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Hydrogeologic Data and Water-Quality Data from a Thick Unsaturated Zone at a Proposed Wastewater-Treatment Facility Site, Yucca Valley, San Bernardino County, California, 2008–11

Data Series 925

U.S. Department of the Interior
U.S. Geological Survey

Cover. Pilot pond at sunset, San Bernardino County, California. Photography by Laurel Rogers, U.S. Geological Survey, 2008.

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SALLY JEWELL, Secretary

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Conversion Factors

Inch/Pound to SI

Multiply	By	To obtain
	Length	
inch (in.)	2.54	centimeter (cm)
inch (in.)	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
	Area	
square mile (mi^2)	259.0	hectare (ha)
square mile (mi^2)	2.590	square kilometer (km^2)
	Volume	
gallon (gal)	3.785	liter (L)
gallon (gal)	3.785	cubic decimeter (dm^3)
acre-foot (acre-ft)	1,233	cubic meter (m^3)
acre-foot (acre-ft)	0.001233	cubic hectometer (hm^3)
	Flow rate	
acre-foot per year (acre-ft/yr)	1,233	cubic meter per year (m^3/yr)
foot per day (ft/d)	0.3048	meter per day (m/d)
	Pressure	
Bar	100	kilopascal (kPa)
Bar	0.1	megapascal (Mpa)
	Radioactivity	
picocurie per liter (pCi/L)	0.037	becquerel per liter (Bq/L)

SI to Inch/Pound

Multiply	By	To obtain
	Length	
micrometer (µm)	0.00003937	inch (in.)
	Area	
square kilometer (km^2)	247.1	acre
square kilometer (km^2)	0.3861	square mile (mi^2)
	Volume	
cubic centimeter (cm^3)	0.06102	cubic inch (in^3)
microliter (µL)	0.00003382	ounce, fluid (fl. oz)
	Mass	
gram (g)	0.03527	ounce, avoirdupois (oz)
	Pressure	
kilopascal (kPa)	0.009869	atmosphere, standard (atm)
kilopascal (kPa)	0.01	bar

Conversion Factors—Continued

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as follows:

°F=(1.8×°C)+32

Vertical coordinate information is referenced to North American Vertical Datum of 1988 (NAVD 88).

Horizontal coordinate information is referenced to the North American Datum of 1983 (NAD 83).

Altitude, as used in this report, refers to distance above the vertical datum.

Land-surface datum (LSD) is a horizontal datum plane that is approximately at land surface in the vicinity of each well site.

Specific conductance (SC) is given in microsiemens per centimeter at 25 degrees Celsius (µS/cm at 25°C).

Concentrations of chemical constituents in water are given either in milligrams per liter (mg/L) or micrograms per liter (µg/L). Milligrams per liter is equivalent to parts per million (ppm) and micrograms per liter is equivalent to parts per billion (ppb). Activities for radiochemical constituents in water are given in picocuries per liter (pCi/L).

Abbreviations

bls	below land surface
HDWD	Hi-Desert Water District
YVUZ	Yucca Valley Unsaturated Zone
AT	advanced tensiometer
DEPS	dielectric permittivity sensor
EM	electromagnetic
MCL	maximum contaminant level (U.S. Environmental Protection Agency)
MPN	most probable number
NFM	National Field Manual
NWIS	National Water Information System (USGS)
NWQL	National Water Quality Laboratory, Denver, Colorado (USGS)
PVC	polyvinyl chloride
SC	specific conductance
STIL	Stable Isotope Laboratory, Reston, Virginia (USGS)
USGS	U.S. Geological Survey
$\delta^{i}E$	delta notation, the ratio of a heavier isotope of an element (^{i}E) to the more common lighter isotope of that element, relative to a standard reference, expressed as per mil (per thousand)

Acknowledgments

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Hydrogeologic Data and Water-Quality Data from a Thick Unsaturated Zone at a Proposed Wastewater-Treatment Facility Site, Yucca Valley, San Bernardino County, California, 2008–11

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Abstract

The Hi-Desert Water District, in the community of Yucca Valley, California, is considering constructing a wastewater-treatment facility and using the reclaimed water to recharge the aquifer system through surface spreading. The Hi-Desert Water District is concerned with possible effects of this recharge on water quality in the underlying groundwater system; therefore, an unsaturated-zone monitoring site was constructed by the U.S. Geological Survey (USGS) to characterize the unsaturated zone, monitor a pilot-scale recharge test, and, ultimately, to monitor the flow of reclaimed water to the water table once the treatment facility is constructed.

In June and July 2008, a borehole (YVUZ-5) was drilled by the USGS through the unsaturated zone in the vicinity of the proposed wastewater-treatment facility site by using an overburden drilling method. In addition to a variety of unsaturated-zone instrumentation, an observation well screened near the water table was installed in the borehole. The drilling procedures, lithologic and geophysical data, construction details, physical properties of unsaturated alluvial deposits, and instrumentation installed in YVUZ-5 are described in this report. Core material was analyzed for bulk-density, porosity, effective porosity, volumetric water content, residual water content, saturation, effective saturation, matric-potential, and saturated hydraulic conductivity. Concentrations of soluble anions, including bromide, chloride, fluoride, sulfate, nitrate, nitrite, phosphate, and orthophosphate, in unsaturated-zone sediment and dissolved in unsaturated-zone water were determined by analyzing water extracted from drill-cutting material. A 0.1-acre pilot-scale infiltration pond was constructed in the vicinity of YVUZ-5. Water was applied to the pond over a period of about 8 months and allowed to infiltrate into the underlying unsaturated zone. Data were collected on chemical and isotopic composition of the groundwater, unsaturated-zone water, and infiltration pond water before, during, and after infiltration of water from the constructed pond. Selected drill cuttings and core samples collected during drilling were analyzed for the presence or absence of denitrifying and nitrate-reducing bacteria.

Water levels in the observation well ranged from about 367 to 370 feet below land surface during the period of the study. Measured saturated hydraulic conductivity of core material ranged from 2.1 to 11.0 feet per day. Average vertical infiltration rates in the pilot-scale infiltration pond ranged from 0.7 to 2.4 feet per day. Both denitrifying and nitrate-reducing bacteria were present in drill cutting material in most probable numbers ranging from below detection limits to 2,400,000 for denitrifying and to 93,000 for nitrate-reducing bacteria.

Introduction

Residents and businesses in Yucca Valley, California, rely primarily on septic tanks to treat their wastewater (Nishikawa and others, 2003). Between 1995 and 2001, nitrate concentrations in parts of the groundwater system in the vicinity of Yucca Valley increased from less than the U.S. Environmental Protection Agency water-quality maximum contaminant level (MCL) of 10 milligrams per liter (mg/L) as nitrogen to levels higher than the MCL (Nishikawa and others, 2003). In 1997, the U.S. Geological Survey (USGS) began a cooperative study with Hi-Desert Water District (HDWD) to evaluate the effects of current and future recharge in the Warren subbasin. Nishikawa and others (2003) concluded that septic effluent was the primary source of nitrate to the groundwater system and that rising groundwater levels, resulting from an artificial-recharge program, entrained septic effluent with elevated nitrate concentrations in the unsaturated zone. HDWD is considering constructing a wastewater treatment facility, which would collect and treat a portion of wastewater generated within the water district (Hi-Desert Water District, 2012). The treated wastewater would then be reclaimed by surface spreading by using recharge ponds. The proposed location of the wastewater-treatment facility and recharge site is in the east hydrogeologic unit of the Warren subbasin (Nishikawa and others, 2003) at an elevation of about 3,200 feet above mean sea level (fig. 1). The east hydrogeologic unit is relatively undeveloped; the location of the proposed wastewater treatment facility was chosen, in part, in an effort to minimize the potential entrainment of septic effluent with elevated nitrate as a result of rising groundwater levels related to the treatment facility. An instrumented borehole (YVUZ-5) and an adjacent pilot-scale infiltration pond were installed by the USGS to aid in determining the suitability of the site for recharging treated wastewater generated by the proposed wastewater-treatment facility.

Hydrogeologic Setting

The study area is located in the Warren subbasin on the southern edge of the Mojave Desert about 100 miles (mi) east of Los Angeles, California, and is part of the Morongo groundwater basin (fig. 1; Nishikawa and others, 2003). The Warren subbasin, as described by Nishikawa and others (2003), is a modified version of the Warren Valley Groundwater Basin, as defined by the California Department of Water Resources (2004). The Warren subbasin is bordered on the north by the San Bernardino Mountains and the Pinto Mountain fault, on the south by the little San Bernardino Mountains, on the west by a natural topographic and groundwater divide, and on the east by a series of faults that make up the Yucca barrier, which was initially defined on the basis of water-level differences across the barrier as great as 400 ft (Lewis, 1972). The subbasin is about 19 square miles (mi^2), although the areal extent of the water-bearing deposits within the subbasin is estimated to be about 5.5 mi^2 (Nishikawa and others, 2003).

Extensive faulting has compartmentalized the subbasin into five hydrogeologic units: west, midwest, mideast, northeast, and east. The water-bearing units in the basin are the Quaternary alluvial deposits and the Tertiary sedimentary deposits. The Quaternary deposits are primarily composed of alluvial-fan deposits of sand and gravel and were divided into three aquifers (upper, middle, and lower) by Nishikawa and others (2003). The Tertiary deposits are referred to as the deep aquifer and are composed mainly of fanglomerates overlying a pre-Tertiary granitic and metamorphic basement complex (Nishikawa and others, 2003). This study focuses on the unsaturated zone and unconfined aquifer, which are within the Quaternary deposits.

The climate of the Warren subbasin is characterized by sunny days, low rainfall, hot summers, and relatively cool winters. For the years 1957 through 2010, the average annual precipitation was about 6.3 inches (in.) at Yucca Valley (Hi-Desert Water District, 2010); the majority of precipitation is lost through evapotranspiration (California Irrigation Management Information System, 2002).

The main source of natural recharge to the subbasin is from surficial and subsurface drainage along the bordering mountain fronts to the north and south. Lewis (1972) estimated this recharge to be less than 200 acre-feet per year (acre-ft/yr). Nishikawa and others (2003) subsequently estimated the average annual natural recharge to be about 83 acre-ft.

Sources of artificial recharge to the subbasin include septic-tank effluent, infiltration of irrigation-return water, and spreading of imported water in recharge ponds. Nishikawa and others (2003) estimated the quantity of recharge in the subbasin from septic-tank effluent and irrigation-return to be about 1,750 acre-feet (acre-ft) for 2001. From October 1994 through September 2010, more than 52,900 acre-ft of imported water (mean of 3,306 acre-ft/yr) was released into recharge ponds in the subbasin (Warren Valley Basin Watermaster, 2010).

Natural discharge from the Warren subbasin is in the form of groundwater outflow through the Yucca Barrier at the east end of the subbasin and is estimated to be about 84 acre-ft/yr (Nishikawa and others, 2003). Most of the groundwater discharged from the basin is through groundwater pumping. Pumpage in 2009–2010 was about 2,656 acre-ft; a total volume of about 36,096 acre-ft (mean of 2,256 acre-ft/yr) was pumped from the subbasin from 1994 through 2010 (Warren Valley Basin Watermaster, 2010).

Purpose and Scope

The purpose of this report is to present methods used and data collected from June 2008 to October 2011 as part of a cooperative study between the USGS and HDWD at unsaturated-zone monitoring site YVUZ-5 and the adjacent pilot-scale infiltration pond in the vicinity of the proposed wastewater treatment facility in Yucca Valley, California. The scope of the study included the installation of a water-table observation well and unsaturated-zone instrumentation, the construction of a 0.1-acre pilot-scale infiltration pond at the study site, and monitoring of the subsequent infiltration of water from the pond through the underlying unsaturated zone. This report presents the methods used for installing the borehole, observation well, and unsaturated-zone instrumentation and for monitoring the overlying pilot-scale infiltration pond. This report also presents the methods and results from the collection of hydrogeologic data (lithologic and geophysical data from the borehole and physical properties of the unsaturated zone material), pond infiltration data, and water-quality data (chemical composition, isotopic composition, and bacteria data) from selected environmental matrixes.

Site Names and Instrument-Numbering System

Several names were assigned to YVUZ-5 and to the instrumentation at the site, including a descriptive name, station name, and the USGS site identification number. The descriptive name (table 1, first column) begins with the acronym YVUZ; YV stands for Yucca Valley (the community in which the borehole is located), and UZ indicates the

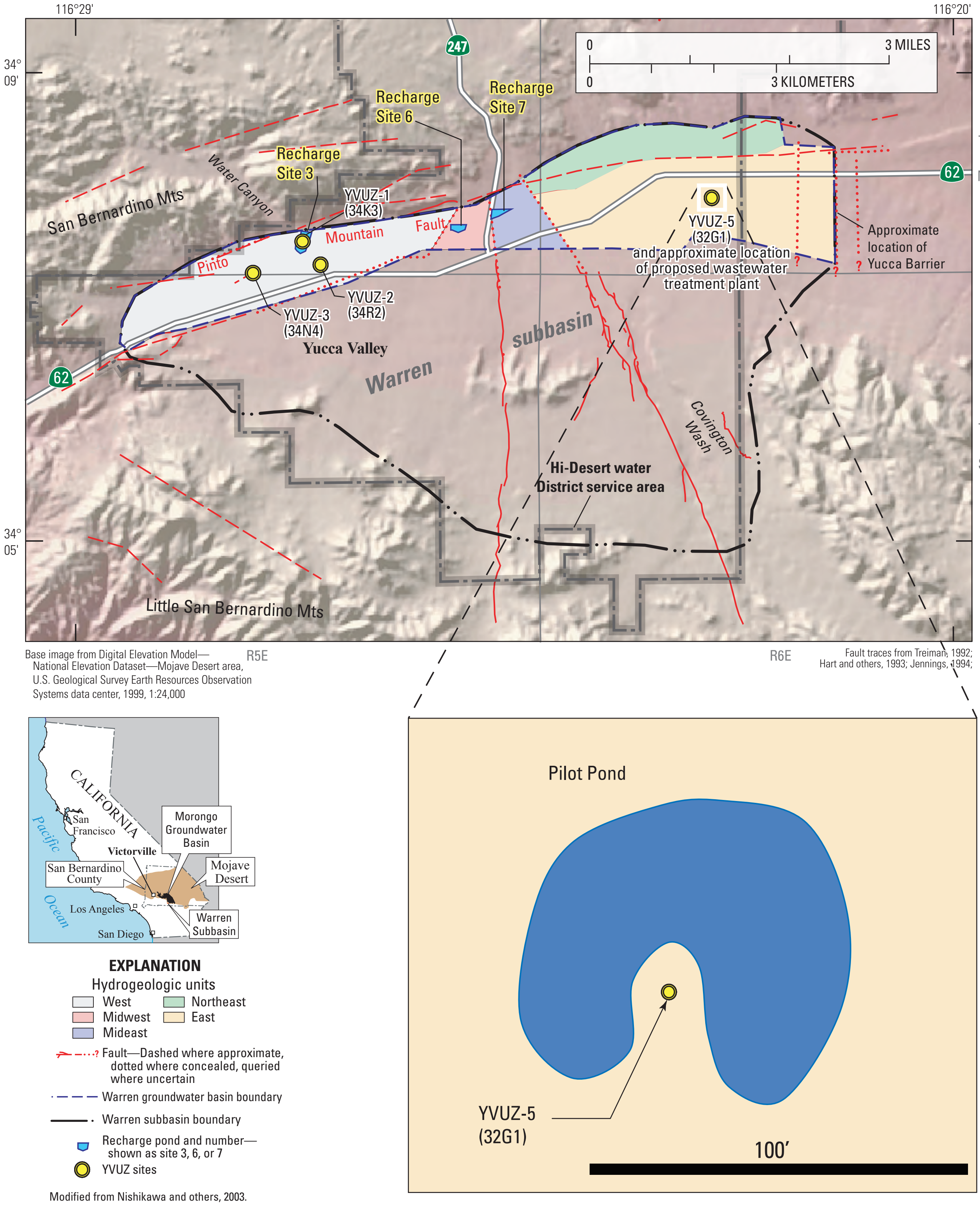


Figure 1. Location of study area, artificial recharge sites, and unsaturated-zone monitoring site YVUZ-5 (1N/6E-32G1-33S), Warren subbasin, San Bernardino County, California.

Table 1. Site name, instrument names and numbers, and description of instrumentation for unsaturated-zone monitoring site YVUZ-5 (1N/6E-32G1-33S), Warren subbasin, San Bernardino County, California.

[Site location is shown in figure 1. Depth below land surface; altitude of land surface datum is 3,195 feet above mean sea level. Station name, see well-numbering diagram (fig. 2) and explanation in text. **Abbreviations**: AT, advanced tensiometer; DEPS, dielectric permittivity sensor; ft, foot; GS, gas sampler; HDP, heat dissipation probe; LSD, land surface datum; LYS, suction-cup lysimeter; NR, near; USGS ID, U.S. Geological Survey identification number; WD, water district; @, at; ”, inch]

Descriptive name (number is depth below LSD)	Station name	Abbreviated station name	USGS ID	Description of instrumentation (number is depth below LSD)
		YVUZ-5		
YVUZ-5 2” WELL	001N006E32G001S	1N/6E-32G1	340751116222801	Well, perforated from 378 to 388 ft
YVUZ-5 LYS @ 391	001N006E32G002SLYS	1N/6E-32G2LYS	340751116222802	Suction-cup lysimeter at 391 ft
YVUZ-5 AT @ 368.5	001N006E32G AT @ 368.5FT	1N/6E-32G AT @ 368.5FT	340751116222803	Advanced tensiometer at 368.5 ft
YVUZ-5 LYS @ 368	001N006E32G003SLYS	1N/6E-32G3LYS	340751116222804	Suction-cup lysimeter at 368 ft
YVUZ-5 GS @ 367.5	001N006E32G GS @ 367.5FT	1N/6E-32G GS @ 367.5FT	340751116222805	Gas sampler at 367.5 ft
YVUZ-5 DEPS @ 331.5	001N006E32G DEPS @ 331.5FT	1N/6E-32G DEPS @ 331.5FT	340751116222806	Dielectric permittivity sensor at 331.5 ft
YVUZ-5 HDP @ 307.5	001N006E32G HDP @ 307.5FT	1N/6E-32G HDP @ 307.5FT	340751116222807	Heat dissipation probe at 307.5 ft
YVUZ-5 AT @ 293	001N006E32G AT @ 293FT	1N/6E-32G AT @ 293FT	340751116222808	Advanced tensiometer at 293 ft
YVUZ-5 LYS @ 292	001N006E32G004SLYS	1N/6E-32G4LYS	340751116222809	Suction-cup lysimeter at 292 ft
YVUZ-5 GS @ 291	001N006E32G GS @ 291FT	1N/6E-32G GS @ 291FT	340751116222810	Gas sampler at 291 ft
YVUZ-5 DEPS @ 290	001N006E32G DEPS @ 290FT	1N/6E-32G DEPS @ 290FT	340751116222811	Dielectric permittivity sensor at 290 ft
YVUZ-5 HDP @ 260	001N006E32G HDP @ 260FT	1N/6E-32G HDP @ 260FT	340751116222812	Heat dissipation probe at 260 ft
YVUZ-5 LYS @ 233	001N006E32G005SLYS	1N/6E-32G5LYS	340751116222813	Suction-cup lysimeter at 233 ft
YVUZ-5 GS @ 232	001N006E32G GS @ 232FT	1N/6E-32G GS @ 232FT	340751116222814	Gas sampler at 232 ft
YVUZ-5 DEPS @ 231	001N006E32G DEPS @ 231FT	1N/6E-32G DEPS @ 231FT	340751116222815	Dielectric permittivity sensor at 231 ft
YVUZ-5 HDP @ 231	001N006E32G HDP @ 231FT	1N/6E-32G HDP @ 231FT	340751116222816	Heat dissipation probe at 231 ft
YVUZ-5 HDP @ 203	001N006E32G HDP @ 203FT	1N/6E-32G HDP @ 203FT	340751116222817	Heat dissipation probe at 203 ft
YVUZ-5 HDP @ 165	001N006E32G HDP @ 165FT	1N/6E-32G HDP @ 165FT	340751116222818	Heat dissipation probe at 165 ft
YVUZ-5 LYS @ 143	001N006E32G006SLYS	1N/6E-32G6LYS	340751116222819	Suction-cup lysimeter at 143 ft
YVUZ-5 GS @ 142	001N006E32G GS @ 142FT	1N/6E-32G GS @ 142FT	340751116222820	Gas sampler at 142 ft
YVUZ-5 DEPS @ 141	001N006E32G DEPS @ 141FT	1N/6E-32G DEPS @ 141FT	340751116222821	Dielectric permittivity sensor at 141 ft
YVUZ-5 HDP @ 141	001N006E32G HDP @ 141FT	1N/6E-32G HDP @ 141FT	340751116222822	Heat dissipation probe at 141 ft
YVUZ-5 HDP @ 105	001N006E32G HDP @ 105FT	1N/6E-32G HDP @ 105FT	340751116222823	Heat dissipation probe at 105 ft
YVUZ-5 AT @ 87	001N006E32G AT @ 87FT	1N/6E-32G AT @ 87FT	340751116222824	Advanced tensiometer at 87 ft
YVUZ-5 LYS @ 86	001N006E32G007SLYS	1N/6E-32G7LYS	340751116222825	Suction-cup lysimeter at 86 ft
YVUZ-5 GS @ 85	001N006E32G GS @ 85FT	1N/6E-32G GS @ 85FT	340751116222826	Gas sampler at 85 ft
YVUZ-5 DEPS @ 84	001N006E32G DEPS @ 84FT	1N/6E-32G DEPS @ 84FT	340751116222827	Dielectric permittivity sensor at 84 ft
YVUZ-5 DEPS @ 65	001N006E32G DEPS @ 65FT	1N/6E-32G DEPS @ 65FT	340751116222828	Dielectric permittivity sensor at 65 ft
YVUZ-5 LYS @ 44	001N006E32G008SLYS	1N/6E-32G8LYS	340751116222829	Suction-cup lysimeter at 44 ft
YVUZ-5 GS @ 43	001N006E32G GS @ 43FT	1N/6E-32G GS @ 43FT	340751116222830	Gas sampler at 43 ft
YVUZ-5 DEPS @ 42	001N006E32G DEPS @ 42FT	1N/6E-32G DEPS @ 42FT	340751116222831	Dielectric permittivity sensor at 42 ft
YVUZ-5 HDP @ 42	001N006E32G HDP @ 42FT	1N/6E-32G HDP @ 42FT	340751116222832	Heat dissipation probe at 42 ft
YVUZ-5 DEPS @ 20	001N006E32G DEPS @ 20FT	1N/6E-32G DEPS @ 20FT	340751116222833	Dielectric permittivity sensor at 20 ft
		HI-DESERT WD RECHARGE PIPE A POND NR YUCCA VALLEY		
—	HI-DESERT WD RECHARGE PIPE A POND NR YUCCA VALLEY	—	340751116222834	Surface water at land-surface elevation (approximately)

borehole was established to study the unsaturated zone. Following YVUZ is a site number (5) and a code identifying the type of instrumentation and its depth: gas sampler (GS), suction-cup lysimeter (LYS), heat-dissipation probe (HDP), dielectric permittivity sensor (DEPS), advanced tensiometer (AT), or screened well sections (WELL). For example, "YVUZ-5 LYS @ 368" is a lysimeter 368 ft below land surface (bls) in the borehole for unsaturated-zone site number 5 located in the community of Yucca Valley.

Monitoring sites are also assigned a station name (table 1, second column) according to their location in the State Well Numbering System (California Department of Water Resources, 2000), which is based on the rectangular grid system for the subdivision of public lands (fig. 2). Identification—for example, "001N006E32G001S"—consists of the township number (001), north or south (N); the range number (006), east or west (E); the section number (32); the tract (G); the well sequence number (001); and the base line/meridian (S). 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 each tract, wells are sequentially numbered in the order they are inventoried. California has three base lines and meridians—Humboldt (H), Mount Diablo (M), and San Bernardino (S)—and all wells in the study area are referenced to the San Bernardino base line and meridian. The final component in the station name is a suffix identifying the type of instrumentation and depth of deployment in a similar manner as described above; for example, "001N006E32G AT @ 368.5FT." In portions of this report, the station name is abbreviated; for example, "001N006E32G001S" can be abbreviated as "1N/6E-32G1" (table 1, third column), which can be further abbreviated as "32G1."

Finally, each instrument at YVUZ-5 was assigned a 15-digit USGS site identification number. The first 13 digits of the identification number (3407511162228) are related to the site's location (latitude and longitude) and are the same for all instruments at the site: latitude degrees (two digits), minutes (two digits), and seconds (two digits); and longitude degrees (three digits), minutes (two digits), and seconds (two digits). The last two digits of the identification number are assigned to instruments sequentially from the bottom to the top of the borehole. The identification numbers at YVUZ-5 range from 340751116222801 through 340751116222833. These numbers are the primary identifier of site instrumentation within USGS databases. Details of site names and instruments are provided in table 1.

Drilling Procedures, Borehole Data Collection, and Site Construction

The unsaturated-zone monitoring site YVUZ-5 was installed in the vicinity of the proposed wastewater treatment facility (fig. 1) during June and July 2008. There are a total of 33 instruments at the site (including the observation well), labeled 1N/6E-32G1 through 1N/6E-32G33 and 340751116222801 through 340751116222833. YVUZ-5 was installed prior to the construction of the infiltration pond. The 15-digit USGS site identification number associated with samples collected from the recharge pond is 340751116222834.

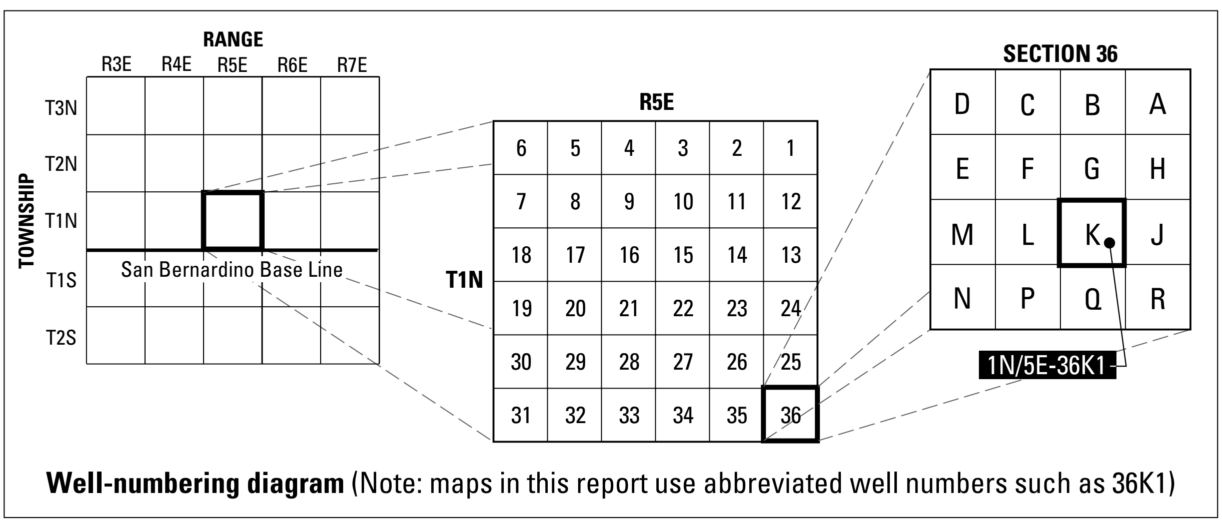


Figure 2. Well-numbering diagram.

Drilling Procedures

YVUZ-5 was drilled and constructed in cooperation with the USGS Western Research Drilling Operation by using an overburden drilling method referred to as the "ODEX" (overburden drilling by the excenter, which is Swedish for "eccentric") air hammer method, also known as the under-reamer method (Driscoll, 1986; Hammermeister and others, 1986). The ODEX method, which consists of a percussion hammer and an eccentric reamer at the end of a drill stem and a separate casing, allows the casing to follow the reamer downward as the borehole is drilled, preventing the hole from collapsing. The ODEX method was selected to minimize disturbance of the unsaturated material near the drill hole, to reduce potential contamination from drilling fluids, and to allow the collection of high-quality cuttings (fig. 3) and cores. Each night (and other times when drilling was not occurring), the ODEX casing was capped at the surface to prevent the movement of air into and out of the borehole. When the completion depth was reached (approximately 399 ft bls), the drill stem, percussion hammer, and reamer were pulled up through the casing, the instruments were installed, and then the casing was gradually pulled from the 8.875 in. diameter borehole as backfill materials were added around the instruements and the 2-inch-diameter observation well.

During drilling, materials from the borehole were discharged through a cyclone-style separator as a means of dissipating the force of the compressed air used in drilling (fig. 3). These borehole cuttings were collected by depth intervals in 5-gallon buckets. Sample collection was coordinated with drilling rates to allow collection of cuttings from discrete 1-ft increments. The cuttings were then immediately sub-sampled and placed in separate storage containers for water extractions, lithologic description, and archival purposes. For each of the sub-samples, the site name, date, time, and depth from which the cuttings originated were recorded. Cuttings for water extractions, lithologic description, and archival purposes were placed in individual plastic zipper storage bags labeled with the sample depth, date, and time of collection. Additional archival cuttings were also placed in plastic storage boxes with internal dividers.

Coring Procedures

Three sediment cores were collected during drilling at depths of 80–82.5, 200–202.5, and 240–242.5 ft bls. These depth intervals were selected on the basis of lithologic changes observed in borehole cuttings, particularly following a change in lithology from coarser-grained to finer-grained materials, since finer-grained materials have a higher potential to impede the vertical movement of water through the unsaturated zone. The 2.5-ft-long cores were collected by using a 4-inch-diameter piston-core barrel. Prior to collection, the core barrel was lined with four pre-cleaned 6-inch-long aluminum or brass core liners; in addition, the 6-inch long nose of the core barrel (the "shoe") was cleaned and flame-sterilized. The following procedures were performed immediately after each core was collected: (1) the core barrel was retrieved and disassembled; (2) the material in the shoe was collected and saved in a heat-sealable aluminum pouch (discussed below); (3) the core liners (containing the core) were extruded from the core barrel; (4) the core liners were capped with plastic end-caps containing filter paper (Whatman® Grade No. 42 ashless quantitative filter paper) to measure absorbed moisture, by following methods described by Campbell and Gee (1986), and then sealed with electrical tape; (5) the depth and vertical orientation of each core segment were recorded on the end-caps; (6) each core segment was wrapped in plastic and placed into a heat-sealable aluminum pouch; and (7) the site name, date, time, and depth of each core segment were recorded on the sealed pouch. Four pouches (one for each 6-in.-long core liner) were required for each core. Commercially available heat-sealable aluminum pouches were used to store core material because they were designed and tested to retain moisture in core material (Izbicki and others, 2000b).

Lithologic Log

A detailed lithologic log (at 1-ft intervals) was compiled from descriptions of drill cuttings and core material collected at YVUZ-5 (table 2). The lithologic log was based on preliminary field descriptions, which were later refined by using observations with a binocular microscope. In the field, subsamples of cuttings were laid out on the ground at 1-ft intervals in 10-ft long rows so that major lithologic changes could be identified as the drilling proceeded (fig. 4). Cuttings and core material were described in the field on the basis of texture (fig. 5; Folk, 1954), sorting, degree of rounding, color (Munsell, 1994), and other significant features (for example, significant changes in mineralogy). The drill cuttings were later examined under a binocular microscope to verify and amend the preliminary field descriptions by using the same descriptive criteria.

Field Measurement of Specific Conductance from Drill Cutting Extracts

In addition to lithologic data, soluble anions in sediment (and those dissolved in unsaturated-zone water) were determined in the field by measuring the specific conductance (SC) of a mixture consisting of de-ionized water and cutting materials obtained from 1-ft intervals (fig. 6). Cuttings from each interval were sieved through a 1-millimeter (mm) mesh-size sieve to obtain about 50 grams of material. The sieved sample was mixed with 50 milliliters (mL) of de-ionized water. The resulting mixture was shaken vigorously, allowed to settle, and the SC of the overlying extract was measured and recorded. These measurements indicate the relative abundance of soluble ions (including salts) in the sediment or dissolved in soil moisture.

Photograph by John Izbicki, U.S. Geological Survey, 2008.

Figure 3. Collection of ODEX cuttings from ‘cyclone’ discharge, unsaturated-zone monitoring site YVUZ-5 (1N/6E-32G1-33S), Warren subbasin, San Bernardino County, California, June 2008.

Table 2. Lithologic log for unsaturated-zone monitoring site YVUZ-5 (1N/6E-32G1-33S), Warren subbasin, San Bernardino County, California, June–July 2008.

[Site location shown in figure 1. Altitude of land surface, about 3,200 ft above vertical datum. Depth is in feet below land surface. Drilled by U.S. Geological Survey using ODEX, June 24, 2008–July 5, 2008. Total depth drilled: 399 ft. Construction and instrumentation information presented in table 1 and figure 6. Grain size abbreviation given in parentheses (Folk, 1954). Munsell notation of color given in parentheses following color name (Munsell, 1994); cutting colors identified as dry or moist. **Abbreviations**: ft, feet; mm, millimeter; SC, specific conductance; >, greater than; <, less than; =, equal; %, percent]

Depth (ft)		Description
From	To	
0	6	No sample collected
6	7	Silty sand (zS); very fine to very coarse sand and silt with some granules and pebbles <15 mm in diameter; poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry; plag, K-spar, quartz, biotite, accessory pyroxene/amphibole
7	8	Silty sand (zS); very fine to very coarse sand and silt with some granules and pebbles <15 mm in diameter; poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry; plag, K-spar, quartz, biotite, accessory pyroxene/amphibole, SC=150
8	9	Silty sand (zS); very fine to very coarse sand and silt with some granules and pebbles <15 mm in diameter; poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry; plag, K-spar, quartz, biotite, accessory pyroxene/amphibole, SC=133
9	10	Silty sand (zS); very fine to very coarse sand and silt with some granules and pebbles <15 mm in diameter; poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry; plag, K-spar, quartz, biotite, accessory pyroxene/amphibole, SC=146
10	11	Silty sand (zS); very fine to very coarse sand and silt with some granules and pebbles <15 mm in diameter; poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry; plag, K-spar, quartz, biotite, accessory pyroxene/amphibole, SC=161
11	12	Silty sand (zS); very fine to very coarse sand and silt with some granules and pebbles <15 mm in diameter; poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry; 10 mm Biotite (>60%), plag tonalite, pebble (dark, no quartz) , SC=157
12	13	Silty sand (zS); very fine to very coarse sand and silt with some granules and pebbles <15 mm in diameter; poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=144
13	14	Silty sand (zS); very fine to very coarse sand and silt with some granules; moderately sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=162
14	15	Silty sand (zS); very fine to very coarse sand and silt with some granules and pebbles <15 mm in diameter; poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry; sample in boxes is coarser (more granules) than adjacent samples, SC=152
15	16	Silty sand (zS); very fine to very coarse sand and silt with some granules; moderately sorted; angular to subangular; light brownish gray (10YR 6/2); dry; higher % silt than previous, SC=185
16	17	Silty sand (zS); very fine to very coarse sand and silt with some granules; poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=178
17	18	Silty sand (zS); very fine to very coarse sand and silt with some granules; moderately sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=250
18	19	Silty sand (zS); very fine to very coarse sand and silt with some granules; moderately sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=246
19	20	Silty sand (zS); very fine to very coarse sand and silt with some granules; moderately sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=222
20	21	Silty sand (zS); very fine to very coarse sand and silt with some granules and pebbles <15 mm in diameter; poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=240
21	22	Silty sand (zS); very fine to very coarse sand and silt with some granules; moderately sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=142
22	23	Silty sand (zS); very fine to very coarse sand and silt with some granules; moderately sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=158
23	24	Gravelly silty sand (gzS); very fine to very coarse sand and silt with some granules and <30% pebbles <25 mm in diameter; very poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=155
24	25	Silty sand (zS); very fine to very coarse sand and silt with some granules and pebbles <15 mm in diameter; poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=282
25	26	Gravelly silty sand (gzS); very fine to very coarse sand and silt with some granules and <30% pebbles <25 mm in diameter; very poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=272
26	27	Silty sand (zS); very fine to very coarse sand and silt with some granules; moderately sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=250
27	28	Gravelly silty sand (gzS); very fine to very coarse sand and silt with some granules and <30% pebbles <25 mm in diameter; very poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=242
28	29	Silty sand (zS); very fine to very coarse sand and silt with some granules; moderately sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=213
29	30	Silty sand (zS); very fine to very coarse sand and silt with some granules; moderately sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=258

Table 2. Lithologic log for unsaturated-zone monitoring site YVUZ-5 (1N/6E-32G1-33S), Warren subbasin, San Bernardino County, California, June–July 2008.—Continued

[Site location shown in figure 1. Altitude of land surface, about 3,200 ft above vertical datum. Depth is in feet below land surface. Drilled by U.S. Geological Survey using ODEX, June 24, 2008–July 5, 2008. Total depth drilled: 399 ft. Construction and instrumentation information presented in table 1 and figure 6. Grain size abbreviation given in parentheses (Folk, 1954). Munsell notation of color given in parentheses following color name (Munsell, 1994); cutting colors identified as dry or moist. **Abbreviations**: ft, feet; mm, millimeter; SC, specific conductance; >, greater than; <, less than; =, equal; %, percent]

Depth (ft)		Description
From	To	
30	31	Silty sand (zS); very fine to very coarse sand and silt with some granules; moderately sorted; angular to subangular; light brownish gray (10YR 6/2);dry, SC=249
31	32	Silty sand (zS); very fine to very coarse sand and silt with some granules; moderately sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=363
32	33	Silty sand (zS); very fine to very coarse sand and silt with some granules; poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=304
33	34	Silty sand (zS); very fine to very coarse sand and silt with some granules; moderately sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=306
34	35	Silty sand (zS); very fine to very coarse sand and silt with some granules; moderately sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=12
35	36	Silty sand (zS); very fine to very coarse sand and silt with some granules and pebbles <10 mm in diameter; moderately sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=374
36	37	Gravelly silty sand (gzS); very fine to very coarse sand and silt with some granules and pebbles <25 mm in diameter; very poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=338
37	38	Silty sand (zS); very fine to very coarse sand and silt with some granules and pebbles <10 mm in diameter; moderately sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=334
38	39	Silty sand (zS); very fine to very coarse sand and silt with some granules and pebbles <10 mm in diameter; moderately sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=337
39	40	Silty sand (zS); very fine to very coarse sand and silt with some granules and pebbles <10 mm in diameter; moderately sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=187
40	41	Sandy silt (sZ); silt and very fine to coarse sand with some granules; moderately sorted; light brownish gray (10YR 6/2); dry; >30 mm caliche pebbles, SC=430
41	42	Sandy silt (sZ); silt and very fine to coarse sand with some granules; moderately sorted; light brownish gray (10YR 6/2); dry; >30 mm caliche pebble, possibly from the casing; <30 mm tonalite pebble, SC=186
42	43	Sandy silt (sZ); silt and very fine to medium sand with some coarse sand and granules; moderately sorted; light brownish gray (10YR 6/2); dry; >30 mm caliche pebble, possibly from the casing; 15 mm granite/quartz-rich granite pebble, SC=342
43	44	Sandy silt (sZ); silt and very fine to coarse sand with some granules and pebbles; moderately sorted; light brownish gray (10YR 6/2); dry; >30 mm caliche pebble, possibly from the casing; 30 mm granite pebble, SC=406
44	45	Silty sand (zS); very fine to very coarse sand and silt with some granules and pebbles <10 mm in diameter; poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=346
45	46	Silty sand (zS); very fine to very coarse sand and silt with some granules and pebbles <10 mm in diameter; poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=294
46	47	Silty sand (zS); very fine to very coarse sand and silt with some granules and pebbles <10 mm in diameter; poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=304
47	48	Silty sand (zS); very fine to very coarse sand and silt with some granules and pebbles <10 mm in diameter; very poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=304
48	49	Sand (S); very fine to very coarse sand with granules and some silt; poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=172
49	50	Silty sand (zS); very fine to very coarse sand and silt with some granules and pebbles <20 mm in diameter; poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=209
50	51	Silty sand (zS); very fine to very coarse sand and silt with some granules and pebbles <10 mm in diameter; poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=214
51	52	Gravelly silty sand (gzS); very fine to very coarse sand and silt with some granules and <30% pebbles <25 mm in diameter; very poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=197
52	53	Gravelly silty sand (gzS); very fine to very coarse sand and silt with some granules and <30% pebbles <25 mm in diameter; very poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=194
53	54	Silty sand (zS); very fine to very coarse sand and silt with some granules; poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=170
54	55	Silty sand (zS); very fine to very coarse sand and silt with some granules and pebbles <10 mm in diameter; poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=170
55	56	Silty sand (zS); very fine to very coarse sand and silt with some granules and pebbles <10 mm in diameter; poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=180

Table 2. Lithologic log for unsaturated-zone monitoring site YVUZ-5 (1N/6E-32G1-33S), Warren subbasin, San Bernardino County, California, June–July 2008.—Continued

[Site location shown in figure 1. Altitude of land surface, about 3,200 ft above vertical datum. Depth is in feet below land surface. Drilled by U.S. Geological Survey using ODEX, June 24, 2008–July 5, 2008. Total depth drilled: 399 ft. Construction and instrumentation information presented in table 1 and figure 6. Grain size abbreviation given in parentheses (Folk, 1954). Munsell notation of color given in parentheses following color name (Munsell, 1994); cutting colors identified as dry or moist. **Abbreviations**: ft, feet; mm, millimeter; SC, specific conductance; >, greater than; <, less than; =, equal; %, percent]

Depth (ft)		Description
From	To	
56	57	Silty sand (zS); very fine to very coarse sand and silt with some granules and pebbles <10 mm in diameter; poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=223
57	58	Silty sand (zS); very fine to very coarse sand and silt with some granules and pebbles <10 mm in diameter; poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=224
58	59	Silty sand (zS); very fine to very coarse sand and silt; moderately sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=218
59	60	Silty sand (zS); very fine to very coarse sand and silt with some granules; poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=109
60	61	Silty sand (zS); very fine to very coarse sand and silt with some granules; poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=117
61	62	Silty sand (zS); very fine to very coarse sand and silt with some granules; poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=110
62	63	Silty sand (zS); very fine to very coarse sand and silt with some granules; poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=101
63	64	Silty sand (zS); very fine to very coarse sand and silt with some granules and pebbles <10 mm in diameter; very poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=81
64	65	Silty sand (zS); very fine to very coarse sand and silt with some granules and pebbles <10 mm in diameter; very poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=85
65	66	Silty sand (zS); very fine to very coarse sand and silt with some granules and pebbles <10 mm in diameter; very poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=70
66	67	Silty sand (zS); very fine to very coarse sand and silt with some granules and pebbles <10 mm in diameter; very poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=77
67	68	Silty sand (zS); very fine to very coarse sand and silt with some granules; poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=78
68	69	Silty sand (zS); very fine to very coarse sand and silt with some granules; poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=65
69	70	Silty sand (zS); very fine to very coarse sand and silt with some granules and pebbles <10 mm in diameter; very poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=63
70	71	Silty sand (zS); very fine to very coarse sand and silt with some granules and pebbles <10 mm in diameter; very poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=67
71	72	Silty sand (zS); very fine to very coarse sand and silt with some granules and pebbles <10 mm in diameter; very poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=59
72	73	Silty sand (zS); very fine to very coarse sand and silt with some granules and pebbles <10 mm in diameter; very poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=61
73	74	Silty sand (zS); very fine to very coarse sand and silt with some granules and pebbles <10 mm in diameter; very poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=27
74	75	Silty sand (zS); very fine to very coarse sand and silt with some granules and pebbles <10 mm in diameter; very poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=55
75	76	Silty sand (zS); very fine to very coarse sand and silt with some granules and pebbles <10 mm in diameter; very poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=40
76	77	Silty sand (zS); very fine to very coarse sand and silt with some granules; poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=34
77	78	Silty sand (zS); very fine to very coarse sand and silt; moderately sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=34
78	79	Silty sand (zS); very fine to very coarse sand and silt; moderately sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=41
79	80	Gravelly silty sand (gzS); very fine to very coarse sand and silt with some granules and <30% pebbles <25 mm in diameter; very poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=186
80	81	Silty sand (zS); very fine to very coarse sand and silt with some granules and pebbles <10 mm in diameter; very poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=267
81	82	Silty sand (zS); very fine to very coarse sand and silt with some granules and pebbles <10 mm in diameter; very poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=172

Table 2. Lithologic log for unsaturated-zone monitoring site YVUZ-5 (1N/6E-32G1-33S), Warren subbasin, San Bernardino County, California, June–July 2008.—Continued

[Site location shown in figure 1. Altitude of land surface, about 3,200 ft above vertical datum. Depth is in feet below land surface. Drilled by U.S. Geological Survey using ODEX, June 24, 2008–July 5, 2008. Total depth drilled: 399 ft. Construction and instrumentation information presented in table 1 and figure 6. Grain size abbreviation given in parentheses (Folk, 1954). Munsell notation of color given in parentheses following color name (Munsell, 1994); cutting colors identified as dry or moist. **Abbreviations**: ft, feet; mm, millimeter; SC, specific conductance; >, greater than; <, less than; =, equal; %, percent]

Depth (ft) From	Depth (ft) To	Description
82	83	Sandy silt (sZ); silt and very fine to coarse sand with some granules; moderately sorted; light brownish gray (10YR 6/2); dry, SC=102
83	84	Sandy silt (sZ); silt and very fine to coarse sand with some granules; moderately sorted; light brownish gray (10YR 6/2); dry, SC=93
84	85	Silty sand (zS); very fine to very coarse sand and silt with some granules and pebbles <10 mm in diameter; very poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=91
85	86	Silty sand (zS); very fine to very coarse sand and silt with some granules and pebbles <10 mm in diameter; very poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=144
86	87	Sandy silt (sZ); silt and very fine to coarse sand with some granules; well sorted; yellowish brown (10YR 5/6); dry; possible paleosol, SC=132
87	88	Sandy silt (sZ); silt and very fine to coarse sand with some granules; well sorted; yellowish brown (10YR 5/6); dry, SC=115
88	89	Sandy silt (sZ); silt and very fine to coarse sand with some granules; well sorted; yellowish brown (10YR 5/6); dry, SC=56
89	90	Sandy silt (sZ); silt and very fine to coarse sand with some granules; moderately sorted; light yellowish brown (10YR 6/4); dry, SC=167
90	91	Sandy silt (sZ); silt and very fine to coarse sand with some granules; moderately sorted; dark greenish yellow (10Y 6/6); dry, SC=35
91	92	Sandy silt (sZ); silt and very fine to coarse sand with some granules and gravels to 25 mm; poorly sorted; pale brown (10YR 6/3); dry, SC=67
92	93	Slightly gravelly sandy silt ((g)sZ); silt and very fine to coarse sand with some granules and gravels to 25 mm; poorly sorted; light brownish gray (10YR 6/2); dry, SC=47
93	94	Silty sand (zS); very fine to very coarse sand and silt with some granules and pebbles <20 mm in diameter; very poorly sorted; angular to subangular; pale brown (10YR 6/3); dry, SC=57
94	95	Silty sand (zS); very fine to very coarse sand and silt with some granules and pebbles <20 mm in diameter; very poorly sorted; angular to subangular; pale brown (10YR 6/3); dry, SC=68
95	96	Silty sand (zS); very fine to very coarse sand and silt with some granules and pebbles <10 mm in diameter; poorly sorted; angular to subangular; pale brown (10YR 6/3); dry, SC=37
96	97	Silty sand (zS); very fine to very coarse sand and silt with some granules and pebbles <10 mm in diameter; very poorly sorted; angular to subangular; pale brown (10YR 6/3); dry, SC=21
97	98	Silty sand (zS); very fine to very coarse sand and silt with some granules and pebbles <10 mm in diameter; very poorly sorted; angular to subangular; pale brown (10YR 6/3); dry, SC=26
98	99	Silty sand (zS); very fine to very coarse sand and silt with some granules and pebbles <10 mm in diameter; very poorly sorted; angular to subangular; pale brown (10YR 6/3); dry, SC=38
99	100	Sandy silt (sZ); silt and very fine to coarse sand with some granules and gravels to 25 mm; poorly sorted; light yellowish brown (10YR 6/4); dry, SC=39
100	101	Sandy silt (sZ); silt and very fine to coarse sand with some granules and gravels to 25 mm; poorly sorted; light yellowish brown (10YR 6/4); dry, SC=38
101	102	Sand (S); very fine to very coarse sand with granules and some silt and pebbles <10 mm in diameter; poorly sorted; angular to subangular; pale brown (10YR 6/3); dry, SC=42
102	103	Silty sand (zS); very fine to very coarse sand and silt with some granules and pebbles <30 mm in diameter; very poorly sorted; angular to subangular; pale brown (10YR 6/3); dry, SC=53
103	104	Sandy silt (sZ); silt and very fine to coarse sand with some granules and gravels to 10 mm; well sorted; pale brown (10YR 6/3); dry, SC=53
104	105	Silty sand (zS); very fine to very coarse sand and silt with some granules and pebbles <10 mm in diameter; poorly sorted; angular to subangular; pale brown (10YR 6/3); dry, SC=605
105	106	Silty sand (zS); very fine to very coarse sand and silt with some granules and pebbles <10 mm in diameter; moderately sorted; angular to subangular; pale brown (10YR 6/3); dry, SC=289
106	107	Silty sand (zS); very fine to very coarse sand and silt with some granules and pebbles <10 mm in diameter; moderately sorted; angular to subangular; pale brown (10YR 6/3); dry, SC=90
107	108	Silty sand (zS); very fine to very coarse sand and silt with some granules and pebbles <10 mm in diameter; moderately sorted; angular to subangular; pale brown (10YR 6/3); dry, SC=127

Table 2. Lithologic log for unsaturated-zone monitoring site YVUZ-5 (1N/6E-32G1-33S), Warren subbasin, San Bernardino County, California, June–July 2008.—Continued

[Site location shown in figure 1. Altitude of land surface, about 3,200 ft above vertical datum. Depth is in feet below land surface. Drilled by U.S. Geological Survey using ODEX, June 24, 2008–July 5, 2008. Total depth drilled: 399 ft. Construction and instrumentation information presented in table 1 and figure 6. Grain size abbreviation given in parentheses (Folk, 1954). Munsell notation of color given in parentheses following color name (Munsell, 1994); cutting colors identified as dry or moist. **Abbreviations**: ft, feet; mm, millimeter; SC, specific conductance; >, greater than; <, less than; =, equal; %, percent]

Depth (ft)		Description
From	To	
108	109	Sandy silt (sZ); silt and very fine to coarse sand with some granules and gravels to 10 mm; well sorted; pale brown (10YR 6/3); dry, SC=81
109	110	Sandy silt (sZ); silt and very fine to coarse sand with some granules and gravels to 10 mm; moderately sorted; pale brown (10YR 6/3); dry, SC=50
110	111	Silty sand (zS); very fine to very coarse sand and silt with some granules and pebbles <10 mm in diameter; moderately sorted; angular to subangular; pale brown (10YR 6/3); dry, SC=56
111	112	Silty sand (zS); very fine to very coarse sand and silt with some granules and pebbles <10 mm in diameter; moderately sorted; angular to subangular; pale brown (10YR 6/3); dry, SC=52
112	113	Silty sand (zS); very fine to very coarse sand and silt with some granules and pebbles <10 mm in diameter; moderately sorted; angular to subangular; pale brown (10YR 6/3); dry, SC=40
113	114	Silty sand (zS); very fine to very coarse sand and silt with some granules and pebbles <10 mm in diameter; very poorly sorted; angular to subangular; pale brown (10YR 6/3); dry, SC=31
114	115	Gravelly silty sand (gzS); very fine to very coarse sand and silt with some granules and <30% pebbles <25 mm in diameter; very poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=32
115	116	Gravelly silty sand (gzS); very fine to very coarse sand and silt with some granules and <30% pebbles <25 mm in diameter; very poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=27
116	117	Silty sand (zS); very fine to coarse sand and silt; well sorted; angular to subangular; pale brown (10YR 6/3); dry, SC=37
117	118	Silty sand (zS); very fine to coarse sand and silt with occasional granules; well sorted; angular to subangular; pale brown (10YR 6/3); dry, SC=40
118	119	Silty sand (zS); very fine to coarse sand and silt with occasional pebble <20 mm in diameter; well sorted; angular to subangular; pale brown (10YR 6/3); dry, SC=32
119	120	Silty sand (zS); very fine to very coarse sand and silt with occasional pebble <20 mm in diameter; moderately sorted; angular to subangular; pale brown (10YR 6/3); dry, SC=262
120	121	Silty sand (zS); very fine to very coarse sand and silt with occasional pebble <20 mm in diameter; poorly sorted; angular to subangular; pale brown (10YR 6/3); dry, SC=77
121	122	Silty sand (zS); very fine to very coarse sand and silt with occasional pebble <10 mm in diameter; moderately sorted; angular to subangular; pale brown (10YR 6/3); dry, SC=120
122	123	Sandy silt (sZ); silt and very fine to coarse sand; well sorted; light yellowish brown (10YR 6/4); dry, SC=80
123	124	Sandy silt (sZ); silt and very fine to coarse sand with granules; moderately sorted; pale brown (10YR 6/3); dry, SC=90
124	125	Sandy silt (sZ); silt and very fine to coarse sand; moderately sorted; pale brown (10YR 6/3); dry, SC=73
125	126	Silty sand (zS); very fine to very coarse sand and silt with some granules and pebbles <20 mm in diameter; very poorly sorted; angular to subangular; pale brown (10YR 6/3); dry, SC=74
126	127	Silty sand (zS); very fine to very coarse sand and silt with some granules and pebbles <20 mm in diameter; very poorly sorted; angular to subangular; pale brown (10YR 6/3); dry, SC=39
127	128	Silty sand (zS); very fine to very coarse sand and silt with some granules and pebbles <20 mm in diameter; very poorly sorted; angular to subangular; pale brown (10YR 6/3); dry, SC=42
128	129	Silty sand (zS); very fine to very coarse sand and silt with some granules and pebbles <20 mm in diameter; very poorly sorted; angular to subangular; pale brown (10YR 6/3); dry, SC=31
129	130	Silty sand (zS); very fine to very coarse sand and silt with some granules and pebbles <20 mm in diameter; very poorly sorted; angular to subangular; pale brown (10YR 6/3); dry, SC=37
130	131	Silty sand (zS); very fine to very coarse sand and silt with some granules and pebbles <20 mm in diameter; very poorly sorted; angular to subangular; pale brown (10YR 6/3); dry, SC=27
131	132	Silty sand (zS); very fine to very coarse sand and silt with some granules and pebbles <20 mm in diameter; very poorly sorted; angular to subangular; pale brown (10YR 6/3); dry, SC=21
132	133	Silty sand (zS); very fine to very coarse sand and silt with some granules and pebbles <20 mm in diameter; very poorly sorted; angular to subangular; pale brown (10YR 6/3); dry, SC=25
133	134	Silty sand (zS); very fine to coarse sand and silt with some very coarse sand to pebbles <20 mm in diameter; moderately sorted; angular to subangular; pale brown (10YR 6/3); dry, SC=43
134	135	Silty sand (zS); very fine to coarse sand and silt with some very coarse sand to pebbles <20 mm in diameter; moderately sorted; angular to subangular; pale brown (10YR 6/3); dry, SC=27

Table 2. Lithologic log for unsaturated-zone monitoring site YVUZ-5 (1N/6E-32G1-33S), Warren subbasin, San Bernardino County, California, June–July 2008.—Continued

[Site location shown in figure 1. Altitude of land surface, about 3,200 ft above vertical datum. Depth is in feet below land surface. Drilled by U.S. Geological Survey using ODEX, June 24, 2008–July 5, 2008. Total depth drilled: 399 ft. Construction and instrumentation information presented in table 1 and figure 6. Grain size abbreviation given in parentheses (Folk, 1954). Munsell notation of color given in parentheses following color name (Munsell, 1994); cutting colors identified as dry or moist. **Abbreviations**: ft, feet; mm, millimeter; SC, specific conductance; >, greater than; <, less than; =, equal; %, percent]

Depth (ft)		Description
From	To	
135	136	Silty sand (zS); very fine to very coarse sand and silt with some granules and pebbles <20 mm in diameter; very poorly sorted; angular to subangular; pale brown (10YR 6/3); dry, SC=31
136	137	Silty sand (zS); very fine to very coarse sand and silt with some granules and pebbles <20 mm in diameter; very poorly sorted; angular to subangular; pale brown (10YR 6/3); dry, SC=28
137	138	Silty sand (zS); very fine to very coarse sand and silt with some granules and pebbles <20 mm in diameter; very poorly sorted; angular to subangular; pale brown (10YR 6/3); dry, SC=22
138	139	Sandy silt (sZ); silt and very fine to coarse sand with some granules; well sorted; pale brown (10YR 6/3); dry, SC=44
139	140	Sandy silt (sZ); silt and very fine to coarse sand with some granules; moderately sorted; light yellowish brown (10YR 6/4); dry, SC=244
140	141	Sandy silt (sZ); silt and very fine to coarse sand with some granules; moderately sorted; light yellowish brown (10YR 6/4); dry; SC=77
141	142	Sandy silt (sZ); silt and very fine to coarse sand with some granules; moderately sorted; yellowish brown (10YR 5/4); dry; SC=171
142	143	Silty sand (zS); very fine to very coarse sand and silt with some granules; poorly sorted; angular to subangular; brown (10YR 5/3); dry, SC=534
143	144	Sandy silt (sZ); silt and very fine to coarse sand with some granules; moderately sorted; yellowish brown (10YR 5/4); dry; SC=440
144	145	Silty sand (zS); very fine to very coarse sand and silt with some granules; very poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=36
145	146	Silty sand (zS); very fine to very coarse sand and silt with some granules; very poorly sorted; angular to subangular; light brownish gray (10YR 6/2)’ dry, SC=90
146	147	Silty sand (zS); very fine to very coarse sand and silt with some granules; very poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=112
147	148	Silty sand (zS); fine to coarse sand and silt with some granules; poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=81
148	149	Sand (S); fine to very coarse sand with some silt to fine sand and some granules; very poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=75
149	150	Sandy silt (sZ); silt and very fine to coarse sand with some granules; moderately sorted; light brownish gray (10YR 6/2); dry; SC=33
150	151	Sandy silt (sZ); silt and very fine to coarse sand with some granules; moderately sorted; light brownish gray (10YR 6/2); dry; SC=57
151	152	Sandy silt (sZ); silt and very fine to coarse sand with some granules and pebbles <25 mm in diameter; moderately sorted; light brownish gray (10YR 6/2); dry; SC=54
152	153	Silty sand (zS); very fine to very coarse sand and silt with some granules; poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=47
153	154	Silty sand (zS); very fine to very coarse sand and silt with some granules; moderately sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=59
154	155	Silty sand (zS); very fine to very coarse sand and silt with some granules; moderately sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=43
155	156	Silty sand (zS); very fine to very coarse sand and silt with some granules; moderately sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=49
156	157	Silty sand (zS); very fine to very coarse sand and silt with some granules; moderately sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=39
157	158	Sandy silt (sZ); silt and very fine to coarse sand with some granules; moderately sorted; brown (10YR 5/3); dry; SC=41
158	159	Silty sand (zS); very fine to very coarse sand and silt with some granules; moderately sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=28
159	160	Silty sand (zS); very fine to very coarse sand and silt with some granules; moderately sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=29
160	161	Silty sand (zS); very fine to very coarse sand and silt with some granules and pebbles <10 mm in diameter; very poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=59
161	162	Sandy silt (sZ); silt and very fine to coarse sand; moderately sorted; light brownish gray (10YR 6/2); dry; SC=30

Table 2. Lithologic log for unsaturated-zone monitoring site YVUZ-5 (1N/6E-32G1-33S), Warren subbasin, San Bernardino County, California, June–July 2008.—Continued

[Site location shown in figure 1. Altitude of land surface, about 3,200 ft above vertical datum. Depth is in feet below land surface. Drilled by U.S. Geological Survey using ODEX, June 24, 2008–July 5, 2008. Total depth drilled: 399 ft. Construction and instrumentation information presented in table 1 and figure 6. Grain size abbreviation given in parentheses (Folk, 1954). Munsell notation of color given in parentheses following color name (Munsell, 1994); cutting colors identified as dry or moist. **Abbreviations**: ft, feet; mm, millimeter; SC, specific conductance; >, greater than; <, less than; =, equal; %, percent]

Depth (ft)		Description
From	To	
162	163	Sandy silt (sZ); silt and very fine to coarse sand; moderately sorted; light brownish gray (10YR 6/2); dry; SC=51
163	164	Silty sand (zS); very fine to very coarse sand and silt with some granules; moderately sorted; angular to subangular; pale brown (10YR 6/3); dry, SC=34
164	165	Silty sand (zS); very fine to very coarse sand and silt with some granules; moderately sorted; angular to subangular; pale brown (10YR 6/3); dry, SC=31
165	166	Silty sand (zS); very fine to very coarse sand and silt with some granules; poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=34
166	167	Silty sand (zS); very fine to very coarse sand and silt with some granules and pebbles <30 mm in diameter; poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=34
167	168	Silty sand (zS); very fine to very coarse sand and silt with some granules and pebbles <30 mm in diameter; poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=42
168	169	Silty sand (zS); very fine to very coarse sand and silt with some granules and pebbles <30 mm in diameter; poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=40
169	170	Silty sand (zS); very fine to coarse sand and silt; moderately sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=41
170	171	Silty sand (zS); very fine to very coarse sand and silt with some granules and pebbles <30 mm in diameter; poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=19
171	172	Silty sand (zS); very fine to very coarse sand and silt with some granules and pebbles <30 mm in diameter; poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=20
172	173	Silty sand (zS); very fine to very coarse sand and silt with some granules and pebbles <30 mm in diameter; poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=22
173	174	Silty sand (zS); very fine to very coarse sand and silt with some granules and pebbles <30 mm in diameter; poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=30
174	175	Silty sand (zS); very fine to very coarse sand and silt with some granules and pebbles <30 mm in diameter; poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=15
175	176	Silty sand (zS); very fine to very coarse sand and silt with some granules and pebbles <30 mm in diameter; poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=40
176	177	Silty sand (zS); very fine to very coarse sand and silt with some granules and pebbles <30 mm in diameter; poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=12
177	178	Silty sand (zS); very fine to very coarse sand and silt with some granules and pebbles <30 mm in diameter; poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=27
178	179	Silty sand (zS); very fine to very coarse sand and silt with some granules and pebbles <30 mm in diameter; poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=50
179	180	Silty sand (zS); very fine to very coarse sand and silt with some granules and pebbles <30 mm in diameter; poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=84
180	181	Silty sand (zS); very fine to very coarse sand and silt with some granules and pebbles <30 mm in diameter; poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=25
181	182	Silty sand (zS); very fine to very coarse sand and silt with some granules and pebbles <30 mm in diameter; poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=17
182	183	Silty sand (zS); very fine to very coarse sand and silt with some granules and pebbles <30 mm in diameter; poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=18
183	184	Silty sand (zS); very fine to very coarse sand and silt with some granules and pebbles <30 mm in diameter; poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=22
184	185	Silty sand (zS); very fine to very coarse sand and silt with some granules and pebbles <30 mm in diameter; poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=16
185	186	Silty sand (zS); very fine to medium sand and silt with some coarse sand; moderately sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=18
186	187	Silty sand (zS); fine to medium sand and silt with some very fine to coarse sand and granules and pebbles <10 mm in diameter; poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=17
187	188	Silty sand (zS); fine to medium sand and silt with some very fine to coarse sand and granules and pebbles <10 mm in diameter; poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=12

Table 2. Lithologic log for unsaturated-zone monitoring site YVUZ-5 (1N/6E-32G1-33S), Warren subbasin, San Bernardino County, California, June–July 2008.—Continued

[Site location shown in figure 1. Altitude of land surface, about 3,200 ft above vertical datum. Depth is in feet below land surface. Drilled by U.S. Geological Survey using ODEX, June 24, 2008–July 5, 2008. Total depth drilled: 399 ft. Construction and instrumentation information presented in table 1 and figure 6. Grain size abbreviation given in parentheses (Folk, 1954). Munsell notation of color given in parentheses following color name (Munsell, 1994); cutting colors identified as dry or moist. **Abbreviations**: ft, feet; mm, millimeter; SC, specific conductance; >, greater than; <, less than; =, equal; %, percent]

Depth (ft)		Description
From	To	
188	189	Silty sand (zS); fine to medium sand and silt with some very fine to coarse sand and granules and pebbles <10 mm in diameter; poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=23
189	190	Silty sand (zS); fine to medium sand and silt with some very fine to coarse sand and granules and pebbles <10 mm in diameter; poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=26
190	191	Silty sand (zS); fine to medium sand and silt with some very fine to coarse sand and granules and pebbles <10 mm in diameter; poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=28
191	192	Silty sand (zS); fine to medium sand and silt with some very fine to coarse sand and granules and pebbles <10 mm in diameter; poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=42
192	193	Silty sand (zS); fine to medium sand and silt with some very fine to coarse sand and granules and occasional pebbles <30 mm in diameter; poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=32
193	194	Gravelly silty sand (gzS); fine to very coarse sand with silt and granules and pebbles <20 mm in diameter less than 30%; very poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=30
194	195	Sandy gravel (sG); fine to medium sand and gravel (>30%) with some silt; very poorly sorted; angular to subangular; light gray (10YR 7/2); dry, SC=33
195	196	Gravelly silty sand (gzS); fine to medium sand and silt and gravel and pebbles <20 mm in diameter less than 30%; poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=26
196	197	Gravelly silty sand (gzS); fine to medium sand and silt and gravel and pebbles <20 mm in diameter less than 30%; poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=25
197	198	Silty sand (zS); very fine to medium sand and silt with some coarse sand and granules and occasional pebbles <30 mm in diameter; poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=23
198	199	Silty sand (zS); very fine to medium sand and silt with some coarse sand and granules and occasional pebbles <30 mm in diameter; poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=21
199	200	Silty sand (zS); medium sand and silt with some fine to very coarse sand and granules and occasional pebbles <10 mm in diameter; poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=25
200	201	Silty sand (zS); medium sand and silt with some fine to very coarse sand and granules and occasional pebbles <10 mm in diameter; poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=27
201	202	Silty sand (zS); medium sand and silt with some fine to very coarse sand and granules and occasional pebbles <10 mm in diameter; poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=30
202	203	Silty sand (zS); medium sand and silt with some fine to very coarse sand and granules and occasional pebbles <10 mm in diameter; poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=37
203	204	Silty sand (zS); medium sand and silt with some fine to very coarse sand and granules and occasional pebbles <10 mm in diameter; poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=27
204	205	Sandy silt (sZ); silt and very fine to medium sand with occasional granules and pebbles <10 mm in diameter; well sorted; light brownish gray (10YR 6/2); dry, SC=34
205	206	Silty sand (zS); fine to medium sand and silt with some very fine to very coarse sand, granules and occasional pebbles <10 mm in diameter; poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=51
206	207	Silty sand (zS); fine to medium sand and silt with some very fine to very coarse sand, granules and occasional pebbles <10 mm in diameter; poorly sorted; angular to subangular; light yellowish brown (10YR 6/4); dry, SC=39
207	208	Silty sand (zS); fine to medium sand and silt with some very fine to very coarse sand, granules and occasional pebbles <10 mm in diameter; poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=50
208	209	Silty sand (zS); fine to medium sand and silt with some very fine to very coarse sand, granules and occasional pebbles <10 mm in diameter; very poorly sorted; angular to subangular; brownish yellow (10YR 6/6) dry, SC=46
209	210	Silty sand (zS); fine to medium sand and silt with some very fine to very coarse sand, granules and occasional pebbles <10 mm in diameter; poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=50
210	211	Silty sand (zS); fine to medium sand and silt with some very fine to very coarse sand, granules and occasional pebbles <10 mm in diameter; poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=27
211	212	Gravelly silty sand (gzS); fine to very coarse sand with silt and granules and pebbles <20 mm in diameter less than 30%; poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=26
212	213	Gravelly silty sand (gzS); fine to very coarse sand with silt and granules and pebbles <20 mm in diameter less than 30%; poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=23
213	214	Silty sand (zS); fine to medium sand and silt with some very fine to very coarse sand, granules and occasional pebbles <10 mm in diameter; poorly sorted; angular to subangular; brown (10YR 5/3); dry, SC=52

Table 2. Lithologic log for unsaturated-zone monitoring site YVUZ-5 (1N/6E-32G1-33S), Warren subbasin, San Bernardino County, California, June–July 2008.—Continued

[Site location shown in figure 1. Altitude of land surface, about 3,200 ft above vertical datum. Depth is in feet below land surface. Drilled by U.S. Geological Survey using ODEX, June 24, 2008–July 5, 2008. Total depth drilled: 399 ft. Construction and instrumentation information presented in table 1 and figure 6. Grain size abbreviation given in parentheses (Folk, 1954). Munsell notation of color given in parentheses following color name (Munsell, 1994); cutting colors identified as dry or moist. **Abbreviations**: ft, feet; mm, millimeter; SC, specific conductance; >, greater than; <, less than; =, equal; %, percent]

Depth (ft)		Description
From	To	
214	215	Silty sand (zS); fine to medium sand and silt with some very fine to very coarse sand, granules and occasional pebbles <10 mm in diameter; poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=44
215	216	Silty sand (zS); fine to medium sand and silt with some very fine to very coarse sand, granules and occasional pebbles <10 mm in diameter; poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=41
216	217	Sandy silt (sZ); silt and very fine to medium sand with occasional granules and pebbles <10 mm in diameter; well sorted; light brownish gray (10YR 6/2); dry, SC=47
217	218	Sandy silt (sZ); silt and very fine to medium sand with occasional granules and pebbles <10 mm in diameter; well sorted; light brownish gray (10YR 6/2); dry, SC=54
218	219	Sandy silt (sZ); silt and very fine to medium sand with occasional granules and pebbles <10 mm in diameter; well sorted; light brownish gray (10YR 6/2); dry, SC=42
219	220	Sandy silt (sZ); silt and very fine to medium sand with occasional granules and pebbles <10 mm in diameter; well sorted; light brownish gray (10YR 6/2); dry, SC=25
220	221	Silty sand (zS); fine to medium sand and silt with some very fine to very coarse sand, granules and occasional pebbles <10 mm in diameter; poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=28
221	222	Silty sand (zS); fine to medium sand and silt with some very fine to very coarse sand, granules and occasional pebbles <10 mm in diameter; poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=25
222	223	Silty sand (zS); fine to medium sand and silt with some very fine to very coarse sand, granules and occasional pebbles <10 mm in diameter; poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=18
223	224	Silty sand (zS); fine to medium sand and silt with some very fine to very coarse sand, granules and occasional pebbles <10 mm in diameter; poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=21
224	225	Silty sand (zS); fine to medium sand and silt with some very fine to very coarse sand, granules and occasional pebbles <10 mm in diameter; poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=19
225	226	Silty sand (zS); fine to medium sand and silt with some very fine to very coarse sand, granules and occasional pebbles <10 mm in diameter; poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=25
226	227	Silty sand (zS); fine to medium sand and silt with some very fine to very coarse sand, granules and occasional pebbles <10 mm in diameter; poorly sorted; angular to subangular; pale brown (10YR 6/3); dry, SC=35
227	228	Sandy silt (sZ); silt and very fine to medium sand with occasional granules and pebbles <10 mm in diameter; well sorted; light brownish gray (10YR 6/2); dry, SC=34
228	229	Sandy silt (sZ); silt and very fine to medium sand with occasional granules and pebbles <10 mm in diameter; well sorted; light brownish gray (10YR 6/2); dry, SC=31
229	230	Silty sand (zS); fine to medium sand and silt with some very fine to very coarse sand, granules and occasional pebbles <10 mm in diameter; poorly sorted; angular to subangular; light gray (10YR 7/1); dry, SC=28
230	231	Sandy silt (sZ); silt and very fine to medium sand with occasional granules and pebbles <10 mm in diameter; well sorted; light gray (10YR 7/1); dry, SC=19
231	232	Silty sand (zS); fine to medium sand and silt with some very fine to very coarse sand, granules and occasional pebbles <10 mm in diameter; poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=16
232	233	Sandy silt (sZ); silt and very fine to medium sand with occasional granules and pebbles <10 mm in diameter; well sorted; light brownish gray (10YR 6/2); dry, SC=14
233	234	Sandy silt (sZ); silt and very fine to medium sand with occasional granules and pebbles <10 mm in diameter; well sorted; light yellowish brown (10YR 6/4); dry, SC=22
234	235	Sandy silt (sZ); silt and very fine to medium sand with occasional granules and pebbles <10 mm in diameter; well sorted; light yellowish brown (10YR 6/4); dry, SC=12
235	236	Sandy silt (sZ); silt and very fine to medium sand with occasional granules and pebbles <10 mm in diameter; well sorted; light brownish gray (10YR 6/2); dry, SC=64
236	237	Sandy silt (sZ); silt and very fine to medium sand with occasional granules and pebbles <10 mm in diameter; well sorted; light brownish gray (10YR 6/2); dry, SC=19
237	238	Silty sand (zS); fine to medium sand and silt with some very fine to very coarse sand, granules and occasional pebbles <10 mm in diameter; poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=21
238	239	Silty sand (zS); fine to medium sand and silt with some very fine to very coarse sand, granules and occasional pebbles <10 mm in diameter; very poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=31
239	240	Slightly gravelly silty sand ((g)zS); very fine to very coarse sand and silt with some granules and <30% pebbles <25 mm in diameter; very poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=57

Table 2. Lithologic log for unsaturated-zone monitoring site YVUZ-5 (1N/6E-32G1-33S), Warren subbasin, San Bernardino County, California, June–July 2008.—Continued

[Site location shown in figure 1. Altitude of land surface, about 3,200 ft above vertical datum. Depth is in feet below land surface. Drilled by U.S. Geological Survey using ODEX, June 24, 2008–July 5, 2008. Total depth drilled: 399 ft. Construction and instrumentation information presented in table 1 and figure 6. Grain size abbreviation given in parentheses (Folk, 1954). Munsell notation of color given in parentheses following color name (Munsell, 1994); cutting colors identified as dry or moist. **Abbreviations**: ft, feet; mm, millimeter; SC, specific conductance; >, greater than; <, less than; =, equal; %, percent]

Depth (ft)		Description
From	To	
240	241	Slightly gravelly silty sand ((g)zS); very fine to very coarse sand and silt with some granules and <30% pebbles <25 mm in diameter; very poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=73
241	242	Slightly gravelly silty sand ((g)zS); very fine to very coarse sand and silt with some granules and <30% pebbles <25 mm in diameter; very poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=65
242	243	Sandy silt (sZ); silt and very fine to medium sand with occasional granules and pebbles <10 mm in diameter; well sorted; brown (10YR 5/3); dry, SC=35
243	244	Sandy silt (sZ); silt and very fine to medium sand with occasional granules and pebbles <10 mm in diameter; well sorted; brown (10YR 5/3); dry, SC=65
244	245	Sandy silt (sZ); silt and very fine to medium sand with occasional granules and pebbles <10 mm in diameter; well sorted; brown (10YR 5/3); dry, SC=88
245	246	Sandy silt (sZ); silt and very fine to medium sand with occasional granules and pebbles <10 mm in diameter; well sorted; yellowish brown (10YR 5/4); dry, SC=84
246	247	Sandy silt (sZ); silt and very fine to medium sand with occasional granules and pebbles <10 mm in diameter; well sorted; yellowish brown (10YR 5/4); dry, SC=65
247	248	Silty sand (zS); fine to medium sand and silt with some very fine to very coarse sand, granules and occasional pebbles <10 mm in diameter; poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=68
248	249	Sandy silt (sZ); silt and very fine to medium sand with occasional granules and pebbles <10 mm in diameter; well sorted; yellowish brown (10YR 5/4); dry, SC=78
249	250	Silty sand (zS); fine to medium sand and silt with some very fine to very coarse sand, granules and occasional pebbles <10 mm in diameter; poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=113
250	251	Silty sand (zS); fine to medium sand and silt with some very fine to very coarse sand, granules and occasional pebbles <10 mm in diameter; poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=64
251	252	Silty sand (zS); fine to medium sand and silt with some very fine to very coarse sand, granules and occasional pebbles <10 mm in diameter; poorly sorted; angular to subangular; pale brown (10YR 6/3); dry, SC=54
252	253	Slightly gravelly silty sand ((g)zS); very fine to very coarse sand and silt with some granules and <30% pebbles <25 mm in diameter; very poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=33
253	254	Slightly gravelly silty sand ((g)zS); very fine to very coarse sand and silt with some granules and <30% pebbles <25 mm in diameter; very poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=28
245	255	Sandy gravel (sG); medium to very coarse sand with some granules and <30% pebbles <25 mm in diameter; poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=29
255	256	Sandy gravel (sG); medium to very coarse sand with some granules and <30% pebbles <25 mm in diameter; poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=24
256	257	Sandy gravel (sG); medium to very coarse sand with some granules and <30% pebbles <25 mm in diameter; poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=39
257	258	Silty sand (zS); fine to medium sand and silt with some very fine to very coarse sand, granules and occasional pebbles <10 mm in diameter; very poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=60
258	259	Silty sand (zS); fine to medium sand and silt with some very fine to very coarse sand, granules and occasional pebbles <10 mm in diameter; very poorly sorted; angular to subangular; yellowish brown (10YR 5/4); dry, SC=61
259	260	Sandy silt (sZ); silt and very fine to medium sand with occasional granules and pebbles <10 mm in diameter; well sorted; light brownish gray (10YR 6/2); dry, SC=58
260	261	Sandy silt (sZ); silt and very fine to medium sand with occasional granules and pebbles <10 mm in diameter; well sorted; light brownish gray (10YR 6/2); dry, SC-94
261	262	Sandy silt (sZ); silt and very fine to medium sand with clay and occasional granules; well sorted; brown (10YR 5/3); dry, SC=50
262	263	Sandy silt (sZ); silt and very fine to medium sand with clay and occasional granules; well sorted; gray (10YR 6/1); dry, SC=47
263	264	Sandy silt (sZ); silt and very fine to medium sand with clay and occasional granules; moderately sorted; brown (10YR 5/3); dry, SC=55
264	265	Sandy silt (sZ); silt and very fine to medium sand with clay and occasional granules; well sorted; light brownish gray (10YR 6/2); dry, SC=40
265	266	Sandy silt (sZ); silt and very fine to medium sand with clay and occasional granules; well sorted; brown (10YR 5/3); dry, SC=67
266	267	Sandy silt (sZ); silt and very fine to medium sand with clay and occasional granules; well sorted; brown (10YR 5/3); dry, SC=39
267	268	Sandy silt (sZ); silt and very fine to medium sand with clay and occasional granules; well sorted; brown (10YR 5/3); dry, SC=53

Table 2. Lithologic log for unsaturated-zone monitoring site YVUZ-5 (1N/6E-32G1-33S), Warren subbasin, San Bernardino County, California, June–July 2008.—Continued

[Site location shown in figure 1. Altitude of land surface, about 3,200 ft above vertical datum. Depth is in feet below land surface. Drilled by U.S. Geological Survey using ODEX, June 24, 2008–July 5, 2008. Total depth drilled: 399 ft. Construction and instrumentation information presented in table 1 and figure 6. Grain size abbreviation given in parentheses (Folk, 1954). Munsell notation of color given in parentheses following color name (Munsell, 1994); cutting colors identified as dry or moist. **Abbreviations**: ft, feet; mm, millimeter; SC, specific conductance; >, greater than; <, less than; =, equal; %, percent]

Depth (ft)		Description
From	To	
268	269	Sandy silt (sZ); silt and very fine to medium sand with clay and occasional granules; well sorted; brown (10YR 5/3); dry, SC=34
269	270	Sandy silt (sZ); silt and very fine to medium sand with clay and occasional granules; well sorted; brown (10YR 5/3); dry, SC=43
270	271	Silty sand (zS); very fine to medium sand and silt with some very coarse sand and granules and occasional pebbles <15 mm in diameter; poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=50
271	272	Silty sand (zS); very fine to medium sand and silt with some very coarse sand and granules and occasional pebbles <15 mm in diameter; poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=46
272	273	Silty sand (zS); very fine to medium sand and silt with some very coarse sand and granules and occasional pebbles <15 mm in diameter; poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=43
273	274	Silty sand (zS); fine to medium sand and silt with some very fine to very coarse sand, granules and occasional pebbles <10 mm in diameter; very poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=33
274	275	Silty sand (zS); very fine to medium sand and silt with some very coarse sand and granules and occasional pebbles <15 mm in diameter; poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=44
275	276	Silty sand (zS); very fine to medium sand and silt with some very coarse sand and granules and occasional pebbles <15 mm in diameter; poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=52
276	277	Sandy silt (sZ); silt and very fine to medium sand with clay and occasional granules and pebbles <10 mm in diameter; angular to subangular; brown (10YR 5/3); dry, SC=49
277	278	Sandy silt (sZ); silt and very fine to medium sand with clay and occasional granules and pebbles <10 mm in diameter; moderately sorted; brown (10YR 5/3); dry, SC=38
278	279	Sandy silt (sZ); silt and very fine to medium sand with clay and very coarse sand; well sorted; brown (10YR 5/3); dry, SC=50
279	280	No sample collected
280	281	Sandy silt (sZ); silt and very fine to medium sand with clay and occasional granules and pebbles <10 mm in diameter; moderately sorted; brown (10YR 5/3); dry, SC=64
281	282	Sandy silt (sZ); silt and very fine to medium sand with clay and occasional granules; well sorted; brown (10YR 5/3); dry, SC=72
282	283	Sandy silt (sZ); silt and very fine to medium sand with clay and occasional coarse sand; well sorted; brown (10YR 5/3); dry, SC=51
283	284	Sandy silt (sZ); silt and very fine to medium sand with clay and occasional coarse sand; well sorted; light brownish gray (10YR 6/2); dry, SC=48
284	285	Sandy silt (sZ); silt and very fine to medium sand with clay and occasional coarse sand and granules; moderately sorted; brown (10YR 5/3); dry, SC=48
285	286	Sandy silt (sZ); silt and very fine to medium sand with clay and occasional coarse sand; well sorted; dark yellowish brown (10YR 4/4); dry, SC=30
286	287	Sandy silt (sZ); silt and very fine to medium sand with clay and occasional coarse sand and granules; moderately sorted; brown (10YR 5/3); dry, SC=36
287	288	Sandy silt (sZ); silt and very fine to medium sand with clay and occasional coarse sand; well sorted; dark yellowish brown (10YR 4/4); dry, SC=61
288	289	Sandy silt (sZ); silt and very fine to medium sand with clay and occasional coarse sand; well sorted; dark yellowish brown (10YR 4/4); dry, SC=33
289	290	Sandy silt (sZ); silt and very fine to medium sand with clay and occasional coarse sand and granules; moderately sorted; brown (10YR 4/3); dry, SC=51
290	291	Sandy silt (sZ); silt and very fine to medium sand with clay and occasional coarse sand; well sorted; yellowish brown (10YR 5/4); dry, SC=89
291	292	Silty sand (zS); very fine to medium sand and silt with some very coarse sand and granules and occasional pebbles <15 mm in diameter; poorly sorted; angular to subangular; yellowish brown (10YR 5/4); dry, SC=48
292	293	Silty sand (zS); very fine to medium sand and silt with some very coarse sand and granules and occasional pebbles <15 mm in diameter; poorly sorted; angular to subangular; yellowish brown (10YR 5/4); dry, SC=36
293	294	Silty sand (zS); very fine to medium sand and silt with some very coarse sand and granules and occasional pebbles <15 mm in diameter; poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=35
294	295	Silty sand (zS); very fine to medium sand and silt with some very coarse sand and granules and occasional pebbles <15 mm in diameter; poorly sorted; angular to subangular; yellowish brown (10YR 5/4); dry, SC=38
295	296	Silty sand (zS); very fine to medium sand and silt with some very coarse sand and granules and occasional pebbles <15 mm in diameter; poorly sorted; angular to subangular; yellowish brown (10YR 5/4); dry, SC=34

Table 2. Lithologic log for unsaturated-zone monitoring site YVUZ-5 (1N/6E-32G1-33S), Warren subbasin, San Bernardino County, California, June–July 2008.—Continued

[Site location shown in figure 1. Altitude of land surface, about 3,200 ft above vertical datum. Depth is in feet below land surface. Drilled by U.S. Geological Survey using ODEX, June 24, 2008–July 5, 2008. Total depth drilled: 399 ft. Construction and instrumentation information presented in table 1 and figure 6. Grain size abbreviation given in parentheses (Folk, 1954). Munsell notation of color given in parentheses following color name (Munsell, 1994); cutting colors identified as dry or moist. **Abbreviations**: ft, feet; mm, millimeter; SC, specific conductance; >, greater than; <, less than; =, equal; %, percent]

Depth (ft)		Description
From	To	
296	297	Silty sand (zS); very fine to medium sand and silt with some very coarse sand and granules and occasional pebbles <15 mm in diameter; poorly sorted; angular to subangular; yellowish brown (10YR 5/4); dry, SC=32
297	298	Silty sand (zS); very fine to medium sand and silt with some very coarse sand and granules and occasional pebbles <15 mm in diameter; poorly sorted; angular to subangular; yellowish brown (10YR 5/4); dry, SC=28
298	299	Silty sand (zS); very fine to medium sand and silt with some very coarse sand and granules and occasional pebbles <15 mm in diameter; poorly sorted; angular to subangular; yellowish brown (10YR 5/4); dry, SC=30
299	300	Silty sand (zS); very fine to medium sand and silt with some very coarse sand and granules and occasional pebbles <15 mm in diameter; poorly sorted; angular to subangular; yellowish brown (10YR 5/4); dry, SC=61
300	301	Silty sand (zS); very fine to medium sand and silt with some very coarse sand and granules and occasional pebbles <15 mm in diameter; poorly sorted; angular to subangular; yellowish brown (10YR 5/4); dry, SC=96
301	302	Silty sand (zS); very fine to medium sand and silt with some very coarse sand and granules and occasional pebbles <15 mm in diameter; poorly sorted; angular to subangular; pale brown (10YR 6/3); dry, SC=60
302	303	Silty sand (zS); very fine to medium sand and silt with some very coarse sand and granules and occasional pebbles <15 mm in diameter; poorly sorted; angular to subangular; pale brown (10YR 6/3); dry, SC=41
303	304	Silty sand (zS); very fine to medium sand and silt with some very coarse sand and granules and occasional pebbles <15 mm in diameter; poorly sorted; angular to subangular; pale brown (10YR 6/3); dry, SC=71
304	305	Silty sand (zS); very fine to medium sand and silt with some very coarse sand and granules and occasional pebbles <15 mm in diameter; poorly sorted; angular to subangular; pale brown (10YR 6/3); dry, SC=57
305	306	Silty sand (zS); very fine to medium sand and silt with some very coarse sand and granules and occasional pebbles <15 mm in diameter; poorly sorted; angular to subangular; pale brown (10YR 6/3); dry, SC=44
306	307	Silty sand (zS); very fine to medium sand and silt with some very coarse sand and granules and occasional pebbles <15 mm in diameter; poorly sorted; angular to subangular; pale brown (10YR 6/3); dry, SC=67
307	308	Silty sand (zS); very fine to medium sand and silt with some very coarse sand and granules and occasional pebbles <15 mm in diameter; poorly sorted; angular to subangular; pale brown (10YR 6/3); dry, SC=41
308	309	Sandy silt (sZ); silt and very fine to medium sand with clay and occasional coarse sand; well sorted; pale brown (10YR 6/3); dry, SC=51
309	310	Sandy silt (sZ); silt and very fine to medium sand with clay and occasional coarse sand; well sorted; pale brown (10YR 6/3); dry, SC=33
310	311	Silty sand (zS); very fine to medium sand and silt with some very coarse sand and granules and occasional pebbles <15 mm in diameter; poorly sorted; angular to subangular; yellowish brown (10YR 5/4); dry, SC=47
311	312	Silty sand (zS); very fine to medium sand and silt with some very coarse sand and granules and occasional pebbles <15 mm in diameter; poorly sorted; angular to subangular; brown (10YR 5/3); dry, SC=37
312	313	Silty sand (zS); very fine to medium sand and silt with some very coarse sand and granules and occasional pebbles <15 mm in diameter; poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=36
313	314	Silty sand (zS); very fine to medium sand and silt with some very coarse sand and granules and occasional pebbles <15 mm in diameter; poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=35
314	315	Silty sand (zS); very fine to medium sand and silt with some very coarse sand and granules and occasional pebbles <15 mm in diameter; poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=35
315	316	Silty sand (zS); very fine to medium sand and silt with some very coarse sand and granules and occasional pebbles <15 mm in diameter; poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=38
316	317	Silty sand (zS); very fine to medium sand and silt with some very coarse sand and granules and occasional pebbles <15 mm in diameter; poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=40
317	318	Silty sand (zS); very fine to medium sand and silt with some very coarse sand and granules and occasional pebbles <15 mm in diameter; poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=41
318	319	Silty sand (zS); very fine to medium sand and silt with some very coarse sand and granules and occasional pebbles <15 mm in diameter; poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=32
319	320	Silty sand (zS); very fine to medium sand and silt with some very coarse sand and granules and occasional pebbles <15 mm in diameter; poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=44
320	321	Silty sand (zS); very fine to medium sand and silt with some very coarse sand and granules and occasional pebbles <15 mm in diameter; poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=26
321	322	Silty sand (zS); very fine to medium sand and silt with some very coarse sand and granules and occasional pebbles <15 mm in diameter; poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=22

Table 2. Lithologic log for unsaturated-zone monitoring site YVUZ-5 (1N/6E-32G1-33S), Warren subbasin, San Bernardino County, California, June–July 2008.—Continued

[Site location shown in figure 1. Altitude of land surface, about 3,200 ft above vertical datum. Depth is in feet below land surface. Drilled by U.S. Geological Survey using ODEX, June 24, 2008–July 5, 2008. Total depth drilled: 399 ft. Construction and instrumentation information presented in table 1 and figure 6. Grain size abbreviation given in parentheses (Folk, 1954). Munsell notation of color given in parentheses following color name (Munsell, 1994); cutting colors identified as dry or moist. **Abbreviations**: ft, feet; mm, millimeter; SC, specific conductance; >, greater than; <, less than; =, equal; %, percent]

Depth (ft)		Description
From	To	
322	323	Silty sand (zS); very fine to medium sand and silt with some very coarse sand and granules and occasional pebbles <15 mm in diameter; poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=21
323	324	Gravelly silty sand (gzS); very fine to very coarse sand and silt with some granules and >30% pebbles <25 mm in diameter; very poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=39
324	325	Silty sand (zS); very fine to medium sand and silt with some very coarse sand and granules and occasional pebbles <15 mm in diameter; poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=39
325	326	Sandy silt (sZ); silt and very fine to medium sand with clay and occasional coarse sand; well sorted; light brownish gray (10YR 6/2); dry, SC=45
326	327	Sandy silt (sZ); silt and very fine to medium sand with clay and occasional coarse sand; well sorted; light brownish gray (10YR 6/2); dry, SC=48
327	328	Sandy silt (sZ); silt and very fine to medium sand with clay and occasional coarse sand; well sorted; light brownish gray (10YR 6/2); dry, SC=53
328	329	Silty sand (zS); very fine to medium sand and silt with some very coarse sand and granules and occasional pebbles <15 mm in diameter; poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=36
329	330	Silty sand (zS); very fine to medium sand and silt with some very coarse sand and granules and occasional pebbles <15 mm in diameter; poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=39
330	331	Silty sand (zS); very fine to medium sand and silt with some very coarse sand and granules and occasional pebbles <15 mm in diameter; poorly sorted; angular to subangular; light brownish gray (10YR 6/2); dry, SC=32
331	332	Silty sand (zS); very fine to medium sand and silt with some very coarse sand and granules and occasional pebbles <15 mm in diameter; poorly sorted; angular to subangular; light yellowish brown (10YR 6/4); dry, SC=34
332	333	Silty sand (zS); very fine to medium sand and silt with some very coarse sand and granules and occasional pebbles <15 mm in diameter; poorly sorted; angular to subangular; light yellowish brown (10YR 6/4); dry, SC=73
333	334	Silty sand (zS); very fine to medium sand and silt with some very coarse sand and granules and occasional pebbles <15 mm in diameter; poorly sorted; angular to subangular; light yellowish brown (10YR 6/4); dry, SC=42
334	335	Sandy silt (sZ); silt and very fine to medium sand with clay and occasional coarse sand; well sorted; light brownish gray (10YR 6/2); dry, SC=53
335	336	Sandy silt (sZ); silt and very fine to medium sand with clay and occasional coarse sand; well sorted; light brownish gray (10YR 6/2); dry, SC=40
336	337	Sandy silt (sZ); silt and very fine to medium sand with clay and occasional coarse sand; well sorted; light gray (10YR 7/2); dry, SC=49
337	338	Silty sand (zS); very fine to medium sand and silt with some very coarse sand and granules and occasional pebbles <15 mm in diameter; poorly sorted; angular to subangular; light gray (10YR 7/2); dry, SC=38
338	339	Silty sand (zS); very fine to medium sand and silt with some very coarse sand and granules and occasional pebbles <15 mm in diameter; poorly sorted; angular to subangular; light gray (10YR 7/2); dry, SC=38
339	340	Slightly gravelly silty sand ((g)zS); very fine to very coarse sand and silt with some granules and <30% pebbles <25 mm in diameter; very poorly sorted; angular to subangular; pale brown (10YR 6/3); dry, SC=25
340	341	Slightly gravelly silty sand ((g)zS); very fine to very coarse sand and silt with some granules and <30% pebbles <25 mm in diameter; very poorly sorted; angular to subangular; pale brown (10YR 6/3); dry, SC=28
341	342	Silty sand (zS); very fine to medium sand and silt with some very coarse sand and granules and occasional pebbles <15 mm in diameter; poorly sorted; angular to subangular; pale brown (10YR 6/3); dry, SC=26
342	343	Silty sand (zS); very fine to medium sand and silt with some very coarse sand and granules and occasional pebbles <15 mm in diameter; poorly sorted; angular to subangular; pale brown (10YR 6/3); dry, SC=42
343	344	Sandy silt (sZ); silt and very fine to medium sand with clay and occasional coarse sand; moderately sorted; light brownish gray (10YR 6/2); dry, SC=67
344	345	Silty sand (zS); very fine to medium sand and silt with some very coarse sand and granules and occasional pebbles <15 mm in diameter; poorly sorted; angular to subangular; pale brown (10YR 6/3); dry, SC=29
345	346	Silty sand (zS); very fine to medium sand and silt with some very coarse sand and granules and occasional pebbles <15 mm in diameter; poorly sorted; angular to subangular; pale brown (10YR 6/3); dry, SC=34
346	347	Silty sand (zS); very fine to medium sand and silt with some very coarse sand and granules and occasional pebbles <15 mm in diameter; poorly sorted; angular to subangular; pale brown (10YR 6/3); dry, SC=23
347	348	Silty sand (zS); very fine to medium sand and silt with some very coarse sand and granules and occasional pebbles <15 mm in diameter; poorly sorted; angular to subangular; pale brown (10YR 6/3); dry, SC=35

Table 2. Lithologic log for unsaturated-zone monitoring site YVUZ-5 (1N/6E-32G1-33S), Warren subbasin, San Bernardino County, California, June–July 2008.—Continued

[Site location shown in figure 1. Altitude of land surface, about 3,200 ft above vertical datum. Depth is in feet below land surface. Drilled by U.S. Geological Survey using ODEX, June 24, 2008–July 5, 2008. Total depth drilled: 399 ft. Construction and instrumentation information presented in table 1 and figure 6. Grain size abbreviation given in parentheses (Folk, 1954). Munsell notation of color given in parentheses following color name (Munsell, 1994); cutting colors identified as dry or moist. **Abbreviations**: ft, feet; mm, millimeter; SC, specific conductance; >, greater than; <, less than; =, equal; %, percent]

Depth (ft)		Description
From	To	
348	349	Silty sand (zS); very fine to medium sand and silt with some very coarse sand and granules and occasional pebbles <15 mm in diameter; poorly sorted; angular to subangular; pale brown (10YR 6/3); dry, SC=31
349	350	Silty sand (zS); very fine to medium sand and silt with some very coarse sand and granules and occasional pebbles <15 mm in diameter; poorly sorted; angular to subangular; pale brown (10YR 6/3); dry, SC=29
350	351	Silty sand (zS); very fine to medium sand and silt with some very coarse sand and granules and occasional pebbles <15 mm in diameter; poorly sorted; angular to subangular; pale brown (10YR 6/3); dry, SC=26
351	352	Silty sand (zS); very fine to medium sand and silt with some very coarse sand and granules and occasional pebbles <15 mm in diameter; poorly sorted; angular to subangular; pale brown (10YR 6/3); dry, SC=34
352	353	Silty sand (zS); very fine to medium sand and silt with some very coarse sand and granules and occasional pebbles <15 mm in diameter; poorly sorted; angular to subangular; pale brown (10YR 6/3); dry, SC=27
353	354	Silty sand (zS); very fine to medium sand and silt with some very coarse sand and granules and occasional pebbles <15 mm in diameter; poorly sorted; angular to subangular; pale brown (10YR 6/3); dry, SC=34
354	355	Silty sand (zS); very fine to medium sand and silt with some very coarse sand and granules and occasional pebbles <15 mm in diameter; poorly sorted; angular to subangular; pale brown (10YR 6/3); dry, SC=30
355	356	Silty sand (zS); very fine to medium sand and silt with some very coarse sand and granules and occasional pebbles <15 mm in diameter; poorly sorted; angular to subangular; pale brown (10YR 6/3); dry, SC=43
356	357	Silty sand (zS); very fine to medium sand and silt with some very coarse sand and granules and occasional pebbles <15 mm in diameter; poorly sorted; angular to subangular; pale brown (10YR 6/3); dry, SC=22
357	358	Silty sand (zS); very fine to medium sand and silt with some very coarse sand and granules and occasional pebbles <15 mm in diameter; poorly sorted; angular to subangular; pale brown (10YR 6/3); dry, SC=47
358	359	Silty sand (zS); very fine to medium sand and silt with some very coarse sand and granules and occasional pebbles <15 mm in diameter; poorly sorted; angular to subangular; pale brown (10YR 6/3); dry, SC=32
359	360	Silty sand (zS); very fine to medium sand and silt with some very coarse sand and granules and occasional pebbles <15 mm in diameter; poorly sorted; angular to subangular; pale brown (10YR 6/3); dry, SC=60
360	361	Silty sand (zS); very fine to medium sand and silt with some very coarse sand and granules and occasional pebbles <15 mm in diameter; poorly sorted; angular to subangular; pale brown (10YR 6/3); dry, SC=34
361	362	Silty sand (zS); very fine to medium sand and silt with some very coarse sand and granules and occasional pebbles <15 mm in diameter; poorly sorted; angular to subangular; pale brown (10YR 6/3); dry, SC=82
362	363	Gravelly silty sand (gzS); very fine to very coarse sand and silt with some granules and >30% pebbles <25 mm in diameter; very poorly sorted; angular to subangular; light gray (10YR 7/2); dry, SC=136
363	364	Silty sand (zS); very fine to medium sand and silt with some very coarse sand and granules and occasional pebbles <15 mm in diameter; poorly sorted; angular to subangular; pale brown (10YR 6/3); dry, SC=158
364	365	Sandy silt (sZ); silt and very fine to medium sand with clay and occasional coarse sand; well sorted; pale brown (10YR 6/3); dry, SC=42
365	366	Silty sand (zS); very fine to medium sand and silt with some very coarse sand and granules and occasional pebbles <15 mm in diameter; poorly sorted; angular to subangular; pale brown (10YR 6/3); dry, SC=41
366	367	Silty sand (zS); very fine to medium sand and silt with some very coarse sand and granules and occasional pebbles <15 mm in diameter; poorly sorted; angular to subangular; brown (10YR 5/3); dry, SC=40
367	368	Silty sand (zS); very fine to medium sand and silt with some very coarse sand and granules and occasional pebbles <15 mm in diameter; poorly sorted; angular to subangular; brown (10YR 5/3); dry, SC=51
368	369	Silty sand (zS); very fine to medium sand and silt with some very coarse sand and granules and occasional pebbles <15 mm in diameter; poorly sorted; angular to subangular; brown (10YR 5/3); dry, SC=44
369	370	Silty sand (zS); very fine to medium sand and silt with some very coarse sand and granules and occasional pebbles <15 mm in diameter; poorly sorted; angular to subangular; pale brown (10YR 6/3); dry, SC=35
370	371	Silty sand (zS); very fine to medium sand and silt with some very coarse sand and granules and occasional pebbles <15 mm in diameter; poorly sorted; angular to subangular; pale brown (10YR 6/3); dry, SC=34
371	372	Silty sand (zS); very fine to medium sand and silt with some very coarse sand and granules and occasional pebbles <15 mm in diameter; poorly sorted; angular to subangular; pale brown (10YR 6/3); dry, SC=54
372	373	Silty sand (zS); very fine to medium sand and silt with some very coarse sand and granules and occasional pebbles <15 mm in diameter; poorly sorted; angular to subangular; pale brown (10YR 6/3); dry, SC=37
373	374	Silty sand (zS); very fine to medium sand and silt with some very coarse sand and granules and occasional pebbles <15 mm in diameter; poorly sorted; angular to subangular; pale brown (10YR 6/3); dry, SC=33

Table 2. Lithologic log for unsaturated-zone monitoring site YVUZ-5 (1N/6E-32G1-33S), Warren subbasin, San Bernardino County, California, June–July 2008.—Continued

[Site location shown in figure 1. Altitude of land surface, about 3,200 ft above vertical datum. Depth is in feet below land surface. Drilled by U.S. Geological Survey using ODEX, June 24, 2008–July 5, 2008. Total depth drilled: 399 ft. Construction and instrumentation information presented in table 1 and figure 6. Grain size abbreviation given in parentheses (Folk, 1954). Munsell notation of color given in parentheses following color name (Munsell, 1994); cutting colors identified as dry or moist. **Abbreviations**: ft, feet; mm, millimeter; SC, specific conductance; >, greater than; <, less than; =, equal; %, percent]

Depth (ft)		Description
From	To	
374	375	Silty sand (zS); very fine to medium sand and silt with some very coarse sand and granules and occasional pebbles <15 mm in diameter; poorly sorted; angular to subangular; pale brown (10YR 6/3); dry, SC=38
375	376	Silty sand (zS); very fine to medium sand and silt with some very coarse sand and granules and occasional pebbles <15 mm in diameter; poorly sorted; angular to subangular; pale brown (10YR 6/3); dry, SC=36
376	377	Silty sand (zS); very fine to medium sand and silt with some very coarse sand and granules and occasional pebbles <15 mm in diameter; poorly sorted; angular to subangular; pale brown (10YR 6/3); dry, SC=36
377	378	Silty sand (zS); very fine to medium sand and silt with some very coarse sand and granules and occasional pebbles <15 mm in diameter; poorly sorted; angular to subangular; pale brown (10YR 6/3); dry, SC=44
378	379	Silty sand (zS); very fine to medium sand and silt with some very coarse sand and granules and occasional pebbles <15 mm in diameter; poorly sorted; angular to subangular; brown (10YR 5/3); dry, SC=37
379	380	No sample collected
380	381	No sample collected
381	382	No sample collected
382	383	Silty sand (zS); very fine to medium sand and silt with some very coarse sand and granules and occasional pebbles <15 mm in diameter; poorly sorted; angular to subangular; brown (10YR 5/3); dry, SC=190
383	384	Silty sand (zS); very fine to medium sand and silt with some very coarse sand and granules and occasional pebbles <15 mm in diameter; poorly sorted; angular to subangular; brown (10YR 5/3); dry, SC=144
384	385	Silty sand (zS); very fine to medium sand and silt with some very coarse sand and granules and occasional pebbles <15 mm in diameter; poorly sorted; angular to subangular; brown (10YR 5/3); dry, SC=47
385	386	Silty sand (zS); very fine to medium sand and silt with some very coarse sand and granules and occasional pebbles <15 mm in diameter; poorly sorted; angular to subangular; brown (10YR 5/3); dry, SC=34
386	387	Silty sand (zS); very fine to medium sand and silt with some very coarse sand and granules and occasional pebbles <15 mm in diameter; poorly sorted; angular to subangular; brown (10YR 5/3); dry, SC=44
387	388	Silty sand (zS); very fine to medium sand and silt with some very coarse sand and granules and occasional pebbles <15 mm in diameter; poorly sorted; angular to subangular; brown (10YR 5/3); dry, SC=33
388	389	Silty sand (zS); very fine to medium sand and silt with some very coarse sand and granules and occasional pebbles <15 mm in diameter; poorly sorted; angular to subangular; brown (10YR 5/3); dry, SC=35
389	390	Silty sand (zS); very fine to medium sand and silt with some very coarse sand and granules and occasional pebbles <15 mm in diameter; poorly sorted; angular to subangular; brown (10YR 5/3); dry, SC=42
390	391	Silty sand (zS); very fine to medium sand and silt with some very coarse sand and granules and occasional pebbles <15 mm in diameter; poorly sorted; angular to subangular; brown (10YR 5/3); dry, SC=44
391	392	Silty sand (zS); very fine to medium sand and silt with some very coarse sand and granules and occasional pebbles <15 mm in diameter; poorly sorted; angular to subangular; brown (10YR 5/3); dry, SC=32
392	393	Silty sand (zS); very fine to medium sand and silt with some very coarse sand and granules and occasional pebbles <15 mm in diameter; poorly sorted; angular to subangular; brown (10YR 5/3); dry, SC=37
393	394	Silty sand (zS); very fine to medium sand and silt with some very coarse sand and granules and occasional pebbles <15 mm in diameter; poorly sorted; angular to subangular; brown (10YR 5/3); dry, SC=43
394	395	Silty sand (zS); very fine to medium sand and silt with some very coarse sand and granules and occasional pebbles <15 mm in diameter; poorly sorted; angular to subangular; brown (10YR 5/3); dry, SC=40
395	396	Silty sand (zS); very fine to medium sand and silt with some very coarse sand and granules and occasional pebbles <15 mm in diameter; poorly sorted; angular to subangular; brown (10YR 5/3); dry, SC=34
396	397	Silty sand (zS); very fine to medium sand and silt with some very coarse sand and granules and occasional pebbles <15 mm in diameter; poorly sorted; angular to subangular; brown (10YR 5/3); dry, SC=45
397	398	Silty sand (zS); very fine to medium sand and silt with some very coarse sand and granules and occasional pebbles <15 mm in diameter; poorly sorted; angular to subangular; brown (10YR 5/3); dry, SC=61
398	399	Silty sand (zS); very fine to medium sand and silt with some very coarse sand and granules and occasional pebbles <15 mm in diameter; poorly sorted; angular to subangular; brown (10YR 5/3); dry, SC=123

A

Photograph by David O'Leary, U.S. Geological Survey, 2008.

B

Photograph by David O'Leary, U.S. Geological Survey, 2008.

Figure 4. ODEX cuttings arranged in order of sample depth so that major lithologic changes could be identified, unsaturated-zone monitoring site YVUZ-5 (1N/6E-32G1-33S), Warren subbasin, San Bernardino County, California, June 2008.

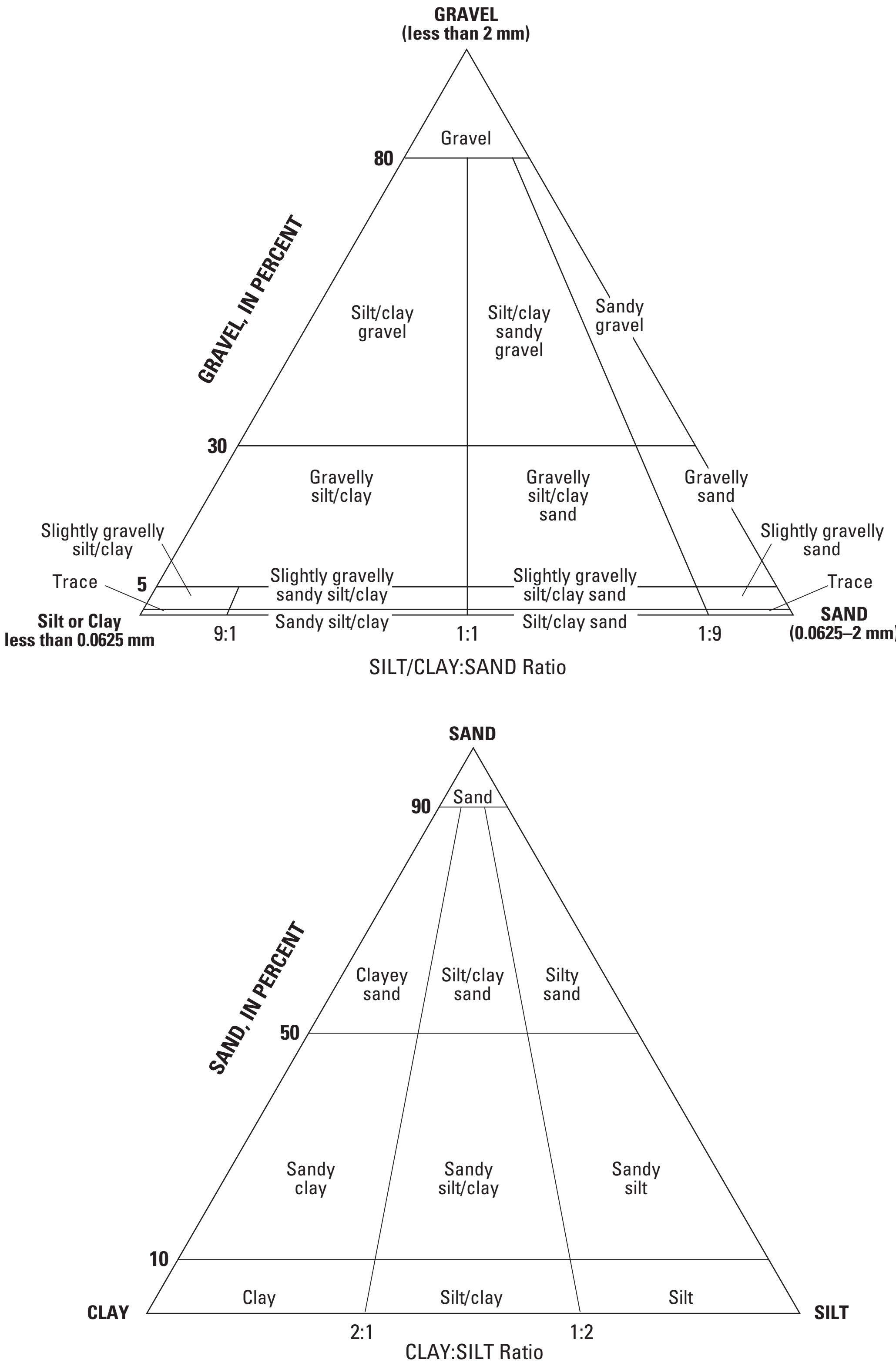


Figure 5. Nomenclature used for description of texture (from Folk, 1954). [mm, millimeters]

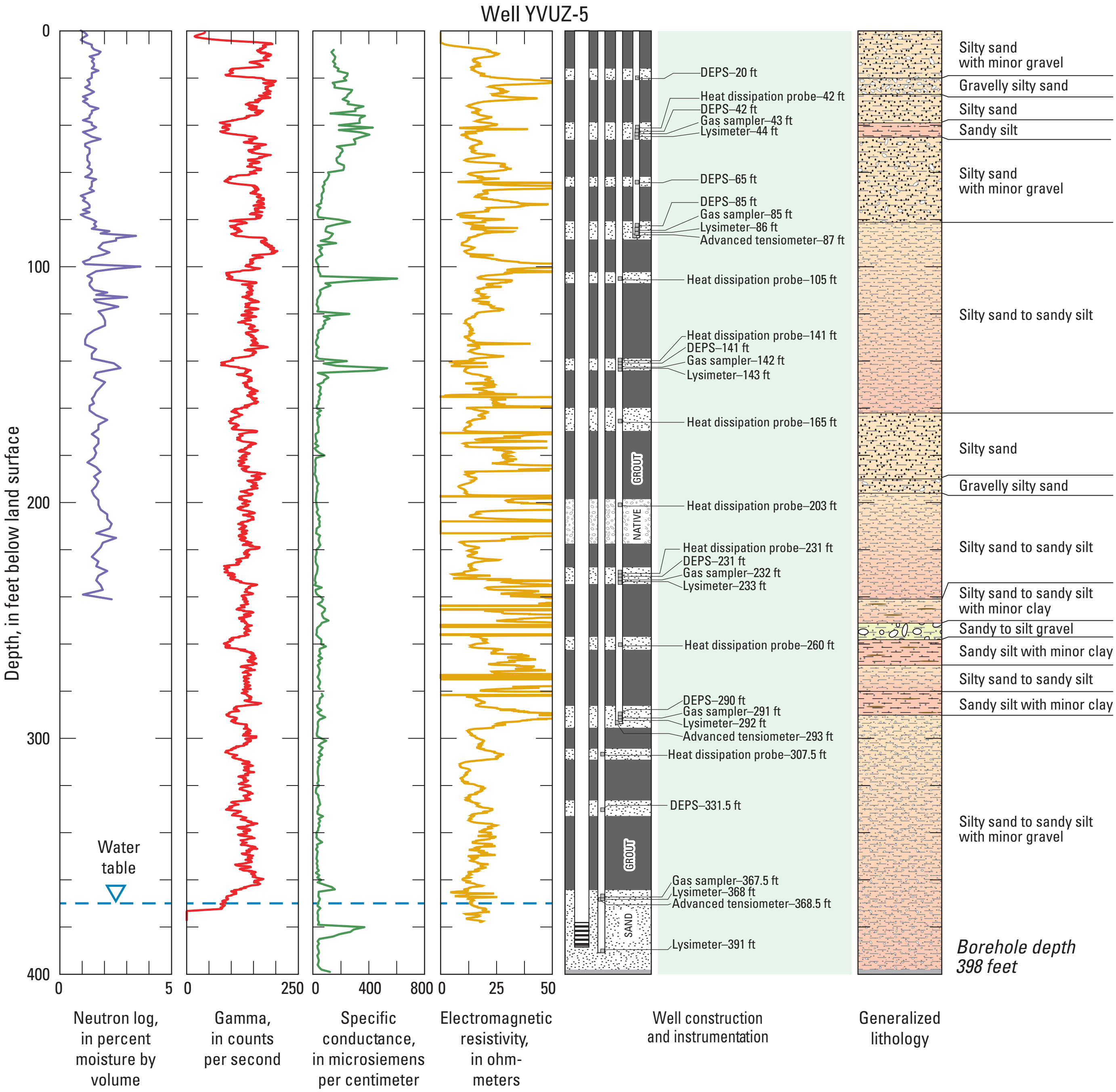


Figure 6. Neutron log, gamma log, lithology, specific conductance of drill cutting extracts, electromagnetic resistivity, instrumentation, and generalized lithology for unsaturated-zone monitoring site YVUZ-5 (1N/6E-32G1-33S), Warren subbasin, San Bernardino County, California. [DEPS, dielectric permittivity sensor; ft, feet]

Geophysical Logs

Boreholes drilled by using the ODEX method are continuously cased with steel pipe during drilling; therefore, it is not possible to collect an extensive suite of geophysical logs prior to completion of the borehole. However, natural gamma and neutron logs were collected in the steel-cased holes before instrumentation was installed and were used as aids for designing instrument placement (fig 6). Natural gamma logs measure the intensity of gamma-ray emissions resulting from natural decay of potassium-40 and the daughter products of uranium and thorium. These logs are used primarily as lithologic indicators and for geologic correlation. Clay has relatively high gamma-ray emissions, as does material rich in potassium feldspar (Schlumberger, 1972; Hearst and Nelson, 1985; Driscoll, 1986). Neutron logs measure the backscattering of neutrons generated from a nuclear source in the logging tool. A direct relation exists between the water content of the formation and the neutron log measurement (Schlumberger, 1972; Hearst and Nelson, 1985; Troxler, 1994). At each measurement depth, the logs can be affected by differences in the position of the neutron source within the pipe and by differences in the thickness of the ODEX pipe.

After construction of YVUZ-5 and removal of the steel casing, electromagnetic resistivity (EM) logs were collected by using a cable-drawn EM sensor through the 2-inch-diameter polyvinyl chloride (PVC) observation well. The EM log is sensitive to changes in lithology, water content, and water salinity; however, changes in water content through time are expected to be the primary process causing any changes in the EM signal over time. The first EM log collected can be used as a baseline for comparison with subsequent EM logs to evaluate changes in subsurface water content near the borehole during infiltration (Ferré and others, 2007). EM logs were collected prior to infiltration of water in the pilot-scale infiltration pond on November 1, 2008. Subsequent EM logs were collected after the start of infiltration on December 3 and December 30, 2008, and January 9, April 30, and December 23, 2009. The November 11, 2008 (pre-infiltration), geophysical logs are shown on figure 6. The remaining EM resistivity logs are included in appendix 1.

The EM logs are sensitive to metal in some of the instruments installed within the borehole. Characteristic low EM resistivity served as a quality-control check on the depth of instrument placement within the borehole.

Site Construction and Instrumentation

Details of site construction and placement of instruments are presented in figure 6 and table 1. The design of YVUZ-5 was determined on the basis of (l) data needed to meet the study objectives; (2) data from cuttings and core material, including lithology (table 2), specific conductance of drill-cutting extracts, gamma logs, and neutron logs (fig. 6); and (3) physical limitations on the amount of instrumentation that can be placed in a single borehole. Instruments installed in YVUZ-5 (table 1 and fig. 6) included a pressure transducer; matric-potential sensors, including advanced tensiometers (ATs), dielectric-permittivity sensors (DEPS), and heat-dissipation probes (HDPs); suction-cup lysimeters; gas samplers; and dataloggers.

Observation Well

A 2-inch-diameter PVC pipe was installed in the borehole to serve as an access tube for geophysical measurements and as an observation well (piezometer) screened near the water table. The observation well is perforated over a 10-ft length near the bottom (378–388 ft bls). A 3-ft long, 2-inch-diameter PVC sump was affixed to the bottom of the screened section of the well from 388 to 391 ft bls. A threaded point-cap was installed on the end of the sump to seal the bottom of the well. A commercially available submersible diaphragm pressure transducer calibrated by the manufacturer was placed below the water table in the observation well. The pressure transducer was connected to a datalogger at land surface, which recorded water level and temperature every 4 hours.

Advanced Tensiometers

Subsequent to the installation of the observation well, three separate lengths of 1-in-diameter PVC pipe with porous ceramic cups affixed to the end of each were placed in the cased borehole to depths of 87, 293 and 368.5 ft bls. A commercially available AT was inserted through the top end of each length of pipe and seated in the ceramic cup at the bottom of each pipe. ATs measure matric potential (Hubbell and Sisson, 1998) in the tensiometer range (less negative than −0.8 bars) and positive pressure (up to 0.8 bars) when saturated. A small amount of de-ionized water was added into each AT pipe to help seat the tensiometers into their respective porous ceramic cups, and the ATs were connected to a datalogger at land surface. The manufacturer calibrated the ATs prior to installation. ATs were installed near the water table as well as above fine-grained layers, as indicated by the lithologic and natural-gamma logs, where the downward movement of water could be impeded and cause wet (or saturated) conditions (Izbicki and others, 2008).

Heat-Dissipation Probes

HDPs measure the rate of movement of heat in a calibrated, ceramic cylinder, which varies with water content (Phene and others, 1971; Reece, 1996). The HDPs were individually calibrated, as described by Flint and others (2002), at the USGS California Water Science Center Hydrologic Research Laboratory in Sacramento, California, to allow the raw millivolt data to be converted to matric potential. The minimum matric potential that the HDPs can measure is about 0.07 negative bars. The HDPs were connected to the surface by wires and installed below fine-grained layers, as well as in more massive lithologic units, where saturated conditions were not likely to develop during artificial recharge (Izbicki and others, 2008).

Dielectric Permittivity Sensors

The DEPS were installed as another means of measuring the matric potential of the surrounding material (Decagon Devices, 2008). The commercially available DEPS comprise a porous ceramic disk bound by two metallic plates that measure matric potential in the range of −0.1 to −5 bars. The dielectric permittivity of the porous ceramic plate is dependent on the amount of moisture present in the pores of the ceramic. When an excitation voltage is applied, the electrical resistance across the ceramic plate varies with changing moisture content, which can be correlated to matric potential. The manufacturer calibrated the DEPS prior to installation. The DEPS were connected to a datalogger at the surface.

Suction-Cup Lysimeters

Suction-cup lysimeters were installed within the borehole to collect unsaturated-zone water-quality samples (Soil Moisture Equipment, 1997). The lysimeters were affixed to the exterior of either the 2-in. PVC well or one of the 1-inch AT pipes. The lysimeters were commonly placed vertically within 1–2 ft of the ATs or HDPs to relate changes in water quality to changes in matric potential (or pressure). Two 1/4-in. diameter polyethylene tubes were connected to each suction-cup lysimeter and routed to land surface for sample collection. One tube was for the application of vacuum to draw soil moisture and/or water into the body of the lysimeter prior to sample collection. This tube was also used for the application of compressed nitrogen gas to force water from the body of the lysimeter to the surface through the other tube during sample collection. The tubes associated with each lysimeter were color-coded in a spectral order from red to white, progressing from deepest to shallowest, respectively. Lysimeters used in this study can collect up to about 1 liter of water per vacuum application, although the volume of water collected is dependent on matric forces in the vicinity of the lysimeter.

Gas Samplers

Gas samplers consisted of a 0.004-inch-slot, stainless-steel well screen 10 in. long and 0.5 in. in diameter, capped on the bottom, and threaded on the top. The samplers were connected to the surface by using 1/4-inch-diameter polyethylene tubing, which was labeled according to a spectral color scheme similar to that of the lysimeters. The gas samplers can be used to sample unsaturated-zone water vapor and other gases, but were not sampled as part of this study.

Backfill Materials

The bottom of the borehole annulus (surrounding the well screen and sump) was backfilled with #3-graded sand to about 368.5 ft bls. Instruments installed in the unsaturated zone within the borehole were packed in material (#60 sand or silica flour, depending on the instrument) designed to facilitate contact with the surrounding unsaturated zone and enhance instrument performance. Instruments were separated from each other vertically by a low-permeability seal consisting of a three-part mixture of bentonite chips, granulated bentonite, and #3-graded sand for structural support. The bentonite was installed dry; Izbicki and others (2000a) have shown through repeated neutron logging that bentonite hydrates to form an effective seal after installation within the borehole.

Dataloggers

The ATs, HDPs, and DEPs were wired to dataloggers for automated activation of the instruments, data collection, and data storage (fig. 7). The dataloggers were powered by a 12-volt, deep-cycle, lead-acid battery. Electronic data were collected at 4-hour (hr) intervals and were manually downloaded from the dataloggers about every 6–8 weeks. The dataloggers and related battery and electronics were placed inside a water-tight plastic case at the top of the borehole. A road-rated vault was installed roughly flush with the land surface by using concrete surface seals.

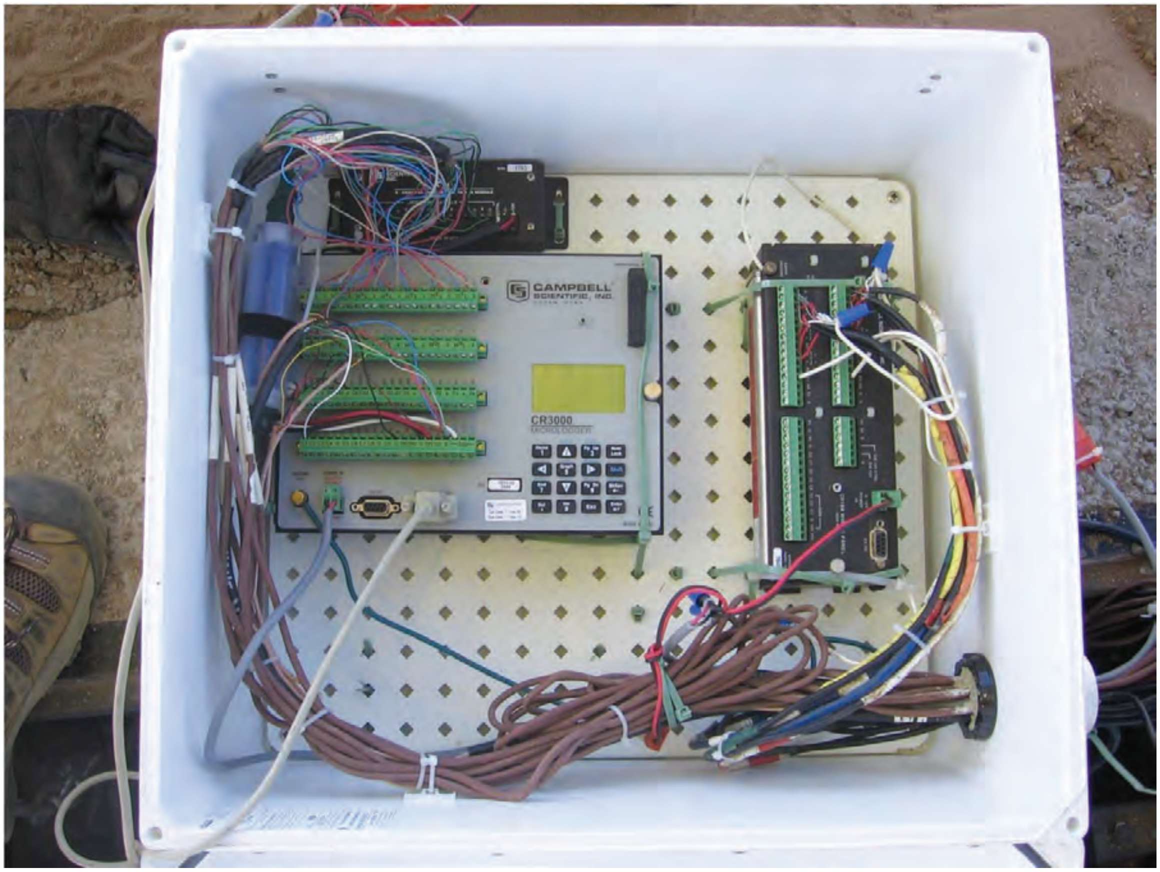
Physical and Hydraulic Properties of Unsaturated-Zone Materials

Prior to the start of infiltration at the site, physical-property data, including bulk density, porosity, effective porosity, volumetric water content, residual water content, saturation, effective saturation, matric potential, saturated hydraulic conductivity, and particle-size distribution were used to evaluate the physical nature and hydraulic characteristics of the materials that composed the unsaturated zone.

Bulk density is a measure of the mass of material per unit volume and is dependent on the density and degree of compaction of the material. Porosity is a measure of the void space in a material calculated as the volume of voids divided by the total volume. Effective porosity is the porosity of a material able to contribute to fluid flow through the material. Volumetric water content describes the quantity of water contained in a volume of material and is defined as the volume of water divided by the total volume. Residual water content is the amount of water retained in the unsaturated alluvium after drainage and is defined as the volume of retained water divided by the total volume. Saturation is defined as a ratio of the water volume to the void volume (porosity) of a given material. Effective saturation is a measure of the degree of saturation of the effective porosity volume. Matric potential describes how tightly water is held in the unsaturated zone and can be used to calculate the degree to which water is draining freely as a result of gravitational forces. Saturated hydraulic conductivity describes the ability of a saturated material to transmit water when subjected to a hydraulic gradient. Particle-size distribution is a measure of the percent mass of particles in different size classes. Laboratory measurements were made at the USGS California Water Science Center Hydrologic Research Laboratory in Sacramento, California.

Physical Core Properties

Bulk density, porosity, effective porosity, volumetric water content, residual water content, saturation, effective saturation, matric potential, and saturated hydraulic conductivity were measured on selected core samples collected from YVUZ-5 by using American Society for Testing and Materials methods (1987). The matric potential of one core (242.0–242.5 ft bls) was measured in the laboratory by using the filter-paper method (Campbell and Gee, 1986). Water content was analyzed gravimetrically and volumetrically by using a water activity meter and filter.



Photograph by David O'Leary, U.S. Geological Survey, 2008.

Figure 7. Electronic dataloggers for unsaturated-zone monitoring site YVUZ-5 (1N/6E-32G1-33S), Warren subbasin, San Bernardino County, California, July 2008.

Because each result represents a discrete depth interval of core material, it was impractical to collect field replicates for quality-assurance purposes. Laboratory quality-assurance methods included verification of the calibration of the analytical balance, thermometers, relative-humidity sensor, drying ovens, and hydrometer and periodic analysis of a standard reference material (Berea sandstone). Instruments were re-calibrated as appropriate, and analyses showed no sources of measurable systematic bias to the environmental samples. Results of laboratory analyses for core bulk-density, porosity, effective porosity, volumetric water content, residual water content, saturation, effective saturation, and matric-potential data are presented in table 3. Results of laboratory analyses for core saturated hydraulic conductivity are presented in table 4.

Particle-Size Distribution of Drill Cuttings

Particle-size distribution (dry-sieve method) was measured on selected drill cuttings collected from YVUZ-5 by using sieving methods for sand-sized material and hydrometer methods for silt- and clay-sized material (American Society for Testing and Materials, 1987). Because each result represents a discrete depth interval of drill-cutting material, it was impractical to collect field replicates for quality-assurance purposes. Laboratory quality-assurance methods included verification of the calibration of the analytical balance and hydrometer. Results of laboratory analyses for particle-size distribution are presented in table 5.

Pilot-Scale Infiltration Pond

A 0.1-acre pilot-scale infiltration pond was constructed in the immediate vicinity of YVUZ-5. The infiltration pond was designed so that it surrounded YVUZ-5 on three sides to maximize the proximity of the borehole and applied water at the surface while still allowing access to the borehole (figs. 1 and 8). Water furnished by the HDWD from the community of Yucca Valley's municipal water supply was conveyed to the infiltration pond through an 8-in. diameter pipe.

The 0.1-acre pilot-scale infiltration pond was surveyed, and a stage-volume curve (fig. 9) was established for the purpose of estimating vertical infiltration rates as a function of inflow to the pond (volume) relative to the area of ponded water (fig. 10). Water levels in the pond were recorded to the nearest 0.01 ft on a daily basis by HDWD personnel using a staff gage; flow rates into the pond were recorded on a daily basis by using a totalizing flow meter on the inlet pipe.

Table 3. Bulk-density, porosity, effective porosity, volumetric water content, residual water content, saturation, effective saturation, and matric-potential data for selected core material from unsaturated-zone monitoring site YVUZ-5 (1N/6E-32G1-33S), Warren subbasin, San Bernardino County, California.

[Analysis by U.S. Geological Survey Hydrologic Research Laboratory in Sacramento, California. Location of site in figure 1. Water content was analyzed gravimetrically and volumetrically using a water activity meter and filter. **Abbreviations**: ft, foot; g, gram; cm^3, cubic centimeter; m^3, cubic meter; s, second; %, percent; MPa, mega pascal; —, no data]

Depth (ft)	Bulk density (g/cm^3)	Porosity (m^3/m^3)	Effective porosity (m^3/m^3)	Volumetric water content (m^3/m^3)	Residual water content (m^3/m^3)	Saturation (%)	Effective saturation (%)	Filter paper matric potential (MPa)
80.0–80.5	1.62	0.42	0.41	0.03	0.01	0.070	0.04	—
201.5–202.0	1.86	0.32	0.31	0.03	0.01	0.090	0.08	—
241.5–242.0	1.91	0.29	0.29	0.04	0.01	0.120	0.09	—
242.0–242.5	—	—	—	—	—	—	—	0.94

Table 4. Saturated hydraulic conductivity data for selected core material from unsaturated-zone monitoring site YVUZ-5 (1N/6E-32G1-33S), Warren subbasin, San Bernardino County, California.

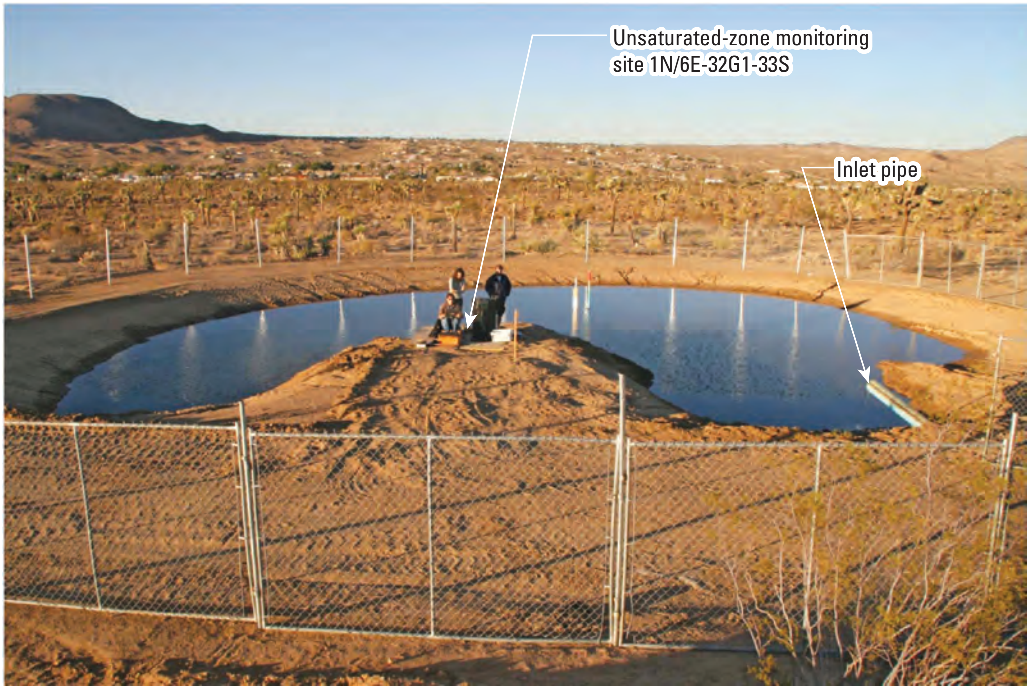
[Analysis by U.S. Geological Survey Hydrologic Research Laboratory in Sacramento, California. Location of site in figure 1. The gradient is the pressure gradient at which saturated conductivity was measured. **Abbreviations**: ft, foot; cm, centimeter; s, second; kPa, kiloPascal]

Sample depth (ft)	Saturated hydraulic conductivity (cm/s)	Saturated hydraulic conductivity (cm/day)	Saturated hydraulic conductivity (ft/day)	Gradient (kPa)
80.0–80.5	3.90E–03	338	11.09	6
201.5–202.0	7.40E–04	64	2.10	10
241.5–242.0	1.40E–03	117	3.84	4
242.0–242.5	1.70E–03	143	4.68	6

Table 5. Particle-size distribution for selected drill cuttings from unsaturated-zone monitoring site YVUZ-5 (1N/6E-32G1-33S), Warren subbasin, San Bernardino County, California.

[Analysis by U.S. Geological Survey Hydrologic Research Laboratory in Sacramento, California. Location of site in figure 1. **Abbreviations**: ft, foot]

Depth (ft)	Percentage finer than size indicated, in millimeters									
	Rock	Gravel		Very coarse sand	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
	19.0	**9.50**	**4.75**	**2.00**	**1.00**	**0.50**	**0.25**	**0.125**	**0.053**	**0.002**
11–12	100	97	93	87	77	62	44	21	9	3
25–26	100	100	99	84	51	26	13	7	4	3
45–46	100	98	96	87	70	50	32	18	11	5
65–66	100	100	94	81	65	43	23	10	4	2
65–66	100	100	94	81	65	45	27	12	5	4
119–120	100	99	98	96	89	77	56	34	18	4
161–162	97	93	89	86	78	63	47	28	14	4
193–194	100	98	94	84	68	46	26	13	7	3
194–195	100	89	75	62	48	32	21	12	5	2
215–216	100	100	100	96	87	71	52	34	20	5
237–238	100	99	97	92	77	55	36	21	11	4
261–262	100	100	98	91	82	70	55	35	22	7
285–286	100	100	98	96	90	82	69	48	31	8
293–294	100	100	100	95	79	56	40	28	18	6
318–319	100	100	99	91	74	54	37	22	12	4
364–365	100	100	100	98	92	81	69	51	34	11



Photograph by Laurel Rogers, U.S. Geological Survey, 2008.

Figure 8. Pilot-scale infiltration pond and unsaturated-zone monitoring site YVUZ-5 (1N/6E-32G1-33S), Warren subbasin, San Bernardino County, California, November, 2008.

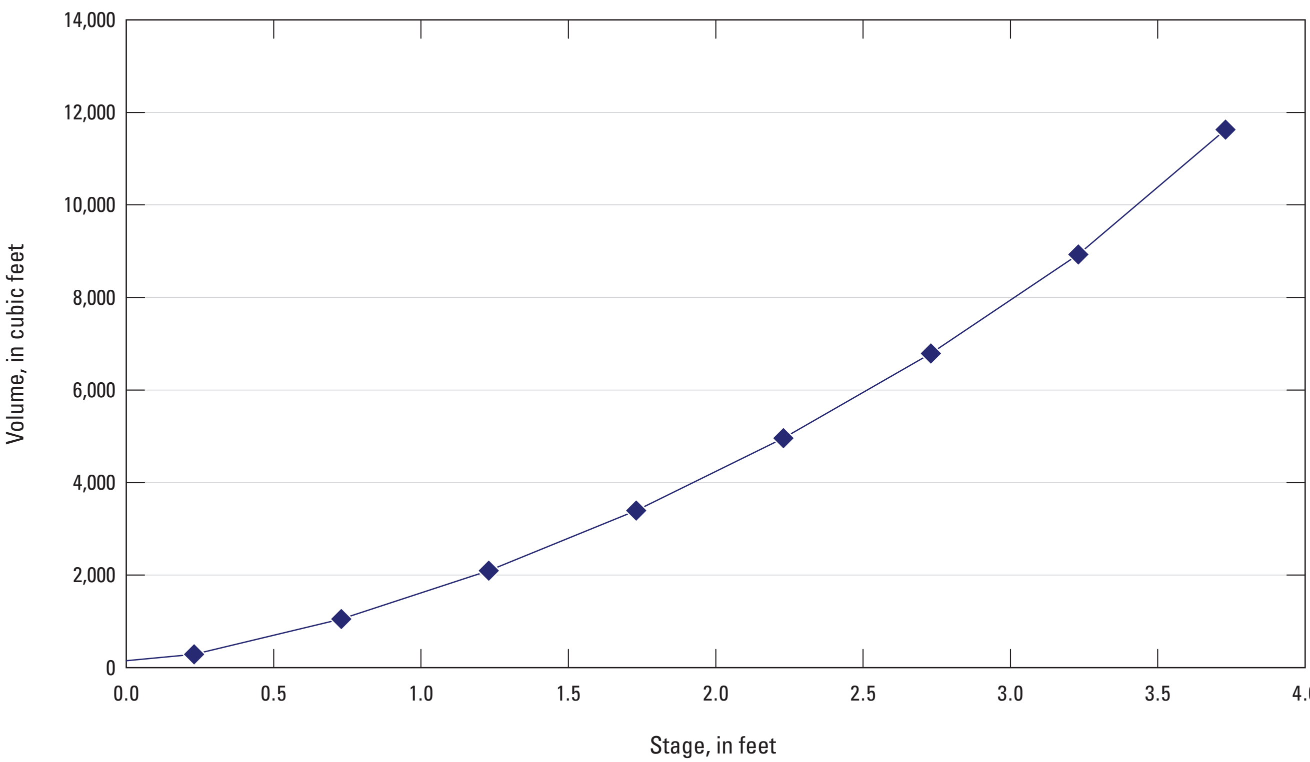


Figure 9. Pilot-scale infiltration pond stage-volume curve, unsaturated-zone monitoring site YVUZ-5 (1N/6E-32G1-33S), Warren subbasin, San Bernardino County, California.

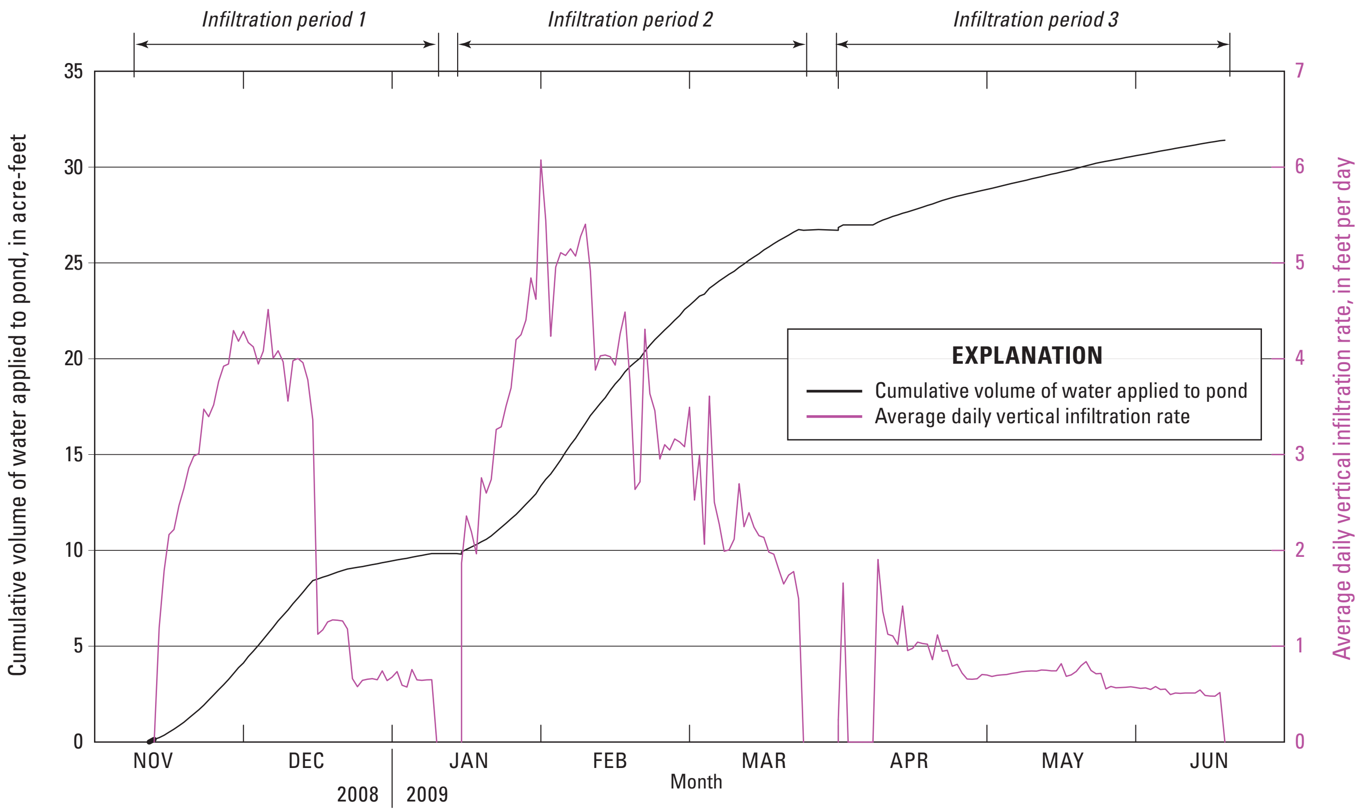


Figure 10. Cumulative volume of water applied to the pilot-scale infiltration pond and vertical infiltration rate at unsaturated-zone monitoring site YVUZ-5 (1N/6E-32G1-33S), Warren subbasin, San Bernardino County, California, November 2008–June 2009.

Water was applied to the pilot-scale infiltration pond during three periods between November 12, 2008, and June 16, 2009 (fig. 10 and table 6). A total of about 31.3 acre-ft of water was applied to the pond. Vertical infiltration rates were as high as 6.1 feet per day (ft/d) and declined during each recharge period to as low as 0.2 ft/d as fine-grained material and algae clogged the pond bottom (fig. 10). Between each recharge period the pond was allowed to dry, and the bottom of the pond was either scraped (between periods 1 and 2) or ripped (between periods 2 and 3). Scraping of the pond bottom (physical removal of the top layer of material) between periods 1 and 2 resulted in infiltration rates returning to their original values; ripping of the pond bottom (disturbance of the top layer of material) between periods 2 and 3 resulted in a relatively small recovery of infiltration rates.

The average vertical infiltration rates during infiltration periods 1, 2, and 3 were 2.4, 3.3, and 0.7 ft/d, respectively, and the peak infiltration rates were 4.5, 6.1, and 1.9 ft/d, respectively (table 6). The average infiltration rate over the entire period of water application was about 2 ft/d.

Pilot-scale infiltration pond evaporation data were not collected as part of this study; however, similar studies elsewhere in the Mojave Desert have indicated that evaporative losses are small compared to the volume of water infiltrated during the study, particularly at high infiltration rates (Izbicki and others, 2008).

Table 6. Pilot-scale infiltration pond summary data near unsaturated-zone monitoring site YVUZ-5 (1N/6E-32G1-33S), Warren subbasin, San Bernardino County, California, November 2008–June 2009.

[Infiltration period dates are days when water was present in pond. **Abbreviations**: acre-ft, acre-foot; d, day; ft, foot; mm/dd/yyyy, month/day/year]

Infiltration period	1	2	3
Dates	11/12/2008 through 01/08/2009 (mm/dd/yyyy)	01/14/2009 through 03/24/2009 (mm/dd/yyyy)	03/31/2009 through 06/16/2009 (mm/dd/yyyy)
Length of period (d)	58	70	78
Volume infiltrated (acre-ft)	9.8	17.1	4.4
Cumulative volume infiltrated (acre-ft)	9.8	26.9	31.3
Percentage of total infiltrated volume	31	55	14
Average vertical infiltration rate (ft/d)	2.4	3.3	0.7
Peak infiltration rate (ft/d)	4.5	6.1	1.9

Observation Well and Unsaturated-Zone Instrumentation Data

Data from the pressure transducer were checked against manual groundwater-level measurements made by using a calibrated electric tape (manual procedure described by Cunningham and others, 2011); water-level data are shown in figure 11. Matric-potential data collected every 4 hours by using HDPs and DEPS are shown in figures 12 and 13, respectively. Four of the eight DEPs failed upon deployment; useful data were recorded for some periods by sensors installed at 42, 84, 141, and 290 ft bls; the DEPS situated at 42 and 84 ft bls (1N/6E-32G32S and 1N/6E-32G27S, respectively) failed during the course of the study. Matric-potential and temperature data collected by using ATs are shown in figures 14 and 15, respectively. All of the data are available from the USGS National Water Information System (NWIS) database at http://waterdata.usgs.gov/nwis. These data are representative of conditions in the underlying unsaturated zone and aquifer prior to, during, and after infiltration of water from the pilot-scale infiltration pond.

Water-Quality Methods and Data

The concentrations of soluble anions extracted from drill cuttings from YVUZ-5 were determined and reported. The chemical and isotopic composition of groundwater, collected from the observation well; unsaturated-zone water, collected by suction cup lysimeters; and water collected from the pilot-scale infiltration pond were analyzed. Analytical methods and reporting limits for water samples submitted to the USGS National Water Quality Laboratory (NWQL), Denver, Colorado, and the USGS Stable Isotope Laboratory (STIL), Reston, Virginia, are presented in table 7. These data are representative of conditions in the underlying unsaturated zone and aquifer prior to, during, and after infiltration of water from the pilot-scale infiltration pond.

Soluble Anions Extracted from Drill Cuttings

Concentrations of soluble anions, including bromide, chloride, fluoride, sulfate, nitrate, nitrite, phosphate, and orthophosphate, in unsaturated-zone sediment and dissolved in unsaturated-zone water were determined by analyzing water extracted from drill-cutting material. Samples were analyzed at the USGS San Diego Water Quality Laboratory by using ion chromatography (U.S. Environmental Protection Agency, 1993).

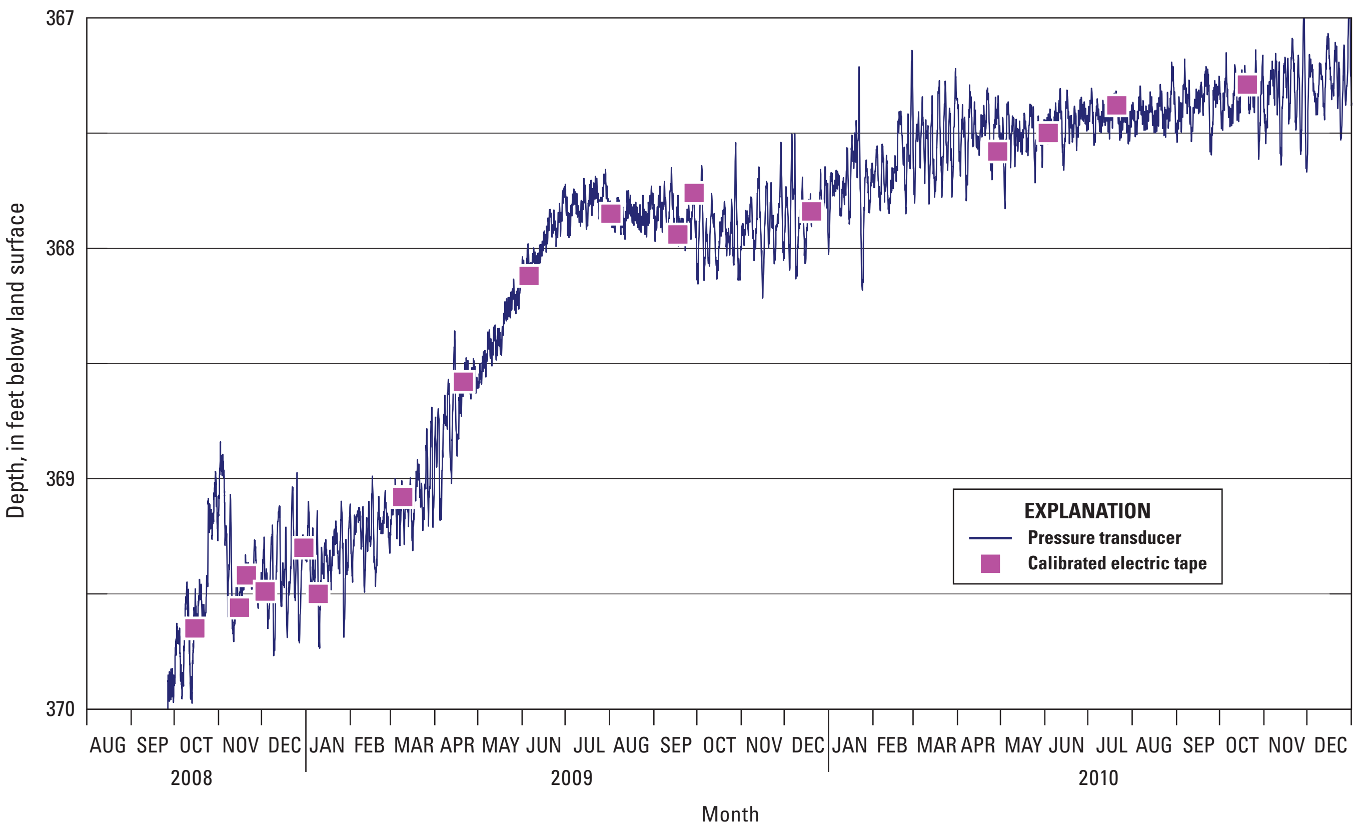


Figure 11. Hydrograph for well 1N/6E-32G1 at unsaturated-zone monitoring site YVUZ-5 (1N/6E-32G1-33S), Warren subbasin, San Bernardino County, California, August 2008–December 2010.

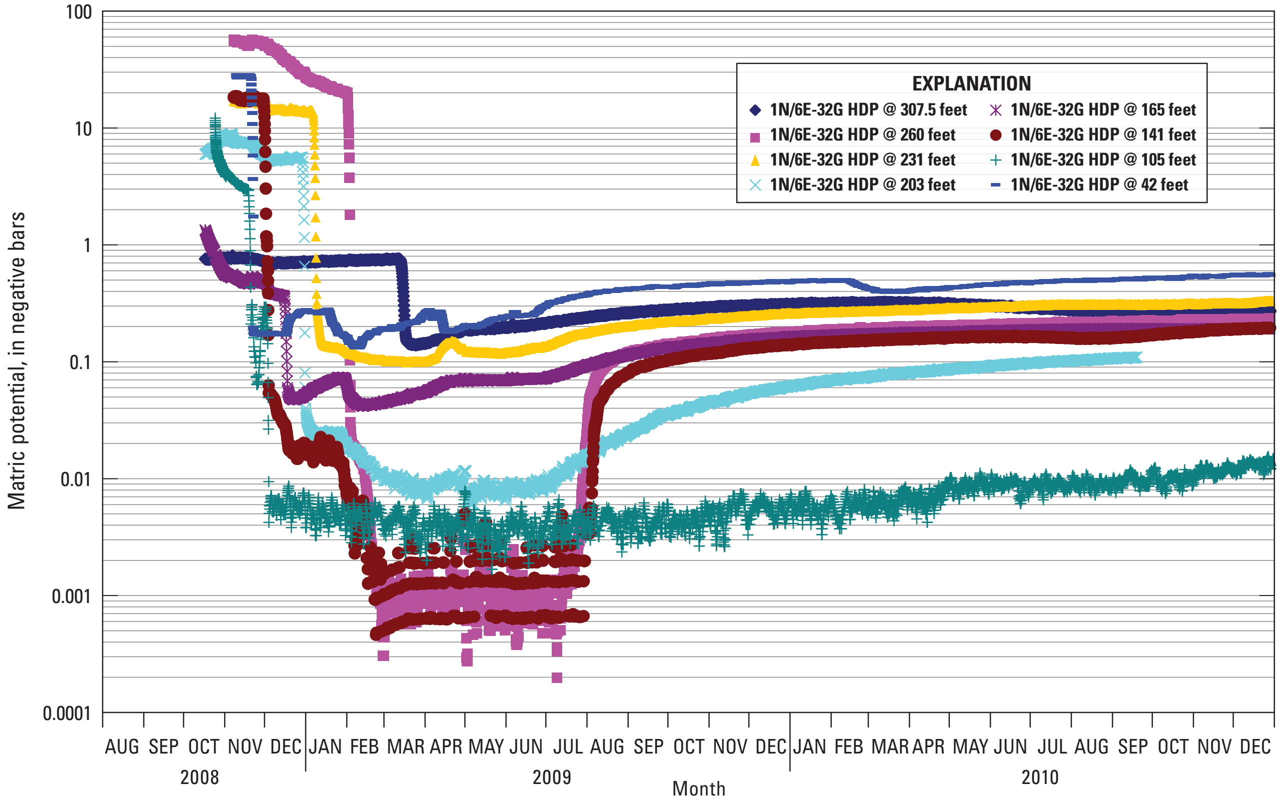


Figure 12. Heat dissipation probe (HDP) matric potential, unsaturated-zone monitoring site YVUZ-5 (1N/6E-32G1-33S), Warren subbasin, San Bernardino County, California, August 2008–December 2010.

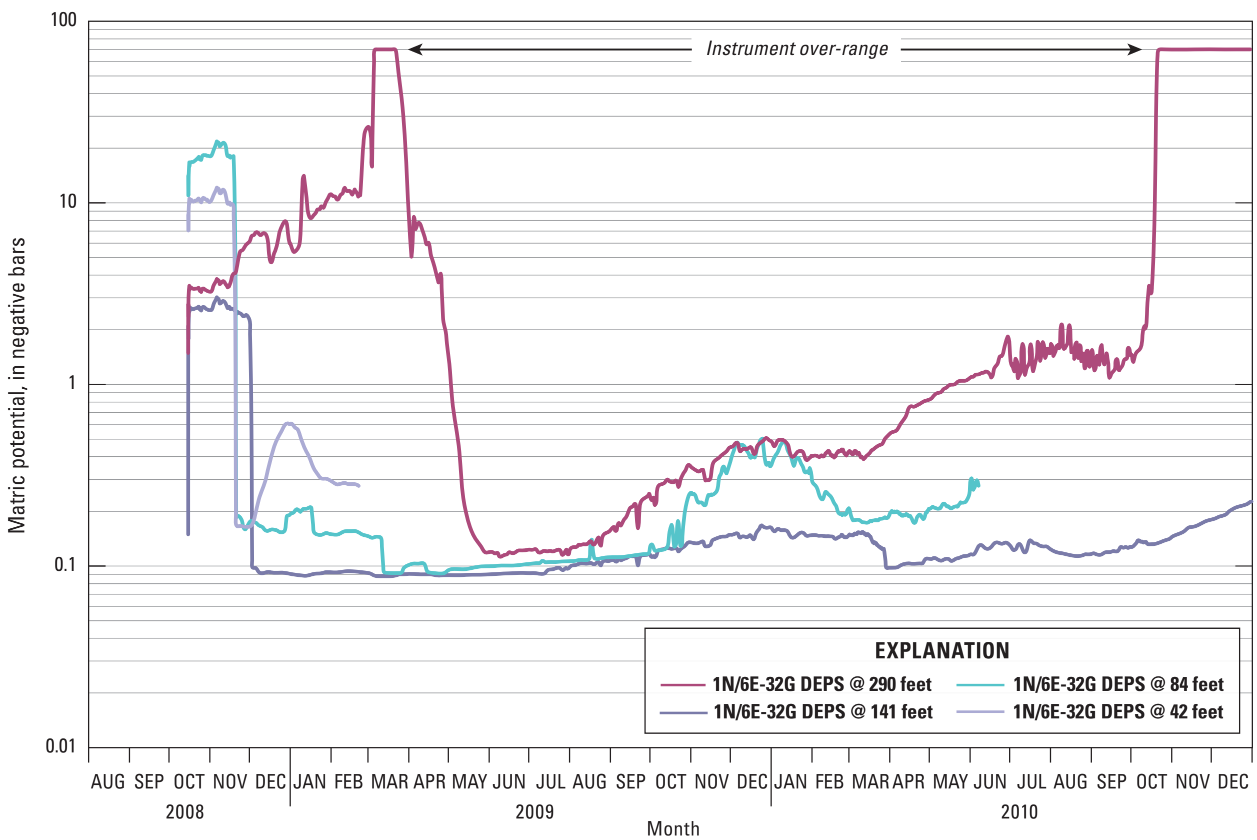


Figure 13. Dielectric permittivity sensor (DEPS) matric potential, unsaturated-zone monitoring site YVUZ-5 (1N/6E-32G1-33S), Warren subbasin, San Bernardino County, California, August 2008–December 2010.

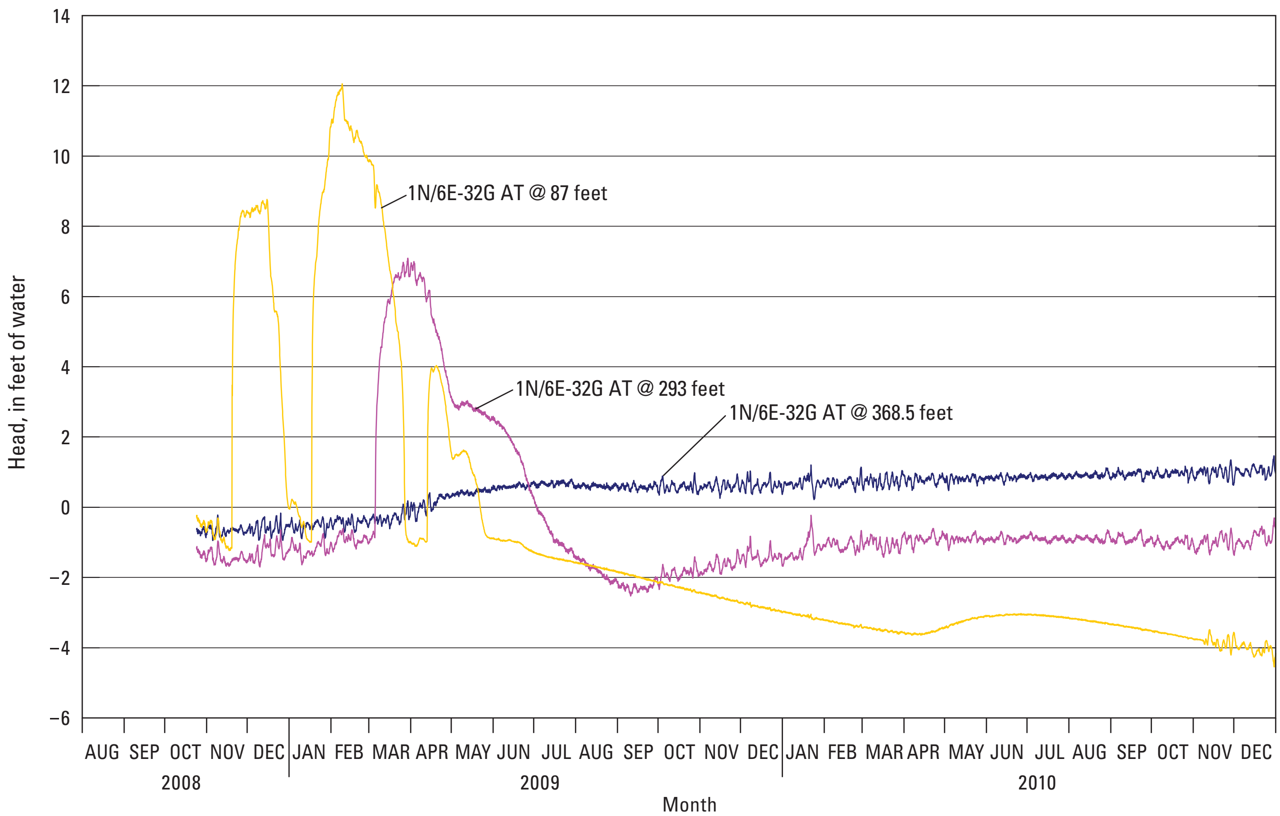


Figure 14. Advanced tensiometer (AT) matric potential, unsaturated-zone monitoring site YVUZ-5 (1N/6E-32G1-33S), Warren subbasin, San Bernardino County, California, August 2008–December 2010.

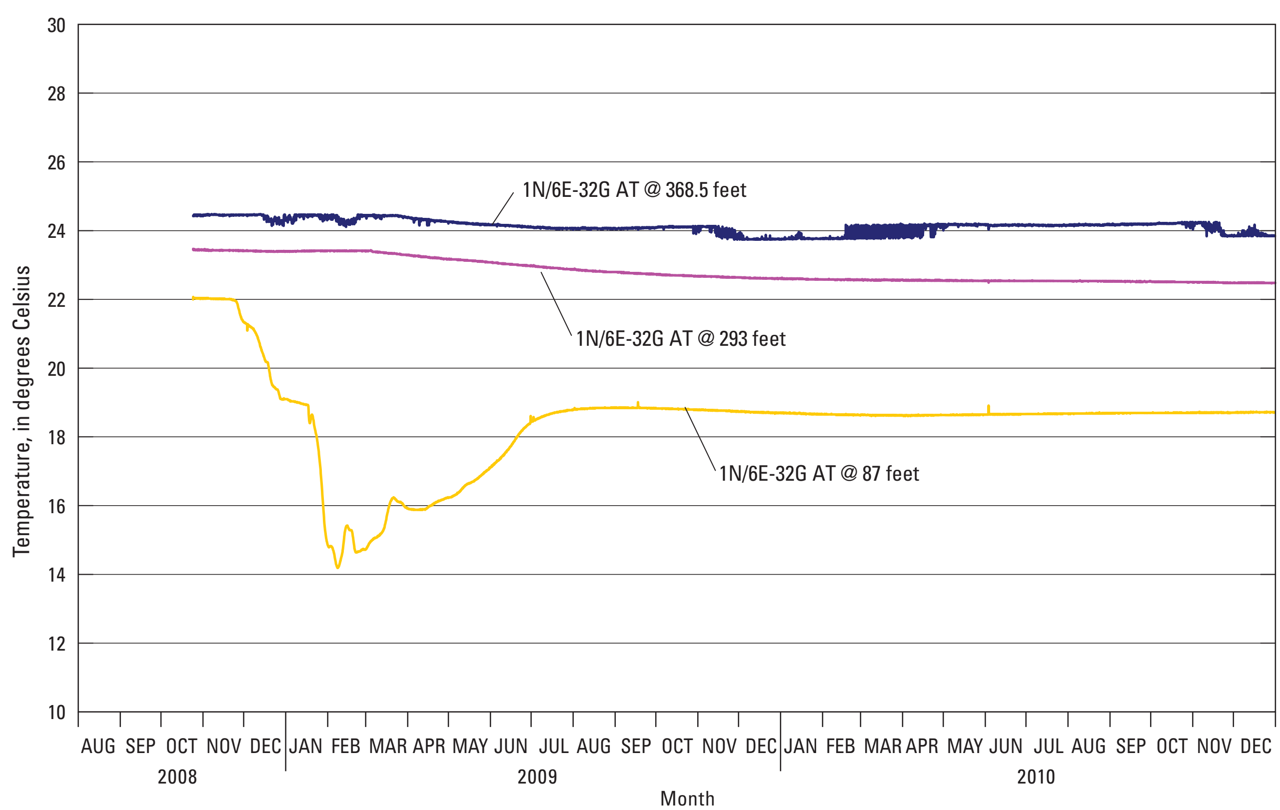


Figure 15. Advanced tensiometer (AT) temperature, unsaturated-zone monitoring site YVUZ-5 (1N/6E-32G1-33S), Warren subbasin, San Bernardino County, California, August 2008–December 2010.

Table 7. Analytical methods and reporting limits for water samples submitted to the U.S. Geological Survey National Water Quality Laboratory and Stable Isotope Laboratory.

[**Abbreviations**: ASF, automated-segmented flow; deg C, degree Celsius; mg/L, milligram per liter; pCi/L, picocurrie per liter, µS/cm, microsiemens per centimeter at 25 degrees Celsius; µg/L, microgram per liter]

Constituent	Methodology	Reporting level	Reporting level type	Reference
Bulk water-quality parameters				
pH	pH electrode	0.1 std units	Minimum reporting level	Fishman and Friedman, 1989
Specific conductance	Wheatstone bridge	5 µS/cm	Minimum reporting level	Fishman and Friedman, 1989
Dissolved oxygen	Indigo carmine	0.2 mg/L	Minimum reporting level	CHEMetrics, Inc., Calverton, Va.
Alkalinity	Titration with sulfuric acid	4.6 mg/L	Long-term method detection level	Fishman and Friedman, 1989
Major ions				
Calcium, dissolved	Inductively coupled plasma	0.022 mg/L	Long-term method detection level	Fishman, 1993
Chloride, dissolved	Ion chromatography	0.06 mg/L	Laboratory reporting level	Fishman and Friedman, 1989
Dissolved solids	Gravimetric, residue on evaporation at 180 deg C	10 mg/L	Minimum reporting level	Fishman and Friedman, 1989
Magnesium, dissolved	Inductively coupled plasma	0.016 mg/L	Laboratory reporting level	Fishman, 1993
Potassium, dissolved	Atomic adsorption, flame	0.064 mg/L	Laboratory reporting level	Fishman and Friedman, 1989
Silica, dissolved	Colorimetry, ASF	0.1 mg/L	Interim reporting level	Fishman and Friedman, 1989
Sodium, dissolved	Inductively coupled plasma	0.1 mg/L	Laboratory reporting level	Fishman, 1993
Sulfate, dissolved	Ion chromatography	0.18 mg/L	Laboratory reporting level	Fishman and Friedman, 1989
Nutrients				
Nitrite, filtered	Colorimetry, ASF,	0.002 mg/L	Interim reporting level	Fishman, 1993
Nitrite + nitrate, filtered	Colorimetry, ASF, cadmium reduction-diazotization	0.04 mg/L	Interim reporting level	Patton and Kryskalla, 2011
Ammonia, dissolved	Colorimetry, ASF, salicylate-hypochlorite	0.02 mg/L	Laboratory reporting level	Fishman, 1993
Ammonia + organic nitrogen, dissolved	Colorimetry, ASF, microkjeldahl digestion	0.10 mg/L	Laboratory reporting level	Patton and Truitt, 2000
Total nitrogen	Colorimetry, ASF, microkjeldahl digestion	0.04 mg/L	Interim reporting level	Patton and Kryskalla, 2011
Phosphorus, dissolved	Colorimetry, ASF, microkjeldahl digestion	0.04 mg/L	Laboratory reporting level	Patton and Truitt, 1992
Orthophosphate, dissolved	Colorimetry, ASF, phosphomolybdate	0.008 mg/L	Laboratory reporting level	Fishman, 1993
Dissolved organic carbon	UV oxidatoin and infrared spectrometry	0.23 mg/L	Laboratory reporting level	Brenton and Arnett, 1993
Trace elements				
Aluminum, dissolved	Inductively coupled plasma	3.4 µg/L	Laboratory reporting level	Garbarino and others, 2006
Arsenic, dissolved	Graphite furnace atomic adsorption	0.06 µg/L	Laboratory reporting level	Garbarino and others, 2006
Barium, dissolved	Inductively coupled plasma	0.6 µg/L	Laboratory reporting level	Fishman, 1993
Boron, dissolved	Inductively coupled plasma	2 µg/L	Laboratory reporting level	Struzeski and others, 1996
Bromide, dissolved	Colorimetry, ASF	0.02 mg/L	Interim reporting level	Struzeski and others, 1996; Fishman and Friedman, 1989
Chromium, dissolved	Inductively coupled plasma	0.12 µg/L	Interim reporting level	Garbarino and others, 2006
Fluoride, dissolved	ASF, ion-selective electrode	0.08 mg/l	Laboratory reporting level	Fishman and Friedman, 1989
Iodide, dissolved	Colorimetry, ASF, cericarseneous	0.002 mg/L	Laboratory reporting level	Fishman and Friedman, 1989
Iron, dissolved	Inductively coupled plasma	4 µg/L	Laboratory reporting level	Fishman, 1993
Lithium, dissolved	Inductively coupled plasma	0.06 µg/L	Laboratory reporting level	Fishman, 1993
Manganese, dissolved	Inductively coupled plasma	0.02 µg/L	Laboratory reporting level	Fishman, 1993
Strontium, dissolved	Inductively coupled plasma	0.4 µg/L	Laboratory reporting level	Fishman, 1993
Isotopes				
Deuterium/Protium	Mass Spectrometry	2 per mil	Laboratory reporting level	Coplen and others, 1991
Nitrogen-15/ Nitrogen-14	Mass Spectrometry	0.5 per mil	Laboratory reporting level	Coplen and others, 2012
Oxygen-18/Oxygen-16	Mass Spectrometry	0.2 per mil	Laboratory reporting level	Epstein and Mayeda, 1953
Tritium	Electrolytic enrichment and liquid scintillation	1.0 pCi/L	Laboratory reporting level	Thatcher and others, 1977

Drill cuttings were dried in an oven at 70 degrees Celsius (°C) for 12 hrs and then sieved to obtain 50 (±0.005) grams (g) of material having particle sizes of less than 1.4 mm (coarse sand and finer material). Each sieved sample was mixed with 50 milliliters (mL) of de-ionized water and shaken vigorously on a wrist shaker for 24 hr, then centrifuged at 5,000 revolutions per minute (rpm) for 1 hr to allow the remaining solids to settle. The resulting supernatant was then pressure-filtered (by using a syringe) through a 0.45-mirometer (µm) pore-sized disk filter. The first 10 mL of sample was used to rinse the filter and then discarded. The remaining sample was filtered and analyzed for soluble anions (bromide, chloride, fluoride, sulfate, nitrate, nitrite, phosphate, and orthophosphate) at the USGS San Diego Water-Quality Laboratory by using the ion-chromatography method (U.S. Environmental Protection Agency, 1993). Sample handling and extraction procedures were similar to those used by Prudic (1994), except that in this study the samples were centrifuged prior to filtration and the ratio of drill cutting material to de-ionized water (1:1, by weight) was greater than that used by Prudic (1:3, by weight). The samples were centrifuged before filtration to remove any fine-grained or colloidal material that would have impeded the filtration process. The ratio of drill-cutting material (solids) to de-ionized water used for the laboratory extractions for analysis of anions was based on a weight per volume ratio, whereas the ratio used for specific-conductance measurements in the field was based on a volume per volume ratio. However, the results are believed to be comparable (Izbicki and others, 2000a). Concentrations of soluble anions in water extracted from the drill cuttings are presented in table 8. Assuming a standard chloride concentration in the incoming rainfall, water-extractable chloride can be used to calculate the length of time since recharge at the site (Izbicki and Michel, 2004). Nitrate concentrations can be used to calculate mass of nitrate in the subsurface that could be mobilized as a result of groundwater recharge (artificial or natural).

Chemistry of Groundwater

Groundwater samples from the observation well at YVUZ-5 were collected and analyzed to classify the chemical and isotopic composition of groundwater at the site. Samples were collected by using a positive-displacement piston pump after at least three casing volumes had been pumped from the well and field measurements of pH, specific conductance, and temperature had stabilized to within 5 percent of the previously recorded value. Groundwater samples were collected and processed in accordance with the protocols established by the USGS National Field Manual (NFM; U.S. Geological Survey, variously dated). These sampling protocols ensure that a representative sample of groundwater is collected and that potential contamination of samples during collection and handling is minimized.

Groundwater samples were submitted to the NWQL for analysis of major ions, nutrients, dissolved organic carbon, and selected trace elements by using methods by Fishman and Friedman (1989), Fishman (1993), Brenton and Arnett (1993), and Garbarino and others (2002, 2006). Selected samples were sent to the STIL for analysis of the stable-isotope ratios of oxygen-18/oxygen-16 ($\delta^{18}O$), nitrogen-15/nitrogen-14 (δ15N) and deuterium/protium (δD) by using mass spectrometry (Epstein and Mayeda, 1953; Coplen and others, 1991). Field blanks and field replicates were not collected from the observation well at YVUZ-5; however the well was sampled with other wells in the area as part of the same sampling trip. The blank and replicate samples collected as part of the collective sampling events showed no sources of measurable systematic bias to the environmental samples. The results for chemical and isotopic analysis of groundwater from the observation well are presented in tables 9, 10 and 11.

Chemistry of Unsaturated-Zone Water

Suction-cup lysimeters were used to collect samples by applying a vacuum (of about 65 centibars) to the vacuum tube, which induces water to flow from the unsaturated zone into the lysimeters. Once in the lysimeters, the water was forced to the land surface by pressurizing the system by applying nitrogen gas to one tube of the two-tube system. If the matric potential of the unsaturated zone near the lysimeter is more negative than inside the lysimeter, water will not enter the lysimeter. Most lysimeters required a vacuum application many times for several months before the lysimeters yielded water and the first sample could be collected. Although the amount of water yielded varied considerably from one lysimeter to another, about 2–4 weeks were required after a vacuum was applied to ensure a maximum accumulation of water within most lysimeters cups. Umari and others (1995) reported that shorter sampling periods resulted in incomplete water recovery and longer sampling periods resulted in partial loss of the sample through leakage back into the surrounding material.

There is some uncertainty about whether the samples from the suction-cup lysimeters reliably represent the water in the unsaturated zone. This uncertainty is attributed to the potential contamination of the sample by lysimeter materials, the inability to collect sufficient sample volume for analysis, variability in sample collection due to variability in the applied vacuum, and changes in the sample (such as chemical precipitation) during collection and storage within the body of the lysimeter (Umari and others, 1995).

The chemical and isotopic composition of unsaturated-zone water was analyzed for samples collected from the suction-cup lysimeters. Analyses for samples collected from the lysimeters included soluble anions (fluoride, chloride, nitrite, bromide, nitrate, orthophosphate, and sulfate) at the USGS San Diego Water Quality Laboratory by using ion chromatography (U.S. Environmental Protection

Table 8. Chemical compositions of water extractions from cuttings from unsaturated-zone monitoring site YVUZ-5 (1N/6E-32G1-33S), Warren subbasin, San Bernardino County, California, 2008.

[Analysis by U.S. Geological Survey laboratory in San Diego, California, except for specific conductance, which was measured in the field. Location of sites in figure 1. **Abbreviations**: E, estimated value; mg/kg, milligram per kilogram; —, no data; <, less than value shown; µS/cm, microsiemens per centimeter at 25 degrees Celsius]

Depth to top of sample interval, feet below land surface datum	Depth to bottom of sample interval, feet below land surface datum	Specific conductance, unfiltered field (µS/cm) (00095)	Bromide, filtered (mg/kg as Br) (71870)	Chloride, filtered (mg/kg as Cl) (00940)	Fluoride, filtered (mg/kg as F) (00950)	Sulfate, filtered (mg/kg as SO_4) (00945)	Nitrate, as nitrogen (mg/kg) (00618)	Nitrite, as nitrogen (mg/kg) (00613)	Phosphate, orthophosphate, as phosphorus (mg/kg) (00671)
6	7	—	0.10	10.0	2.23	17.5	2.54	E0.013	0.222
7	8	—	0.10	6.1	1.38	16.9	1.62	0.052	0.185
8	9	150	0.10	5.3	1.21	19.8	1.02	0.062	0.287
9	10	133	0.10	5.5	2.59	14.0	0.89	E0.031	0.753
10	11	146	0.10	9.3	1.81	18.1	0.80	E0.013	0.851
11	12	161	0.20	15.7	2.32	31.4	0.88	E0.014	0.673
12	13	157	—	—	—	—	—	—	—
13	14	144	0.20	17.7	3.11	23.5	0.40	E0.015	1.220
14	15	162	0.10	18.7	1.66	22.9	0.14	E0.013	0.438
15	16	152	0.10	23.0	2.01	31.5	0.35	E0.012	0.345
16	17	185	0.20	24.5	2.38	41.1	0.10	E0.012	0.429
17	18	178	0.20	27.3	2.72	50.8	0.18	E0.016	0.355
18	19	250	0.10	20.2	1.99	39.7	0.08	<0.050	0.256
19	20	246	0.10	18.5	2.48	48.7	E0.05	<0.050	0.253
20	21	222	0.10	19.6	1.27	30.6	0.08	E0.011	0.383
21	22	240	0.10	20.0	0.99	27.1	0.08	<0.050	0.306
22	23	142	0.10	18.1	1.32	21.8	E0.05	<0.050	0.648
23	24	158	0.20	29.1	1.50	30.4	0.10	<0.050	0.538
24	25	155	0.20	44.5	0.69	53.3	0.12	<0.050	0.097
25	26	282	0.20	38.6	1.12	29.8	0.12	E0.014	0.216
26	27	272	0.20	36.0	0.69	23.8	0.15	<0.050	E0.238
27	28	250	0.20	33.7	0.59	40.7	0.10	<0.050	0.160
28	29	242	0.30	54.2	0.93	34.8	0.18	<0.050	0.110
29	30	213	0.30	51.2	0.65	25.7	0.19	<0.050	0.119
30	31	258	0.30	48.6	0.69	24.1	0.14	<0.050	0.111
31	32	249	0.50	93.8	0.81	44.3	0.27	<0.050	E0.045
32	33	363	0.50	82.6	0.90	37.2	0.26	<0.050	0.057
33	34	304	0.50	96.4	0.62	40.5	0.28	<0.050	E0.038
34	35	306	0.50	92.0	1.11	40.7	0.35	<0.050	0.056
35	36	126	0.50	88.7	1.15	46.0	0.34	<0.050	E0.028
36	37	374	0.50	87.5	0.97	40.7	0.32	<0.050	E0.028
37	38	338	0.40	73.4	1.05	31.1	0.28	<0.050	E0.028
38	39	334	0.50	84.6	1.19	33.6	0.35	<0.050	E0.029
39	40	337	0.30	63.8	1.49	163	0.87	<0.050	0.208
40	41	187	0.30	76.2	1.03	107	0.61	<0.050	E0.035
41	42	430	0.40	84.6	1.29	51.1	0.55	<0.050	E0.045
42	43	186	0.40	76.8	1.14	30.2	0.42	<0.050	E0.049
43	44	342	0.40	83.4	0.96	17.6	0.40	<0.050	0.067
44	45	406	0.50	87.4	1.01	14.4	0.39	<0.050	0.073
45	46	346	0.60	109	0.97	14.7	0.47	<0.050	0.074
46	47	294	0.40	73.6	0.83	6.1	0.32	<0.050	0.071
49	50	172	0.60	54.3	1.16	4.5	0.29	<0.050	0.081
50	51	209	0.60	49.4	1.00	3.4	0.29	<0.050	0.081
51	52	214	0.60	44.7	1.32	3.0	0.27	<0.050	0.084
52	53	197	0.60	35.4	1.37	3.1	0.22	<0.050	0.079
53	54	194	0.20	43.5	1.43	4.7	0.27	<0.050	0.088
54	55	170	0.20	34.8	1.19	3.1	0.22	<0.050	0.061
55	56	170	0.20	32.7	1.26	3.8	0.22	<0.050	0.051
56	57	180	0.20	46.3	1.17	3.5	0.27	<0.050	0.076

Table 8. Chemical compositions of water extractions from cuttings from unsaturated-zone monitoring site YVUZ-5 (1N/6E-32G1-33S), Warren subbasin, San Bernardino County, California, 2008.—Continued

[Analysis by U.S. Geological Survey laboratory in San Diego, California, except for specific conductance, which was measured in the field. Location of sites in figure 1. **Abbreviations**: E, estimated value; mg/kg, milligram per kilogram; —, no data; <, less than value shown; µS/cm, microsiemens per centimeter at 25 degrees Celsius]

Depth to top of sample interval, feet below land surface datum	Depth to bottom of sample interval, feet below land surface datum	Specific conductance, unfiltered field (µS/cm) (00095)	Bromide, filtered (mg/kg as Br) (71870)	Chloride, filtered (mg/kg as Cl) (00940)	Fluoride, filtered (mg/kg as F) (00950)	Sulfate, filtered (mg/kg as SO_4) (00945)	Nitrate, as nitrogen (mg/kg) (00618)	Nitrite, as nitrogen (mg/kg) (00613)	Phosphate, orthophosphate, as phosphorus (mg/kg) (00671)
57	58	223	0.30	53.6	0.95	4.3	0.31	<0.050	0.056
58	59	224	—	—	—	—	—	—	—
59	60	218	—	—	—	—	—	—	—
60	61	109	0.20	30.1	1.00	3.3	0.24	<0.050	0.074
61	62	117	0.20	28.8	1.22	2.3	0.23	<0.050	0.097
62	63	110	0.10	25.4	1.11	2.4	0.21	<0.050	0.105
63	64	101	0.10	19.3	1.43	2.0	0.18	<0.050	0.121
64	65	81	0.10	14.4	1.15	E1.6	0.17	<0.050	0.120
65	66	85	0.10	15.7	1.38	2.6	0.24	<0.050	0.106
66	67	70	0.10	8.6	0.89	2.0	E0.04	E0.011	0.113
67	68	77	0.10	10.3	1.26	E1.9	0.20	E0.011	0.109
68	69	78	0.10	12.1	1.36	2.6	0.26	E0.011	0.109
69	70	65	0.05	6.7	1.30	2.0	0.20	E0.011	0.159
70	71	63	0.10	8.2	1.15	2.7	0.29	E0.011	0.119
71	72	67	E0.03	4.2	1.17	E1.6	0.20	E0.011	0.168
72	73	59	E0.03	3.1	1.10	E1.6	0.19	E0.011	0.142
73	74	61	E0.02	2.1	0.92	E1.4	0.21	E0.011	0.171
74	75	27	E0.02	1.2	0.80	E1.0	<0.05	E0.010	0.236
75	76	55	E0.02	1.2	1.19	E1.5	E0.05	<0.050	0.139
76	77	40	E0.02	1.6	1.05	E1.9	E0.04	E0.011	0.145
77	78	34	E0.02	1.4	0.87	2.4	E0.05	E0.011	0.143
78	79	34	E0.03	1.8	0.96	2.8	<0.05	<0.050	0.111
79	80	41	E0.03	6.8	0.97	43.6	E0.05	<0.050	0.173
80	81	186	E0.03	2.8	0.97	14.3	0.14	E0.011	0.098
81	82	267	E0.03	7.6	0.94	44.8	0.10	E0.011	0.060
82	83	172	E0.03	2.9	0.83	13.6	0.05	E0.010	E0.045
83	84	102	E0.02	2.3	0.87	13.2	E0.04	<0.050	0.065
84	85	93	E0.03	3.0	0.98	13.5	0.08	E0.011	0.051
85	86	91	E0.02	2.0	1.07	9.7	0.05	E0.014	0.097
86	87	144	E0.02	2.1	0.89	8.3	0.10	E0.011	0.127
87	88	132	E0.02	1.7	1.03	6.1	0.09	E0.013	0.138
88	89	115	E0.02	3.3	0.94	20.7	E0.05	E0.011	0.120
89	90	56	E0.02	2.3	1.06	9.7	0.05	<0.050	0.115
90	91	167	E0.02	1.9	0.98	6.9	0.06	E0.010	0.168
91	92	35	E0.01	1.5	1.69	4.8	0.10	E0.012	0.199
92	93	67	E0.02	1.6	2.02	4.0	0.08	E0.012	0.132
93	94	47	E0.02	1.3	1.69	3.9	0.26	E0.013	0.149
94	95	57	E0.02	1.2	1.10	3.5	0.14	E0.015	0.067
95	96	68	E0.02	1.1	1.60	3.4	0.22	E0.012	0.173
96	97	37	E0.01	1.3	2.95	4.4	0.08	E0.011	0.352
97	98	21	E0.01	1.1	2.70	2.8	0.10	E0.015	0.344
98	99	26	E0.01	E0.5	0.56	E1.4	0.14	E0.013	0.098
99	100	38	0.10	37.0	1.55	232	0.95	E0.016	0.225
100	101	39	E0.04	23.4	1.55	123	0.66	E0.012	0.172
101	102	38	E0.02	6.8	1.47	35.3	0.28	E0.012	0.134
102	103	42	E0.02	3.8	1.43	20.1	0.23	E0.012	0.108
103	104	53	E0.02	2.1	1.24	8.8	0.20	E0.014	0.092
104	105	53	E0.01	1.2	1.49	3.7	0.27	<0.050	0.235
105	106	605	E0.02	1.2	1.41	3.8	0.24	E0.017	0.180

Table 8. Chemical compositions of water extractions from cuttings from unsaturated-zone monitoring site YVUZ-5 (1N/6E-32G1-33S), Warren subbasin, San Bernardino County, California, 2008.—Continued

[Analysis by U.S. Geological Survey laboratory in San Diego, California, except for specific conductance, which was measured in the field. Location of sites in figure 1. **Abbreviations**: E, estimated value; mg/kg, milligram per kilogram; —, no data; <, less than value shown; µS/cm, microsiemens per centimeter at 25 degrees Celsius]

Depth to top of sample interval, feet below land surface datum	Depth to bottom of sample interval, feet below land surface datum	Specific conductance, unfiltered field (µS/cm) (00095)	Bromide, filtered (mg/kg as Br) (71870)	Chloride, filtered (mg/kg as Cl) (00940)	Fluoride, filtered (mg/kg as F) (00950)	Sulfate, filtered (mg/kg as SO_4) (00945)	Nitrate, as nitrogen (mg/kg) (00618)	Nitrite, as nitrogen (mg/kg) (00613)	Phosphate, orthophosphate, as phosphorus (mg/kg) (00671)
106	107	289	E0.01	1.1	1.46	2.9	0.24	E0.015	0.223
107	108	90	E0.02	1.4	1.26	3.8	0.24	E0.015	0.116
108	109	127	E0.02	1.3	1.22	3.9	0.25	E0.015	0.107
109	110	81	E0.02	1.3	1.31	3.7	0.26	E0.015	0.118
110	111	50	E0.02	1.5	1.52	4.3	0.23	E0.013	0.100
111	112	56	E0.02	1.4	1.75	4.5	0.22	E0.013	0.120
112	113	52	E0.02	1.2	1.83	3.4	0.17	E0.013	0.148
113	114	40	E0.02	E1.0	1.65	2.3	0.16	E0.012	0.243
114	115	31	E0.01	1.1	1.64	2.7	0.14	E0.012	0.126
115	116	32	<0.1	E1.0	1.47	2.2	0.16	E0.013	0.206
116	117	27	E0.02	1.2	1.46	2.8	0.21	E0.014	0.130
117	118	37	—	—	—	—	—	—	—
118	119	40	E0.02	1.1	1.36	2.8	0.20	E0.014	0.116
119	120	32	E0.02	E1.0	1.68	2.4	0.21	E0.013	0.170
120	121	262	E0.02	4.8	1.45	20.9	0.29	E0.012	0.111
121	122	77	E0.02	4.6	1.39	21.8	0.29	E0.012	0.107
122	123	120	E0.02	3.2	1.31	16.2	0.32	E0.012	0.085
123	124	80	E0.02	3.1	1.15	15.9	0.24	E0.012	0.066
124	125	90	E0.03	4.5	1.16	23.4	0.16	E0.012	<0.050
125	126	73	E0.02	2.7	1.37	11.0	0.23	E0.012	0.110
126	127	74	E0.02	2.0	1.29	8.5	0.20	E0.011	0.188
127	128	39	E0.02	1.4	1.38	4.8	0.11	E0.015	0.189
128	129	42	E0.01	1.3	1.34	3.9	0.12	E0.014	0.222
129	130	31	E0.02	1.1	1.33	2.6	0.08	E0.013	0.209
130	131	37	E0.02	1.3	1.46	4.1	0.10	E0.015	0.265
131	132	27	E0.01	E0.9	1.12	E1.6	0.08	E0.013	0.268
132	133	21	E0.02	1.1	1.33	3.2	<0.05	<0.050	0.119
133	134	25	E0.02	E1.0	1.28	2.7	E0.05	E0.010	0.167
134	135	43	E0.02	1.2	1.35	3.0	0.05	<0.050	0.140
135	136	27	E0.02	1.2	1.29	2.4	0.11	E0.018	0.208
136	137	31	E0.01	E1.0	1.22	2.2	0.15	E0.014	0.224
137	138	28	E0.01	E0.9	1.41	2.0	0.19	E0.013	0.332
138	139	22	E0.02	1.1	1.13	2.6	0.22	E0.012	0.108
139	140	44	E0.04	19.5	1.37	168	0.81	E0.011	0.213
140	141	244	E0.04	29.6	1.31	222	0.84	E0.013	E0.045
141	142	77	E0.02	6.3	1.10	45.9	0.46	E0.013	0.096
142	143	171	E0.02	1.9	1.45	10.8	0.38	E0.013	0.164
143	144	534	E0.02	2.8	1.34	15.0	0.21	E0.011	0.103
144	145	440	E0.03	3.9	1.22	25.6	0.10	E0.012	0.055
145	146	36	E0.02	5.1	1.15	28.3	0.10	E0.012	E0.043
146	147	90	E0.02	4.5	1.27	21.5	0.08	E0.012	0.054
147	148	112	E0.02	3.5	1.48	11.9	0.12	E0.013	0.108
148	149	81	E0.02	1.5	2.00	2.2	0.07	E0.037	0.176
149	150	75	E0.02	1.3	1.47	2.7	0.06	E0.039	0.085
150	151	33	E0.02	1.4	1.59	3.3	0.07	E0.022	0.057
151	152	57	—	—	—	—	—	—	—
152	153	54	—	—	—	—	—	—	—
153	154	47	—	—	—	—	—	—	—
154	155	59	—	—	—	—	—	—	—

Table 8. Chemical compositions of water extractions from cuttings from unsaturated-zone monitoring site YVUZ-5 (1N/6E-32G1-33S), Warren subbasin, San Bernardino County, California, 2008.—Continued

[Analysis by U.S. Geological Survey laboratory in San Diego, California, except for specific conductance, which was measured in the field. Location of sites in figure 1. **Abbreviations**: E, estimated value; mg/kg, milligram per kilogram; —, no data; <, less than value shown; µS/cm, microsiemens per centimeter at 25 degrees Celsius]

Depth to top of sample interval, feet below land surface datum	Depth to bottom of sample interval, feet below land surface datum	Specific conductance, unfiltered field (µS/cm) (00095)	Bromide, filtered (mg/kg as Br) (71870)	Chloride, filtered (mg/kg as Cl) (00940)	Fluoride, filtered (mg/kg as F) (00950)	Sulfate, filtered (mg/kg as SO_4) (00945)	Nitrate, as nitrogen (mg/kg) (00618)	Nitrite, as nitrogen (mg/kg) (00613)	Phosphate, orthophosphate, as phosphorus (mg/kg) (00671)
155	156	43	E0.01	1.2	1.67	2.4	0.09	E0.011	0.171
156	157	49	—	—	—	—	—	—	—
157	158	39	—	—	—	—	—	—	—
158	159	41	—	—	—	—	—	—	—
159	160	28	—	—	—	—	—	—	—
160	161	29	E0.02	1.1	1.83	E1.9	0.06	E0.022	0.183
161	162	59	—	—	—	—	—	—	—
162	163	30	—	—	—	—	—	—	—
163	164	51	—	—	—	—	—	—	—
164	165	34	—	—	—	—	—	—	—
165	166	31	E0.02	E1.0	1.88	2.1	E0.04	E0.014	0.070
166	167	34	—	—	—	—	—	—	—
167	168	34	—	—	—	—	—	—	—
168	169	42	—	—	—	—	—	—	—
169	170	40	—	—	—	—	—	—	—
170	171	41	E0.01	E1.0	2.00	E1.9	0.07	E0.011	0.180
171	172	19	—	—	—	—	—	—	—
172	173	20	—	—	—	—	—	—	—
173	174	22	—	—	—	—	—	—	—
174	175	30	—	—	—	—	—	—	—
175	176	15	E0.02	1.3	2.01	2.7	0.05	E0.011	0.157
176	177	40	—	—	—	—	—	—	—
177	178	12	—	—	—	—	—	—	—
178	179	27	—	—	—	—	—	—	—
179	180	50	—	—	—	—	—	—	—
180	181	84	E0.01	1.3	1.93	5.7	0.10	E0.013	0.172
181	182	25	—	—	—	—	—	—	—
182	183	17	—	—	—	—	—	—	—
183	184	18	—	—	—	—	—	—	—
184	185	22	—	—	—	—	—	—	—
185	186	16	E0.02	1.4	1.51	4.1	<0.05	<0.050	E0.031
186	187	18	—	—	—	—	—	—	—
187	188	17	—	—	—	—	—	—	—
188	189	12	—	—	—	—	—	—	—
189	190	23	—	—	—	—	—	—	—
190	191	26	E0.02	1.7	1.51	9.5	0.06	<0.050	0.072
191	192	28	—	—	—	—	—	—	—
192	193	42	—	—	—	—	—	—	—
193	194	32	—	—	—	—	—	—	—
194	195	30	—	—	—	—	—	—	—
195	196	33	E0.02	1.6	1.19	6.6	0.08	E0.012	0.055
196	197	26	—	—	—	—	—	—	—
197	198	25	—	—	—	—	—	—	—
198	199	23	—	—	—	—	—	—	—
199	200	21	—	—	—	—	—	—	—
200	201	25	<0.1	E0.9	1.51	2.3	0.16	E0.014	0.164
201	202	27	—	—	—	—	—	—	—
202	203	30	—	—	—	—	—	—	—
203	204	37	—	—	—	—	—	—	—

Table 8. Chemical compositions of water extractions from cuttings from unsaturated-zone monitoring site YVUZ-5 (1N/6E-32G1-33S), Warren subbasin, San Bernardino County, California, 2008.—Continued

[Analysis by U.S. Geological Survey laboratory in San Diego, California, except for specific conductance, which was measured in the field. Location of sites in figure 1. **Abbreviations**: E, estimated value; mg/kg, milligram per kilogram; —, no data; <, less than value shown; µS/cm, microsiemens per centimeter at 25 degrees Celsius]

Depth to top of sample interval, feet below land surface datum	Depth to bottom of sample interval, feet below land surface datum	Specific conductance, unfiltered field (µS/cm) (00095)	Bromide, filtered (mg/kg as Br) (71870)	Chloride, filtered (mg/kg as Cl) (00940)	Fluoride, filtered (mg/kg as F) (00950)	Sulfate, filtered (mg/kg as SO_4) (00945)	Nitrate, as nitrogen (mg/kg) (00618)	Nitrite, as nitrogen (mg/kg) (00613)	Phosphate, orthophosphate, as phosphorus (mg/kg) (00671)
204	205	27	—	—	—	—	—	—	—
205	206	34	E0.01	E0.9	1.62	2.1	0.20	E0.014	0.174
206	207	51	—	—	—	—	—	—	—
207	208	39	—	—	—	—	—	—	—
208	209	50	—	—	—	—	—	—	—
209	210	46	—	—	—	—	—	—	—
210	211	50	E0.01	E0.9	1.77	E1.7	0.13	E0.013	0.335
211	212	27	—	—	—	—	—	—	—
212	213	26	—	—	—	—	—	—	—
213	214	23	—	—	—	—	—	—	—
214	215	52	—	—	—	—	—	—	—
215	216	44	E0.02	1.3	1.53	3.0	0.08	E0.019	<0.050
216	217	41	—	—	—	—	—	—	—
217	218	47	—	—	—	—	—	—	—
218	219	54	—	—	—	—	—	—	—
219	220	42	—	—	—	—	—	—	—
220	221	25	E0.02	1.1	1.54	2.0	0.08	E0.016	0.052
221	222	28	—	—	—	—	—	—	—
222	223	25	—	—	—	—	—	—	—
223	224	18	—	—	—	—	—	—	—
224	225	21	—	—	—	—	—	—	—
225	226	19	E0.01	1.3	1.78	2.3	0.09	E0.012	0.192
226	227	25	—	—	—	—	—	—	—
227	228	35	—	—	—	—	—	—	—
228	229	34	—	—	—	—	—	—	—
229	230	31	—	—	—	—	—	—	—
230	231	28	E0.02	1.3	1.62	2.5	0.09	E0.013	0.120
231	232	19	—	—	—	—	—	—	—
232	233	16	—	—	—	—	—	—	—
233	234	14	—	—	—	—	—	—	—
234	235	22	—	—	—	—	—	—	—
235	236	12	E0.02	E0.8	1.47	E1.7	0.06	E0.010	0.142
236	237	64	—	—	—	—	—	—	—
237	238	19	—	—	—	—	—	—	—
238	239	21	—	—	—	—	—	—	—
239	240	31	—	—	—	—	—	—	—
240	241	57	E0.02	2.8	1.27	18.1	<0.05	<0.050	E0.040
241	242	73	—	—	—	—	—	—	—
242	243	65	—	—	—	—	—	—	—
243	244	35	—	—	—	—	—	—	—
244	245	65	—	—	—	—	—	—	—
245	246	88	E0.02	2.2	1.43	12.1	<0.05	E0.011	0.112
246	247	84	—	—	—	—	—	—	—
247	248	65	—	—	—	—	—	—	—
248	249	68	—	—	—	—	—	—	—
249	250	78	—	—	—	—	—	—	—
250	251	113	E0.01	2.4	1.47	11.0	0.13	E0.012	0.152
251	252	64	—	—	—	—	—	—	—
252	253	54	—	—	—	—	—	—	—

Table 8. Chemical compositions of water extractions from cuttings from unsaturated-zone monitoring site YVUZ-5 (1N/6E-32G1-33S), Warren subbasin, San Bernardino County, California, 2008.—Continued

[Analysis by U.S. Geological Survey laboratory in San Diego, California, except for specific conductance, which was measured in the field. Location of sites in figure 1. **Abbreviations**: E, estimated value; mg/kg, milligram per kilogram; —, no data; <, less than value shown; µS/cm, microsiemens per centimeter at 25 degrees Celsius]

Depth to top of sample interval, feet below land surface datum	Depth to bottom of sample interval, feet below land surface datum	Specific conductance, unfiltered field (µS/cm) (00095)	Bromide, filtered (mg/kg as Br) (71870)	Chloride, filtered (mg/kg as Cl) (00940)	Fluoride, filtered (mg/kg as F) (00950)	Sulfate, filtered (mg/kg as SO_4) (00945)	Nitrate, as nitrogen (mg/kg) (00618)	Nitrite, as nitrogen (mg/kg) (00613)	Phosphate, orthophosphate, as phosphorus (mg/kg) (00671)
253	254	33	—	—	—	—	—	—	—
254	255	28	—	—	—	—	—	—	—
255	256	29	E0.01	1.9	1.26	2.6	E0.05	E0.011	0.202
256	257	24	—	—	—	—	—	—	—
257	258	39	—	—	—	—	—	—	—
258	259	60	—	—	—	—	—	—	—
259	260	61	—	—	—	—	—	—	—
260	261	58	E0.02	2.2	0.92	8.7	0.10	E0.014	<0.050
261	262	94	—	—	—	—	—	—	—
262	263	50	—	—	—	—	—	—	—
263	264	47	—	—	—	—	—	—	—
264	265	55	—	—	—	—	—	—	—
265	266	40	E0.02	1.2	1.47	2.5	E0.05	E0.011	0.054
266	267	67	—	—	—	—	—	—	—
267	268	39	—	—	—	—	—	—	—
268	269	53	—	—	—	—	—	—	—
269	270	34	—	—	—	—	—	—	—
270	271	43	E0.02	6.1	1.40	6.7	0.22	E0.011	<0.050
271	272	50	—	—	—	—	—	—	—
272	273	46	—	—	—	—	—	—	—
273	274	43	—	—	—	—	—	—	—
274	275	33	—	—	—	—	—	—	—
275	276	44	E0.02	1.2	1.40	2.6	0.07	E0.017	0.153
276	277	52	—	—	—	—	—	—	—
277	278	49	—	—	—	—	—	—	—
278	279	38	—	—	—	—	—	—	—
279	280	50	—	—	—	—	—	—	—
280	281	—	E0.02	5.0	1.66	6.8	E0.05	E0.011	<0.050
281	282	64	—	—	—	—	—	—	—
282	283	72	—	—	—	—	—	—	—
283	284	51	—	—	—	—	—	—	—
284	285	48	—	—	—	—	—	—	—
285	286	48	E0.02	E1.0	1.29	2.3	0.14	E0.018	0.094
286	287	30	—	—	—	—	—	—	—
287	288	36	—	—	—	—	—	—	—
288	289	61	—	—	—	—	—	—	—
289	290	33	—	—	—	—	—	—	—
290	291	51	E0.02	1.7	1.39	15.3	<0.05	<0.050	0.063
291	292	89	—	—	—	—	—	—	—
292	293	48	—	—	—	—	—	—	—
293	294	36	—	—	—	—	—	—	—
294	295	35	—	—	—	—	—	—	—
295	296	38	E0.02	4.3	1.46	2.9	0.05	E0.011	0.139
296	297	34	—	—	—	—	—	—	—
297	298	32	—	—	—	—	—	—	—
298	299	28	—	—	—	—	—	—	—
299	300	30	—	—	—	—	—	—	—
300	301	61	E0.02	1.2	1.42	4.3	E0.04	E0.011	0.134
301	302	96	—	—	—	—	—	—	—

Table 8. Chemical compositions of water extractions from cuttings from unsaturated-zone monitoring site YVUZ-5 (1N/6E-32G1-33S), Warren subbasin, San Bernardino County, California, 2008.—Continued

[Analysis by U.S. Geological Survey laboratory in San Diego, California, except for specific conductance, which was measured in the field. Location of sites in figure 1. **Abbreviations**: E, estimated value; mg/kg, milligram per kilogram; —, no data; <, less than value shown; µS/cm, microsiemens per centimeter at 25 degrees Celsius]

Depth to top of sample interval, feet below land surface datum	Depth to bottom of sample interval, feet below land surface datum	Specific conductance, unfiltered field (µS/cm) (00095)	Bromide, filtered (mg/kg as Br) (71870)	Chloride, filtered (mg/kg as Cl) (00940)	Fluoride, filtered (mg/kg as F) (00950)	Sulfate, filtered (mg/kg as SO_4) (00945)	Nitrate, as nitrogen (mg/kg) (00618)	Nitrite, as nitrogen (mg/kg) (00613)	Phosphate, orthophosphate, as phosphorus (mg/kg) (00671)
302	303	60	—	—	—	—	—	—	—
303	304	41	—	—	—	—	—	—	—
304	305	71	—	—	—	—	—	—	—
305	306	57	E0.02	1.4	1.38	4.4	E0.05	E0.010	0.057
306	307	44	—	—	—	—	—	—	—
307	308	67	—	—	—	—	—	—	—
308	309	41	—	—	—	—	—	—	—
309	310	51	—	—	—	—	—	—	—
310	311	33	E0.02	1.1	1.38	2.8	0.06	E0.010	0.100
311	312	47	—	—	—	—	—	—	—
312	313	37	—	—	—	—	—	—	—
313	314	36	—	—	—	—	—	—	—
314	315	35	—	—	—	—	—	—	—
315	316	35	E0.02	1.3	1.52	3.3	<0.05	<0.050	E0.030
316	317	38	—	—	—	—	—	—	—
317	318	40	—	—	—	—	—	—	—
318	319	41	—	—	—	—	—	—	—
319	320	32	—	—	—	—	—	—	—
320	321	44	E0.01	E1.0	1.56	2.1	0.07	E0.011	0.051
321	322	26	—	—	—	—	—	—	—
322	323	22	—	—	—	—	—	—	—
323	324	21	—	—	—	—	—	—	—
324	325	39	—	—	—	—	—	—	—
325	326	39	E0.02	1.1	1.41	3.1	<0.05	E0.010	<0.050
326	327	45	—	—	—	—	—	—	—
327	328	48	—	—	—	—	—	—	—
328	329	53	—	—	—	—	—	—	—
329	330	36	—	—	—	—	—	—	—
330	331	39	E0.01	E0.9	1.43	2.4	<0.05	<0.050	E0.034
331	332	32	—	—	—	—	—	—	—
332	333	34	—	—	—	—	—	—	—
333	334	73	—	—	—	—	—	—	—
334	335	42	—	—	—	—	—	—	—
335	336	53	E0.02	1.1	1.57	3.4	<0.05	E0.010	E0.049
336	337	40	—	—	—	—	—	—	—
337	338	49	—	—	—	—	—	—	—
338	339	38	—	—	—	—	—	—	—
339	340	38	—	—	—	—	—	—	—
340	341	25	E0.02	1.2	1.45	3.4	0.06	E0.011	0.096
341	342	28	—	—	—	—	—	—	—
342	343	26	—	—	—	—	—	—	—
343	344	42	—	—	—	—	—	—	—
344	345	67	—	—	—	—	—	—	—
345	346	29	E0.04	E0.9	1.50	2.1	<0.05	<0.050	0.086
346	347	34	—	—	—	—	—	—	—
347	348	23	—	—	—	—	—	—	—
348	349	35	—	—	—	—	—	—	—
349	350	31	—	—	—	—	—	—	—
350	351	29	E0.02	E0.9	1.10	2.3	E0.04	<0.050	E0.049

Table 8. Chemical compositions of water extractions from cuttings from unsaturated-zone monitoring site YVUZ-5 (1N/6E-32G1-33S), Warren subbasin, San Bernardino County, California, 2008.—Continued

[Analysis by U.S. Geological Survey laboratory in San Diego, California, except for specific conductance, which was measured in the field. Location of sites in figure 1. **Abbreviations**: E, estimated value; mg/kg, milligram per kilogram; —, no data; <, less than value shown; µS/cm, microsiemens per centimeter at 25 degrees Celsius]

Depth to top of sample interval, feet below land surface datum	Depth to bottom of sample interval, feet below land surface datum	Specific conductance, unfiltered field (µS/cm) (00095)	Bromide, filtered (mg/kg as Br) (71870)	Chloride, filtered (mg/kg as Cl) (00940)	Fluoride, filtered (mg/kg as F) (00950)	Sulfate, filtered (mg/kg as SO_4) (00945)	Nitrate, as nitrogen (mg/kg) (00618)	Nitrite, as nitrogen (mg/kg) (00613)	Phosphate, orthophosphate, as phosphorus (mg/kg) (00671)
351	352	26	—	—	—	—	—	—	—
352	353	34	—	—	—	—	—	—	—
353	354	27	—	—	—	—	—	—	—
354	355	34	—	—	—	—	—	—	—
355	356	30	E0.02	1.2	1.18	4.1	E0.04	<0.050	0.067
356	357	43	—	—	—	—	—	—	—
357	358	22	—	—	—	—	—	—	—
358	359	47	—	—	—	—	—	—	—
359	360	32	—	—	—	—	—	—	—
360	361	60	E0.05	3.8	1.11	42.3	E0.04	<0.050	E0.022
361	362	34	E0.03	2.2	1.13	21.2	E0.04	<0.050	E0.042
362	363	82	E0.02	2.0	1.16	16.5	E0.05	<0.050	0.059
363	364	136	E0.02	2.0	1.37	11.9	E0.04	<0.050	0.097
364	365	158	E0.03	2.3	1.36	10.4	E0.04	E0.010	E0.047
365	366	42	E0.03	2.2	1.36	8.5	0.07	E0.010	0.073
366	367	41	E0.05	2.1	1.78	6.5	E0.04	<0.050	0.097
367	368	40	0.10	2.4	1.41	6.6	<0.05	<0.050	E0.042
368	369	51	0.10	2.8	1.94	7.1	E0.04	<0.050	E0.045
369	370	44	E0.1	2.6	2.42	6.0	E0.04	<0.050	0.129
370	371	35	E0.04	2.7	2.11	6.7	E0.04	<0.050	0.111
371	372	34	—	—	—	—	—	—	—
372	373	54	—	—	—	—	—	—	—
373	374	37	—	—	—	—	—	—	—
374	375	33	—	—	—	—	—	—	—
375	376	38	0.10	2.9	2.00	6.0	E0.04	<0.050	0.089
376	377	36	—	—	—	—	—	—	—
377	378	36	—	—	—	—	—	—	—
378	379	44	—	—	—	—	—	—	—
379	380	37	—	—	—	—	—	—	—
380	381	370	—	—	—	—	—	—	—
381	382	293	—	—	—	—	—	—	—
382	383	270	0.10	9.4	2.14	67.0	E0.04	E0.012	0.056
383	384	190	E0.05	6.6	2.78	41.9	E0.04	<0.050	0.155
384	385	144	E0.03	3.4	2.80	16.6	0.05	<0.050	0.430
385	386	47	E0.02	3.2	3.03	14.2	E0.05	<0.050	0.418
386	387	34	E0.03	3.6	2.37	10.9	0.36	E0.015	0.177
387	388	44	—	—	—	—	—	—	—
388	389	33	—	—	—	—	—	—	—
389	390	35	—	—	—	—	—	—	—
390	391	42	E0.02	2.7	2.44	9.4	0.06	<0.050	0.261
391	392	44	—	—	—	—	—	—	—
392	393	32	—	—	—	—	—	—	—
393	394	37	—	—	—	—	—	—	—
394	395	43	—	—	—	—	—	—	—
395	396	40	E0.03	3.0	2.51	8.1	E0.04	<0.050	0.251
396	397	34	—	—	—	—	—	—	—
397	398	45	—	—	—	—	—	—	—
398	399	61	—	—	—	—	—	—	—
399	400	123	—	—	—	—	—	—	—

Table 9. Isotopic data for water from observation well in unsaturated-zone monitoring site YVUZ-5 (1N/6E-32G1-33S), Warren subbasin, San Bernardino County, California, 2008–11.

[State well number, see well-numbering diagram (figure 2). The five-digit number in parentheses below the constituent name is the U.S. Geological Survey (USGS) parameter code used to uniquely identify a specific constituent or property. Deuterium/Protium and Oxygen-18/16 analyzed at USGS National Research Program, Stable Isotope Laboratory, Reston, Virginia. Nitrogen-15/14 and Oxygen-18/16 in nitrate fraction analyzed at USGS National Research Program, Stable Isotope Laboratory, Reston, Virginia. Location of site shown in figure 1. Numbering system for site explained in text. **Abbreviations**: mm/dd/yyyy, month/day/year; hh:mm, hour:minute; —, no data]

Date (mm/dd/yyyy)	Time (hh:mm)	Deuterium/Protium unfiltered, per mil (82082)	Nitrogen-15/ Nitrogen-14 ratio in nitrate fraction, filtered, per mil (82690)	Oxygen-18/ Oxygen-16 ratio in nitrate fraction, filtered, per mil (63041)	Oxygen-18/ Oxygen-16 unfiltered, per mil (82085)
State well number 1N/6E-32G1S; USGS site number 340751116222801					
09/11/2008	13:10	–79.3	—	—	–10.91
02/05/2009	14:45	–80.5	11.58	2.56	–10.94
03/09/2009	13:30	–78.4	9.98	0.93	–10.96
07/02/2009	11:00	–76.8	—	—	–10.56
09/17/2009	10:40	–76.8	—	—	–10.80
01/11/2011	10:15	–76.8	—	—	–10.60
10/21/2011	09:00	–77.6	—	—	–10.67

Table 10. Nutrient data for water from observation well in unsaturated-zone monitoring site YVUZ-5 (1N/6E-32G1-33S), Warren subbasin, San Bernardino County, California, 2008–11.

[State well number, see well-numbering diagram (fig. 2). The five-digit number in parentheses below the constituent name is the U.S. Geological Survey (USGS) parameter code used to uniquely identify a specific constituent or property. Samples analyzed by USGS National Water Quality Laboratory in Denver, Colorado. Location of site shown in figure 1. Numbering system for site explained in text. **Abbreviations**: mm/dd/yyyy, month/day/year; hh:mm, hour:minute; mg/L, milligram per liter: —, no data; <, less than value shown; E, estimated value]

Date (mm/dd/yyyy)	Time (hh:mm)	Ammonia plus organic nitrogen, as nitrogen (mg/L) (00623)	Ammonia, as nitrogen (mg/L) (00608)	Nitrate plus nitrite, as nitrogen (mg/L) (00631)	Nitrate, as nitrogen (mg/L) (00618)	Nitrite, as nitrogen (mg/L) (00613)	Phosphate, orthophosphate, as phosphorus (mg/L) (00671)	Phosphorus, as phosphorus (mg/L) (00666)	Total nitrogen (nitrate + nitrite + ammonia + organic-N) (mg/L) (62854)	Dissolved organic carbon (mg/L) (00681)
State well number 1N/6E-32G1S; USGS site number 340751116222801										
09/11/2008	13:10	—	—	—	—	—	—	—	—	1.7
02/05/2009	14:45	0.21	0.162	0.46	0.447	0.008	0.036	E0.03	—	3.0
03/09/2009	13:30	0.21	0.135	0.83	0.828	0.006	0.036	E0.04	—	1.0
07/02/2009	11:00	<0.10	<0.020	2.72	E2.72	E0.002	0.081	0.07	—	—
09/17/2009	10:40	—	—	—	—	—	—	—	—	E0.40
01/11/2011	10:15	0.06	<0.010	2.45	2.45	<0.001	0.075	0.06	—	—
10/21/2011	09:00	<0.07	0.022	2.48	2.48	<0.001	0.079	0.07	2.6	—

Table 11. Field measurements and water-quality data from observation well in unsaturated-zone monitoring site YVUZ-5 (1N/6E-32G1-33S), Warren subbasin, San Bernardino County, California, 2008–11.

[State well number, see well-numbering diagram in text (fig. 2). The five-digit number in parentheses below the constituent name is the U.S. Geological Survey (USGS) parameter code used to uniquely identify a specific constituent or property. Analysis by USGS National Water Quality Laboratory in Denver, Colorado, except for specific conductance, and pH, which were measured in the field. Location of site shown in figure 1. Numbering system for sites explained in text. **Abbreviations**: mm/dd/yyyy, month/day/year; hh:mm, hour:minute; °C, degrees Celsius; µS/cm, microsiemens per centimeter at 25°C; mg/L, milligram per liter; µg/L, microgram per liter; FET, fixed end-point titration; INC, incremental titration; —, no data; <, less than value shown; E, estimated value]

Date (mm/dd/yyyy)	Time (hh:mm)	Dissolved oxygen, unfiltered (mg/L) (00300)	pH, unfiltered field, standard units (00400)	pH, unfiltered laboratory, standard units (00403)	Specific conductance, unfiltered laboratory (µS/cm) (90095)	Specific conductance, unfiltered field (µS/cm) (00095)	Dissolved solids dried at 180 °C, water, filtered (mg/L) (70300)
State well number 1N/6E-32G1S; USGS site number 340751116222801							
09/11/2008	13:10	<0.2	8.1	8.1	485	485	289
02/05/2009	14:45	—	8.1	7.8	536	531	296
03/09/2009	13:30	0.8	8.1	8.0	465	469	259
07/02/2009	11:00	6.7	7.9	8.1	444	438	258
09/17/2009	10:40	6.3	8.1	8.1	401	393	232
01/11/2011	10:15	5.7	8.1	8.2	399	412	250
10/21/2011	09:00	8.92	8.2	8.1	418	410	239

Table 11. Field measurements and water-quality data from observation well in unsaturated-zone monitoring site YVUZ-5 (1N/6E-32G1-33S), Warren subbasin, San Bernardino County, California, 2008–11.—Continued

[State well number, see well-numbering diagram in text (fig. 2). The five-digit number in parentheses below the constituent name is the U.S. Geological Survey (USGS) parameter code used to uniquely identify a specific constituent or property. Analysis by USGS National Water Quality Laboratory in Denver, Colorado, except for specific conductance, and pH, which were measured in the field. Location of site shown in figure 1. Numbering system for sites explained in text. **Abbreviations**: mm/dd/yyyy, month/day/year; hh:mm, hour:minute; °C, degrees Celsius; µS/cm, microsiemens per centimeter at 25°C; mg/L, milligram per liter; µg/L, microgram per liter; FET, fixed end-point titration; INC, incremental titration; —, no data; <, less than value shown; E, estimated value]

Date (mm/dd/yyyy)	Calcium, filtered (mg/L as Ca) (00915)	Magnesium, filtered (mg/L as Mg) (00925)	Potassium, filtered (mg/L as K) (00935)	Sodium, filtered (mg/L as Na) (00930)	Alkalinity, filtered, FET field (mg/L as $CaCO_3$) (39036)	Alkalinity, filtered, FET laboratory (mg/L as $CaCO_3$) (29801)	Alkalinity, filtered, INC field (mg/L as $CaCO_3$) (39086)	Bicarbonate, filtered, FET field (mg/L as $CaCO_3$) (29804)
State well number 1N/6E-32G1S; USGS site number 340751116222801								
09/11/2008	23.6	8.79	5.80	61.5	140	145	139	166
02/05/2009	27.8	11.5	6.58	65.7	140	158	142	—
03/09/2009	24.4	9.69	5.57	52.0	140	147	134	164
07/02/2009	29.9	8.82	4.20	45.1	110	105	105	128
09/17/2009	27.0	7.54	3.53	38.1	110	112	112	136
01/11/2011	29.7	8.13	3.65	41.8	110	116	108	130
10/21/2011	31.1	8.94	3.68	44.0	—	124	—	—

Table 11. Field measurements and water-quality data from observation well in unsaturated-zone monitoring site YVUZ-5 (1N/6E-32G1-33S), Warren subbasin, San Bernardino County, California, 2008–11.—Continued

[State well number, see well-numbering diagram in text (fig. 2). The five-digit number in parentheses below the constituent name is the U.S. Geological Survey (USGS) parameter code used to uniquely identify a specific constituent or property. Analysis by USGS National Water Quality Laboratory in Denver, Colorado, except for specific conductance, and pH, which were measured in the field. Location of site shown in figure 1. Numbering system for sites explained in text. **Abbreviations**: mm/dd/yyyy, month/day/year; hh:mm, hour:minute; °C, degrees Celsius; µS/cm, microsiemens per centimeter at 25°C; mg/L, milligram per liter; µg/L, microgram per liter; FET, fixed end-point titration; INC, incremental titration; —, no data; <, less than value shown; E, estimated value]

Date (mm/dd/yyyy)	Bicarbonate, filtered, INC field (mg/L as $CaCO_3$) (00453)	Bromide, filtered (mg/L as Br) (71870)	Chloride, filtered (mg/L as Cl) (00940)	Fluoride, filtered (mg/L as F) (00950)	Silica, filtered (mg/L as SiO_2) (00955)	Sulfate, filtered (mg/L as SO_4) (00945)	Aluminum, filtered (µg/L as Al) (01106)	Barium, filtered (µg/L as Ba) (01005)
State well number 1N/6E-32G1S; USGS site number 340751116222801								
09/11/2008	166	0.14	39.7	0.66	15.7	28.6	5.7	20.1
02/05/2009	—	0.21	47.0	0.71	11.6	34.6	4.2	20.1
03/09/2009	161	0.16	31.8	0.70	12.8	34.1	4.3	17.1
07/02/2009	127	0.13	34.7	0.46	20.7	36.9	E3.3	9.1
09/17/2009	134	0.13	26.0	0.49	19.9	31.8	E3.2	5.2
01/11/2011	130	0.12	32.4	0.49	18.0	28.1	5.4	5.6
10/21/2011	—	0.14	32.3	0.52	18.3	27.4	7.4	7.9

Table 11. Field measurements and water-quality data from observation well in unsaturated-zone monitoring site YVUZ-5 (1N/6E-32G1-33S), Warren subbasin, San Bernardino County, California, 2008–11.—Continued

[State well number, see well-numbering diagram in text (fig. 2). The five-digit number in parentheses below the constituent name is the U.S. Geological Survey (USGS) parameter code used to uniquely identify a specific constituent or property. Analysis by USGS National Water Quality Laboratory in Denver, Colorado, except for specific conductance, and pH, which were measured in the field. Location of site shown in figure 1. Numbering system for sites explained in text. **Abbreviations**: mm/dd/yyyy, month/day/year; hh:mm, hour:minute; °C, degrees Celsius; µS/cm, microsiemens per centimeter at 25°C; mg/L, milligram per liter; µg/L, microgram per liter; FET, fixed end-point titration; INC, incremental titration; —, no data; <, less than value shown; E, estimated value]

Date (mm/dd/yyyy)	Chromium, filtered (µg/L as Cr) (01030)	Iron, filtered (µg/L as Fe) (01046)	Lithium, filtered (µg/L as Li) (01130)	Manganese, filtered (µg/L as Mn) (01056)	Strontium, filtered (µg/L as Sr) (01080)	Arsenic, filtered (µg/L as As) (01000)	Boron, filtered (µg/L as B) (01020)	Iodide, filtered (mg/L as I) (71865)
State well number 1N/6E-32G1S; USGS site number 340751116222801								
09/11/2008	0.28	10	5	268	172	1.2	88	0.018
02/05/2009	—	9	5	223	191	1.5	207	0.035
03/09/2009	—	E4	5	184	175	1.3	146	0.021
07/02/2009	—	<4	6	6.2	202	2.2	50	0.004
09/17/2009	—	<4	5	<0.2	182	2.1	51	0.002
01/11/2011	—	4	5	0.3	206	2.3	45	0.003
10/21/2011	—	5	5	0.9	220	2.7	53	0.005

Agency, 1993). Selected samples from the suction-cup lysimeters were sent to the NWQL for analysis of major ions, nutrients, and selected trace elements by using methods by Fishman and Friedman (1989), Fishman (1993), and Garbarino and others (2002, 2006). Selected samples were sent to the STIL for analysis of the stable isotope ratios of $\delta^{18}O$, $\delta^{15}N$, and δD by using mass spectrometry (Epstein and Mayeda, 1953; Coplen and others, 1991). Results of chemical and isotopic analysis for water from the suction-cup lysimeters are presented in tables 12, 13, and 14. The lysimeter at 44 feet (1N/6E-32G8) held a vacuum, but did not produce sufficient quantities of water for analysis during the course of the study.

Chemistry of Infiltration Pond Water

Samples collected from the pilot-scale infiltration pond at YVUZ-5 were sent to the NWQL for the analysis of major ions, nutrients, and selected trace elements elements, by using methods by Fishman and Friedman (1989), Fishman (1993), and Garbarino and others (2002, 2006). Selected samples were sent to the STIL for analysis of the stable isotope ratios $\delta^{18}O$, $\delta^{15}N$, and δD by using mass spectrometry (Epstein and Mayeda, 1953; Coplen and others, 1991). Results for chemical and isotopic analyses of water from the pilot-scale infiltration pond are presented in tables 15, 16, and 17.

Table 12. Isotopic data for water from suction-cup lysimeters in unsaturated-zone monitoring site YVUZ-5 (1N/6E-32G1-33S), Warren subbasin, San Bernardino County, California, 2008–09.

[State well number, see well-numbering diagram (fig. 2). The five-digit number in parentheses below the constituent name is the U.S. Geological Survey (USGS) parameter code used to uniquely identify a specific constituent or property. Deuterium/Protium and Oxygen-18/16 analyzed at USGS National Research Program, Stable Isotope Laboratory, Reston, Virginia. Nitrogen-15/14 and Oxygen-18/16 in nitrate fraction analyzed at USGS National Research Program, Stable Isotope Laboratory, Reston, Virginia. Location of site shown in figure 1. Numbering system for sites explained in text. Begin Date and Time are the time at which the vacuum (about 0.65 bar) was set on the lysimeter; End Date and Time are the time at which the sample was collected from the lysimter. **Abbreviations**: FT, foot; hh:mm, hour:minute; LYS, lysimeter; mL, milliliters; mm/dd/yyyy, month/day/year; —, no data; @, at]

Begin date (mm/dd/yyyy)	Begin time (hh:mm)	End date (mm/dd/yyyy)	End time (hh:mm)	Sample volume (mL) (32002)	Deuterium/ Protium unfiltered, per mil (82082)	Oxygen-18/ Oxygen-16 unfiltered, per mil (82085)	Nitrogen-15/ Nitrogen-14 ratio in nitrate fraction, filtered, per mil (82690)	Oxygen-18/ Oxygen-16 ratio in nitrate fraction, filtered, per mil (63041)
State well number 1N/6E-32G3SLYS; USGS site number 340751116222804; LYS @ 368 FT								
09/11/2008	11:05	01/07/2009	12:10	200	–76.6	–10.81	—	—
03/09/2009	16:15	04/20/2009	16:20	350	—	—	6.85	–7.55
06/05/2009	14:38	06/30/2009	09:50	400	–77.4	–10.62	—	—
06/30/2009	10:50	09/17/2009	09:05	400	–76.1	–10.35	—	—
State well number 1N/6E-32G4SLYS; USGS site number 340751116222809; LYS @ 292 FT								
03/09/2009	15:00	04/20/2009	16:32	400	—	—	6.17	–3.01
06/05/2009	14:43	06/30/2009	10:30	500	–76.2	–10.44	—	—
06/30/2009	11:30	09/17/2009	09:20	600	–75.9	–10.39	—	—
State well number 1N/6E-32G5SLYS; USGS site number 340751116222813; LYS @ 233 FT								
03/09/2009	15:50	04/20/2009	16:45	400	—	—	4.51	–5.17
06/05/2009	14:48	06/30/2009	10:20	300	–76.6	–10.61	—	—
06/30/2009	11:20	09/17/2009	09:30	500	–77.4	–10.75	—	—
State well mumber 1N/6E-32G6SLYS; USGS site number 340751116222819; LYS @ 143 FT								
01/07/2009	13:30	03/09/2009	14:30	300	–74.4	–10.12	7.48	0.44
06/05/2009	14:53	06/30/2009	10:00	500	–78.8	–10.83	—	—
06/30/2009	11:00	09/17/2009	09:50	400	–78.0	–10.63	—	—
State well number 1N/6E-32G7SLYS; USGS site number 340751116222825; LYS @ 86 FT								
11/20/2008	12:45	01/07/2009	12:40	500	–72.9	–8.94	—	—
01/07/2009	13:40	03/09/2009	14:10	500	–74.8	–10.17	6.86	–2.31
06/05/2009	14:58	06/30/2009	10:10	50	–77.8	–10.74	—	—

Table 13. Nutrient data for water from suction-cup lysimeters in unsaturated-zone monitoring site YVUZ-5 (1N/6E-32G1-33S), Warren subbasin, San Bernardino County, California, 2009.

[State well number, see well-numbering diagram (fig. 2). The five-digit number in parentheses below the constituent name is the U.S. Geological Survey (USGS) parameter code used to uniquely identify a specific constituent or property. Samples analyzed by USGS National Water Quality Laboratory in Denver, Colorado. Location of site shown in figure 1. Numbering system for sites explained in text. Begin date and Time are the time at which the vacuum (about 0.65 bar) was set on the lysimeter; End date and Time are the time at which the sample was collected from the lysimter. **Abbreviations**: FT, feet; hh:mm, hour:minute; mg/L, milligram per liter; mL, milliliters; mm/dd/yyyy, month/day/year; <, less than value shown; @, at]

Begin date (mm/dd/yyyy)	Begin time (hh:mm)	End date (mm/dd/yyyy)	End time (hh:mm)	Sample volume (mL) (32002)	Ammonia plus organic nitrogen, as nitrogen (mg/L) (00623)	Ammonia, as nitrogen (mg/L) (00608)	Nitrate plus nitrite, as nitrogen (mg/L) (00631)	Nitrate, as nitrogen (mg/L) (00618)	Nitrite, as nitrogen (mg/L) (00613)	Phosphate, orthophosphate, as phosphorus (mg/L) (00671)	Phosphorus, as phosphorus (mg/L) (00666)
State well number 1N/6E-32G3SLYS; USGS site number 340751116222804; LYS @ 368 FT											
03/09/2009	16:15	04/20/2009	16:20	350	1.6	0.681	23.8	23.8	0.012	0.179	0.19
State well number 1N/6E-32G4SLYS; USGS site number 340751116222809; LYS @ 292 FT											
03/09/2009	16:00	04/20/2009	16:32	400	3.0	0.645	7.86	7.82	0.039	0.113	0.27
State well number 1N/6E-32G5SLYS; USGS site number 340751116222813; LYS @ 233 FT											
03/09/2009	15:50	04/20/2009	16:45	400	1.2	0.218	4.87	4.54	0.333	0.117	0.14
State well number 1N/6E-32G7SLYS; USGS site number 340751116222825; LYS @ 86 FT											
09/11/2008	10:45	01/07/2009	12:40	500	1.6	0.180	6.57	5.88	0.685	0.035	0.08
01/07/2009	13:40	03/09/2009	14:10	500	0.91	<0.020	2.41	2.09	0.322	0.045	0.07

Table 14. Field measurements and water-quality data for water from suction-cup lysimeters in unsaturated-zone monitoring site YVUZ-5 (1N/6E-32G1-33S), Warren subbasin, San Bernardino County, California, 2008–09.

[State well number, see well-numbering diagram (fig. 2). The five-digit number in parentheses below the constituent name is the U.S. Geological Survey (USGS) parameter code used to uniquely identify a specific constituent or property. Analysis by USGS National Water Quality Laboratory in Denver, Colorado, except for specific conductance, and pH, which were measured in the field. Location of site shown in figure 1. Numbering system for sites explained in text. Begin date and Time are the time at which the vacuum (about 0.65 bar) was set on the lysimeter; End date and Time are the time at which the sample was collected from the lysimter. **Abbreviations**: E, estimated value; FET, fixed end-point titration; FT, feet; hh:mm, hour:minute; INC, incremental titration; LYS, lysimeter; mg/L, milligram per liter; mL, milliliters; mm/dd/yyyy, month/day/year; °C, degree Celsius; µS/cm, microsiemens per centimeter at 25 °C; µg/L, microgram per liter; @, at; —, no data; <, less than value shown]

Begin date (mm/dd/yyyy)	Begin time (hh:mm)	End date (mm/dd/yyyy)	End time (hh:mm)	Sample volume (mL) (32002)	pH, unfiltered field, standard units (00400)	Specific conductance, unfiltered laboratory (µS/cm) (90095)	Specific conductance, unfiltered field (µS/cm) (00095)
State well number 1N/6E-32G3SLYS; USGS site number 340751116222804; LYS @ 368 FT							
09/11/2008	11:05	01/07/2009	12:10	200	8.2	—	3,570
03/09/2009	16:15	04/20/2009	16:20	350	8.0	—	1,520
04/20/2009	17:20	06/05/2009	13:38	250	8.1	—	476
06/05/2009	14:38	06/30/2009	09:50	400	8.0	412	—
06/30/2009	10:50	09/17/2009	09:05	400	8.3	—	405
State well number 1N/6E-32G4SLYS; USGS site number 340751116222809; LYS @ 292 FT							
03/09/2009	15:00	04/20/2009	16:32	400	7.7	—	1,690
04/20/2009	17:32	06/05/2009	13:43	500	7.8	—	697
06/05/2009	14:43	06/30/2009	10:30	500	7.6	639	—
06/30/2009	11:30	09/17/2009	09:20	600	7.8	526	514
State well number 1N/6E-32G5SLYS; USGS site number 340751116222813; LYS @ 233 FT							
03/09/2009	15:50	04/20/2009	16:45	400	8.0	—	959
04/20/2009	17:45	06/05/2009	13:48	40	—	—	911
06/05/2009	14:48	06/30/2009	10:20	300	7.8	974	938
06/30/2009	11:20	09/17/2009	09:30	500	7.9	1,040	987
State well number 1N/6E-32G6SLYS; USGS site number 340751116222819; LYS @ 143 FT							
01/07/2009	13:30	03/09/2009	14:30	300	7.8	—	539
04/20/2009	17:45	06/05/2009	13:53	200	7.9	—	440
06/05/2009	14:53	06/30/2009	10:00	500	—	461	—
06/30/2009	11:00	09/17/2009	09:50	400	8.0	493	483
State well number 1N/6E-32G7SLYS; USGS site number 340751116222825; LYS @ 86 FT							
11/20/2008	12:45	01/07/2009	12:40	500	7.6	—	3,170
01/07/2009	13:40	03/09/2009	14:10	500	7.7	—	625
04/20/2009	18:00	06/05/2009	13:58	200	8.0	—	417
06/30/2009	14:58	09/17/2009	10:00	50	8.5	—	809

Table 14. Field measurements and water-quality data for water from suction-cup lysimeters in unsaturated-zone monitoring site YVUZ-5 (1N/6E-32G1-33S), Warren subbasin, San Bernardino County, California, 2008–09.—Continued

[State well number, see well-numbering diagram (fig. 2). The five-digit number in parentheses below the constituent name is the U.S. Geological Survey (USGS) parameter code used to uniquely identify a specific constituent or property. Analysis by USGS National Water Quality Laboratory in Denver, Colorado, except for specific conductance, and pH, which were measured in the field. Location of site shown in figure 1. Numbering system for sites explained in text. Begin date and Time are the time at which the vacuum (about 0.65 bar) was set on the lysimeter; End date and Time are the time at which the sample was collected from the lysimter. **Abbreviations**: E, estimated value; FET, fixed end-point titration; FT, feet; hh:mm, hour:minute; INC, incremental titration; LYS, lysimeter; mg/L, milligram per liter; mL, milliliters; mm/dd/yyyy, month/day/year; °C, degree Celsius; µS/cm, microsiemens per centimeter at 25 °C; µg/L, microgram per liter; @, at; —, no data; <, less than value shown]

End date (mm/dd/yyyy)	Magnesium, filtered (mg/L as Mg) (00925)	Potassium, filtered (mg/L as K) (00935)	Sodium (mg/L as Na) (00930)	Alkalinity, filtered, FET field (mg/L as $CaCO_3$) (39036)	Alkalinity, filtered, INC field (mg/L as $CaCO_3$) (39086)	Bicarbonate, filtered, FET field (mg/L as $CaCO_3$) (29804)	Bicarbonate, filtered, INC field (mg/L as $CaCO_3$) (00453)	Bromide, filtered (mg/L as Br) (71870)	Chloride, filtered (mg/L as Cl) (00940)
State well number 1N/6E-32G3SLYS; USGS site number 340751116222804; LYS @ 368 FT									
01/07/2009	—	—	—	—	—	—	—	—	—
04/20/2009	—	—	—	—	—	—	—	—	—
06/05/2009	—	—	—	—	—	—	—	—	—
06/30/2009	7.08	3.30	44.3	—	—	—	—	0.12	35.7
09/17/2009	7.33	3.03	42.4	—	—	—	—	0.11	37.5
State well number 1N/6E-32G4SLYS; USGS site number 340751116222809; LYS @ 292 FT									
04/20/2009	—	—	—	—	—	—	—	—	—
06/05/2009	—	—	—	—	—	—	—	—	—
06/30/2009	13.1	4.61	66.4	—	—	—	—	0.26	61.1
09/17/2009	10.5	3.96	55.2	—	—	—	—	0.14	37.8
State well number 1N/6E-32G5SLYS; USGS site number 340751116222813; LYS @ 233 FT									
04/20/2009	—	—	—	—	—	—	—	—	—
06/05/2009	—	—	—	—	—	—	—	—	—
06/30/2009	13.1	7.89	146	—	—	—	—	0.13	32.4
09/17/2009	13.4	7.67	156	—	—	—	—	0.11	26.8
State well number 1N/6E-32G6SLYS; USGS site number 340751116222819; LYS @ 143 FT									
03/09/2009	7.62	2.49	57.3	110	110	133	134	0.11	43.2
06/05/2009	—	—	—	—	—	—	—	—	—
06/30/2009	8.69	2.12	53.6	—	—	—	—	0.11	20.5
09/17/2009	7.25	2.00	58.8	—	—	—	—	0.11	22.3
State well number 1N/6E-32G7SLYS; USGS site number 340751116222825; LYS @ 86 FT									
01/07/2009	108	5.60	142	—	—	—	—	3.86	717
03/09/2009	9.08	1.31	50.5	120	116	141	140	0.13	40.9
06/05/2009	—	—	—	—	—	—	—	—	—
09/17/2009	—	—	—	—	—	—	—	—	—

Table 14. Field measurements and water-quality data for water from suction-cup lysimeters in unsaturated-zone monitoring site YVUZ-5 (1N/6E-32G1-33S), Warren subbasin, San Bernardino County, California, 2008–09.—Continued

[State well number, see well-numbering diagram (fig. 2). The five-digit number in parentheses below the constituent name is the U.S. Geological Survey (USGS) parameter code used to uniquely identify a specific constituent or property. Analysis by USGS National Water Quality Laboratory in Denver, Colorado, except for specific conductance, and pH, which were measured in the field. Location of site shown in figure 1. Numbering system for sites explained in text. Begin date and Time are the time at which the vacuum (about 0.65 bar) was set on the lysimeter; End date and Time are the time at which the sample was collected from the lysimter. **Abbreviations**: E, estimated value; FET, fixed end-point titration; FT, feet; hh:mm, hour:minute; INC, incremental titration; LYS, lysimeter; mg/L, milligram per liter; mL, milliliters; mm/dd/yyyy, month/day/year; °C, degree Celsius; µS/cm, microsiemens per centimeter at 25 °C; µg/L, microgram per liter; @, at; —, no data; <, less than value shown]

End date (mm/dd/yyyy)	Silica, filtered (mg/L as SiO_2) (00955)	Sulfate, filtered (mg/L as SO_4) (00945)	Barium, filtered (µg/L as Ba) (01005)	Chromium, filtered (µg/L as Cr) (01030)	Iron, filtered (µg/L as Fe) (01046)	Manganese, filtered (µg/L as Mn) (01056)	Arsenic, filtered (µg/L as As) (01000)	Boron, filtered (µg/L as B) (01020)	Iodide, filtered (mg/L as I) (71865)
State well number 1N/6E-32G3SLYS; USGS site number 340751116222804; LYS @ 368 FT									
01/07/2009	—	—	—	—	—	—	—	—	—
04/20/2009	—	—	—	—	—	—	—	—	—
06/05/2009	—	—	—	—	—	—	—	—	—
06/30/2009	23.9	30.9	3.4	20.1	E2	3.7	1.9	48	0.003
09/17/2009	24.2	30.4	3.6	10.5	E3	2.7	1.9	43	0.003
State well number 1N/6E-32G4SLYS; USGS site number 340751116222809; LYS @ 292 FT									
04/20/2009	—	—	—	—	—	—	—	—	—
06/05/2009	—	—	—	—	—	—	—	—	—
06/30/2009	29.2	80.4	17.9	6.5	<4	3.9	3.2	75	0.004
09/17/2009	25.7	153	23.6	1.8	32	3.9	3.3	64	0.014
State well number 1N/6E-32G5SLYS; USGS site number 340751116222813; LYS @ 233 FT									
04/20/2009	—	—	—	—	—	—	—	—	—
06/05/2009	—	—	—	—	—	—	—	—	—
06/30/2009	83.1	231	24.9	4.2	17	2.7	17.6	186	0.027
09/17/2009	76.5	273	30.7	3.9	30	3.0	17.3	168	0.014
State well number 1N/6E-32G6SLYS; USGS site number 340751116222819; LYS @ 143 FT									
03/09/2009	31.1	43.6	7.3	4.3	17	19.7	2.4	171	E0.002
06/05/2009	—	—	—	—	—	—	—	—	—
06/30/2009	24.9	32.6	35.3	2.0	4	0.5	1.6	90	0.002
09/17/2009	23.5	38.7	39.2	1.7	E4	0.6	1.5	95	E0.003
State well number 1N/6E-32G7SLYS; USGS site number 340751116222825; LYS @ 86 FT									
01/07/2009	26.9	440	238	2.7	34	29.3	1.3	178	0.036
03/09/2009	27.3	34.3	39.6	2.3	E2	0.6	1.0	79	E0.001
06/05/2009	—	—	—	—	—	—	—	—	—
09/17/2009	—	—	—	—	—	—	—	—	—

Table 15. Isotopic data for recharge water from pilot-scale infiltration pond near unsaturated-zone monitoring site YVUZ-5 (1N/6E-32G1-33S), Warren subbasin, San Bernardino County, California, 2009.

[State well number, see well-numbering diagram (fig. 2). The five-digit number in parentheses below the constituent name is the U.S. Geological Survey (USGS) parameter code used to uniquely identify a specific constituent or property. Deuterium/Protium and Oxygen-18/16 analyzed at USGS National Research Program, Stable Isotope Laboratory, Reston, Virginia. Nitrogen-15/14 and Oxygen-18/16 in nitrate fraction analyzed at USGS National Research Program, Stable Isotope Laboratory, Reston, Virginia. Location of site shown in figure 1. Numbering system for sites explained in text. **Abbreviations**: mm/dd/yyyy, month/day/year; hh:mm, hour:minute; —, no data]

USGS site number	Date (mm/dd/yyyy)	Time (hh:mm)	Deuterium/ Protium unfiltered, per mil (82082)	Oxygen-18/ Oxygen-16 unfiltered, per mil (82085)	Nitrogen-15/ Nitrogen-14 ratio in nitrate fraction, filtered, per mil (82690)	Oxygen-18/ Oxygen-16 ratio in nitrate fraction, filtered, per mil (63041)
HI-DESERT WD RECHARGE PIPE A POND NR YUCCA VALLEY						
340751116222834	01/07/2009	13:30	–72.6	–10.07	—	—
340751116222834	03/09/2009	14:30	–80.9	–11.17	2.92	0.72

Table 16. Nutrient data for recharge water from pilot-scale infiltration pond near unsaturated-zone monitoring site YVUZ-5 (1N/6E-32G1-33S), Warren subbasin, San Bernardino County, California, 2009.

[The five-digit number in parentheses below the constituent name is the U.S. Geological Survey (USGS) parameter code used to uniquely identify a specific constituent or property. Samples analyzed by USGS National Water Quality Laboratory in Denver, Colorado. Location of site shown in figure 1. Numbering system for sites explained in text. **Abbreviations**: mm/dd/yyyy, month/day/year; hh:mm, hour:minute; mg/L, milligram per liter: —, no data; <, less than value shown; E, estimated value]

USGS site number	Date (mm/dd/yyyy)	Time (hh:mm)	Ammonia plus organic nitrogen, as nitrogen (mg/L) (00623)	Ammonia, as nitrogen (mg/L) (00608)	Nitrate plus nitrite, as nitrogen (mg/L) (00631)	Nitrite, as nitrogen (mg/L) (00613)	Phosphate, orthophosphate, as phosphorus (mg/L) (00671)	Phosphorus, as phosphorus (mg/L) (00666)
HI-DESERT WD RECHARGE PIPE A POND NR YUCCA VALLEY								
340751116222834	01/07/2009	13:30	E0.08	<0.020	2.43	<0.002	0.024	E0.03
340751116222834	03/09/2009	14:30	<0.10	<0.020	1.23	<0.002	0.031	E0.03

Table 17. Field measurements and water-quality data for recharge water from pilot-scale infiltration pond near unsaturated-zone monitoring site YVUZ-5 (1N/6E-32G1-33S), Warren subbasin, San Bernardino County, California, 2009.

[The five-digit number in parentheses below the constituent name is the U.S. Geological Survey (USGS) parameter code used to uniquely identify a specific constituent or property. Analysis by USGS National Water Quality Laboratory in Denver, Colorado, except for specific conductance, and pH, which were measured in the field. Location of site shown in figure 1. Numbering system for sites explained in text. **Abbreviations**: E, estimated value; FET, fixed end-point titration; hh:mm, hour:minute; INC, incremental titration; mg/L, milligram per liter; mm/dd/yyyy, month/day/year; NR, near; WD, water district; °C, degrees Celsius; µS/cm, microsiemens per centimeter at 25°C; µg/L, microgram per liter; —, no data; <, less than value shown]

USGS site number	Date (mm/dd/yyyy)	Time (hh:mm)	Dissolved oxygen, unfiltered (mg/L) (00300)	pH, unfiltered field, standard units (00400)	pH, unfiltered laboratory, standard units (00403)	Specific conductance, unfiltered laboratory (µS/cm) (90095)	Specific conductance, unfiltered field (µS/cm) (00095)	Dissolved solids dried at 180 °C, water, filtered (mg/L) (70300)	Calcium, filtered (mg/L as Ca) (00915)
HI-DESERT WD RECHARGE PIPE A POND NR YUCCA VALLEY									
340751116222834	01/07/2009	13:30	—	7.8	—	—	433	—	41.5
340751116222834	03/09/2009	14:30	7.2	7.9	7.8	443	436	265	45.8

USGS site number	Date (mm/dd/yyyy)	Time (hh:mm)	Magnesium, filtered (mg/L as Mg) (00925)	Potassium, filtered (mg/L as K) (00935)	Sodium, filtered (mg/L as Na) (00930)	Alkalinity, filtered, FET field (mg/L as $CaCO_3$) (39036)	Alkalinity, filtered, FET laboratory (mg/L as $CaCO_3$) (29801)	Alkalinity, filtered, INC field (mg/L as $CaCO_3$) (39086)	Bicarbonate, filtered, FET field (mg/L as $CaCO_3$) (29804)	Bicarbonate, filtered, INC field (mg/L as $CaCO_3$) (00453)
HI-DESERT WD RECHARGE PIPE A POND NR YUCCA VALLEY										
340751116222834	01/07/2009	13:30	5.79	1.64	38.3	—	—	—	—	—
340751116222834	03/09/2009	14:30	7.94	2.12	40.3	170	178	166	201	200

USGS site number	Date (mm/dd/yyyy)	Time (hh:mm)	Bromide, filtered (mg/L as Br) (71870)	Chloride, filtered (mg/L as Cl) (00940)	Fluoride, filtered (mg/L as F) (00950)	Silica, filtered (mg/L as SiO_2) (00955)	Sulfate, filtered (mg/L as SO_4) (00945)	Aluminum, filtered (µg/L as Al) (01106)	Barium, filtered (µg/L as Ba) (01005)	Chromium, filtered (µg/L as Cr) (01030)
HI-DESERT WD RECHARGE PIPE A POND NR YUCCA VALLEY										
340751116222834	01/07/2009	13:30	0.02	49.6	—	31.1	30.5	—	45.4	2.2
340751116222834	03/09/2009	14:30	0.03	17.4	E0.69	24.3	23.1	<4	37.8	—

USGS site number	Date (mm/dd/yyyy)	Time (hh:mm)	Iron, filtered (µg/L as Fe) (01046)	Lithium, filtered (µg/L as Li) (01130)	Manganese, filtered (µg/L as Mn) (01056)	Strontium, filtered (µg/L as Sr) (01080)	Arsenic, filtered (µg/L as As) (01000)	Boron, filtered (µg/L as B) (01020)	Iodide, filtered (mg/L as I) (71865)
HI-DESERT WD RECHARGE PIPE A POND NR YUCCA VALLEY									
340751116222834	01/07/2009	13:30	E3	—	E0.2	—	3.5	55	<0.002
340751116222834	03/09/2009	14:30	<4	13	<0.2	277	3.5	108	<0.002

Microbiological Analyses of Cores and Cuttings

Concentrations of denitrifying and nitrate-reducing bacteria were determined (as estimates) for selected drill cuttings to establish their presence or absence and whether there is potential for denitrification or nitrate reduction in the unsaturated zone.

Microbial samples were collected during drilling activities and are representative of conditions in the unsaturated zone prior to the infiltration of water from the constructed pond. All field equipment used to collect samples for microbiological analysis, including the core liners and the canula (used to inject nitrogen gas into the aluminum pouch), were flame sterilized prior to use. Cutting materials collected for microbiological analysis were stored immediately after collection in heat-sealable aluminum pouches. Nitrogen gas was used to displace ambient atmosphere from the pouches before they were sealed. The sealed pouches were placed in a cool container and transported to the USGS San Diego Water Quality Laboratory at the end of the day's drilling and analyzed within 24 hrs.

Before being analyzed in the laboratory, samples were passed through a 2-mm mesh-size sieve to remove gravel in order to create a more uniform sample medium and to facilitate comparison of the data from different samples having a range of particle-size distributions. Denitrifying and nitrate-reducing bacteria abundances (in most probable number, or MPN), were estimated by using 10-grams of material incubated at 28 °C in a nutrient broth containing 0.1-percent potassium nitrate according to methods described by Britton and Greeson (1989). According to these methods, the production of nitrogen gas by denitrifying bacteria is determined after a 14-day incubation period by a visual assessment of the change in nitrogen gas accumulated in an inverted tube (Durham Tube), which is in the culture tube. Nitrite produced by nitrate-reducing bacteria is identified by adding a zinc-copper-manganese-dioxide reagent to the culture tube. Nitrate remaining within the culture tube, indicative of incomplete or an absence of nitrate reduction, reacts with this reagent and produces a deep-red color. Enumeration of the bacteria over a range from 40–9,300 MPN per sample was performed through five serial dilutions from the initial culture tubes by using procedures described in American Public Health Association (1992).

All laboratory equipment, including bottles, test tubes, and sample handling equipment, were sterilized by the autoclave method as described in the USGS NFM (U.S. Geological Survey, variously dated). Equipment used during the analysis to handle cutting and core material were flame sterilized after each use. Additionally, all equipment and sample media were cleaned and autoclaved after each use and before being stored or discarded.

Precision of the analytical methods performed on microbiological samples was evaluated with quality-control analyses (replicate samples). Analysis of the replicate data showed a median precision of about 25 percent. These analyses are highly variable and only comparable on an order of magnitude scale, which is expected for this type of constituent. Denitrifying and nitrate-reducing bacteria abundance data are presented in table 18.

Table 18. Denitrifying and nitrate reducing bacteria data from drill cuttings from unsaturated-zone monitoring site YVUZ-5 (1N/6E-32G1-33S), Warren subbasin, San Bernardino County, California, 2008.

[State well number, see well-numbering diagram (fig. 2). The five-digit number in parentheses below the constituent name is the U.S. Geological Survey (USGS) parameter code used to uniquely identify a specific constituent or property. Analysis by USGS laboratory in San Diego, California. Location of site shown in figure 1. Altitude of land surface datum is 3,195 feet above mean sea level. Numbering system for sites explained in text. **Abbreviations**: mm/dd/yyyy, month/day/year; R, indicates replicate analysis; —, no data; MPN, most probable number; <, less than value shown]

Date of analysis (mm/dd/yyyy)	Depth to top of sample interval, feet below land surface datum	Depth to bottom of sample interval, feet below land surface datum	Bacteria, denitrifying (MPN)	Bacteria, nitrate reducing (MPN)	Replicate analysis
State well number 1N/6E-32G1S; USGS site number 340751116222801					
06/26/2008	8.0	9.0	<30	430	—
06/26/2008	19.0	20.0	<30	40	—
06/26/2008	29.0	30.0	<30	90	—
06/26/2008	29.0	30.0	<30	150	R
06/26/2008	38.0	39.0	<30	430	—
06/27/2008	44.0	45.0	<30	1,500	—
06/27/2008	44.0	45.0	90	2,400	R
06/27/2008	57.0	58.0	<30	90	—
06/27/2008	65.0	66.0	<30	400	—
06/27/2008	76.0	77.0	<30	90	—

Table 18. Denitrifying and nitrate reducing bacteria data from drill cuttings from unsaturated-zone monitoring site YVUZ-5 (1N/6E-32G1-33S), Warren subbasin, San Bernardino County, California, 2008.—Continued

[State well number, see well-numbering diagram (fig. 2). The five-digit number in parentheses below the constituent name is the U.S. Geological Survey (USGS) parameter code used to uniquely identify a specific constituent or property. Analysis by USGS laboratory in San Diego, California. Location of site shown in figure 1. Altitude of land surface datum is 3,195 feet above mean sea level. Numbering system for sites explained in text. **Abbreviations**: mm/dd/yyyy, month/day/year; R, indicates replicate analysis; —, no data; MPN, most probable number; <, less than value shown]

Date of analysis (mm/dd/yyyy)	Depth to top of sample interval, feet below land surface datum	Depth to bottom of sample interval, feet below land surface datum	Bacteria, denitrifying (MPN)	Bacteria, nitrate reducing (MPN)	Replicate analysis
State well number 1N/6E-32G1S; USGS site number 340751116222801—Continued					
06/27/2008	80.0	80.5	<30	—	—
06/27/2008	86.0	87.0	40	200	—
06/27/2008	98.0	99.0	<30	90	—
06/27/2008	100.0	101.0	210	93,000	—
06/27/2008	110.0	111.0	150	2,300	—
06/27/2008	123.0	124.0	<30	40	—
06/27/2008	141.0	142.0	230	4,300	—
06/27/2008	150.0	151.0	<30	<30	—
06/27/2008	158.0	159.0	<30	<30	—
06/27/2008	163.0	164.0	<30	40	—
06/28/2008	176.0	177.0	<30	90	—
06/28/2008	185.0	186.0	<30	40	—
06/28/2008	191.0	192.0	<30	90	—
06/28/2008	191.0	192.0	<30	70	R
06/28/2008	203.0	203.5	<30	400	—
06/28/2008	208.0	209.0	<30	40	—
06/28/2008	233.0	234.0	<30	430	—
06/28/2008	235.0	236.0	<30	40	—
06/30/2008	242.0	243.0	40	150	—
06/30/2008	242.0	243.0	40	230	R
06/30/2008	243.0	243.5	<30	40	—
06/30/2008	249.0	250.0	<30	430	—
06/30/2008	261.0	262.0	<30	70	—
06/30/2008	266.0	267.0	<30	70	—
07/05/2008	296.0	297.0	2,300	4,300	—
07/05/2008	308.0	309.0	<30	90	—
07/05/2008	318.0	319.0	<30	<30	—
07/05/2008	339.5	340.0	2,300	<30	—
07/06/2008	348.0	349.0	<30	430	—
07/06/2008	348.0	349.0	<30	70	R
07/06/2008	364.0	—	90	930	—
07/06/2008	348.0	—	2,400,000	<30	—
07/06/2008	348.0	—	230	140	—

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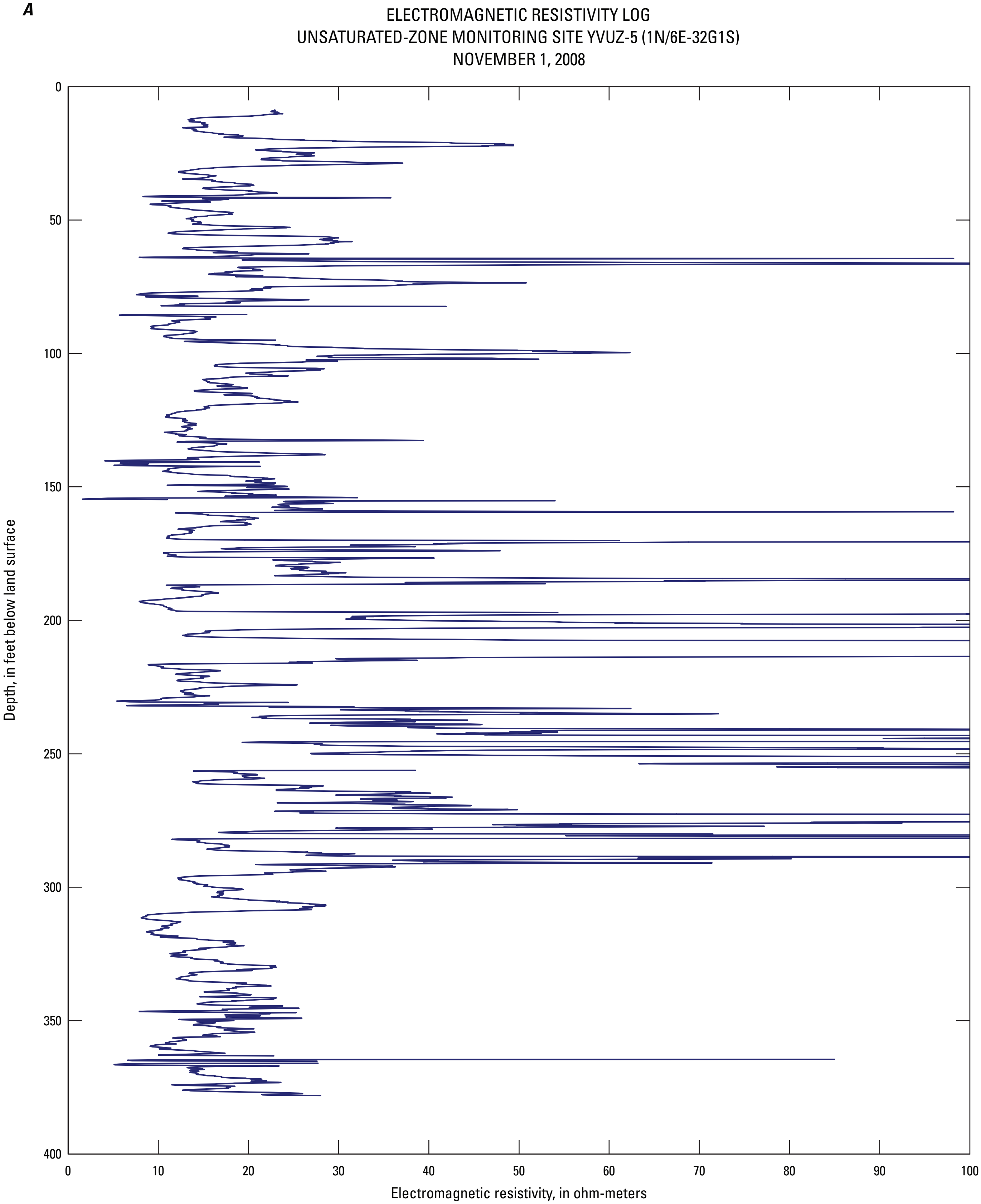
Appendix 1.

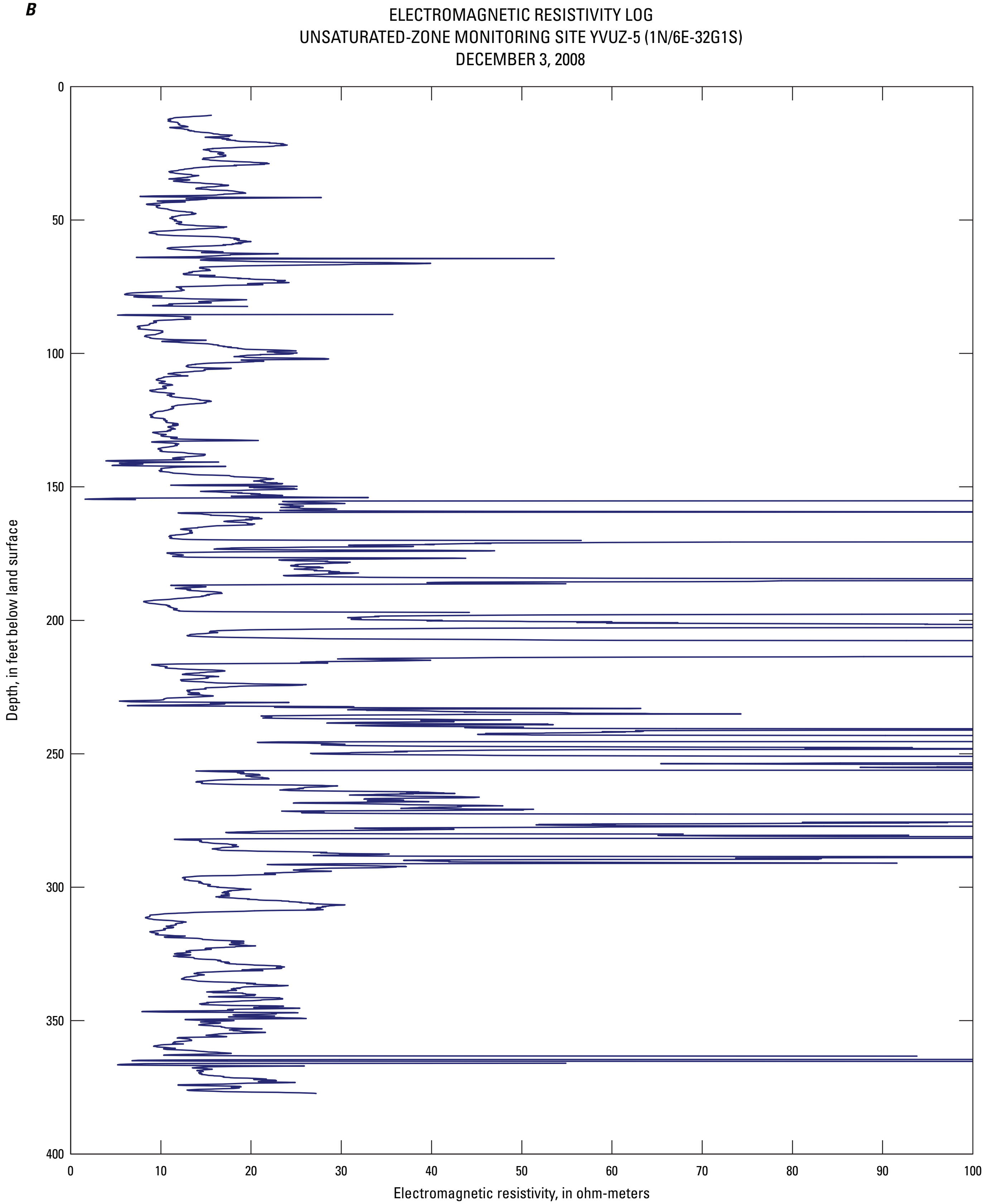
Electromagnetic resistivity logs for unsaturated-zone monitoring site YVUZ-5 (1N/6E-32G1S)

A



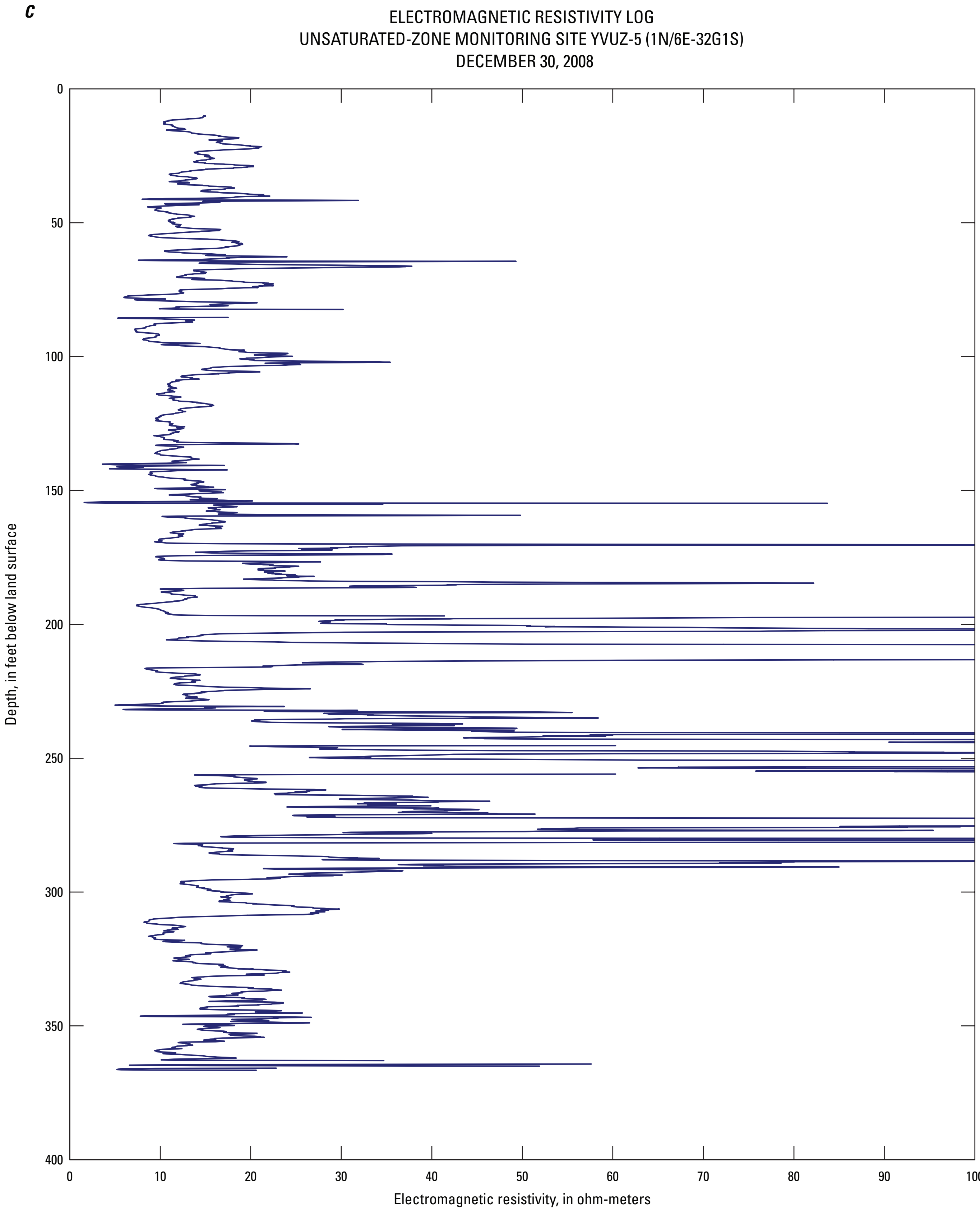
Appendix 1. Electromagnetic resistivity logs for unsaturated-zone monitoring site YVUZ-5 (1N/6E-32G1S) on *A*, November 1, 2008; *B*, December 3, 2008; *C*, December 30, 2008; *D*, January 9, 2009; *E*, April, 30, 2009; and *F*, December 23, 2009.

B



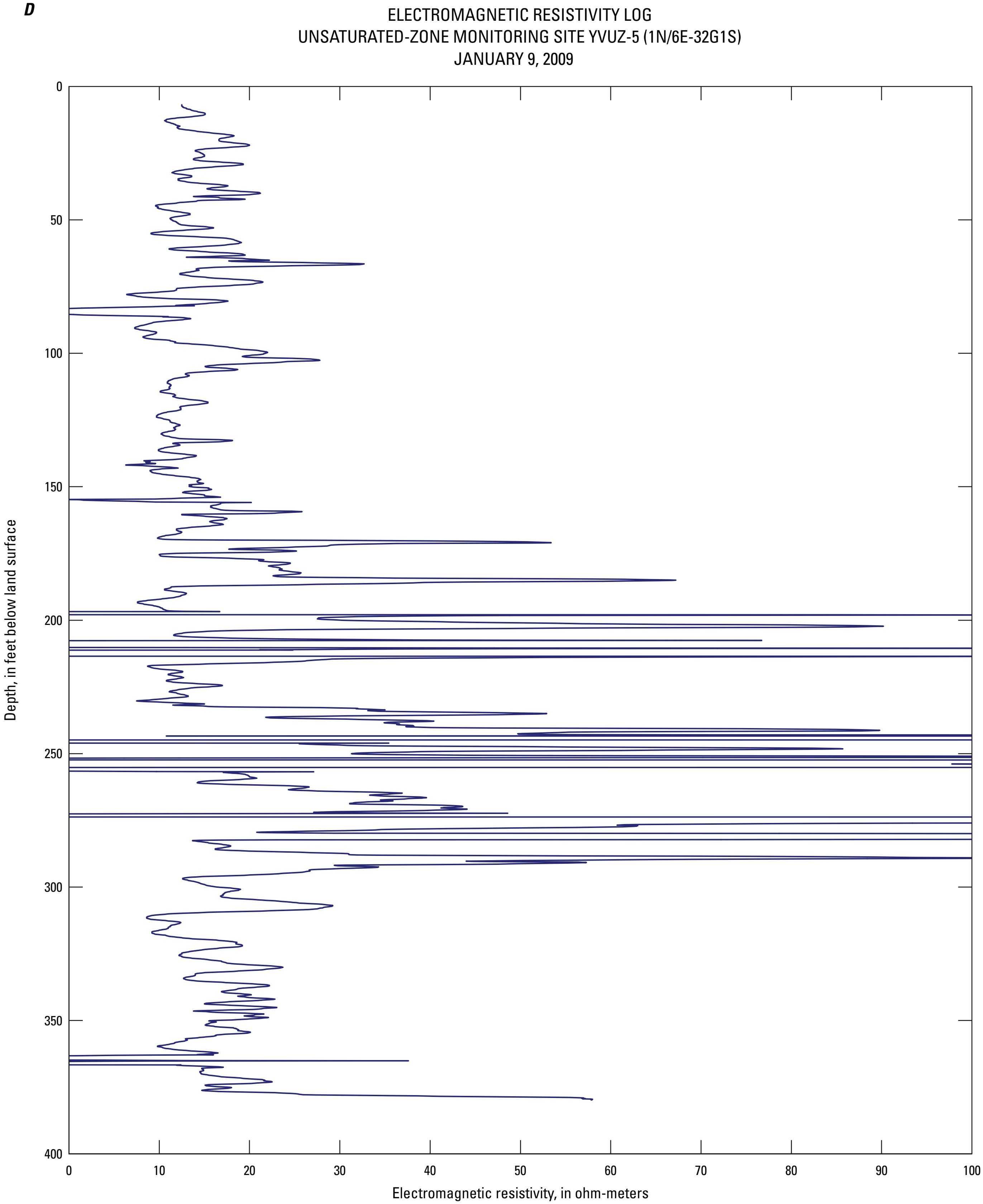
Appendix 1. —Continued

C



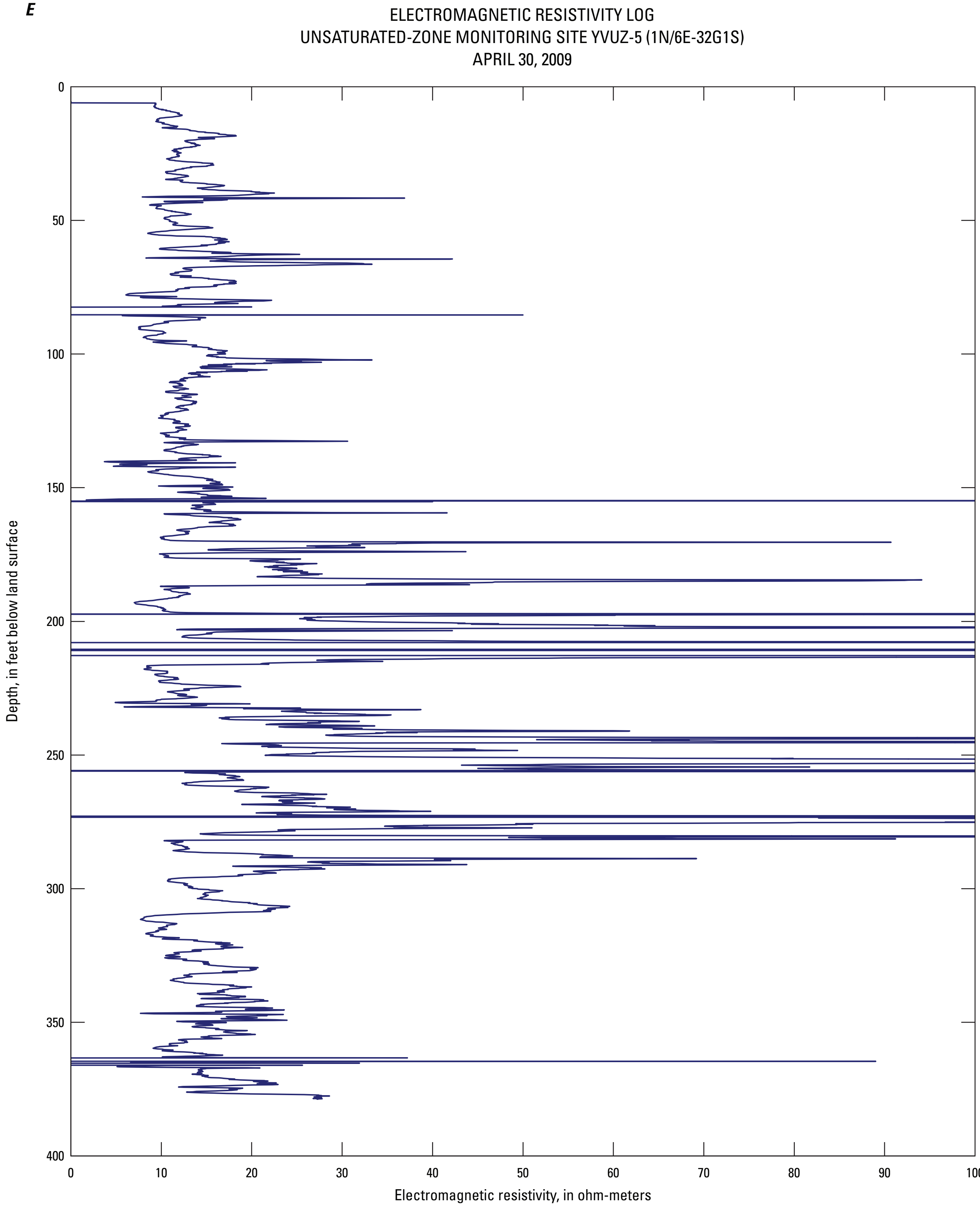
Appendix 1. —Continued

D



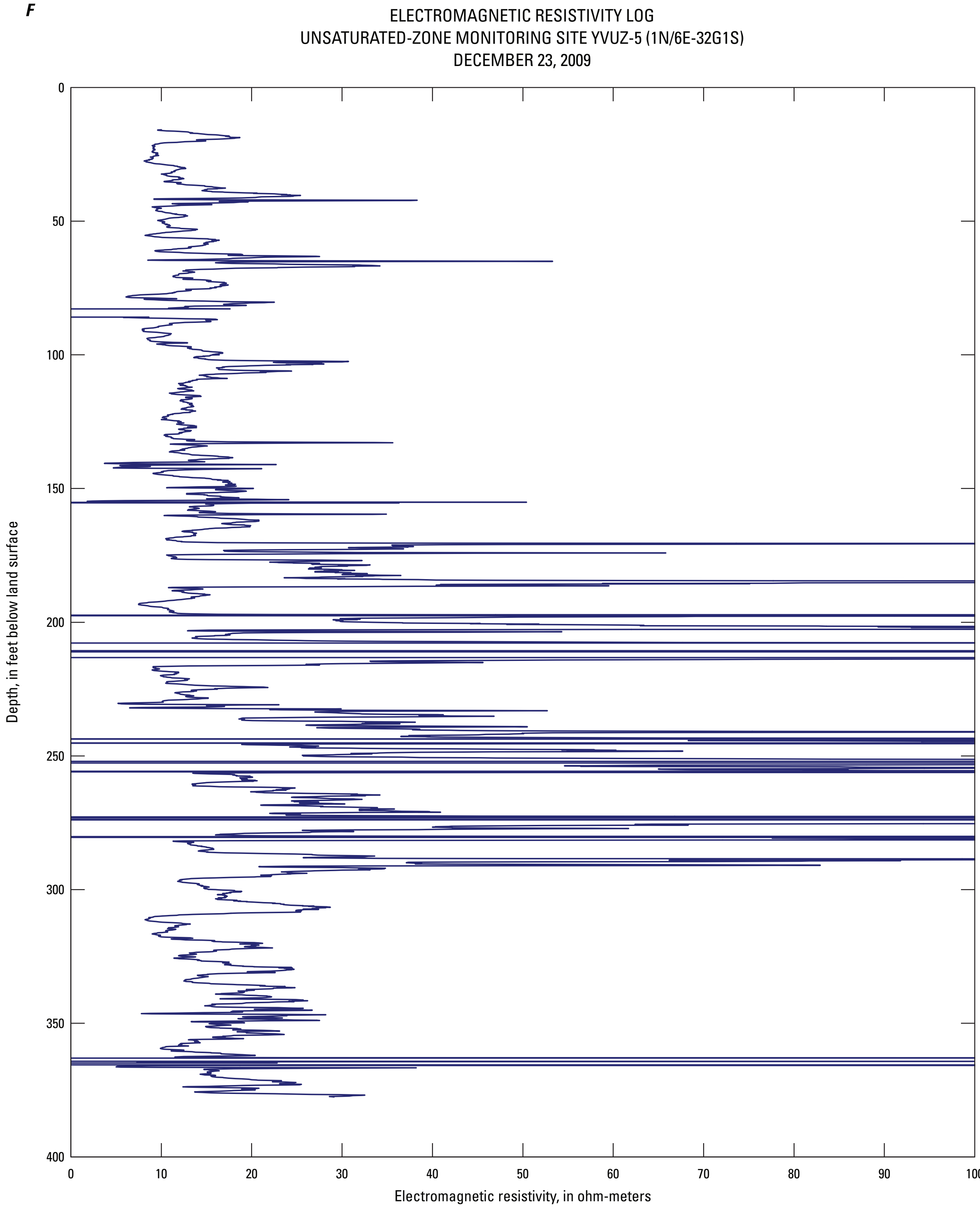
Appendix 1. —Continued

E



Appendix 1. —Continued

F



Appendix 1. —Continued

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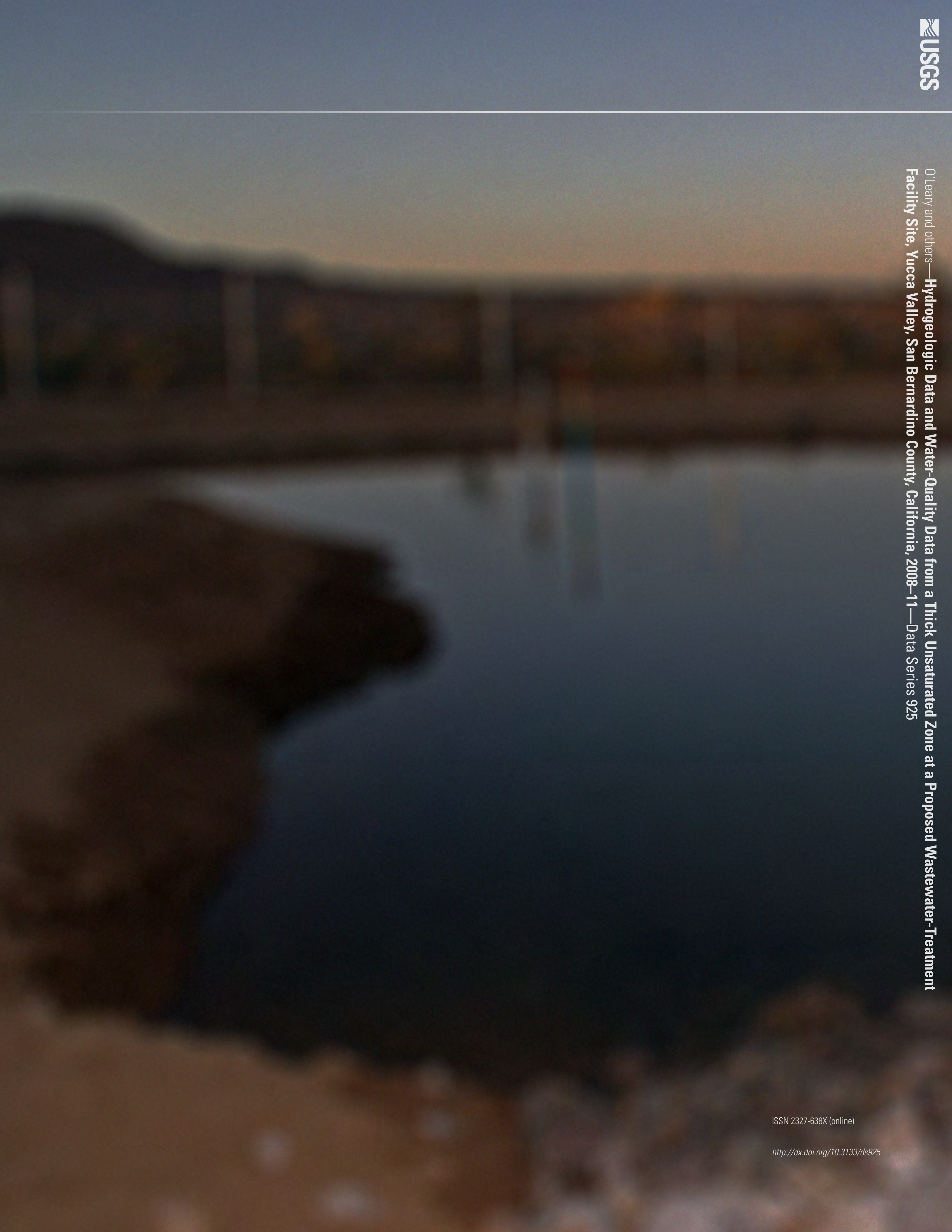

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