--	--	--	--	--
-14E1	03-25-93	--	--	--	--	--	--	--	--	--
-15Q1	09-01-92	700	--	--	--	--	--	--	<1	11
-15R1	03-25-93	916	.01	6.50	.020	<.20	<.010	.010	3	110
10N/1E-20M1	08-02-93	1,460	.01	1.20	.050	<.20	1.90	1.20	61	<100
	08-12-93	--	--	--	--	--	--	--	--	--
-27C1	05-29-92	2,240	<.01	3.40	<.010	--	--	<.010	10	--
-28G3	05-29-92	1,300	<.01	2.80	.010	--	--	.020	200	--
	05-17-94	1,290	<.01	1.60	<.010	--	--	.030	--	--

Table 4. Water-quality data for selected wells in the vicinity of the Marine Corps Logistics Base, Nebo and Yermo Annrxes, near Barstow, California, January 1992-October 1995—*Continued*

State well No.	Date of sampling	Boron, dissolved (µg/L)	Iron, dissolved (µg/L)	Manganese, dissolved (µg/L)	Strontium, dissolved (µg/L)	Tritium in water molecules (TU)	$^{13}C/^{12}C$ stable isotope ratio (per mil)	$^{2}H/^{1}H$ stable isotope ratio (per mil)	$^{18}O/^{16}O$ stable isotope ratio (per mil)	Carbon-14, percent modern
9N/1W-12L3	06-30-92	2,200	530	80	--	0.7	--	-82.5	-10.15	--
	06-15-93	2,300	20	100	9,100	--	--	-85.0	-10.44	--
-12L4	06-30-92	370	5	19	--	4.9	--	-59.5	-8.30	--
	06-16-93	380	<3	9	1,600	--	--	-59.7	-8.42	--
-12L5	06-30-92	400	<3	15	--	5.4	--	-58.5	-8.30	--
	06-15-93	450	<3	6	1,600	--	--	-60.0	-8.37	--
-12N4	07-30-92	370	60	90	1,500	--	--	--	--	--
	09-01-92	2,700	220	90	1,500	.2	--	-80.0	-10.40	11.8
	03-03-93	2,700	40	140	1,500	.2	--	-81.0	-10.46	--
-12N5	09-03-92	600	400	88	190	1.2	--	-61.5	-8.80	52.6
	03-03-93	910	56	19	290	.2	--	-63.8	-9.11	--
-12N6	07-29-92	450	<3	22	1,300	6.3	--	--	--	--
	03-03-93	450	<3	4	1,300	6.0	--	-60.1	-8.36	--
-12N7	07-29-92	640	55	30	1,100	6.0	--	--	--	--
	03-03-93	520	5	14	1,000	8.0	--	-61.1	-8.28	--
-12N8	03-24-93	980	<3	<1	1,600	6.7	--	-54.3	-7.09	--
-13B2	05-27-92	680	11	<1	--	--	--	--	--	--
	05-17-94	690	7	<1	--	--	--	--	--	--
	05-11-95	--	5	3	--	--	--	--	--	--
	10-18-95	--	9	6	--	--	--	--	--	--
-13B3	05-27-92	580	6	2	--	--	--	--	--	--
	05-17-95	--	<3	3	--	--	--	--	--	--
	10-17-95	--	<3	1	--	--	--	--	--	--
-13C1	03-24-93	1,100	--	--	--	5.0	--	-60.1	-7.87	--
-13H2	05-27-92	310	<3	<1	--	--	--	--	--	--
	05-17-94	320	<3	<1	--	--	--	--	--	--
	05-11-95	--	7	<1	--	--	--	--	--	--
	10-18-95	--	<3	<1	--	--	--	--	--	--
-14D1	03-25-93	1,300	--	--	--	5.0	--	-60.1	-7.80	--
-14E1	03-25-93	840	--	--	--	4.3	--	-60.7	-8.01	--
-15Q1	09-01-92	6,100	22	35	310	--	--	-87.5	-11.20	--
-15R1	03-25-93	1,100	13	<1	1,100	2.3	-12.20	-68.7	-8.92	65.5
10N/1E-20M1	08-02-93	3,800	<10	60	1,100	<.3	-7.10	-90.6	-11.00	7.9
	08-12-93	4,100	--	--	--	--	--	-92.8	-11.34	--
-27C1	05-29-92	3,300	<10	<10	--	--	--	--	--	--
-28G3	05-29-92	4,100	70	<10	--	--	--	--	--	--
	05-17-94	4,200	130	<10	--	--	--	--	--	--

[1]Estimated from specific conductance.

Table 5. Water-quality data for wastewater at Barstow Sewage-Treatment Plant, California, November 18, 1993

[Altitude of land surface in feet above sea level. µS/cm, microsiemen per centimeter at 25 °C; °C , degree Celsius; mg/L, milligram per liter; µg/L, microgram per liter]

Site identifier	Altitude of land surface	Specific conductance (µS/cm)	Specific conductance, laboratory (µS/cm)	pH water, whole field (standard units)	pH water, whole laboratory (standard units)	Temperature, air (°C)	Temperature, water (°C)	Calcium, dissolved (mg/L as Ca)	Magnesium, dissolved (mg/L as Mg)
Holding chamber	2,050	1,260	1,350	7.8	8.1	16	14	74	14
Holding pond, east	2,050	1,330	1,440	8.0	7.6	16	14	79	15
Holding pond, west	2,050	1,310	1,410	7.6	7.5	16	14	77	14

Site identifier	Sodium, dissolved (mg/L as Na)	Potassium, dissolved (mg/L)	Alkalinity, wat dis fix end, field (mg/L as $CaCO_3$)	Alkalinity, wat dis tot it, field (mg/L as $CaCO_3$)	Alkalinity, laboratory (mg/L as $CaCO_3$)	Sulfate, dissolved (mg/L as SO_4)	Chloride, dissolved (mg/L as Cl)	Fluoride, dissolved (mg/L as F)	Bromide, dissolved (mg/L as Br)
Holding chamber	180	15	180	184	175	190	160	0.60	0.10
Holding pond, east	180	15	230	225	180	200	170	0.60	.090
Holding pond, west	180	15	210	205	177	210	170	0.70	.09

Site identifier	Iodide, dissolved (mg/L as I)	Silica, dissolved (mg/L as SiO_2)	Solids, residue at 180°C, dissolved (mg/L)	Nitrogen, nitrite, dissolved (mg/L as N)	Nitrogen, $NO_2 + NO_3$, dissolved (mg/L as N)	Nitrogen, ammonia, dissolved (mg/L as N)	Nitrogen, ammonia plus organic, dissolved (mg/L as N)	Phosphorus, dissolved (mg/L as P)
Holding chamber	0.010	32	846	0.140	14.0	0.980	2.0	5.40
Holding pond, east	.035	32	851	.310	7.40	6.90	8.6	5.60
Holding pond, west	.030	30	867	.320	10.0	3.00	4.7	5.60

Site identifier	Phosphorous, ortho, dissolved (mg/L as P)	Arsenic, dissoved (µg/L as As)	Boron, dissolved (µg/L as B)	Iron, dissolved (µg/L as Fe)	Lithium, dissolved (µg/L as Li)	Manganese, dissolved (µg/L as Mn)	Strontium, dissolved (µg/L as Sr)	$^2H/^1H$ stable isotope ratio per mil	$^{18}O/^{16}O$ stable isotope ratio per mil
Holding chamber	5.30	3	870	99	23	11	750	-60.2	-8.66
Holding pond, east	5.20	4	880	27	23	17	790	-60.8	-8.19
Holding pond, west	4.00	4	890	49	23	7	760	-59.9	-8.22

Table 6. Lithologic logs for multiple-well monitoring site: MC1 (9N/1W-10J12, -10J13, -10J14, -10J15)

[MC1, local well name. Altitude of land surface, approximately 2,033.59 feet. Depth is in feet below land surface. Drilled by U.S. Geological Survey using mud rotary, March 15–19, 1992. Soil and rock color are from Munsell Color (1975) system. Total depth drilled 620 feet. Screened intervals: 590-610, 350-370, 180-200, and 80-100 feet]

Depth From	Depth To	Description
Site MC1 (9N/1W-10J12, -10J13, -10J14, -10J15)		
Cuttings		
0	20	Sand, coarse to fine; moderately well sorted; subrounded to rounded; grayish olive (10Y 4/2); quartz, biotite, rock fragments.
20	40	Sand, coarse to granules; poorly sorted; subrounded to rounded; pale olive (10Y 6/2); quartz, biotite, rock fragments.
40	60	Sand, very coarse to fine, with some small pebbles; poorly sorted; subangular to rounded; pale olive (10Y 6/2); quartz, biotite, rock fragments.
60	80	Sand, coarse to medium, with occasional small pebbles; moderately sorted; subrounded to rounded; pale olive (10Y 6/2); quartz, rock fragments.
80	100	Sand, coarse to medium, with granules; moderately sorted; subangular to rounded; pale olive (10Y 6/2); quartz, rock fragments.
100	107	Sand, coarse to medium, with occasional granules; moderately sorted; subrounded to rounded; pale olive (10Y 6/2); quartz, rock fragments, biotite.
107	140	Sand, medium to coarse; well sorted; subrounded to rounded; grayish olive (10Y 4/2); quartz, biotite.
140	155	Sand, medium to coarse; well sorted; subrounded to rounded; grayish olive (10Y 4/2); quartz, biotite.
155	180	Sand, very coarse to medium, and gravel, medium pebble-sized; poorly sorted; subangular to rounded; grayish olive (10Y 4/2); quartz, rock fragments, biotite.
180	200	Sand, coarse to medium, and gravel, medium pebble-sized; poorly sorted; angular to rounded; grayish olive (10Y 4/2); quartz, rock fragments, biotite.
200	210	Sand, coarse to fine, and gravel, medium pebble-sized; very poorly sorted; angular to rounded; light olive gray (5Y 5/2); quartz, rock fragments.
210	240	Consolidated sand, coarse to fine, and silt, with some granules; very poorly sorted; subangular to rounded; dark yellowish brown (10YR 4/2).

Table 6. Lithologic logs for multiple-well monitoring site: MC1—*Continued*

Depth From	Depth To	Description
240	260	Consolidated sand, medium to coarse, silt, and clay, with some very coarse grains; poorly sorted; subangular to rounded; dark yellowish brown (10YR 4/2); quartz, rock fragments.
260	280	Consolidated sand, medium to very coarse, silt, and clay; poorly sorted; subrounded to rounded; dark yellowish brown (10YR 4/2); quartz, rock fragments.
280	300	Sand, medium to very coarse, with silt, and clay, some small pebbles; very poorly sorted; subangular to rounded; dark yellowish brown (10YR 4/2).
300	320	Sand, coarse to medium, with silt and clay, some granules; moderately sorted; subangular to rounded; dark yellowish brown (10YR 4/2); quartz, rock fragments.
320	340	Sand, medium to coarse, silt, and clay; poorly sorted; subrounded to rounded; dark yellowish brown (10YR 4/2); quartz, rock fragments.
340	350	Sand, medium to coarse, with silt and clay, occasional granules; poorly sorted; subrounded to rounded; dark yellowish brown (10YR 4/2); quartz, rock fragments.
350	380	Sand, medium to coarse, silt, and clay; poorly sorted; subrounded to rounded; dark yellowish brown (10YR 4/2); quartz, rock fragments.
380	400	Sand, medium to coarse, silt, and clay; poorly sorted; subangular to rounded; dark yellowish brown (10YR 4/2); quartz, biotite, rock fragments.
400	410	Sand, coarse, with fine to very coarse grains; moderately sorted; angular to rounded; dark yellowish brown (10YR 4/2); quartz, rock fragments.
410	440	Sand, medium, and clay, with some silt; moderately sorted; subrounded to rounded; moderate yellowish brown (10YR 5/4); quartz.
440	460	Sand, fine to medium, and clay; moderately sorted; subrounded to rounded; moderately yellowish brown (10YR 5/4); quartz, rock fragments.
460	475	Sand, fine to medium, silt, and clay, with occasional very coarse grains; moderately sorted; subrounded to rounded; moderate yellowish brown (10YR 5/4); quartz, rock fragments.

Table 6. Lithologic logs for multiple-well monitoring site: MC1—*Continued*

Depth From	Depth To	Description
475	515	Sand, fine to medium, silt, and clay, with some coarse grains; moderately sorted; subangular to rounded; moderate yellowish brown (10YR 5/4); quartz, rock fragments.
515	520	Sand, fine, silt, and clay; moderately sorted; subrounded to rounded; moderate yellowish brown (10YR 5/4); quartz, rock fragments.
520	540	Sand, fine, and clay, with some silt; moderately sorted; subrounded to rounded; moderate yellowish brown (10YR 5/4); quartz.
540	560	Sand, fine, and clay, with silt; moderately sorted; subrounded to rounded; moderate yellowish brown (10YR 5/4).
560	580	Sand, fine, and clay, with occasional coarse grains; moderately sorted; subrounded to rounded; moderate yellowish brown (10YR 5/4).
580	600	Sand, fine, silt, and clay; moderately sorted; subrounded to rounded; moderate yellowish brown (10YR 5/4).
600	620	Sand, medium to coarse, and clay, with some silt; moderately sorted; subrounded to rounded; moderate yellowish brown (10YR 5/4).

Table 7. Lithologic logs for multiple-well monitoring site: MC4 (9N/1W-11K12, -11K13, -11K14, -11K15)

[MC4, local well name. Altitude of land surface, approximately 2,022.28 feet. Depth is in feet below land surface. Soil and rock color are from Munsell Color (1975). Drilled by U.S. Geological Survey using mud rotary June 29–July 10, 1992. Tota' depth drilled 600 feet. Screened intervals: 570-590, 295-315, 160-180, and 70-90 feet]

Depth From	Depth To	Description
Site MC4 (9N/1W-11K12, -11K13, -11K14, -11K15)		
Cuttings		
0	20	Sand, coarse grained; very well sorted; angular to subrounded; grayish orange (10YR 7/4); quartz, feldspar, hornblend, biotite.
20	40	Sand, coarse to very coarse, and gravel; granules and pebbles; moderately sorted; angular to subrounded grayish orange (10YR 7/4).
40	60	Sand, coarse to very coarse, and granules and pebbles, with minor silt; moderately sorted; angular to subrounded; moderate yellowish brown (10YR 5/4).
60	80	Gravelly sand, coarse to very coarse, gravel, granules and pebbles; moderately sorted; angular to subrounded; grayish orange (10YR 7/4).
80	100	Sand, coarse to very coarse; well sorted; angular to subrounded; grayish orange (10YR 7/4).
100	120	Gravelly sand, coarse to very coarse, gravel, granules and pebbles; moderately sorted; grayish orange (10YR 7/4).
120	140	Sand, coarse to very coarse, and some gravel, granules; well sorted; angular to subrounded; grayish orange (10YR 7/4).
140	160	Sand, coarse to very coarse, and some gravel, granules, with minor silt; well sorted; angular to subrounded; grayish orange (10YR 7/4).
160	180	Sandy gravel, granules to pebbles, and sand, coarse to very coarse; moderately sorted; angular to rounded; grayish orange (10YR 7/4).
180	200	Sandy gravel, granules to pebbles, mostly pebbles, and coarse to very coarse sand; well sorted; angular to subrounded; grayish orange (10YF 7/4).
200	220	Silty sand, medium to coarse; moderately sorted; angular to subrounded; moderate yellowish brown (10YR 5/4).
220	240	Sand, medium to coarse, with some gravel, granules, minor silt; well sorted; angular to subrounded; moderate yellowish brown (10YR 5/4).
240	270	Silty sand, medium to coarse, and some gravel, granules; well sorted; angular to subrounded; moderate yellowish brown (10YR 5/4).
270	280	Sand, silt, medium to coarse, with some gravel, small pebbles; moderately sorted; angular to subrounded; moderate yellowish brown (10YR 5/4).

Table 7. Lithologic logs for multiple-well monitoring site: MC4—Continued

Depth		
From	To	Description
280	300	Sandy silt, medium to very coarse, with some gravel, granules, small pebbles; moderately sorted; angular to subrounded; (10YR 5/4).
300	320	Silty sand, medium to coarse, with some gravel, small pebbles; moderately sorted; angular to subrounded; (10YR 5/4).
320	340	Silty sand, medium to very coarse; angular to rounded; moderate yellowish brown (10YR 5/4).
340	360	Silty sand, medium to very coarse, with minor gravel, minor clay; moderately sorted; angular to subrounded; moderate yellowish brown (10YR 5/4).
360	380	Silty sand, medium to very coarse, moderately sorted, angular to subrounded; moderate yellowish brown (10YR 5/4).
380	400	Silty sand, medium to very coarse; moderately poorly sorted; angular to subrounded; moderate yellowish brown (10YR 5/4).
400	420	Silty sand, medium to very coarse, with some clay; moderately poorly sorted; angular to subrounded; moderate yellowish brown (10YR 5/4).
420	440	Silty sand, fine to coarse, with some clay; moderately poorly sorted; angular to subrounded; moderate yellowish brown (10YR 5/4).
440	460	Silty sand, fine to very coarse, with some clay; poorly sorted; angular to subrounded; moderate yellowish brown (10YR 5/4).
460	480	Silty sand, fine to very coarse, with some clay; poorly sorted; angular to subrounded; moderate yellowish brown (10YR 5/4).
480	500	Silty sand, fine to coarse, with some clay; poorly sorted; angular to subrounded; yellowish brown (10YR 5/4).
500	520	Silty sand, fine to very coarse, with some clay; poorly sorted; angular to rounded; moderate yellowish brown (10YR 5/4).
520	540	Silty sand, fine to very coarse, with some clay; poorly sorted; angular to rounded; moderate yellowish brown (10YR 5/4).
540	560	Silty sand, fine to very coarse, with minor clay; poorly sorted; angular to subrounded; moderate yellowish brown (10YR 5/4).
560	580	Silty sand, fine to very coarse, with some clay; poorly sorted; angular to subrounded; moderate yellowish brown (10YR 5/4).
580	600	Silty sand, fine to coarse, with minor clay; moderately sorted; angular to subrounded; moderate yellowish brown (10YR 5/4).

Table 8. Lithologic logs for multiple-well monitoring site: MC2 (9N/1W-12L2, -12L3, -12L4, -12L5)

[MC1, local well name. Altitude of land surface, approximately 2,002 feet. Depth is in feet below land surface. Drilled by U.S. Geological Survey using mud rotary, June 13–18, 1992. Soil and rock color are from Munsell Color (1975). Total depth drilled 481.5 feet. Screened intervals: 430-450, 300-320, 165-185, and 60-80 feet]

Depth From	Depth To	Description
Site MC2 (9N/1W-12L2, -12L3, -12L4, -12L5)		
Cuttings		
0	20	Slightly gravelly sand, fine to coarse, with little silt; moderately to well sorted; subrounded; moderate yellowish brown (10YR 5/4); predominantly quartz, dark lithic fragments, biotite.
20	40	Slightly gravelly sand, fine to coarse, with occasional granules; moderate to well sorted; subrounded to rounded; moderate yellowish brown (10YR 5/4); quartz, lithic fragments, some biotite.
40	60	Slightly gravelly sand, medium to coarse, with occasional pebbles; moderately sorted; subrounded; moderate yellowish brown (10YR 5/4); quartz, dark lithic fragments.
60	80	Slightly gravelly sand, fine to coarse, with occasional granules; moderately sorted; subrounded; moderate yellowish brown (10YR 5/4); quartz, lithic fragments, biotite.
80	100	Slightly gravelly sand, very fine to coarse, with occasional granules, some silt; moderately sorted; subrounded; moderate brown (5YR 4/4); quartz, dark lithic fragments, biotite.
100	120	Slightly gravelly sand, fine to coarse, with occasional granules; moderately sorted; subangular to subrounded; moderate brown (5YR 4/4); quartz, dark lithic fragments.
120	140	Gravelly sand, very fine to coarse, with clay, occasional pebbles; poorly sorted; subrounded; moderate brown (5YR 4/4); quartz, dark lithic fragments.
140	155	Gravelly clayey sand, very fine to coarse, with occasional pebbles; poorly sorted; subrounded; moderate brown (5YR 4/4); quartz, lithic fragments.
155	180	Sandy gravel, medium to very coarse pebbles, with some clay, poorly sorted; subangular; moderate yellowish brown (10YR 5/4); quartz, dark lithic fragments.
180	200	Gravelly sand, very fine to very coarse, with some clay; poorly sorted; subangular; moderate brown (5YR 4/4); quartz, dark lithic fragments.
200	220	Gravelly clayey sand, very fine to coarse, with some clay, occasional pebbles; poorly sorted; subangular; moderate brown (5YR 4/4); quartz, dark lithic fragments.
220	240	Gravelly clayey sand, very fine to coarse, with some clay, occasional pebbles; poorly sorted; subangular; moderate brown (5YR 4/4); quartz, dark lithic fragments.

Table 8. Lithologic logs for multiple-well monitoring site: MC2—*Continued*

Depth		
From	To	Description
240	262	Sand, very fine to coarse, with some clay, occasional very coarse pebbles; moderately sorted; subrounded; moderate brown (5YR 4/4); quartz, dark lithic fragments.
262	280	Gravelly clayey sand, very fine to coarse, with some clay, occasional very coarse pebbles; moderate to poorly sorted; subangular; moderate brown (5YR 3/4); quartz, dark lithic fragments.
280	300	Gravelly clayey sand, very fine to coarse, occasional very coarse grains with pebbles; poorly sorted; subangular; moderate brown (5YR 4/4); quartz, dark lithic fragments.
300	320	Gravelly clayey sand, very fine to coarse, and clay, with occasional very coarse grains; moderately sorted; subrounded; moderate brown (5YR 4/4); quartz, dark lithic fragments.
320	340	Slightly gravelly clayey sand, very fine to medium; moderately sorted; subrounded; moderate brown (5YR 4/4); quartz, dark lithic fragments.
340	360	Slightly gravelly clayey sand, very fine to medium; moderately sorted; subangular; moderate brown (5YR 4/4); quartz, dark lithic fragments.
360	380	Slightly gravelly clayey sand, very fine to medium, with silt and clay; moderately sorted; subrounded to subangular; moderate brown (5YR 4/4); quartz, dark lithic fragments.
380	400	Slightly gravelly clayey sand, very fine to medium, with silt and clay; moderately sorted; subangular; moderate brown (5YR 4/4); quartz, dark lithic fragments, biotite.
400	415	Gravelly clayey sand, fine to coarse, with occasional pebbles; poorly sorted; subangular to angular; moderate brown (5YR 3/4); quartz, dark lithic fragments.
415	430	Sandy gravel, fine to coarse, occasional pebbles; poorly sorted; subangular to angular; moderate brown (5YR 3/4); quartz, dark lithic fragments.
430	460	Gravelly sand, fine to very coarse (only shaker sample available); poorly sorted; subangular to angular; quartz, dark lithic fragments.
460	480	Breccia; gravelly sand, fine to medium, with occasional coarse grains, granules, and cobbles; poorly sorted; angular to subangular; moderate brown (5YR 3/4); quartz, dark lithic fragments.
480	481.5	Core: consolidated breccia with carbonate mudstone matrix. Rock fragments: angular, poorly sorted, from mostly igneous sources. Matrix: light brown (5YR 5/6) to moderate brown (5YR 4/4), overlain by approximately 8 inches of andesite (?); consolidated, dense, aphanitic, extrusive rock. Calcification along surface at approximately 4 in from top; pale brown (5YR 5/2) to dark yellowish brown (10YR 4/2); intruded by 2.5-inch granitic vein (piece not with core--only in drilling log).

Table 9. Lithologic logs for multiple-well monitoring site: MC3 (9N/1W-12N4, -12N5, -12N6, -12N7)

[MC3, local well name. Altitude of land surface, approximately 2,010.24 feet. Depth is in feet below land surface. Drilled by U.S. Geological Survey using mud rotary June 24–June 29, 1992. Soil and rock color are from Munsell Color (1975). Total depth drilled 660 feet. Screened intervals: 620-640, 290-310, 150-170, and 60-80 feet]

Depth		
From	To	Description
Site MC3 (9N/1W-12N4, -12N5, -12N6, -12N7)		
Cuttings		
0	20	Sand, fine to very coarse; poorly sorted; subangular; angular; dark yellowish orange (10YR 6/6); quartz, feldspar, biotite.
20	40	Sand, fine to very coarse; poorly sorted; subangular to subrounded; grayish orange (10YR 7/4); quartz, feldspar, biotite.
40	60	Sand, fine to very coarse, and gravel, pebbles; poorly sorted, subrounded to subangular; grayish orange (10YR 7/4); quartz, feldspar, biotite.
60	80	Sand, fine to very coarse, gravel, granules and pebbles; poorly sorted; subangular; grayish orange (10YR 7/4); quartz, feldspar, biotite, chert.
80	90	Sand, fine to very coarse, and gravel, granules to pebbles, poorly sorted; subangular; grayish orange (10YR 7/4); quartz, feldspar.
90	120	Sand, fine to very coarse, with rock chips; poorly sorted; subangular; grayish orange (10YR 7/4); quartz, feldspar.
120	145	Sand, fine to very coarse, with some rock chips, some fine gravel; poorly sorted; subangular; grayish orange (10YR 7/2); quartz.
145	160	Sand, fine to very coarse with some gravel, fine to medium; poorly sorted; subangular; grayish orange (10YR 7/4).
160	180	Sand, fine to very coarse, and gravel, granules and pebbles; poorly sorted; subrounded to subangular; grayish orange (10YR 7/4).
180	200	Gravelly sand, and some silt, sand, very fine to very coarse, and gravel, pebbles and granules: poorly sorted; subangular to angular rock chips; moderate yellowish brown (10YR 5/4).
200	220	Silty sand, very fine to very coarse, and some gravel, granules; poorly sorted; subangular to subrounded; moderate yellowish brown (10YR 5/4).
220	240	Silty sand, very fine to very coarse, with some clay, some gravel; poorly sorted; subangular and subrounded; moderate yellowish brown (10YR 5/4).
240	260	Silty sand, very fine to very coarse with, some clay, some gravel; poorly sorted; subrounded to angular; dark yellowish brown (10YR 4/2).
260	280	Silty sand very fine to very coarse, with some clay, some gravel; poorly sorted; angular to rounded; dark yellowish brown (10YR 4/2).
280	300	Silty sand, very fine to very coarse, with some gravel, some clay; poorly sorted; angular to subrounded; dark yellowish brown (10YR 4/2).

Table 9. Lithologic logs for multiple-well monitoring site: MC3—*Continued*

Depth From	Depth To	Description
300	320	Silty sand, very fine to very coarse, with some gravel, some clay; very poorly sorted; angular to subrounded; dark yellowish brown (10YR 4/2).
320	340	Silty sand, very fine to very coarse, with some gravel, some clay; poorly sorted; angular to subrounded; dark yellowish brown (10YR 4/2).
340	360	Silty sand, very fine to coarse, with some gravel, some clay; poorly sorted; angular to subangular; dark yellowish brown (10YR 4/2).
360	380	Silty sand, very fine to very coarse, with some gravel, minor clay; poorly sorted; subrounded to subangular; moderate brown (5YR 4/4).
380	400	Silty sand, very fine to very coarse, with some gravel, minor clay; poorly sorted; moderate brown (5YR 4/4).
400	420	Silty sand, very fine to very coarse, minor gravel, minor clay; poorly sorted; subangular to subrounded; moderate brown (5YR 4/4).
420	440	Silty sand, very fine to very coarse, with some gravel, some clay; poorly sorted; subrounded to subangular; moderate brown (5YR 4/4).
440	460	Silty sand, very fine to very coarse, with some gravel, some clay; very poorly sorted; subangular to subrounded; moderate brown (5YR 4/4).
460	480	Silty sand, very fine to very coarse, with minor gravel, minor clay; moderately well sorted; subangular to subrounded; moderate brown (5YR 4/4).
480	500	Silty sand, very fine to very coarse, with minor gravel, minor clay; poorly sorted; subrounded to subangular; moderate brown (5YR 4/4).
500	520	Silty sand, very fine to very coarse, with some gravel, minor clay; poorly sorted; subangular to subrounded; moderate brown (5YR 4/4).
520	540	Silty sand, very fine to very coarse, with some gravel, minor clay; moderately well sorted; subangular to subrounded; moderate brown (5YR 4/4).
540	560	Silty sand, very fine to very coarse, with some gravel, minor clay; poorly sorted; angular to subangular; moderate brown (5YR 4/4).
560	580	Silty sand, very fine to very coarse, with some gravel, minor clay; poorly sorted; angular to subangular; moderate brown (5YR 4/4).
580	600	Silty sand, very fine to very coarse, with some gravel, some clay; poorly sorted; angular to subrounded; moderate brown (5YR 4/4).
600	620	Silty sand, very fine to very coarse, with some gravel, minor clay; poorly sorted; angular to subrounded; moderate brown (5YR 4/4).
620	640	Silty sand, very fine to very coarse, with some gravel, trace clay; poorly sorted; angular to rounded; moderate brown (5YR 4/4).
640	660	Sand, very fine to very coarse, with some silt; angular to rounded; moderate brown (5YR 4/4).

Table 10. Lithologic logs for multiple-well monitoring site: YEMBB (9N/1E-4K1, -4K2, -4K3)

[YEMBB, name of local well. Altitude of land surface, approximately 1,965 feet. Depth is in feet below land surface. Drilled by U.S. Geological Survey using mud rotary June 7–June 9, 1993. Soil and rock color are from Munsell Color (1975). Total depth drilled 480 feet. Screened intervals: 450-470, 320-340, and 175-195 feet]

Depth From	Depth To	Description
Site YEMBB (9N/1E-4K1, -4K2, -4K3)		
Cuttings		
0	20	Silty sand, fine to very fine, with minor clay; poorly sorted; angular to rounded; biotite, quartz; moderate yellowish brown (10YR 5/4).
20	40	Sand, very fine to very coarse, but skewed toward coarse, with some silt; poorly sorted; angular to rounded; quartz, biotite, feldspar; moderate yellowish brown (10YR 5/4).
40	60	Silty sand, very fine to very coarse, with minor clay; poorly sorted; angular to rounded; moderate yellowish brown (10YR 5/4).
60	80	Sand, fine to very coarse; poorly sorted; angular biotite to rounded quartz; dark yellowish orange (10YR 6/6).
80	100	Silty sand, very fine to very coarse, with some clay; poorly sorted; angular to rounded; moderate to rounded; moderate yellowish brown (10YR 5/4).
100	120	Sand, fine to coarse; moderately sorted; angular to subrounded; moderate yellowish brown (10YR 5/4).
120	140	Silty sand, very fine to very coarse; very poorly sorted; angular to subrounded; moderate yellowish brown (10YR 5/4).
140	160	Sand, very fine to very coarse, very poorly sorted; angular to subrounded; dark yellowish orange (10YR 6/6).
160	180	Sand, fine to very fine, with some silt; poorly sorted; angular to rounded; moderate yellowish brown (10YR 5/4).
180	190	Sand, fine to very coarse, with some silt; angular to rounded; moderate yellowish brown (10YR 5/4).
190	220	Sandy silt, very fine to very coarse but skewed toward fine; moderately sorted; angular to rounded; dark yellowish brown (10YR 4/2).
220	235	Silty sand, medium to very coarse, with some clay; poorly sorted; angular to rounded; dark yellowish brown (10YR 4/2).
235	260	Silty sand, very fine to very coarse, with some clay; poorly sorted; angular to rounded; moderate yellowish brown (10YR 5/4).

Table 10. Lithologic logs for multiple-well monitoring site: YEMBB—*Continued*

Depth		Description
From	To	
260	280	Sandy silt, very fine to very coarse, with some clay; poorly sorted; angular to rounded; moderate yellowish brown (10YR 5/4).
280	300	Sandy silt, very fine to very coarse, with some clay; poorly sorted; angular to rounded; moderate yellowish brown (10YR 5/4).
300	320	Sandy silt, very fine to very coarse, with some silt; poorly sorted; moderate yellowish brown (10YR 5/4).
320	340	Silty sand, medium to very coarse, with trace clay; poorly sorted; angular to rounded; moderate yellowish brown (10YR 5/4).
340	355	Silty sand, very fine to very coarse, with minor clay; very poorly sorted; angular to rounded; moderate yellowish brown (10YR 5/4).
355	380	Sandy clay, very fine to very coarse; poorly sorted; angular to subrounded; no organics; pale yellowish brown (10YR 6/2).
380	400	Sandy clay, very fine to very coarse; poorly sorted; subangular to subrounded; no organics; pale yellowish brown (10YR 6/2).
400	420	Clay, with some sand, very fine to coarse; poorly sorted; subangular to subrounded: no organics; pale yellowish brown (10YR 6/2).
420	445	Clay, with some sand, very fine to very coarse; poorly sorted; subrounded to subangular; no organics; pale yellowish brown (10YR 6/2).
445	455	Sandy clay, very fine to very coarse; poorly sorted; subangular; no organics; moderate yellowish brown (10YR 5/4).
455	480	Sandy clay, very fine to very coarse; poorly sorted; subangular to subrounded; no organics; moderate yellowish brown (10YR 5/4).

Table 11. Lithologic logs for multiple-well monitoring site: YEMRR (9N/1E-10Q2, -10Q3, -10Q4)

[YEMRR, local well name. Altitude of land surface, approximately 1,948 feet. Depth is in feet below land surface. Drilled by U.S. Geological Survey using mud rotary June 3–June 6, 1993. Soil and rock color are from Munsell Color (1975). Total depth drilled 560 feet. Screened intervals: 530-550, 330-350, and 180-200 feet]

Depth		
From	To	Description
Site YEMRR (9N/1E-10Q2, -10Q3, -10Q4)		
Cuttings		
0	20	Sand, fine to very coarse, with minor gravel, trace silt; moderately sorted; angular to rounded; grayish orange (10YR 7/4).
20	40	Silt, with trace coarse to very coarse sand, trace gravel; moderately sorted; subrounded; yellowish brown (10YR 5/4).
40	60	Sand, fine to very coarse but skewed toward coarse, with some gravel, minor silt; poorly sorted; angular to rounded; dark yellowish orange (10YR 6/6).
60	80	Sand, fine to very coarse, skewed toward coarse, with some gravel, trace silt; poorly sorted; angular to rounded; dark yellowish orange (10YR 6/6).
80	100	Sand, fine to very coarse, with some gravel, trace silt; poorly sorted; angular to rounded; dark yellowish orange (10YR 6/6).
100	125	Gravel, granules and pebbles, with some sand, trace silt; poorly sorted; angular to rounded; dark yellowish orange (10YR 6/6).
125	140	Sandy silt, fine to very coarse, with some gravel, trace to minor clay; poorly sorted; angular to subrounded; moderate yellowish brown (10YR 5/4).
140	160	Sand, fine to very coarse, with some silt, some gravel; poorly sorted; angular to subrounded; dark yellowish orange (10YR 6/6).
160	170	Silty sand, fine to very coarse; poorly sorted; angular to subrounded; moderate yellowish brown (10YR 5/4).
170	200	Gravelly sand, coarse to very coarse, with gravel, granules to pebbles, skewed toward pebbles, trace silt; moderately sorted; angular to subrounded; dark yellowish orange (10YR 6/6).
200	220	Sandy gravel, granules to pebbles, skewed toward pebbles, with sand, coarse to very coarse, trace silt; well sorted; angular to rounded; dark yellowish orange (10YR 6/6).
220	240	Sand, coarse to very coarse, with some gravel; well sorted; angular to subrounded; dark yellowish orange (10YR 6/6).
240	265	Sandy gravel, silt; granules, pebbles and sand; medium to very coarse; moderately sorted; angular to rounded; moderate yellowish brown (10YR 5/4).

Table 11. Lithologic logs for multiple-well monitoring site: YEMRR—*Continued*

Depth		Description
From	To	
265	280	Sand, medium to very coarse, some gravel and silt; moderately sorted; dark yellowish orange (10YR 6/6).
280	310	Sand, medium to very coarse, with some gravel and silt; moderately sorted; angular to subrounded; dark yellowish orange (10YR 6/6).
310	320	Sand, medium to very coarse; moderately sorted; angular to rounded; abundant quartz and muscovite; grayish orange (10YR 7/4).
320	340	Gravelly sand, coarse to very coarse, with gravel, pebbles and granules; moderately sorted; angular to subrounded; dark yellowish orange (10YR 6/6).
340	360	Gravelly sand, coarse to very coarse, with gravel, pebbles and granules; moderately sorted; angular to subrounded; dark yellowish orange (10YR 6/6).
360	380	Gravelly sand, coarse to very coarse, with gravel and granules, moderately sorted; angular to subrounded; dark yellowish orange (10YR 6/6).
380	390	Gravelly sand, coarse to very coarse, with gravel and granules, moderately sorted; subrounded; moderate yellowish orange (10YR 5/4).
390	410	Sandy gravel, coarse to very coarse sand; pebbles and granules; moderately to poorly sorted; angular to subrounded; moderate yellowish brown (10YR 5/4).
410	440	Sand, coarse to very coarse, some gravel, trace-silt; moderately sorted; angular to subrounded; basalt clasts; moderate yellowish brown (10YR 5/4).
440	460	Sand, coarse to very coarse, with some gravel, trace silt; angular to subrounded; moderate yellowish brown (10YR 5/4).
460	480	Sand, coarse to very coarse, with some silt, some gravel; angular to subrounded; moderate yellowish brown (10YR 54).
480	500	Silty sand, fine to very coarse, with some gravel; poorly sorted; angular to subrounded; dark yellowish brown (10YR 4/20).
500	520	Sandy silt, fine to very coarse, with some clay; poorly sorted; angular to subrounded; moderate brown (5YR 3/4).
520	540	Silty sand, very fine to very coarse but skewed toward fine, with some clay; poorly sorted; angular to subrounded; light brown (5YR 6/4).

Table 12. Lithologic logs for multiple-well monitoring site: YEMRIV (9N/1E-16F1, -16F2, -16F3, -16F4)

[YEMRIV, name of local well. Altitude of land surface, approximately 1,950 feet. Depth is given in feet below land surface. Drilled by U.S. Geological Survey using mud rotary July 14–July 17, 1993. Soil and rock color are from Munsell Color (1975). Total depth drilled 422 feet. Screened intervals: 390-410, 320-340, 230-250, and 130-150 feet]

Depth From	Depth To	Description
Site YEMRIV (9N/1E-16F1, -16F2, -16F3, -16F4)		
Cuttings		
0	20	Sand and some gravel, very fine to very coarse sand, some granules and silt, with associated small pebbles; very poorly sorted; subrounded to angular; moderate yellowish brown (10YR 5/4).
20	40	Sand, with some granules and silt, occasional small pebbles; very poorly sorted; subrounded to subangular; dark yellowish brown (10YR 4/2).
40	60	Sand, very fine to very coarse, with gravel granules, and small pebbles some silt; very poorly sorted; subrounded to subangular; dark yellowish brown (10YR 4/2).
60	90	Sand, very fine to very coarse, with gravel, granules, and small pebbles; poorly sorted; subrounded to subangular; dark yellowish brown (10YR 4/2).
90	100	Gravel, granules to small pebbles, with some very fine to very coarse sand, and some silt and clay; very poorly sorted; subrounded to angular; dark yellowish brown (10YR 4/2).
100	120	Gravel, granules to small pebbles, with very fine to very coarse sand, and some silt and clay; very poorly sorted; subrounded to angular; dark yellowish brown (10YR 4/2).
120	140	Gravel, granules to small pebbles, with very fine to very coarse sand; very poorly sorted; subangular; moderate yellowish brown (10YR 5/4).
140	160	Sand, very coarse to very fine, with gravel, granules to small pebbles, and some silt; poorly sorted; subangular to subrounded; dark yellowish brown (10YR 4/2).
160	180	Sand, very coarse to very fine, with gravel, some granules to small pebbles, and some silt; poorly sorted; subangular to subrounded; dark yellowish brown (10YR 4/2).
180	200	Sand, fine to very coarse, with some silt; angular to rounded; moderate yellowish brown (10YR 5/4).
200	220	Sand, very fine to very coarse, and gravel, granules, to small pebbles, some silt; very poorly sorted; subangular to subrounded; dark yellowish brown (10YR 4/2).
220	235	Sand, very fine to very coarse, and gravel, granules to small pebbles, with some silt; very poorly sorted; subrounded to angular; dark yellowish brown; (10YR 4/2).

Table 12. Lithologic logs for multiple-well monitoring site: YEMRIV—*Continued*

Depth		
From	To	Description
235	265	Sand, very fine to very coarse with gravel, granules, and small pebbles, and silt; very poorly sorted; subrounded to angular; dark yellowish brown (10YR 4/2).
265	280	Gravel, granules to small pebbles, with very fine to very coarse sand, and some silt; very poorly sorted; angular to subrounded; dark yellowish brown (10YR 4/2).
280	300	Gravel, small pebbles to granules, with very fine to very coarse sand, and some silt; very poorly sorted; angular to subrounded; dark yellowish brown (10YR 4/2).
300	320	Gravel, and sand, very fine to very coarse, granules to small pebbles, with some silt; poorly sorted; subrounded to subangular; dark yellowish brown (10YR 4/2).
320	340	Sand, very fine to very coarse, with gravel, granules, and small pebbles; very poorly sorted; angular to subrounded; dark yellowish brown (10YR 4/2).
340	360	Sand, very fine to very coarse, and gravel, granules to small pebbles, with some silt; very poorly sorted; angular to subrounded; dark yellowish brown (10YR 4/2).
360	370	Gravel, granules to small pebbles, with some silt; very poorly sorted; angular to subrounded; dark yellowish brown (10YR 4/2).
370	400	Sand, very fine to very coarse, with granules to small pebbles, some clay; very poorly sorted; subangular to subrounded; moderate brown (10YR 4/4).
400	419.5	No sample collected. Logbook: Fractured rock with some hydrated clay matrix.
419.5	422	Core: Calcite cemented, sandy, silty, clay matrix, volcanic breccia.

Table 13. Lithologic logs for multiple-well monitoring site: CALFAN (10N/1E-20M1, -20M2)

[CALFAN, local well name. Altitude of land surface, approximately 2,090 feet. Depth is in feet below land surface. Drilled by U.S. Geological Survey using mud rotary, June 16–18, 1993. Soil and rock color are from Munsell Color (1975). Total depth 360 feet. Screened intervals: 340-350 and 265-285 feet]

Depth		Description
From	To	
Site CALFAN (10N/1E-20M1, -20M2)		
Cuttings		
0	20	Sand, fine to coarse, with granules and pebbles; poorly sorted; subangular to subrounded; rock fragments; moderate yellowish brown (10YR 5/4).
20	40	Sand, fine to coarse, with granules and pebbles; poorly sorted; subangular to subrounded; moderate yellowish brown (10YR 5/4).
40	60	Sand, fine to coarse, with granules and pebbles; poorly sorted; subangular to subrounded; moderate yellowish brown (10YR 5/4).
60	80	Sand, fine to coarse, with granules and pebbles; poorly sorted; subangular to subrounded; moderate yellowish brown (10YR 5/4).
80	100	Sand, fine to medium, with some garanules and pebbles; moderately sorted; subangular to subrounded; moderate yellowish brown (10YR 5/4).
100	120	Sand, fine to coarse, with granules and pebbles; poorly sorted; subangular to subrounded; moderate yellowish brown (10YR 5/4).
120	140	Sand, fine to coarse, with granules and pebbles; poorly sorted; subangular to subrounded; moderate yellowish brown (10YR 5/4).
140	160	Sand, fine to coarse, with granules and pebbles; poorly sorted; subangular to subrounded; moderate yellowish brown (10YR 5/4).
160	180	Sand, fine to coarse, with granules and pebbles; poorly sorted; subangular to subrounded; rock fragments, some mica; moderate yellowish brown (10YR 5/4).
180	280	Sand, fine to coarse, with granules and pebbles; poorly sorted; subangular to subrounded; moderate yellowish brown (10YR 5/4).
280	300	Sand, fine to coarse, with granules and pebbles and some clay; poorly sorted; subangular to subrounded; moderate yellowish brown (10YR 5/4).
300	320	Sand, fine to coarse, with clay and occasional pebbles; poorly sorted; subangular to subrounded; moderate yellowish brown (10YR 5/4).
320	340	Sand, fine to coarse, with clay and occasional pebbles; poorly sorted; subangular to subrounded; moderate yellowish brown (10YR 5/4).
340	360	Clay, with fine to coarse sand; moderate yellowish brown (10YR 5/4).

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