SELECTED HYDROLOGIC DATA FROM FORTYMILE WASH IN THE YUCCA MOUNTAIN AREA, NEVADA, WATER YEARS 1993–94

U.S. GEOLOGICAL SURVEY

Open-File Report 95–709

Prepared in cooperation with the
NEVADA OPERATIONS OFFICE
U.S. DEPARTMENT OF ENERGY under
Interagency Agreement DE-AI08-92NV10874

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Denver, Colorado
1996

U.S. DEPARTMENT OF THE INTERIOR

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CONVERSION FACTORS AND VERTICAL DATUM

Multiply	By	To obtain
centimeter (cm)	0.3937	inch
foot (ft)	0.3048	meter
inch (in.)	2.54	centimeter
inch (in.)	25.40	millimeter
kilometer (km)	0.6214	mile
meter (m)	3.281	foot
mile (mi)	1.609	kilometer
millimeter (mm)	0.03937	inch

Degree Celsius (°C) may be converted to degree Fahrenheit (°F) by using the following equation:

$$°F = 9/5\ (°C) + 32.$$

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

Selected Hydrologic Data from Fortymile Wash in the Yucca Mountain Area, Nevada, Water Years 1993–94

By Charles S. Savard

Abstract

Precipitation totals of 296 and 277 millimeters were measured at neutron-access boreholes UE-29 UZN#91 and UE-29 UZN#92, respectively, during water year 1993, October 1, 1992, to September 30, 1993. Precipitation totals of 104 and 108 millimeters were measured at UE-29 UZN#91 and UE-29 UZN#92, respectively, during water year 1994, October 1, 1993, to September 30, 1994. Approximately 90 percent of water year 1993 precipitation fell during the period November 16 to March 29. Localized streamflow was generated in the Fortymile Wash drainage basin during precipitation events in January and February 1993 and infiltrated into the streambed materials as it went down the channel system. Enough streamflow infiltrated in the Pah Canyon-Fortymile Wash area to recharge the ground-water system, as evidenced by rises in water levels of more than 3 meters in well UE-29 a#1, more than 2 meters in UE-29 a#2, and almost 2 meters in neutron-access borehole UE-29 UZN#91. Ground-water levels steadily declined after the recharge until October 1994. The streamflow went over the UE-29 UZN#91 and UE-29 UZN#92 neutron-access borehole locations. Neutron logging showed increases in the volumetric water content at UE-29 UZN#91 to the water table, more than 15 meters deep. Increases at UE-29 UZN#92 were indicated at depths of up to 8 meters. The volumetric water content then gradually decreased in both boreholes until October 1994. Water samples from streamflow in Pah Canyon Wash and Delirium Canyon Wash and from well UE-29 a#1 were analyzed for chemical constituents and physical properties.

INTRODUCTION

The Yucca Mountain area is being evaluated by the U.S. Department of Energy for its suitability to store high-level nuclear waste in a mined, underground repository (U.S. Department of Energy, 1988). Hydrologic data are being collected by the U.S. Geological Survey throughout a 150-km^2 study area about 150 km northwest of Las Vegas in southern Nevada (fig. 1) for site characterization studies. Ongoing hydrologic studies are investigating atmospheric precipitation, streamflow, movement of water through the unsaturated zone, movement of water through the saturated zone, and paleohydrology.

This study at Fortymile Wash involves some components of each of these studies. Fortymile Wash is an ephemeral stream near Yucca Mountain with tributaries draining the east side of Yucca Mountain and then forming a distributary system in the Amargosa Desert. An objective of the study is to determine the amount of recharge from Fortymile Wash to the ground-water flow system that has been proposed by Czarnecki and Waddell (1984), Claassen (1985), White and Chuma (1987), and Benson and Klieforth (1989). Understanding the ground-water flow system is important because it is a possible mechanism for radionuclide migration from the potential repository to the accessible environment. An adequate understanding of the ground-water flow system is necessary for an evaluation of the safety issues involved in siting the potential repository.

Purpose and Scope

The purpose of this report is to compile selected hydrologic data for water years 1993 and 1994, which corresponds to the period of October 1, 1992, to September 30, 1994. Precipitation readings and water-content profiles from two sites (UE-29 UZN#91 and UE-29 UZN#92), miscellaneous streamflow observations, depth-to-ground-water data from three sites

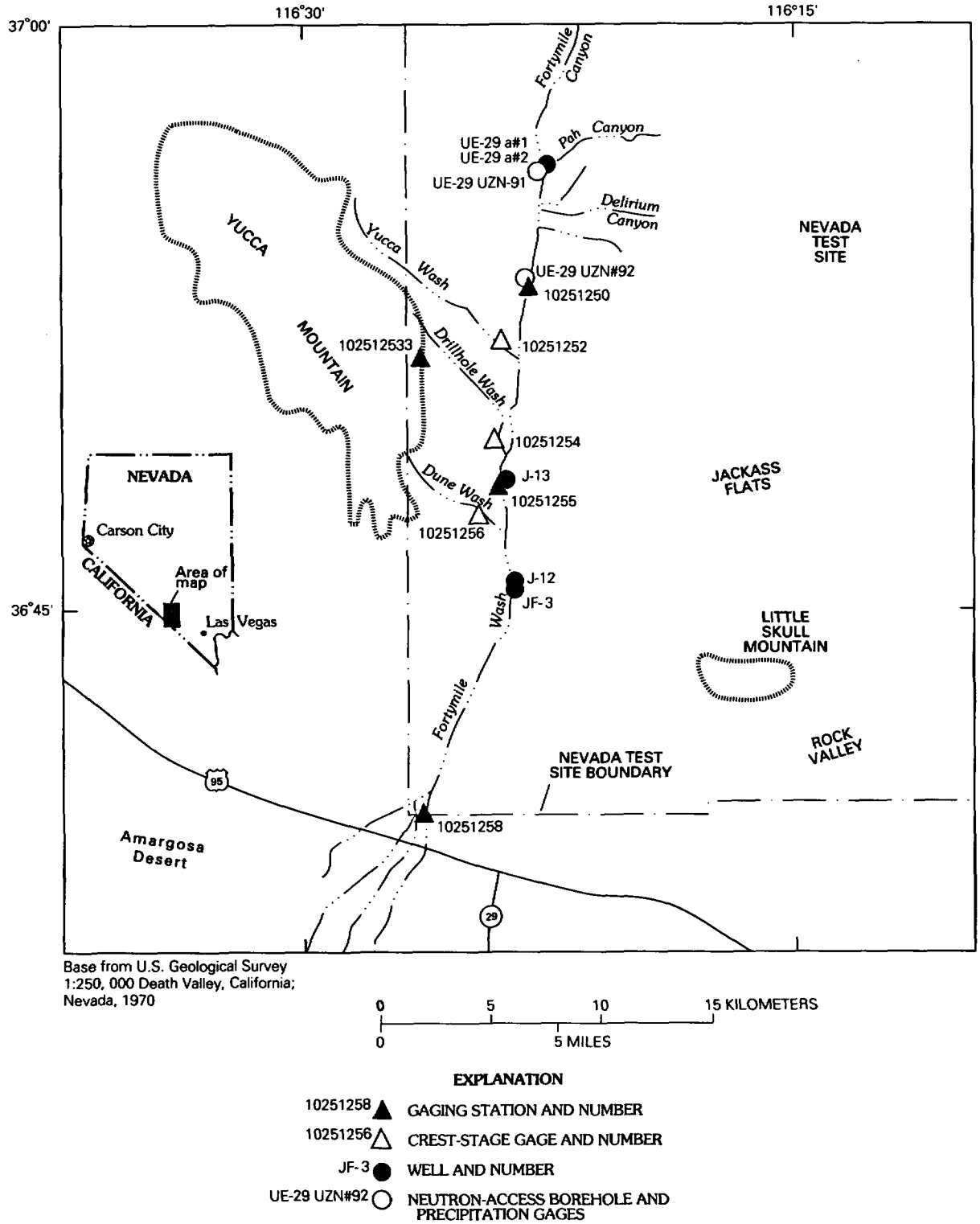

Figure 1. Location of gaging stations, crest-stage gages, neutron-access boreholes, and wells in the Yucca Mountain area, Nevada.

(UE-29 a#1, UE-29 a#2, and UE-29 UZN#91), and the chemical composition of water from one well site (UE-29 a#1) and two streamflow sites (Delirium Canyon tributary and Pah Canyon tributary) are presented in this report. These data are considered important to understanding recharge processes to the ground-water flow system in the Fortymile Wash area.

Previous Work

The U.S. Geological Survey has been investigating the hydrology of the Yucca Mountain area since the 1960's as part of other Nevada Test Site studies (Moore, 1961, 1962; Thordarson and others, 1967; Young, 1972; Winograd and Thordarson, 1975). Waddell (1982, 1984), Robison (1984), Waddell and others (1984), Robison and others (1988), Gemmel (1990), O'Brien (1991), Luckey and others (1993), Boucher (1994), LaCamera and Westenburg (1994), Hale and Westenburg (1995), O'Brien and others (1995), and Savard (1995) have presented ground-water-level data for wells in the Fortymile Wash and Yucca Mountain area since hydrologic characterization of the potential repository became a national concern. Squires and Young (1984), Pabst and others (1993), and Kane and others (1994) investigated streamflow in Fortymile Wash. Streamflow and precipitation data for the Fortymile Wash area collected during water years 1991–93 are included in a statewide report (Emett and others, 1994). Huber (1988) investigated the geomorphic evolution of Fortymile Wash. Osterkamp and others (1994) made ground-water recharge estimates in the Fortymile Wash drainage basin as part of their study of the Amargosa River Basin. Savard (1994) investigated ground-water recharge in Fortymile Canyon.

Quality Assurance

Data in this report will be used to evaluate the suitability of the Yucca Mountain site for a potential high-level nuclear-waste repository. Reliability in the collection, processing, and reporting of the hydrologic data is necessary so the data may be used with confidence to assess the expected performance of the potential repository. A quality-assurance program has been implemented to support the reliability of the data. The precipitation, neutron-logging, water-level, and water-quality data were all collected under a quality-assurance program.

The precipitation, neutron-logging profiles, and water-level and water-quality measurements were obtained by methods described by formal technical procedures as required by the quality-assurance program. The technical procedures included tests and adjustments performed during the measuring operation to ensure that the equipment was operating properly and that the expected precision and accuracy were attained. For example, the technical procedure to neutron log a borehole specifies how to perform standardization tests, log the borehole, and process the data.

Acknowledgments

Numerous personnel have helped in the collection, compilation, and quality assurance of the data included in this report. Those making notable specific contributions from Foothills Engineering, Inc., were Dale Ambos, Earl Christensen, and David Vohman for compiling the precipitation data; David Hudson and Kevin Ellett for compiling the neutron-logging data; and Gordon Buchanan for collecting field measurements and compiling the ground-water data.

HYDROLOGIC DATA

Precipitation readings and water-content profiles from two sites (UE-29 UZN#91 and UE-29 UZN#92), miscellaneous streamflow observations, depth-to-ground-water data from three sites (UE-29 a#1, UE-29 a#2, and UE-29 UZN#91), and the chemical composition of water from one well site (UE-29 a#1) and two streamflow sites (Delirium Canyon tributary and Pah Canyon tributary) in the Fortymile Wash drainage basin were collected to understand recharge processes.

Precipitation Data

Nonrecording precipitation wedges were mounted on posts near the neutron-access borehole sites, UE-29 UZN#91 and UE-29 UZN#92 (fig. 1) during water years 1993–94. Nonrecording canister precipitation gages were installed on the same posts on December 2, 1992. Differences between successive measurements were used to determine the amount of precipitation that fell in the intervening period between

readings (tables 1–4). Oil was added to the nonrecording gages to prevent evaporation of the collected precipitation. Antifreeze was added so snowfall would melt and to keep the precipitation from freezing, allowing precipitation measurements to be made during the winter.

Precipitation totals at both sites were generally lower for the wedge gage than the canister gages. Both gages were mounted on the same post approximately 6 in. apart with the orifices at the same elevation at a site. The wedge has a 2.3- by 2.5-in. rectangular orifice, with a total orifice area of 5.75 in^2. The canister gage has a 4.0-in.-diameter circular orifice, with a total orifice area of 12.57 in^2. Ambos, Flint, and Hevesi (1995) attribute the precipitation total differences to an increase in wind turbulence above the wedge orifice because of a combination of orifice shape and size.

Total precipitation measured with the wedges was 296 mm at UE-29 UZN#91 and 277 mm at UE-29 UZN#92 for water year 1993. Total precipitation measured with the canisters was 301 mm at UE-29 UZN#91 and 284 mm at UE-29 UZN#92 for the period December 2, 1992, to September 9, 1993. November 16, 1992, to March 29, 1993, was the wettest period of water year 1993, when a series of storms came across the Fortymile Wash drainage basin. During this period, 89 percent of the total annual precipitation at the UE-29 UZN#91 site and 90 percent at the UE-29 UZN#92 site was measured (fig. 2).

Total precipitation measured with the wedges was 104 mm at UE-29 UZN#91 and 108 mm at UE-29 UZN#92 for water year 1994. Total precipitation measured with the canisters was 123 mm at UE-29 UZN#91 and 122 mm at UE-29 UZN#92 for water year 1994. January 21, 1994, to February 28, 1994, was the wettest period of water year 1994, when a series of storms came across the Fortymile Wash drainage basin. During this period, 37 percent of the wedge and 36 percent of the canister annual precipitation at the UE-29 UZN#91 site and 41 percent of the wedge and 39 percent of the canister annual precipitation at the UE-29 UZN#92 site was measured (fig. 3).

Streamflow Data

Streamflow data were collected from a network of four continuous-recording gaging stations and three crest-stage gages in the lower Fortymile Wash drainage basin. Locations of the gages are shown in figure 1 and described in table 5. Periods of streamflow occurred during January 17–19, February 9, and February 23, 1993. Peak flow and mean daily discharge data at the gaging stations and crest-stage gages for water year 1993 are contained in a statewide report (Emett and others, 1994). This section of the report documents miscellaneous streamflow observations and evidence from field reconnaissance for the distances the streamflow traveled before infiltrating into the streambed sediments.

Fortymile Wash had several periods of streamflow during January 17–19, 1993. Streamflow originated in the headwaters of the Fortymile Wash drainage basin and went over the UE-29 UZN#91 location. The streamflow received inflow from Pah Canyon and Delirium Canyon and then went through the Fortymile Wash at Narrows gage. The streamflow continued downstream, receiving inflow from Yucca Wash. The streamflow went down to approximately 2.5 km above the Fortymile Wash at J-13 gage.

Pah Canyon tributary had periods of streamflow during January 17–19, February 9, and February 23, 1993. The January 17–19 streamflow contributed to the Fortymile Wash streamflow. The February 9 and 23 streamflow were not very large and infiltrated into the streambed materials before reaching UE-29 UZN#91, several hundred feet below the confluence of Pah Canyon tributary and Fortymile Wash. The February 23 streamflow was estimated to be 0.5 ft^3/s at 1405, when a sample was taken for physical properties and chemical analysis.

Delirium Canyon tributary had periods of streamflow January 17–19, February 9, and February 23, 1993. The January 17–19 streamflow contributed to the Fortymile Wash streamflow. The gravel deposited from the February 12 and March 31, 1992, streamflow in a section of the stream (fig. 4) was mostly eroded away during the January 17–19, 1993, streamflow (fig. 5). The February 9 and 23 streamflow were not very large and infiltrated into the streambed materials within several hundred feet of the confluence of Delirium Canyon tributary and Fortymile Wash. The February 9 streamflow was estimated to be 0.5 ft^3/s at 1330, when a sample was taken for physical properties and chemical analysis.

Yucca Wash had periods of streamflow on January 18, 1993. Two separate peak flows were recorded at the crest-stage gage near the mouth. The

Table 1. Precipitation totals for the UE-29 UZN#91 site, Yucca Mountain area, Nevada, during water year 1993

[in., inches; mm, millimeters; --, no data; WY, water year]

Period		Wedge gage totals		Canister gage totals*	
Begin date	End date	(in.)	(mm)	(in.)	(mm)
Oct. 1, 1992	Oct. 27, 1992	0.18	5	--	--
Oct. 27, 1992	Nov. 2, 1992	0.28	7	--	--
Nov. 2, 1992	Nov. 16, 1992	0.00	0	--	--
Nov. 16, 1992	Dec. 9, 1992	2.11	54	1.99	51
Dec. 9, 1992	Dec. 14, 1992	0.05	1	0.07	2
Dec. 14, 1992	Dec. 29, 1992	0.42	11	0.48	12
Dec. 29, 1992	Jan. 5, 1993	0.19	5	0.10	2
Jan. 5, 1993	Jan. 8, 1993	0.44	11	0.50	13
Jan. 8, 1993	Jan. 14, 1993	1.00	25	1.13	29
Jan. 14, 1993	Jan. 20, 1993	2.05	52	2.25	57
Jan. 20, 1993	Feb. 1, 1993	0.10	2	0.13	3
Feb. 1, 1993	Feb. 8, 1993	0.50	13	0.53	13
Feb. 8, 1993	Feb. 9, 1993	0.70	18	0.75	19
Feb. 9, 1993	Feb. 12, 1993	0.15	4	0.15	4
Feb. 12, 1993	Feb. 22, 1993	0.60	15	0.68	17
Feb. 22, 1993	Feb. 24, 1993	0.45	11	0.47	12
Feb. 24, 1993	Mar. 1, 1993	0.50	13	0.59	15
Mar. 1, 1993	Mar. 29, 1993	1.05	27	1.08	27
Mar. 29, 1993	Jun. 7, 1993	0.63	16	0.73	18
Jun. 7, 1993	Aug. 10, 1993	0.18	5	0.23	6
Aug. 10, 1993	Aug. 30, 1993	0.03	1	0.04	1
Aug. 30, 1993	Sep. 9, 1993	0.00	0	0.00	0
	1993 WY total	11.61	296	11.90	301

*4-in. canister installed December 2, 1992.

Table 2. Precipitation totals for the UE-29 UZN#91 site, Yucca Mountain area, Nevada, during water year 1994

[in., inches; mm, millimeters; WY, water year]

Period		Wedge gage totals		Canister gage totals	
Begin date	End date	(in.)	(mm)	(in.)	(mm)
Sep. 9, 1993	Oct. 15, 1993	0.49	12	0.55	14
Oct. 15, 1993	Nov. 3, 1993	0.04	1	0.00	0
Nov. 3, 1993	Nov. 9, 1993	0.00	0	0.00	0
Nov. 9, 1993	Nov. 15, 1993	0.15	4	0.22	6
Nov. 15, 1993	Nov. 22, 1993	0.00	0	0.00	0
Nov. 22, 1993	Dec. 2, 1993	0.29	7	0.35	9
Dec. 2, 1993	Dec. 7, 1993	0.01	0	0.00	0
Dec. 7, 1993	Dec. 13, 1993	0.20	5	0.27	7
Dec. 13, 1993	Dec. 16, 1993	0.26	7	0.29	7
Dec. 16, 1993	Jan. 21, 1994	0.00	0	0.00	0
Jan. 21, 1994	Jan. 27, 1994	0.64	16	0.62	16
Jan. 27, 1994	Feb. 4, 1994	0.06	2	0.08	2
Feb. 4, 1994	Feb. 10, 1994	0.55	14	0.64	16
Feb. 10, 1994	Feb. 28, 1994	0.25	6	0.34	9
Feb. 28, 1994	Mar. 10, 1994	0.01	0	0.02	1
Mar. 10, 1994	Mar. 21, 1994	0.07	2	0.06	2
Mar. 21, 1994	Mar. 30, 1994	0.25	6	0.29	7
Mar. 30, 1994	Apr. 12, 1994	0.13	3	0.16	4
Apr. 12, 1994	Apr. 28, 1994	0.37	9	0.44	11
Apr. 28, 1994	Apr. 29, 1994	0.08	2	0.09	2
Apr. 29, 1994	May 12, 1994	0.02	1	0.07	2
May 12, 1994	May 20, 1994	0.01	0	0.01	0
May 20, 1994	Jun. 1, 1994	0.03	1	0.04	1
Jun. 1, 1994	Aug. 12, 1994	0.00	0	0.00	0
Aug. 12, 1994	Sep. 15, 1994	0.14	4	0.14	4
Sep. 15, 1994	Sep. 29, 1994	0.06	2	0.13	3
Sep. 29, 1994	Oct. 12, 1994	0.00	0	0.00	0
	1994 WY total	4.11	104	4.81	123

Table 3. Precipitation totals for the UE-29 UZN#92 site, Yucca Mountain area, Nevada, during water year 1993

[in., inches; mm, millimeters; --, no data; WY, water year]

Period		Wedge gage totals		Canister gage totals*	
Begin date	End date	(in.)	(mm)	(in.)	(mm)
Oct. 1, 1992	Oct. 27, 1992	0.10	2	--	--
Oct. 27, 1992	Nov. 2, 1992	0.53	13	--	--
Nov. 2, 1992	Nov. 16, 1992	0.00	0	--	--
Nov. 16, 1992	Dec. 9, 1992	2.15	55	2.16	55
Dec. 9, 1992	Dec. 14, 1992	0.10	2	0.07	2
Dec. 14, 1992	Dec. 29, 1992	0.33	8	0.41	10
Dec. 29, 1992	Jan. 5, 1993	0.12	3	0.03	1
Jan. 5, 1993	Jan. 8, 1993	0.45	11	0.50	13
Jan. 8, 1993	Jan. 14, 1993	0.90	23	0.96	24
Jan. 14, 1993	Jan. 20, 1993	1.55	39	1.70	43
Jan. 20, 1993	Feb. 1, 1993	0.08	2	0.13	3
Feb. 1, 1993	Feb. 8, 1993	0.50	13	0.57	14
Feb. 8, 1993	Feb. 9, 1993	0.65	17	0.67	17
Feb. 9, 1993	Feb. 12, 1993	0.05	1	0.07	2
Feb. 12, 1993	Feb. 22, 1993	0.55	14	0.61	15
Feb. 22, 1993	Feb. 24, 1993	0.88	22	0.98	25
Feb. 24, 1993	Mar. 1, 1993	0.50	13	0.53	13
Mar. 1, 1993	Mar. 29, 1993	1.02	26	1.17	30
Mar. 29, 1993	Jun. 7, 1993	0.43	11	0.49	12
Jun. 7, 1993	Aug. 10, 1993	0.06	1	0.11	3
Aug. 10, 1993	Aug. 30, 1993	0.05	1	0.09	2
Aug. 30, 1993	Sep. 9, 1993	0.00	0	0.00	0
	1993 WY total	11.00	277	11.25	284

*4-in. canister installed December 2, 1992.

Table 4. Precipitation totals for the UE-29 UZN#92 site, Yucca Mountain area, Nevada, during water year 1994

[in., inches; mm, millimeters; WY, water year]

Period		Wedge gage totals		Canister gage totals	
Begin date	End date	(in.)	(mm)	(in.)	(mm)
Sep. 9, 1993	Oct. 15, 1993	0.44	11	0.50	13
Oct. 15, 1993	Nov. 3, 1993	0.02	1	0.00	0
Nov. 3, 1993	Nov. 9, 1993	0.00	0	0.00	0
Nov. 9, 1993	Nov. 15, 1993	0.10	3	0.16	4
Nov. 15, 1993	Nov. 22, 1993	0.00	0	0.00	0
Nov. 22, 1993	Dec. 2, 1993	0.29	7	0.30	8
Dec. 2, 1993	Dec. 7, 1993	0.01	0	0.00	0
Dec. 7, 1993	Dec. 13, 1993	0.17	4	0.25	6
Dec. 13, 1993	Dec. 16, 1993	0.30	8	0.35	9
Dec. 16, 1993	Jan. 21, 1994	0.00	0	0.00	0
Jan. 21, 1994	Jan. 27, 1994	0.80	20	0.73	19
Jan. 27, 1994	Feb. 4, 1994	0.06	2	0.08	2
Feb. 4, 1994	Feb. 10, 1994	0.57	14	0.62	16
Feb. 10, 1994	Feb. 28, 1994	0.35	9	0.40	10
Feb. 28, 1994	Mar. 10, 1994	0.01	0	0.01	0
Mar. 10, 1994	Mar. 21, 1994	0.06	2	0.05	1
Mar. 21, 1994	Mar. 30, 1994	0.22	6	0.27	7
Mar. 30, 1994	Apr. 12, 1994	0.17	4	0.15	4
Apr. 12, 1994	Apr. 28, 1994	0.45	11	0.55	14
Apr. 28, 1994	Apr. 29, 1994	0.01	0	0.01	0
Apr. 29, 1994	May 12, 1994	0.02	1	0.06	2
May 12, 1994	May 20, 1994	0.06	2	0.09	2
May 20, 1994	Jun. 1, 1994	0.02	1	0.04	1
Jun. 1, 1994	Aug. 12, 1994	0.00	0	0.00	0
Aug. 12, 1994	Sep. 15, 1994	0.00	0	0.00	0
Sep. 15, 1994	Sep. 29, 1994	0.09	2	0.14	4
Sep. 29, 1994	Oct. 12, 1994	0.00	0	0.00	0
	1994 WY total	4.22	108	4.76	122

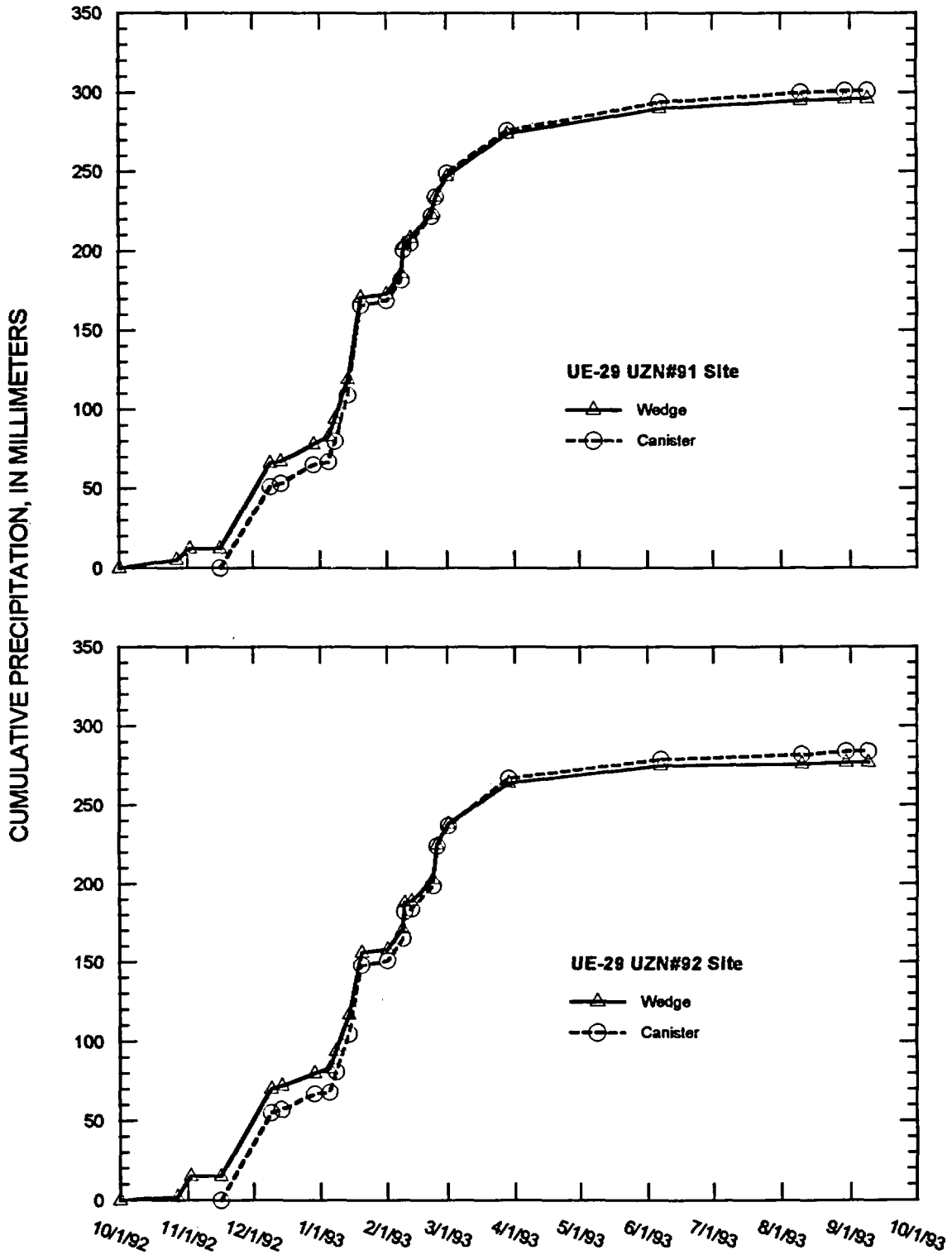

Figure 2. Cumulative precipitation at UE-29 UZN#91 and UE-29 UZN#92 sites in the Yucca Mountain area, Nevada, during water year 1993.

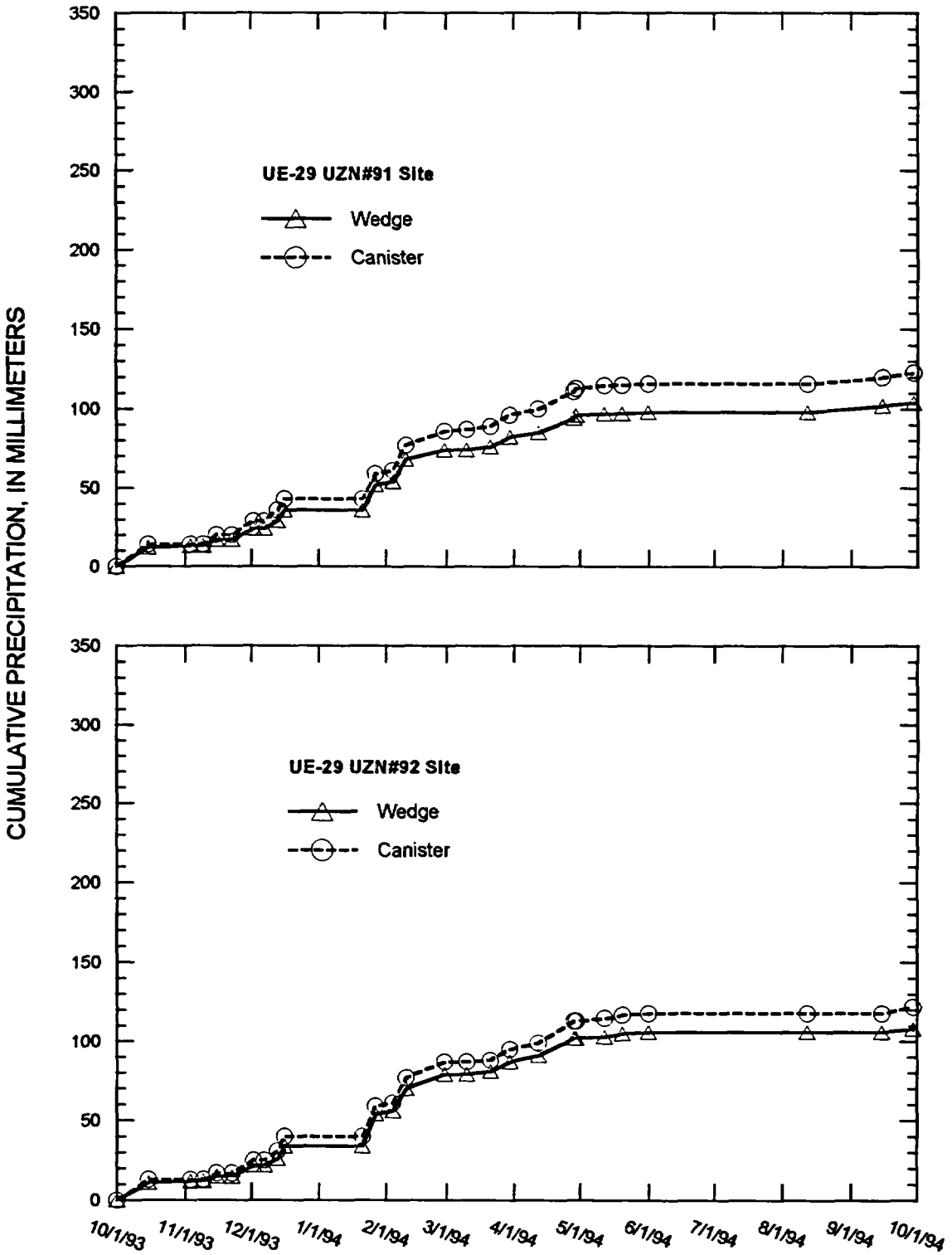

Figure 3. Cumulative precipitation at UE-29 UZN#91 and UE-29 UZN#92 sites in the Yucca Mountain area, Nevada, during water year 1994.

Table 5. Gaging station and crest-stage locations in the Yucca Mountain area, Nevada

[mi^2, square miles; G, continuous-recording gaging station; C, crest-stage gage]

Station number	Station name	Location		Gage type	Drainage area (mi^2)
		Latitude	Longitude		
10251250	Fortymile Wash at Narrows, Nevada Test Site, Nevada	36°53'13"	116°22'50"	G	258
10251252	Yucca Wash near mouth, Nevada Test Site, Nevada	36°51'58"	116°23'38"	C	17.0
102512533	Pagany Wash #1 near well UZ-4, Nevada Test Site, Nevada	36°51'39"	116°26'08"	G	0.82
10251254	Drillhole Wash at mouth, Nevada Test Site, Nevada	36°49'13"	116°23'52"	C	16.3
10251255	Fortymile Wash near well J-13, Nevada Test Site, Nevada	36°48'27"	116°24'01"	G	304
10251256	Dune Wash near Busted Butte, Nevada Test Site, Nevada	36°47'35"	116°24'29"	C	6.77
10251258	Fortymile Wash near Amargosa Valley, Nevada	36°40'18"	116°26'03"	G	316

streamflow went to Fortymile Wash and joined the Fortymile Wash streamflow.

No streamflow was recorded at the gaging stations, Fortymile Wash near well J-13 and Fortymile Wash near Amargosa Valley; or at the crest-stage gages, Drillhole Wash at mouth and Dune Wash near Busted Butte, during water year 1993. No streamflow was recorded at any of the gaging stations or crest-stage gages during water year 1994.

Unsaturated-Zone Water-Content Profiles

The water content of the unsaturated zone was monitored by neutron logging at UE-29 UZN#91 and UE-29 UZN#92, which are both located in the main Fortymile Wash channel. UE-29 UZN#91 was drilled to a depth of 28.6 m and UE-29 UZN#92 to 36.6 m (table 6). A measurement point was established at each neutron-access borehole so successive neutron logs could be compared. The UE-29 UZN#91 measurement point is the top of the well casing with the cover removed, approximately 0.9 m above land surface. The UE-29 UZN#92 measurement point is the top of the well casing with the cover removed, approximately 0.7 m above the land surface. Only the water content of the alluvium and colluvium was monitored in UE-29 UZN#91, because the contact with the underlying volcanic bedrock is at 20.4 m below the measurement point (Blout and others, 1994), which is below the water table. The alluvium and colluvium contact with the underlying volcanic bedrock is at 18.3 m below the measurement point in UE-29 UZN#92, so the vertical water-content profiles represent conditions in the alluvium, colluvium, and the volcanic bedrock to a depth of 19.4 m.

The hand-held neutron-logging system outputs the number of counts, which are proportional to the water content of the surrounding geologic medium (Gardner, 1986). The system has a resolution distance of less than 1 m, thus the moisture contents derived represent only a small portion of the study area. Repeat measurements over the same intervals and depths allow for comparison of changes in moisture content. The neutron-logging tool was hand lowered into the neutron-access borehole with a depth-marked cable allowing vertical profiles of the water content to be made throughout the year (figs. 6 and 7). Neutron counts were recorded every 0.1 m from land surface to 5 m below the measurement point and then every 0.3 m. Neutron counts were converted to volumetric water content using a calibration equation. The calibration equation and volumetric water-content readings for each depth are stored in Yucca Mountain Project data bases. Readings at UE-29 UZN#91 were stopped at varying depths to prevent the neutron tool from becoming immersed in the ground water and damaging the tool. Readings at UE-29 UZN#92 were stopped at 19.4-m depth. Generally both neutron-access boreholes were logged on the same day except for January 15, 1993, when only UE-29 UZN#92 was logged, and February 12, 1993, when only UE-29 UZN#91 was logged.

At UE-29 UZN#91, there were no major differences from October 8, 1992, to December 11, 1992, in the volumetric water-content profiles except for a slight increase in the upper 1.0 m. After the January 17–19, 1993, period of streamflow, the

Figure 4. Delirium Canyon tributary velocity section in the Yucca Mountain area, Nevada, on March 31, 1992 (from Savard, 1995, fig. 5). A, reference point.

Figure 5. Delirium Canyon tributary velocity section in the Yucca Mountain area, Nevada, on January 19, 1993. A, reference point.

Table 6. Well and neutron-access borehole locations in the Yucca Mountain area, Nevada

Name	Site ID	Location		Depth of open interval below land surface	
		Latitude	Longitude	Top (meters)	Bottom (meters)
UE-29 a#1	365629116222601	36°56'29"	116°22'26"	10.7	65.5
UE-29 a#2	365629116222602	36°56'29"	116°22'26"	86.9	213
				247	421
UE-29 UZN#91	365624116222901	36°56'24"	116°22'29"	27.1	28.6
UE-29 UZN#92	365324116225101	36°53'14"	116°22'51"	32.0	36.6
J-13	364829116234001	36°48'28"	116°23'40"	304	424
				820	1,010
J-12	364554116232401	36°45'54"	116°23'24"	265	347
JF-3	364528116232201	36°45'28"	116°23'22"	224	347

January 19, 1993, profile increased in water content relative to the December 11, 1992, profile from a depth of 0.7 to 12 m. From January 19 to January 23, 1993, the profile decreased in water content from a depth of 0.7 to 12.5 m, and increased from 12.5 to 15.5 m, the approximate depth of the water table. From January 23, 1993, to September 15, 1994, the entire profile generally decreased or remained constant in water content.

At UE-29 UZN#92, there were no major differences from October 8, 1992, to January 15, 1993, in the volumetric water-content profiles except for a slight increase in the upper 1.0 m. After the January 17–19, 1993, period of streamflow, the January 19, 1993, profile increased in water content relative to the December 11, 1992, profile from a depth of 0.7 to 6.5 m. From January 19, 1993, to January 26, 1993, the profile decreased in water content from a depth of 0.7 to 6.5 m and increased from 6.5 to 8 m. From January 26, 1993, to September 15, 1994, the entire profile generally decreased or remained constant in water content.

Depth-to-Water Data

Depth-to-water measurements were made in two wells, UE-29 a#1 and UE-29 a#2, and one neutron-access borehole, UE-29 UZN#91, during water years 1993–94 (tables 7–9). These wells and the neutron-access borehole are either in or near Fortymile Wash. Depth-to-water measurements were made in three other wells near Fortymile Wash, J-12, J-13, and JF-3, during water years 1993–94 but are reported in other publications (Hale and Westenburg, 1995).

A measurement point was established at each well so successive depth-to-water measurements could be compared. The UE-29 a#1 measurement point is a scribed point on the top of the well cover, approximately 0.09 m above land surface. The UE-29 a#2 measurement point is a scribed point on the well cover, approximately 0.1 m above the land surface. The UE-29 UZN#91 measurement point is the same as for the neutron logging, the top of the well casing with the cover removed, approximately 0.9 m above the land surface. The land surface around UE-29 UZN#91 is not stable because of erosion and deposition of stream sediments in the channel. Because measurement point elevations are not known to an adequate accuracy, the depth-to-water measurements have not been converted to an elevation with reference to mean sea level.

The measurements were made with a hand-held steel tape, an electric tape, or both. Both the steel tape and the electric tape use feet as a measurement scale. The steel tape measurements were made by lowering a steel tape into the well and holding at the measurement point a known depth on the tape. When the tape was removed from the well, the water cut was read. The water cut is the portion of the tape wetted by water in the well. Subtraction of the water cut from the hold results in the depth to water for the well below the measurement point at the measurement time. The electric tape measurements were made by lowering the probe in the well until the contacts in the probe just touched

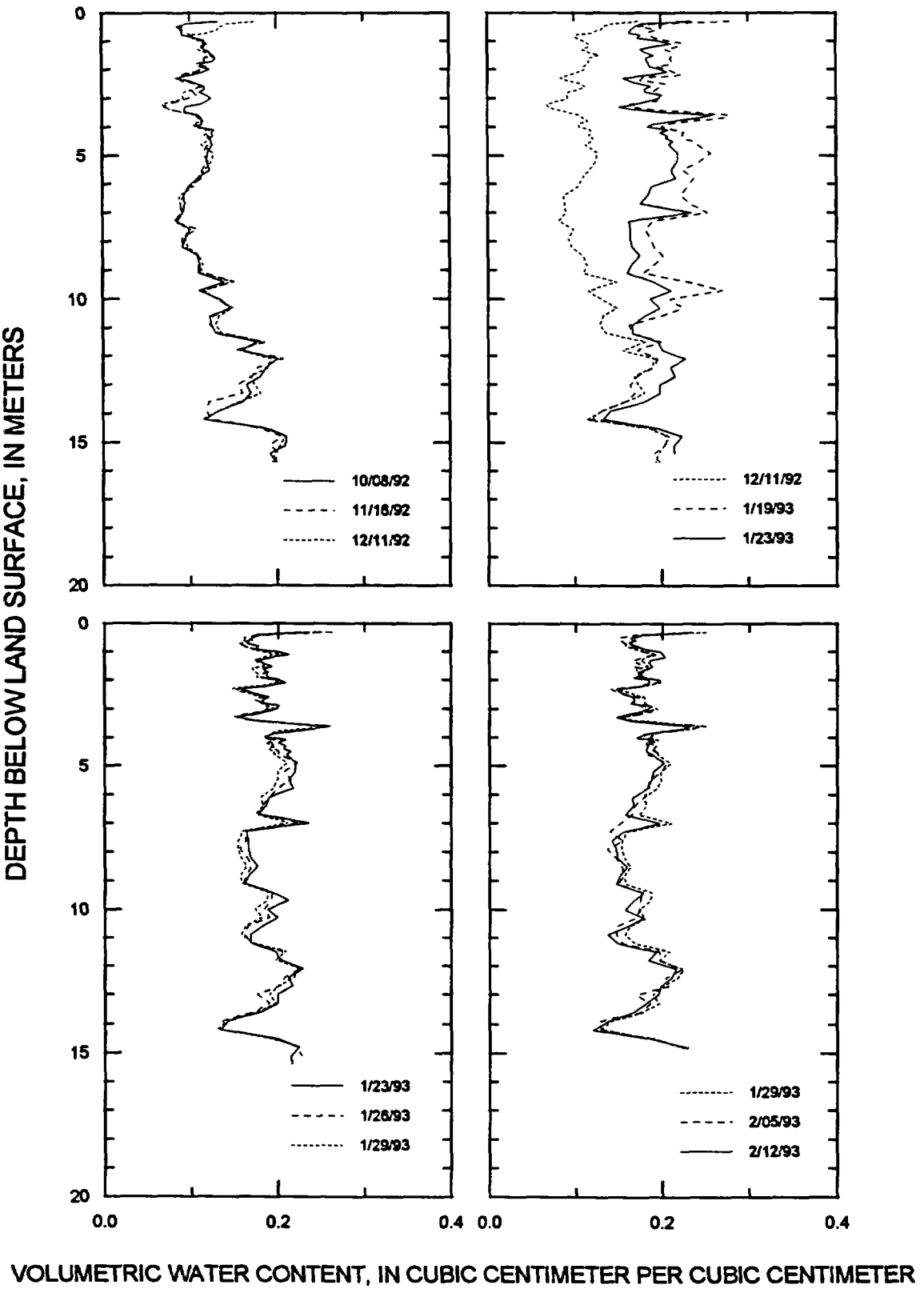

Figure 6. Volumetric water-content profiles for UE-29 UZN#91 in the Yucca Mountain area, Nevada.

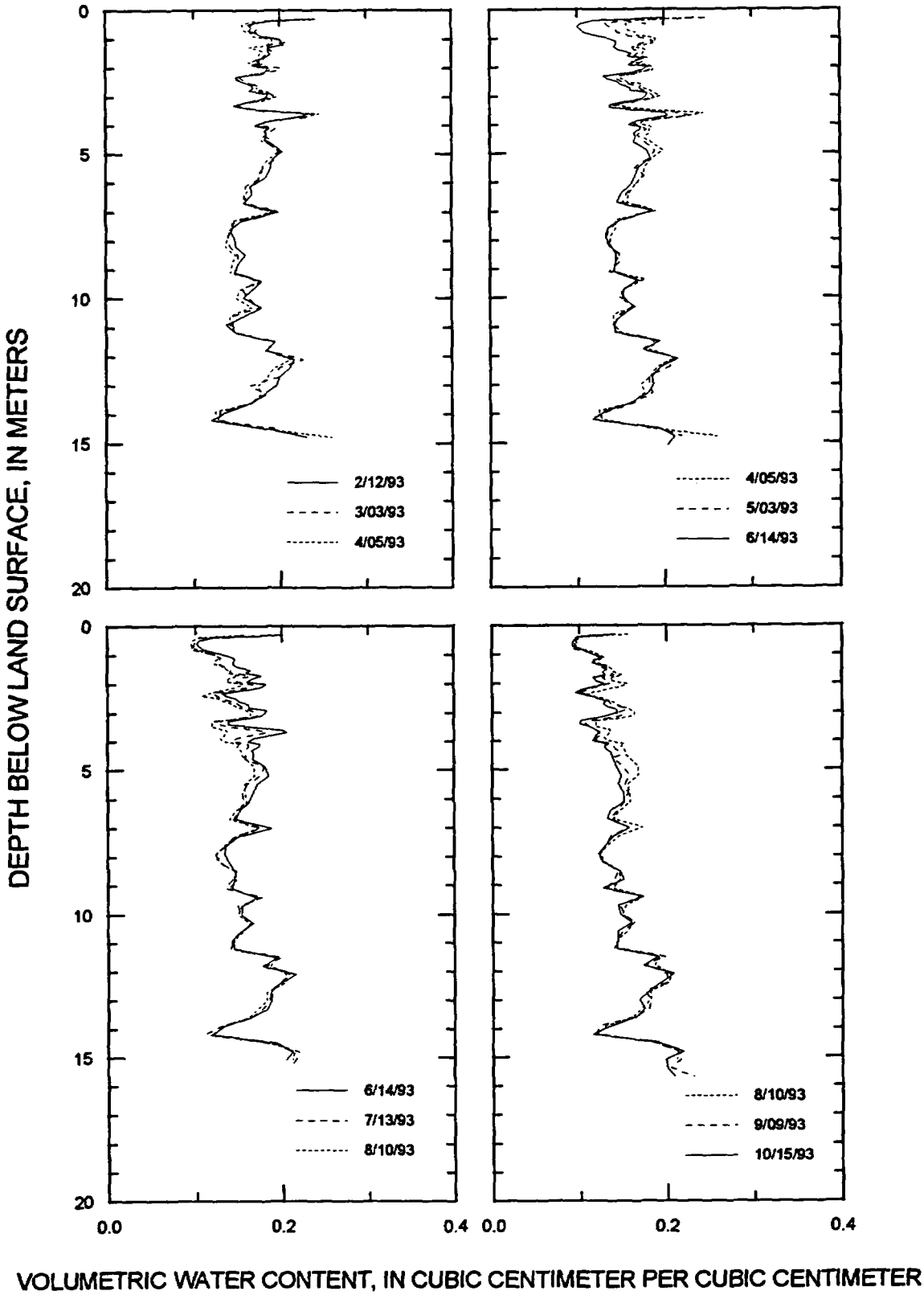

Figure 6. Volumetric water-content profiles for UE-29 UZN#91 in the Yucca Mountain area, Nevada--Continued.

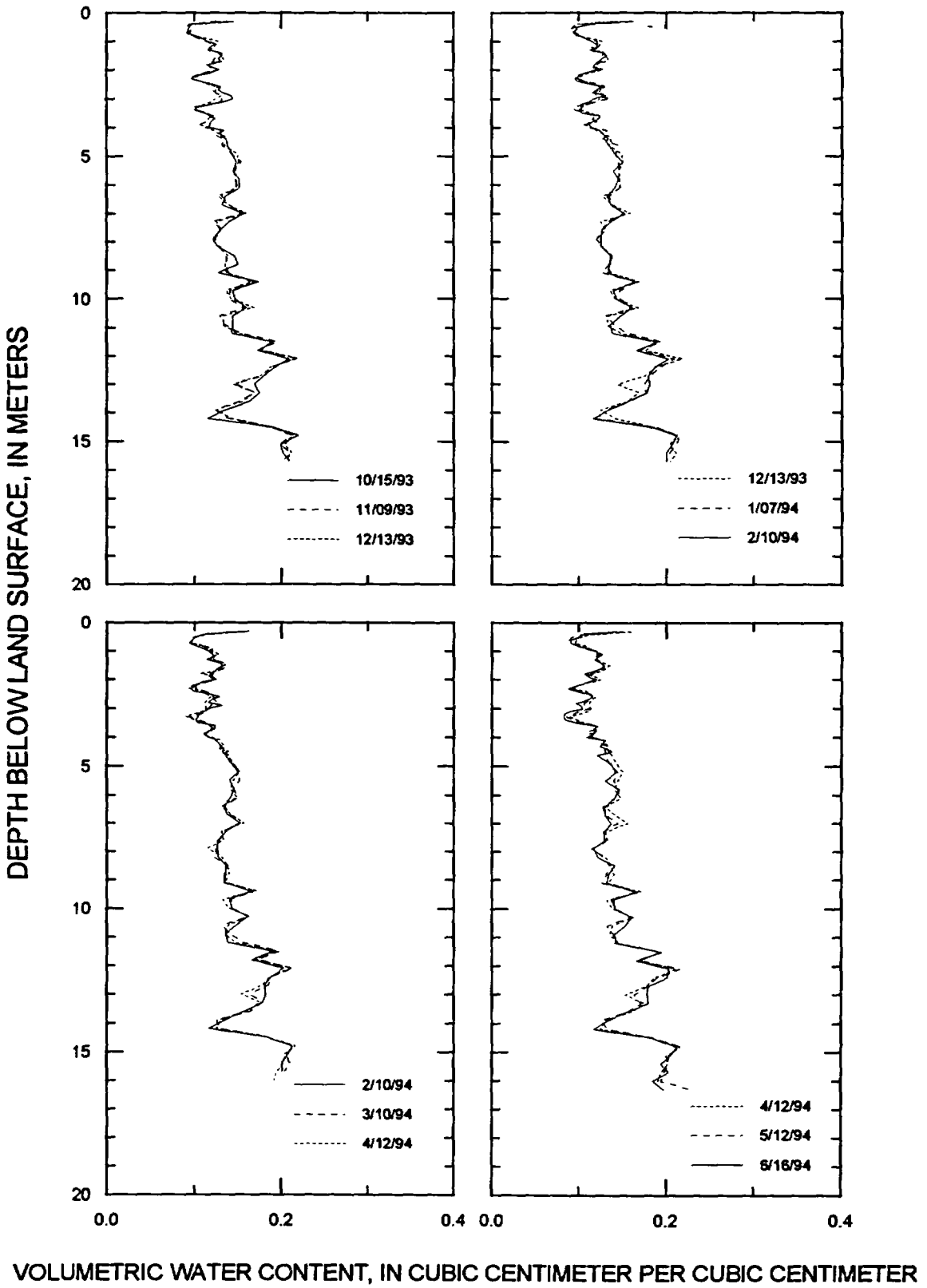

Figure 6. Volumetric water-content profiles for UE-29 UZN#91 in the Yucca Mountain area, Nevada--Continued.

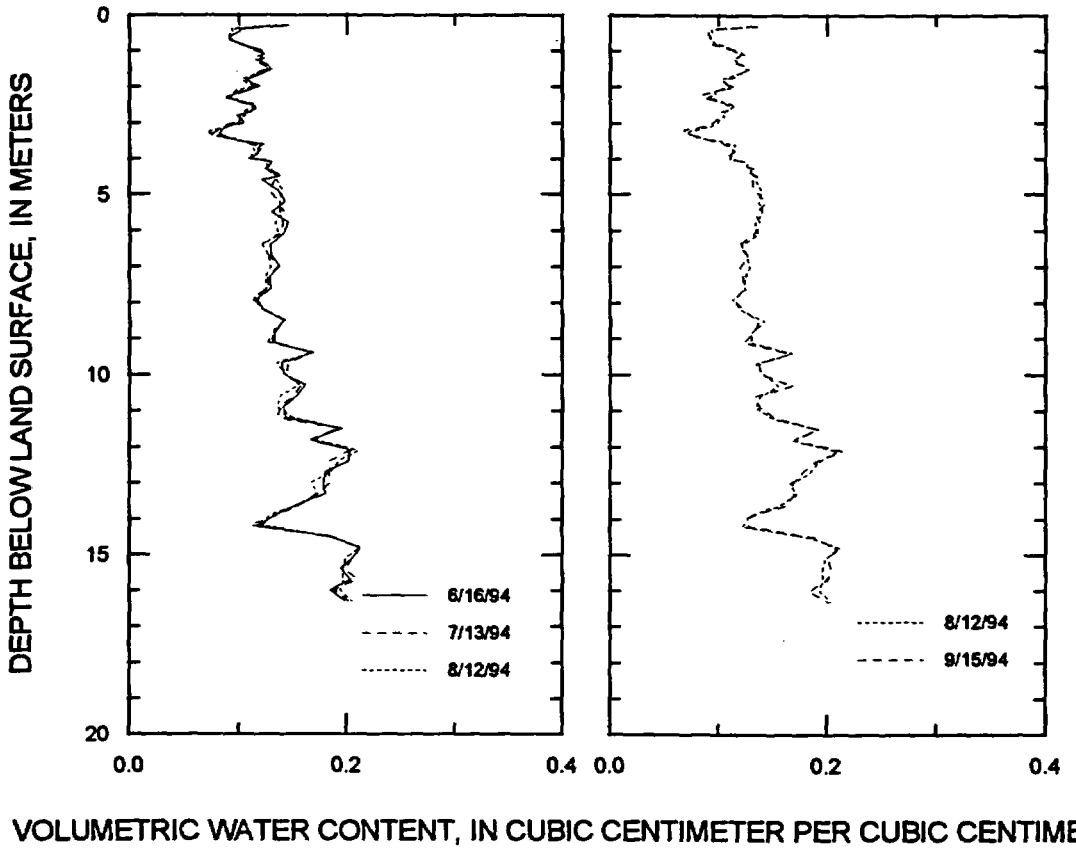

Figure 6. Volumetric water-content profiles for UE-29 UZN#91 in the Yucca Mountain area, Nevada--Continued.

the water. When the contacts touch the water, an electrical circuit is completed and visual and audio devices signal the contacts are in the water. Depth to water could be read directly from the electric tape because the water cut was at a reading of 0.00 ft. When both measurement techniques were used, the steel tape was the method used to report the depth-to-water measurement. Depth-to-water measurements were converted from feet to meters for reporting purposes.

Depth to water decreased after the January and February periods of streamflow in all three wells, indicating a rise in water levels. The measuring frequency was varied to document changes in the water levels (figs. 8–10). Wells UE-29 a#1 and UE-29 a#2 are only 10 m apart and have depth-to-water measurements that generally differ by 3 m, with UE-29 a#1 having the smaller depth to water. This is because the wells are open to different intervals of the geologic strata. The depth to the open intervals of the wells are listed in table 6. Well UE-29 a#2 is open to the deepest interval of the three wells in the Pah Canyon area.

The highest water level in UE-29 a#1 was on February 14, 1993, when a depth to water of 23.41 m was measured. The lowest water level was on January 11, 1993, when a depth to water of 27.30 m was measured. The observed range in water level was 3.89 m for water years 1993–94. Water levels were in a decreasing trend from October 1, 1992, to January 11, 1993. After the January 17–19, 1993, period of streamflow, the ground-water level rose 2.94 m in 7 to 9 days until January 26, 1993. Water levels then decreased until February 9, 1993. After the February 9, 1993, streamflow, the ground-water level rose 1.27 m in 5 days until February 14, 1993. Water levels then decreased until February 24, 1993. After the February 23, 1993, streamflow, the ground-water level rose 0.06 m in 8 days until March 3, 1993. Water levels then generally decreased until September 29, 1994.

The highest water level in UE-29 a#2 occurred on three days (March 3, 8, and 10, 1993) when a depth to water of 26.41 m was measured. The lowest water level was on January 11, 1993, when a depth to water

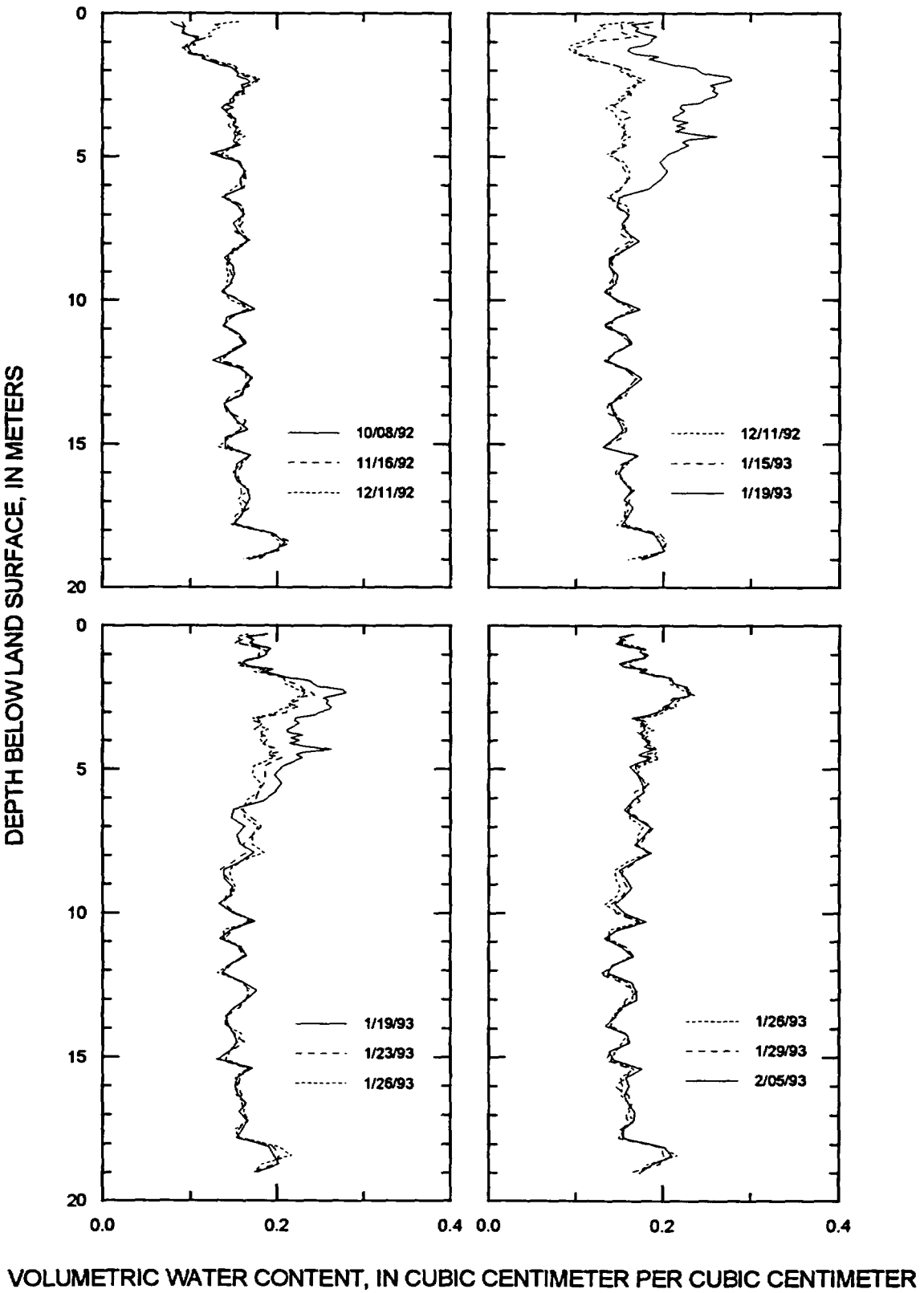

Figure 7. Volumetric water-content profiles for UE-29 UZN#92 in the Yucca Mountain area, Nevada.

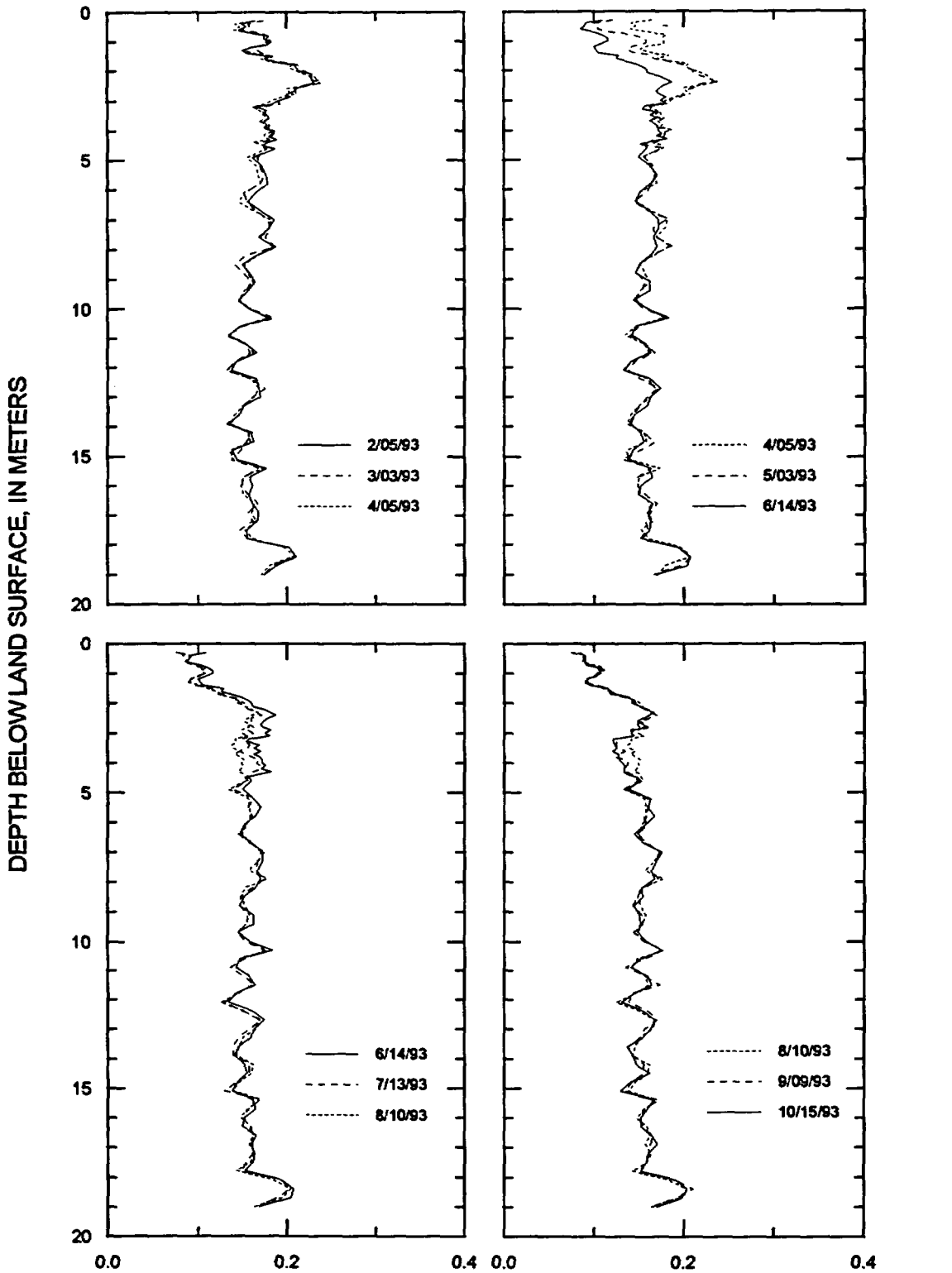

Figure 7. Volumetric water-content profiles for UE-29 UZN#92 in the Yucca Mountain area, Nevada--Continued.

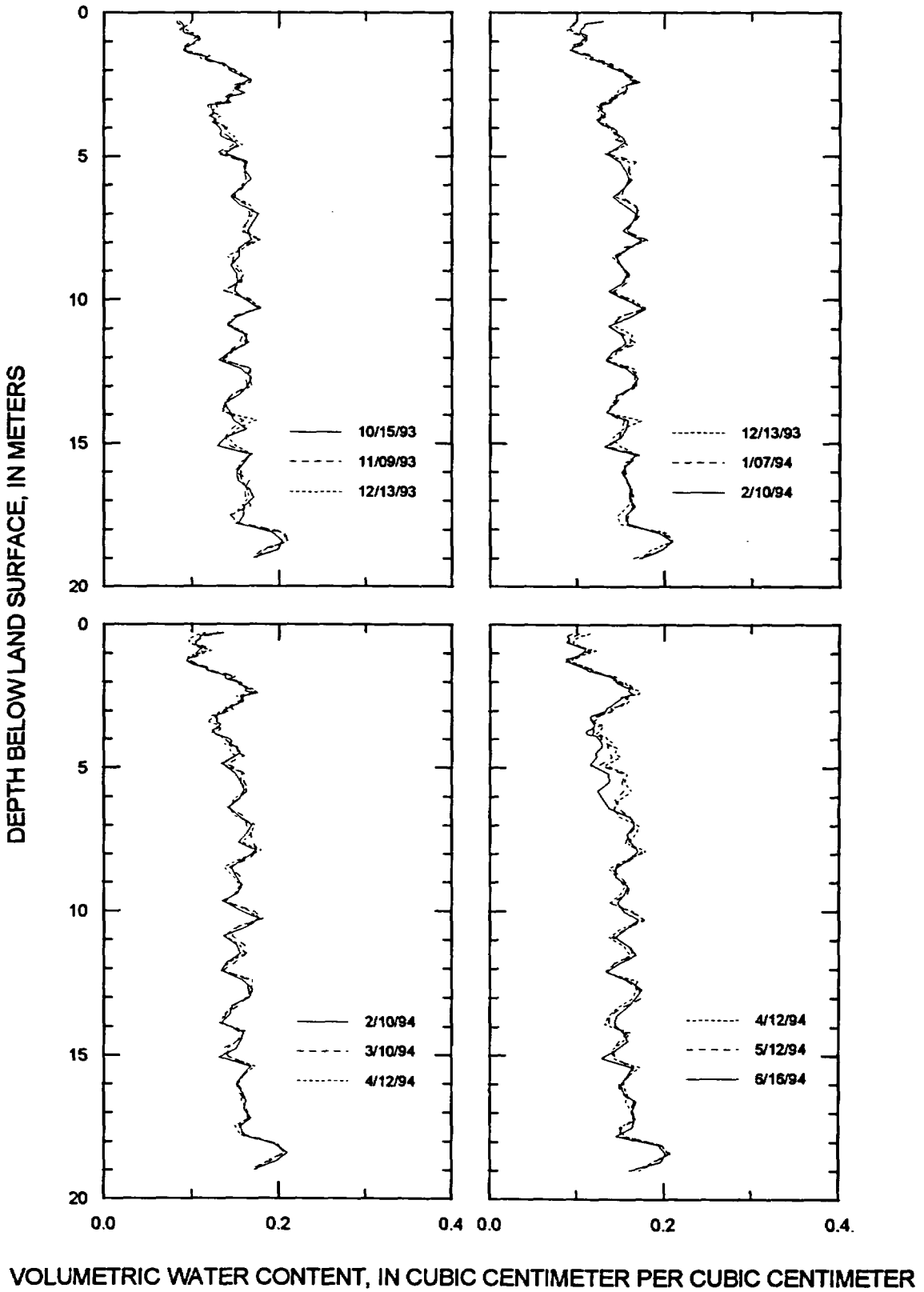

Figure 7. Volumetric water-content profiles for UE-29 UZN#92 in the Yucca Mountain area, Nevada--Continued.

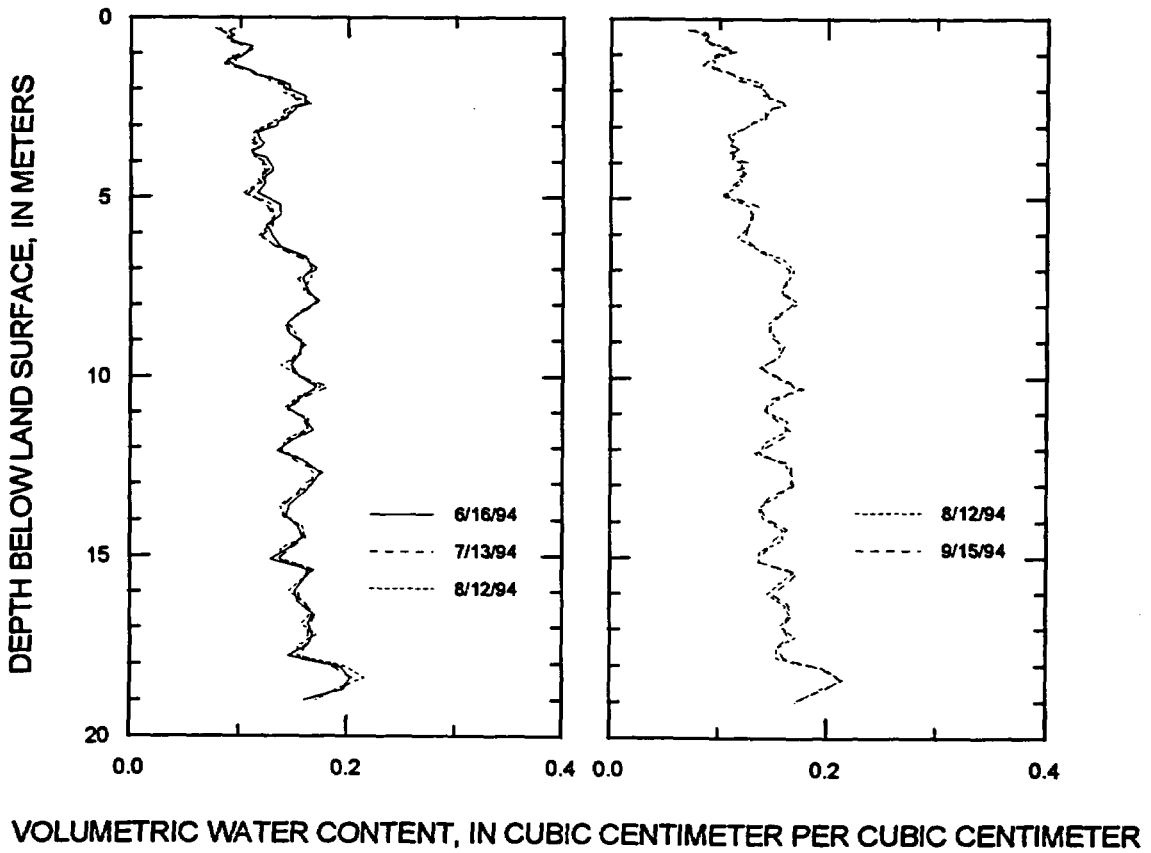

Figure 7. Volumetric water-content profiles for UE-29 UZN#92 in the Yucca Mountain area, Nevada--Continued.

of 29.11 m was measured. The observed range in water level was 2.70 m for water years 1993–94. Water levels were in a decreasing trend from October 1, 1992, to January 11, 1993. After the January 17–19, 1993, period of streamflow, the ground-water level rose 1.99 m in 18 days until February 8, 1993. Water levels decreased from February 8–9, 1993. After the February 9, 1993, streamflow, the ground-water level rose 0.69 m in 9 days until February 19, 1993. Water levels decreased from February 19–22, 1993. After the February 23, 1993, streamflow, the ground-water level rose 0.20 m in 9 days until March 3, 1993. Water levels then generally decreased until September 29, 1994.

The highest water level in UE-29 UZN#91 was on March 10, 1993, when a depth to water of 15.49 m was measured. The lowest water level was on January 4–14, 1993, when a depth to water of 17.41 m was measured. The observed range in water level was 1.92 m for water years 1993–94. Water levels were in a decreasing trend from October 1, 1992, to January 14, 1993. After the January 17–19, 1993, period of streamflow, the ground-water level rose 1.62 m in 25 days. Water levels decreased from February 8–10, 1993. After the February 9, 1993, streamflow, the ground-water level rose 0.29 m in 14 days. Water levels decreased from February 24–25, 1993. After the February 23, 1993, streamflow, the ground-water level rose 0.07 m in 13 days until March 10, 1993. Water levels then generally decreased until September 29, 1994.

Water-Quality Data

Three water samples were collected for analysis of chemical composition and physical properties (table 10). A bailed sample was collected from UE-29 a#1 on February 3, 1993. Although the well was not bailed enough to empty three well-bore volumes, the 2-in.-diameter bailer was much too small for large volume bailing of the 3-ft-diameter well; the sample should represent recently recharged ground water. Water was heard dripping in the well after the January 17–19, 1993, period of streamflow. Water

Table 7. Depth-to-water measurements in UE-29 a#1 in the Yucca Mountain area, Nevada

[S, steel tape; E, electric tape]

Date	Time	Depth to water below measuring point (meters)	Method	Date	Time	Depth to water below measuring point (meters)	Method
Oct. 8, 1992	1306	27.07	S	Mar. 12, 1993	1013	23.96	E
Oct. 23, 1992	1115	27.15	S	Mar. 15, 1993	1000	24.02	E
Oct. 26, 1992	1027	27.14	S	Mar. 18, 1993	1410	24.10	E
Nov. 2, 1992	1048	27.15	S	Mar. 23, 1993	1025	24.25	E
Nov. 16, 1992	1302	27.20	S	Mar. 29, 1993	1048	24.41	E
Nov. 30, 1992	1135	27.28	S	Apr. 5, 1993	1518	24.56	E
Dec. 9, 1992	1153	27.27	S	Apr. 14, 1993	1217	24.76	E
Dec. 14, 1992	1031	27.28	S	Apr. 23, 1993	1038	24.88	E
Dec. 22, 1992	1139	27.29	S	May 3, 1993	1440	24.99	E
Dec. 29, 1992	1123	27.24	S	May 17, 1993	1135	25.19	E
Jan. 4, 1993	1415	27.28	S	June 1, 1993	1106	25.33	E
Jan. 11, 1993	1140	27.30	S	June 7, 1993	1009	25.38	E
Jan. 14, 1993	1120	27.29	S	June 14, 1993	1637	25.42	E
Jan. 19, 1993	1154	26.56	E	June 29, 1993	0910	25.48	E
Jan. 20, 1993	1302	25.79	S	July 13, 1993	1311	25.61	E
Jan. 21, 1993	1121	25.12	S	Aug. 10, 1993	1351	25.91	E
Jan. 22, 1993	1030	24.65	S	Aug. 26, 1993	1510	26.05	S
Jan. 23, 1993	1355	24.46	S	Sep. 9, 1993	1356	26.11	E
Jan. 24, 1993	0911	24.38	S	Oct. 15, 1993	1113	26.21	S
Jan. 25, 1993	1122	24.37	S	Nov. 9, 1993	1154	26.34	S
Jan. 26, 1993	1221	24.35	E	Nov. 15, 1993	0937	26.37	S
Jan. 27, 1993	1430	24.35	E	Nov. 22, 1993	1027	26.32	S
Jan. 28, 1993	1110	24.38	E	Dec. 2, 1993	0951	26.41	S
Jan. 29, 1993	1605	24.42	E	Dec. 13, 1993	1116	26.43	S
Jan. 30, 1993	0850	24.43	E	Dec. 16, 1993	1359	26.43	S
Feb. 1, 1993	1106	24.50	E	Jan. 7, 1994	1145	26.48	S
Feb. 3, 1993	1037	24.55	E	Jan. 21, 1994	0924	26.52	S
Feb. 5, 1993	1510	24.60	E	Jan. 27, 1994	1408	26.51	S
Feb. 8, 1993	1100	24.62	E	Feb. 4, 1994	1235	26.50	S
Feb. 9, 1993	1409	24.68	E	Feb. 10, 1994	1202	26.51	S
Feb. 10, 1993	1040	24.64	E	Feb. 28, 1994	1416	26.59	S
Feb. 11, 1993	1010	24.13	E	Mar. 10, 1994	1122	26.65	S
Feb. 12, 1993	1128	23.66	E	Mar. 21, 1994	1047	26.69	S
Feb. 14, 1993	1200	23.41	E	Mar. 30, 1994	0940	26.70	S
Feb. 16, 1993	1407	23.51	E	Apr. 12, 1994	1206	26.73	S
Feb. 18, 1993	1025	23.63	E	Apr. 28, 1994	1050	26.68	S
Feb. 19, 1993	1315	23.62	E	Apr. 29, 1994	0947	26.69	S
Feb. 22, 1993	1057	23.83	E	May 12, 1994	1125	26.68	S
Feb. 24, 1993	1116	23.84	E	May 20, 1994	0932	26.74	S
Feb. 25, 1993	1000	23.89	E	June 1, 1994	1416	26.75	S
Feb. 26, 1993	1100	23.87	E	June 16, 1994	1009	26.69	S
Mar. 1, 1993	1051	23.86	E	July 13, 1994	1015	26.72	S
Mar. 3, 1993	1400	23.83	E	July 25, 1994	1050	26.80	S
Mar. 5, 1993	1051	23.88	E	Aug. 12, 1994	1021	26.84	S
Mar. 8, 1993	1121	23.87	E	Sep. 15, 1994	1023	26.93	S
Mar. 10, 1993	1033	23.88	E	Sep. 29, 1994	1320	26.91	S

Table 8. Depth-to-water measurements in UE-29 a#2 in the Yucca Mountain area, Nevada

[S, steel tape; E, electric tape]

Date	Time	Depth to water below measuring point (meters)	Method	Date	Time	Depth to water below measuring point (meters)	Method
Oct. 8, 1992	1300	28.83	S	Mar. 12, 1993	1016	26.47	E
Oct. 23, 1992	1045	28.93	S	Mar. 15, 1993	1004	26.49	E
Oct. 26, 1992	1017	28.90	S	Mar. 18, 1993	1416	26.54	E
Nov. 2, 1992	1041	28.92	S	Mar. 23, 1993	1035	26.68	E
Nov. 16, 1992	1256	28.94	S	Mar. 29, 1993	1052	26.79	E
Nov. 30, 1992	1125	29.02	S	Apr. 5, 1993	1523	26.86	E
Dec. 9, 1992	1217	29.04	S	Apr. 14, 1993	1220	27.05	E
Dec. 14, 1992	1023	29.03	S	Apr. 23, 1993	1043	27.18	E
Dec. 22, 1992	1123	29.07	S	May 3, 1993	1445	27.24	E
Dec. 29, 1992	1135	29.02	S	May 17, 1993	1140	27.40	E
Jan. 4, 1993	1409	29.05	S	June 1, 1993	1111	27.58	E
Jan. 11, 1993	1129	29.11	S	June 7, 1993	1019	27.62	E
Jan. 14, 1993	1112	29.06	S	June 14, 1993	1640	27.63	E
Jan. 19, 1993	1149	28.78	E	June 29, 1993	0915	27.77	E
Jan. 20, 1993	1252	28.56	S	July 13, 1993	1320	27.88	S
Jan. 21, 1993	1105	28.35	S	Aug. 10, 1993	1400	28.01	E
Jan. 22, 1993	1017	28.10	S	Aug. 26, 1993	1515	28.06	S
Jan. 23, 1993	1349	27.90	S	Sep. 9, 1993	1407	28.10	E
Jan. 24, 1993	0905	27.75	S	Oct. 15, 1993	1119	28.25	S
Jan. 25, 1993	1114	27.61	S	Nov. 9, 1993	1215	28.36	S
Jan. 26, 1993	1217	27.47	E	Nov. 15, 1993	0943	28.38	S
Jan. 27, 1993	1425	27.37	E	Nov. 22, 1993	1032	28.35	S
Jan. 28, 1993	1117	27.32	E	Dec. 2, 1993	0958	28.43	S
Jan. 29, 1993	1610	27.28	E	Dec. 13, 1993	1121	28.45	S
Jan. 30, 1993	0855	27.24	E	Dec. 16, 1993	1404	28.46	S
Feb. 1, 1993	1101	27.21	E	Jan. 7, 1994	1152	28.52	S
Feb. 3, 1993	1033	27.19	E	Jan. 21, 1994	0933	28.55	S
Feb. 8, 1993	1053	27.12	E	Jan. 27, 1994	1417	28.52	S
Feb. 9, 1993	1404	27.19	E	Feb. 4, 1994	1244	28.54	S
Feb. 10, 1993	1045	27.20	E	Feb. 10, 1994	1210	28.56	S
Feb. 11, 1993	1017	27.10	E	Feb. 28, 1994	1427	28.65	S
Feb. 12, 1993	1123	26.97	E	Mar. 10, 1994	1134	28.63	S
Feb. 14, 1993	1210	26.73	E	Mar. 21, 1994	1100	28.65	S
Feb. 16, 1993	1402	26.62	E	Mar. 30, 1994	0952	28.69	S
Feb. 18, 1993	1030	26.60	E	Apr. 12, 1994	1216	28.73	S
Feb. 19, 1993	1325	26.51	E	Apr. 28, 1994	1109	28.74	S
Feb. 22, 1993	1100	26.61	E	Apr. 29, 1994	1001	28.74	S
Feb. 24, 1993	1112	26.54	E	May 12, 1994	1131	28.75	S
Feb. 25, 1993	0953	26.57	E	May 20, 1994	0939	28.78	S
Feb. 26, 1993	1107	26.54	E	June 1, 1994	1422	28.76	S
Mar. 1, 1993	1046	26.49	E	June 16, 1994	1016	28.80	S
Mar. 3, 1993	1407	26.41	E	July 13, 1994	1021	28.80	S
Mar. 5, 1993	1057	26.45	E	July 25, 1994	1055	28.83	S
Mar. 8, 1993	1125	26.41	E	Aug. 12, 1994	1027	28.84	S
Mar. 10, 1993	1037	26.41	E	Sep. 15, 1994	1031	28.91	S
				Sep. 29, 1994	1326	28.84	S

Table 9. Depth-to-water measurements in UE-29 UZN#91 in the Yucca Mountain area, Nevada

[S, steel tape; E, electric tape]

Date	Time	Depth to water below measuring point (meters)	Method	Date	Time	Depth to water below measuring point (meters)	Method
Oct. 8, 1992	1144	17.25	S	Mar. 12, 1993	1005	15.51	S
Oct. 23, 1992	1025	17.29	S	Mar. 15, 1993	0953	15.51	S
Oct. 26, 1992	1008	17.29	S	Mar. 18, 1993	1350	15.52	S
Nov. 2, 1992	1029	17.30	S	Mar. 23, 1993	1007	15.57	S
Nov. 16, 1992	1145	17.33	S	Mar. 29, 1993	1043	15.63	S
Nov. 30, 1992	1100	17.37	S	Apr. 5, 1993	1340	15.69	S
Dec. 9, 1992	1135	17.38	S	Apr. 14, 1993	1200	15.79	E
Dec. 14, 1992	1009	17.37	S	Apr. 23, 1993	1027	15.87	S
Dec. 22, 1992	1055	17.39	S	May 3, 1993	1322	15.94	S
Dec. 29, 1992	1037	17.39	S	May 17, 1993	1110	16.05	S
Jan. 4, 1993	1353	17.41	S	June 1, 1993	1057	16.14	S
Jan. 11, 1993	1110	17.41	S	June 7, 1993	1001	16.17	S
Jan. 14, 1993	1057	17.41	S	June 14, 1993	1448	16.21	S
Jan. 19, 1993	1138	17.28	S	June 29, 1993	0854	16.28	S
Jan. 20, 1993	1238	17.01	S	July 13, 1993	1135	16.35	S
Jan. 21, 1993	1140	16.75	S	Aug. 10, 1993	1232	16.47	S
Jan. 22, 1993	0945	16.54	S	Aug. 26, 1993	1500	16.54	S
Jan. 23, 1993	1320	16.33	S	Sep. 9, 1993	1205	16.60	S
Jan. 24, 1993	0850	16.23	S	Oct. 15, 1993	1017	16.74	S
Jan. 25, 1993	1104	16.12	S	Nov. 9, 1993	1032	16.83	S
Jan. 26, 1993	1119	16.03	S	Nov. 15, 1993	0924	16.85	S
Jan. 27, 1993	1420	15.97	S	Nov. 22, 1993	1016	16.86	S
Jan. 28, 1993	1057	15.94	S	Dec. 2, 1993	0942	16.90	S
Jan. 29, 1993	1400	15.90	S	Dec. 13, 1993	1015	16.93	S
Jan. 30, 1993	0828	15.88	S	Dec. 16, 1993	1352	16.94	S
Feb. 1, 1993	1052	15.85	S	Jan. 7, 1994	1032	17.00	S
Feb. 3, 1993	1027	15.83	S	Jan. 21, 1994	0913	17.03	S
Feb. 5, 1993	1324	15.82	S	Jan. 27, 1994	1354	17.03	S
Feb. 8, 1993	1046	15.79	E	Feb. 4, 1994	1217	17.05	S
Feb. 9, 1993	1356	15.80	E	Feb. 10, 1994	1056	17.06	S
Feb. 10, 1993	1020	15.83	S	Feb. 28, 1994	1401	17.09	S
Feb. 11, 1993	0958	15.80	S	Mar. 10, 1994	1014	17.10	S
Feb. 12, 1993	1057	15.77	S	Mar. 21, 1994	1032	17.12	S
Feb. 14, 1993	1132	15.67	S	Mar. 30, 1994	0925	17.13	S
Feb. 16, 1993	1352	15.61	S	Apr. 12, 1994	1103	17.15	S
Feb. 18, 1993	1007	15.58	S	Apr. 28, 1994	1001	17.17	S
Feb. 19, 1993	1310	15.56	S	Apr. 29, 1994	0931	17.17	S
Feb. 22, 1993	1049	15.57	S	May 12, 1994	1025	17.18	S
Feb. 24, 1993	1106	15.54	S	May 20, 1994	0918	17.19	S
Feb. 25, 1993	0941	15.56	E	June 1, 1994	1405	17.20	S
Feb. 26, 1993	1044	15.55	S	June 16, 1994	0908	17.22	S
Mar. 1, 1993	1024	15.54	S	July 13, 1994	0916	17.24	S
Mar. 3, 1993	1239	15.51	E	July 25, 1994	1042	17.25	S
Mar. 5, 1993	1043	15.51	S	Aug. 12, 1994	0920	17.26	S
Mar. 8, 1993	1105	15.50	S	Sep. 15, 1994	0920	17.30	S
Mar. 10, 1993	1026	15.49	S	Sep. 29, 1994	1309	17.30	S

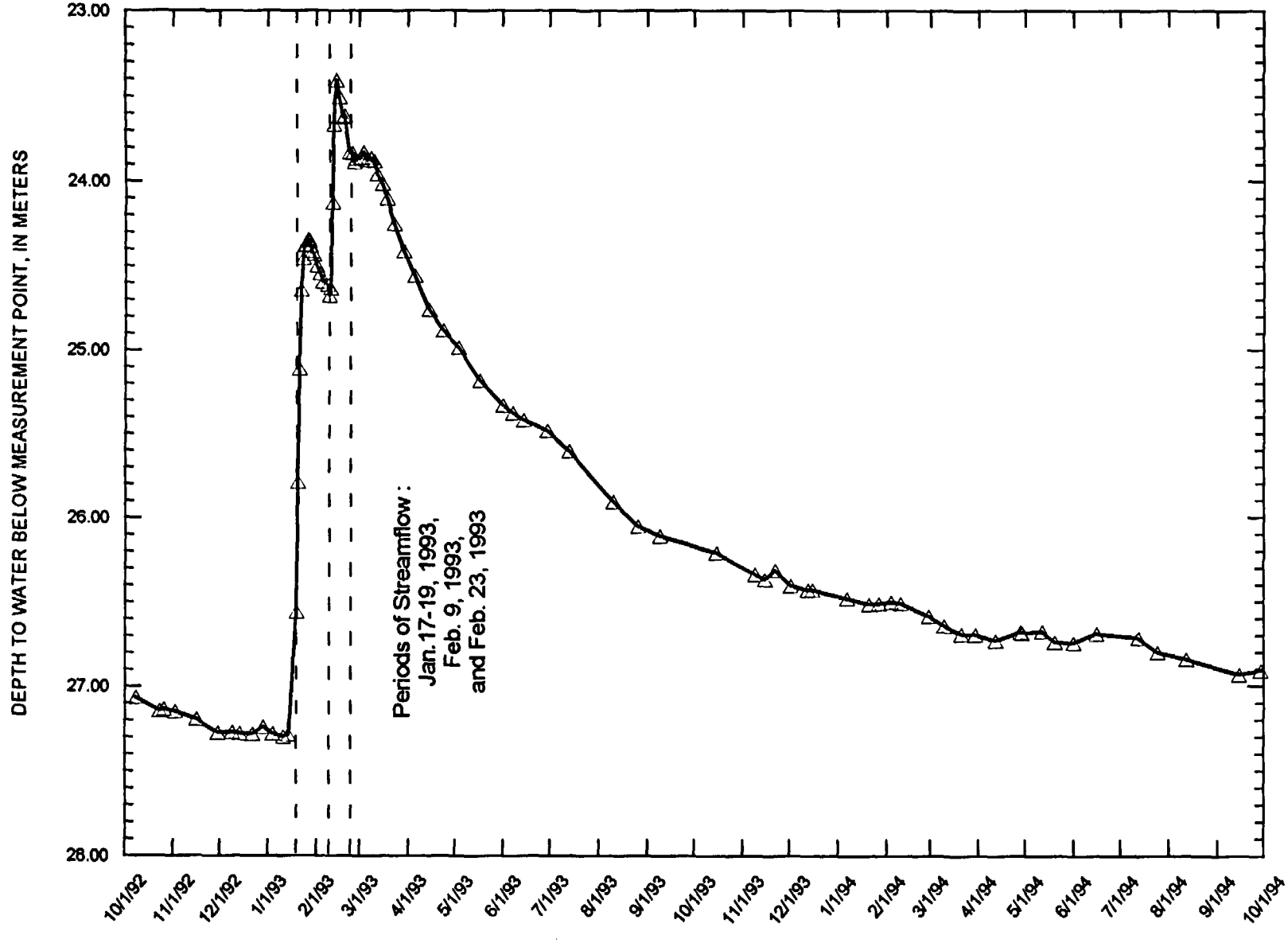

Figure 8. Depth-to-water measurements in UE-29 a#1 in the Yucca Mountain area, Nevada.

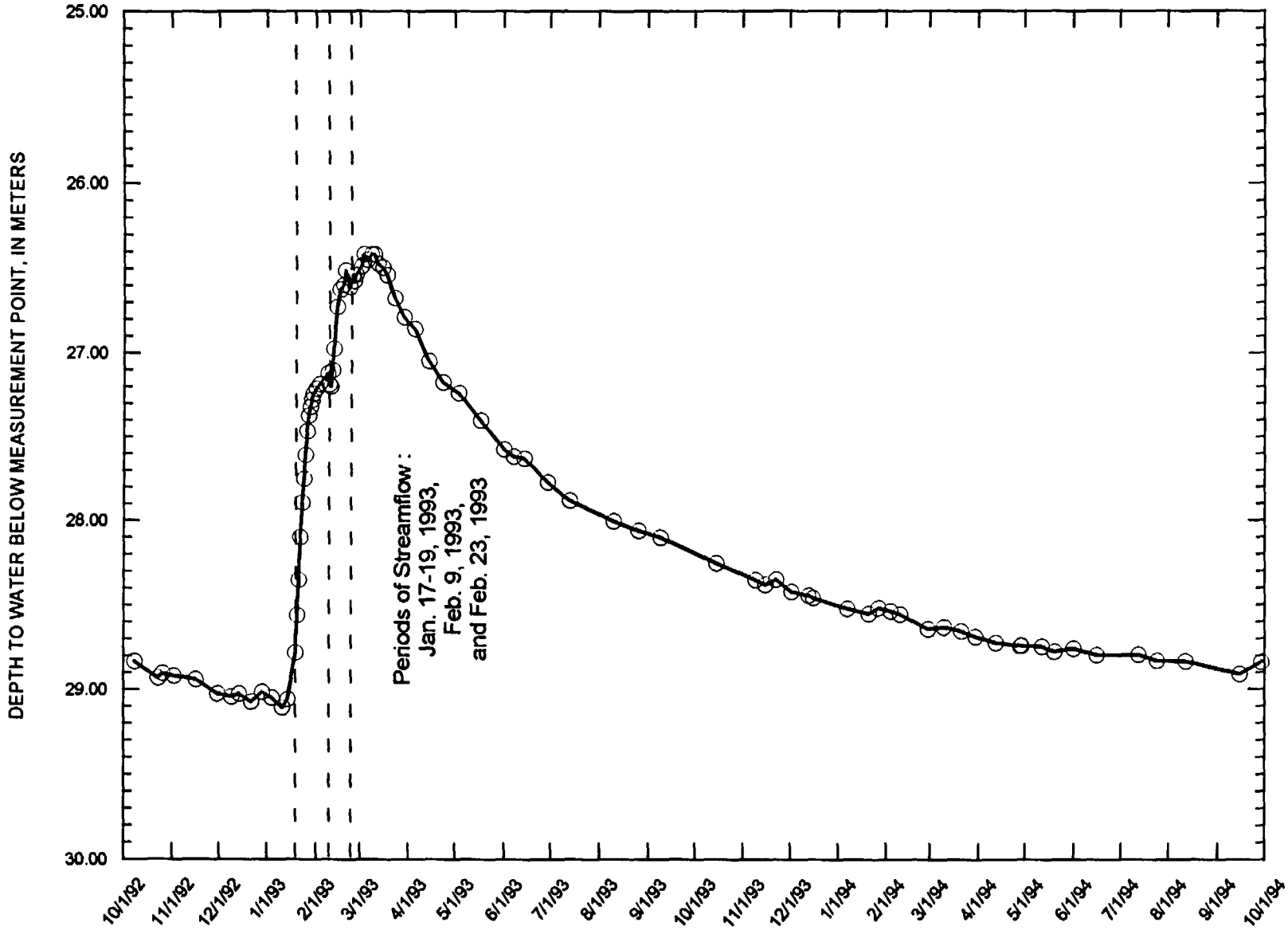

Figure 9. Depth-to-water measurements in UE-29 a#2 in the Yucca Mountain area, Nevada.

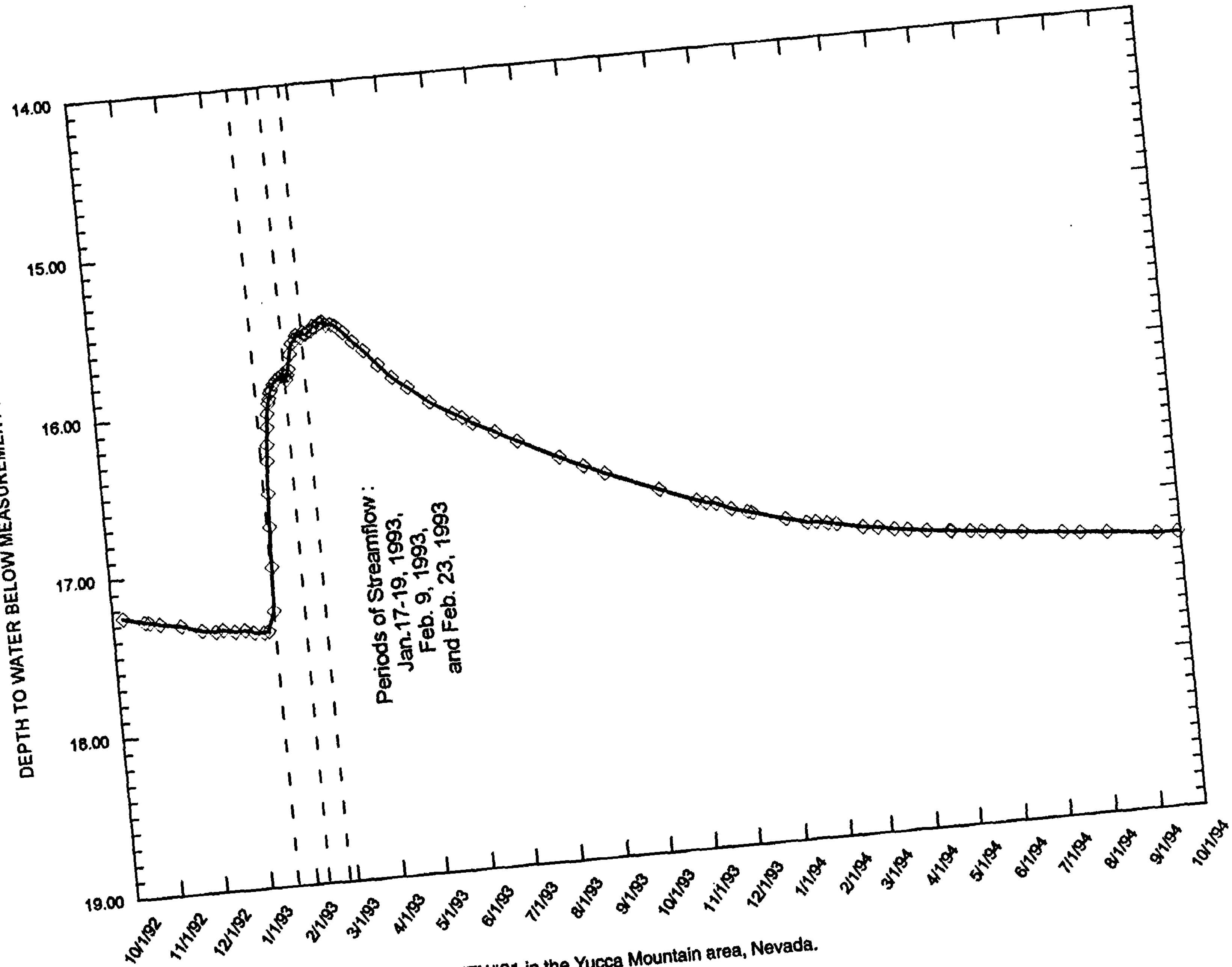

Figure 10. Depth-to-water measurements in UE-29 UZN#91 in the Yucca Mountain area, Nevada.

Table 10. Chemical composition of water samples obtained in the Fortymile Wash drainage basin in the Yucca Mountain area, Nevada

[Analyses by U.S. Geological Survey; µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; µg/L, micrograms per liter; pCi/L, picocuries per liter; ‰, parts per thousand relative to standard mean ocean water; --, no data]

Constituent, property, or isotope	Bailed sample from UE-29 a#1 February 3, 1993	Dipped sample from Delirium Canyon Wash February 9, 1993	Dipped sample from Pah Canyon Wash February 23, 1993
Specific conductance (µS/cm)	247	118	140
pH (units)	6.4	7.8	8.0
Calcium (mg/L)	16	12	14
Sodium (mg/L)	36	7.6	9.3
Magnesium (mg/L)	2.3	2.4	2.6
Alkalinity as HCO_3 (mg/L)	108	48	54
Sulfate (mg/L)	7.6	7.8	10
Chloride (mg/L)	9.6	3.2	4.3
Fluoride (mg/L)	0.2	0.3	0.3
Iron (µg/L)	4	27	19
Manganese (µg/L)	1	2	1
Nitrate (mg/L)	--	--	2
Silica (mg/L)	54	33	34
Strontium (µg/L)	55	18	21
Lithium (µg/L)	37	5	6
Bromide (mg/L)	0.07	--	--
Tritium (pCi/L)	35	33	32
δD (‰)	-90.2	-88.1	-82.3
$\delta^{18}O$ (‰)	-12.53	-12.37	-11.28

levels in the well rose approximately 2.5 m after the streamflow.

The other two samples were dipped samples during periods of streamflow. One sample was dipped from Delirium Canyon tributary at the road crossing approximately 100 m above the confluence with Fortymile Wash on February 9, 1993. The nearly steady or slowly declining streamflow was well mixed. The other sample was dipped from Pah Canyon tributary approximately 300 m above the confluence with Fortymile Wash on February 23, 1993. The nearly steady or slowly declining streamflow was well mixed.

SUMMARY

From October to early December 1992, there was a small amount of precipitation in the Fortymile Wash drainage basin. No streamflow was observed, and neutron logging indicated no precipitation was infiltrating. From early December 1992 until early April 1993, precipitation occurred from a series of regional storms. Streamflow occurred throughout most of the upper Fortymile Wash drainage basin during January 17–19, 1993. Localized streamflow occurred in the Pah and Delirium Canyon drainage basins of the Fortymile Wash drainage basin during February 9 and 23, 1993. The January streamflow went over two neutron-access borehole locations and infiltrated into the streambed sediments. The moisture moved into the unsaturated zone and then redistributed in the vertical profile during the remainder of January. Ground-water levels rose at wells UE-29 a#1 and UE-29 a#2, and neutron-access borehole UE-29 UZN#91 after each of the three periods of streamflow for approximately 1 to 2 weeks and then declined.

For the remainder of water year 1993, from early April 1993 to September 1993, there were only small amounts of precipitation, and no streamflow was observed. The moisture in the entire vertical profiles of the two neutron-access boreholes generally decreased from February to September 1993. Ground-water levels steadily declined during this period.

During water year 1994, there was only a small amount of precipitation during the year. The winter/spring period, December to April 1994, had the most precipitation. No streamflow was observed during water year 1994. The vertical moisture content profiles had only minor fluctuations in the upper 1 m during water year 1994. Ground-water levels continued their steady decline from the 1993 highs.

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