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# WATER LEVELS IN THE YUCCA MOUNTAIN AREA, NEVADA, 1995

*USGS/OFR--97-101*

U.S. GEOLOGICAL SURVEY

Open-File Report 97-101

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# Water Levels in the Yucca Mountain Area, Nevada, 1995

by Robert P. Graves and Robert L. Goemaat

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## CONVERSION FACTORS AND VERTICAL DATUM

Multiply	By	To obtain
cubic meter (m <sup>3</sup> )	264.2	gallon
kilometer (km)	0.6214	mile
liter (L)	0.03531	cubic foot
meter (m)	3.281	foot
millimeter (mm)	0.03937	inch
pound per square inch (psi)	703.1	kilogram per square meter
square kilometer (km <sup>2</sup> )	0.3861	square mile

**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.

# Water Levels in the Yucca Mountain Area, Nevada, 1995

By Robert P. Graves and Robert L. Goemaat

## Abstract

Water levels were monitored in 28 wells in the Yucca Mountain area, Nevada, during 1995. Seventeen wells representing 18 depth intervals were monitored periodically, generally on a monthly basis, 2 wells representing 3 depth intervals were monitored hourly, and 9 wells representing 15 depth intervals were monitored both periodically and hourly. All wells monitor water levels in Tertiary volcanic rocks except one that monitors water levels in Paleozoic carbonate rocks. Water levels were measured using calibrated steel tapes, a multiconductor cable unit, and/or pressure transducers.

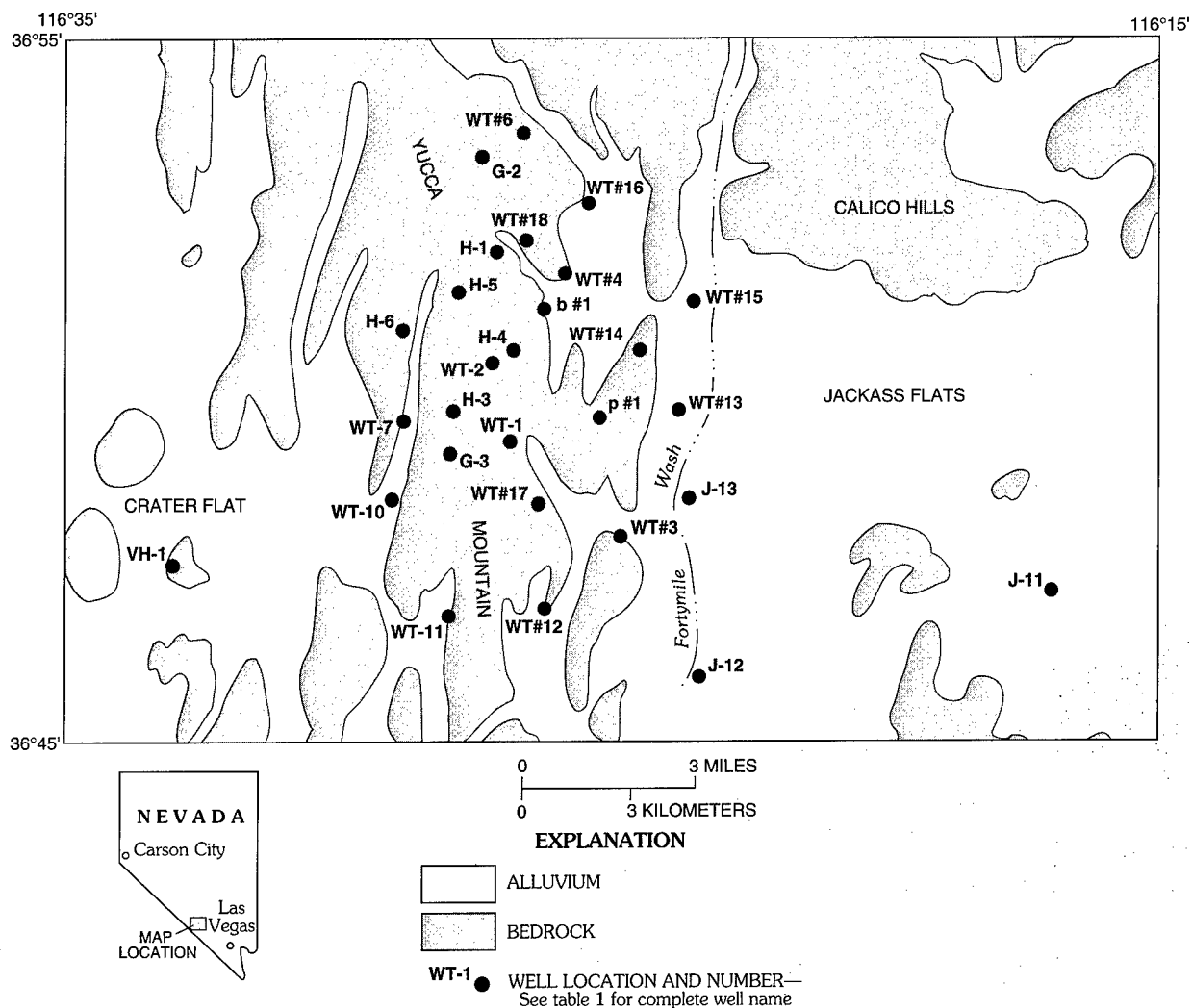
Mean water-level altitudes in the Tertiary volcanic rocks ranged from about 728 to about 1,034 meters above sea level during 1995. The mean water-level altitude in the well monitoring the Paleozoic carbonate rocks was about 753 meters above sea level during 1995. Mean water level altitudes were only an average of about 0.01 meters higher than 1994 mean water level altitudes. A single-well aquifer test was conducted on well UE-25 WT#12 during August and September 1995. Well USW G-2 was also pumped during October and November 1995, in preparation for single-well aquifer test at that well. All data were acquired in accordance with a quality-assurance program to support the reliability of the data.

## INTRODUCTION

The Yucca Mountain area is being evaluated by the U.S. Department of Energy for suitability to store high-level nuclear waste in a mined, underground repository. A 150 km<sup>2</sup> area located about 150 km northwest of Las Vegas in southern Nevada is being studied extensively (fig. 1). Water levels in selected wells have been measured periodically since 1981. The purpose of the water-level monitoring program is to gain a better understanding of the ground-water flow system in the area. The water-level data will be used to determine the direction and rate of ground-water flow, and to estimate hydraulic parameters of the flow system. In the Yucca Mountain area, the water table is in air-fall and ash-flow tuffs of Tertiary age. Saturated carbonate rocks of Paleozoic age underlie the Tertiary volcanic rocks. The geology and description of stratigraphic units in the study area have been defined by Winograd and Thordarson (1975), Byers and others (1976), Carr and others (1986), and Carr (1988). The nomenclature for stratigraphic units in the study area was revised by Sawyer and others (1994), and this report uses the new revised geologic nomenclature.

This report describes the equipment and methods used during 1995 to collect and process water-level data, presents the 1995 data, and lists 1995 water-level altitudes for a network of 28 wells (fig. 1, table 1). The network has evolved into one that, in 1995, included 17 wells representing 18 depth intervals that were monitored periodically by means of manual measurements, 2 wells representing 3 depth intervals that were equipped with transducers and monitored hourly, and 9 wells representing 15 depth intervals that were monitored both periodically and hourly. Continuous water-level and fluid-pressure data were also collected at wells USW H-5 and USW H-6, using analog-chart recorders, to allow monitoring of fluctuations caused by earthquakes; however, these continuous data are not included in this report. All wells monitor water levels in the various Tertiary volcanic rocks that underlie the Yucca Mountain area except well UE-25 p#1, which monitors water levels in the Paleozoic carbonate rocks that underlie the volcanic rocks.





**Figure 1.** Location of Yucca Mountain area and location of wells.

During September 1995, all but two wells that were being monitored hourly during most of the year had data-collection equipment removed. Following removal of the equipment these wells were only measured periodically. One of these wells was well USW H-6, and during September the analog-chart recorder was also removed from this well.

Water-level data are presented as hydrographs of water-level altitudes for each well. Data sets for the hydrographs include periodic manually measured water levels and/or daily mean water levels of the hourly transducer data. The periodic manual measurements were generally made monthly, using calibrated steel tapes or a multiconductor cable. The hourly water levels were collected using pressure transducers and electronic data loggers.

This report is a companion and supplement to other reports that present water levels in the Yucca Mountain area (Robison and others, 1988; Gemmell, 1990; O'Brien, 1991; Boucher, 1994b; Luckey and others, 1993;

**Table 1.** Summary of wells monitored for water levels, 1995

[p & h, well measured periodically and hourly during 1995; p, well measured periodically during 1995; h, well measured hourly during 1995; ---, data not available]

Well name	Drilled depth (meters)	Depth below land surface of bottom of monitoring tube (meters)	Date completed (month/year)	Water level		Frequency monitored
				Approximate mean, 1995, depth below reference point (meters)	Approximate mean, 1995, altitude (meters)	
USW WT-1	515	507.5	5/83	471	730	p & h
USW WT-2	628	622.0	7/83	571	731	p
UE-25 WT#3	348	343.0	5/83	300	730	p & h
UE-25 WT#4	482	477.6	6/83	438	731	p & h
UE-25 WT#6	383	372.0	6/83	280	1,034	p
USW WT-7	491	481.3	7/83	421	776	p
USW WT-10	431	402.6	8/83	347	776	p & h
USW WT-11	441	416.0	8/83	363	731	p
UE-25 WT#12	399	388.9	8/83	345	729	p
UE-25 WT#13	354	346.0	7/83	303	729	p
UE-25 WT#14	399	397.2	9/83	346	730	p & h
UE-25 WT#15	415	406.9	11/83	354	729	p
UE-25 WT#16	521	514.0	11/83	472	738	p
UE-25 WT#17	443	419.4	10/83	394	730	p
UE-25 WT#18	623	609.0	5/84	606	731	p
UE-25 b#1	1,220	---	9/81	---	---	---
upper interval	---	488.0	---	470	731	p
lower interval	---	1,199.0	---	471	730	p
UE-25 p#1	1,805	<sup>1</sup> 418.0	5/83	362	753	h
USW G-2	1,831	<sup>2</sup> 597.0	10/81	534	1,020	p
USW G-3	1,533	792.0	3/82	750	731	p
USW H-1	1,829	---	1/81	---	---	---
Tube 1	---	1,806.0	---	517	786	p
Tube 2	---	1,115.0	---	567	736	p
Tube 3	---	741.0	---	572	731	p & h
Tube 4	---	640.0	---	572	731	p & h
USW H-3	1,219	---	3/82	---	---	---
upper interval	---	762.0	---	752	731	<sup>3</sup> p & h
lower interval	---	1,114.0	---	724	759	p & h
USW H-4	1,219	---	6/82	---	---	---
upper interval	---	525.0	---	518	730	p & h
lower interval	---	1,188.0	---	518	730	p & h
USW H-5	1,219	---	8/82	---	---	---
upper interval	---	709.0	---	704	775	h
lower interval	---	846.0	---	703	776	h
USW H-6	1,220	---	10/82	---	---	---
upper interval	---	533.0	---	526	776	p & h
lower interval	---	752.0	---	526	776	p & h

**Table 1.** Summary of wells monitored for water levels, 1995—Continued

[p & h, well measured periodically and hourly during 1995; p, well measured periodically during 1995; h, well measured hourly during 1995; ---, data not available]

Well name	Drilled depth (meters)	Depth below land surface of bottom of monitoring tube (meters)	Date completed (month/year)	Water level		
				Approximate mean, 1995, depth below reference point (meters)	Approximate mean, 1995, altitude (meters)	Frequency monitored
USW VH-1	762	205.4	2/81	184	779	p
J-11	405	(4)	7/57	317	732	p
J-12	<sup>5</sup> 347	---	8/68	227	728	p
J-13	1,063	---	1/63	283	728	p

<sup>1</sup>Well is constructed so that the hydraulic head in the Paleozoic carbonate rocks located 1,244 meters below land surface is monitored.

<sup>2</sup>Before October 1, 1995, well measured through open casing. Well is open hole from 242 meters below land surface to the bottom of the well. After October 1, 1995, well monitored through monitoring tube which was placed to a depth of 597.0 meters.

<sup>3</sup>Transducer removed from well USW H-3, lower interval on September 21, 1995, and a manual water-level measurement was attempted in the well on the same date. While making the measurement the steel tape broke off in the well and was unrecoverable. No further water-level measurements were made in USW H-3 lower interval during 1995.

<sup>4</sup>Well measured through open casing. Well is cased to bottom of well. Casing is perforated from 328.3 to 334.4 meters below land surface and from 379.2 to 396.2 meters below land surface.

<sup>5</sup>Original drilled depth 271 meters in 1957; well deepened to present depth in 1968.

Lobmeyer and others, 1995; Tucci, O'Brien, and Burkhardt, 1996; O'Brien and others, 1995; Tucci, Goemaat, and Burkhardt, 1996; and Graves and others, 1996). Robison and others (1988) describe the details of how the manual water-level measurements were made and corrected to compute the water-level altitude.

The water-level data were obtained as part of the Yucca Mountain Project of the U.S. Department of Energy. The Yucca Mountain Project is described by a Site Characterization Plan (U.S. Department of Energy, 1988). The data in this study were collected by the U.S. Geological Survey and its contractors in cooperation with the U.S. Department of Energy under Interagency Agreement DE-AI08-92NV10874.

## WELL DESIGNATIONS

Each well used in the study of the Yucca Mountain area has a unique name or number. Wells on the Nevada Test Site (NTS) use an NTS designation, whereas wells off the NTS use a slightly different designation. Wells on the NTS begin with UE (for Underground Exploratory), followed by the NTS area number (always 25 in this report). This designation—UE-25—commonly is followed by one or more letters signifying the purpose of the well or simply by a sequential letter, followed by a sequence number. Wells off the NTS begin with the letters USW (for Underground, Southern Nevada, Waste). The designation—USW—is followed by one or more letters signifying the primary purpose of the well followed by a sequence number. The letters signifying purpose that are used in this report are G (collection of geologic data), H (collection of hydrologic data), P (collection of data on rocks of Paleozoic age), VH (collection of hydrologic and geologic data of volcanic rocks) and WT (collection of water-table data). The only wells not using this designation system and referred to in this report are wells J-11, J-12, and J-13, which were drilled as water-supply wells.

Nevada State Coordinates are used to identify the location of wells cited in this report. These coordinates are for the central zone of Nevada and are based on a Transverse Mercator projection. The origin of this projection for the central zone of Nevada is latitude 34°45'N., and the central meridian is at longitude 116°40'W. The Nevada State Coordinates are in meters north of the baseline and in meters, plus 152,400 east of the central meridian. The Nevada State Coordinate locations for the wells were determined by Holmes & Narver, Inc., contractor to the U.S. Department of Energy for surveying at the NTS and Yucca Mountain area. Latitude and longitude values of the wells were calculated from the Nevada State Coordinates.

The Site ID number is used for unique identification of the well in the U.S. Geological Survey's databases. The Site ID is generated by combining the original designations of the latitude and longitude with a two-digit sequence number. The Site ID is for convenience of identification only and should not be used as an actual location number because the original designations of latitude and longitude may be inaccurate. Even if original values of the latitude and longitude are revised later, the Site ID for the well is not changed. If more than one well exists within the 1-second rectangle of latitude and longitude, the two-digit sequence number is used to ensure uniqueness of the Site ID.

Some wells within the water-level network have had packers or piezometers installed so the water level at discrete depth intervals can be measured. In these instances, before the packers or piezometers were installed, the well was assigned one Site ID (generally with a sequence number of 01), and, prior to 1990, each depth interval was assigned its own unique Site ID by incrementing the sequence number. Hence, some wells within the network have several Site ID's. However, since 1990, the water-level data are generally stored in the National Water Information System (NWIS) data base under the Site ID with sequence number 01. Exceptions are wells USW H-5 and UE-25 p#1, which use the Site ID with sequence number 02. For those wells that have more than one zone monitored, the water levels are kept distinct in NWIS with the use of data descriptors which define each unique zone.

## **DATA-COLLECTION SYSTEM**

Water-level data are collected at Yucca Mountain by means of manual periodic measurements and by use of pressure transducers that are monitored hourly by data loggers. Periodic measurements are discussed first, followed by a discussion of the pressure-transducer system. All water-level measurements are subject to various corrections, and these corrections are also discussed.

### **Periodic Measurements**

Periodic, manual, water-level measurements at wells require visits by trained personnel, who perform specific operations and record the results. Operational plans for 1995 called for measurements about once per month at each well. Measurement frequency, however, did vary; water levels in some wells were measured less frequently because of factors such as temporary shortage of trained personnel, breakdown of equipment, or well-site inaccessibility due to road washouts. Manual water-level measurements also are made at hourly monitored wells at times of calibration or replacement of defective pressure transducers.

Periodic measurements during 1995 were made primarily with Chain #3, which is a specially constructed reeled steel tape that is 7.9 mm wide and 792 m long. Measurements were also made with Chains #2 and #4, reeled steel tapes that are also 7.9 mm wide and 792 m long, the 2,800-foot reference steel tape, a reeled steel tape that is 6.4 mm wide and 853 m long, and the multiconductor cable unit. Detailed descriptions of Chain #2, the 2,800-foot reference steel tape, and the multiconductor cable unit are given by O'Brien (1991), and are not repeated here. Because of the similarities between Chains #2, #3, and #4, the detailed description of Chain #2 is considered to be the same for Chains #3 and #4.

### **Corrections and Adjustments to Manual Measurements**

Various factors affect the accuracy of manual water-level measurements and are considered in the process of determining an accurate depth below land surface and the water-level altitude. All measurements in this report have been corrected to obtain the most accurate water-level altitudes. The correction factors applied to steel-tape measurements for each well are summarized in tables 2 and 3.

Corrections made for steel-tape water-level measurements include mechanical stretch and thermal expansion of the tape. Multiconductor-cable measurements are corrected using a regression equation obtained during calibration of the unit. All measurements, except those at wells J-11, J-12, and J-13, are corrected for borehole deviation from vertical. Borehole-deviation information is not available for wells J-11, J-12, and J-13. All measurements are referenced to sea-level datum.

**Table 2. Corrections applicable to the 2,800-foot steel tape and Chain #2, 1995**

[--, not applicable]

Well name (superscript is tube # or interval)	Assumed average air temperature, in well (degrees Celsius)	Correction for 2,800-foot reference steel tape (meters)			Correction for Chain #2 (meters)			Correction for hole deviation from vertical (meters)	Measuring point (meters)		Reference point (meters)	
		Mechanical stretch	Thermal expansion	Total <sup>1</sup>	Mechanical stretch	Thermal expansion	Total <sup>1</sup>		Interval <sup>2</sup>	Upper		Lower
USW WT-1	25.0	-0.043	0.027	-0.016	-0.020	0.027	0.008	-0.326	0.314	--	1,201.11	
USW WT-2	24.4	-0.038	0.029	-0.009	-0.012	0.029	0.017	-0.445	0.311	--	1,301.13	
UE-25 WT#3	26.1	-0.041	0.021	-0.020	-0.024	0.021	-0.002	-0.271	0.155	--	1,030.11	
UE-25 WT#4	25.0	-0.044	0.025	-0.019	-0.021	0.025	0.004	-0.454	0.311	--	1,169.21	
UE-25 WT#6	23.3	-0.040	0.011	-0.029	-0.023	0.011	-0.012	-0.204	0.463	--	1,314.78	
USW WT-7	27.8	-0.044	0.038	-0.006	-0.022	0.038	0.016	-0.034	0.302	--	1,196.88	
USW WT-10	29.4	-0.043	0.038	-0.005	-0.024	0.038	0.014	-0.030	0.314	--	1,123.40	
USW WT-11	28.3	-0.044	0.035	-0.009	-0.024	0.035	0.011	-0.116	0.311	--	1,094.11	
UE-25 WT#12	27.2	-0.043	0.029	-0.014	-0.024	0.029	0.005	-0.183	0.171 <sup>3</sup>	--	1,074.74	
UE-25 WT#13	24.4	-0.041	0.015	-0.026	-0.024	0.015	-0.008	-0.012	0.305	--	1,032.51	
UE-25 WT#14	24.4	-0.043	0.018	-0.025	-0.024	0.018	-0.006	-0.085	0.311	--	1,076.05	
UE-25 WT#15	23.9	-0.043	0.016	-0.027	-0.024	0.016	-0.008	-0.189	0.314	--	1,082.94	
UE-25 WT#16	26.1	-0.043	0.033	-0.010	-0.020	0.033	0.014	-0.064	0.314	--	1,210.63	
UE-25 WT#17	25.0	-0.044	0.023	-0.021	-0.023	0.023	0.000	-0.482	0.158	--	1,124.06	
UE-25 WT#18	25.1	-0.035	0.036	0.001	-0.008	0.036	0.028	-0.155	0.210	--	1,336.32	
UE-25 b#1	25.6	-0.043	0.031	-0.013	-0.020	0.031	0.011	-0.244	0.302	0.134	1,200.73	
UE-25 p#1	25.6	-0.044	0.024	-0.020	-0.024	0.023	0.000	-0.021	0.158	--	1,114.21	
USW G-2	22.8	-0.041	0.017	-0.024	-0.016	0.017	0.001	-0.192	0.198 <sup>4</sup>	--	1,553.86	
USW G-3	23.3	-0.015	0.029	0.013	0.014	0.029	0.042	-0.564	0.329	--	1,480.47	
USW H-1 tube 1	25.0	-0.042	0.030	-0.012	-0.016	0.030	0.014	-0.143	0.311	--	1,303.10	
USW H-1 tube 2	25.0	-0.038	0.033	-0.005	-0.012	0.033	0.021	-0.171	0.311	--	1,303.10	
USW H-1 tubes 3, 4	25.0	-0.038	0.033	-0.005	-0.012	0.033	0.022	-0.174	0.311	--	1,303.10	
USW H-3 upper	26.1	-0.015	0.053	0.038	0.014	0.053	0.067	-0.079	0.174	--	1,483.47	
USW H-3 lower	26.1	-0.019	0.052	0.033	0.010	0.052	0.061	-0.058	--	0.201	1,483.47	
USW H-4	24.4	-0.042	0.026	-0.015	-0.016	0.026	0.010	-0.064	0.597	0.308	1,248.74	
USW H-5	23.9	-0.023	0.032	0.009	0.006	0.032	0.037	-0.079	0.329	0.235	1,478.94	
USW H-6	25.0	-0.041	0.031	-0.011	-0.016	0.031	0.015	-0.052	0.207	0.235	1,302.06	
USW VH-1	23.9	-0.031	0.008	-0.022	-0.019	0.008	-0.011	-0.049	0.631	--	963.23	
Well J-11	25.0	-0.042	0.018	-0.023	-0.024	0.018	-0.005	unknown	0.555	--	1,049.45	
Well J-12	25.0	-0.035	0.013	-0.022	-0.021	0.013	-0.008	unknown	0.195 <sup>5</sup>	--	954.54	
Well J-13	25.0	-0.040	0.016	-0.023	-0.023	0.016	-0.007	unknown	0.165	--	1,011.47	

<sup>1</sup>Total correction may not equal sum of mechanical stretch and thermal expansion due to rounding.

<sup>2</sup>Wells with only one interval have measuring point listed as upper.

<sup>3</sup>Measuring point 0.305 meters 01-01-95 through 07-07-95 and 0.171 meters 07-28-95 through 12-31-95.

<sup>4</sup>Measuring point 0.332 meters 01-01-95 through 10-01-95 and 0.198 meters 10-02-95 through 12-31-95.

<sup>5</sup>Measuring point 0.527 meters before 10-01-95, after 10-01-95 measuring point 0.195 meters.

**Table 3. Corrections applicable to Chain #3 and Chain #4, 1995**  
 [—, not applicable]

Well name (superscript is tube # or interval)	Assumed average air temperature, in well (degrees Celsius)	Correction for Chain #3 (meters)			Correction for Chain #4 (meters)			Correction for hole deviation from vertical (meters)	Measuring point (meters)		Reference point (meters)
		Mechanical stretch	Thermal expansion	Total <sup>1</sup>	Mechanical stretch	Thermal expansion	Total <sup>1</sup>		Interval <sup>2</sup>		
									Upper	Lower	
USW WT-1	25.0	-0.019	0.027	0.008	-0.019	0.027	0.008	-0.326	0.314	--	1,201.11
USW WT-2	24.4	-0.010	0.029	0.019	-0.011	0.029	0.018	-0.445	0.311	--	1,301.13
UE-25 WT#3	26.1	-0.024	0.021	-0.002	-0.024	0.021	-0.002	-0.271	0.155	--	1,030.11
UE-25 WT#4	25.0	-0.021	0.025	0.004	-0.021	0.025	0.004	-0.454	0.311	--	1,169.21
UE-25 WT#6	23.3	-0.023	0.011	-0.012	-0.023	0.011	-0.013	-0.204	0.463	--	1,314.78
USW WT-7	27.8	-0.022	0.038	0.016	-0.022	0.038	0.016	-0.034	0.302	--	1,196.88
USW WT-10	29.4	-0.024	0.038	0.014	-0.024	0.038	0.014	-0.030	0.314	--	1,123.40
USW WT-11	28.3	-0.023	0.035	0.012	-0.024	0.035	0.012	-0.116	0.311	--	1,094.11
UE-25 WT#12	27.2	-0.024	0.029	0.005	-0.024	0.029	0.005	-0.183	0.171 <sup>3</sup>	--	1,074.74
UE-25 WT#13	24.4	-0.024	0.015	-0.008	-0.024	0.016	-0.008	-0.012	0.305	--	1,032.51
UE-25 WT#14	24.4	-0.024	0.018	-0.006	-0.024	0.018	-0.006	-0.085	0.311	--	1,076.05
UE-25 WT#15	23.9	-0.024	0.016	-0.008	-0.024	0.016	-0.008	-0.189	0.314	--	1,082.94
UE-25 WT#16	26.1	-0.019	0.033	0.015	-0.019	0.034	0.014	-0.064	0.314	--	1,210.63
UE-25 WT#17	25.0	-0.023	0.023	0.000	-0.023	0.023	0.000	-0.482	0.158	--	1,124.06
UE-25 WT#18	25.1	-0.006	0.036	0.030	-0.007	0.035	0.028	-0.155	0.210	--	1,336.32
UE-25 b#1	25.6	-0.019	0.031	0.012	-0.019	0.030	0.011	-0.244	0.302	0.134	1,200.73
UE-25 p#1	25.6	-0.023	0.023	0.000	-0.024	0.023	0.000	-0.021	0.158	--	1,114.21
USW G-2	22.8	-0.015	0.017	0.002	-0.015	0.017	0.001	-0.192	0.198 <sup>4</sup>	--	1,553.86
USW G-3	23.3	0.017	0.029	0.045	0.015	0.029	0.044	-0.564	0.329	--	1,480.47
USW H-1 tube 1	25.0	-0.015	0.030	0.015	-0.016	0.027	0.011	-0.143	0.311	--	1,303.10
USW H-1 tube 2	25.0	-0.011	0.033	0.022	-0.011	0.033	0.022	-0.171	0.311	--	1,303.10
USW H-1 tubes 3, 4	25.0	-0.010	0.033	0.023	-0.011	0.033	0.022	-0.174	0.311	--	1,303.10
USW H-3 upper	26.1	0.017	0.053	0.070	0.016	0.053	0.069	-0.079	0.174	--	1,483.47
USW H-3 lower	26.1	0.013	0.052	0.064	0.011	0.052	0.062	-0.058	--	0.201	1,483.47
USW H-4	24.4	-0.015	0.026	0.011	-0.016	0.027	0.011	-0.064	0.597	0.308	1,248.74
USW H-5	23.9	0.008	0.032	0.040	0.007	0.032	0.039	-0.079	0.329	0.235	1,478.94
USW H-6	25.0	-0.015	0.031	0.016	-0.015	0.031	0.015	-0.052	0.207	0.235	1,302.06
USW VH-1	23.9	-0.019	0.008	-0.011	-0.019	0.008	-0.011	-0.049	0.631	--	963.23
Well J-11	25.0	-0.024	0.018	-0.005	-0.024	0.018	-0.005	unknown	0.555	--	1,049.45
Well J-12	25.0	-0.022	0.013	-0.008	-0.022	0.013	-0.008	unknown	0.195 <sup>5</sup>	--	954.54
Well J-13	25.0	-0.023	0.016	-0.007	-0.023	0.016	-0.007	unknown	0.165	--	1,011.47

<sup>1</sup>Total correction may not equal sum of mechanical stretch and thermal expansion due to rounding.

<sup>2</sup>Wells with only one interval have measuring point listed as upper.

<sup>3</sup>Measuring point 0.305 meters 01-01-95 through 07-07-95 and 0.171 meters 07-28-95 through 12-31-95.

<sup>4</sup>Measuring point 0.332 meters 01-01-95 through 10-01-95 and 0.198 meters 10-02-95 through 12-31-95.

<sup>5</sup>Measuring point 0.527 meters before 10-01-95, after 10-01-95 measuring point 0.195 meters.

### Mechanical Stretch

Mechanical stretch is associated with the weight of the suspended steel tape and attached plumb bob (Garber and Koopman, 1968, and Robison and others, 1988). The calculated adjustment for the steel tapes used during 1995, based on stretch coefficients and an approximate weight of 0.45 kg for the plumb bob for Chains #2 and #3 and the 2,800 foot reference steel tape, and 0.36 kg for Chain #4, ranged from -0.044 to +0.017 m (tables 2 and 3) for water levels measured in the vicinity of Yucca Mountain.

The correction for mechanical stretch of the tape is given by:

$$C = (L^2 WS)/2 + PLS - KLS \quad (1)$$

where,

- C is the correction, in meters;
- L is the apparent length of tape, in meters;
- W is the unit weight of the tape, in kilograms per meter;
- S is the stretch coefficient, in meters per (meter kilogram);
- P is the weight of the plumb bob, in kilograms; and
- K is reference tension during manufacture, in kilograms.

The apparent length of tape (L) corresponds to the depth to water in each well. Values for W were determined at a calibration laboratory at the NTS, and values for S were determined by the U.S. Geological Survey and are estimated to be accurate to 7 percent (R.R. Luckey, U.S. Geological Survey, oral commun., 1993). Values for the reference tension (K) are provided by the manufacturer at the time of purchase.

### Thermal Expansion

Thermal expansion of a steel tape occurs because of temperature changes. The calculated correction for thermal expansion for steel tapes is based on manufacturer specifications for thermal-expansion coefficients and on average hole temperatures calculated from temperature profiles in wells at Yucca Mountain (Garber & Koopman, 1968, and Sass and Lachenbruch, 1982). The correction ranges from +0.008 to +0.053 m (tables 2 and 3).

Correction for thermal expansion of the tape is given by:

$$E = (D - R) TL, \quad (2)$$

where,

- E is the correction, in meters;
- D is the assumed average air temperature in the well, in degrees Celsius;
- R is the reference temperature during manufacture, in degrees Celsius;
- T is the thermal expansion coefficient, in meters per meter-degree Celsius; and
- L is the apparent length of the tape, in meters.

Equation 2 differs from that of Garber & Koopman (1968, p. 4). The correction for thermal expansion in their report was subtracted from the measured depth to water when it should have been added (J.H. Robison, U.S. Geological Survey, written commun., 1985).

The tape corrections, which include mechanical stretch and thermal expansion, and average air temperature in the well, are given in tables 2 and 3. Approximate depth to water is analogous to apparent length of the tape, L, in equations 1 and 2. The tape-dependent variables for equations 1 and 2 are defined for each tape in table 4.

**Table 4.** Mechanical stretch and thermal expansion equation variable values for the 2,800 foot reference steel tape, Chain #2, Chain #3 and Chain #4.

Variable	2,800-foot reference steel tape	Chain #2
Unit weight of the tape, W (kilogram/meter)	$2.08 \times 10^{-2}$	$2.59 \times 10^{-2}$
Stretch coefficient, S [meter/(meter kilogram)]	$2.48 \times 10^{-5}$	$1.66 \times 10^{-5}$
Weight of plumb bob, P (kilogram)	0.45	0.45
Reference tension during manufacture, K (kilogram)	9.07	9.07
Reference temperature during manufacture, R (degree Celsius)	20	20
Thermal expansion coefficient, T [meter/(meter degree Celsius)]	$1.16 \times 10^{-5}$	$1.16 \times 10^{-5}$

Variable	Chain #3	Chain #4
Unit weight of the tape, W (kilogram/meter)	$2.65 \times 10^{-2}$	$2.64 \times 10^{-2}$
Stretch coefficient, S [meter/(meter kilogram)]	$1.69 \times 10^{-5}$	$1.67 \times 10^{-5}$
Weight of plumb bob, P (kilogram)	0.45	0.36
Reference tension during manufacture, K (kilogram)	9.07	9.07
Reference temperature during manufacture, R (degree Celsius)	20	20
Thermal expansion coefficient, T [meter/(meter degree Celsius)]	$1.16 \times 10^{-5}$	$1.16 \times 10^{-5}$

#### Multiconductor-Cable Correction

Water-level measurements were made with the multiconductor-cable unit and the 2,800-foot reference steel tape at three wells between August 1 and 9, 1995, to calculate a correction factor for the multiconductor-cable unit (table 5). The range of depth to water in the wells measured span the range normally found in the Yucca Mountain area. The correction factor for the multiconductor-cable unit was determined by subtracting the multiconductor-cable unit depth-to-water measurement from the 2,800-foot reference steel tape measurement. The difference was then graphed and a regression analysis was performed on the data to determine the equation for the correction factor. The equation determined is:

$$y = -0.0020176x + 0.14 \quad (3)$$

where,

- y is the correction factor, in meters, and
- x is the apparent depth to water, in meters.

**Table 5.** Water-level measurements used to calibrate the multiconductor-cable unit.

Well name	Date water-level measurement made	Depth to water below reference point of 2,800-foot reference steel tape (meters)	Depth to water below reference point of multiconductor cable unit (meters)
USW H-3, lower interval	08-09-95	724.10	725.43
UE-25 WT#16	08-02-95	472.33	473.13
UE-25 WT#6	08-01-95	280.24	280.68



For example, if the apparent depth to water is 300 m, the correction factor is -0.47 m. This correction factor is applied in place of the mechanical stretch and thermal expansion corrections for the steel tapes, however, the borehole-deviation correction is applied.

Because of a broken float switch, the multiconductor-cable unit was taken out of service and repaired during January 1995. The breakdown of equipment occurred just after the unit was calibrated. Following the repair of the multiconductor-cable unit, the unit was not calibrated before being used to collect water-level data. It was not until August 1995 that the error was realized and the unit calibrated. Following the August calibration, all water-level measurements collected between January and August 1995 were reviewed with the August 1995 correction factor applied to the data. The review of data indicated that water-level measurements made with the multiconductor-cable unit prior to the August calibration were good.

Sheave slippage occurs with the multiconductor cable because of change in diameter of the sheave or operator error. Slippage can vary with hoist design, but errors can be minimized by comparing IN and OUT readings of water levels. The sheaves used for depth indicators can wear, eventually causing measurement errors. Annual calibration of the multiconductor-cable unit decreases this error and, along with visual inspection of the sheave, indicates when the sheave needs to be replaced. This factor is not applicable to steel tapes that have permanently marked units.

### **Borehole-Deviation Correction**

In addition to the corrections for mechanical stretch, thermal expansion, and multiconductor-cable correction, corrections must also be made for boreholes that are not vertical (borehole deviation). Gyroscopic surveys were made in all measured wells except wells J-11, J-12, and J-13. The gyroscopic surveys measured borehole deviation from vertical. The difference between measured depth and true vertical depth is the borehole deviation, or borehole correction. Corrections range from -0.01 to -0.56 m (tables 2 and 3). Corrections generally increase with increasing well depth.

### **Water-Level Altitudes**

Water-level altitudes are calculated by subtracting the corrected depth to water from the altitude of the reference point. The reference point generally is a metal tag on the well casing located at or near land surface. The measuring point for the wells, at the top of the access tube, is at some distance above the reference point, and the height of the measuring point is subtracted from the apparent depth to water to calculate the corrected depth to water. Reference-point and measuring-point values for all wells are listed in tables 2 and 3, and described in the individual well sections. Water-level altitudes in this report generally are based on a survey of the water-level monitoring network reference points made in late 1984 by the U.S. Geological Survey.

### **Example Calculations**

Example measurements for well USW WT-2 for March 24, 1995, and for well UE-25 b#1, lower interval for March 8, 1995, are presented to illustrate the calculations made to derive the altitude of the water level. The units of measurement for the steel tapes and multiconductor cable unit are feet. All water-level measurements are recorded to the nearest 0.01 foot and later converted to meters. The calculated altitude is the value reported in the section "Well Data and Water Levels."

At least two measurements of the water level are made and averaged during each visit to the well, and the appropriate corrections are applied after averaging the water-level measurements. When either Chains #2, #3, or #4 or the 2,800 foot reference steel tape are used, additional measurements are made only if the two measured depths differ by more than 1 part in 10,000 for measurements of more than 1,000 feet, or more than 0.1 foot for measurements less than 1,000 feet. When the multiconductor cable unit is used additional measurements are made if the difference in water level is more than 0.50 feet.

### Example A: Chain #3

The water-level measurement on March 24, 1995, at USW WT-2 was made with Chain #3. The HELD is the indicated footage on the tape when it is held at the MP during a measurement, and CUT is the footage of tape that is wetted during its submersion in the water. The difference between HELD and CUT is the apparent depth to water below the MP.

Reading	Measurement 1	Measurement 2	
HELD (ft)	1,879.00	1,880.00	
CUT (ft)	-4.74	-5.75	
Apparent depth to water (ft)	1,874.26	1,874.25	
Average of two apparent depths to water (ft)			1,874.26
Apparent depth to water (1,874.26 ft $\times$ 0.3048 m/ft) (m)			571.274
Measuring point (m) (table 3)			-0.311
Tape correction (m) (table 3)			+0.019
Correction for borehole deviation from vertical (m) (table 3)			-0.445
Corrected depth below reference point (m)			570.537
Determination of water-level altitude:			
Altitude of reference point (m) (table 3)			1,301.13
Corrected depth (m)			-570.54
Altitude of water level (m)			730.59

### Example B: Multiconductor cable

The water-level measurement on March 8, 1995, at UE-25 b#1, lower interval was made with the multiconductor-cable unit. The IN reading is the indicated footage of the cable displayed by the depth indicator when the sensing device (generally a float switch) is at the water surface. The OUT reading is the indicated footage when the sensing device has been withdrawn to the MP. The measurements and corrections for UE-25 b#1, lower interval on March 8, 1995, were:

Reading	Measurement 1	Measurement 2	
IN reading (ft)	1,546.64	1,546.64	
OUT reading (ft)	-3.81	-3.87	
Tool length (ft)	+4.67	+4.67	
Apparent depth to water (ft)	1,547.50	1,547.44	
Average of two apparent depths to water (ft)			1,547.470
Apparent depth to water (1,547.470 ft $\times$ 0.3048 m/ft) (m)			471.669
Measuring point (m) (table 2)			-0.134
Cable correction (m)			-0.811
Correction for borehole deviation from vertical (m) (table 2)			-0.244
Corrected depth below reference point (m)			470.480
Determination of water-level altitude:			
Altitude of reference point (m) (table 2)			1,200.73
Corrected depth (m)			-470.48
Altitude of water level (m)			730.25

## Precision and Accuracy

An analysis of precision and accuracy of field data was conducted for manual water-level measurements, which include all periodic measurements obtained during 1988–90 (Boucher, 1994a). The mean precision range of the 2,800-ft reference steel tape, based on 31 measurements, was 0.026 ft (because of changes in accuracy due to conversion to metric units and rounding of conversions, this discussion of precision and accuracy is in the units of the referenced report). The mean precision range of Chain #2, based on 341 measurements, was 0.014 ft. Ninety-seven percent of all measurements obtained with the steel tapes were precise to within 0.05 ft during 1988–90. The precision of Chains #3 or #4 are not known, but are believed to be the same or nearly the same as that of Chain #2 because each chain has nearly the same physical characteristics and because they were identically constructed.

The overall accuracy of the computed water-level altitude depends on the individual accuracies of its computational components such as: (1) water-level measurement, (2) borehole correction, (3) height of the measuring point, (4) altitude of the reference point, and (5) the precision of the 2,800-ft reference steel tape. The total accuracy of measurements taken with the steel tapes during 1988–90 was estimated to be 0.36 ft, neglecting the accuracy of the borehole correction factors (Boucher, 1994a). Accuracy of the borehole correction factors is indeterminate because documentation of the borehole-deviation surveys was inadequate to assess their accuracy, and because no borehole-deviation data are available for wells J-11, J-12, and J-13. The unknown accuracy of the borehole corrections poses a problem in the calculation of overall accuracy values.

## Hourly Measurements

Hourly water-level measurements require that equipment be installed in the well to record water levels. Trained personnel install the equipment in the well, periodically calibrate equipment or replace it as necessary, and periodically retrieve the data from the site.

Hourly measurements are of a sufficient frequency that water-level fluctuations are adequately defined to evaluate daily or longer term trends. Hourly measurements are not sufficient, however, to detect short-term water-level fluctuations, such as those induced by earthquakes (O'Brien, 1992). Hourly measurements were stored and later retrieved from the data loggers at each site. Continuous measurements were collected at wells USW H-5 and USW H-6 in 1995 to monitor water-level and fluid-pressure response to earthquakes; however, these continuous data are not included in this report.

Pressure transducers and data loggers are used to measure water-level fluctuations. Because of the large depths to water (up to 752 m), traditional water-level sensing methods, such as float-cable-pulley system, water-seeking device, and bubble tube, are not feasible. However, electronic signals from a submerged pressure transducer are relatively easy to transmit through a multi-conductor suspension cable to a recording device accessible to personnel on the surface. Electronic data loggers at the surface are used to control, measure, and store data from the pressure transducers.

## Equipment

The hourly water-level network equipment consists of a pressure transducer, which senses depth of submergence, a wireline cable to transmit voltage between the transducer and the surface, and a data logger to control the system, measure the transducer output, and store the data. An external 12-volt battery provides power to the system, and a solar panel charges the battery.

The wireline cable, consisting of four conductors, appropriate insulation, and two external wire wraps (for strength and stability), is used to transmit voltage between the data logger at the surface and the downhole pressure transducer. The required length of wireline cable to monitor a typical well at Yucca Mountain weighs several tens of kilograms, so power equipment is used to install and calibrate the system.

The water-level monitoring systems are calibrated at least every 4 months, and the calibration includes a water-level measurement. The water-level measurements are made using either the transducer, a steel tape, or a multiconductor cable unit. The water-level measurements, after adjustments, result in altitudes of water surface at the time of calibration.

## Transducers

Water-level fluctuations in the hourly network were measured with pressure transducers and pressure transmitters during 1995. Transducers and transmitters are pressure sensors which convert a change in a mechanical quantity (such as pressure) into a change in an electrical quantity (such as resistance). In this report, the term "transducer" refers to either a depth-measurement pressure transducer or pressure transmitter. These sensors are used to measure pressure and are capable of being immersed in water to measure the depth of submersion. Because the transducer remains at a fixed depth in the well, water-level fluctuations are equivalent to changes in the depth of submersion detected by the transducer.

The pressure-sensing components of a transducer consist of a strain gage to convert pressure into electrical resistance and a Wheatstone bridge to allow measurement of the change in resistance. The major difference between pressure transducers and transmitters is in the form of the input and output. Pressure transducers use voltage as input and output, whereas pressure transmitters use current as input and output. Pressure transmitters are constructed with the same strain gage and Wheatstone bridge arrangement as a pressure transducer; however, the current input is converted to voltage by an amplifier before it enters the strain gage and the voltage is converted back to current by a regulator after it passes through the Wheatstone bridge. The required wiring of pressure transducers and transmitters differs because the data loggers are not capable of measuring current. The output signal of a transmitter must be connected to a resistance load, and the drop in voltage across the load is then measured by the data logger. Regardless of which type of pressure sensor is used, the transducer output increases as the depth of submergence increases.

Transducers are made for a range of pressures. Generally, the smaller the pressure range of the transducer the more accurately pressure changes and water-level fluctuations can be measured. Transducer pressure ranges used in the hourly water-level network were 5 and 20 psi (pounds per square inch); however, the 5 psi range was most commonly used.

The water-level network historically has used both absolute and gage transducers. An absolute transducer measures pressure relative to a fixed reference pressure, whereas a gage transducer measures pressure relative to atmospheric pressure. A gage transducer has a vent tube from the reference side of the strain gage to a point above the water surface. Gage transducers are preferable in the water-level network because only water-level fluctuations (and not air-pressure changes) affect the transducer output, and these were used exclusively in the water-level network during 1995.

As a part of the calibration process, a water-level measurement must be obtained by either a manual measurement, using a steel tape, multiconductor cable, or by "tagging" the water level using the transducer. Tagging the water level, which is the more frequently used method of water-level measurement during calibrations, is done by raising or lowering the transducer until it comes in contact with the water surface in the well. The difference in the depth to water from the last manual measurement, indicated by a tape mark on the transducer cable, is then noted in the log book as part of the calibration record. If the transducer is functioning properly, the water level obtained by tagging should be as accurate as a manual measurement; however, if the transducer is not functioning properly, errors in the measured water level (probably less than 0.1 m) are possible.

The transducers are calibrated when installed in the well, when removed from the well (if possible), and at least every 4 months while in service in the well. The calibration consists of manually raising or lowering the transducer in increments and noting the change in transducer output. The data logger (described in the next section) is used in the calibration to provide the applied voltage, if necessary, and to measure the output voltage, so the calibration is for the entire transducer/data-logger system and not only for the transducer.

On January 18, 1995, the transducer/data-logger system at well UE-25 WT#3 was calibrated. The calibration started with the transducer submerged 1.52 m below the water surface. The following values were obtained:

Depth of submergence below water surface (meters)	Average transducer output (millivolts)
1.52	27.12
1.22	23.69
1.16	23.00
1.10	22.34
1.04	21.67
0.98	20.96
0.91	20.34
0.85	19.62
0.79	18.95
0.73	18.28
0.67	17.60
0.61	16.91
0.30	13.49
0.00	10.10

The transducer output is the average of three readings taken after the transducer output has stabilized. A regression analysis was performed on the calibration data, excluding any points where the transducer was not submerged. The slope of the regression line for well UE-25 WT#3 on January 18, 1995, was 0.090 meters per millivolt with a coefficient of determination ( $r^2$ ) of 1.0. The slope of the regression line, the transducer output at the set point after calibration and before the next calibration, and the water-level measurement at the time of calibration were used to convert transducer output to water-level altitude. The set point is the position below the water surface at which the transducer is placed for water-level monitoring.

### Data Loggers

Data-collection platforms (DCP's) that collect, store, and transmit data to a satellite from which the data are relayed to a ground station, were used as the primary data-acquisition system for the hourly water-level network during 1995. The Campbell Scientific 21X Micrologger, used in the hourly water-level network as the primary data-acquisition system prior to 1993, is a microprocessor-based system that was used as a supplemental data-acquisition system at selected wells. Details of the 21X Micrologger operation and programming are described by Luckey and others (1993) and Lobmeyer and others (1995).

A DCP was first installed at well USW G-3 in December 1989, and at all hourly monitored wells by May 1993. Handar model 570A units were the DCP's used to replace the 21X Micrologger system. The DCP has the same functions as a micrologger, but, in addition to internal storage of data, data are transmitted to a Geostationary Operational Environmental Satellite (GOES). Details of DCP use and operation, and GOES systems are described by Blee and others (1986). Data are collected hourly, stored, and transmitted every 4 hours to a GOES satellite. The data are then relayed to a Direct Readout Ground Station (DRGS) and stored in USGS computers for evaluation and further processing.

In addition to transducer output, the data loggers also read information such as battery voltage, excitation voltage, and the panel temperature of the data loggers. These variables are important in evaluation of the reliability of the system and are also transmitted with the transducer data. All internally stored data in the DCP are periodically transferred to computer diskettes using a portable computer. These data files are identified with station ID and time tags and are used as backups to the transmitted data; filling in data gaps that may occur due to any malfunctions in the transmission or receiving process.

## Processing and Adjustments

The data stored in the data loggers and transferred to computers are not water-level data but rather transducer output, in millivolts. The transducer output are converted to water levels, as explained in the following section, "Conversion to Water-Level Altitude." The water-levels are then evaluated. Anomalous data points, such as those produced during transducer calibrations, by random electronic signals, or due to instrument malfunction are not retained as water levels.

### Conversion to Water-Level Altitude

In an ideal circumstance, a transducer would be calibrated several times during its operating life, its output would be free of drift, and its characteristics would not change with time. However, this ideal situation rarely occurred, causing the transducer output conversion to be more difficult. As a result, some of the transducer output and resulting converted water levels were not considered reliable.

Converted water levels were evaluated for data reliability. The data were examined at a time scale which clearly showed the hourly and daily fluctuations so that the validity of the data could be determined. The data were compared to barometric-pressure data, earth-tide potential data, and other periods of record for the same site and depth interval. If the data were independently validated, the data were retained and included in this report. If the data were not validated independently, the data were given indeterminate status and are not included in this report.

The equation for converting transducer output to water-level altitude under ideal conditions is:

$$W = W_c + (T - T_c) S_c \quad (4)$$

where,

$W$  is the water-level altitude, in meters;

$W_c$  is the water-level altitude at calibration, in meters;

$T$  is the transducer output, in millivolts;

$T_c$  is the transducer output at set point following calibration, in millivolts; and

$S_c$  is the slope of the regression line, in meters per millivolt.

Equation 4 is from O'Brien and others (1995).

The following example calculation from UE-25 WT#3 illustrates how transducer data was converted to water levels. The water-level altitude for the calibration on January 18, 1995, was 729.66 m (based on a tag of the water level with the transducer). The calibration indicated that a 0.090-m change in water level would cause the transducer output to change by approximately 1 millivolt. The transducer output at the post-calibration set point (0.91 m below water surface) was 20.28 millivolts. The transducer output at 15:00:00 on January 20, 1995, was 21.14 millivolts. To summarize, equation 4 variables are:

$$W_c = 729.66 \text{ meters}$$

$$T = 21.14 \text{ millivolts}$$

$$T_c = 20.28 \text{ millivolts}$$

$$S_c = 0.090 \text{ meters/millivolt}$$

Given these data, the water-level calculation for 15:00:00 on January 20, 1995, would be as follows:

$$W = 729.66 + (21.14 - 20.28) 0.090 = 729.74 \text{ meters}$$

Change in the slope of the regression line,  $S_c$ , and change in the transducer output at set point,  $T_c$ , between consecutive calibrations, are types of drift corrected for in the conversion process. Although the slope of the regression line generally does not change dramatically between calibrations, it usually changes to some degree.

The change in slope is assumed to be linear between calibrations. Set-point drift occurs when the expected transducer output (based on manual tags) does not match the actual measured set-point output. Set-point drift is also assumed to be linear over time.

The water-level altitude is assumed to have remained constant from the last transducer output prior to calibration through the first transducer output after calibration. This assumption probably introduces, at most, a few hundredths of a meter error in the calculation of water-level altitude. If more than one calibration was done on a transducer on the same day, the last calibration is used to calculate water-level altitude for the following period unless the coefficients of determination of the regression lines indicated that another calibration was superior.

## **Quality-assurance**

Water-level data for Yucca Mountain and vicinity may be used to assess the expected performance of a potential high-level nuclear-waste repository, and confidence in the reliability of the data used in such an assessment is required. A quality-assurance program has been implemented by the U.S. Geological Survey for the Yucca Mountain Project to support the reliability of the data and interpretations of the data.

### **Onsite Procedures**

The quality-assurance program requires that water-level measurements be obtained by methods described by formal technical procedures. The technical procedures include calibrations and adjustments done during the measuring operation to ensure that the equipment is operating properly and that expected precision and accuracy are attained. For example, the procedure for measuring water-level changes with a pressure transducer specifies how to install and calibrate the transducer, and how to maintain the records of the calibrations.

Data are recorded in logbooks at the well site. Data recorded include: time and date of the visit; names of operators making the visit; identification of specific equipment used; calibration data; water-level measurement data; and correction factors, if any, applied to the data at the well site. In addition, the entry in the logbooks may include comments concerning factors that may be relevant to the collected data, such as discussion of problems with equipment or weather conditions during the water-level measurement or transducer calibration.

### **Office Processing and Review**

The original logbooks and records are maintained throughout the calendar year at the onsite operations headquarters on the Nevada Test Site. The records are reviewed for completeness and accuracy and to ensure that proper technical procedures were followed. Any needed adjustments not done during onsite operations, such as tape and borehole-deviation corrections, are made in the Denver office. After independent data review and any needed adjustments, the logbooks and related records are transferred to a Yucca Mountain Project archive.

The transducer output is entered into a temporary computer data base and is plotted to facilitate data review and to discover any instrumentation problems. After this review, the transducer output is converted to water levels. The converted water-level data are reviewed for technical quality. In addition to being published by the U.S. Geological Survey, both the raw transducer output and the water-level altitudes are placed in permanent computer data bases, such as the Unit Values file of the NWIS used by the U.S. Geological Survey. Water-level altitudes obtained from manual measurements are also placed in the computer data base.

### **Qualified and Unqualified data**

Data used by the Yucca Mountain Project are classified as either "qualified" or "unqualified". Qualified data are defined as "data acquired or developed for the Yucca Mountain Project under a Nuclear Regulatory Commission accepted quality assurance plan or qualified in accordance with appropriate Yucca Mountain Project procedures. Developed data cannot be classified as 'Qualified' if derived from unqualified data sources"

(U.S. Department of Energy, written commun., 1993). An example of "developed" data is a water-level altitude that is calculated from a depth-to-water-measurement, altitude of measuring point, and various correction factors.

Depth-to-water measurements collected at Yucca Mountain after 1989 are obtained in accordance with approved Yucca Mountain Project quality-assurance procedures, and these uncorrected measurements are classified as qualified data. However, measuring point altitudes and data used to calculate correction factors, such as borehole-temperature and borehole-deviation data, were obtained prior to the implementation of the accepted Yucca Mountain Project quality-assurance program in 1989. Therefore, these data and the calculated water-level altitudes presented in this report are classified as unqualified data.

## WELL DATA AND WATER LEVELS

This section contains information and data of all wells monitored as part of the Yucca Mountain Potentiometric Site Studies Project during 1995. Information for each well includes source of information about the well, of which most is published information. Borehole-geophysical logs and core-measurement data for the wells are given by Nelson and others (1991). Previously collected water-level data can be found in Boucher (1994b), Gemmell (1990), Lobmeyer and others (1995), Luckey and others (1993), O'Brien (1991, 1992, and 1993), O'Brien and others (1995), Tucci, O'Brien, and Burkhardt (1996), Tucci, Goemaat, and Burkhardt (1996) and Graves and others (1996). Complete bibliographic citations are in the "References Cited" section. Important information about each well (location and identification, drilling and casing information, access to and description of interval for measuring water levels, and information for calculation of water-level altitude) are summarized in the "Well Specifications" subsection of each well. Although water-level altitudes are corrected for borehole deviation, other depth-related values (such as casing or access-tube depths) in this subsection are uncorrected. Various statistical information concerning the water levels, and hydrographs of water-level altitudes are also presented for each well. Hydrographs are uniformly plotted for calendar year 1995 with a y-axis (water-level) span of 2.5 m.

Additional information included for each well is specific to the frequency of data collection (periodic or hourly measurements). For wells that were measured periodically at any time during the year, a table with the periodic measurement and method of measurement is included. For wells that were measured hourly at any time during the year, two tables are shown, one with the transducer calibration information and the other with the monthly mean water levels for the months the hourly measurements were made. The monthly mean water levels were calculated from available daily mean values. The monthly values were calculated regardless of the number of missing daily mean values. Calibration information includes the transducer serial number, calibration date, slope of the regression line, coefficient of determination, and the water-level altitude determined at the time of calibration. Comments concerning any special conditions or information that might affect the results of the calibrations or conversion of data to water levels are included, as well as explanations for periods of missing water-level data.

The 1995 mean water-level altitude is given and compared to the 1994 mean water-level altitude for each well. For wells monitored hourly during 1995, the mean water level used to compare to the 1994 mean was calculated solely from the hourly data. Because the 1995 mean water level of the hourly data is calculated from daily mean values, and because there is minimal water level change in each well, these mean water levels were not recalculated to include the one or two manual measurements made during the remainder of the year. An exception to this procedure was well USW H-3, lower interval. Because of the significant rising trend of the water level in this well, the 1995 mean was recalculated by averaging the monthly mean water-level altitudes with the October and December manual water-level measurements. For those wells that were only measured periodically, the 1995 mean water-level altitude is calculated from all of the periodic measurements.

In comparing the 1995 and 1994 mean water-level altitudes, there is no distinction made in respect to the frequency of measurements. The comparisons are made to the 1994 values reported in Graves and others (1996), regardless of whether or not the frequency of measurement was the same in 1995 as in 1994.



Hydrographs of wells monitored periodically are plots of the periodic data. Hydrographs of wells monitored hourly are plots of the daily mean values of the hourly data. Only those hourly values that were evaluated as "valid" were used to calculate the daily mean values. For any day that 6 or more consecutive hours of data were missing, a daily mean value was not calculated. Hydrographs of wells monitored periodically and hourly includes both sets of data. For identification purposes on hydrographs of combined data, the manual periodic data is labeled as "**PERIODIC MEASUREMENTS**" and the daily mean values are labeled as "**HOURLY MEASUREMENTS.**"

Annual minimum and maximum water-level altitudes are presented for each well. For wells monitored periodically, the range of water-level altitudes is from the periodic measurements. For wells monitored hourly the range of water-level altitudes is from the daily mean values of the hourly data. For wells monitored periodically and hourly, the range of water-level altitudes is from the combined sets of data.

On average, mean 1995 water levels were higher than 1994 mean water levels; however, the average difference was only 0.01 m higher. Mean water levels ranged from 1.05 m higher (USW H-3, lower interval) to 0.35 m lower (USW G-2) than 1994 mean levels. The water-level rise in well USW H-3, lower interval, is anomalously large because the water level in this interval is still equilibrating in response to well reconfiguration in 1990. The water-level drop in well USW G-2 is anomalously large because well USW G-2 was pumped during October and November 1995, and the mean water level only represents data collected during the time the well was pumped. Excluding wells USW H-3, lower interval and USW G-2, the mean water levels ranged from 0.23 m higher (USW H-1, tube 1) to 0.12 m lower (USW H-1, tube 2) than 1994 mean water levels. The average water-level difference of 0.01 m between 1995 and 1994 mean levels does not include the data for wells USW H-3, lower interval or USW G-2.

## **Well USW WT-1**

Information about the history of well USW WT-1 and about previous data from the well was obtained from various sources. These sources are: Robison (1984); Robison (U.S. Geological Survey, written commun., 1986); Robison and others (1988); Holmes & Narver, Inc. (written commun., 1986); and Fenix & Scisson, Inc. (1986a, 1987c).

### **Well specifications**

#### **1. Location and identification:**

Latitude and longitude: 36°49'16"N.; 116°26'56"W.

Nevada State Central Zone Coordinates (m): N 229,801; E 171,828.

U.S. Geological Survey Site ID: 364916116265601.

#### **2. Drilling and casing information:**

Well started: April 28, 1983.

Well completed: May 18, 1983.

Drilling method: Rotary, using rock bits and air, water, and soap-circulating medium; core obtained from bottom of the borehole.

Bit diameter below water level: 222 mm.

Casing: Surface casing only, to a depth of 9.91 m.

Total drilled depth: 515 m.

3. Access to and description of depth interval for measuring water levels:

62-mm inside-diameter tubing that has a 3.7-m-long well screen on the bottom; tubing and attached screen extend from land surface to a depth of 507.5 m; saturated interval of the borehole is within the Calico Hills Formation and Bullfrog Tuff of the Crater Flat Group.

4. Information for calculating water-level altitude:

Reference point: Top of metal tag on well casing, altitude 1,201.11 m (surveyed by U.S. Geological Survey, 1984).

Measuring point: Top of access tube, 0.314 m above reference point.

Depth correction for borehole deviation from vertical: 0.326 m, based on approximate depth to water of 471 m (1990 data).

Well USW WT-1 was measured hourly and periodically during 1995. Hourly measurements were made until September 27, 1995; the day the transducer was removed from the well. During the period of hourly measurements, four calibrations of one transducer were performed. In addition, a calibration was completed on September 15, 1994. This calibration was used to calculate water-level altitudes at the beginning of 1995. Results of the transducer calibrations are as follows:

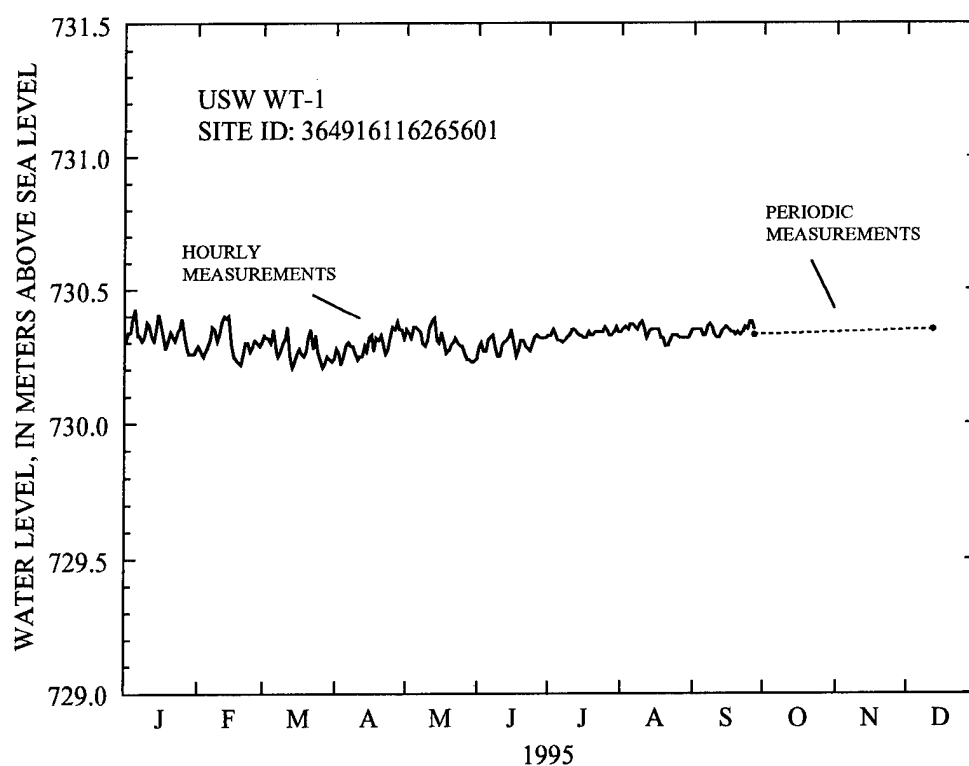
Transducer serial number	Calibration date	Slope (meters/millivolt)	Coefficient of determination	Water-level altitude (meters)	Method of measuring water level
567097	09-15-94	0.089	1.00	730.29	Tag with transducer
567097	01-18-95	.089	1.00	730.28	Tag with transducer
567097	05-24-95	.089	1.00	730.28	Chain #3
567097	08-31-95	.091	0.99	730.25	Tag with transducer
567097	09-27-95	.091	1.00	730.33	Chain #3

All transducer data collected for USW WT-1 for 1995 were considered to be valid. There was no lost record during the period of instrumentation.

Following the removal of the transducer, well USW WT-1 was measured periodically during the remainder of 1995. Measurements were made with Chain #3 with the following results:

Date	Measured water-level altitude (meters, above sea level)	Method of measuring water level
09-27-95	730.33	Chain #3
12-12-95	730.35	Chain #3

Daily mean water-level altitudes of the hourly data for well USW WT-1 ranged from 730.21 to 730.43 m above sea level in 1995 (fig. 2). Monthly mean water-level altitudes for January through September 1995, are listed in table 6. The mean water-level altitude of the 1995 hourly data was 730.31 m above sea level. This mean altitude was 0.02 m lower than the mean altitude of 730.33 m for 1994 (Graves and others, 1996).



**Figure 2.** Water-level altitudes, 1995, for well USW WT-1.

**Table 6.** Monthly mean water-level altitudes, 1995, for well USW WT-1.

[Monthly means were calculated regardless of the number of missing data. Daily means were not calculated if 6 or more consecutive hours of data were missing; --, data not available; NA, not applicable, well not instrumented during this month]

Month	Monthly mean water-level altitude (meters, above sea level)	Number of missing daily means
January	730.33	0
February	730.30	0
March	730.28	0
April	730.30	0
May	730.31	0
June	730.30	0
July	730.33	0
August	730.34	0
September	730.35	0
October	--	NA
November	--	NA
December	--	NA

## Well USW WT-2

Information about the history of well USW WT-2 and about previous data from the well was obtained from various sources. These sources are: Robison (1984); Robison (U.S. Geological Survey, written commun., 1986); Robison and others (1988); and Fenix & Scisson, Inc. (1986a, 1987c).

### Well specifications

#### 1. Location and identification:

Latitude and longitude: 36°50'23"N.; 116°27'18"W.

Nevada State Central Zone Coordinates (m): N 231,849; E 171,274.

U.S. Geological Survey Site ID: 365023116271801.

#### 2. Drilling and casing information:

Well started: July 8, 1983.

Well completed: July 16, 1983.

Drilling method: Rotary, using rock bits and air-foam circulating medium; core obtained from bottom of the borehole.

Bit diameter below water level: 222 mm.

Casing: Surface casing only, to a depth of 18 m.

Total drilled depth: 628 m.

#### 3. Access to and description of depth interval for measuring water levels:

62-mm inside-diameter access tubing that has a 3.6-m-long well screen on bottom, extending from land surface to a depth of 622 m; saturated interval of the borehole is within the Prow Pass Tuff of the Crater Flat Group.

#### 4. Information for calculating water-level altitude:

Reference point: Top of metal tag on well casing; altitude 1,301.13 m (surveyed by U.S. Geological Survey, 1984).

Measuring point: Top of access tube, 0.305 m above reference point after 12/08/93, 0.146 m above reference point between 9/09/93 and 12/08/93, and 0.311 m above reference point prior to 9/09/93.

Depth correction for borehole deviation from vertical: 0.445 m after 12/08/93 and 0.533 m prior to 12/08/93, based on approximate depth to water of 571 m.

Well USW WT-2 was measured periodically during 1995. Measurements were made with the 2,800 foot reference steel tape and Chain #3 with the following results:

Date	Measured water-level altitude (meters, above sea level)	Method of measuring water level
01-10-95	730.63	2,800 foot reference steel tape
03-02-95	730.58	Chain #3
03-24-95	730.59	Chain #3
04-10-95	730.53	Chain #3
05-04-95	730.62	Chain #3
06-13-95	730.51	Chain #3
08-16-95	730.54	Chain #3
09-06-95	730.54	2,800 foot reference steel tape
12-12-95	730.62	Chain #3

Water-level altitudes for well USW WT-2 ranged from 730.51 to 730.63 m above sea level in 1995 (fig. 3). The mean water-level altitude of the 1995 periodic data was 730.57 m above sea level. This mean altitude was 0.04 m higher than the mean altitude of 730.53 m for 1994 (Graves and others, 1996).

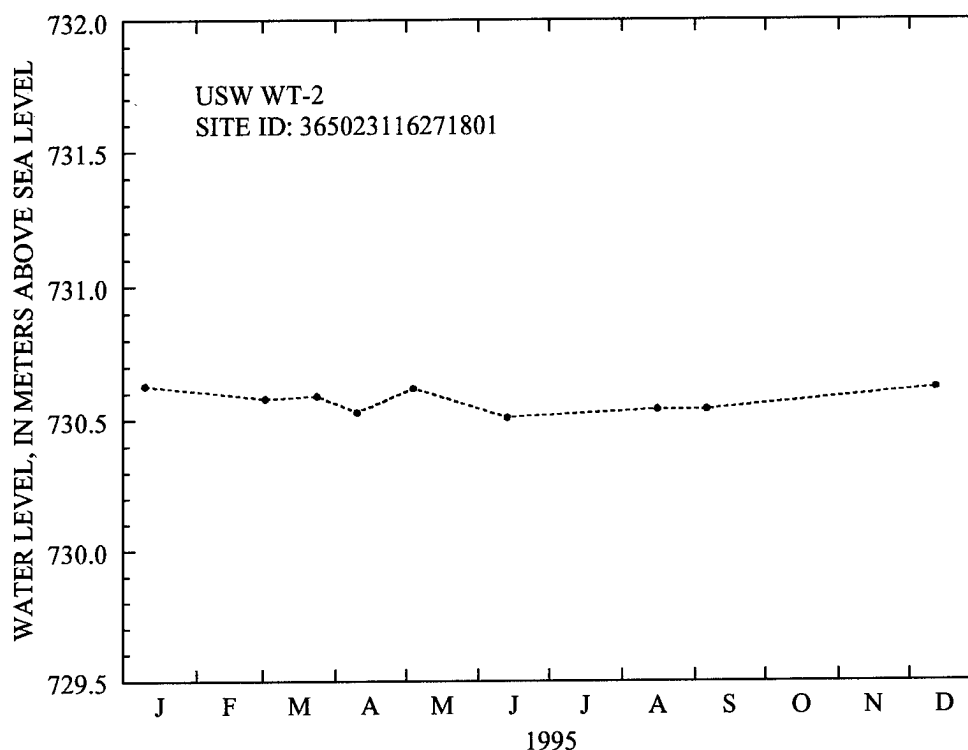


Figure 3. Water-level altitudes, 1995, for well USW WT-2.

## Well UE-25 WT#3

Information about the history of well UE-25 WT#3 and about previous data from the well was obtained from various sources. These sources are: Robison (1984); Robison (U.S. Geological Survey, written commun., 1986); Robison and others (1988); and Fenix & Scisson, Inc. (1986a, 1987c).

### Well specifications

#### 1. Location and identification:

Latitude and longitude: 36°47'57"N.; 116°24'58"W.

Nevada State Central Zone Coordinates (m): N 227,379; E 174,768.

U.S. Geological Survey Site ID: 364757116245801.

#### 2. Drilling and casing information:

Well started: April 29, 1983.

Well completed: May 25, 1983.

Drilling method: Rotary, using rock bits and air-foam circulating medium; core obtained from bottom of the borehole.

Bit diameter below water level: 222 mm.

Casing: Surface casing only, to a depth of 12 m.

Total drilled depth: 348 m.

#### 3. Access to and description of depth interval for measuring water levels:

62-mm inside-diameter tubing that has a 3.6-m-long well screen on bottom, extending from land surface to a depth of 343 m; saturated interval of the borehole is within the Bullfrog Tuff of the Crater Flat Group.

#### 4. Information for calculating water-level altitude:

Reference point: Top of metal tag on well casing; altitude 1,030.11 m (surveyed by U.S. Geological Survey, 1984).

Measuring point: Top of access tubing, 0.155 m above reference point.

Depth correction for borehole deviation from vertical: 0.271 m, based on approximate depth to water of 300 m (1990 data).

Well UE-25 WT#3 was measured hourly and periodically during 1995. Hourly measurements were made until September 26, 1995, the day the transducer was removed from the well. During the period of hourly measurements, four calibrations of one transducer were performed. In addition, a calibration was completed on September 19, 1994. This calibration was used to calculate water-level altitudes at the beginning of 1995. Results of the transducer calibrations are as follows:

Transducer serial number	Calibration date	Slope (meters/millivolt)	Coefficient of determination	Water-level altitude (meters)	Method of measuring water level
621313	09-19-94	0.090	1.00	729.66	Chain #3
621313	01-18-95	.090	1.00	729.66	Tag with transducer
621313	05-11-95	.090	1.00	729.78	Tag with transducer
621313	06-27-95	.090	1.00	729.66	Tag with transducer
621313	09-26-95	.090	1.00	729.75	Chain #3

Although the transducer was removed from well UE-25 WT#3 on September 26, 1995, the transducer data were only converted through part of September 25, 1995. A series of spikes were removed from the transducer data on June 27, 1995, the spikes were due to the calibration of the transducer on the same date. Because of the deleted data, a daily mean was not calculated for June 27, 1995. All other transducer data for 1995 were considered to be valid.

Following the removal of the transducer, well UE-25 WT#3 was measured periodically during the remainder of 1995. Measurements were made with Chain #3 with the following results:

Date	Measured water-level altitude (meters, above sea level)	Method of measuring water level
09-26-95	729.75	Chain #3
12-12-95	729.76	Chain #3

Daily mean water-level altitudes of the hourly data for well UE-25 WT#3 ranged from 729.63 to 729.80 m above sea level in 1995 (fig. 4). Monthly mean water-level altitudes for January through September are listed in table 7. The mean water-level altitude of the 1995 hourly data was 729.71 m above sea level. This mean altitude was 0.01 m higher than the mean altitude of 729.70 m for 1994 (Graves and others, 1996).

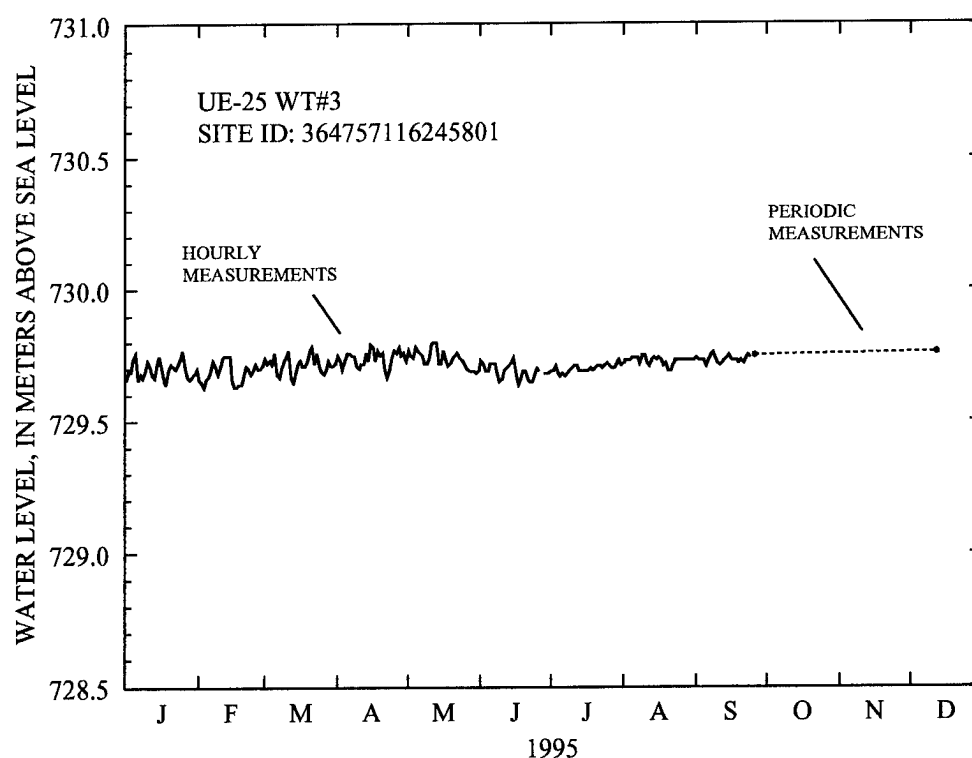


Figure 4. Water-level altitudes, 1995, for well UE-25 WT#3.

**Table 7.** Monthly mean water-level altitudes, 1995, for well UE-25 WT#3.

[Monthly means were calculated regardless of the number of missing data. Daily means were not calculated if 6 or more consecutive hours of data were missing; --, data not available; NA, not applicable, well not instrumented during this month]

Month	Monthly mean water-level altitude (meters, above sea level)	Number of missing daily means
January	729.70	0
February	729.69	0
March	729.72	0
April	729.74	0
May	729.74	0
June	729.69	1
July	729.70	0
August	729.73	0
September	729.73	0
October	--	NA
November	--	NA
December	--	NA

## Well UE-25 WT#4

Information about the history of well UE-25 WT#4 and about previous data from the well was obtained from various sources. These sources are: Robison (1984); Robison (U.S. Geological Survey, written commun., 1986); Robison and others (1988); Holmes & Narver, Inc. (written commun., 1986); and Fenix & Scisson, Inc. (1986a, 1987c).

### Well specifications

#### 1. Location and identification:

Latitude and longitude: 36°51'40"N.; 116°26'03"W.

Nevada State Central Zone Coordinates (m): N 234,242; E 173,139.

U.S. Geological Survey Site ID: 365140116260301.

#### 2. Drilling and casing information:

Well started: May 28, 1983.

Well completed: June 6, 1983.

Drilling method: Rotary, using rock bits and air-foam circulating medium; Core obtained from bottom of the borehole.

Bit diameter below water level: 222 mm.

Casing: Surface casing only, to a depth of 14.6 m.

Total drilled depth: 482 m.



3. Access to and description of depth interval for measuring water levels:

62-mm inside-diameter tubing that has a 3.7-m-long well screen on the bottom; tubing and attached screen extend from land surface to a depth of 477.6 m; saturated interval of the borehole is within the Calico Hills Formation.

4. Information for calculating water-level altitude:

Reference point: Top of metal tag on well casing, altitude 1,169.21 m (surveyed by U.S. Geological Survey, 1984).

Measuring point: Top of access tube, 0.311 m above reference point.

Depth correction for borehole deviation from vertical: 0.454 m, based on approximate depth to water of 438 m (1990 data).

Well UE-25 WT#4 was measured hourly and periodically during 1995. Hourly measurements were made through September 26, 1995, the day the transducer was removed from the well. During the period of hourly measurements, three calibrations of one transducer were performed. In addition, a calibration was completed on December 21, 1994. This calibration was used to calibrate water-level altitudes at the beginning of 1995. Results of the transducer calibrations are as follows:

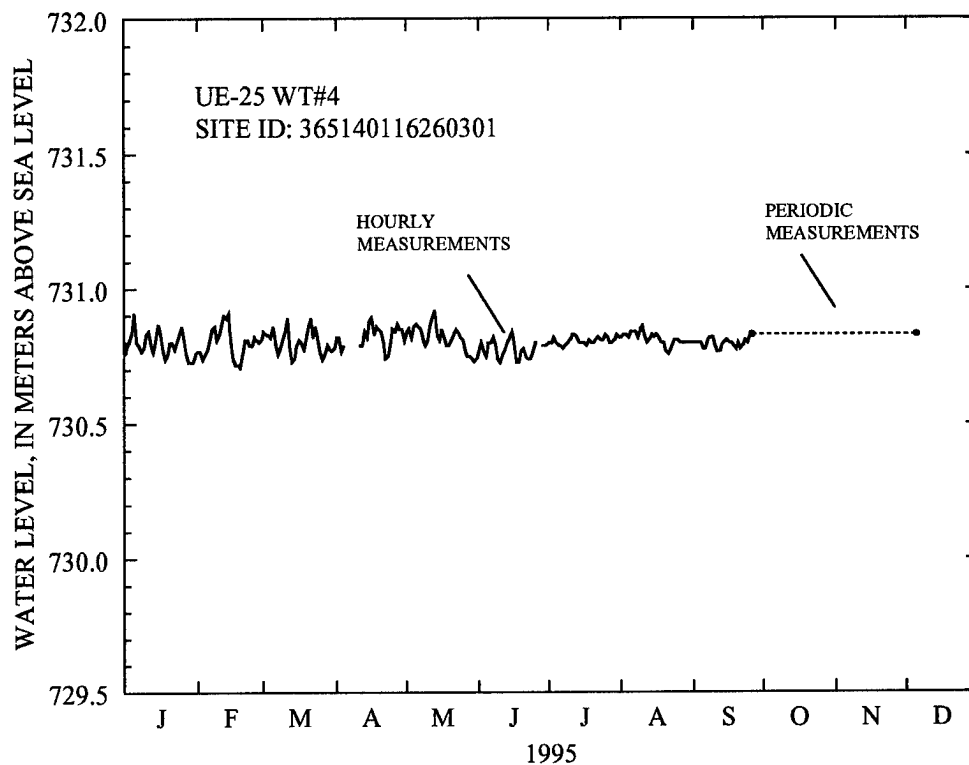
Transducer serial number	Calibration date	Slope (meters/millivolt)	Coefficient of determination	Water-level altitude (meters)	Method of measuring water level
592472	12-21-94	0.087	1.00	730.77	Tag with transducer
592472	04-06-95	.087	1.00	730.86	Chain #3
592472	07-13-95	.087	1.00	730.81	Tag with transducer
592472	09-26-95	.088	1.00	730.83	Chain #3

Spikes were removed from the transducer data on April 5 through 10, 1995. The spikes were due to a weak battery that was not holding its charge. The battery was replaced on April 10, 1995. Because of the amount of missing data following the deletion of the spikes, daily mean values were not calculated for these dates. Partial data were recorded for June 27, 1995; the reason for the partial data is not known. A daily mean value was not calculated for this date. All other hourly transducer data for 1995 are considered to be valid.

Following the removal of the transducer, well UE-25 WT#4 was measured periodically during the remainder of 1995. Measurements were made with Chain #3 with the following results:

Date	Measured water-level altitude (meters, above sea level)	Method of measuring water level
09-26-95	730.83	Chain #3
12-05-95	730.83	Chain #3

Daily mean water-level altitudes of the hourly data for well UE-25 WT#4 ranged from 730.71 to 730.92 m above sea level in 1995 (fig. 5). Monthly mean water-level altitudes for January through September 1995, are listed in table 8. The mean water-level altitude of the 1995 hourly data was 730.80 m above sea level. This mean altitude was 0.02 m higher than the mean altitude of 730.78 m for 1994 (Graves and others, 1996).



**Figure 5.** Water-level altitudes, 1995, for well UE-25 WT#4.

**Table 8.** Monthly mean water-level altitudes, 1995, for well UE-25 WT#4.

[Monthly means were calculated regardless of the number of missing data. Daily means were not calculated if 6 or more consecutive hours of data were missing; --, data not available; NA, not applicable, well not instrumented during this month]

Month	Monthly mean water-level altitude (meters, above sea level)	Number of missing daily means
January	730.80	0
February	730.80	0
March	730.80	0
April	730.82	6
May	730.82	0
June	730.78	1
July	730.81	0
August	730.81	0
September	730.80	0
October	--	NA
November	--	NA
December	--	NA

## Well UE-25 WT#6

Information about the history of well UE-25 WT#6 and about previous data from the well was obtained from various sources. These sources are: Robison (1984); Robison (U.S. Geological Survey, written commun., 1986); Robison and others (1988); and Fenix & Scisson, Inc. (1986a, 1987c).

### Well specifications

#### 1. Location and identification:

Latitude and longitude: 36°53'40"N.; 116°26'46"W.

Nevada State Central Zone Coordinates (m): N 237,920; E 172,067.

U.S. Geological Survey Site ID: 365340116264601.

#### 2. Drilling and casing information:

Well started: June 20, 1983.

Well completed: June 29, 1983.

Drilling method: Rotary, using rock bits and air-foam circulating medium; core obtained from bottom of the borehole.

Bit diameter below water level: 171 mm.

Casing: Surface casing only, to a depth of 76.5 m.

Total drilled depth: 383 m.

#### 3. Access to and description of depth interval for measuring water levels:

62-mm inside-diameter tubing that has a 3.6-m-long well screen on bottom, extending from land surface to a depth of 372 m; saturated interval of the borehole is within the Calico Hills Formation.

#### 4. Information for calculating water-level altitude:

Reference point: Top of metal tag on well casing; altitude 1,314.78 m (surveyed by U.S. Geological Survey, 1984).

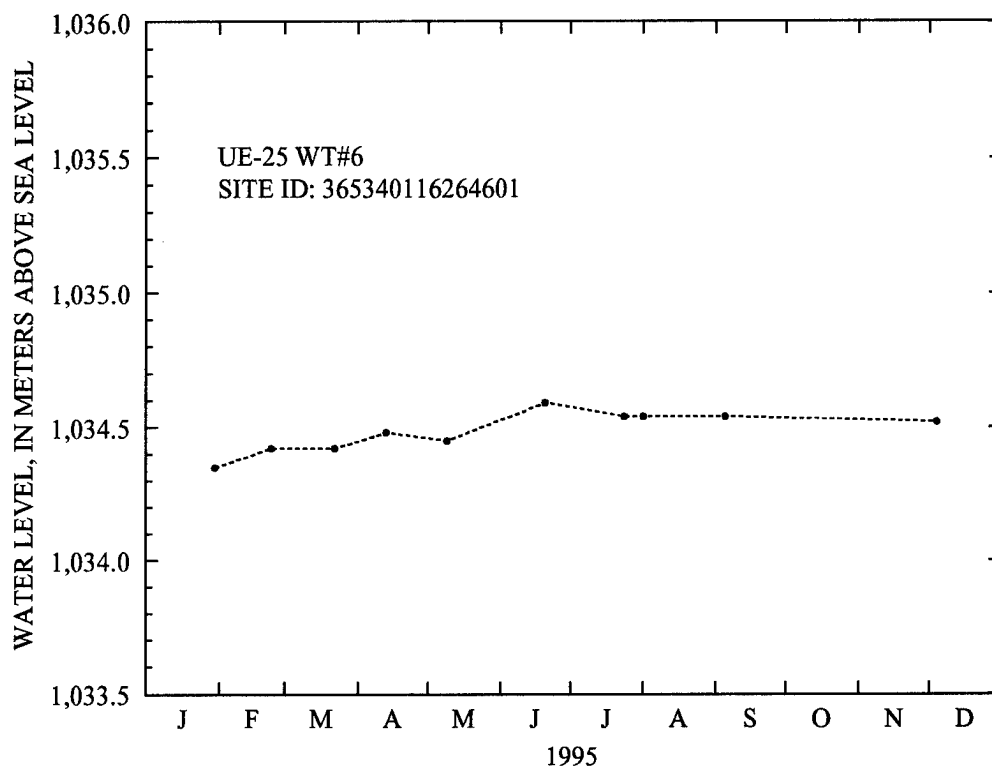
Measuring point: Top of access tube, 0.463 m above reference point.

Depth correction for borehole deviation from vertical: 0.204 m, based on approximate depth to water of 280 m (1990 data).

Well UE-25 WT#6 was measured periodically during 1995. Measurements were made with Chain #3, Chain #4, and the 2,800 foot reference steel tape with the following results:

Date	Measured water-level altitude (meters, above sea level)	Method of measuring water-level
01-30-95	1,034.35	Chain #4
02-23-95	1,034.42	Chain #4
03-22-95	1,034.42	Chain #3
04-13-95	1,034.48	Chain #3
05-09-95	1,034.45	Chain #3
06-20-95	1,034.59	Chain #3
07-24-95	1,034.54	Chain #3
08-01-95	1,034.54	2,800 foot reference steel tape
09-05-95	1,034.54	Chain #4
12-04-95	1,034.52	Chain #3

Water-level altitudes for well UE-25 WT#6 ranged from 1,034.35 to 1,034.59 m above sea level in 1995 (fig. 6). The mean water-level altitude of the 1995 periodic data was 1,034.48 m above sea level. This mean altitude was 0.01 m lower than the mean altitude of 1,034.49 m for 1994 (Graves and others, 1996).



**Figure 6.** Water-level altitudes, 1995, for well UE-25 WT#6.

## Well USW WT-7

Information about the history of well USW WT-7 and about previous data from the well was obtained from various sources. These sources are: Robison (1984); Robison (U.S. Geological Survey, written commun., 1986); Robison and others (1988); Holmes & Narver, Inc. (written commun., 1986); and Fenix & Scisson, Inc. (1986a, 1987c).

### Well specifications

#### 1. Location and identification:

Latitude and longitude: 36°49'33"N.; 116°28'57"W.

Nevada State Central Zone Coordinates (m): N 230,298; E 168,826.

U.S. Geological Survey Site ID: 364933116285701.

#### 2. Drilling and casing information:

Well started: July 19, 1983.

Well completed: July 26, 1983.

Drilling method: Rotary, using rock bits and air-foam circulating medium; core obtained from bottom of the borehole.

Bit diameter below water level: 222 mm.

Casing: Surface casing only, to a depth of 15.8 m.

Total drilled depth: 491 m.

3. Access to and description of depth interval for measuring water levels:

62-mm inside-diameter tubing that has a 3.7-m-long well screen on the bottom; tubing and attached screen extend from land surface to a depth of 481.3 m; saturated interval of the borehole is within the Topopah Spring Tuff of the Paintbrush Group and the Prow Pass Tuff of the Crater Flat Group.

4. Information for calculating water-level altitude:

Reference point: Top of metal tag on well casing, altitude 1,196.88 m (surveyed by U.S. Geological Survey, 1984).

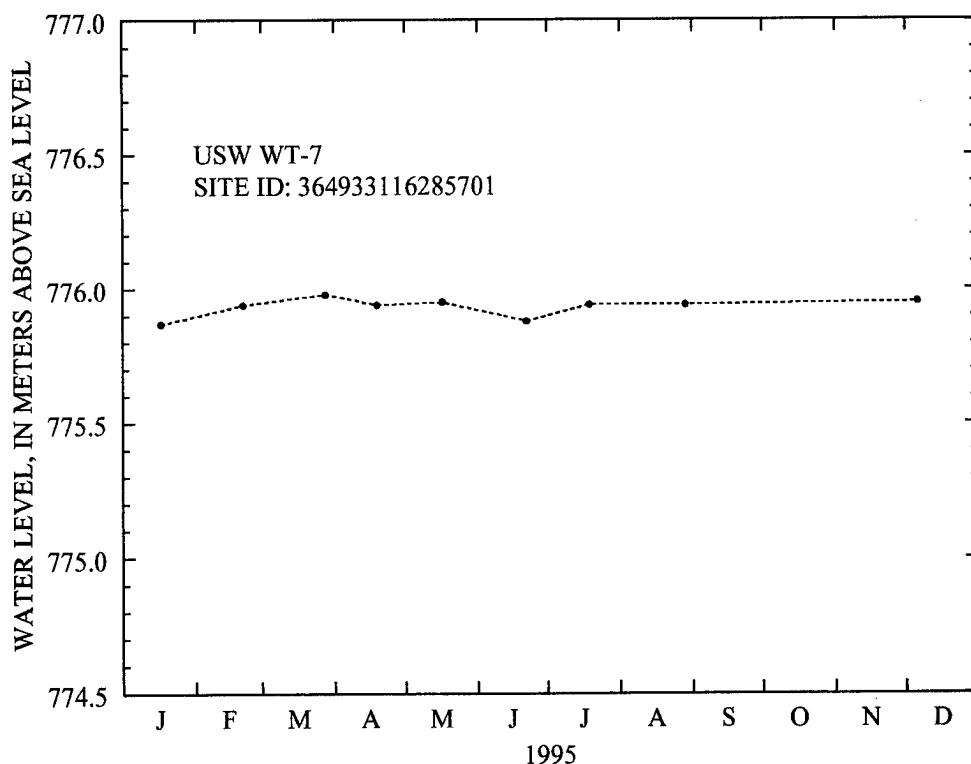
Measuring point: Top of access tube, 0.302 m above reference point.

Depth correction for borehole deviation from vertical: 0.034 m, based on approximate depth to water of 421 m (1990 data).

Well USW WT-7 was measured periodically during 1995. Measurements were made with Chain #3, Chain #4, and the 2,800 foot reference steel tape with the following results:

Date	Measured water-level altitude (meters, above sea level)	Method of measuring water level
01-17-95	775.87	Chain #4
02-21-95	775.94	Chain #4
03-28-95	775.98	2,800 foot reference steel tape
04-19-95	775.94	Chain #3
05-17-95	775.95	Chain #3
06-22-95	775.88	Chain #3
07-19-95	775.94	Chain #3
08-29-95	775.94	Chain #3
12-06-95	775.95	Chain #3

Water-level altitudes for well USW WT-7 ranged from 775.87 to 775.98 m above sea level in 1995 (fig. 7). The mean water-level altitude of the 1995 periodic data was 775.93 m above sea level. This mean altitude was 0.05 m higher than the mean altitude of 775.88 m for 1994 (Graves and others, 1996).



**Figure 7.** Water-level altitudes, 1995, for well USW WT-7.

## Well USW WT-10

Information about the history of well USW WT-10 and about previous data from the well was obtained from various sources. These sources are: Robison (1984); Robison (U.S. Geological Survey, written commun., 1986); Robison and others (1988); Holmes & Narver, Inc. (written commun., 1986); and Fenix & Scisson, Inc. (1986a, 1987c).

### Well specifications

#### 1. Location and identification:

Latitude and longitude: 36°48'25"N.; 116°29'05"W.

Nevada State Central Zone Coordinates (m): N 228,225; E 168,646.

U.S. Geological Survey Site ID: 364825116290501.

#### 2. Drilling and casing information:

Well started: July 26, 1983.

Well completed: August 2, 1983.

Drilling method: Rotary, using rock bits and air-foam circulating medium; core obtained from bottom of the borehole.

Bit diameter below water level: 222 mm.

Casing: Surface casing only, to a depth of 34.7 m.

Total drilled depth: 431 m.

3. Access to and description of depth interval for measuring water levels:

62-mm inside-diameter tubing that has a 3.7-m-long well screen on the bottom; tubing and attached screen extend from land surface to a depth of 402.6 m; saturated interval of the borehole is within the Topopah Spring Tuff of the Paintbrush Group.

4. Information for calculating water-level altitude:

Reference point: Top of metal tag on well casing, altitude 1,123.40 m (surveyed by U.S. Geological Survey, 1984).

Measuring point: Top of access tube, 0.314 m above reference point.

Depth correction for borehole deviation from vertical: 0.030 m, based on approximate depth to water of 347 m (1990 data).

Well USW WT-10 was measured hourly and periodically during 1995. Hourly measurements were made until September 5, 1995, the day the transducer was removed from the well. During the period of hourly measurements, four calibrations of two transducers were performed. In addition, a calibration was completed on December 22, 1994. This calibration was used to calculate water-level altitudes at the beginning of 1995. Results of the transducer calibrations are as follows:

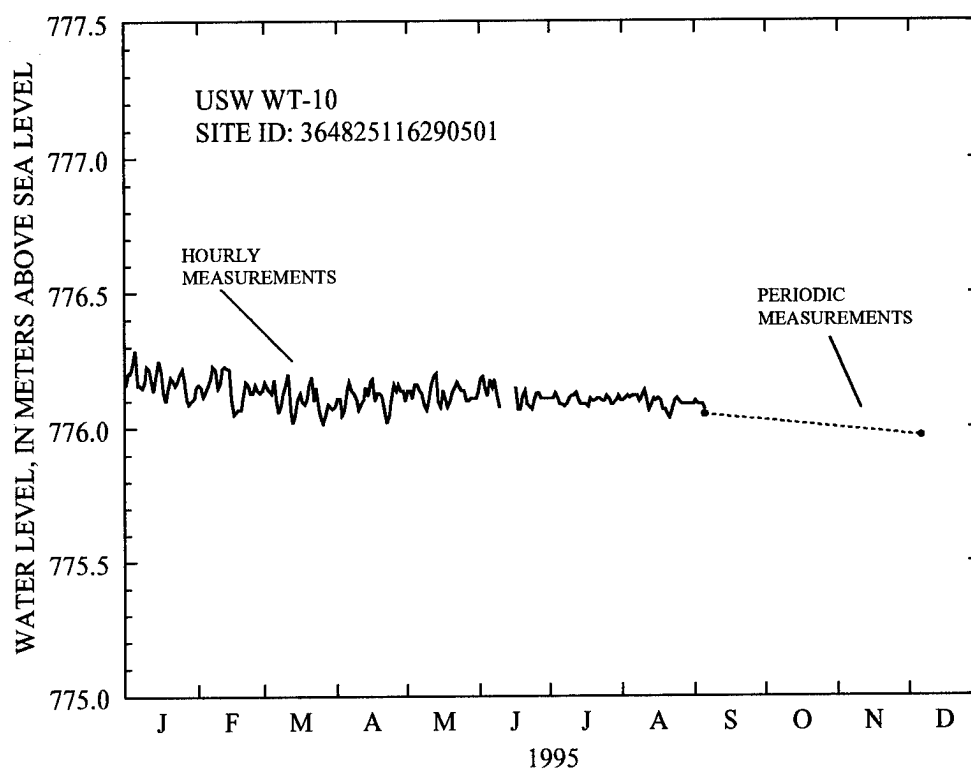
Transducer serial number	Calibration date	Slope (meters/millivolt)	Coefficient of determination	Water-level altitude (meters)	Method of measuring water level
592476	12-22-94	0.089	1.00	776.07	Tag with transducer
592476	04-05-95	.088	1.00	776.12	Tag with transducer
592476	06-15-95	.091	0.99	776.16	Chain #3
670686	06-15-95	.087	1.00	776.16	Chain #3
670686	09-05-95	.087	1.00	776.05	Chain #4

Bad data were removed from June 11 through 15, 1995. The bad data were due to problems with the transducer. The transducer was replaced on June 15. Daily mean values were not calculated for these dates. All other hourly transducer data for 1995 are considered to be valid.

Following the removal of the transducer, well USW WT-10 was measured periodically during the remainder of 1995. Measurements were made with Chain #3 and Chain #4 with the following results:

Date	Measured water-level altitude (meters, above sea level)	Method of measuring water level
09-05-95	776.05	Chain #4
12-06-95	775.97	Chain #3

Daily mean water-level altitudes from the hourly data for well USW WT-10 ranged from 776.02 to 776.29 m above sea level in 1995 (fig. 8). The periodic measurement made during December 1995 increased the range to a minimum of 775.97 m. Monthly mean water-level altitudes for January through September 1995 are listed in table 9. The mean water-level altitude of the 1995 hourly data was 776.12 m above sea level. This mean altitude was 0.03 m lower than the mean altitude of 776.15 m for 1994 (Graves and others, 1996).



**Figure 8.** Water-level altitudes, 1995, for well USW WT-10.

**Table 9.** Monthly mean water-level altitudes, 1995, for well USW WT-10.

[Monthly means were calculated regardless of the number of missing data. Daily means were not calculated if 6 or more consecutive hours of data were missing; --, data not available; NA, not applicable, well not instrumented during this month]

Month	Monthly mean water-level altitude (meters, above sea level)	Number of missing daily means
January	776.17	0
February	776.15	0
March	776.11	0
April	776.12	0
May	776.13	0
June	776.12	5
July	776.10	0
August	776.10	0
September	776.09	0
October	--	NA
November	--	NA
December	---	NA



## Well USW WT-11

Information about the history of well USW WT-11 and about previous data from the well was obtained from various sources. These sources are: Robison (1984); Robison (U.S. Geological Survey, written commun., 1986); Robison and others (1988); and Fenix & Scisson, Inc. (1986a, 1987c).

### Well specifications

#### 1. Location and identification:

Latitude and longitude: 36°46'49"N.; 116°28'02"W.

Nevada State Central Zone Coordinates (m): N 225,269; E 170,193.

U.S. Geological Survey Site ID: 364649116280201.

#### 2. Drilling and casing information:

Well started: August 3, 1983.

Well completed: August 9, 1983.

Drilling method: Rotary, using rock bits and air-foam circulating medium; core obtained from bottom of the borehole.

Bit diameter below water level: 222 mm.

Casing: Surface casing only, to a depth of 14 m.

Total drilled depth: 441 m.

#### 3. Access to and description of depth interval for measuring water levels:

62-mm inside-diameter tubing that has a 3.6-m-long well screen on bottom, extending from land surface to a depth of 416 m; saturated interval of the borehole is within the Topopah Spring Tuff of the Paintbrush Group and the Calico Hills Formation.

#### 4. Information for calculating water-level altitude:

Reference point: Top of metal tag on well casing; altitude 1,094.11 m (surveyed by U.S. Geological Survey, 1984).

Measuring point: Top of access tube, 0.311 m above reference point.

Depth correction for borehole deviation from vertical: 0.116 m, based on approximate depth to water of 363 m (1990 data).

Well USW WT-11 was measured periodically during 1995. Measurements were made with Chain #3 and Chain #4 with the following results:

Date	Measured water-level altitude (meters, above sea level)	Method of measuring water level
01-17-95	730.74	Chain #4
02-21-95	730.67	Chain #4
04-05-95	730.69	Chain #3
04-19-95	730.76	Chain #3
05-17-95	730.66	Chain #3
06-22-95	730.62	Chain #3
08-29-95	730.67	Chain #3
12-06-95	730.68	Chain #3

Water-level altitudes for well USW WT-11 ranged from 730.62 to 730.76 m above sea level in 1995 (fig. 9). The mean water-level altitude of the 1995 periodic data was 730.69 m. This mean altitude was 0.01 m higher than the mean altitude of 730.68 m for 1994 (Graves and others, 1996).

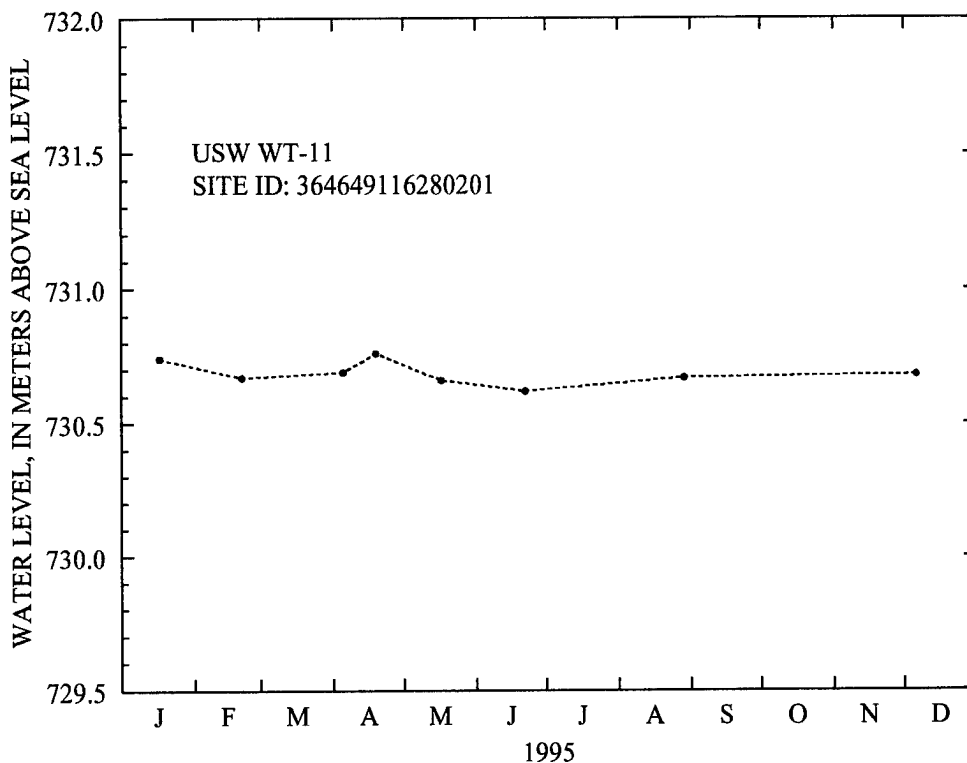


Figure 9. Water-level altitudes, 1995, for well USW WT-11.

## Well UE-25 WT#12

Information about the history of well UE-25 WT#12 and about previous data from the well was obtained from various sources. These sources are: Robison (1984); Robison (U.S. Geological Survey, written commun., 1986); Robison and others (1988); Holmes & Narver, Inc. (written commun., 1986); and Fenix & Scisson, Inc. (1986a, 1987c).

### Well specifications

#### 1. Location and identification:

Latitude and longitude: 36°46'56"N.; 116°26'16"W.

Nevada State Central Zone Coordinates (m): N 225,468; E 172,825.

U.S. Geological Survey Site ID: 364656116261601.

#### 2. Drilling and casing information:

Well started: August 11, 1983.

Well completed: August 16, 1983.

Drilling method: Rotary, using rock bits and air-foam circulating medium; core obtained from bottom of the borehole.

Bit diameter below water level: 222 mm.

Casing: Surface casing only, to a depth of 21.3 m.

Total drilled depth: 399 m.

3. Access to and description of depth interval for measuring water levels:

From January 1 through July 7, 1995, the monitoring string used in well UE-25 WT#12 was a 62-mm inside-diameter tubing that had a 3.7-m-long well screen on the bottom; tubing and attached screen extended from land surface to a depth of 388.9 m. Between July 7 and 10, 1995, this monitoring string was pulled from the well to prepare the well for a series of single-well aquifer tests. On July 27 and 28, 1995, a new monitoring string was installed in the well. Dimensions of this monitoring string are 62-mm inside-diameter tubing with a 2.44-m-long well screen on the bottom; tubing and attached screen extend from land surface to a depth of 386.73 m.

The saturated interval of the borehole is within the Topopah Spring Tuff of the Paintbrush Group and the Calico Hills Formation.

4. Information for calculating water-level altitude:

Reference point: Top of metal tag on well casing, altitude 1,074.74 m (surveyed by U.S. Geological Survey, 1984).

Measuring point: Top of access tube, 0.305 m above reference point for January 1 through July 7, 1995. Top of access tube, 0.171 m above reference point for July 28 through December 31, 1995.

Depth correction for borehole deviation from vertical: 0.183 m, based on approximate depth to water of 345 m (1990 data).

From August 17, through September 19, 1995, well UE-25 WT#12 was equipped with a progressive cavity pump and a series of 11 single-well aquifer tests were conducted (O'Brien, 1997). The well was pumped at a rate of 1.08 to 1.67 L/s, with length of time of pumping ranging from 0.9 to 151.8 hours. Total ground water withdrawal from the well was approximately 1,600 m<sup>3</sup>. Maximum drawdown in the well was 18 meters, occurring during the 151.8 hour test. Observations made during the series of tests indicated that within 1 hour of stopping the pump for each test, the water level in the well had fully recovered to prepumping levels.

During the single-well aquifer tests, well UE-25 WT#12 was monitored continuously with a transducer and data logger. However, the aquifer-test drawdown data were not included in this report because the pumpage did not cause long-term declines in the water level. On the contrary, there was actually a rise in water level following the series of tests instead of a decline which might have been expected (fig 10). Complete information on the aquifer test conducted at well UE-25 WT#12 can be found in O'Brien (1997).

Well UE-25 WT#12 was measured periodically during 1995. Measurements were made with Chain #3 and Chain #4 with the following results:

Date	Measured water-level altitude (meters, above sea level)	Method of measuring water level
01-30-95	729.39	Chain #4
02-24-95	729.41	Chain #3
03-23-95	729.51	Chain #3
04-24-95	729.48	Chain #3
05-22-95	729.48	Chain #3
06-21-95	729.39	Chain #3
08-17-95	729.39	Chain #3
09-19-95	729.51	Chain #4
09-27-95	729.40	Chain #3
09-29-95	729.34	Chain #3
12-13-95	729.42	Chain #3

Water-level altitudes for well UE-25 WT#12 ranged from 729.34 to 729.51 m above sea level in 1995 (fig. 10) The mean water-level altitude of the 1995 periodic data was 729.43 m above sea level. This mean altitude was the same as the mean altitude of 729.43 m for 1994 (Graves and others, 1996).

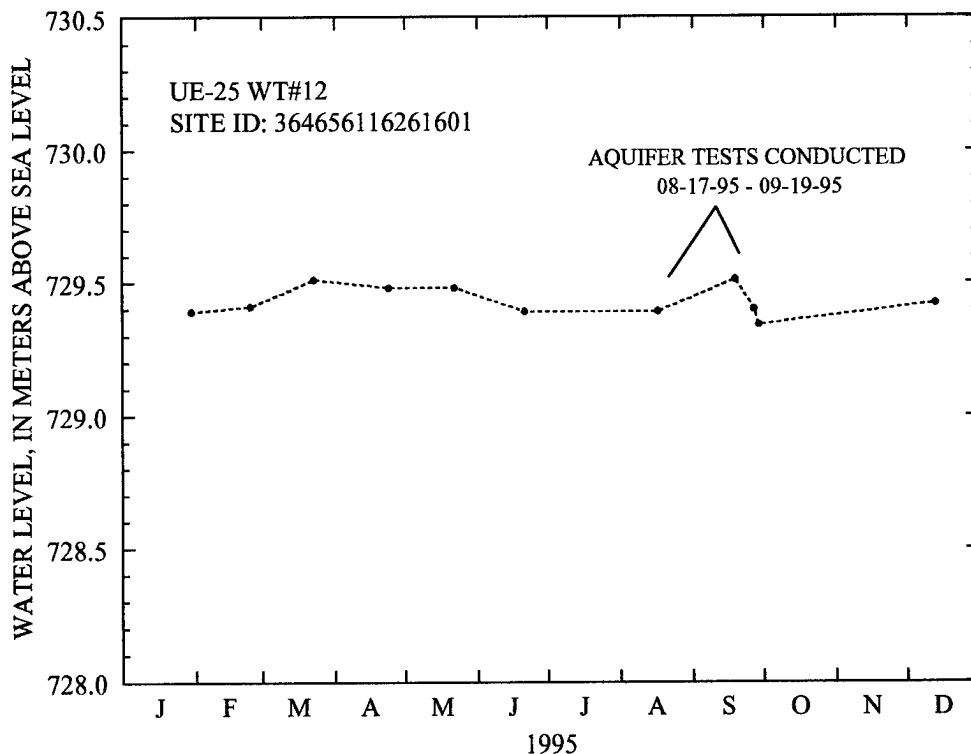


Figure 10. Water-level altitudes, 1995, for well UE-25 WT#12.

## Well UE-25 WT#13

Information about the history of well UE-25 WT#13 and about previous data from the well was obtained from various sources. These sources are: Robison (1984); Robison (U.S. Geological Survey, written commun., 1986); Robison and others (1988); and Fenix & Scisson, Inc. (1986a, 1987c).

### Well specifications

#### 1. Location and identification:

Latitude and longitude: 36°49'43"N.; 116°23'51"W.

Nevada State Central Zone Coordinates (m): N 230,647; E 176,405.

U.S. Geological Survey Site ID: 364945116235001.

#### 2. Drilling and casing information:

Well started: June 29, 1983.

Well completed: July 7, 1983.

Drilling method: Rotary, using rock bits and air-foam circulating medium; core obtained from bottom of the borehole.

Bit diameter below water level: 222 mm.

Casing: Surface casing only, to a depth of 68 m.

Total drilled depth: 354 m.

#### 3. Access to and description of depth interval for measuring water levels:

62-mm inside-diameter tubing that has a 3.6-m-long well screen on bottom, extending from land surface to a depth of 346 m; saturated interval of the borehole is within the Topopah Spring Tuff of the Paintbrush Group.

#### 4. Information for calculating water-level altitude:

Reference point: Top of metal tag on well casing; altitude 1,032.51 m (surveyed by U.S. Geological Survey, 1984).

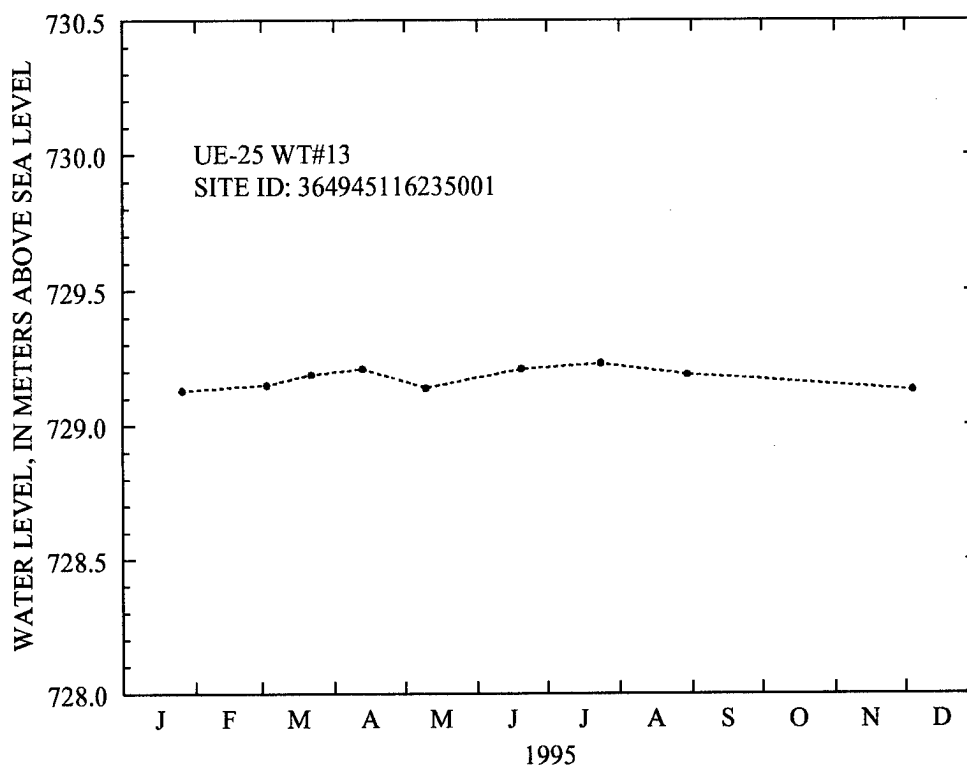
Measuring point: Top of access tube, 0.305 m above reference point.

Depth correction for borehole deviation from vertical: 0.012 m, based on approximate depth to water of 304 m (1990 data).

Well UE-25 WT#13 was measured periodically during 1995. Measurements were made with Chain #3 and Chain #4 with the following results:

Date	Measured water-level altitude (meters, above sea level)	Method of measuring water level
01-26-95	729.13	Chain #4
03-03-95	729.15	Chain #3
03-22-95	729.19	Chain #3
04-13-95	729.21	Chain #3
05-10-95	729.14	Chain #3
06-20-95	729.21	Chain #3
07-24-95	729.23	Chain #3
08-30-95	729.19	Chain #3
12-04-95	729.13	Chain #3

Water-level altitudes for well UE-25 WT#13 ranged from 729.13 to 729.23 m above sea level in 1995 (fig. 11). The mean water-level altitude of the 1995 periodic data was 729.18 m above sea level. This mean altitude was 0.01 m higher than the mean altitude of 729.17 m of 1994 (Graves and others, 1996).



**Figure 11.** Water-level altitudes, 1995, for well UE-25 WT#13.

## Well UE-25 WT#14

Information about the history of well UE-25 WT#14 and about previous data from the well was obtained from various sources. These sources are: Robison (1984); Robison (U.S. Geological Survey, written commun., 1986); Robison and others (1988); Holmes & Narver, Inc. (written commun., 1986); and Fenix & Scisson, Inc. (1986a, 1987c).

### Well specifications

#### 1. Location and identification:

Latitude and longitude: 36°50'32"N.; 116°24'35"W.

Nevada State Central Zone Coordinates (m): N 232,151; E 175,324.

U.S. Geological Survey Site ID: 365032116243501.

#### 2. Drilling and casing information:

Well started: August 17, 1983.

Well completed: September 30, 1983.

Drilling method: Rotary, using rock bits and air-foam circulating medium; core obtained from bottom of the borehole.

Bit diameter below water level: 222 mm.

Casing: Surface casing only, to a depth of 36.6 m.

Total drilled depth: 399 m.

3. Access to and description of depth interval for measuring water levels:

62-mm inside-diameter tubing that has a 3.7-m-long well screen on the bottom; tubing and attached screen extend from land surface to a depth of 397.2 m; saturated interval of the borehole is within the Topopah Spring Tuff of the Paintbrush Group and the Calico Hills Formation.

4. Information for calculating water-level altitude:

Reference point: Top of metal tag on well casing, altitude 1,076.05 m (surveyed by U.S. Geological Survey, 1984).

Measuring point: Top of access tube, 0.311 m above reference point.

Depth correction for borehole deviation from vertical: 0.085 m, based on approximate depth to water of 346 m (1990 data).

Well UE-25 WT#14 was measured hourly and periodically during 1995. Hourly measurements were made until September 26, 1995, the day the transducer was removed from the well. During the period of hourly measurements, four calibrations of one transducer were performed. In addition, a calibration was completed on September 20, 1994. This calibration was used to calculate water-level altitudes at the beginning of 1995. Results of the transducer calibrations are as follows:

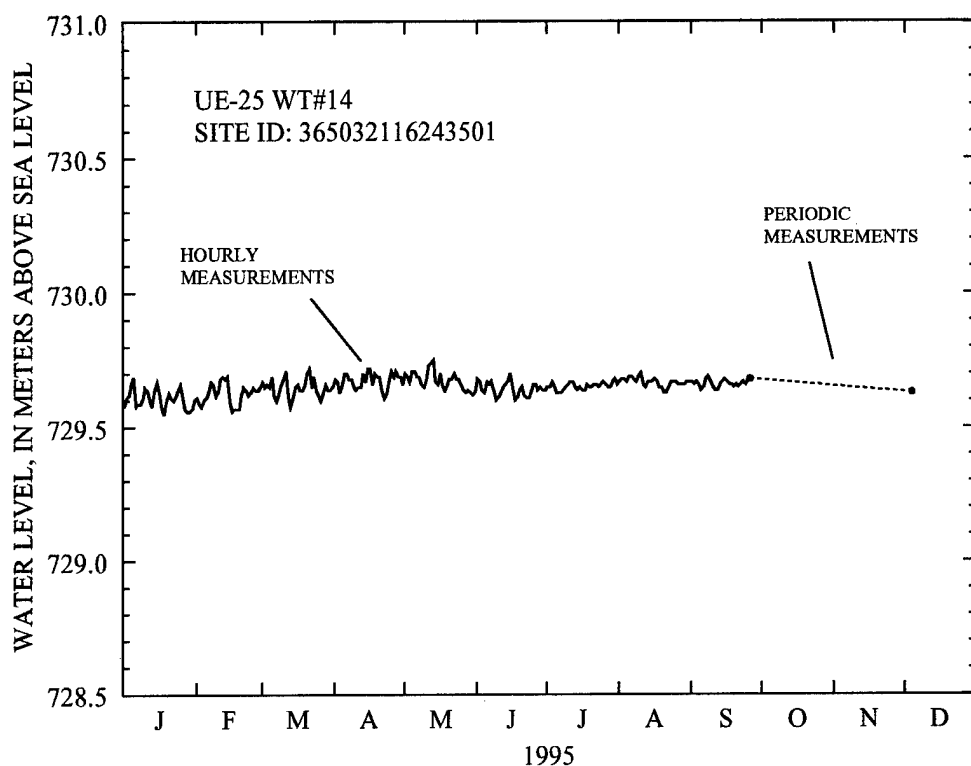
Transducer serial number	Calibration date	Slope (meters/millivolt)	Coefficient of determination	Water-level altitude (meters)	Method of measuring water level
592473	09-20-94	0.088	1.00	729.60	Tag with transducer
592473	01-24-95	.089	1.00	729.64	Tag with transducer
592473	05-16-95	.089	1.00	729.71	Chain #3
592473	06-28-95	.088	1.00	729.63	Tag with transducer
592473	09-26-95	.088	1.00	729.68	Chain #3

Spikes were removed from the transducer data on May 16 and June 28, 1995. These spikes were due to the calibration of the transducer on these dates. Spikes were also removed on June 27, 1995. The reason for this spike is not known. All other hourly transducer data for 1995 are considered to be valid.

Following the removal of the transducer, well UE-25 WT#14 was measured periodically during the remainder of 1995. Measurements were made with Chain #3 with the following results:

Date	Measured water-level altitude (meters, above sea level)	Method of measuring water level
09-26-95	729.68	Chain #3
12-04-95	729.63	Chain #3

Daily mean water-level altitudes from the hourly data for well UE-25 WT#14 ranged from 729.55 to 729.75 m above sea level in 1995 (fig. 12). Monthly mean water-level altitudes for January through September 1995 are listed in table 10. The mean water-level altitude of the 1995 hourly data was 729.65 m above sea level. This mean altitude was 0.04 m higher than the mean altitude of 729.61 m for 1994 (Graves and others, 1996).



**Figure 12.** Water-level altitudes, 1995, for well UE-25 WT#14.

**Table 10.** Monthly mean water-level altitudes, 1995, for well UE-25 WT#14.

[Monthly means were calculated regardless of the number of missing data. Daily means were not calculated if 6 or more consecutive hours of data were missing; --, data not available; NA, not applicable, well not instrumented during this month]

Month	Monthly mean water-level altitude (meters, above sea level)	Number of missing daily means
January	729.61	0
February	729.63	0
March	729.65	0
April	729.67	0
May	729.68	0
June	729.64	0
July	729.65	0
August	729.67	0
September	729.66	0
October	--	NA
November	--	NA
December	--	NA



## Well UE-25 WT#15

Information about the history of well UE-25 WT#15 and about previous data from the well was obtained from various sources. These sources are: Robison (1984); Robison (U.S. Geological Survey, written commun., 1986); Robison and others (1988); Holmes & Narver, Inc. (written commun., 1986); and Fenix & Scisson, Inc. (1986a, 1987c).

### Well specifications

#### 1. Location and identification:

Latitude and longitude: 36°51'16"N.; 116°23'38"W.

Nevada State Central Zone Coordinates (m): N 233,512; E 176,725.

U.S. Geological Survey Site ID: 365116116233801.

#### 2. Drilling and casing information:

Well started: November 12, 1983.

Well completed: November 22, 1983.

Drilling method: Rotary, using rock bits and air-foam circulating medium; core obtained from bottom of the borehole.

Bit diameter below water level: 222 mm.

Casing: Surface casing only, to a depth of 38.7 m.

Total drilled depth: 415 m.

#### 3. Access to and description of depth interval for measuring water levels:

62-mm inside-diameter tubing that has a 3.7-m-long well screen on the bottom; tubing and attached screen extend from land surface to a depth of 406.9 m; saturated interval of the borehole is within the Topopah Spring Tuff of the Paintbrush Group.

#### 4. Information for calculating water-level altitude:

Reference point: Top of metal tag on well casing, altitude 1,082.94 m (surveyed by U.S. Geological Survey, 1984).

Measuring point: Top of access tube, 0.314 m above reference point.

Depth correction for borehole deviation from vertical: 0.189 m, based on approximate depth to water of 354 m (1990 data).

Well UE-25 WT#15 was measured periodically during 1995. Measurements were made with Chain #3, the 2,800 foot reference steel tape, and the multiconductor cable unit with the following results:

Date	Measured water-level altitude (meters, above sea level)	Method of measuring water level
01-11-95	729.24	2,800 foot reference steel tape
04-27-95	729.34	Multiconductor cable unit
05-09-95	729.22	Chain #3
06-20-95	720.30	Chain #3
08-29-95	729.32	Chain #3
12-04-95	729.18	Chain #3

Water-level altitudes for well UE-25 WT#15 ranged from 729.18 to 729.34 m above sea level in 1995 (fig. 13). The mean water-level altitude of the 1995 periodic data was 729.27 m above sea level. This mean altitude was 0.08 m higher than the mean altitude of 729.19 m for 1994 (Graves and others, 1996).

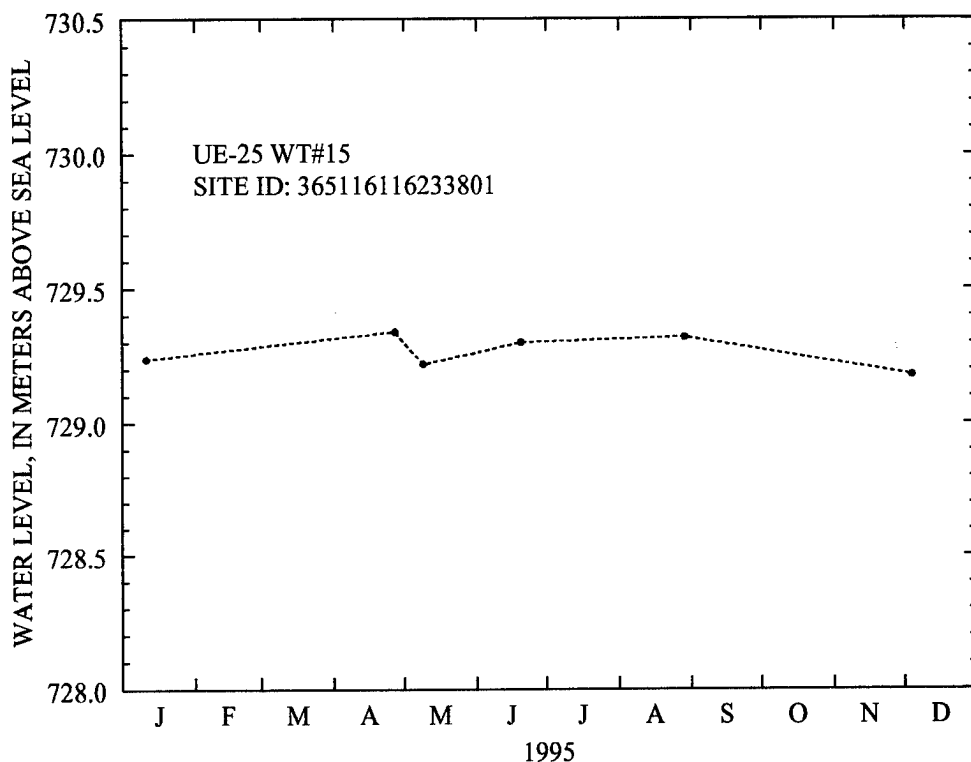


Figure 13. Water-level altitudes, 1995, for well UE-25 WT#15.

## Well UE-25 WT#16

Information about the history of well UE-25 WT#16 and about previous data from the well was obtained from various sources. These sources are: Robison (1984); Robison (U.S. Geological Survey, written commun., 1986); Robison and others (1988); and Fenix & Scisson, Inc. (1986a, 1987c).

### Well specifications

#### 1. Location and identification:

Latitude and longitude: 36°52'39"N.; 116°25'34"W.

Nevada State Central Zone Coordinates (m): N 236,043; E 173,856.

U.S. Geological Survey Site ID: 365239116253401.

#### 2. Drilling and casing information:

Well started: November 2, 1983.

Well completed: November 10, 1983.

Drilling method: Rotary, using rock bits and air-foam circulating medium; core obtained from bottom of the core hole.

Bit diameter below water level: 222 mm.

Casing: Surface casing only, to a depth of 31 m.

Total drilled depth: 521 m.

3. Access to and description of depth interval for measuring water levels:

62-mm inside-diameter tubing that has a 3.6-m-long well screen on bottom, extending from land surface to a depth of 514 m; saturated interval of borehole is within the Calico Hills Formation.

4. Information for calculating water-level altitude:

Reference point: Top of metal tag on well casing; altitude 1,210.63 m (surveyed by U.S. Geological Survey, 1984).

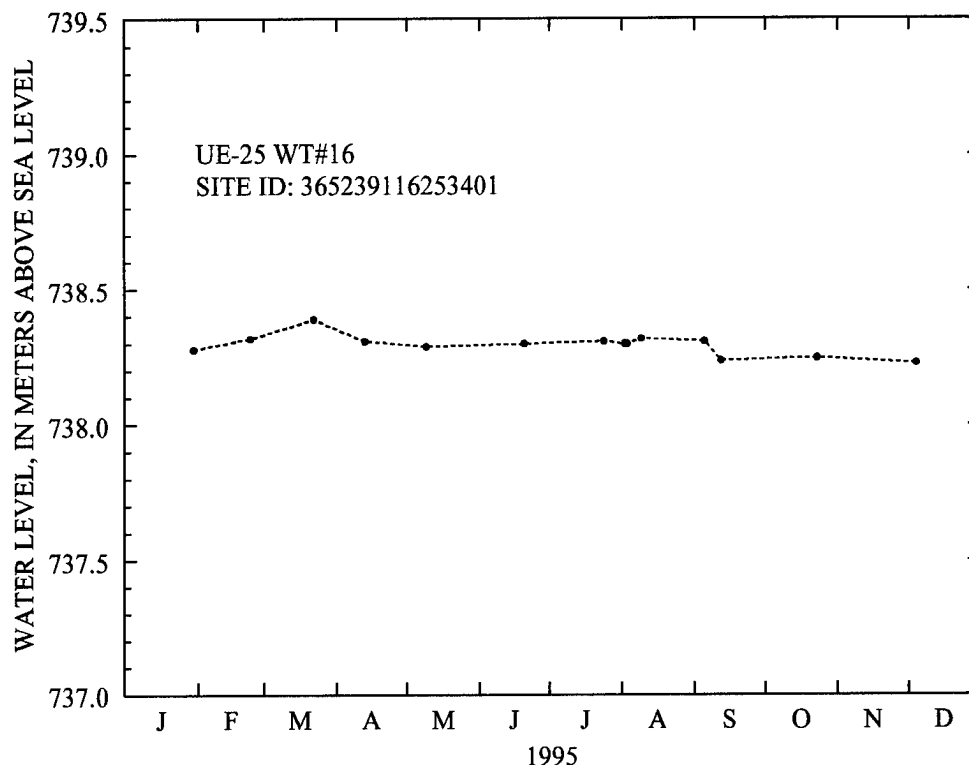
Measuring point: Top of access tube, 0.314 m above reference point.

Depth correction for borehole deviation from vertical: 0.064 m, based on approximate depth to water of 473 m (1990 data).

Well UE-25 WT#16 was measured periodically during 1995. Measurements were made with Chain #3, Chain #4, and the 2,800 foot reference steel tape with the following results:

Date	Measured water-level altitude (meters, above sea level)	Method of measuring water level
01-30-95	738.28	Chain #4
02-23-95	738.32	Chain #4
03-22-95	738.39	Chain #3
04-13-95	738.31	Chain #3
05-09-95	738.29	Chain #3
06-20-95	738.30	Chain #3
07-24-95	738.31	Chain #3
08-02-95	738.30	2,800 foot reference steel tape
08-03-95	738.30	2,800 foot reference steel tape
08-09-95	738.32	2,800 foot reference steel tape
09-05-95	738.31	Chain #4
09-12-95	738.24	2,800 foot reference steel tape
10-23-95	738.25	2,800 foot reference steel tape
12-04-95	738.23	Chain #3

Water-level altitudes for well UE-25 WT#16 ranged from 738.23 to 738.39 m above sea level in 1995 (fig. 14). The mean water-level altitude of the 1995 periodic data was 738.30 m above sea level. This mean altitude was 0.05 m lower than the mean altitude of 738.35 m for 1994 (Graves and others, 1996).



**Figure 14.** Water-level altitudes, 1995, for well UE-25 WT#16.

## Well UE-25 WT#17

Information about the history of well UE-25 WT#17 and about previous data from the well was obtained from various sources. These sources are: Robison (1984); Robison (U.S. Geological Survey, written commun., 1986); Robison and others (1988); Holmes & Narver, Inc. (written commun., 1986); and Fenix & Scisson, Inc. (1986a, 1987c).

### Well specifications

#### 1. Location and identification:

Latitude and longitude: 36°48'22"N.; 116°26'26"W.

Nevada State Central Zone Coordinates (m): N 228,118; E 172,581.

U.S. Geological Survey Site ID: 364822116262601.

#### 2. Drilling and casing information:

Well started: October 20, 1983.

Well completed: October 30, 1983.

Drilling method: Rotary, using rock bits and air-foam circulating medium; attempt to obtain bottom-hole core unsuccessful, core not obtained from bottom of borehole.

Bit diameter below water level: 222 mm.

Casing: Surface casing only, to a depth of 16.8 m.

Total drilled depth: 443 m.

3. Access to and description of depth interval for measuring water levels:

62-mm inside-diameter tubing that has a 3.7-m-long well screen on the bottom; tubing and attached screen extend from land surface to a depth of 419.4 m; saturated interval of borehole is within the Prow Pass Tuff of the Crater Flat Group.

4. Information for calculating water-level altitude:

Reference point: Top of metal tag on well casing, altitude 1,124.06 m (surveyed by U.S. Geological Survey, 1984).

Measuring point: Top of access tube, 0.158 m above reference point.

Depth correction for borehole deviation from vertical: 0.482 m, based on approximate depth to water of 394 m (1990 data).

Well UE-25 WT#17 was measured periodically through June 1995. Water-level measurements in UE-25 WT#17 were discontinued after June 1995. All measurements made during 1995 were made with the multiconductor cable unit with the following results:

Date	Measured water-level altitude (meters, above sea level)	Method of measuring water level
03-15-95	729.71	Multiconductor cable unit
04-27-95	729.78	Multiconductor cable unit
06-01-95	729.72	Multiconductor cable unit
06-28-95	729.45	Multiconductor cable unit

Water-level altitudes for well UE-25 WT#17 ranged from 729.45 to 729.78 m above sea level in 1995 (fig. 15). The mean water-level altitude of the 1995 periodic data was 729.66 m above sea level. This mean altitude was 0.02 m higher than the mean altitude of 729.64 m for 1994 (Graves and others, 1996).

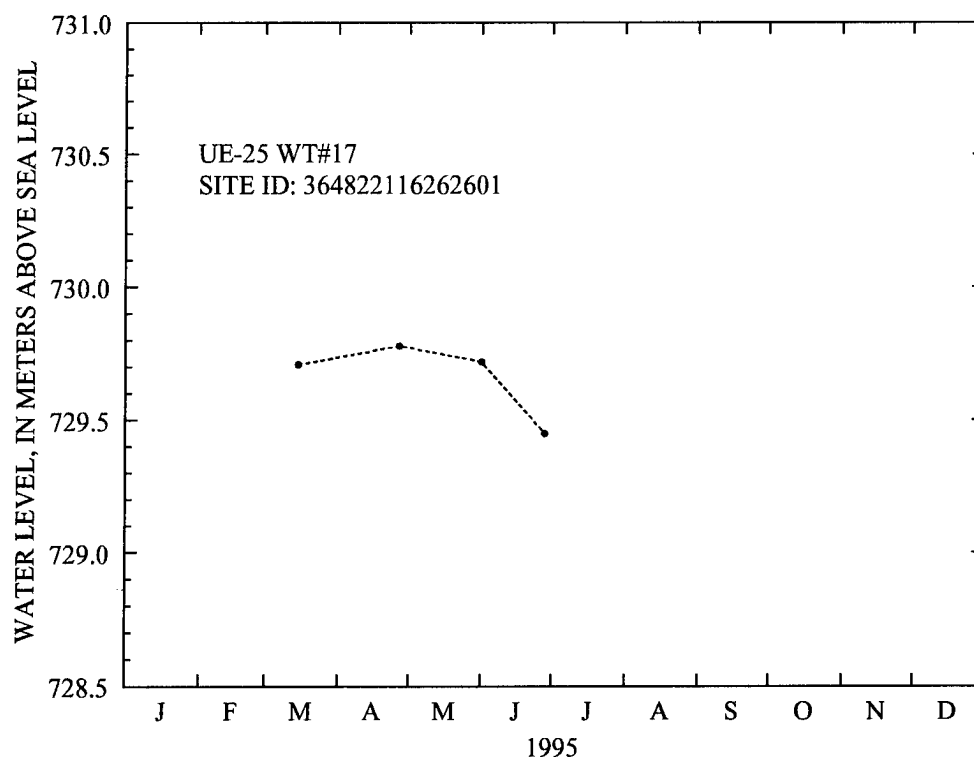


Figure 15. Water-level altitudes, 1995, for well UE-25 WT#17.

## Well UE-25 WT#18

Information about the history of well UE-25 WT#18 and about previous data from the well was obtained from various sources. These sources are: Fenix & Scisson, Inc. (1986a); Holmes & Narver, Inc. (written commun., 1986); and Muller and Kibler (1985).

### Well specifications

#### 1. Location and identification:

Latitude and longitude: 36°52'07"N; 116°26'42"W.

Nevada State Central Zone Coordinates (m): N 235,052; E 172,168.

U.S. Geological Survey Site ID: 365207116264201.

#### 2. Drilling and casing information:

Well started: May 9, 1984.

Well completed: May 23, 1984.

Drilling method: Rotary using rock bits and air-foam circulating medium; core obtained from bottom of the borehole.

Bit diameter below water level: 222 mm.

Casing: Surface casing only, to a depth of 27 m.

Total depth drilled: 623 m.

#### 3. Access to and description of depth interval for measuring water levels:

62-mm inside-diameter tubing that has a 3.7-m-long well screen on the bottom; tubing and attached screen originally extended from land surface to a depth of 597 m, but tubing was extended to a depth of 609 m, December 1990; saturated interval is within the Calico Hills Formation.

#### 4. Information for calculating water-level altitude:

Reference point: Top of metal tag on well casing, altitude 1336.32 m (surveyed by U.S. Geological Survey, 1984).

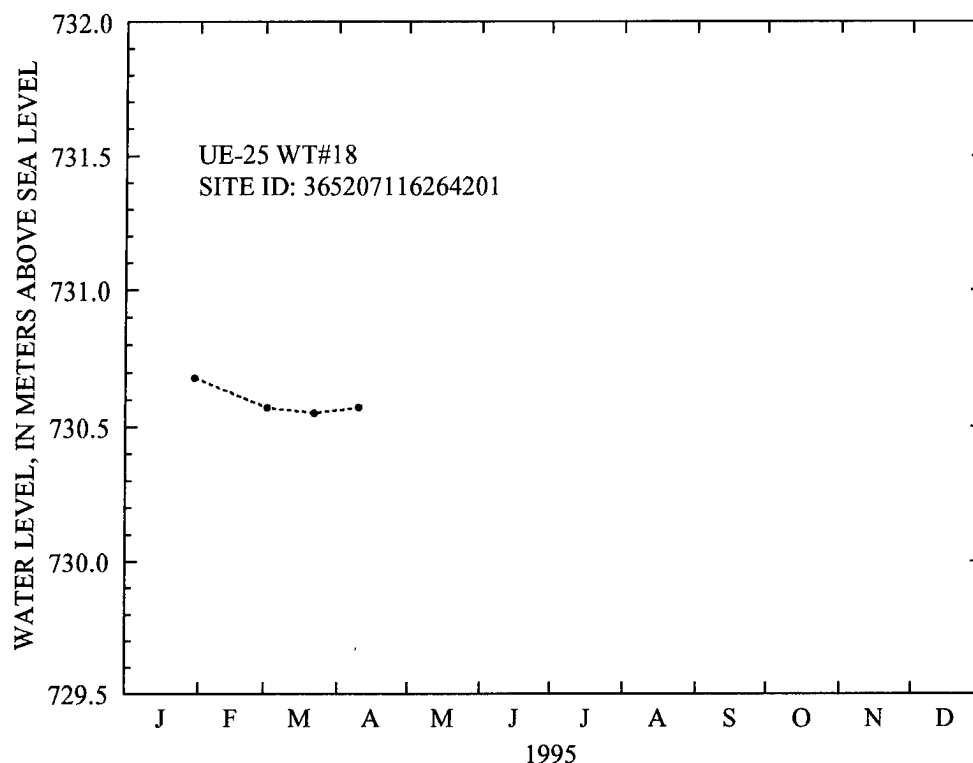
Measuring point: Top of access tube, 0.210 m above reference point.

Depth correction for borehole deviation from vertical: 0.155 m, based on approximate depth to water of 607 m (1990 data).

Well UE-25 WT#18 was measured periodically during 1995. Water-level measurements in UE-25 WT#18 were discontinued after August 1995. Water-level measurements made during May and August 1995, were determined to be bad data and were not used in this report. Measurements made during 1995 were made with Chain #3 and Chain #4 with the following results:

Date	Measured water-level altitude (meters, above sea level)	Method of measuring water level
01-30-95	730.68	Chain #4
03-02-95	730.57	Chain #3
03-22-95	730.55	Chain #3
04-10-95	730.57	Chain #3

Water-level altitudes for well UE-25 WT#18 ranged from 730.57 to 730.68 m above sea level from January through April 1995 (fig. 16). The mean water-level altitude of the 1995 periodic data was 730.59 m above sea level. This mean altitude was 0.11 m lower than the mean altitude of 730.70 m for 1994 (Graves and others, 1996).



**Figure 16.** Water-level altitudes, 1995, for well UE-25 WT#18.

## Well UE-25 b#1

Information about the history of well UE-25 b#1 and about previous data from the well was obtained from various sources. These sources are: Lobmeyer and others (1983); Lahoud and others (1984); Robison (1984); Robison (U.S. Geological Survey, written commun., 1986); Robison and others (1988); and Fenix & Scisson, Inc. (1986b, 1987c).

### Well specifications

#### 1. Location and identification:

Latitude and longitude: 36°51'08"N.; 116°26'23"W.

Nevada State Central Zone Coordinates (m): N 233,246; E 172,644.

U.S. Geological Survey Site ID: 365108116262301.

#### 2. Drilling and casing information:

Well started: April 3, 1981.

Well completed: September 22, 1981.

Drilling method: Rotary, using rock bits and air-foam circulating medium; cores obtained from selected intervals.

Bit diameter below water level: 311 mm to 520 m; 222 mm to 650 m; 216 mm from 650 to 1,220 m.

Casing extending below water level: 226-mm inside diameter to 518 m; casing string is tack cemented in and perforated below the water level.

Total drilled depth: 1,220 m.

3. Access to and description of depth interval for measuring water levels:

Upper interval:

48-mm inside diameter tubing, open ended, to depth of about 488 m; upper interval of borehole, from near water table to top of inflatable packer, is within the Calico Hills Formation, and Prow Pass, Bullfrog, and upper Tram Tuffs of the Crater Flat Group;

Lower interval:

62-mm inside diameter tubing that has an inflatable packer on bottom end, to depth of 1,199 m; lower interval of borehole, from below packer to bottom of well, is within the lower Tram Tuff of the Crater Flat Group and Lithic Ridge Tuff.

4. Information for calculating water-level altitude:

Reference point: Top of metal tag on well casing; altitude 1,200.73 m (surveyed by U.S. Geological Survey, 1984).

Measuring point: Top of access tubes, 0.302 m above reference point, upper interval; 0.134 m above reference point, lower interval.

Depth correction for borehole deviation from vertical: 0.244 m, based on approximate depth to water of 470 m (1990 data).

Well UE-25 b#1, upper interval was measured periodically during 1995. Measurements were made with Chain #3 and Chain #4 with the following results:

Date	Measured water-level altitude (meters, above sea level)	Method of measuring water level
01-30-95	730.54	Chain #4
03-02-95	730.64	Chain #3
04-10-95	730.62	Chain #3
05-10-95	730.61	Chain #3
06-13-95	730.57	Chain #3
07-12-95	730.61	Chain #3
08-16-95	730.65	Chain #3
09-14-95	730.62	Chain #4
12-05-95	730.59	Chain #3

Water-level altitudes for well UE-25 b#1, upper interval ranged from 730.54 to 730.65 m above sea level in 1995 (fig. 17). The mean water-level altitude of the 1995 periodic data was 730.61 m above sea level. This mean altitude was 0.01 m higher than the mean altitude of 730.60 m for 1994 (Graves and others, 1996).



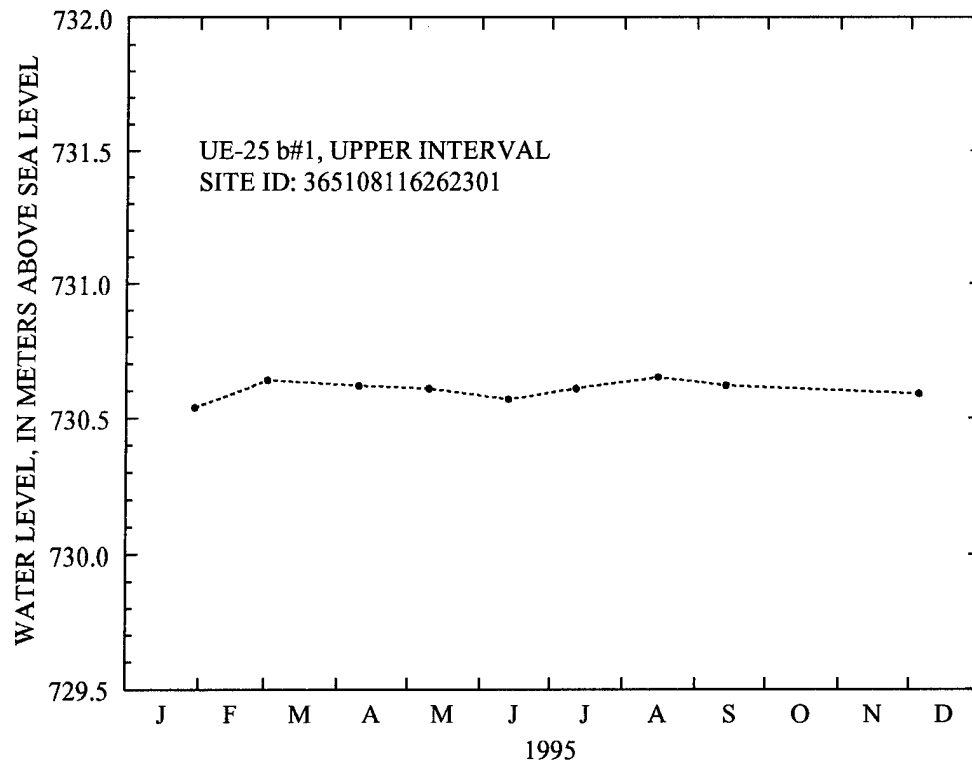
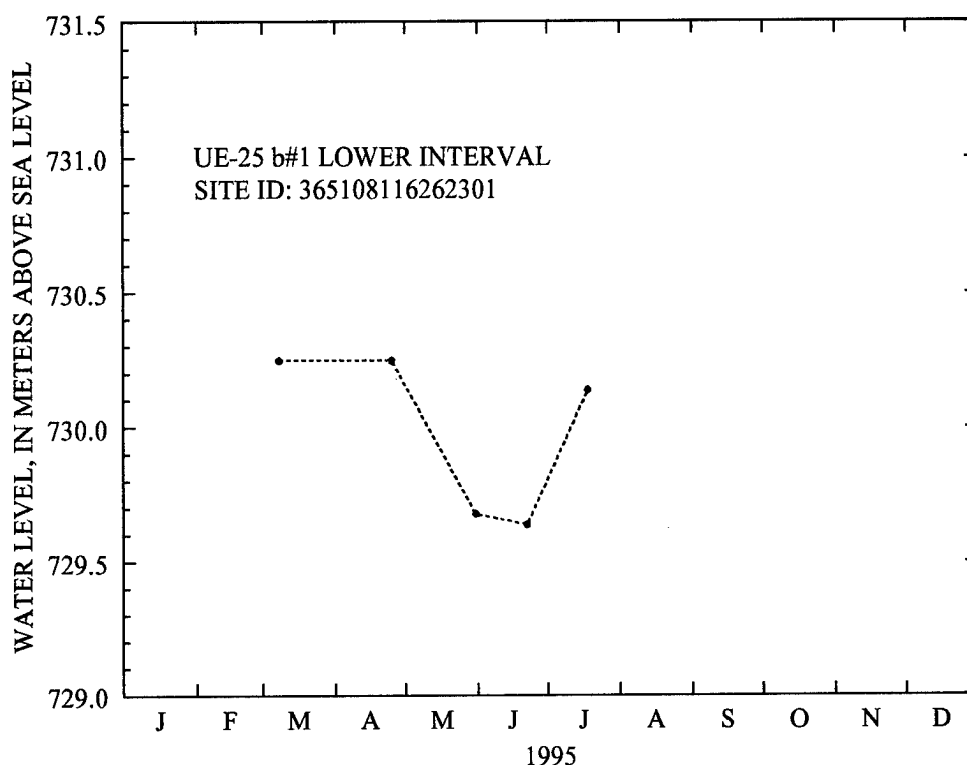


Figure 17. Water-level altitudes, 1995, for well UE-25 b#1, upper interval.

Well UE-25 b#1, lower interval was measured periodically during 1995. Water-level measurements in UE-25 b#1 lower interval were discontinued after July 1995. All measurements were made with the multiconductor cable unit with the following results:

Date	Measured water-level altitude (meters, above sea level)	Method of measuring water level
03-08-95	730.25	Multiconductor cable unit
04-25-95	730.25	Multiconductor cable unit
05-31-95	729.68	Multiconductor cable unit
06-22-95	729.64	Multiconductor cable unit
07-18-95	730.14	Multiconductor cable unit

Water-level altitudes for well UE-25 b#1, lower interval ranged from 729.64 to 730.25 m above sea level in 1994 (fig. 18). The mean water-level altitude of the 1995 periodic data was 729.99 m above sea level. This mean altitude was 0.07 m lower than the mean altitude of 730.06 m for 1994 (Graves and others, 1996).



**Figure 18.** Water-level altitudes, 1995, for well UE-25 b#1 lower interval.

## Well UE-25 p#1

Information about the history of well UE-25 p#1 and about previous data from the well was obtained from various sources. These sources are: Craig and Johnson (1984); Craig and Robison (1984); Robison (1984); Robison (U.S. Geological Survey, written commun., 1986); Robison and others (1988); and Fenix & Scisson, Inc. (1986c, 1987c).

### Well specifications

#### 1. Location and identification:

Latitude and longitude: 36°49'38"N.; 116°25'21"W.

Nevada State Central Zone Coordinates (m): N 230,481; E 174,188.

U.S. Geological Survey Site ID: 364938116252102.

#### 2. Drilling and casing information:

Well started: November 13, 1982.

Well completed: May 24, 1983.

Drilling method: Rotary, using rock bits and air-foam circulating medium; cores obtained from selected intervals.

Bit diameter below water level: 375 mm to 487 m; 251 mm from 487 to 1,304 m;

17 mm from 1,304 to 1,317 m; 171 mm from 1,317 to 1,798 m; 156 mm from 1,798 to 1,805 m.

Casing extending below water level: 255-mm inside diameter from land surface to 477 m; 177-mm inside diameter from 453 to 1,297 m; casing string is cemented in, has no perforations.

Total drilled depth: 1,805 m.

3. Access to and description of depth interval for measuring water levels:

38-mm inside-diameter tubing, open end, to depth of 418 m; well construction is such that water level of the tuffs of Tertiary age is not monitored. Only the water level in the underlying carbonate rocks of Paleozoic age is measured (Tertiary-Paleozoic contact is at 1,244 m).

Note: A 38-mm inside-diameter tubing, closed end, and filled with water, to a depth of 413 m below land surface is also installed in the well to allow access for temperature logging.

4. Information for calculating water-level altitude:

Reference point: Top of metal tag on well casing; altitude 1,114.21 m (surveyed by U.S. Geological Survey, 1984).

Measuring point: Top of access tube, 0.158 m above reference point.

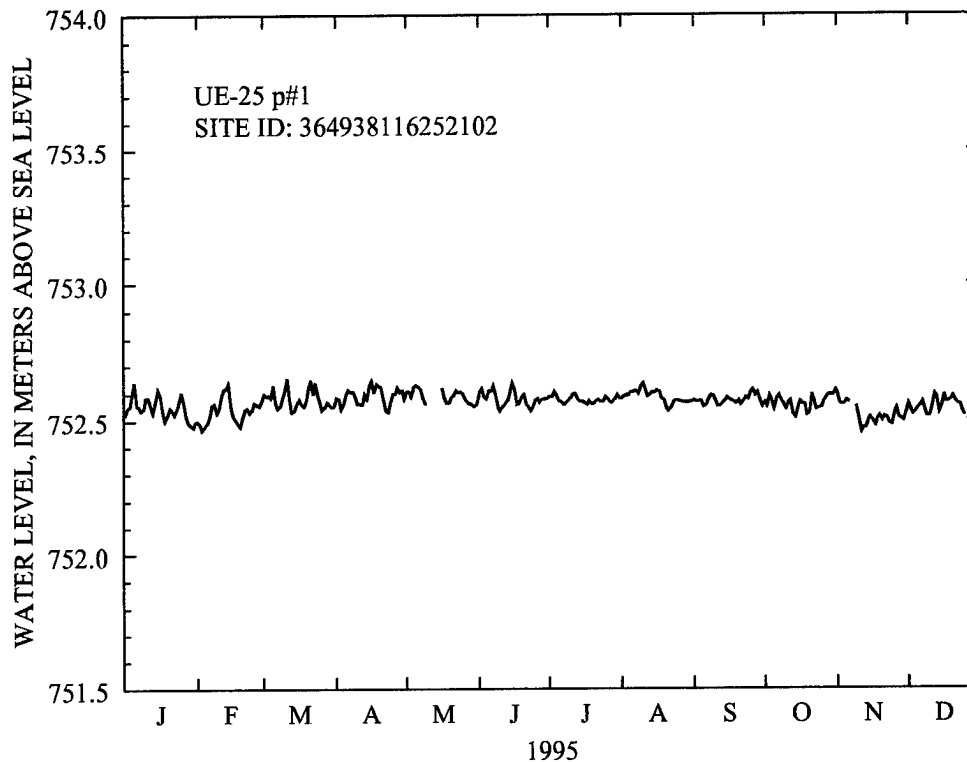
Depth correction for borehole deviation from vertical: 0.021 m, based on approximate depth to water of 362 m (1990 data).

Well UE-25 p#1 was measured hourly during 1995. Four calibrations of one transducer were performed during 1995. In addition, calibrations on November 23, 1994, and May 8, 1996, were used to calculate water levels for 1995. Results of the transducer calibrations are as follows:

Transducer serial number	Calibration date	Slope (meters/millivolt)	Coefficient of determination	Water-level altitude (meters)	Method of measuring water level
592477	11-23-94	0.089	1.00	752.51	Tag with transducer
592477	02-16-95	.088	1.00	752.50	Chain #4
592477	06-08-95	.088	1.00	752.61	Tag with transducer
592477	06-28-95	.089	1.00	752.56	Tag with transducer
592477	11-07-95	.089	1.00	752.52	Tag with transducer
592477	05-08-96	.088	1.00	752.67	Chain #3

No data were collected May 11 through 14, 1995. Data were lost because of scanner problems on the DCP. Partial data were collected on May 10 and 15, 1995, for the same reason. Spikes were removed from the data on November 28 and 29, 1995. The reason for the spikes is not known. Partial data were collected November 7 and 8, 1995, because the DCP was off line while the transducer was being calibrated. Partial data were collected December 26 and 27, 1995. The reason for the partial data for these two days is not known. Daily mean water-level altitudes were not calculated for May 10 through 15, November 7 through 8, or December 26 through 27, 1995. All other transducer data collected for 1995 were considered valid.

Daily mean water-level altitudes of the hourly data for well UE-25 p#1 ranged from 752.46 to 752.66 m above sea level in 1995 (fig. 19). Monthly mean water-level altitudes are listed in table 11. The mean water-level altitude of the 1995 hourly data was 752.57 m above sea level. This mean altitude was 0.02 m higher than the mean altitude of 752.55 m for 1994 (Graves and others, 1996).



**Figure 19.** Water-level altitudes, 1995, for well UE-25 p#1.

**Table 11.** Monthly mean water-level altitudes, 1995, for well UE-25 p#1.

[Monthly means were calculated regardless of the number of missing data. Daily means were not calculated if 6 or more consecutive hours of data were missing]

Month	Monthly mean water-level altitude (meters, above sea level)	Number of missing daily means
January	752.55	0
February	752.54	0
March	752.58	0
April	752.59	0
May	752.59	6
June	752.58	0
July	752.58	0
August	752.59	0
September	752.57	0
October	752.56	0
November	752.52	2
December	752.55	2

## Well USW VH-1

Information about the history of well USW VH-1 and about previous data from the well was obtained from various sources. These sources are: Robison (1984); Robison (U.S. Geological Survey, written commun., 1986); Robison and others (1988); Holmes & Narver, Inc. (written commun., 1986); and Thordarson and Howells (1987).

### Well specifications

#### 1. Location and identification:

Latitude and longitude: 36°47'32"N.; 116°33'07"W.

Nevada State Central Zone Coordinates (m): N 226,575; E 162,649.

U.S. Geological Survey Site ID: 364732116330701.

#### 2. Drilling and casing information:

Well started: October 28, 1980.

Well completed: February 18, 1981.

Drilling method: Rotary, using rock bits, and air-foam and polymer circulating medium.

Bit diameter below water level: 222 mm to 278 m; 159 mm from 278 m to total depth.

Casing extending below water level: 177-mm inside diameter to 278 m.

Total drilled depth: 762 m.

#### 3. Access to and description of depth interval for measuring water levels:

48-mm inside-diameter tubing, open ended from land surface to 205.4 m; saturated interval of the well is within the Tiva Canyon and Topopah Spring Tuffs of the Paintbrush Group, and the Prow Pass and Bullfrog Tuffs of the Crater Flat Group. A pump was installed in the well on July 8, 1982, at a depth of 212.8 m.

#### 4. Information for calculating water-level altitude:

Reference point: Top of metal tag on well casing, altitude 963.23 m (surveyed by Holmes & Narver, Inc., March 3, 1986).

Measuring point: Top of access tube, 0.631 m above reference point.

Depth correction for borehole deviation from vertical: 0.049 m, based on approximate depth to water of 184 m (1990 data).

Well USW VH-1 was measured periodically during 1995. Measurements were made with Chain #3, Chain #4, and the 2,800 foot reference steel tape with the following results:

Date	Measured water-level altitude (meters, above sea level)	Method of measuring water level
01-05-95	779.53	Chain #4
01-12-95	779.45	Chain #4
02-21-95	779.52	Chain #4
03-28-95	779.50	2,800 foot reference steel tape
04-19-95	779.51	Chain #3
05-17-95	779.49	Chain #3
06-22-95	779.45	Chain #3
07-19-95	779.44	Chain #3
08-10-95	779.51	2,800 foot reference steel tape
10-24-95	779.49	2,800 foot reference steel tape
12-06-95	779.50	Chain #3

Water-level altitudes for well USW VH-1 ranged from 779.44 to 779.53 m above sea level in 1995 (fig. 20). The mean water-level altitude of the 1995 periodic data was 779.49 m above sea level. This mean altitude was 0.03 m higher than the mean altitude of 779.46 m for 1994 (Graves and others, 1996).

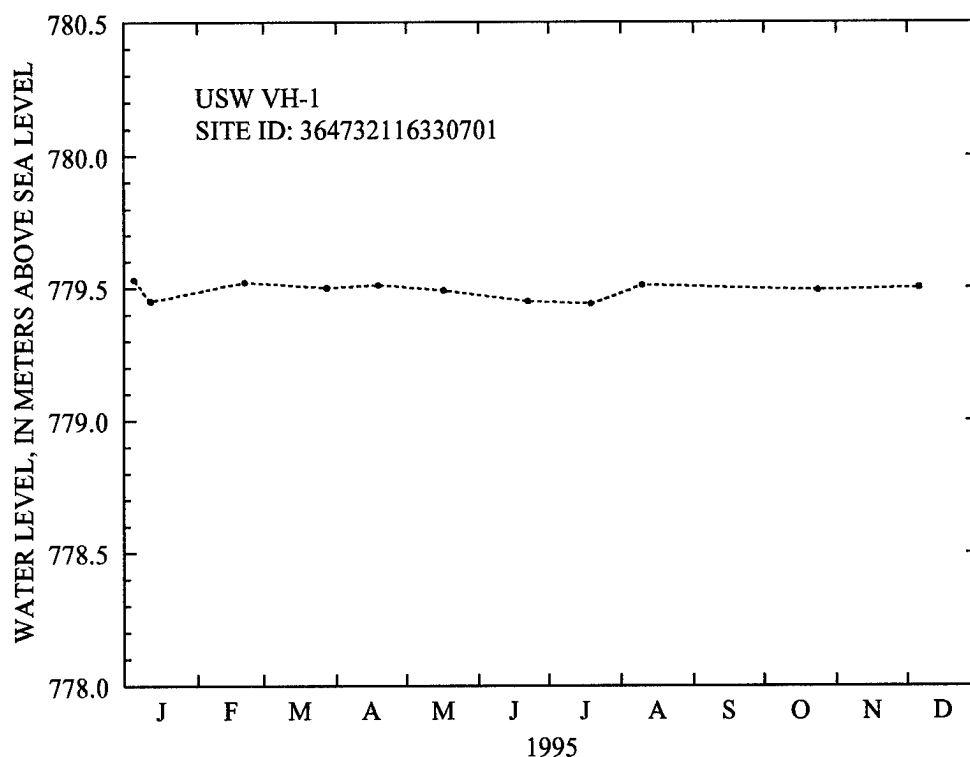


Figure 20. Water-level altitudes, 1995, for well USW VH-1.

## Well USW G-2

Information about the history of well USW G-2 and about previous data from the well was obtained from various sources. These sources are: Maldonado and Koether (1983); Robison (1984); Robison (U.S. Geological Survey, written commun., 1986); Robison and others (1988); Holmes & Narver, Inc. (written commun., 1986); Fenix & Scisson, Inc. (1987b, 1987c); and Nelson and Schimschal (1993).

### Well specifications

#### 1. Location and identification:

Latitude and longitude: 36°53'22"N.; 116°27'35"W.

Nevada State Central Zone Coordinates (m): N 778,825; E 560,503.

U.S. Geological Survey Site ID: 365322116273501.

#### 2. Drilling and casing information:

Well started: March 25, 1981.

Well completed: October 24, 1981.

Drilling method: Rotary, using rock bits, with polymer mud to 88 m; cored from 88 m to total depth.

Bit diameter below water level: 222 mm to 814 m; 159 mm from 814 m to 947 m; 156 mm from 947 to 1,439 m; 76 mm from 1,439 m to total depth.

Casing extending below water level: None (surface casing, 320 mm inside diameter, 0–85 m and 276 mm inside diameter, 0–242 m).

Total drilled depth: 1,831 m.

#### 3. Access to and description of depth interval for measuring water levels:

Saturated interval of borehole is within the Topopah Spring Tuff of the Paintbrush Group, the Calico Hills Formation, Prow Pass, Bullfrog, and Tram Tuffs of the Crater Flat Group, Lithic Ridge Tuff, and older flows and tuffs.

Bridge plug at a depth of 806 m. Second bridge plug installed in well on September 29, 1995. Top of second bridge plug at a depth of 792 m.

Until October 1995, measurements were made through the well casing. On October 3, 1995, a 62-mm inside-diameter tubing extending from land surface to 597 m was installed in well. The bottom of the tube is capped with a 1.5-m-long well screen above the cap.

#### 4. Information for calculating water-level altitude:

Reference point: Top of metal tag on well casing, altitude 1,553.86 m (surveyed by U.S. Geological Survey, 1984).

Measuring point: Top of casing, 0.034 m before 2/3/93, 0.332 m 2/3/93 to 10/01/95. Monitoring tube placed in well on October 3, 1995. Measuring point changed to top of monitoring tube. Measuring point after 10/01/95, 0.198 m. All measuring points above reference point.

Depth correction for borehole deviation from vertical: 0.158 m, based on approximate depth to water of 524 m (1984 data) through 12/31/94. After 01/01/95 depth correction for borehole deviation from vertical: 0.192 m, based on approximate depth to water of 534 m (1994 data).

#### 5. During 1995, well USW G-2 was instrumented to conduct a single-well aquifer test. Pump failure prevented the test from being conducted and, from October 24 through November 1, 1995, only pretesting pump cycles

of 10 to 15 minutes, pumping at approximately 0.95 L/s were completed. It is estimated that approximately 10 m<sup>3</sup> of ground water was pumped from well USW G-2 and maximum drawdown was about 3.5 m (G.M. O'Brien, U.S. Geological Survey, oral commun., 1996).

Although well USW G-2 was monitored continuously by transducer during October and November 1995, only the manual water-level measurements made during this period are discussed in this report. The decline in water level from October to November (fig. 21) is due to pumpage and slow recovery of water levels in the well. Because of limited access to the well site during 1995, no water-level measurements were made prior to October. Water-level measurements made in well USW G-2 were made with Chain #2 and Chain #3 with the following results:

Date	Measured water-level altitude (meters, above sea level)	Method of measuring water level
10-10-95	1,019.91	Chain #2
11-02-95	1,019.58	Chain #3
12-05-95	1,019.74	Chain #3
12-11-95	1,019.75	Chain #3

Water-level altitudes for well USW G-2 ranged from 1,019.58 to 1,019.91 m above sea level in 1995 (fig. 21). The mean water-level altitude of the 1995 periodic data was 1,019.74 m above sea level. This mean altitude was 0.36 m lower than the mean altitude of 1,020.10 m for 1994 (Graves and others, 1996). This lower mean water level is due to the pumpage of the well during October and November.

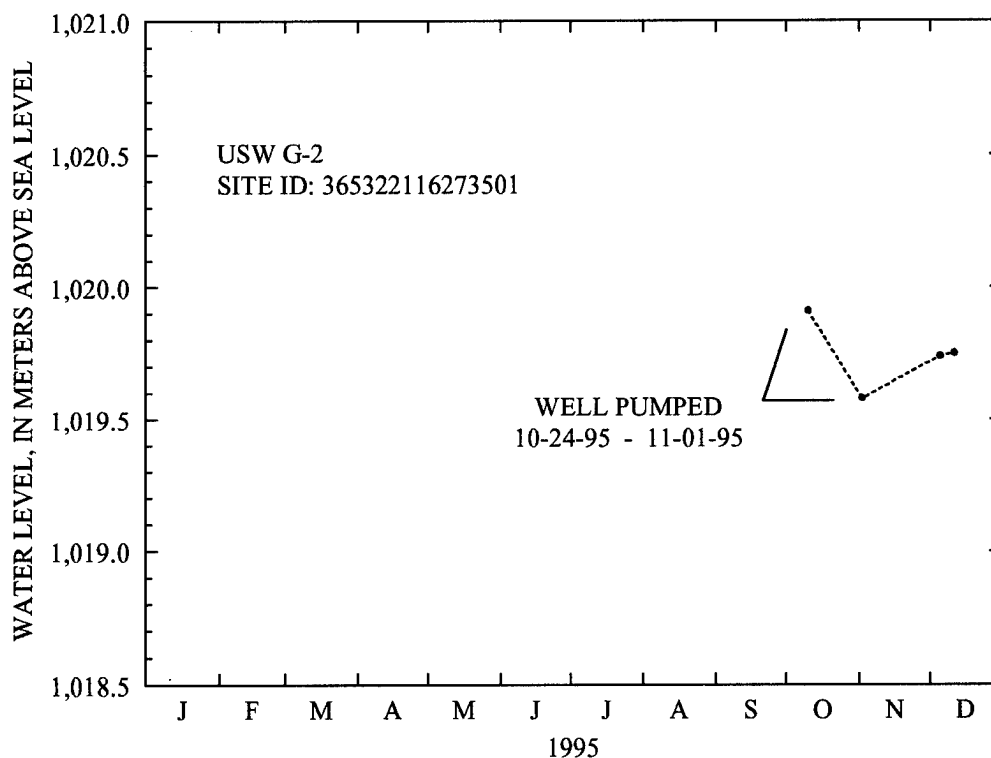


Figure 21. Water-level altitudes, 1995, for well USW G-2.



## Well USW G-3

Information about the history of well USW G-3 and about previous data from the well was obtained from various sources. These sources are: Robison (1984); Robison (U.S. Geological Survey, written commun., 1986); Robison and others (1988); and Fenix & Scisson, Inc. (1987b, 1987c).

### Well specifications

#### 1. Location and identification:

Latitude and longitude: 36°49'05"N.; 116°28'01"W.

Nevada State Central Zone Coordinates (m): N 229,447; E 170,226.

U.S. Geological Survey Site ID: 364905116280101.

#### 2. Drilling and casing information:

Well started: January 8, 1982.

Well completed: March 21, 1982.

Drilling method: Rotary, using mostly air-foam, and occasional polymer added for circulating medium; many drilling problems encountered in upper part of borehole, including lost circulation and lost or stuck tools; borehole cored from 795 m to total drilled depth.

Bit diameter below water level: 222 mm to 792 m; 121 mm from 792 to 795 m; 100 mm from 795 m to total drilled depth.

Casing extending below water level: 126-mm inside diameter to 792 m; bottom casing back cemented; no perforations.

Total drilled depth: 1,533 m.

#### 3. Access to and description of depth interval for measuring water levels:

Casing, 126-mm inside diameter, extending from land surface to a depth of 792 m; saturated interval of borehole is within the Tram Tuff of the Crater Flat Group and the Lithic Ridge Tuff.

#### 4. Information for calculating water-level altitude:

Reference point: Top of metal tag on well casing; altitude 1,480.47 m (surveyed by U.S. Geological Survey, 1984).

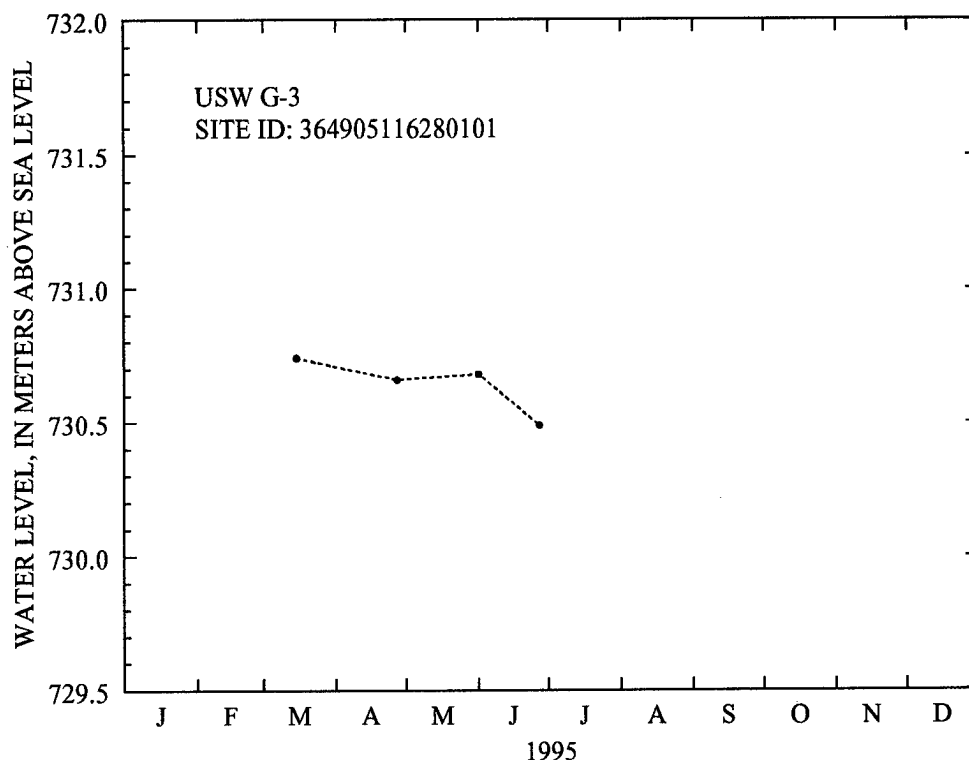
Measuring point: Top of access tube, 0.329 m above reference point.

Depth correction for borehole deviation from vertical: 0.564 m, based on approximate depth to water of 750 m (1990 data).

Well USW G-3 was measured periodically during 1995. Water-level measurements in USW G-3 were discontinued after June 1995. Measurements were made with the multiconductor cable unit with the following results:

Date	Measured water-level altitude (meters, above sea level)	Method of measuring water level
03-15-95	730.74	Multiconductor cable unit
04-27-95	730.66	Multiconductor cable unit
06-01-95	730.68	Multiconductor cable unit
06-27-95	730.49	Multiconductor cable unit

Water-level altitudes for well USW G-3 ranged from 730.49 to 730.68 m above sea level in 1995 (fig. 22). The mean water-level altitude of the 1995 periodic data was 730.64 m above sea level. This mean altitude was the same as the mean altitude of 730.64 m for 1994 (Graves and others, 1996).



**Figure 22.** Water-level altitudes, 1995, for well USW G-3.

## Well USW H-1

Information about the history of well USW H-1 and about previous data from the well was obtained from various sources. These sources are: Rush and others (1983); Rush and others (1984); Robison (1984); Robison (U.S. Geological Survey, written commun., 1986); Robison and others (1988); and Fenix & Scisson, Inc. (1987a, 1987c).

### Well specifications

#### 1. Location and identification:

Latitude and longitude: 36°51'57"N.; 116°27'12"W.

Nevada State Central Zone Coordinates (m): N 234,774; E 171,416.

U.S. Geological Survey Site ID: 365157116271201.

#### 2. Drilling and casing information:

Well started: September 3, 1980.

Well completed: January 25, 1981 (initial completion, including geophysical logging and hydraulic testing); July 6, 1982 (recompletion; four piezometers installed).

Drilling method: Rotary, using rock bits and air-foam circulating medium; cores obtained from selected intervals.

Bit diameter below water level: 311 mm to 688 m; 222 mm from 688 m to 1,829 m.

Casing extending below water level: 226-mm inside diameter to 687 m. Casing string is tack cemented and perforated below the water table. See section 3 for description of intervals open to water.

Total drilled depth: 1,829 m.

3. Access to and description of depth interval for measuring water levels:

Tube 1:

44-mm inside diameter, that has a 3.6-m-long well screen on bottom, extending from land surface to depth of 1,806 m; responds to depth interval from 1,783 to 1,814 m within older flows and tuffs beneath the Lithic Ridge Tuff;

Tube 2:

44 mm inside diameter, that has a 3.6-m-long well screen on bottom, extending from land surface to depth of 1,115 m; responds to depth interval from 1,097 to 1,123 m within the Tram Tuff of the Crater Flat Group, and lava flow and flow breccia beneath the Tram Tuff;

Tube 3:

44-mm inside diameter, that has a 3.6-m-long well screen on bottom, extending from land surface to depth of 741 m; responds to depth interval from 716 to 765 m within the Bullfrog Tuff of the Crater Flat Group;

Tube 4:

62-mm inside diameter, open ended, extending from land surface to depth of 640 m; responds to depth interval from 572 to 673 m within the Prow Pass Tuff of the Crater Flat Group.

Note: During recompletion, a gravel pack was placed in the vicinity of the well screens for tubes 1, 2, and 3; and other intervals were grouted with cement to ensure that the piezometers are hydraulically isolated from each other.

4. Information for calculating water-level altitude:

Reference point: Top of metal tag on well casing; altitude 1,303.10 m (surveyed by U.S. Geological Survey, 1984).

Measuring point: Top of access tubes, 0.311 m above reference point, all intervals.

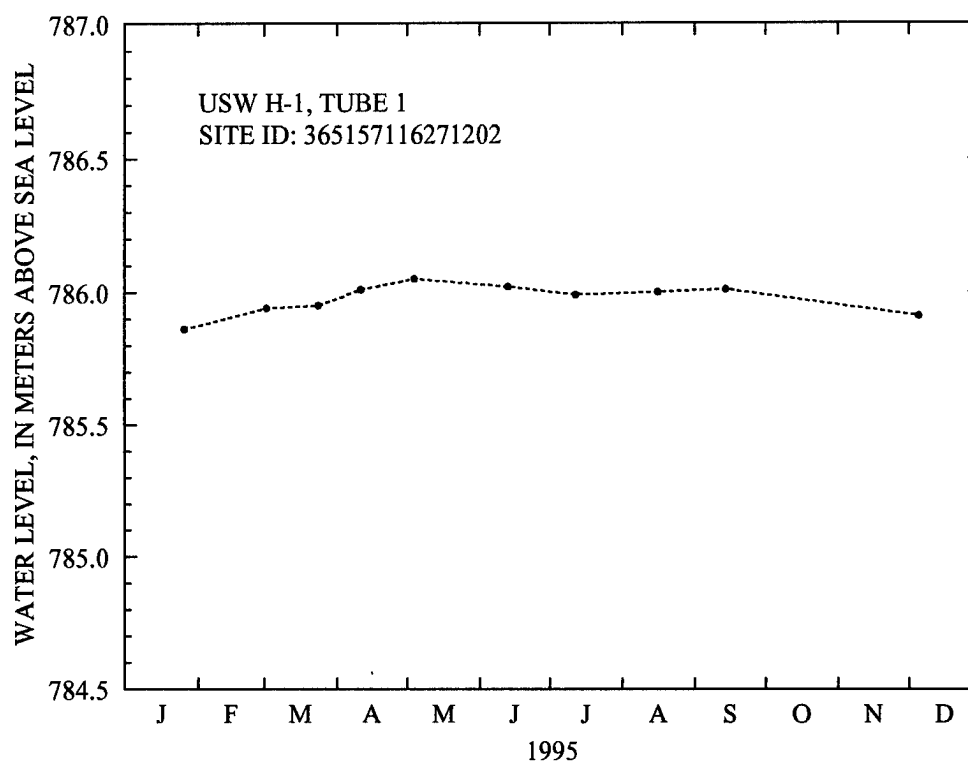
Depth correction for borehole deviation from vertical: 0.143 m in tube 1, based on approximate depth to water of 518 m (1990 data); 0.171 m in tube 2, based on approximate depth to water of 567 m (1993 data); 0.174 m in tubes 3 and 4, based on approximate depths to water of 572 m (1990 data).

Tube 1:

Well USW H-1, tube 1 was measured periodically during 1995. Measurements were made with Chain #3 and Chain #4 with the following results:

Date	Measured water-level altitude (meters, above sea level)	Method of measuring water level
01-26-95	785.86	Chain #4
03-02-95	785.94	Chain #3
03-24-95	785.95	Chain #3
04-11-95	786.01	Chain #3
05-04-95	786.05	Chain #3
06-13-95	786.02	Chain #3
07-12-95	785.99	Chain #3
08-16-95	786.00	Chain #3
09-14-95	786.01	Chain #3
12-05-95	785.91	Chain #3

Water-level altitudes for well USW H-1, tube 1 ranged from 785.86 to 786.05 m above sea level in 1995 (fig. 23). The mean water-level altitude of the 1995 periodic data was 785.97 m above sea level. This mean altitude was 0.23 m higher than the mean altitude of 785.74 m for 1994 (Graves and others, 1996).



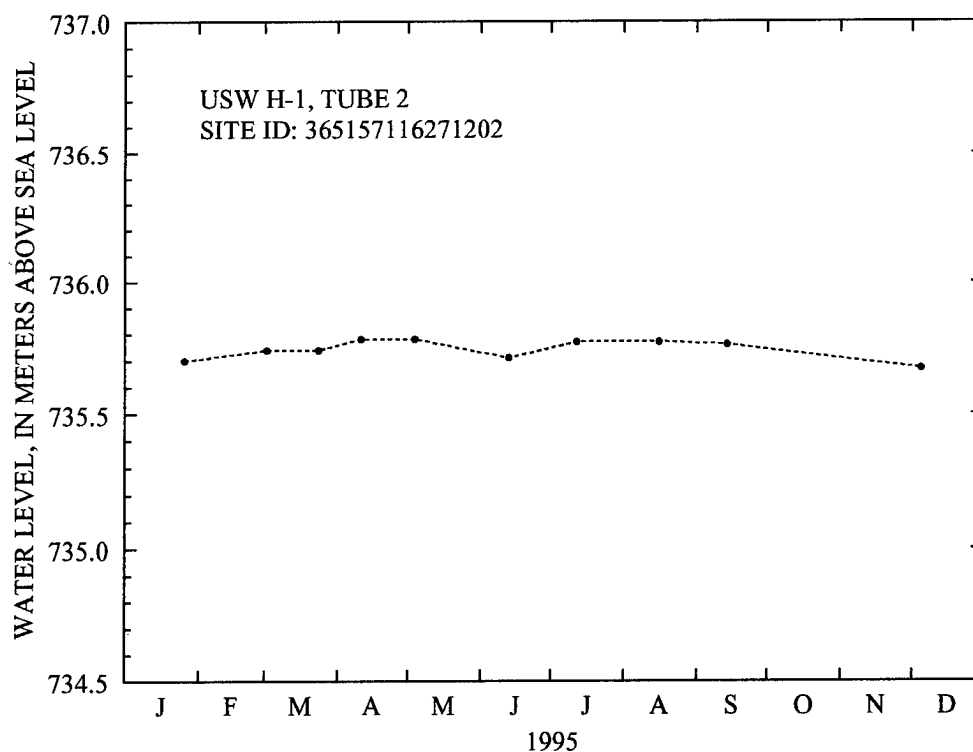
**Figure 23.** Water-level altitudes, 1995, for well USW H-1, tube 1.

Tube 2:

Well USW H-1, tube 2 was measured periodically during 1995. Measurements were made with Chain #3 and Chain #4 with the following results:

Date	Measured water-level altitude (meters, above sea level)	Method of measuring water level
01-26-95	735.70	Chain #4
03-02-95	735.74	Chain #3
03-24-95	735.74	Chain #3
04-11-95	735.78	Chain #3
05-04-95	735.78	Chain #3
06-13-95	735.71	Chain #3
07-12-95	735.77	Chain #3
08-16-95	735.77	Chain #3
09-14-95	735.76	Chain #4
12-05-95	735.67	Chain #3

Water-level altitudes for well USW H-1, tube 2 ranged from 735.67 to 735.78 m above sea level in 1995 (fig. 24). The mean water-level altitude of the 1995 periodic data was 735.74 m above sea level. This mean altitude was 0.12 m lower than the mean altitude of 735.86 m for 1994 (Graves and others, 1996).



**Figure 24.** Water-level altitudes, 1995, for well USW H-1, tube 2.

### Tube 3:

Well USW H-1, tube 3 was measured hourly and periodically during 1995. Hourly measurements were made until September 22, 1995; the day the transducer was removed from the well. During the period of hourly measurements, five calibrations of two transducers were performed. In addition, a calibration was completed on December 20, 1994 to calculate water-level altitudes at the beginning of 1995. Results of the transducer calibrations are as follows:

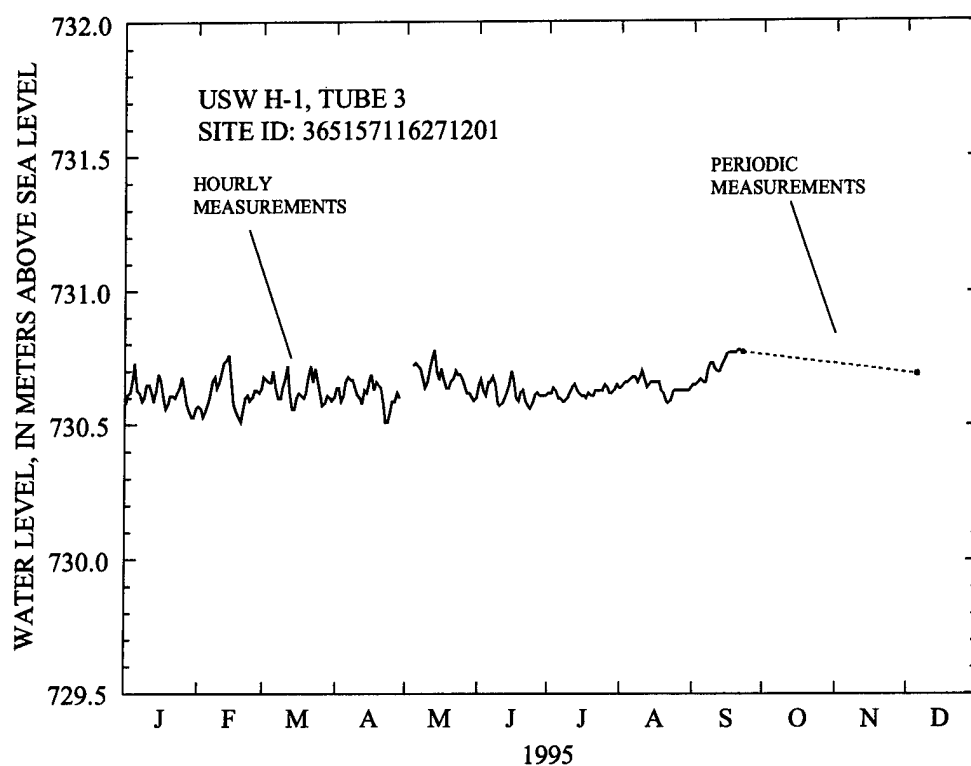
Transducer serial number	Calibration date	Slope (meters/millivolt)	Coefficient of determination	Water-level altitude (meters)	Method of measuring water level
567096	12-20-94	0.086	0.99	730.63	Chain #3
567096	04-11-95	.089	0.99	730.59	Tag with transducer
567096	05-03-95	Failed final calibration	Failed final calibration	730.68	Chain #3
670688	05-03-95	.089	0.99	730.68	Chain #3
670688	08-30-95	.087	1.00	730.63	Tag with transducer
670688	09-22-95	.088	0.99	730.77	Chain #3

Partial data were collected from well USW H-1, tube 3 on April 29 and May 3, 1995, and no data were collected from April 30 through May 2, 1995, because of a failed transducer. The transducer was replaced on May 3, 1995. Daily mean water-level altitudes were not calculated for April 29 through May 3, 1995. All other hourly transducer data for 1995 are considered to be valid.

Following the removal of the transducer, well USW H-1, tube 3 was measured periodically during the remainder of 1995. Measurements were made with Chain #3 with the following results:

Date	Measured water-level altitude (meters, above sea level)	Method of measuring water level
09-22-95	730.77	Chain #3
12-05-95	730.69	Chain #3

Daily mean water-level altitudes of the hourly data for well USW H-1, tube 3 ranged from 730.51 to 730.78 m above sea level in 1995 (fig. 25). Monthly mean water-level altitudes for January through September 1995, are listed in table 12. The mean water-level altitude of the 1995 hourly data was 730.64 m above sea level. This mean altitude was 0.06 m higher than the mean altitude of 730.58 m for 1994 (Graves and others, 1996).



**Figure 25.** Water-level altitudes, 1995, for well USW H-1, tube 3.

**Table 12.** Monthly mean water-level altitudes, 1995, for well USW H-1, tube 3.

[Monthly means were calculated regardless of the number of missing data. Daily means were not calculated if 6 or more consecutive hours of data were missing; --, data not available; NA, not applicable, well not instrumented during this month]

Month	Monthly mean water-level altitude (meters, above sea level)	Number of missing daily means
January	730.61	0
February	730.62	0
March	730.63	0
April	730.62	2
May	730.67	3
June	730.62	0
July	730.62	0
August	730.64	0
September	730.72	0
October	--	NA
November	--	NA
December	--	NA

#### Tube 4:

Well USW H-1, tube 4 was measured hourly and periodically during 1995. Hourly measurements were made until September 22, 1995; the day the transducer was removed from the well. During the period of hourly measurements, three calibrations of one transducer were performed. In addition, a calibration was completed on December 12, 1995, to calculate water-level altitudes at the beginning of 1995. Results of the transducer calibrations are as follows:

Transducer serial number	Calibration date	Slope (meters/millivolt)	Coefficient of determination	Water-level altitude (meters)	Method of measuring water level
621310	12-20-94	0.090	1.00	730.87	Tag with transducer
621310	04-11-95	.089	1.00	730.88	Tag with transducer
621310	07-11-95	.089	1.00	730.88	Chain #3
621310	09-22-95	.088	1.00	730.91	Chain #3

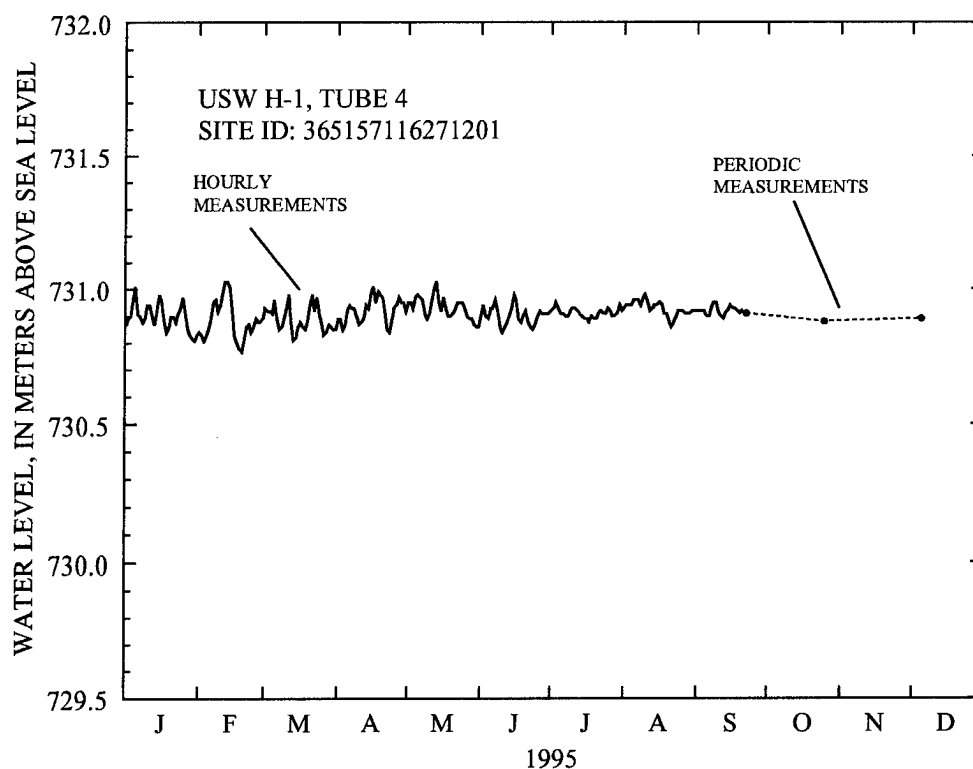
Spikes were removed from the data on April 7, and May 27, 1995. The reasons for the spikes are not known. All other hourly transducer data for 1995 are considered to be valid.

Following the removal of the transducer, well USW H-1, tube 4 was measured periodically during the remainder of 1995. Measurements were made with Chain #3 and the 2,800 foot reference steel tape with the following results:

Date	Measured water-level altitude (meters, above sea level)	Method of measuring water level
09-22-95	730.91	Chain #3
10-25-95	730.88	2,800 foot reference steel tape
12-05-95	730.89	Chain #3

Daily mean water-level altitudes of the hourly data for well USW H-1, tube 4 ranged from 730.77 to 731.03 m above sea level in 1995 (fig. 26). Monthly mean water-level altitudes are listed in table 13. The mean water-level altitude of the 1995 hourly data was 730.91 m above sea level. This mean altitude was 0.04 m higher than the mean altitude of 730.87 m for 1994 (Graves and others, 1996).





**Figure 26.** Water-level altitudes, 1995, for well USW H-1, tube 4.

**Table 13.** Monthly mean water-level altitudes, 1995, for well USW H-1, tube 4.

[Monthly means were calculated regardless of the number of missing data. Daily means were not calculated if 6 or more consecutive hours of data were missing; --, data not available; NA, not applicable, well not instrumented during this month]

Month	Monthly mean water-level altitude (meters, above sea level)	Number of missing daily means
January	730.90	0
February	730.88	0
March	730.89	0
April	730.92	0
May	730.93	0
June	730.90	0
July	730.91	0
August	730.93	0
September	730.92	0
October	--	NA
November	--	NA
December	--	NA

## Well USW H-3

Information about the history of well USW H-3 and about previous data from the well was obtained from various sources. These sources are: Thordarson, Rush, Spengler, and Waddell (1984); Thordarson, Rush, and Waddell (1984); Robison (1984); Robison (U.S. Geological Survey, written commun., 1986); Robison and others (1988); and Fenix & Scisson, Inc. (1987a, 1987c).

### Well specifications

#### 1. Location and identification:

Latitude and longitude: 36°49'42"N.; 116°28'00"W.

Nevada State Central Zone Coordinates (m): N 230,594; E 170,216.

U.S. Geological Survey Site ID: 364942116280001.

#### 2. Drilling and casing information:

Well started: January 27, 1982.

Well completed: March 19, 1982.

Drilling method: Rotary, using rock bits and air-foam circulating medium.

Bit diameter below water level: 375 mm to 808 m; 222 m from 808 m to 1,219 m.

Casing extending below water level: 253 mm diameter to 792 m, not perforated below the water level.

Total drilled depth: 1,219 m.

#### 3. Access to and description of depth intervals for measuring water levels:

##### Upper interval:

41-mm inside diameter open ended tubing, extending from land surface to depth of about 762 m; upper interval of well, from near water table to top of inflatable packer, is within bedded tuff and the Tram Tuff of the Crater Flat Group;

##### Lower interval:

62-mm inside diameter tubing that has an inflatable packer on bottom end extending from land surface to 1,061 m; lower interval from below packer to bottom of well, is within the Tram Member of the Crater Flat Tuff and the Lithic Ridge Tuff.

Note: Inflatable packer installed January 1983 at a depth of 1,190 m; removed late November 1983 during period of additional hydraulic testing; reinstalled during May 1984 at depth of 1,114 m; removed and reinstalled during December 1990 at a depth of 1,061 m.

#### 4. Information for calculating water-level altitude:

Reference point: Top of metal tag on well casing; altitude 1483.47 m (surveyed by U.S. Geological Survey, 1984).

Measuring point: Top of access tubes, 0.174 m, upper interval; 0.201 m, lower interval. Each measuring point above reference point.

Depth correction for borehole deviation from vertical: 0.079 m, upper interval, based on approximate depth to water of 752 m (1990 data); 0.058 m, lower interval, based on approximate depth to water of 728 m (1990 data).

Well USW H-3 upper interval was measured hourly during 1995. Hourly measurements were made until September 21, 1995; the day the transducer was removed from the well. During the period of hourly

measurements, three calibrations of one transducer were performed. In addition, a calibration was completed on December 07, 1994, to calculate water-level altitudes at the beginning of 1995. Results of the transducer calibrations are as follows:

Transducer serial number	Calibration date	Slope (meters/millivolt)	Coefficient of determination	Water-level altitude (meters)	Method of measuring water level
621315	12-07-94	0.089	1.00	731.22	Tag with transducer
621315	04-20-95	.089	1.00	731.35	Tag with transducer
621315	07-26-95	.090	1.00	731.32	2,800 foot reference steel tape
621315	09-21-95	.091	1.00	731.28	Tag with transducer

Partial data were collected on August 8, 1995, because the DCP was off line this date for calibration of the lower interval. A daily mean water-level altitude was not calculated for this date. All other hourly transducer data for 1995 are considered to be valid.

During the September 21, 1995, calibration of well USW H-3 upper interval Chain #4 broke inside of the monitoring tube blocking access to the water table. This blockage prevented any further water level measurements from being made in the upper interval during 1995.

Daily mean water-level altitudes of the hourly data for well USW H-3 upper interval ranged from 731.15 to 731.42 m above sea level in 1995 (fig. 27). Monthly mean water-level altitudes for January through September 1995, are listed in table 14. The mean water-level altitude of the 1995 hourly data was 731.29 m above sea level. This mean altitude was 0.05 m higher than the mean altitude of 731.24 m for 1994 (Graves and others, 1996).

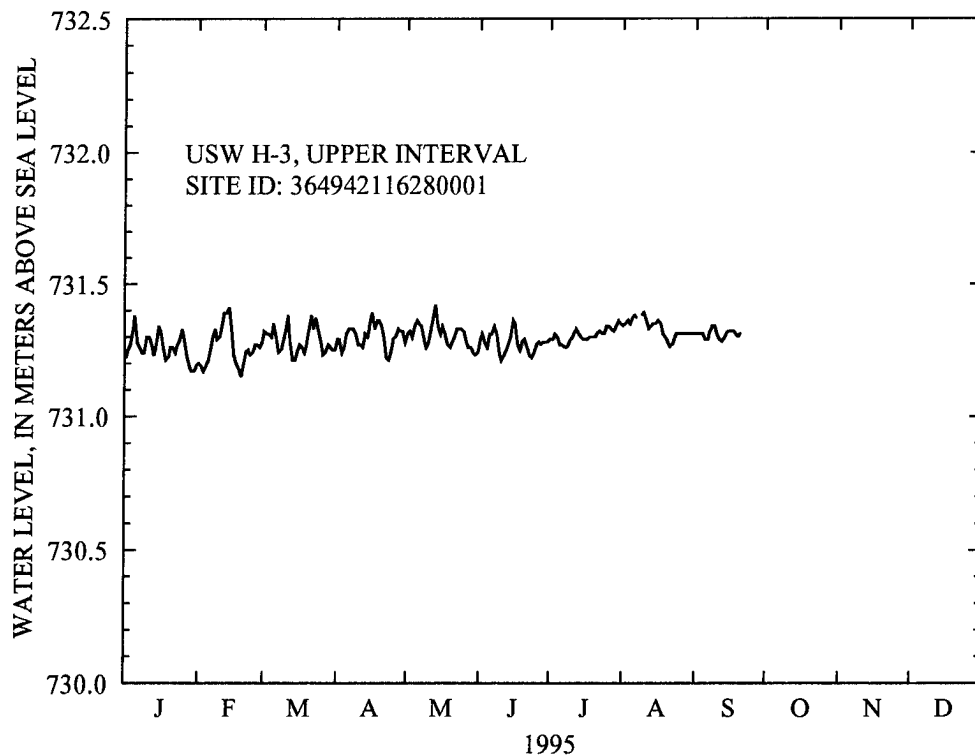


Figure 27. Water-level altitudes, 1995, for well USW H-3, upper interval.

**Table 14.** Monthly mean water-level altitudes, 1995, for well USW H-3 upper interval

[Monthly means were calculated regardless of the number of missing data. Daily means were not calculated if 6 or more consecutive hours of data were missing; --, data not available; NA, not applicable, well not instrumented during this month]

Month	Monthly mean water-level altitude (meters, above sea level)	Number of missing daily means
January	731.26	0
February	731.26	0
March	731.29	0
April	731.30	0
May	731.31	0
June	731.28	0
July	731.31	0
August	731.33	1
September	731.31	0
October	--	NA
November	--	NA
December	--	NA

Well USW H-3 lower interval was measured hourly and periodically during 1995. Hourly measurements were made until September 21, 1995; the day the transducer was removed from the well. During the period of hourly measurements, four calibrations of one transducer were performed. In addition, a calibration was completed on December 7, 1994, to calculate water-level altitudes at the beginning of 1995. Results of the transducer calibrations are as follows:

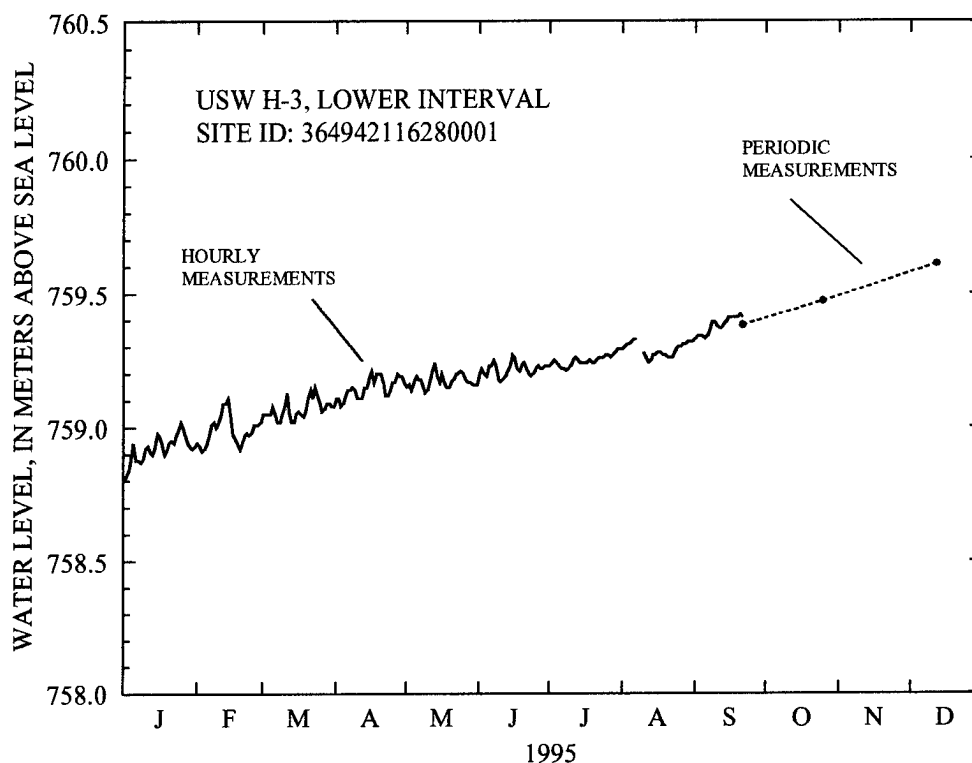
Transducer serial number	Calibration date	Slope (meters/millivolt)	Coefficient of determination	Water-level altitude (meters)	Method of measuring water level
621282	12-07-94	0.088	1.00	758.69	2,800 foot reference steel tape
621282	04-20-95	.088	1.00	759.22	Tag with transducer
621282	08-08-95	.087	1.00	759.30	2,800 foot reference steel tape
621282	08-09-95	.087	1.00	759.37	2,800 foot reference steel tape
621282	09-21-95	.087	1.00	759.38	Chain #3

Partial data were collected on August 8 and 9, 1995, two days the well was calibrated. Daily mean water-level altitudes were not calculated for these two dates. All other hourly transducer data for 1995 are considered to be valid.

Following the removal of the transducer, well USW H-3 lower interval was measured periodically during the remainder of 1995. Measurements were made with Chain #3 and the 2,800 foot reference steel tape with the following results:

Date	Measured water-level altitude (meters, above sea level)	Method of measuring water level
09-21-95	759.38	Chain #3
10-25-95	759.47	2,800 foot reference steel tape
12-12-95	759.61	Chain #3

Daily mean water-level altitudes of the hourly data for well USW H-3 lower interval ranged from 758.80 to 759.42 m above sea level in 1995 (fig. 28). This range was extended to 759.61 m by the manual water-level measurement made on December 12, 1995. Monthly mean water-level altitudes for January through September 1995, are listed in table 15. The mean water-level altitude for 1995 was 759.23 m above sea level. Because of the significant rising trend of the water level in this well, the 1995 mean was calculated by averaging the January through September monthly mean water-level altitudes with the October and December manual water-level measurements. This mean altitude was 1.05 m higher than the mean altitude of 758.18 m for 1994 (Graves and others, 1996). The reason for this significant difference in mean water levels, is because the inflatable packer, which divides the well into two intervals, was moved to a different location on December 14, 1990. Following this move the water level in the lower interval has been rising, in the process of reaching equilibration, to a new static water-level.



**Figure 28.** Water-level altitudes, 1995, for well USW H-3, lower interval.

**Table 15.** Monthly mean water-level altitudes, 1995, for well USW H-3 lower interval.

[Monthly means were calculated regardless of the number of missing data. Daily means were not calculated if 6 or more consecutive hours of data were missing; --, data not available; NA, not applicable, well not instrumented during this month]

Month	Monthly mean water-level altitude (meters, above sea level)	Number of missing daily means
January	758.92	0
February	758.99	0
March	759.07	0
April	759.15	0
May	759.17	0
June	759.22	0
July	759.25	0
August	759.29	2
September	759.38	0
October	--	NA
November	--	NA
December	--	NA

## Well USW H-4

Information about the history of well USW H-4 and about previous data from the well was obtained from various sources. These sources are: Whitfield and others (1984); Whitfield and others (1985); Robison (1984); Robison (U.S. Geological Survey, written commun., 1986); Robison and others (1988); Erickson and Waddell (1985); and Fenix & Scisson, Inc. (1987a, 1987c).

### Well specifications

#### 1. Location and identification:

Latitude and longitude: 36°50'32"N.; 116°26'54"W.

Nevada State Central Zone Coordinates (m): N 232,149; E 171,880.

U.S. Geological Survey Site ID: 365032116265401.

#### 2. Drilling and casing information:

Well started: March 22, 1982.

Well completed: June 7, 1982.

Drilling method: Rotary, using rock bits and air-foam circulating medium; cores obtained from selected intervals.

Bit diameter below water level: 375 mm to 564 m; 222 mm from 564 m to 1,219 m.

Casing extending below water level: 253 mm diameter to 561 m, perforated below the water level.

Total drilled depth: 1,219 m.

3. Access to and description of depth interval for measuring water levels:

Upper interval:

48-mm inside diameter open-ended tubing, extending from land surface to depth of 525 m; upper interval of well near water table to top of inflatable packer is within the Prow Pass, Bullfrog, and Tram Tuffs of the Crater Flat Group, bedded tuff, and upper Lithic Ridge Tuff;

Lower interval:

62-mm inside diameter tubing with inflatable packer on bottom end, extending from land surface to 1,188 m; lower interval of well is within the Lithic Ridge Tuff.

4. Information for calculating water-level altitude:

Reference point: Top of metal tag on well casing; altitude 1,248.74 m (surveyed by U.S. Geological Survey, 1984).

Measuring point: Top of access tubes, 0.597 m, upper interval; 0.308 m, lower interval. Both measuring points above reference point.

Depth correction for borehole deviation from vertical: 0.064 m, based on approximate depth to water of 518 m (1990 data).

Well USW H-4 upper interval was measured hourly and periodically during 1995. Hourly measurements were made until September 25, 1995; the day the transducer was removed from the well. During the period of hourly measurements, four calibrations of one transducer were performed. In addition, a calibration was completed on November 15, 1994, to calculate water-level altitudes at the beginning of 1995. Results of the transducer calibrations are as follows:

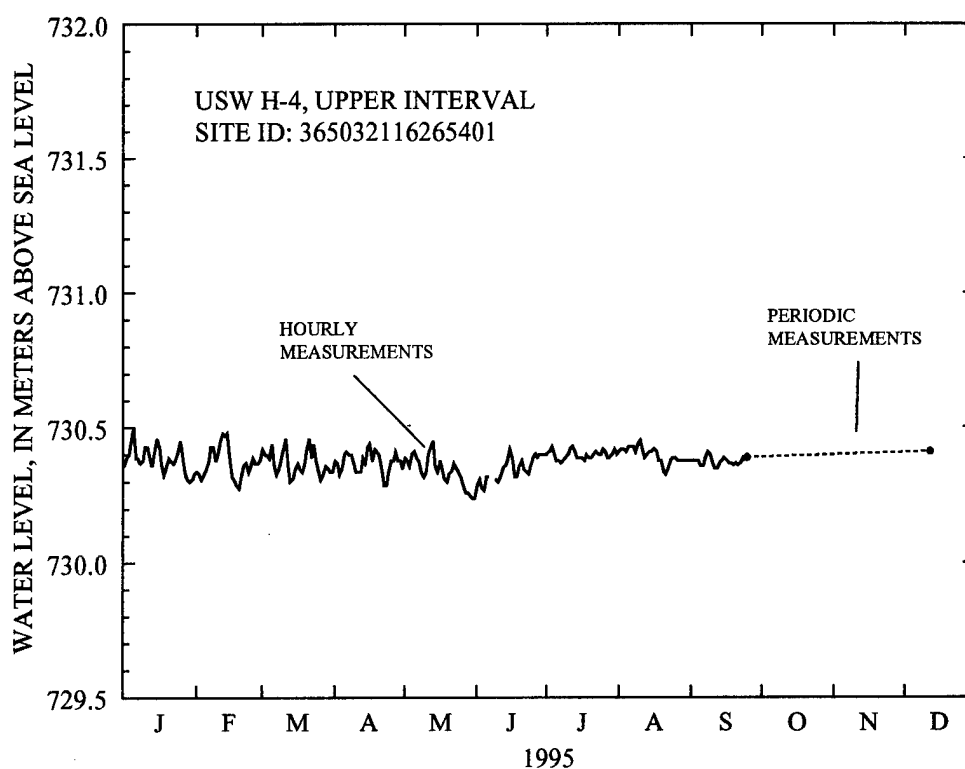
Transducer serial number	Calibration date	Slope (meters/millivolt)	Coefficient of determination	Water-level altitude (meters)	Method of measuring water level
592474	11-15-94	0.089	1.00	730.38	Tag with transducer
592474	02-15-95	.089	1.00	730.38	Chain #3
592474	06-08-95	.091	1.00	730.36	Tag with transducer
592474	06-27-95	.092	1.00	730.37	Tag with transducer
592474	09-25-95	.094	1.00	730.39	Chain #3

Partial data were collected June 7 and 8, 1995, because the transducer was out of the well for calibration these two days. Daily mean water-level altitudes were not calculated for June 7 or 8, 1995. All other hourly transducer data for 1995 are considered to be valid.

Following the removal of the transducer, well USW H-4 upper interval was measured periodically during the remainder of 1995. Measurements were made with Chain #3 with the following results:

Date	Measured water-level altitude (meters, above sea level)	Method of measuring water level
09-25-95	730.39	Chain #3
12-12-95	730.41	Chain #3

Daily mean water-level altitudes of the hourly data for well USW H-4 upper interval ranged from 730.24 to 730.50 m above sea level in 1995 (fig. 29). Monthly mean water-level altitudes for January through September 1995, are listed in table 16. The mean water-level altitude of the 1995 hourly data was 730.37 m above sea level. This mean altitude was 0.02 m lower than the mean altitude of 730.39 m for 1994 (Graves and others, 1996).



**Figure 29.** Water-level altitudes, 1995, for well USW H-4, upper interval.

**Table 16.** Monthly mean water-level altitudes, 1995, for well USW H-4 upper interval.

[Monthly means were calculated regardless of the number of missing data. Daily means were not calculated if 6 or more consecutive hours of data were missing; --, data not available; NA, not applicable, well not instrumented during this month]

Month	Monthly mean water-level altitude (meters, above sea level)	Number of missing daily means
January	730.39	0
February	730.37	0
March	730.37	0
April	730.37	0
May	730.34	0
June	730.35	2
July	730.40	0
August	730.40	0
September	730.37	0
October	--	NA
November	--	NA
December	--	NA



Well USW H-4 lower interval was measured hourly and periodically during 1995. Hourly measurements were made until September 25, 1995; the day the transducer was removed from the well. During the period of hourly measurements, four calibrations of two transducers were performed. In addition, a calibration was completed on November 15, 1994, to calculate water-level altitudes at the beginning of 1995. Results of the transducer calibrations are as follows:

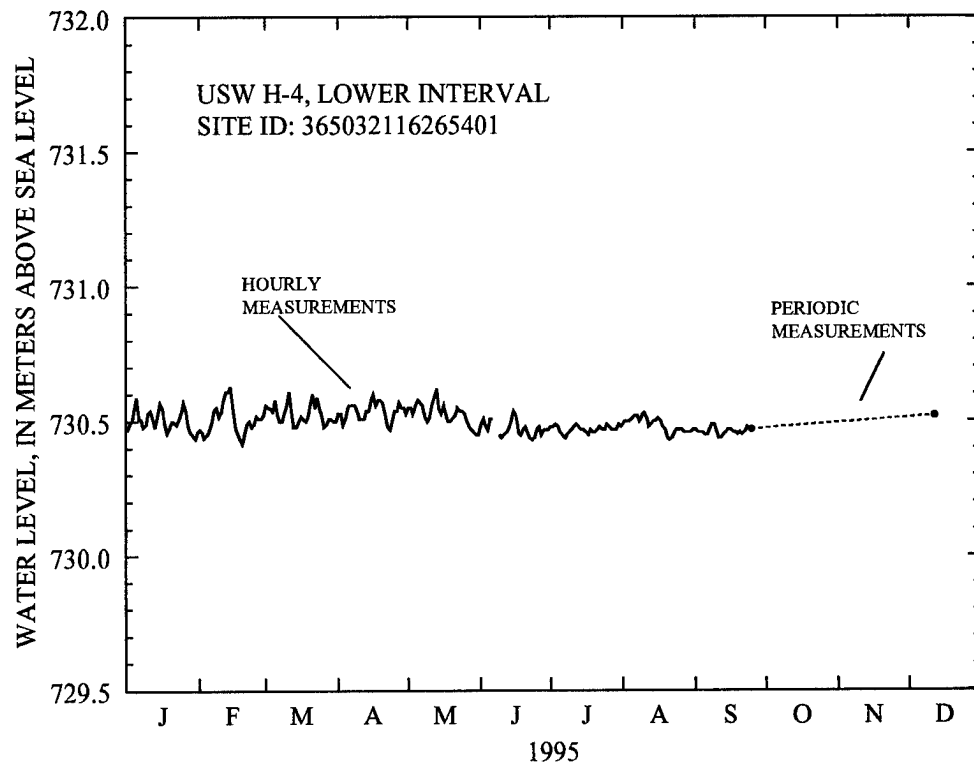
Transducer serial number	Calibration date	Slope (meters/millivolt)	Coefficient of determination	Water-level altitude (meters)	Method of measuring water level
567098	11-15-94	0.089	1.00	730.44	Tag with transducer
567098	02-15-95	.089	1.00	730.53	Tag with transducer
567098	06-07-95	.089	1.00	730.51	Chain #3
621287	06-08-95	.089	1.00	730.50	Chain #3
621287	09-25-95	.090	1.00	730.47	Chain #3

Partial data were collected on June 7 and 8, 1995, and spikes in the data were removed on May 15, 1995. The transducer was out of the well for calibration for June 7 and 8 and the spikes were due to changing the DCP scan time from 1 to 10 minutes on May 15. Because of the length of time the transducer was out of the well on June 7 and 8, daily mean water-level altitudes were not calculated for either of these two dates. All other hourly transducer data for 1995 are considered to be valid.

Following the removal of the transducer, well USW H-4 lower interval was measured periodically during the remainder of 1995. Measurements were made with Chain #3 with the following results:

Date	Measured water-level altitude (meters, above sea level)	Method of measuring water level
09-25-95	730.47	Chain #3
12-12-95	730.52	Chain #3

Daily mean water-level altitudes of the hourly data for well USW H-4 lower interval ranged from 730.42 to 730.63 m above sea level in 1995 (fig. 30). Monthly mean water-level altitudes for January through September 1995, are listed in table 17. The mean water-level altitude of the 1995 hourly data was 730.50 m above sea level. This mean altitude was 0.01 m higher than the mean altitude of 730.49 m for 1994 (Graves and others, 1996).



**Figure 30.** Water-level altitudes, 1995, for well USW H-4, lower interval.

**Table 17.** Monthly mean water-level altitudes, 1995, for well USW H-4 lower interval.

[Monthly means were calculated regardless of the number of missing data. Daily means were not calculated if 6 or more consecutive hours of data were missing; --, data not available; NA, not applicable, well not instrumented during this month]

Month	Monthly mean water-level altitude (meters, above sea level)	Number of missing daily means
January	730.51	0
February	730.51	0
March	730.53	0
April	730.54	0
May	730.53	0
June	730.47	2
July	730.47	0
August	730.48	0
September	730.46	0
October	--	NA
November	--	NA
December	--	NA

## Well USW H-5

Information about the history of well USW H-5 and about previous data from the well was obtained from various sources. These sources are: Bentley and others (1983); Robison (1984); Robison (U.S. Geological Survey, written commun., 1986); Robison and others (1988); Fenix & Scisson, Inc. (1987a, 1987c); Carr (1988, p. 37); and Sawyer and others (1994, p. 1305).

### Well specifications

#### 1. Location and identification:

Latitude and longitude: 36°51'22"N.; 116°27'55"W.

Nevada State Central Zone Coordinates (m): N 233,670; E 170,355.

U.S. Geological Survey Site ID: 365122116275502.

#### 2. Drilling and casing information:

Well started: May 19, 1982.

Well completed: August 1, 1982.

Drilling method: Rotary, using rock bits and air-foam circulating medium; cores obtained from selected intervals.

Bit diameter below water level: 375 mm to 792 m; 222 mm from 792 m to 1,219 m.

Casing extending below water level: 255 mm diameter to 788 m, perforated below the water level.

Total drilled depth: 1,219 m.

#### 3. Access to and description of depth interval for measuring water levels:

##### Upper interval:

48-mm inside-diameter open-ended tubing, extending from land surface to a depth of 709 m; upper saturated interval of the borehole is within the Bullfrog and Tram Tuffs of the Crater Flat Group, bedded tuff, and unnamed lava beneath the Tram Tuff.

##### Lower interval:

62-mm inside-diameter tubing that has a 3.6-m-long inflatable packer on bottom end, extending from land surface to 846 m; lower interval is within the Tram Tuff of the Crater Flat Group, and within an unnamed lava unit below the Tram Tuff.

Note: The packer was reset at its present depth (846 m) on 3/25/93, from its previous depth of 1,091 m (G.M. O'Brien, U.S. Geological Survey, written commun., 1993).

#### 4. Information for calculating water-level altitude:

Reference point: Top of metal tag on well casing; altitude 1,478.94 m (surveyed by U.S. Geological Survey, 1984).

Measuring point: Top of access tubes, 0.329 m, upper interval; 0.235 m, lower interval. Both measuring points above the reference point.

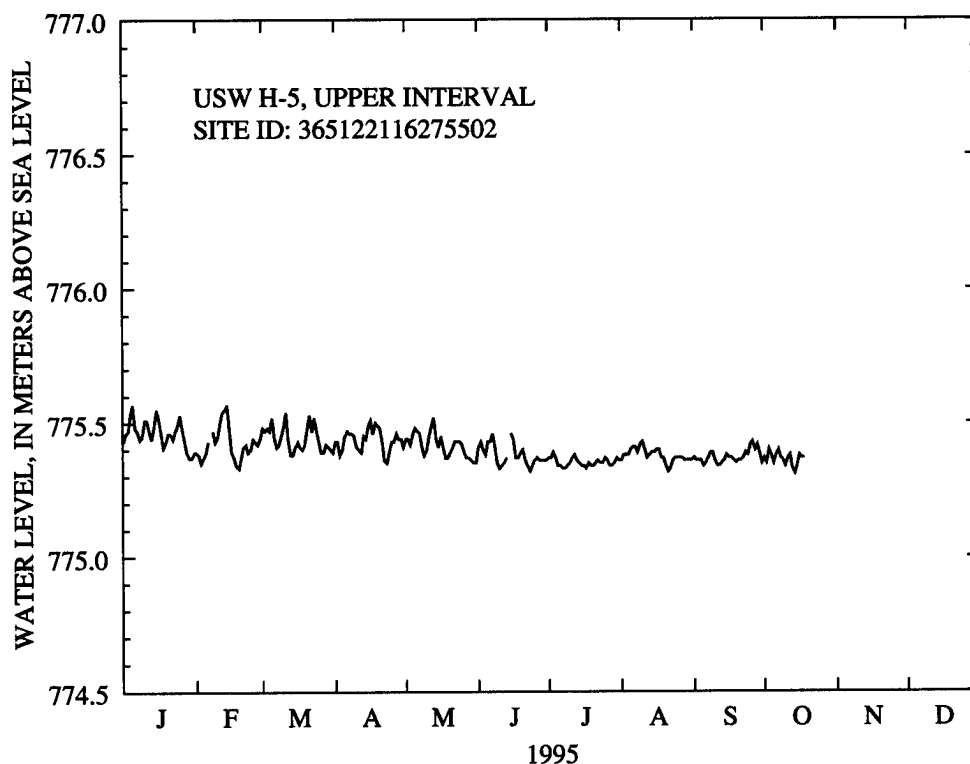
Depth correction for borehole deviation from vertical: 0.079 m, based on approximate depth to water of 703 m (1990 data).

Well USW H-5 upper interval was measured hourly during all of 1995. During 1995 three calibrations of one transducer were performed. In addition, calibrations completed on October 14, 1994, and June 4, 1996, were used to calculate water levels for 1995. Results of the transducer calibrations are as follows:

Transducer serial number	Calibration date	Slope (meters/millivolt)	Coefficient of determination	Water-level altitude (meters)	Method of measuring water level
570799	10-14-94	0.088	1.00	775.59	Tag with transducer
570799	02-07-95	.089	1.00	775.46	Chain #3
570799	06-19-95	.089	1.00	775.38	Tag with transducer
570799	12-18-95	.089	1.00	775.40	Tag with transducer
570799	06-04-96	.088	1.00	775.44	Chain #3

No data were collected for this well from October 19, through December 31, 1995. The data were lost because of wiring problems caused by the removal of a barometer which was hooked into well USW H-5's data collector. Partial data were collected June 14, 1995, because the DCP was off line for calibration of the lower interval. Spikes were removed from the data on February 7 and June 19, 1995. The spikes were due to the calibration of the transducer these two days. A spike was also removed from the data on October 9, 1995. The reason for the spike is not known. Daily mean water-level altitudes were not calculated for February 7, June 14, or October 19 through December 31, 1995. All other hourly transducer data for 1995 are considered to be valid.

Daily mean water-level altitudes of the hourly data for well USW H-5 upper interval ranged from 775.31 to 775.57 m above sea level in 1995 (fig. 31). Monthly mean water-level altitudes for 1995, are listed in table 18. The mean water-level altitude of the 1995 hourly data was 775.40 m above sea level. This mean altitude was 0.08 m lower than the mean altitude of 775.48 m for 1994 (Graves and others, 1996).



**Figure 31.** Water-level altitudes, 1995, for well USW H-5, upper interval.

**Table 18.** Monthly mean water-level altitudes, 1995, for well USW H-5 upper interval

[Monthly means were calculated regardless of the number of missing data. Daily means were not calculated if 6 or more consecutive hours of data were missing; --, data not available]

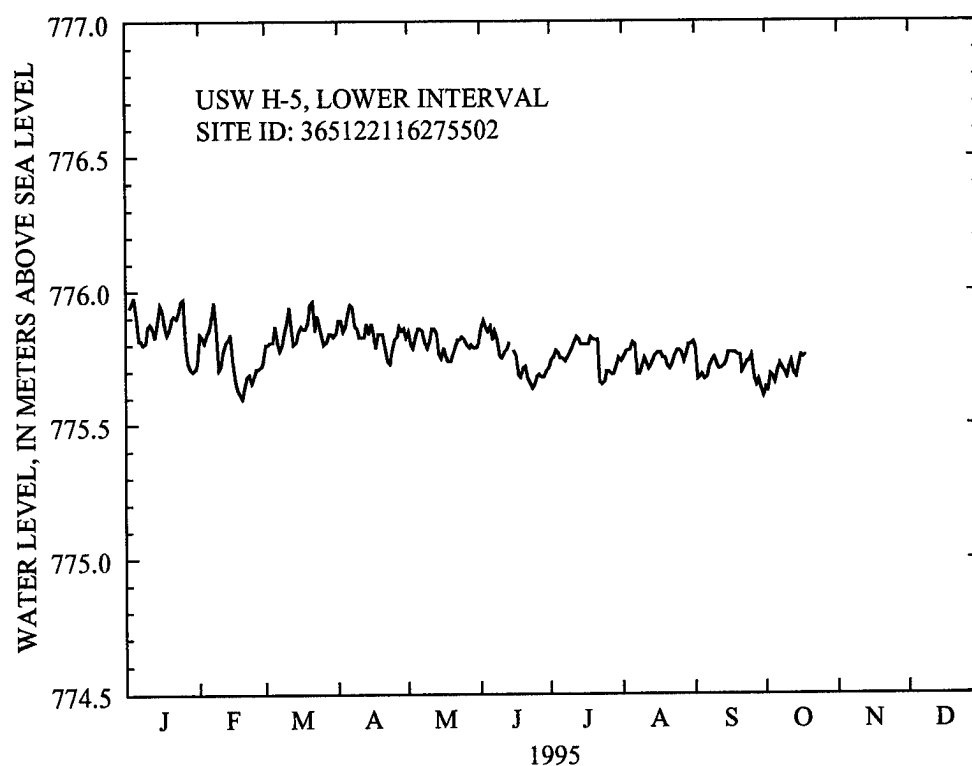
Month	Monthly mean water-level altitude (meters, above sea level)	Number of missing daily means
January	775.46	0
February	775.42	1
March	775.44	0
April	775.44	0
May	775.42	0
June	775.38	1
July	775.35	0
August	775.38	0
September	775.37	0
October	775.36	13
November	--	30
December	--	31

Well USW H-5 lower interval was measured hourly during all of 1995. During 1995 four calibrations of two transducers were performed. In addition, calibrations completed on October 14, 1994, and June 5, 1996, were used to calculate water levels for 1995. Results of the transducer calibrations are as follows:

Transducer serial number	Calibration date	Slope (meters/ millivolt)	Coefficient of determination	Water-level altitude (meters)	Method of measuring water level
525611	10-14-94	0.356	1.00	775.79	Tag with transducer
525611	02-08-95	.353	1.00	775.74	Chain #3
525611	06-14-95	.354	1.00	775.73	Chain #3
631046	06-14-95	.355	1.00	775.73	Chain #3
631046	12-19-95	.376	0.99	775.76	Tag with transducer
631046	06-05-96	.356	1.00	775.71	Chain #3

No data were collected for this well from October 20, through December 31, 1995. The data were lost because of wiring problems caused by the removal of a barometer which was hooked into well USW H-5's data collector. Partial data were collected June 14, 1995, because the DCP was off line for calibration of the lower interval. Partial data were also collected on October 19, 1995, the first day of wiring problems. A spike was removed from the data on October 9, 1995. The reason for the spike is not known. A daily mean value was not collected for January 1, 1995, because the 2400 reading of the previous day, December 31, 1994, was removed. Daily mean water-level altitudes were also not calculated for June 14 or for October 19 through December 31, 1995. All other hourly transducer data for 1995 are considered to be valid.

Daily mean water-level altitudes of the hourly data for well USW H-5 lower interval ranged from 775.60 to 775.98 m above sea level in 1995 (fig. 32). Monthly mean water-level altitudes for 1995, are listed in table 19. The mean water-level altitude of the 1995 hourly data was 775.78 m above sea level. This mean altitude was 0.13 m higher than the mean altitude of 775.65 m for 1994 (Graves and others, 1996).



**Figure 32.** Water-level altitudes, 1995, for well USW H-5, lower interval.

**Table 19.** Monthly mean water-level altitudes, 1995, for well USW H-5 lower interval.

[Monthly means were calculated regardless of the number of missing data. Daily means were not calculated if 6 or more consecutive hours of data were missing; --, data not available]

Month	Monthly mean water-level altitude (meters, above sea level)	Number of missing daily means
January	775.86	1
February	775.75	0
March	775.85	0
April	775.85	0
May	775.81	0
June	775.75	1
July	775.76	0
August	775.76	0
September	775.72	0
October	775.70	13
November	--	30
December	--	31

## Well USW H-6

Information about the history of well USW H-6 and about previous data from the well was obtained from various sources. These sources are: Craig and others (1983); Robison (1984); Robison (U.S. Geological Survey, written commun., 1986); Robison and others (1988); and Fenix & Scisson, Inc. (1987a, 1987c).

### Well specifications

#### 1. Location and identification:

Latitude and longitude: 36°50'49"N.; 116°28'55"W.

Nevada State Central Zone Coordinates (m): N 232,654; E 168,882.

U.S. Geological Survey Site ID: 365049116285501.

#### 2. Drilling and casing information:

Well started: August 7, 1982.

Well completed: October 28, 1982.

Drilling method: Rotary, using rock bits and air-foam circulating medium; cores obtained from selected intervals.

Bit diameter below water level: 375 mm to 583 m; 222 mm from 583 to 1,216 m; 156 mm from 1,216 m to 1,220 m.

Casing extending below water level: 250-mm diameter to 581 m, perforated below the water level.

Total drilled depth: 1,220 m.

#### 3. Access to and description of depth interval for measuring water levels:

##### Upper interval:

48-mm inside diameter open-ended tubing, extending from land surface to 533 m; saturated upper interval is within the Prow Pass, Bullfrog, and Tram Tuffs of the Crater Flat Group, and bedded tuff;

##### Lower interval:

62-mm inside diameter tubing with inflatable packer on bottom end, extending from land surface to 752 m; lower interval is within the Tram Tuff of the Crater Flat Group, bedded tuff, an unnamed lava between the Tram Tuff and Lithic Ridge Tuff, (Carr, 1988 p. 37) (Sawyer and others, 1994, p. 1305) and the Lithic Ridge Tuff.

#### 4. Information for calculating water-level altitude:

Reference point: Top of metal tag on well casing; altitude 1,302.06 m (surveyed by U.S. Geological Survey, 1984).

Measuring point: Top of access tubes, 0.207 m above reference point, upper interval; 0.235 m above reference point, lower interval.

Depth correction for borehole deviation from vertical: 0.052 m, based on approximate depth to water of 526 m (1990 data).

Well USW H-6 upper interval was measured hourly and periodically during 1995. Hourly measurements were made until September 20, 1995; the day the transducer was removed from the well. During the period of hourly measurements, four calibrations of two transducers were performed. In addition, a calibration was completed on October 04, 1994, to calculate water-level altitudes at the beginning of 1995. Results of the transducer calibrations are as follows:

Transducer serial number	Calibration date	Slope (meters/millivolt)	Coefficient of determination	Water-level altitude (meters)	Method of measuring water level
567094	10-04-94	0.089	1.00	776.16	Tag with transducer
567094	02-01-95	.089	1.00	776.10	Tag with transducer
567094	06-12-95	Failed final calibration	Failed final calibration	776.07	Chain #3
621308	06-12-95	0.089	1.00	776.07	Chain #3
621308	07-25-95	.089	1.00	776.08	Chain #3
621308	09-20-95	.089	1.00	776.14	Chain #4

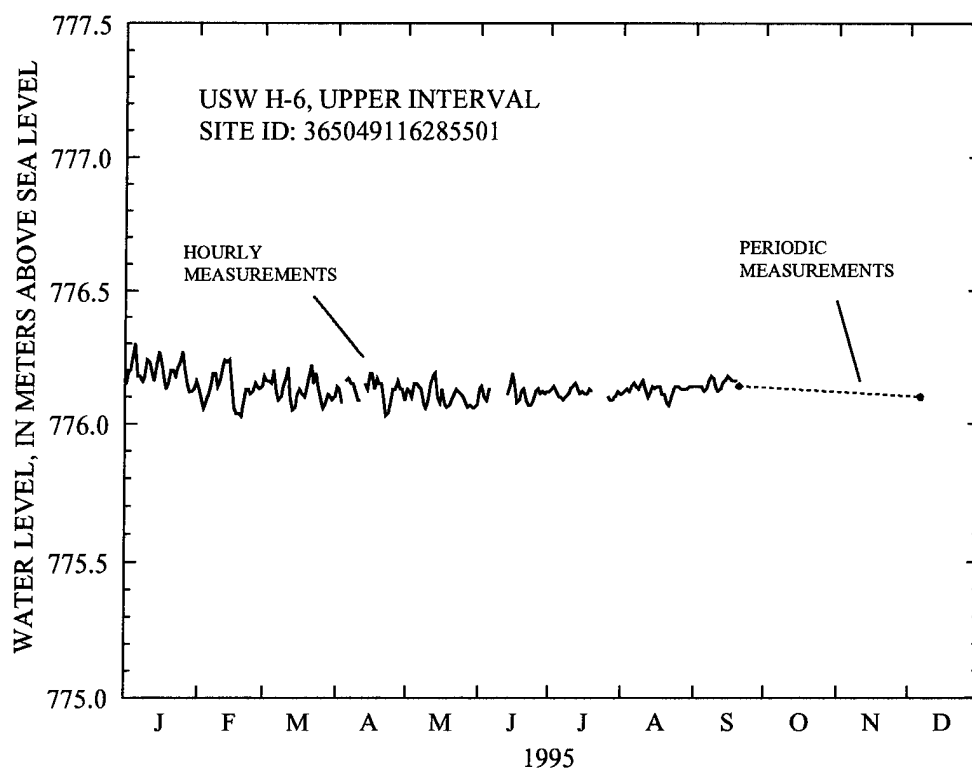
No data were collected for well USW H-6, upper interval from June 8 through 11, 1995. The data were lost because of failure of transducer 567094. The defective transducer was replaced on June 12, 1995. There was no data collected from July 21 through 25, 1995. These data were lost because of broken wires in the transducer. The transducer was repaired on July 25, 1995. Partial data were collected on April 4 and 12, 1995, because the DCP was off line these two days for calibration of the lower interval. Partial data were collected on July 20 and 25, 1995 because of the broken wire in the transducer. Daily mean water-level altitudes were not calculated for April 4, April 12, June 7 through 12, or July 20 through 25, 1995. All other hourly transducer data for 1995 are considered to be valid.

Following the removal of the transducer, well USW H-6 upper interval was measured periodically during the remainder of 1995. Measurements were made with Chains #3 and #4 with the following results:

Date	Measured water-level altitude (meters, above sea level)	Method of measuring water level
09-20-95	776.14	Chain #4
12-06-95	776.10	Chain #3

Daily mean water-level altitudes of the hourly data for well USW H-6 upper interval ranged from 776.03 to 776.30 m above sea level in 1995 (fig. 33). Monthly mean water-level altitudes for January through September 1995, are listed in table 20. The mean water-level altitude of the 1995 hourly data was 776.13 m above sea level. This mean altitude was 0.02 m higher than the mean altitude of 776.11 m for 1994 (Graves and others, 1996).





**Figure 33.** Water-level altitudes, 1995, for well USW H-6, upper interval.

**Table 20.** Monthly mean water-level altitudes, 1995, for well USW H-6 upper interval.

[Monthly means were calculated regardless of the number of missing data. Daily means were not calculated if 6 or more consecutive hours of data were missing; --, data not available; NA, not applicable, well not instrumented during this month]

Month	Monthly mean water-level altitude (meters, above sea level)	Number of missing daily means
January	776.19	0
February	776.13	0
March	776.13	0
April	776.13	2
May	776.10	0
June	776.11	6
July	776.11	6
August	776.13	0
September	776.15	0
October	--	NA
November	--	NA
December	--	NA

Well USW H-6 lower interval was measured hourly and periodically during 1995. Hourly measurements were made until September 20, 1995; the day the transducer was removed from the well. During the period of hourly measurements, five calibrations of two transducers were performed. In addition, a calibration was completed on November 17, 1994, to calculate water-level altitudes at the beginning of 1995. Results of the transducer calibrations are as follows:

Transducer serial number	Calibration date	Slope (meters/millivolt)	Coefficient of determination	Water-level altitude (meters)	Method of measuring water level
626830	11-17-94	0.354	1.00	776.04	Chain #3
626830	02-01-95	.353	1.00	776.04	Tag with transducer
626830	04-04-95	Failed final calibration	Failed final calibration	775.97	Chain #3
651110	04-04-95	0.356	1.00	775.97	Chain #3
651110	04-12-95	.371	0.99	775.94	Chain #3
651110	07-25-95	.355	1.00	776.03	Tag with transducer
651110	09-20-95	.465	0.98	775.97	Chain #4

Transducer 626830 failed its final calibration on April 4, 1995. This transducer was replaced with transducer 651110. Following the replacement of the transducer, no data were collected for well USW H-6, lower interval from April 4 through 12, 1995, because of a short in a wire in the brass connector of the transducer. Partial data were collected on April 2 and 3, 1995, because of the same short in the wire in the brass connector. The failed transducer was also due to the short in the wire however, this was not known until April 12, 1995. Partial data were collected on July 24 and 25, 1995 because the DCP was off line for the calibration of the upper interval. Daily mean water-level altitudes were not calculated for April 2 through 13, or July 24 and 25, 1995. All other hourly data for 1995 for well USW H-6 lower interval are considered to be valid.

Following the removal of the transducer, well USW H-6 lower interval was measured periodically during the remainder of 1995. Measurements were made with Chains #3 and #4 with the following results:

Date	Measured water-level altitude (meters, above sea level)	Method of measuring water level
09-20-95	775.97	Chain #4
12-06-95	775.98	Chain #3

Daily mean water-level altitudes of the hourly data for well USW H-6 lower interval ranged from 775.89 to 776.16 m above sea level in 1995 (fig. 34). Monthly mean water-level altitudes for January through September 1995, are listed in table 21. The mean water-level altitude of the 1995 hourly data was 776.01 m above sea level. This mean altitude was 0.02 m higher than the mean altitude of 775.99 m for 1994 (Graves and others, 1996).

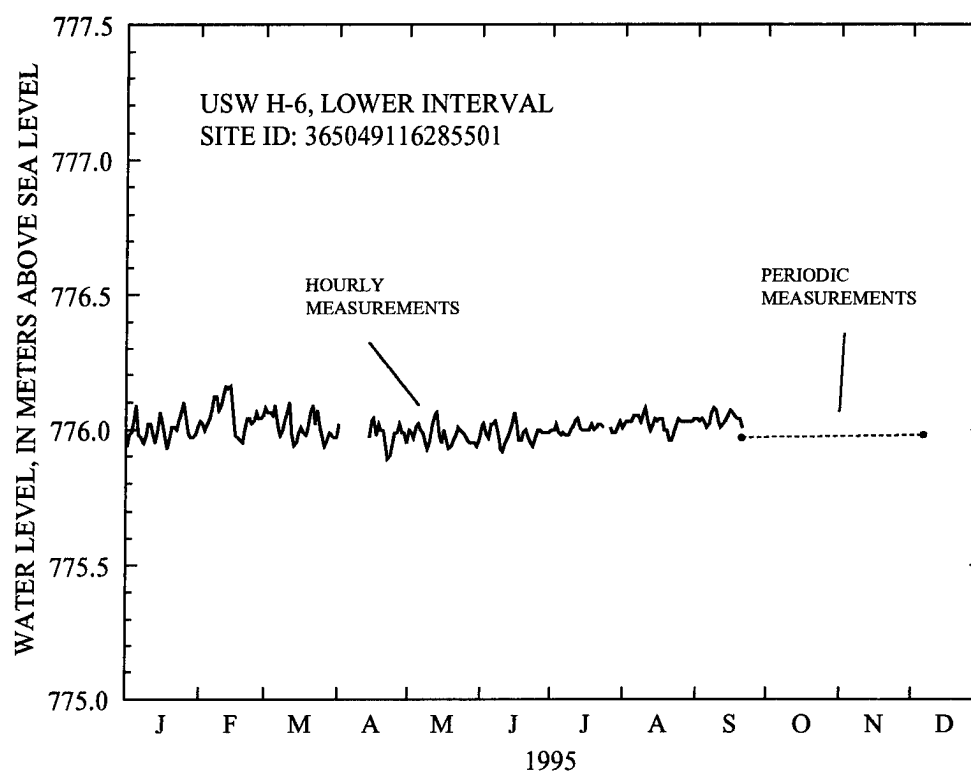


Figure 34. Water-level altitudes, 1995, for well USW H-6, lower interval.

**Table 21.** Monthly mean water-level altitudes, 1995, for well USW H-6 lower interval.

[Monthly means were calculated regardless of the number of missing data. Daily means were not calculated if 6 or more consecutive hours of data were missing; --, data not available; NA, not applicable, well not instrumented during this month]

Month	Monthly mean water-level altitude (meters, above sea level)	Number of missing daily means
January	776.00	0
February	776.05	0
March	776.01	0
April	775.98	12
May	775.98	0
June	775.99	0
July	776.01	2
August	776.03	0
September	776.04	0
October	---	NA
November	---	NA
December	---	NA

## Well J-11

Information about the history of well J-11 and about previous data from the well was obtained from Young (1972), and Fenix & Scisson, Inc. (1987c).

### Well specifications

#### 1. Location and identification:

Latitude and longitude: 36°47'06"N.; 116°17'06"W.

Nevada State Central Zone Coordinates (m): N 740,968; E 611,764.

U.S. Geological Survey Site ID: 364706116170601.

#### 2. Drilling and casing information:

Well started: June 4, 1957.

Well completed: July 19, 1957.

Drilling method: Cable-tool.

Bit diameter below water level: 400 mm.

Casing extending below water level: 308-mm inside-diameter casing extends from land surface to 404.5 m.

Total drilled depth: 405 m.

#### 3. Access to and description of depth interval for measuring water levels:

308-mm inside-diameter casing; the casing is perforated from 328.3 to 334.4 m and from 379.2 to 396.2 m. The well produces water from the basalt of Kiwi Mesa and from the welded-tuff aquifer, located within the Topopah Spring Tuff of the Paintbrush Group.

#### 4. Information for calculating water-level altitude:

Reference point: Chiseled "X" in concrete pad near well; altitude 1,049.45 m (surveyed by U.S. Geological Survey, 1993).

Measuring point: Top of casing, even with top of concrete block, 0.555 m above reference point.

Depth correction for borehole deviation from vertical is not available.

Well J-11 was measured periodically during 1995. Measurements were made with Chain #3, Chain #4, and the 2,800 foot reference steel tape with the following results:

Date	Measured water-level altitude (meters, above sea level)	Method of measuring water level
01-13-95	732.20	2,800 foot reference steel tape
02-10-95	732.26	Chain #4
03-09-95	732.28	Chain #3
04-05-95	732.28	Chain #3
05-08-95	732.23	Chain #3
06-06-95	732.27	Chain #3
07-13-95	732.25	Chain #3
07-24-95	732.25	Chain #3
08-29-95	732.29	Chain #3
09-14-95	732.24	2,800 foot reference steel tape
12-04-95	732.24	Chain #3

Water-level altitudes for well J-11 ranged from 732.20 to 732.29 m above sea level in 1995 (fig. 35). The mean water-level altitude of the 1995 periodic data was 732.25 m above sea level. This mean altitude was 0.04 m higher than the mean altitude of 732.21 m for 1994 (Graves and others, 1996).

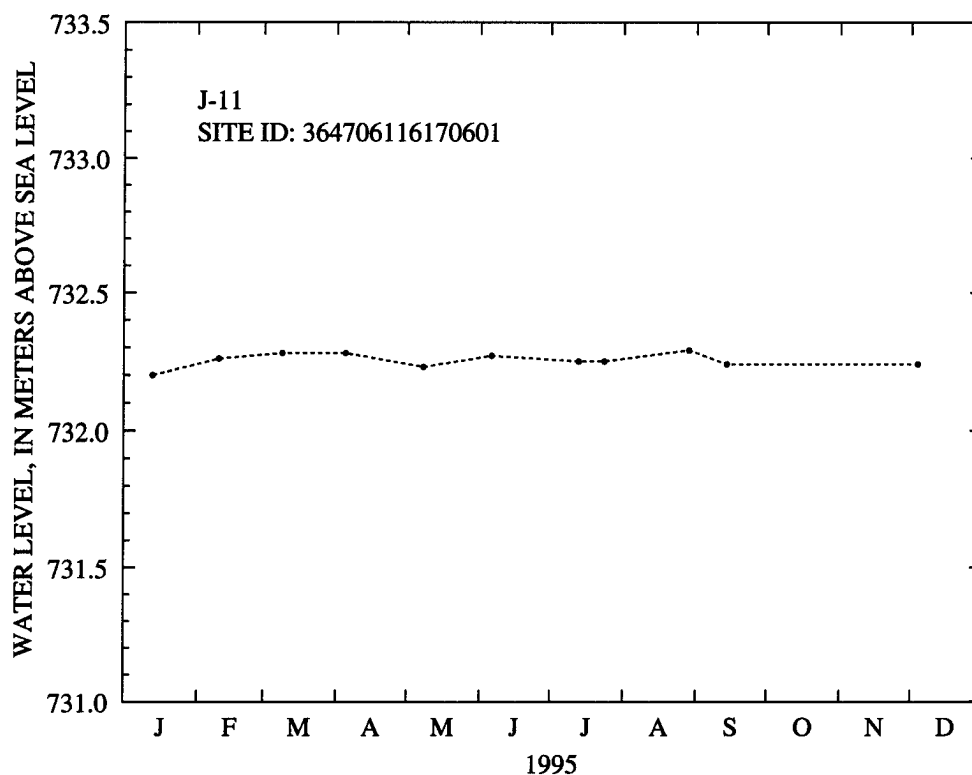


Figure 35. Water-level altitudes, 1995, for well J-11.

## Well J-12

Information about the history of well J-12 and about previous data from the well was obtained from Young (1972), and Fenix & Scisson, Inc. (1987c).

### Well specifications

#### 1. Location and identification:

Latitude and longitude: 36°45'54"N.; 116°23'24"W.

Nevada State Central Zone Coordinates (m): N 733,508; E 581,012.

U.S. Geological Survey Site ID: 364554116232401.

#### 2. Drilling and casing information:

Well started: August 4, 1957.

Well completed: October 9, 1957; well was deepened in August 1968.

Drilling method: Cable-tool (1957); unknown 1968.

Bit diameter below water level: 400-mm to 271 m, 298-mm to 347 m.

Casing extending below water level: 308-mm inside-diameter casing extending from land surface to 271 m.

Total drilled depth: 271 m (1957); 347 m after the deepening in 1968.

3. Access to and description of depth interval for measuring water levels:

308-mm inside-diameter casing; the casing is perforated between 241–264 m; the hole is open from 271 m to 347 m; access tube is 54-mm outside-diameter. The well produces water from the welded-tuff aquifer, located within the Topopah Spring Tuff of the Paintbrush Group.

4. Information for calculating water-level altitude:

Reference point: Top of well collar, altitude 954.54 m (surveyed by U.S. Geological Survey, 1993).

Measuring point: Top of the 54-mm outside-diameter access tube, 0.527 m above reference point through 10-01-95. After 10-01-95 measuring point 0.195 m above reference point.

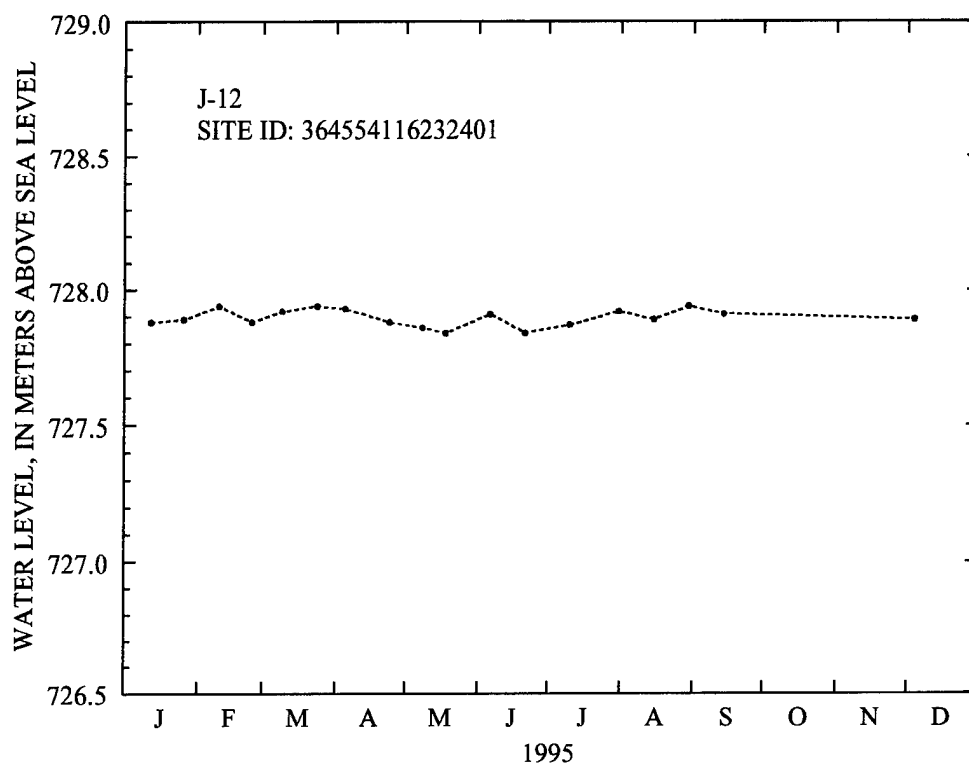
Depth correction for borehole deviation from vertical is not available.

5. The amount of water pumped from well J-12 in 1995 was approximately 135,000 m<sup>3</sup> (R.A. LaCamera, U.S. Geological Survey, written commun., 1996).

Well J-12 was measured periodically during 1995. Measurements were made with Chain #3 and Chain #4 with the following results:

Date	Measured water-level altitude (meters, above sea level)	Method of measuring water level
01-12-95	727.88	Chain #4
01-26-95	727.89	Chain #4
02-10-95	727.94	Chain #4
02-24-95	727.88	Chain #3
03-09-95	727.92	Chain #3
03-24-95	727.94	Chain #3
04-05-95	727.93	Chain #3
04-24-95	727.88	Chain #3
05-08-95	727.86	Chain #3
05-18-95	727.84	Chain #3
06-06-95	727.91	Chain #3
06-21-95	727.84	Chain #3
07-10-95	727.87	Chain #3
07-31-95	727.92	Chain #3
08-15-95	727.89	Chain #3
08-30-95	727.94	Chain #3
09-14-95	727.91	Chain #4
12-04-95	727.89	Chain #3

Water-level altitudes for well J-12 ranged from 727.84 to 727.94 m above sea level in 1995 (fig. 36). The mean water-level altitude of the 1995 periodic data was 727.90 m above sea level. This mean altitude was 0.01 m lower than the mean altitude of 727.91 m for 1994 (Graves and others, 1996).



**Figure 36.** Water-level altitudes, 1995, for well J-12.

## Well J-13

Information about the history of well J-13 and about previous data from the well was obtained from various sources. These sources are: Robison (1984); Robison (U.S. Geological Survey, written commun., 1986); Robison and others (1988); Holmes & Narver, Inc. (written commun., 1986); Thordarson (1983); Young (1972); and Fenix & Scisson, Inc. (1987c).

### Well specifications

#### 1. Location and identification:

Latitude and longitude: 36°48'29"N.; 116°23'40"W.

Nevada State Central Zone Coordinates (m): N 228,359; E 176,678.

U.S. Geological Survey Site ID: 364828116234001.

#### 2. Drilling and casing information:

Well started: September 12, 1962.

Well completed: January 8, 1963.

Drilling method: Rotary, using air and aerated mud as circulating medium.

Bit diameter below water level: 438 mm to 402 m; 380 mm from 402 m to 471 m; 194 mm from 471 m to total depth.

Casing extending below water level: 323-mm inside diameter, from land surface to 396.5 m; 282-mm inside diameter from 396.5 to 471.2 m; 126-mm inside diameter from 452.3 to 1,031.7 m; casing perforated from 303.6 to 423.7 m is within the Topopah Spring Tuff of the Paintbrush Group, and from 819.9 to 1,009.5 m is within the Tram Tuff of the Crater Flat Group and upper part of the Lithic Ridge Tuff.

Total drilled depth: 1,063 m.

3. Access to and description of depth interval for measuring water levels:

50.8-mm inside-diameter access tube, installed in 1986, in order for measuring equipment to bypass pump assembly.

4. Information for calculating water-level altitude:

Reference point: Chiseled square on concrete well collar, altitude 1,011.47 m above reference point (surveyed by U.S. Geological Survey, 1984).

Measuring point: Top of access tube, 0.165 m.

Depth correction for borehole deviation from vertical is not available.

5. The amount of water pumped from well J-13 in 1995 was approximately 184,600 m<sup>3</sup> (R.A. LaCamera, U.S. Geological Survey, written commun., 1996).

Well J-13 was measured periodically during 1995. Measurements were made with Chain #3 and Chain #4 with the following results:

Date	Measured water-level altitude (meters, above sea level)	Method of measuring water level
01-12-95	728.41	Chain #4
01-26-95	728.42	Chain #4
02-10-95	728.48	Chain #4
02-24-95	728.38	Chain #3
03-09-95	728.43	Chain #3
03-24-95	728.44	Chain #3
04-05-95	728.46	Chain #3
04-24-95	728.40	Chain #3
05-08-95	728.39	Chain #3
05-18-95	728.59	Chain #3
06-06-95	728.59	Chain #3
06-29-95	728.43	Chain #3
07-12-95	728.39	Chain #3
07-31-95	728.36	Chain #3
08-15-95	728.34	Chain #3
12-12-95	728.43	Chain #3

Water-level altitudes from the hourly data for well J-13 ranged from 728.34 to 728.59 m above sea level in 1995 (fig. 37). The mean water-level altitude of the 1995 periodic data was 728.43 m above sea level. This mean altitude was 0.03 m was higher than the mean altitude of 728.40 m for 1994 (Graves and others, 1996).



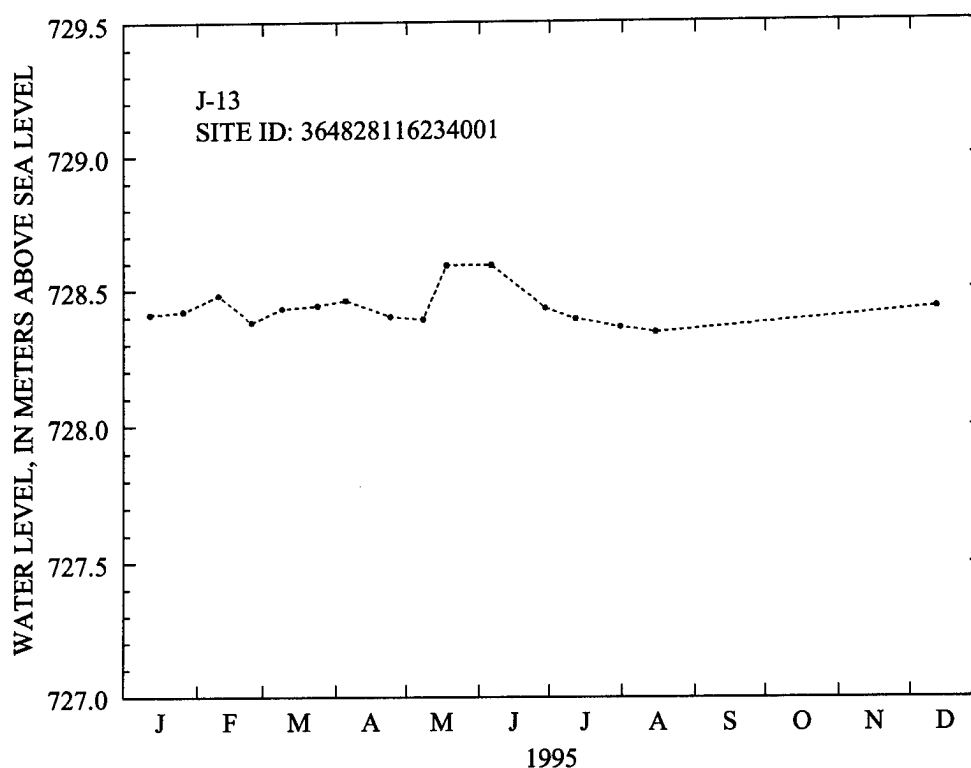


Figure 37. Water-level altitudes, 1995, for well J-13.

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