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HYDROGEOLOGIC MONITORING AT THE FAULTLESS SITE, NYE COUNTY, NEVADA

By William Thordarson

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METRIC CONVERSION TABLE

For those readers who prefer to use inch-pound rather than metric units, conversion factors for the terms used in this report are listed below:

Metric unit	*By*	*To obtain inch-pound unit*
centimeter (cm)	3.937×10^{-1}	inch
millimeter (mm)	3.937×10^{-2}	inch
kilometer (km)	6.214×10^{-1}	mile
meter (m)	3.281	foot
degree Celsius (°C)	1.8°C + 32	degree Fahrenheit
milligram per liter (mg/L)	[1]1.0	part per million
microgram per liter (μg/L)	[1]1.0	part per billion
picocurie per liter (pCi/L)	3.785	picocurie per gallon
liter per second (L/s)	1.585×10^{1}	gallon per minute
milliliter (mL)	2.642×10^{-4}	gallon
liter (L)	2.642×10^{-1}	gallon
gram per cubic centimeter (g/cm^3)	6.243×10^{1}	pound per cubic foot
meter per second (m/s)	3.281	foot per second
gram (g)	3.527×10^{-2}	ounce
kilopascal (kPa)	1.450×10^{-1}	pound per square inch

[1]Approximate.

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ABSTRACT

The Faultless event was the detonation of an intermediate-yield nuclear device on January 19, 1968, at a depth of 975 meters below the surface of Hot Creek Valley, Nevada. This report presents details of the hydrogeology and radiochemical monitoring, primarily for the reentry hole UC-1-P-2SR; data from test holes HTH-1, HTH-2, UCE-18, instrument holes UC-1-I-1 and UC-1-I-2, and the abandoned reentry hole UC-1-P-1S are included.

The surface location of reentry hole UC-1-P-2SR is 91 meters north of the emplacment hole UC-1. The reentry hole UC-1-P-2SR was drilled to a total depth of 1,097 meters. The hole penetrated valley-fill sediments above the rubble chimney, as well as valley-fill and Tertiary tuffaceous sediments within the rubble chimney and rubble-filled cavity. The completion program (casing to a depth of 851 meters) was designed to permit monitoring of the rate of water infill in the rubble chimney and the concentration of radionuclides in the water.

Monitoring of the water level in the reentry hole indicated that, from 1970 to 1974, the water level was approximately 694.9 meters in depth below land surface. From 1974 to the present (1983), the water level rose slowly to a depth of 335.1 meters below land surface as the rubble chimney became filled with water. The water level rose after the Faultless event in nearby test holes, HTH-1 and HTH-2. In 1976, the water-level in test hole HTH-1 returned to a depth 6.7 meters above the pre-event water level, and the water level in test hole HTH-2 returned to a depth 2.7 meters above the pre-event water level.

Ground water sampled from reentry hole UC-1-P-2SR is a predominantly sodium bicarbonate type containing some sulfate and minor chloride, similar to water from test hole HTH-1. Tritium concentrations fluctuated from a maximum value of 9.2×10^8 picocuries per liter in 1976, decreasing to 10^5 picocuries per liter in 1977, followed by a gradual increase to values of 10^7 picocuries per liter from 1980 to 1982. After 1971, gross-beta concentration ranged between 1.2 and 130 picocuries per liter, but generally was less than 10 picocuries per liter. Gross-alpha concentration generally was less than 10 micrograms per liter from 1975 to 1982.

INTRODUCTION

The Faultless event was the detonation of a nuclear device of intermediate yield at 1015:076 hours Pacific Standard Time on January 19, 1968, in Hot Creek Valley, Nye County, Nevada. The responsibility of the U.S. Atomic Energy Commission, now assumed by the U.S. Department of Energy, was to determine the suitability of using sites in Hot Creek Valley in central Nevada for underground testing of nuclear devices of greater yield than possible at the Nevada Test Site because of potential adverse seismic effects at Las Vegas, Nevada. Investigations by U.S. Geological Survey described in this report were performed under Interagency Agreement DE-AI08-76DP00474.

Purpose and scope

The U.S. Geological Survey, in cooperation with the U.S. Department of Energy, has been making hydrologic studies of sites of underground nuclear tests in order to provide data on the occurrence, quality, and quantity of ground and surface waters that might be affected by the nuclear tests. These site studies, such as that of the Faultless event, provide data on the hydraulic properties of rocks near the site, the rate of water inflow to the rubble chimney, the distribution of radionuclides, and the capacity of ground water to affect initial transport of radionuclides away from the rubble chimney (West and Grove, 1969).

This report presents detailed hydrogeologic data primarily from the Faultless reentry hole, UC-1-P-2SR, although some data from other boreholes are included. Only the infilling of the ground water into the rubble chimney is described; discussion of the regional flow system before and after the Faultless event is beyond the scope of this report.

The hydrogeology was investigated jointly by the U.S. Geological Survey, Teledyne Isotopes, and the Desert Research Institute before the Faultless event. Since this event, the Geological Survey, Teledyne Isotopes, and the U.S. Environmental Protection Agency have monitored water levels and radiochemical quality of ground water at the Faultless site. After 1971, Teledyne Isotopes was no longer involved.

Location of Study Area and Boreholes

The Faultless site is in Hot Creek Valley, about 97 km northeast of Tonopah, Nye County, Nevada (fig. 1). The latitude is 38°38'3.4774" N.; the longitude is 116°12'55.1936" W. (Nevada central-zone coordinates N. 1,414,339.91, E. 628,920.87) at the emplacement hole, UC-1. At the reentry hole, UC-1-P-2SR, the latitude is 38°38'06" N.; the longitude is 116°12'59" W. (Nevada central-zone coordinates N. 1,414,632.50 E. 628,982.18). Instrument holes, UC-1-I-1 and UC-1-I-2, are located at emplacement hole UC-1 because they are within 25 m of emplacement hole UC-1 (fig. 1). The abandoned reentry hole, UC-1-P-1-S, is 399 m southeast of hole UC-1. Other test holes in the study area are test holes UCE-11, UCE-17, UCE-18, and UCE-20 (fig. 1). Altitude of each hole is presented in table 1.

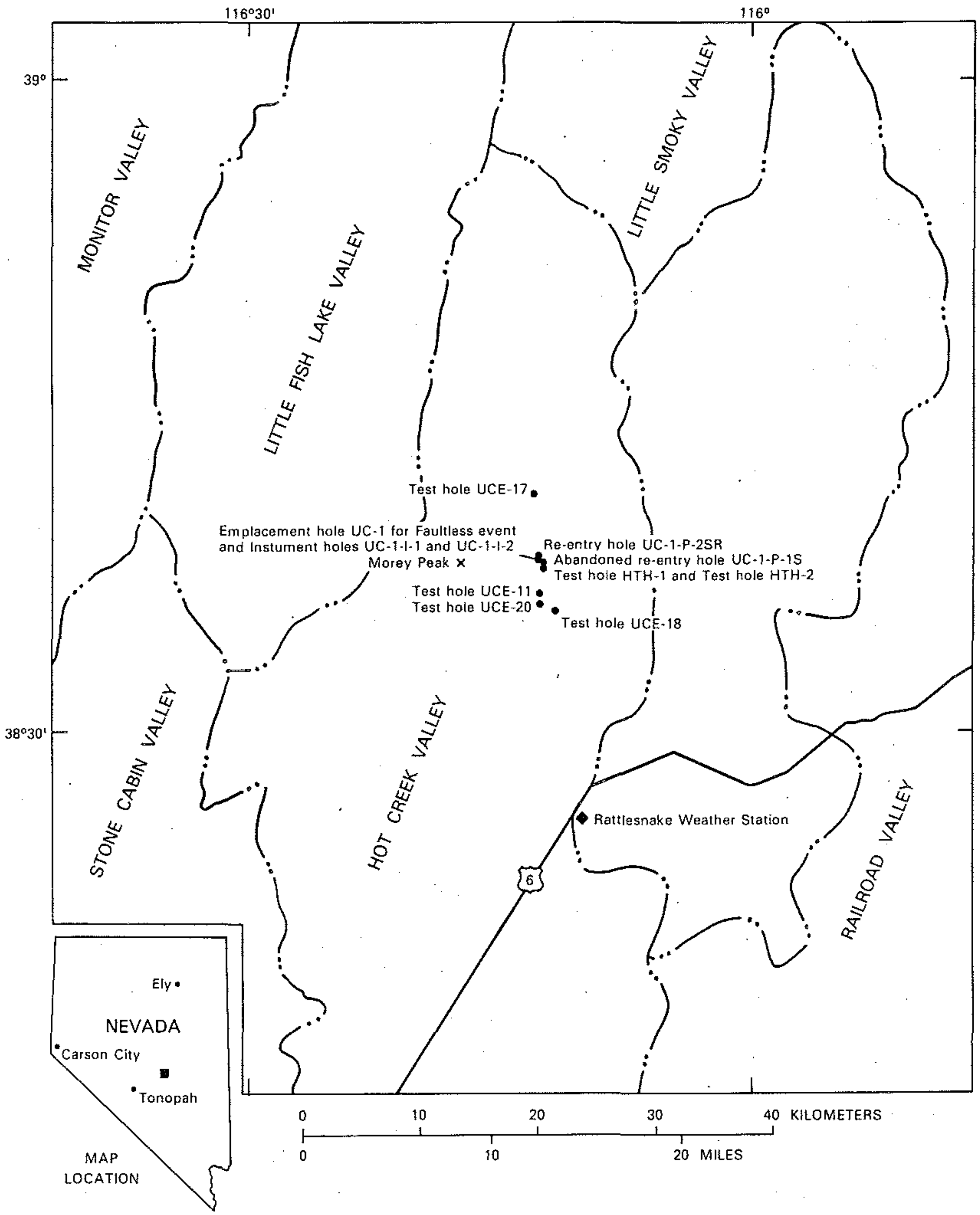

Figure 1.--Location of the Faultless site in Hot Creek Valley, and boreholes described in this report.

Table 1.--*Altitude of boreholes*

Type and number of borehole	Altitude of *land surface*[1] (meters)
Test hole HTH-1	1,832.2
Test hole HTH-2	1,836.1
Emplacement hole UC-1	1,860.8
Abandoned reentry hole UC-1-P-1S	1,839.3
Reentry hole UC-1-P-2SR	1,854.6
Test hole UCE-11	1,764.5
Test hole UCE-17	1,994.9
Test hole UCE-18	1,756.6
Test hole UCE-20	1,755.3
Instrument hole UC-1-I-1	1,860.0
Instrument hole UC-1-I-2	1,860.4

[1]Datum is National Geodetic Vertical Datum of 1929

Previous Investigations

The general hydrology and chemical data in Hot Creek Valley were reported by Dinwiddie and Schroder (1971) and by Robinson and others (1967). Discussions of ground-water flow systems in Hot Creek Valley and vicinity were made by Fiero and others (1974) and by West and Grove (1969). The lithology of rocks penetrated by test holes UCE-11, UCE-17, UCE-18, and UCE-20 have been presented previously (Barnes and Hoover, 1977; Corchary, 1969; Dixon and Snyder, 1977; Hoover, 1977; and Snyder, 1977). Geologic effects of the Faultless event have been described by McKeown and others (1970).

PHYSICAL SETTING

Geography

Hot Creek Valley trends northward for 110 km, and is 8 to 30 km wide, between north-trending ranges of the basin and range physiographic province. To the west, the Hot Creek Range rises to a maximum altitude of 3,111 m at Morey Peak, just west of the Faultless site. The floor of the valley ranges from about 1,580 to 1,830 m in altitude.

Climate is arid in the valley; precipitation averages 119 mm annually at the Rattlesnake Weather Station, 22 km to the south of the Faultless site in Hot Creek Valley at an altitude of 1,802 m. Average yearly temperature in Hot Creek Valley is 10.6°C; maximum recorded temperature was 39.4°C, and minimum recorded temperature was -28.3°C.

Geology

Hot Creek Valley is a large graben in which a sequence of valley fill of Quaternary and Tertiary age, about 1,220 m thick, is underlain by a thick sequence of volcanic rocks of Tertiary age. Flanking mountain ranges are large fault-block mountains, in which volcanic rocks of Tertiary age generally overlie thick carbonate rocks of Paleozoic age.

In emplacement hole UC-1, at the Faultless site, valley fill is 732 m thick, and underlain by tuffaceous sediment and zeolitized tuff to the total depth of 998 m. The section penetrated by other test holes, UCE-17, UCE-18, UCE-20, and HTH-1, contains some densely welded tuff or rhyolite in the Tertiary volcanic rocks. Lithology, hydrology, and construction of test holes HTH-1, HTH-2, and UCE-18 are presented in figure 2. Temperature data for 1970 and 1971 in the lower part of the reentry hole, UC-1-P-2SR, are presented in figure 3. Geophysical well logs that were run in reentry hole UC-1-P-2SR are listed in table 2.

Table 2.--*Geophysical well logs available for reentry in hole UC-1-P-2SR*

Geophysical log	Depth interval (meters)	Geophysical log	Depth interval (meters)
Gamma ray-neutron	0-540	Caliper	30-326
Do.	307-366		
Do.	564-701	Radioactive tracer survey	671-800
		Do.	690-801
Gamma ray	0-307		
Do.	533-884	Radioactive tracer location finder	671-801
		Do.	671-800
Nuclear cement top locator	30-576	Water locator	640-695
		Do.	655-702
3-D velocity	40-365	Do.	671-701
Do.	46-363	Do.	671-701
		Do.	671-696
Electric	46-365	Do.	671-699
		Do.	680-703
Temperature	0-307		
Do.	0-327		
Do.	351-801		
Do.	686-800		
Do.	701-801		
Do.	701-885		

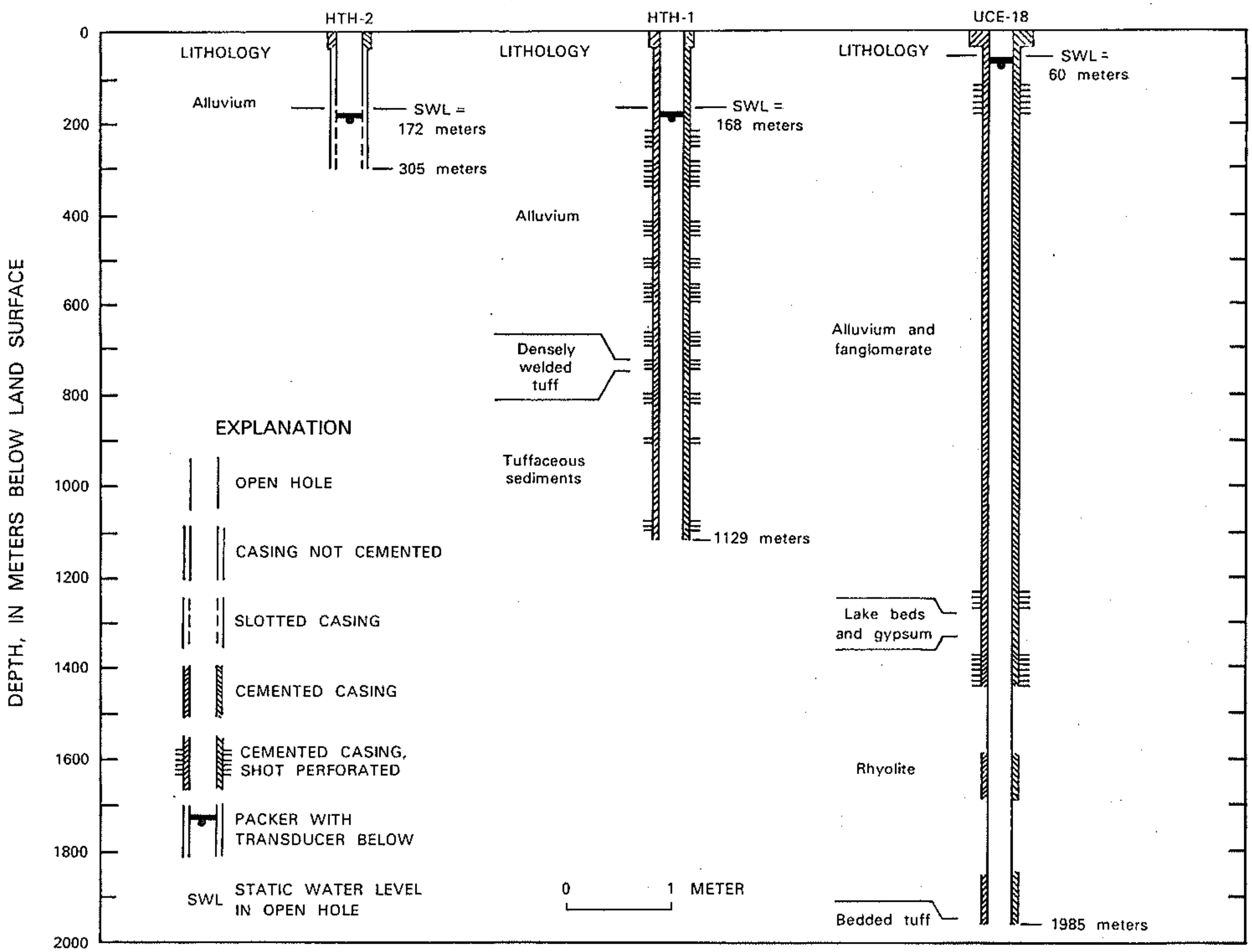

Figure 2.--Lithologic zones penetrated by, water levels in, and construction of test holes HTH-2, HTH-1, and UCE-18.

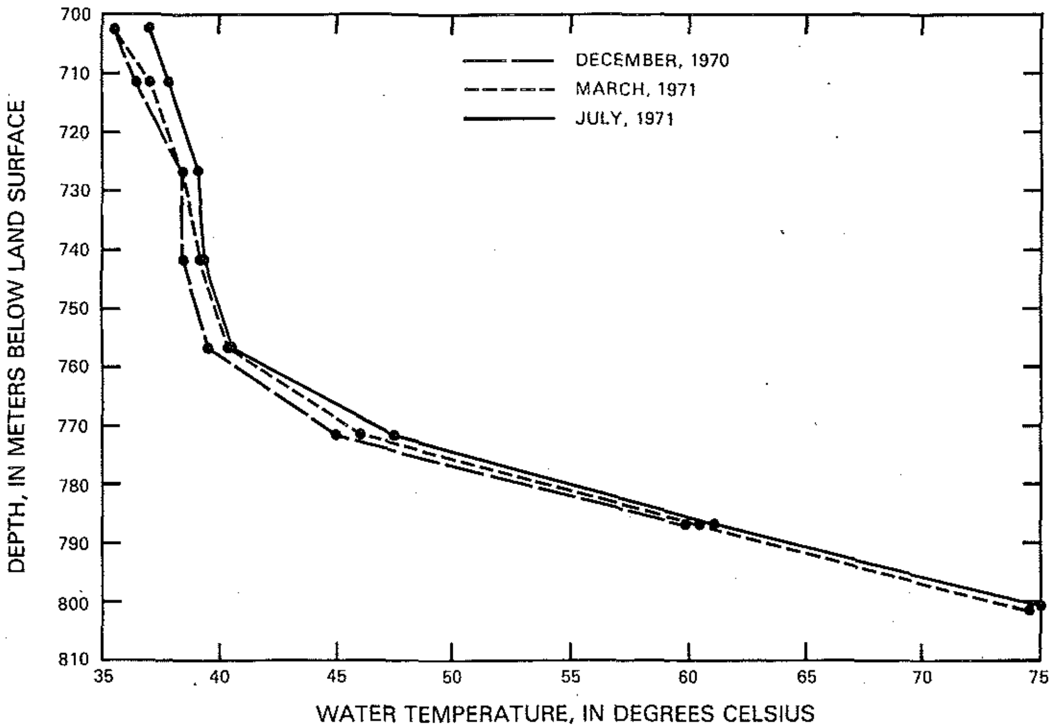

Figure 3.--Temperature data for reentry hole UC-1-P-2SR.

Lithology of Rocks Penetrated by Boreholes at and near the Faultless Site

This section includes a detailed lithologic log of emplacement hole UC-1 and instrument holes UC-1-I-1 and UC-1-I-2 (table 3); a general description of the lithology and stratigraphy of rocks penetrated by boreholes at and near the Faultless site (table 4); physical properties of rocks cored in instrument hole UC-1-I-1 and test hole HTH-1 (table 5); and a description of general lithologic types; all data are from a written communication from D.L. Hoover, U.S. Geological Survey, 1968.

Emplacement hole UC-1, instrument hole UC-1-I-1, and test hole HTH-1 penetrated the alluvium and were bottomed in tuffaceous sediments (table 4). The alluvium consists of a matrix cemented by clay containing sand-size crystal grains and welded tuff and rare Paleozoic chert, siltstone and carbonate fragments. The matrix encloses pebble- to boulder-size fragments of welded tuff and rare Paleozoic rocks. Some welded-tuff boulders are as much as 1.5 to 3 m in diameter; however, nearly all the fragments are less than 0.5 m in diameter, and the average size of fragments larger than sand size probably is less than 15 cm. The upper 150 to 300 m of the alluvium usually is unconsolidated. This interval may cave or erode severely during drilling, especially if the drilling fluid is water or air and water. The degree of induration of the alluvium generally increases downward, possibly because of compaction. A few thin intervals that appear to be almost entirely clay or sand were penetrated but not cored.

Table 3.--*Lithologic log of emplacement hole UC-1 and instrument holes UC-1-I-1 and UC-1-I-2*[1]

(Terms denoting grain sizes in alluvium and tuffaceous sediments are as follows: silt and clay <1/16 millimeter; sand, 1/16-4 millimeters; pebbles, 4-64 millimeters; cobbles, 64-256 millimeters; boulders, >256 millimeters. In volcanic rocks, fragment and phenocryst sizes are as follows: fine, <1 millimeter; coarse, 1-4 millimeters; lapilli, 4-32 millimeters. Contacts are corrected to geophysical logs. <, less than; >, greater than.)

Lithology	Thickness (meters)	Depth to base of unit (meters)
Alluvium; contains subrounded to rounded pebbles to cobbles of welded tuff (10-15) percent and medium- to dark-gray Paleozoic calcareous siltstone, chert, and claystone (1-5 percent in upper 549 meters and <1 percent below 549 meters) in a matrix (50-90 percent) of sand-size grains of quartz, feldspar, rare biotite, and rock fragments, bound by clay. Welded tuff fragments are light- to dark-gray, brown and pale-pink in upper 88 meters, mostly greenish-gray and gray with some buff to white between 401 and 549 meters, and mostly buff to white with some greenish-gray and gray fragments between 549 and 733 meters. White welded-tuff fragments with large biotite phenocrysts are abundant below 582 meters. No samples between 88 and 401 meters because of lost circulation. Contact cored at 733 meters.	733	733
Tuffaceous sediments; consisting of very pale-orange to grayish-orange-pink to light-brownish-gray conglomerates and conglomeratic sandstones (90 percent) similar in texture, fragment size, and appearance to alluvium but containing varying quantities of altered volcanic glass; white to light-yellowish-gray reworked ash-fall tuffs, tuffaceous sandstones and siltstones (<10 percent) relatively free of large fragments; and yellowish-gray zeolitized nonwelded ash-flow tuffs (<1 percent); conglomerate and conglomeratic sandstones contain pebbles to boulders (10-75 percent) of gray, reddish-brown and purplish-gray welded tuff and gray to black Paleozoic chert, siltstone, and calcareous siltstone (1-10 percent above 914 meters and <1 percent below 914 meters); beds with larger and more abundant fragments have more clay in matrix than conglomeratic sandstones that are partly zeolitized; zeolitization and euhedral		

Table 3.--*Lithologic log of emplacement hole UC-1 and instrument holes UC-1-I-1 and UC-1-I-2*[1]*--Continued*

Lithology	Thickness (meters)	Depth to base of unit (meters)
biotite plates in matrix indicate nearby source of volcanic glass--probably ash-fall tuffs; matrix consists of sand-size quartz, feldspar, biotite, and rock fragments bound by clay derived by erosion, and clay (?) and zeolites derived by alteration of volcanic glass; core from 1,064 to 1,067 meters is a conglomerate containing subangular to subrounded pebbles to cobbles of dark-greenish-gray welded tuff (25-70 percent) containing coarse quartz (5-10 percent), plagioclase (?) altered to bright green clay (15-25 percent), glassy sanidine (5-10 percent), mostly coarse black biotite (2-5 percent), and rare lapilli pumice or lithic fragments altered to green clay, in a matrix which also contains coarse biotite; reworked ash-fall tuffs, tuffaceous sandstones and siltstones consist mostly of volcanic glass altered to clay and zeolites; quartz, feldspar and biotite grains (5-20 percent) and sand- to pebble-size welded-tuff fragments (<5 percent); zeolitized nonwelded ash-flow tuffs cored at 947 meters and 973 to 976 meters contain fine to coarse quartz and feldspar (<5 percent), rare black fine biotite, and lapilli pumice (5 percent).	334	1,067

[1]Logged by: R. Holcomb, D. L. Hoover, and R. P. Snyder, 1967, U.S. Geological Survey.

Table 4.--*Lithology of rocks penetrated in boreholes at and near the Faultless site*

(Modified from Hoover, D.L., U.S. Geological Survey, written commun., 1968)

Borehole and depth interval (meters)	Lithology	Stratigraphic unit
UC-1		
0- 732	Alluvium.	
732- 998	Conglomeratic tuffaceous sandstone and conglomerate with a few thin nonwelded zeolitized tuffs, tuffaceous siltstones and claystones.	Tuffaceous sediments of northern Hot Creek Valley.
UC-1-I-1		
0- 733	Alluvium.	
733-1,067	Conglomeratic tuffaceous sandstone and conglomerate with a few thin nonwelded zeolitized tuffs, tuffaceous siltstones, and claystones.	Tuffaceous sediments of northern Hot Creek Valley.
UC-1-I-2		
0- 457	Alluvium.	
HTH-1		
0- 728	Alluvium.	
728- 752	Densely welded tuff.	
752-1,057	Conglomeratic tuffaceous sandstone and conglomerate with a few thin bedded tuffs and tuffaceous sandstones and siltstones.	Tuffaceous sediments of northern Hot Creek Valley.
1,057-1,128	Tuffaceous sandstone and siltstone with interbedded tuffaceous conglomerate and pebbly clay beds.	Tuffaceous sediments of northern Hot Creek Valley.
HTH-2		
0- 305	Alluvium.	

Table 5.--*Physical properties of rocks cored in instrument hole UC-1-I-1 and test hole HTH-1*

(g/cm^3, grams per cubic centimeter; kPa, kilopascal)

Sample depth (meters)	Lithology	Dry bulk density (g/cm^3)	Grain density (g/cm^3)	Total porosity (percent)	Saturated bulk density (g/cm^3)	Unconfined compressive strength (kPa)
547.1	Alluvium	2.24	2.60	13.9	2.38	--
731.5	Tuffaceous sediments	2.06	2.55	19.2	2.25	8,793
733.3	do.	1.81	2.48	27.0	2.08	--
917.1	do.	1.77	2.46	28.1	2.05	18,503
931.2	do.	2.07	2.64	34.9	2.07	--
946.4	do.	1.86	2.41	22.8	2.09	20,000
965.6	do.	2.24	2.61	14.2	2.38	9,166
971.4	do.	2.06	2.57	19.8	2.26	10,683
976.9	do.	2.03	2.64	23.1	2.26	--
987.6	do.	2.02	2.55	20.8	2.23	13,966

The tuffaceous sediments are a mixture of alluvium, derived by erosion of nearby volcanic rocks and Paleozoic sediments, and tuffs deposited in Hot Creek Valley and partly reworked by erosion. The tuffaceous sediments are probably the youngest rocks in the Morey Peak-Hot Creek Valley caldera, which are derived at least partly from volcanic activity. In the vicinity of the caldera, the tuffaceous sediments probably are absent in test hole UCE-17, present in fault contact with older welded tuffs in test hole UCE-11 and unconformably overlie welded tuffs in test hole UCE-20. Dips in cores taken from instrument hole UC-1-I-1 between 945 and 959 m ranged from 5° to 15°. A few fractures were noted in the tuffaceous sediments in cores taken from instrument hole UC-1-I-1.

The tuffaceous sediments are similar in texture, fragment sizes and general appearance to the alluvium; most of the sediments were derived by erosion of nearby volcanic rocks and Paleozoic sediments as was the alluvium. However, the sediments differ from the alluvium in that:

1. They are generally more indurated, and, thus, stronger. The induration was caused by zeolitization. Clay minerals also are a major binding material of the sediments, and probably were derived both by weathering in areas supplying sediments and by alteration of volcanic glass.

2. The sediments contain thin (less than 30 m) intervals of nonwelded zeolitized tuff, densely welded tuff, reworked ash-fall tuff, and tuffaceous sandstones and siltstones that lack the large fragments that characterize the alluvium.

3. Cores and geophysical logs indicate that bedding is better developed in the tuffaceous sediments.

4. Preservation of euhedral biotite plates in the sediments indicate only minor reworking.

DRILLING PROCEDURES AND WELL CONSTRUCTION FOR REENTRY HOLE

The post-shot reentry hole UC-1-P-2SR (fig. 4) was spudded on February 19, 1968. Difficulty was experienced during drilling, including bridges, cave-ins, and loss of circulation. The hole was initially designated UC-1-P-2; from this hole, the first sidetrack hole (UC-1-P-2S) was unsuccessfully attempted at a depth of 823.0 m. A later, successful side-track hole, UC-1-P-2SR, was used as the monitoring hole. Large quantities of drilling mud and cement were lost during drilling; the quantity of mud and cement lost is not known but it may be similar to the 1,060,000 L of mud that was lost during drilling of emplacement hole UC-1. The effects of these lost materials on monitoring water levels and radiochemistry may be appreciable. The hole was completed by installing 14.0-cm O.D. (outside diameter) casing that was hung on slips at a depth of 851 m, and was perforated from 349.9 to 850.4 m with three hundred thirteen 13-g shots, or one 0.952-cm hole every 1.5 m (fig. 4). Fill was tagged by the drill pipe and left inside the 14.0-cm O.D. casing at a depth of 833.3 m. Previously, the 24.45-cm O.D. casing that was cemented totally had been perforated from 349.9 to 592.8 m with one hundred forty-five 28-g shots, or one shot per 1.5 m. Finally, fluid from the decontamination pad was pumped down the tubing, while water was pumped down the casing-tubing annulus; each joint of tubing was washed into the hole as the tubing was pulled from the hole. Drilling water used was obtained from test hole UCE-18. A directional survey is presented in table 6.

RESPONSE OF AQUIFER SYSTEMS TO THE FAULTLESS EVENT

The U.S. Geological Survey monitored three test holes drilled prior to the Faultless event: HTH-1, HTH-2, and UCE-18. These test holes were sealed with inflatable packers to measure close-in seismic effects of the Faultless event (fig. 3). The test holes contained instrumentation designed to record water-pressure changes taking place during and immediately after the event. The packers were installed 10 m below static water level in test hole UCE-18 and 15 m below static water level in test holes HTH-1 and HTH-2.

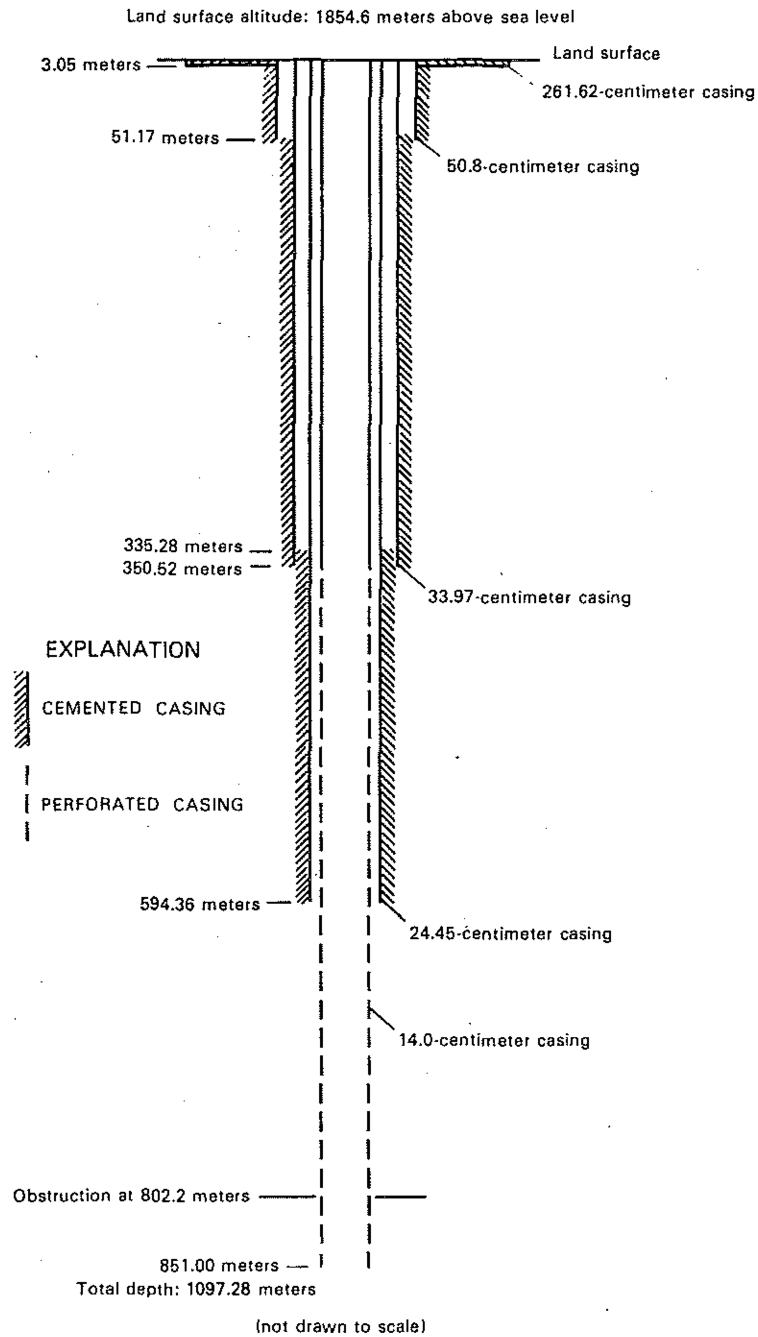

Figure 4.--Lithologic zones penetrated by and construction of reentry hole UC-1-P-2SR.

Table 6.--*Directional survey of reentry hole UC-1-P-2SR*

Measured depth (meters)	Vertical depth (meters)	Horizontal distance (meters)	Bearing (degrees)	Inclination at depth (degrees)
99.1	99.1	0.6	N 64.8 E	0.5
198.1	198.1	1.8	N 54.0 E	.8
297.2	297.2	3.4	N 45.0 E	1.2
373.4	373.4	5.5	N 37.3 E	2.1
396.2	396.2	6.4	N 35.5 E	2.1
426.7	426.6	6.3	N 34.6 E	1.7
457.2	457.0	4.8	N 54.1 E	5.7
487.7	487.3	5.3	S 87.4 E	6.2
518.2	517.7	7.4	S 65.0 E	6.8
548.6	547.8	11.5	S 52.0 E	9.7
579.1	577.7	16.9	S 46.7 E	11.2
606.6	604.5	22.3	S 40.8 E	12.5
634.0	631.3	27.3	S 34.7 E	12.0
670.6	667.1	33.6	S 26.5 E	12.2
698.0	693.8	38.0	S 18.9 E	14.6
725.4	720.3	42.6	S 11.0 E	15.3
743.7	737.8	46.1	S 6.4 E	16.0
771.1	764.2	51.7	S 0.1 E	16.4
789.4	781.6	55.9	S 3.6 W	17.3
816.9	807.8	62.2	S 8.5 W	17.3
901.9	890.9	77.6	S 15.9 W	8.0
1,001.0	989.2	87.7	S 12.3 W	10.2
1,083.3	1,070.7	97.8	S 8.9 W	6.9

Responses of all the sealed test holes are presented in table 7 and for two of the test holes in figure 5. Initial-pressure increase was detected 0.3 seconds after dentonation in test hole HTH-1 and at 1.8 seconds after dentonation in test hole UCE-18; these pressure increases preceded the arrival at the surface of the seismic pulse by almost 0.1 second. Maximum pressures measured in test hole HTH-1 and HTH-2 were measured after the event-induced seismic signals had subsided. At test hole UCE-18, the galvanometer was overdriven in the first pressure pulse, and no further data were measured. Subsequent monitoring of the water levels in these test holes is discussed in the following section.

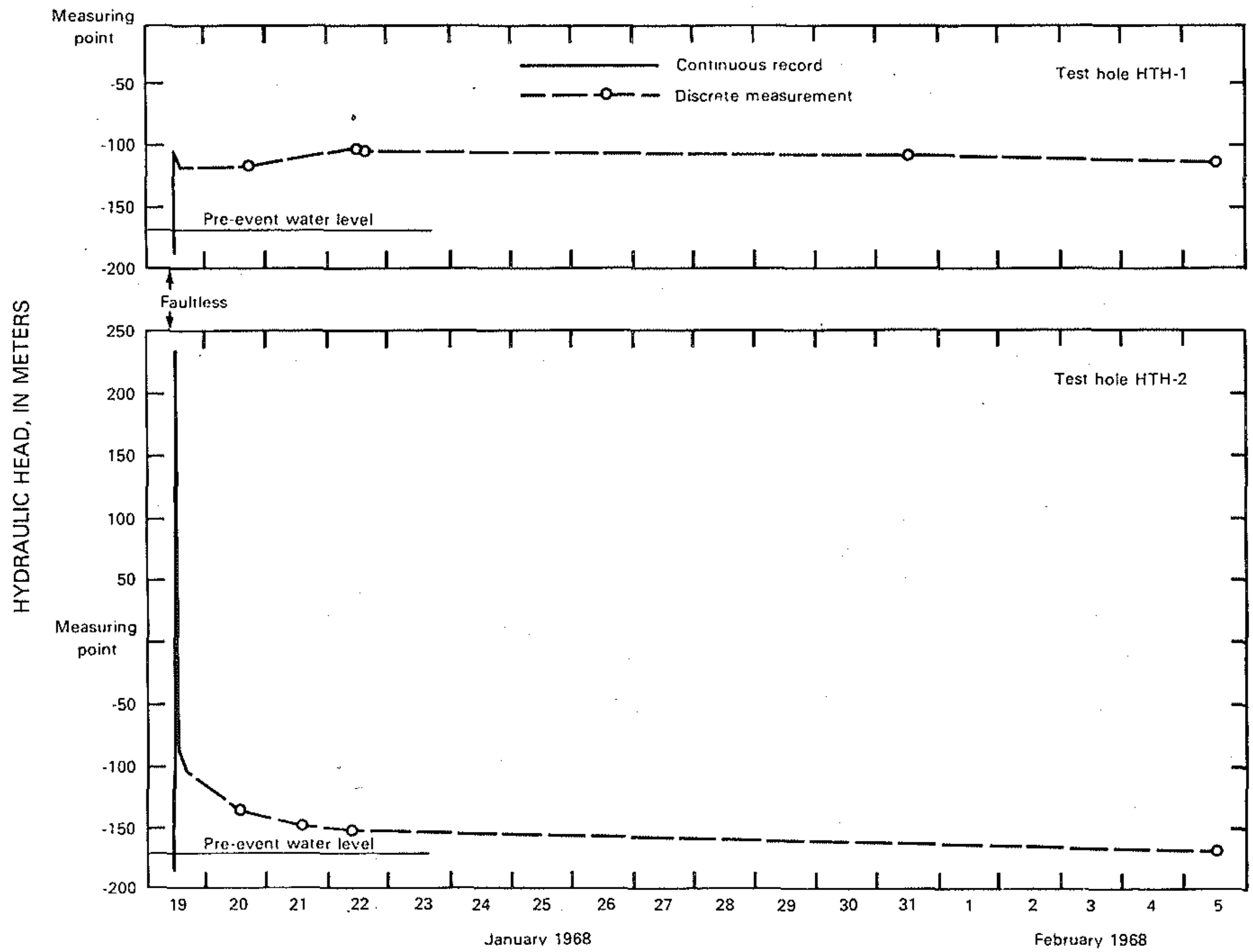

Figure 5.--Water-pressure response to Faultless event in test holes HTH-1 and HTH-2.

Table 7.--*Water-pressure response to Faultless event in test holes HTH-1, HTH-2, and UCE-18*

Test hole	Distance to emplacement hole (meters)	Depth of test hole (meters)	Responses of water pressure (meters of water)	Time
HTH-1	916	1,128	+ 60 - 16	0.3 to 3 seconds
			+ 12	3 seconds
			+ 61	30 seconds
			+ 46	4 hours
			+ 51	1 day
			[1]+ 65	3 days
			+ 52	30 days
			+ 37	110 days
HTH-2	762	306	+ 14 - 14	Initial
			[1]+410	50 minutes
			+ 50	4 hours
			+ 38.6	1 day
			+ 2.6	30 days
			+ 2.0	110 days
UCE-18	5,738	1,985	> + 30	1.8 seconds
			+ 18	1 day

[1]Maximum measured response.

MONITORING OF WATER LEVELS

Monitoring of water levels in the postevent reentry hole, UC-1-P-2SR, and in test holes HTH-1 and HTH-2, and abandoned reentry hole UC-1-P-1S continued after the reentry hole was completed. Water levels for all these boreholes are presented in table 8 and for the reentry hole in figure 6. A diagrammatic sketch showing some water levels in the rubble chimney is presented in figure 7; this diagram is based on schematic cross sections presented in Teller and others (1968).

Table 8.--*Water levels in boreholes at and near Faultless site*

(L/s, liter per second; >, greater than)

Date	Depth to water below measuring point in indicated borehole[1] (meters)			
	HTH-1	HTH-2	UC-1-P-1S	UC-1-P-2SR
1-19-68 (pre-event)	168.2	172.2	---	---
1-20-68	117.1	135.5	---	---
1-22-68	103.3	151.2	---	---
2-02-68	---	---	Flowing (0.32 L/s)	---
2-11-68	---	---	Flowing (0.95 L/s)	---
2-19-68	116.1	169.8	---	---
2-29-68	120.7	170.7	---	---
3-01-68	---	---	67.4	---
3-15-68	126.2	171.0	---	---
3-27-68	129.5	171.0	---	---
4-06-68	130.1	170.7	---	---
4-09-68	---	---	---	653.5
5-02-68	131.7	170.7	---	---
6-05-68	---	---	---	646.2
7-17-68	142.3	170.7	---	---
7-31-68	---	---	---	649.8
9-09-68	144.5	170.4	77.1	---
10-22-68	145.4	170.4	---	---
10-31-68	---	---	77.4	---
1-14-69	148.4	170.7	78.0	671.5
5-13-69	150.9	170.4	79.2	675.4
9-24-69	154.2	170.1	79.6	677.6
4-11-70	---	---	---	[2]>712.9
6-12-70	157.0	169.2	79.2	[2]>691.3
10-27-70	157.6	168.9	80.5	[3]699.8
12-01-70	---	---	---	[3]699.8
3-31-71	157.9	168.9	80.2	[3]698.6
7-15-71	---	---	---	[3]696.2
8-10-71	---	---	---	[3]694.0
8-24-71	---	---	---	[3]693.4
9-23-71	---	---	---	[3]692.5
10-28-71	---	---	---	693.1
1-12-72	---	---	---	694.0
1-13-72	159.7	---	---	---
9-12-72	160.3	169.8	81.1	694.9
6-11-73	---	---	---	[3]696.2
6-12-73	[2]> 57.9	168.6	---	696.2
12-07-73	[3]> 57.9	170.1	---	696.8
12-10-73	---	---	---	696.5

Table 8.--*Water levels in boreholes at and near Faultless site*--Continued

Date	Depth to water below measuring point in indicated borehole[1] (meters)			
	HTH-1	HTH-2	UC-1-P-1S	UC-1-P-2SR
4-09-74	[2] > 57.9	168.9	---	696.5
4-10-74	---	---	---	697.1
9-24-74	---	---	---	695.9
1-29-75	161.8	170.1	---	---
2-06-75	---	---	---	665.4
3-12-75	161.2	169.2	---	---
3-13-75	---	---	---	655.3
4-14-75	---	---	---	651.4
5-15-75	---	---	---	645.0
8-14-75	161.8	170.1	---	627.3
11-13-75	---	---	---	611.7
2-13-76	161.5	170.4	---	598.9
5-06-76	161.5	169.5	---	586.7
8-30-76	---	---	---	572.7
11-18-76	---	---	---	561.7
2-28-77	---	---	---	549.9
6-15-77	---	---	---	535.5
10-20-77	---	---	---	516.3
6-13-78	---	---	---	484.6
9-14-78	---	---	---	473.7
12-11-78	---	---	---	464.2
5-22-79	---	---	---	448.1
9-09-79	---	---	---	439.8
12-04-79	---	---	---	430.1
2-28-80	---	---	---	423.4
7-15-80	---	---	---	412.4
12-02-80	---	---	---	401.4
03-14-81	---	---	---	394.4
06-24-81	---	---	---	386.8
10-07-81	---	---	---	380.4
1-27-82	---	---	---	372.4
4-07-82	---	---	---	368.7
7-19-82	---	---	---	362.2
11-16-82	---	---	---	355.2
1-13-83	---	---	---	352.1
4-8-83	---	---	---	346.7
7-18-83	---	---	---	340.3
10-18-83	---	---	---	335.1

[1]HTH-1 measuring point is top of casing, 0.46 meter above land surface. HTH-2 measuring point is top of casing, 0.94 meter above land surface. UC-1-P-1S measuring point was top of gate valve, at land surface. UC-1-P-2SR measuring point is top of grating, at land surface.
[2]Obstruction -- water level below.
[3]Measurement by Birdwell Division of Seismograph Service Corp.

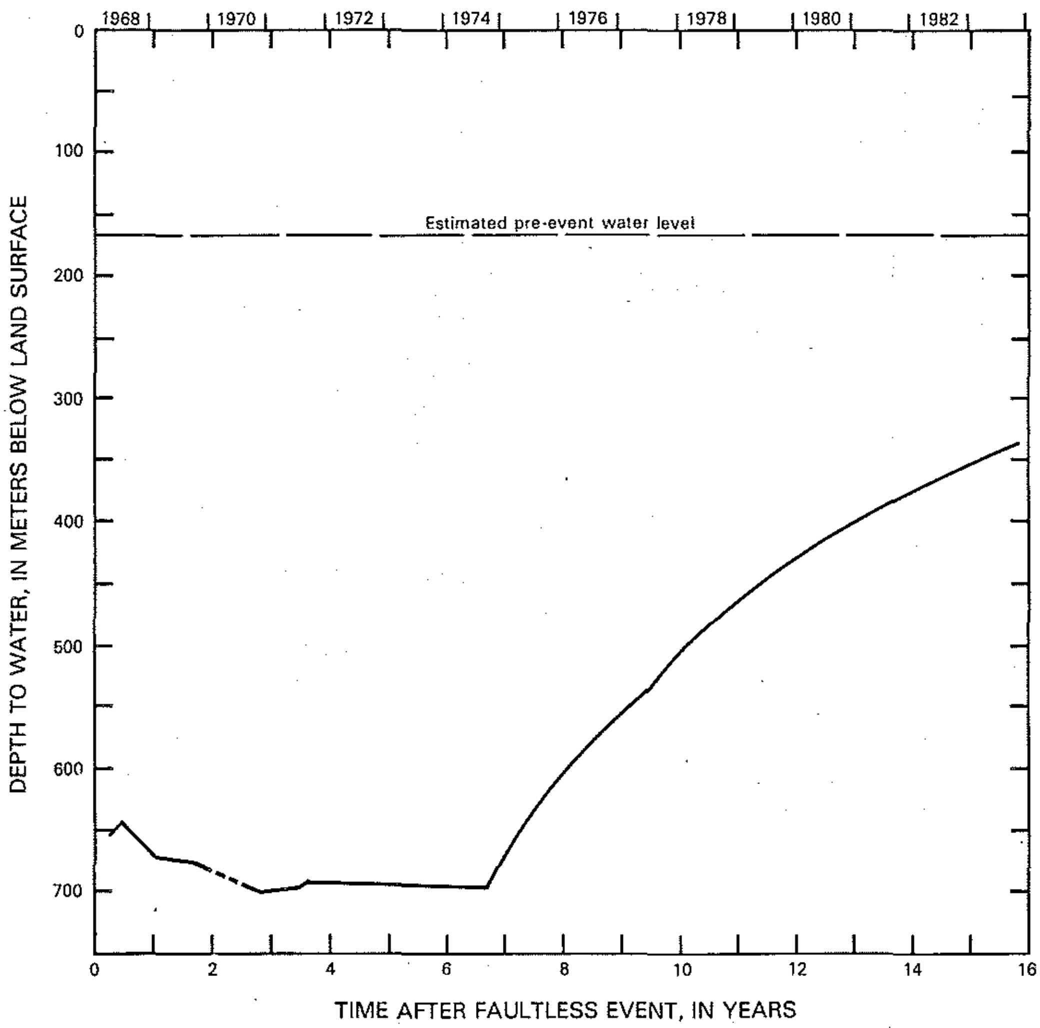

Figure 6.--History of water levels in reentry hole UC-1-P-2SR.

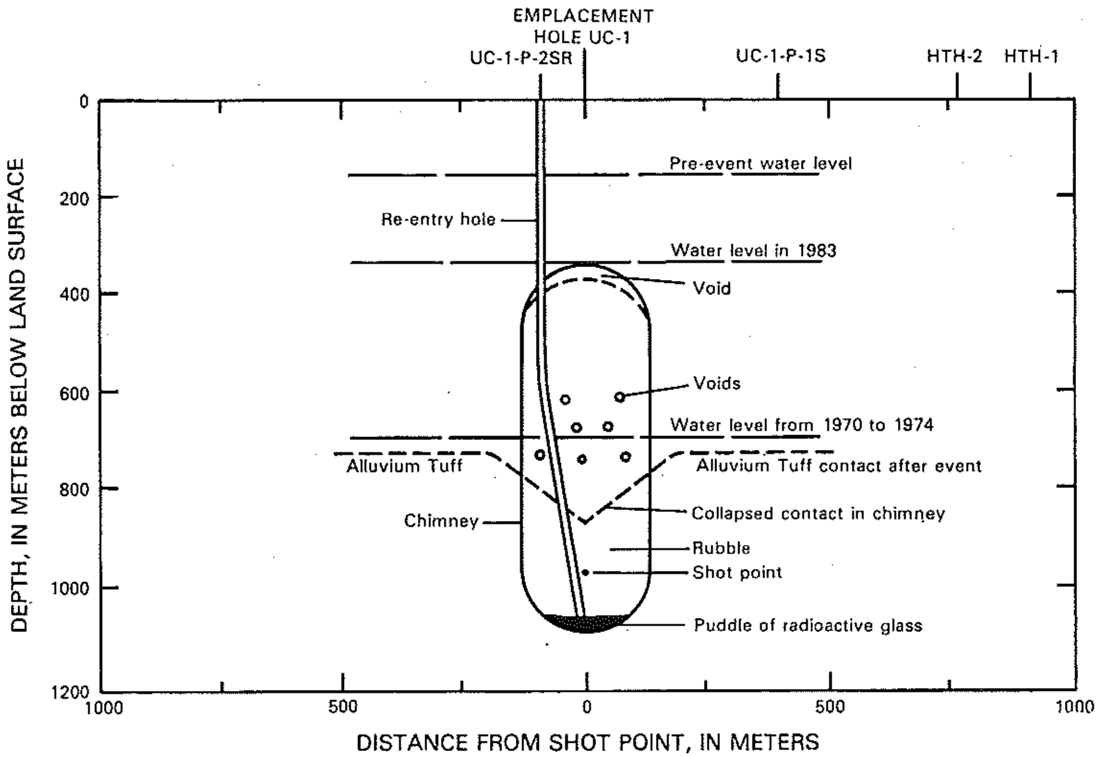

Figure 7.--Diagrammatic sketch of rubble chimney showing water levels at various times.

In reentry hole UC-1-P-2SR, water levels rose for the first 2 months after the end of drilling. After this time, water levels declined slowly for about 2 years, probably from water draining into the bottom of the rubble chimney. The slowness of the decline may be because of partly plugged perforations and rock pores, resulting from large quantities of drilling mud that were lost in both the reentry hole and the emplacement hole. However, during injection tests, 1,290 to 5,700 liters of water were injected into the hole. From 1970 to 1974, the water level was approximately 694.9 m. During this period, the hole was observed to have an obstruction at approximately 701.0 m. Because of this obstruction at 701 m, water levels were not taken during April and June, 1970. On October 27, 1970, a sinker bar, 4.44-cm in diameter, was run through this obstruction to a depth of 802 m, so that water levels could be measured. There still remains a restriction or crimped casing at 802 m. From 1974 to 1983, the water level rose to its present depth of 335.1 m. In test hole HTH-2, water-level measurements indicate that excess hydraulic pressure that resulted from the Faultless event decreased in 1976 to a depth of 169.5 m, 2.7 m above pre-event water-level depth of 172.2 m. In test hole HTH-1, water-level measurements indicate that excess hydraulic pressure that resulted from the Faultless event decreased in 1976 to a depth of 161.5 m, 6.7 m above the pre-event water-level depth of 168.2 m.

HYDRAULIC TESTING

Three injection tests, 1,290 L each, were conducted on June 17-18, 1970, to evaluate the water levels in reentry hole UC-1-P-2SR; one injection test, 5,680 L in 8 minutes, was injected on January 12, 1972. Recovery of the water levels after these injections is presented in figures 8 and 9.

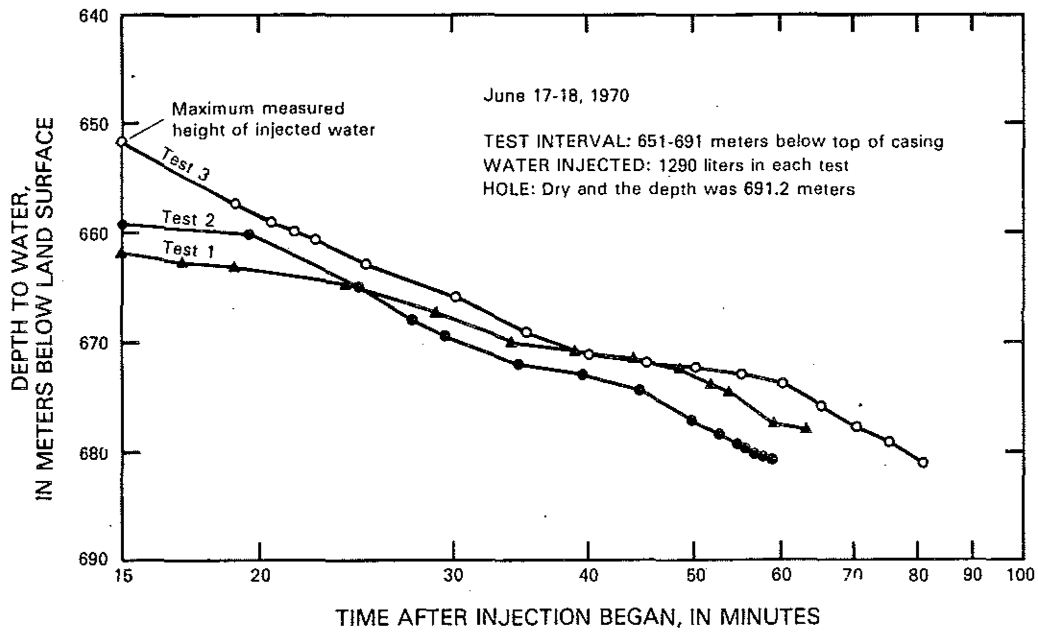

Figure 8.--Recovery of water level during injection test into reentry hole UC-1-P-2SR, June 17 and 18, 1970.

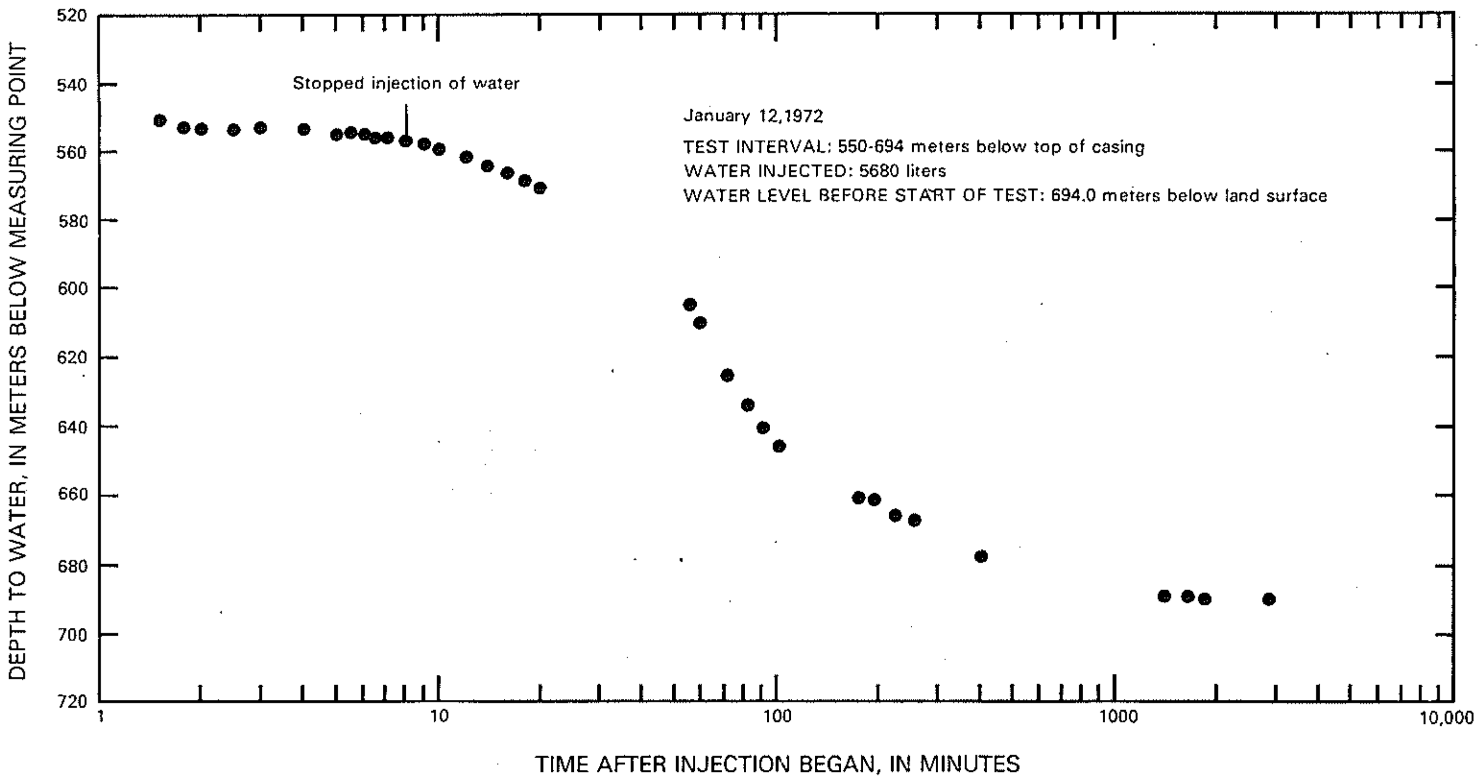

Figure 9.--Recovery of water level during injection test into reentry hole UC-1-P-2SR, January 12, 1972.

CHEMICAL AND RADIOCHEMICAL MONITORING

Results of chemical and radiochemical monitoring of water in test holes HTH-1, HTH-2, UCE-18, UC-1-P-1S, and UC-1-P-2SR are presented in tables 9 through 13. Chemical analyses of the water from reentry hole UC-1-P-2SR, from 1968 to 1983 indicate that the water is very similar to the water in the valley fill as represented by the water from test hole HTH-1 and very dissimilar to the water from test hole UCE-18 that was used to drill reentry hole UC-1-P-2SR.

Major-element and tritium analyses indicate three zones of water in reentry hole UC-1-P-2SR: (1) An upper zone above a depth of 594 m, (2) an intermediate zone from 594 to 728 m, and (3) a lower zone from 728 to 801 m. The upper zone, above a depth of 594 m, is similar to the sodium bicarbonate type waters found throughout the region in the tuffaceous aquifer system (Winograd and Thordarson, 1975; Claassen, 1973). The upper zone is characterized by specific-conductance values less than 280 μS, temperatures less than 30°C, and near-background tritium concentrations of about 1×10^3 pCi/L. The lower zone is characterized by specific-conductance values of 300 to 440 μS, temperatures of 37 to 55°C, and tritium concentrations of about 1×10^7 pCi/L. Although both the upper and lower zones contain the same major constituents of sodium and bicarbonate with minor sulfate and chloride, the lower zone has about 1.5 times the dissolved solids as the upper zone. Water in the intermediate zone, occurring between 594 to 728 m, is characteristic of dilution between the upper and lower zones.

Gross alpha, gross beta, and tritium concentrations in water from boreholes HTH-1, HTH-2, and UC-1-P-1S were almost the same as or slightly greater than background concentrations. Gross alpha, gross beta, and tritium concentrations in hole UC-1-P-2SR were greater than background concentrations, but were very variable. Tritium concentrations in water from reentry hole UC-1-P-2SR increased generally from concentrations of about 10^6 pCi/L in 1968 through 1972, to a maximum value of 9.2×10^8 pCi/L in 1976, then decreased to about 10^5 pCi/L in 1977, and increased gradually to values of about 10^7 pCi/L in 1980 and 1982. These tritium data are summarized in figure 10, where tritium concentrations are plotted against time, in years. Samples from a depth of 789 m represent the deepest samples collected. The two curves for depths of 668 and 698 m probably represent a zone of dilution in the intermediate zone; these curves are similar to each other until 1977. After 1977, tritium concentrations in the deeper-zone water increased, whereas tritium concentrations in the shallower-zone water decreased. The curve for a depth of 607 m generally shows only dilution. Background concentrations of tritium are less than 700 pCi/L, as shown in table 9 for water from test hole HTH-1.

Dissolved gross-beta concentrations in water samples from reentry hole UC-1-P-2SR reached a maximum of 5,540 pCi/L as cesium-137, when first sampled in 1968, but decreased to a maximum value of 130 pCi/L in 1976; gross-beta-concentrations are summarized in figure 11. After 1971, gross-beta concentrations ranged from 1.2 to 130 pCi/L, but generally was less than 10 pCi/L.

Table 9.--*Chemical and radiochemical analyses of water from test hole HTH-1*

[Dissolved constituents: Ca, calcium; Mg, magnesium; Na, sodium; K, potassium; CO^3, carbonate; HCO^3, bicarbonate; Cl, chloride; SO_4, sulfate; SiO_2, aqueous silica; Li, lithium; Sr, strontium; and F, fluoride, in milligrams per liter; gross alpha, dissolved as natural uranium, in micrograms per liter; gross beta, dissolved as cesium-137, and tritium, in picocuries per liter; pH in standard units; water temperature in degrees Celsius; specific conductance in microsiemens.]

Depth (meters)	Sample Date	Sample Time	Ca	Mg	Na	K	CO_3	HCO_3	Cl	SO_4	SiO_2	Li	Sr	F	Gross alpha	Gross beta	Tritium	pH (onsite)	Water temp-erature	Specific conduct-ance
213-259	8-5-67	2235	5.9	0.9	58	6.7	0	137	7.5	18	18	0.08	0.16	1.4	2.2	22	---	7.9	22.0	285
290-351	8-5-67	0635	8.7	.6	39	3.9	0	116	4.4	11	25	.05	.23	.9	2.0	5.6	---	7.7	24.5	218
732-750	8-2-67	0630	3.7	.8	144	7.9	122	47	13	44	44	.15	.14	12	13	24	---	10.2	27.0	663
805-826	8-1-67	1515	4.7	2	107	2.7	1	225	15	36	42	.11	.12	8.2	10	74	---	8.7	33.0	482
899-917	7-31-67	1620	12	.4	110	1.2	5	247	20	34	68	.16	.33	2.6	2.2	33	---	8.4	33.0	567
880	1-16-69		--	--	--	--	--	--	--	--	--	--	--	--	--	--	$<7.1x10^2$	--	--	--
	7-15-71	1125	--	--	--	--	--	--	--	--	--	--	--	--	--	--	$<7.0x10^2$	--	--	--
213-259	3-2-72	1330	3.4	.1	130	1.3	8	236	16	40	57	.14	.08	12	--	--	---	8.4	22.5	555

Table 10.--*Chemical and radiochemical analyses of water from test hole HTH-2*

[Dissolved constituents: Ca, calcium; Mg, magnesium; Na, sodium; K, potassium; CO_3, carbonate; HCO_3, bicarbonate; Cl, chloride; SO_4, sulfate; SiO_2, aqueous silica; Li, lithium; Sr, strontium; and F, fluoride, in milligrams per liter; tritium in picocuries per liter; pH in standard units; specific conductance in microsiemens.]

Depth (meters)	Sample Date	Sample Time	Ca	Mg	Na	K	CO_3	HCO_3	Cl	SO_4	SiO_2	Li	Sr	F	Tritium	pH (lab-oratory)	Specific conduct-ance
174	3-29-71	1046	25	5.6	18	1.5	0	148	2.3	<0.1	23	<0.01	0.44	<0.1	< 700	8.2	234
	7-15-71	1102	--	--	--	--	--	--	--	--	--	--	--	--	2700	--	--
	3-2-72	1150	42	5.8	19	1.5	0	199	2.7	7.2	27	.02	.41	.0	---	8.2	312

Table 11.--*Chemical and radiochemical analyses of water from test hole UCE-18*

[Dissolved constituents: Ca, calcium; Mg, magnesium; Na, sodium; K, potassium; CO_3, carbonate; HCO_3, bicarbonate; Cl, chloride; SO_4, sulfate; SiO_2, aqueous silica; Li, lithium; Sr, strontium; and F, fluoride, in milligrams per liter; gross alpha, dissolved as natural uranium, in micrograms per liter; gross beta, dissolved as cesium-137, in picocuries per liter; pH in standard units; water temperature in degrees Celsius; specific conductance in microsiemens.]

Depth (meters)	Sample Date	Sample Time	Ca	Mg	Na	K	CO_3	HCO_3	Cl	SO_4	SiO_2	Li	Sr	F	Gross alpha	Gross beta	pH (laboratory)	Water temperature	Specific conductance
124- 182	6-7-82	1930	4.2	1	325	5.7	8	656	67	47	54	0.12	0.05	17	525	430	8.4	33.5	1300
1388-1447	6-7-67	--	8.2	1.2	385	7.6	16	790	64	47	58	.16	.09	19	601	329	8.4	40.5	1510
1462-1552	6-12-67	--	6.6	1.4	535	8.4	26	1110	82	55	60	.23	.10	27	700	427	8.4	37.0	2070
1530-1579	6-3-67	--	3.0	.8	880	11	81	1860	76	73	66	.37	.10	39	2340	2570	8.7	41.5	3230
1615-1649	6-6-67	--	2.2	.2	875	9.0	51	1900	61	52	52	.39	.08	49	1197	1384	8.5	54.5	3220
1686-1719	6-5-67	--	2.2	.2	890	9.2	43	1920	74	53	55	.40	.04	60	2053	1613	8.5	46.0	3250
1769-1803	6-4-67	--	1.8	.2	880	8.7	51	1930	71	53	60	.38	.04	60	1784	1216	8.5	53.5	3300
1804-1853	6-1-67	--	2.0	.4	945	8.6	59	2050	80	52	46	.24	.04	62	408	174	8.6	---	3470
1874-1985	6-2-67	--	1.2	.6	875	8.5	67	1900	71	48	58	.36	.04	60	2130	2434	8.6	48.0	3300
	10-20-68	--	--	--	--	--	--	--	--	--	--	--	--	--	770	[1]110	--	49.0	----
	7-2-73	0900	6.8	.5	710	6.4	0	1670	51	69	66	.26	.08	23	210	38	8.3	---	2590
	do	1100	4.5	.4	720	6.2	242	1250	35	110	54	.26	.08	26	190	27	8.4	---	2660
	do	1300	5.8	.4	740	6.5	0	1780	50	59	54	.28	.08	28	340	43	8.2	---	2730
	do	1500	5.3	.5	760	6.6	263	1260	48	60	54	.27	.08	30	200	41	8.4	---	2760
	do	1510	5.6	.5	760	6.8	0	1790	52	59	54	.28	.09	29	---	--	8.3	---	2770
	do	2100	2.3	.4	770	6.8	217	1350	60	82	56	.27	.05	30	---	--	8.7	---	2780

[1]As strontium-90/yttrium-90.

Table 12.--*Chemical and radiochemical analyses of water from abandoned reentry hole UC-1-P-1S*

[Dissolved constituents: Ca, calcium; Mg, magnesium; Na, sodium; K, potassium; CO_3, carbonate; HCO_3, bicarbonate; Cl, chloride; SO_4, sulfate; SiO_2, aqueous silica; Li, lithium; Sr, strontium; and F, fluoride, in milligrams per liter; tritium in picocuries per liter; pH in standard units; specific conductance in microsiemens.]

Depth (meters)	Sample Date	Sample Time	Ca	Mg	Na	K	CO_3	HCO_3	Cl	SO_4	SiO_2	Li	Sr	F	Tritium	pH (Laboratory)	pH (Onsite)	Specific conductance
	1-13-69	----	30	1.4	--	--	0	125	--	--	--	--	--	--	$<7.1\times10^2$	---	8.2	278
83	3-29-71	0950	53	1.4	22	1.4	0	123	1.6	85	18	0.01	0.41	0.1	$<7.0\times10^2$	7.8	---	381
88	7-15-71	1050	--	---	--	--	--	---	--	--	--	--	--	--	1.4×10^4	---	---	---

Table 13.--*Chemical and radiochemical analyses of water from reentry hole UC-1-P-2SR*

Dissolved constituents: Ca, calcium; Mg, magnesium; Na, sodium; K, potassium; CO_3, carbonate; HCO_3, bicarbonate; Cl, chloride; SO_4, sulfate; SiO_2, aqueous silica; Li, lithium; Sr, strontium; and F, fluoride, in milligrams per liter; gross alpha, dissolved as natural uranium in micrograms per liter; gross beta, dissolved as cesium-137, tritium, and dissolved potassium-40 in picocuries per liter; onsite pH in standard units; water temperature in degrees Celsius; specific conductance in microsiemens.]

Depth (meters) Water	Depth (meters) Sample	Sample Date	Sample Time	Ca	Mg	Na	K	CO_3[1]	HCO_3[1]	Cl	SO_4	SiO_2	Li	Sr	F	Gross alpha	Gross beta	Tritium	K_{40}	pH	Water Temperature	Specific Conductance
653	654	4-9-68		1.6	<0.1	88	2.5	27	124	12	37	27	0.10	0.05	--	<20	5540	3.2×10^{6}	--	9.3	--	411
650	650	7-31-68														5.7	158	5.7×10^{5}				
Do.	do.	8-1-68																5.6×10^{5}				
Do.	do.	8-2-68																5.6×10^{5}				
671	671	1-14-69		1.9	< .1	74	5.0	51	0	4.8	16	38	.11	.09	.6	<.7	13.1	3.0×10^{5}	--	10.9	--	422
675	675	5-13-69														≤.3	10	4.1×10^{5}				
678	681	9-24-69														.9	9.1	7.0×10^{5}				
700	702	12-1-70	1133	1.0	< .1	68	2.1	65	12	8.6	22	25	.08	.08	1.0	5.3	8.3	3.6×10^{5}		10.0	35.5	320
Do.	710	do.	1302	1.2	< .1	68	2.0	72	2	7.1	22	24	.07	.09	1.0	9.4	7.9	6.2×10^{5}		10.0	36.5	320
Do.	756	do.	1641	.5	< .1	67	2.1	73	2	6.8	19	25	.08	.08	.9	7.8	50	2.2×10^{6}		10.1	39.5	325
Do.	786	12-2-70	1007	.7	< .1	67	2.2	64	19	6.5	20	26	.08	.07	1.0	5.3	72	2.4×10^{6}		10.1	59.8	325
699	702	3-30-71	1100													10	4.6	3.3×10^{5}			36.0	
Do.	711	do.	1205													2.2	3.5	5.8×10^{5}			36.5	
Do.	725	do.	1318													5.8	8.3	8.1×10^{5}			38.0	
Do.	740	do.	1432													7.6	15	1.5×10^{6}			38.0	
Do.	756	3-31-71	2116													11	51	1.7×10^{6}				
Do.	771	do.	2215													7.9	47	1.6×10^{6}				
Do.	786	do.	2235													10	89	1.3×10^{6}				
Do.	801	do.	2307													45	280	1.4×10^{6}				
696	704	7-14-71	1500													17	49	3.3×10^{5}				
Do.	722	do.	1515													8.2	23	7.0×10^{5}				
Do.	741	do.	1645													10	38	1.8×10^{6}				
Do.	759	do.	1700													9.5	40	5.0×10^{5}				
Do.	777	do.	1720													15	98	4.7×10^{5}				
Do.	796	do.	1740													40	150	4.7×10^{5}				
693	693	9-23-71	1845	2.3	< .1	62	2.7	27	92	5.9	19	22	.12	.10	.7	4.1	8.3	2.0×10^{5}		9.4	31.7	295
695	697	9-13-72	1100													17	3.7	1.7×10^{5}				
Do.	710	do.	1120													11	6.0	1.7×10^{6}				
Do.	725	do.	1210													7.5	3.7	1.9×10^{6}				
Do.	741	do.	1300													< 2.6	4.1	1.9×10^{6}				
Do.	756	do.	1540													< 2.9	3.7	1.5×10^{6}				
Do.	771	do.	1640													8.6	51	2.0×10^{6}				
Do.	789	do.	1720													2.8	20	1.9×10^{6}				
696	699	6-11-73	1215													16	4.2	2.5×10^{6}				
Do.	714	do.	1300													7.4	10	1.7×10^{7}				
Do.	729	do.	1400													5.3	8.3	3.1×10^{7}				
Do.	745	do.	1430													5.1	8.3	3.4×10^{7}				
Do.	760	do.	1455													5.6	9.4	3.5×10^{7}				
Do.	775	do.	1530													4.9	12	3.6×10^{7}				
Do.	790	do.	1600													8.3	14	3.6×10^{7}				
Do.	797	do.	1625													< 3.2	15	3.6×10^{7}				
Do.	698	12-9-73	1110													7.8	5.6	1.3×10^{7}				
Do.	713	do.	1205													8.4	8.0	3.8×10^{7}				
Do.	728	do.	1245													9.1	12	6.5×10^{7}				
Do.		do.	1345													32	13	6.2×10^{7}				
Do.		do.	1530													11	13	6.1×10^{7}				
Do.		do.	1615													13	15	6.1×10^{7}				

Table 13.--*Chemical and radiochemical analyses of water from reentry hole UC-1-P-2SR*-Continued

Depth (meters)		Sample						Alkalinity														
Water	Sample	Date	Time	Ca	Mg	Na	K	Lab-oratory	On-site	Cl	SO_4	SiO_2	Li	Sr	F	Gross alpha	Gross beta	Tritium	K_{40}	pH	Water Temp-erature	Specific Conduct-ance
696	789	12-9-73	1645													12	17	6.2×10^{7}				
Do.	796	do.	1745													14	20	6.3×10^{7}				
697	700	4-10-74	1040													12	3.6	2.6×10^{6}				
Do.	713	do.	1210													19	7.8	3.8×10^{7}				
Do.	728	do.	1245													19	12	6.4×10^{7}				
Do.	744	do.	1320													17	12	6.7×10^{7}				
Do.	759	do.	1400													15	11	6.4×10^{7}				
Do.	774	do.	1525													18	13	6.5×10^{7}				
Do.	789	do.	1605													23	17	6.5×10^{7}				
Do.	799	do.	1650													22	18	6.5×10^{7}				
696	699	9-24-74	1238													3.9	2.8	3.0×10^{6}				
Do.	713	do.	1328													4.0	6.0	4.0×10^{7}				
Do.	728	do.	1409													7.8	11	7.3×10^{7}				
Do.	744	do.	1453													16	11	7.1×10^{7}				
Do.	759	do.	1537													12	12	6.9×10^{7}				
Do.	774	do.	1610													12	15	7.0×10^{7}				
Do.	789	do.	0925													6.9	14	7.3×10^{7}				
Do.	799	do.	1010													29	14	6.9×10^{7}				
665	668	2-5-75	1145													27	5.2	1.2×10^{5}			32.2	
Do.	683	do.	1300													17	1.4	1.2×10^{5}			35.6	
Do.	698	do.	1400													19	2.2	3.4×10^{5}			34.4	
Do.	712	do.	1440													10	2.8	5.4×10^{6}			37.2	
Do.	728	do.	1520													17	3.9	4.9×10^{6}			38.9	
Do.	743	2-6-75	0920													13	3.9	3.9×10^{6}			37.8	
Do.	758	do.	1000													16	3.8	5.8×10^{6}			39.4	
Do.	774	do.	1045													18	6.1	5.7×10^{6}			44.4	
Do.	788	2-6-75	1140													36	11	5.2×10^{6}			54.4	
Do.	797	do.	1245													.9	5.8	5.3×10^{6}			57.8	
627	629	8-12-75	1230	8.0	.2	68	1.7	--	115	8.9	30	26	.07	.10	1.3	8.7	2.7	9.3×10^{4}		9.2	31.7	300
Do.	637	do.	1445													12	3.1	9.6×10^{4}		9.2	31.7	330
Do.	652	do.	1600													16	2.8	1.2×10^{5}		9.2	32.8	280
Do.	668	8-13-75	0830													4.0	2.0	1.7×10^{5}		9.2	33.3	280
Do.	683	do.	0915													7.1	2.3	1.7×10^{5}		9.2	33.9	285
Do.	698	do.	0945													4.1	2.1	1.7×10^{5}		9.3	35.0	275
Do.	713	do.	1030	2.0	.2	68	1.1	--	123	7.2	30	24	.05	.06	1.4	3.4	1.9	2.0×10^{5}		9.3	36.7	275
Do.	728	do.	1115													3.8	11	3.0×10^{6}		9.5	37.8	263
Do.	744	do.	1230													8.3	21	6.0×10^{6}		9.5	40.0	260
Do.	759	do.	1330													8.5	32	7.9×10^{6}		9.6	43.3	255
Do.	774	do.	1415													4.4	29	9.3×10^{6}		9.7	51.1	258
Do.	789	do.	1500	1.8	.8	62	.9	--	102	6.3	32	34	.05	.02	1.6	10	35	9.6×10^{6}		9.6	60.6	265
599	602	2-10-76	1250	2.5	.2	57	1.4		108	4.4	24	20	.07	.13	1.1	4.7	2.2	1.8×10^{4}		9.9		270
Do.	607	do.	1400	4.2	.1	66	1.2		119	5.7	31	21	.06	.08	1.3	<2.4	2.1	8.1×10^{4}		9.5		300
Do.	622	do.	1500	5.0	< .1	61	1.2		114	5.7	28	20	.06	.05	1.3	4.6	2.5	7.0×10^{4}		9.5		288
Do.	637	2-11-76	1000	8.1	< .1	62	1.1		121	5.6	29	20	.06	.06	1.4	5.6	2.0	8.1×10^{4}		9.3		288
Do.	652	do.	1030	2.1	.3	69	1.2		123	5.8	31	21	.06	.07	1.5	6.3	2.2	2.3×10^{5}		9.2		305
Do.	668	do.	1120	2.0	.2	70	1.3		124	6.0	31	22	.06	.07	1.5	5.9	2.8	3.9×10^{5}		9.2		318
Do.	683	do.	1215	2.9	.6	68	.9		124	5.8	32	22	.05	.04	1.5	8.7	5.3	3.9×10^{5}		9.3		305
Do.	698	do.	1330	3.0	.2	68	1.0		122	5.8	32	21	.06	.08	1.5	6.3	7.4	3.8×10^{5}		9.2		307
Do.	713	do.	1420	2.3	.1	69	1.0		122	5.9	31	22	.06	.08	1.5	5.8	4.1	8.6×10^{6}		9.3		303
Do.	728	do.	1505	7.5	.4	70	1.2		116	9.2	44	40	.07	.06	1.8	6.3	79	2.9×10^{8}		9.6		339
Do.	744	do.	1550	3.7	.7	76	1.2		117	10	48	48	.08	.05	1.9	5.7	120	3.8×10^{8}		9.5		352
Do.	759	2-12-76	0930	10	.7	72	1.2		117	11	49	50	.06	.05	2.0	5.4	110	3.6×10^{8}		9.7		354

Table 13.--*Chemical and radiochemical analyses of water from reentry hole UC-1-P-2SR*--Continued

Depth (meters) Water	Depth (meters) Sample	Sample *Date*	Sample *Time*	*Ca*	*Mg*	*Na*	*K*	Alkalinity Lab-*oratory*	Alkalinity On-*site*	Cl	SO_4	SiO_2	Li	Sr	F	Gross alpha	Gross beta	Tritium	K_{40}	pH	Water Temp-erature	Specific Conduct-ance
599	774	12-2-76	1025	1.7	0.3	77	1.4		118	11	49	55	0.07	0.07	1.9	5.8	120	$3.6x10^8$		9.7		357
Do.	789	do.	1110	2.0	.2	79	1.3		116	11	48	51	.08	.07	2.0	<3.6	110	$3.7x10^8$		9.7		362
573	576	8-31-76	1030	2.5	.1	54	1.3		93	6.2	21	19	.05	.33	1.0	3.2	1.9	$2.2x10^3$		10.1	33.0	268
Do.	607	do.	1230				1.0									8.3	1.4	$7.9x10^4$		8.9	30.0	322
Do.	637	do.	1330				.9									5.6	.9	$8.5x10^4$		8.8	31.6	322
Do.	652	do.	1430				.9									10	1.5	$1.8x10^5$		8.8	32.2	330
Do.	668	do.	1530				.9									7.7	1.9	$3.2x10^5$		8.8	32.8	328
Do.	698	do.	1630	2.5	.1	70	.9		119	7.0	31	26	.06	.22	1.6	7.0	3.2	$3.2x10^5$		8.7	33.9	328
Do.	713	9-1-76	1030	2.9	< .1	70	1.0		123	7.2	32	26	.06	.22	1.6	11	2.2	$6.4x10^5$		8.6	35.0	328
Do.	728	do.	1205	1.9	.4	94	1.4		120	17	75	58	.09	.14	2.3	<3.1	110	$6.4x10^8$		8.6	37.8	450
Do.	744	do.	1420				1.3									<3.9	120	$7.6x10^8$		9.1	40.0	475
Do.	774	do.	1630	2.1	.1	98	1.6		120	19	82	64	.11	.13	2.2	<3.8	130	$7.6x10^8$		9.1	52.8	472
Do.	789	9-2-76	1015				1.4									5.1	130	$9.2x10^8$		9.0	62.2	472
550	553	3-1-77	1000	2.3	.2	50	1.5		80	14	21	17	.05	.35	.8	<1.8	2.0	$<4.8x10^2$		9.7	30.0	225
Do.	576	do.	1115	2.1	< .1	49	1.4		94	4.3	20	19	.04	.37	.9			$<4.8x10^2$		10.0	30.5	229
Do.	607	do.	1145	2.1	< .1	65	1.1		110	5.8	28	24	.06	.35	1.3			$5.1x10^4$		9.5	31.5	285
Do.	637	do.	1225	2.4	.1	66	1.1		120	5.8	28	25	.06	.24	1.4			$5.5x10^4$		9.4	33.0	291
Do.	652	do.	1310	2.3	< .1	67	1.0		120	6.0	29	26	.06	.23	1.4			$1.1x10^5$		9.4	33.0	305
Do.	668	do.	1355	2.5	< .1	68	1.0		110	6.2	30	27	.06	.23	1.5			$1.9x10^5$		9.4	34.0	305
Do.	698	do.	1500	2.5	.1	68	1.0		120	6.1	30	29	.06	.22	1.5	<2.9	1.9	$1.9x10^5$		9.0	35.5	303
Do.	713	3-2-77	1030	2.5	.1	70	1.0		120	6.1	30	26	.06	.22	1.5	<3.0	1.7	$1.9x10^5$		9.4	36.0	303
Do.	728	do.	1100				1.0									<2.8	9.8	$3.7x10^7$		9.4	38.5	317
Do.	744	do.	1145															$1.2x10^8$		9.4	40.5	320
Do.	774	do.	1500													<4.0	63	$2.9x10^8$		9.5	53.0	361
Do.	789	do.	1550															$3.2x10^8$		9.5	59.5	372
516	520	10-18-77	1045				1.4									2.6	2.1	$<3.0x10^2$	1.0	9.5	29.0	242
Do.	549	do.	1145		1.2	61	2.8		97	5.0	21	17	.06	.38	.9	2.1	2.5	$<3.0x10^2$	2.1	9.8	30.0	238
Do.	576	do	1245				1.7									<1.6	1.4	$<3.0x10^2$	1.3	9.7	29.5	242
Do.	607	do.	1330				1.7									<2.3	2.6	$4.5x10^4$	1.3	9.3	--	280
Do.	637	do.	1410				1.9									<2.4	2.0	$4.9x10^4$	1.4	9.4	32.0	288
Do.	652	do.	1500				1.3									<2.4	1.9	$1.0x10^5$	1.0	9.3	33.0	300
Do.	668	10-19-77	0940				1.8									3.0	2.9	$2.3x10^5$	1.3	9.4	33.0	272
Do.	698	do.	1030		.1	79	.9		120	6.6	29	27	.07	.19	1.5	5.0	1.6	$2.3x10^5$	.7	9.4	35.0	255
Do.	713	do.	1115				1.7									<2.5	2.0	$2.4x10^5$	1.3	9.3	36.0	261
Do.	728	do.	1200		.1	78	1.0		120	6.6	29	27	.07	.21	1.5	2.8	1.9	$2.4x10^5$	.7	9.1	38.0	265
Do.	744	do.	1245				1.8									2.4	6.0	$2.4x10^5$	1.3	9.2	39.5	250
Do.	774	do.	1330		.1	79	.9		120	6.4	29	27	.07	.21	1.5	<2.3	22	$2.3x10^5$	.7	9.2	49.0	223
Do.	789	do.	1420				.9									2.6	8.4	$2.3x10^5$	.7	9.2	--	221
485	488	6-13-78	1040				1.3									<1.1	2.5	$5.5x10^2$	1.0	9.8	29.0	260
Do.	488	do.	1140		.1	54	1.5		92	5.2	19	16	.05	.37	.9	--	--	--	--	9.8	29.0	260
Do.	515	do.	1240		.4	54	1.3		80	12	19	16	.05	.24	.9	<1.9	1.1	$3.6x10^2$	1.0	9.8	29.0	255
Do.	546	do.	1350		.1	54	1.3		92	4.7	18	16	.05	.33	.9	<1.3	1.2	$5.7x10^2$	1.0	9.8	29.0	257
Do.	576	do.	1500		.1	54	1.3		90	6.5	19	16	.05	.32	.9	<2.0	1.3	$4.1x10^2$	1.0	9.8	30.0	255

Table 13.--*Chemical and radiochemical analyses of water from reentry hole UC-1-P-2SR*--Continued

Depth (meters)		Sample						Alkalinity													Water	Specific
								Lab-	On-							Gross	Gross				Temp-	Conduct-
Water	Sample	Date	Time	Ca	Mg	Na	K	oratory	site	Cl	SO_4	SiO_2	Li	Sr	F	alpha	beta	Tritium	K_{40}	pH	erature	ance
485	576	6-14-78	0830		0.1	54	1.3		92	4.8	19	16	0.05	0.37	0.9	<2.0	1.0	4.8×10^2	1.0	9.8	31.0	250
Do.	607	do.	0940		.1	67	1.1		110	6.1	25	22	.06	.22	1.2	<2.3	<1.0	3.8×10^4	.8	9.4	32.5	300
Do.	637	do.	1040		.1	67	1.2		110	5.9	27	23	.07	.27	1.3	<2.6	<1.0	4.3×10^4	.9	9.3	34.0	285
Do.	652	do.	1145		.1	71	1.1		120	6.1	28	26	.07	.28	1.4	<2.7	<1.1	8.9×10^4	.8	9.2	34.5	330
Do.	668	do.	1255		.1	71	1.1		130	6.6	30	28	.07	.22	1.5	3.8	<1.1	1.5×10^5	.8	9.1	34.5	345
Do.	698	do.	1410		.1	71	.9		130	6.6	30	28	.07	.22	1.6	4.4	<1.1	7.5×10^5	.7	9.1	36.0	345
Do.	713	do.	1535		.1	74	.9		120	6.8	30	28	.07	.20	1.6	4.0	1.3	2.9×10^6	.7	9.1	37.0	345
Do.	728	6-15-78	0820		.1	72	1.3		120	6.8	31	28	.07	.21	1.6	4.0	2.3	2.8×10^6	1.0	9.2	43.0	345
Do.	744	do.	0920		.3	73	1.2		120	6.7	30	28	.07	.21	1.6	3.8	4.0	2.8×10^6	.9	9.2	39.5	350
Do.	774	do.	1020		.1	73	1.0		120	6.7	30	27	.07	.20	1.6	4.5	19	2.8×10^6	.7	9.2	48.0	325
Do.	789	do.	1120	--	.2	74	.9		120	6.7	30	27	.07	.17	1.6	3.8	30	2.9×10^6	.7	9.1	56.0	320
464	466	12-11-78	1630	2.1	< .1	50	1.4		84	--	24	16	.05	.30	.8	--	--	1.6×10^3		9.9	27.0	220
Do.	466	do.	1730	--	--	--	--		--	--	--	--	--	--	--	<1.7	1.7	--		9.9	27.0	240
Do.	485	do.	1810	2.2	.1	49	1.4		84	4.5	19	19	.05	.28	.8	<1.7	2.1	1.3×10^3		10.0	27.5	245
Do.	515	12-12-78	0810	2.2	.1	48	1.4		90	4.6	19	16	.04	.30	.8	<1.7	.9	1.2×10^3		9.8	28.5	235
Do.	546	do.	0910	2.2	< .1	49	1.4		82	4.6	19	16	.05	.30	.8	<1.8	1.4	1.2×10^3		9.9	28.5	225
Do.	576	do.	1000	2.2	.1	51	1.4		87	4.6	19	16	.05	.31	.8	<1.9	1.0	1.3×10^3		9.7	29.0	230
Do.	607	do.	1050	2.5	.1	62	1.2		110	5.8	26	22	.05	.24	1.2	<2.5	1.7	3.6×10^4		9.7	31.0	280
Do.	637	do.	1140	2.6	.1	63	1.2		110	5.8	27	23	.05	.22	1.3	<2.3	<1.0	4.1×10^4		9.6	33.0	280
Do.	652	do.	1305	2.7	.1	65	1.2		110	6.1	29	25	.06	.19	1.4	2.7	1.3	7.7×10^4		9.2	33.0	305
Do.	668	do.	1410	2.7	.1	68	1.1		110	6.7	31	27	.06	.17	1.6	3.8	<1.0	1.3×10^5		9.2	39.0	310
Do.	698	do.	1510	3.0	.1	68	1.1		120	6.9	32	27	.06	.16	1.6	4.4	2.0	2.1×10^6		9.3	35.0	310
Do.	713	do.	1605	2.6	.1	70	1.1		120	6.6	32	28	.08	.17	1.6	5.4	2.2	6.1×10^6		9.4	36.0	310
Do.	728	12-13-78	0800	3.2	.1	70	1.3		120	6.8	33	32	.06	.17	1.6	3.5	2.8	5.6×10^6		9.4	38.5	300
Do.	744	do.	0855	2.7	.1	69	1.2		120	7.0	32	29	.06	.16	1.6	4.8	2.6	5.6×10^6		9.5	39.0	320
Do.	774	do.	0950	2.7	.1	70	1.2		120	6.8	32	29	.06	.16	1.6	6.2	4.1	5.9×10^6		9.3	42.0	300
Do.	789	do.	1055	2.7	.1	71	1.2		110	6.6	32	30	.06	.16	1.6	<2.5	6.3	5.5×10^6		9.1	55.0	300
448	454	5-23-79	1445	5.5	< .1	52	2.0		80	10	24	13	.05	.40	.9	<1.7	1.3	4.8×10^4	1.5	9.5		250
Do.	485	do.	1620	--	< .1	52	1.4		120	5.6	22	14	.06	.40	.9	<1.7	1.4	3.3×10^3	1.0	9.7		245
Do.	515	do.	1830	--	< .1	52	1.5		95	11	18	13	.05	.38	.9	<1.6	1.6	2.7×10^3	1.1	9.6		285
Do.	546	5-24-79	0915	1.8	< .1	50	2.0		81	12	18	13	.05	.48	1.0	<1.7	1.6	1.8×10^3	1.5	9.8		255
Do.	576	do.	1120	--	< .1	51	1.9		80	15	18	12	.05	.50	.9	<1.9	2.0	1.3×10^3	1.4	9.8	30.0	245
Do.	607	do.	1435	--	< .1	57	1.7		100	10	22	16	.05	.39	1.1	<2.1	1.2	1.9×10^4	1.3	9.6	32.0	260
Do.	637	5-24-79	1620	--	< .1	61	1.4		110	10	22	18	.05	.29	1.1	<1.9	1.3	2.1×10^4	1.0	9.5	33.0	270
Do.	652	do.	1840	2.9	< .1	62	1.8		95	10	24	20	.06	.30	1.2	<2.4	1.5	3.9×10^4	1.3	9.4	33.5	280

Table 13.--*Chemical and radiochemical analyses of water from reentry hole UC-1-P-2SR*--Continued

Depth (meters) Water	Depth (meters) Sample	Sample Date	Sample Time	Ca	Mg	Na	K	Alkalinity Lab-oratory	Alkalinity On-site	Cl	SO_4	SiO_2	Li	Sr	F	Gross alpha	Gross beta	Tritium	K_{40}	pH	Water Temp-erature	Specific Conduct-ance
448	668	5-25-79	0930	7.4	<0.1	68	1.5		130	9.5	26	22	0.07	0.33	1.3	<2.4	1.5	$7.4x10^4$	1.1	9.4	34.0	295
Do.	698	do.	1150	5.5	< .1	68	1.4		120	9.2	28	23	.07	.25	1.4	4.2	1.6	$2.3x10^6$	1.0	9.4	35.5	300
Do.	713	do.	1425	7.6	< .1	69	1.4		130	8.8	28	23	.07	.19	1.4	4.3	2.3	$5.5x10^6$	1.0	9.3	36.0	315
Do.	728	5-31-79	1010	6.8	.1	77	1.4		120	10	31	26	--	.25	1.6	3.3	1.9	$3.6x10^6$	1.0	9.2	36.0	315
Do.	744	do.	1230	6.0	.1	50	2.6		93	19	17	10	.05	.50	.9	<1.6	1.7	$1.7x10^4$	2.6	10.0	37.5	235
Do.	774	do.	1505	2.8	.1	74	1.3		120	13	32	26	.07	.24	1.7	5.2	2.3	$7.3x10^6$	1.0	9.2	39.0	315
Do.	789	do.	1720	5.2	< .1	75	.8		130	12	32	26	.08	.31	1.6	<3.3	3.7	$7.2x10^6$	.6	9.2	42.0	315
440	457	9-10-79	2100	2.6	.2	50	1.5		110	5.6	17	15	--	.38	.7	<2.1	1.4	$7.3x10^2$	1.1	9.9		222
Do.	488	do.	2335	4.4	.6	49	1.5		110	5.5	16	15		.37	.8	<2.0	<1.0	$5.8x10^2$	1.1	10.0		227
Do.	518	9-11-79	0150	2.1	.1	49	1.4		110	5.4	16	15		.36	.8	<2.3	2.0	$4.9x10^2$	1.0	10.1		235
Do.	549	do.	1420	2.2	.1	49	1.4	89	110	5.7	16	15		.38	.8	<1.9	1.5	$5.2x10^2$	1.0	10.0		229
Do.	579	do.	1700	2.2	.2	50	1.4	89	110	6.3	17	15		.37	.8	<2.1	1.0	$3.4x10^2$	1.0	10.0		229
Do.	594	9-14-79	1340	2.5	.1	50	1.3	--	92	5.5	18	15		.35	.8	2.4	1.7	$9.7x10^3$	1.1	9.7		224
Do.	634	9-12-79	1230	2.3	< .1	66	1.1	120	140	6.5	24	24		.22	1.3	<2.7	1.7	$3.5x10^4$	.8	9.4		306
Do.	637	9-14-79	1600	2.7	.5	69	1.2	120	--	6.5	25	23		.23	1.3	7.2	4.0	$3.9x10^4$	.9	9.2		316
Do.	698	9-12-79	1605	2.5	.2	75	.9	130	150	7.3	31	29		.16	1.6	<3.8	1.5	$4.0x10^6$	.7	9.1		328
Do.	716	do.	1920	2.5	.3	76	.9	130	140	7.4	31	29		.16	1.7	3.7	3.5	$8.8x10^6$	.7	9.1		335
430	433	12-4-79	1115	2.5	.1	50	1.4	89	110	6.7	17	16		.35	.9	---	---	$1.3x10^3$		9.9	--	226
Do.	433	do.	1150	--	--	--	--	--	107	--	--	--	--	--	--	<1.9	2.2	--		10.0	--	224
Do.	454	do.	1245	2.2	.5	54	1.3	89	110	8.3	17	16	--	.33	.9	<1.8	1.2	$1.1x10^3$		9.6		217
Do.	485	do.	1330	2.1	.7	49	1.4	92	110	6.4	17	15		.32	.9	<2.0	7.4	$1.2x10^3$	1.0	9.6	23.1	218
Do.	515	do.	1410	2.1	.3	49	1.3	93	110	5.3	17	15		.31	.9	<2.2	1.0	$1.1x10^3$	1.0	9.7	28.5	216
Do.	546	do.	1455	2.0	.9	48	1.4	94	110	5.2	17	15		.30	.9	<2.2	<1.0	$1.1x10^3$	1.0	9.8	29.0	220
Do.	576	do.	1535	2.1	.5	55	1.3	94	110	5.0	17	15		.31	.9	<1.9	1.1	$1.1x10^3$	1.0	9.7	29.5	213
Do.	607	12-4-79	1625	2.7	.4	69	1.1	120	140	6.2	24	22		.24	1.2	4.0	1.5	$3.3x10^4$	.8	9.2	30.5	266
Do.	637	12-5-79	1125	2.6	.3	70	1.0	120	140	6.2	25	23		.23	1.3	5.1	2.5	$3.6x10^4$	.7	9.3	33.5	272
Do.	652	do.	1210	3.1	.2	73	.9	130	160	6.6	27	26		.21	1.5	8.0	2.4	$5.2x10^4$	.7	8.8	33.5	282
Do.	668	do.	1300	3.1	.1	76	.9	130	160	7.1	29	29		.19	1.6	6.5	2.2	$9.0x10^4$	.7	8.9	34.0	297
Do.	698	do.	1400	3.4	< .1	78	.9	130	160	7.4	30	29		.19	1.7	12	3.6	$4.9x10^6$	.7	8.6	36.0	305
Do.	713	do.	1455	2.8	.4	79	1.1	130	150	7.6	30	27		.17	1.6	18	6.5	$8.7x10^6$	.8	8.9	36.5	291
Do.	728	do.	1557	3.1	.5	78	1.0	130	160	7.7	31	27		.18	1.7	8.8	4.9	$8.8x10^6$	.7	8.7	37.0	297
Do.	744	12-6-79	1011	2.5	.7	72	1.0	120	160	7.8	31	26		.16	1.6	14	6.4	--	.7	8.9	38.0	294
Do.	774	do.	1125	2.8	.8	80	1.0	130	170	7.7	31	26		.16	1.6	22	10	$8.8x10^6$	.7	8.8	46.0	300
Do.	789	do.	1235	3.1	.2	74	.9	130	160	7.6	31	26		.16	1.6	23	34	$8.0x10^6$	.7	8.7	54.0	290
412	424	7-15-80	1500	2.4	.1	49	1.5	88		6.1	17	16	.04	.31	.9	<1.7	2.1	$1.1x10^3$	1.1	9.8	--	225
Do.	454	do.	1625	1.7	.1	47	1.4	87		6.6	17	16	.04	.33	.9	<1.3	2.2	$8.8x10^2$	1.0	9.9		230
Do.	485	7-16-80	1600	1.7	.1	46	1.5	87		5.8	17	15	.04	.33	.9	<1.5	1.8	$9.2x10^2$	1.1	9.9		232
Do.	509	do.	1720	1.7	.1	46	1.4	88		5.0	16	15	.04	.33	.8	<1.5	1.3	$1.1x10^3$	1.0	9.8		238
Do.	546	do.	1900	1.7	.1	46	1.4	89		5.0	16	15	.04	.33	.9	<1.5	1.7	$7.6x10^2$	1.0	9.9		228
Do.	576	7-17-80	0915	1.8	.2	47	1.4	89		5.0	17	15	.04	.33	.9	<1.5	1.7	$9.7x10^2$	1.0	9.9		231
Do.	607	do.	1110	2.0	.2	60	1.1	110		5.8	24	22	.05	.19	1.2	2.6	1.7	$3.1x10^4$	.8	9.5		295
Do.	637	do.	1305	2.4	.1	65	1.0	110		7.0	25	23	.05	.19	1.3	2.3	1.5	$3.2x10^4$	.7	9.4		292
Do.	652	do.	1500	2.3	.1	65	.9	120		6.4	26	25	.06	.16	1.5	<2.1	<1.3	$4.3x10^4$	.7	9.3	33.0	312

Table 13.--*Chemical and radiochemical analyses of water from reentry hole UC-1-P-2SR*--Continued

Depth (meters)		Sample						Alkalinity													Water	Specific
Water	Sample	Date	Time	Ca	Mg	Na	K	Lab-oratory	On-site	Cl	SO_4	SiO_2	Li	Sr	F	Gross alpha	Gross beta	Tritium	K_{40}	pH	Temp-erature	Conduct-ance
412	668	do.	1710	2.5	0.1	69	0.9	120		6.7	28	28	0.06	0.15	1.7	3.4	<1.4	7.4×10^4	0.7	9.2	34.5	330
Do.	698	do.	1910	2.5	.0	71	.9	120		7.1	30	27	.06	.14	1.7	4.6	2.1	5.7×10^6	.7	9.2	34.0	339
Do.	713	7-18-80	1445	2.2	.0	68	.9	120		8.5	31	27	.06	.13	1.8	3.1	2.5	1.1×10^7	.7	9.0	36.5	341
Do.	728	do.	1645	2.3	.0	69	.9	120		8.3	31	27	.06	.13	1.8	3.5	3.2	1.4×10^7	.7	9.1	38.0	338
Do.	744	do.	1845	2.4	.0	70	.9	120		7.9	31	27	.06	.13	1.8	3.7	4.4	1.4×10^7	.7	8.9	41.0	334
Do.	774	7-19-80	1145	2.5	.0	67	.8	120		9.2	31	26	.06	.12	1.8	<2.4	2.8	1.4×10^7	.6	9.1	39.3	329
Do.	789	do.	1445	2.2	.0	69	.9	120		7.1	31	26	.06	.13	1.8	3.7	4.0	1.4×10^7	.7	9.1	53.5	339
387	393	6-25-81	1000	5.4	.3	45	1.3	74		4.6	18	18	.05	.36	.6	<3.3	3.6	1.1×10^3	1.0	9.4		235
Do.	454	do.	1210	2.2	.1	46	1.2	74		5.2	18	18	.04	--	.7	<3.1	2.1	9.7×10^2	.9	9.5		229
Do.	515	do.	1330	5.4	.1	45	1.2	74		5.3	18	18	.05	.36	.7	<3.2	2.8	9.9×10^2	.9	9.6		229
Do.	576	do.	1500	4.3	.1	46	1.2	75		5.4	15	18	.05	.36	.7	<2.7	2.4	1.1×10^3	.9	9.5		233
Do.	607	6-30-81	1105	2.6	.1	61	1.0	100		5.5	27	24	.05	.20	1.1	<4.6	2.7	2.6×10^4	.7	9.2		295
Do.	668	do.	1240	3.3	.0	71	.8	120		6.2	31	30	.06	.16	1.4	<4.9	<2.1	6.7×10^4	.6	9.2		305
Do.	698	do.	1400	3.3	.1	74	.7	120		6.6	34	30	.06	.14	1.6	<4.8	<1.9	6.8×10^6	.5	9.1	36.7	285
Do.	713	7-1-81	0915	3.5	.1	73	.8	120		6.9	35	30	.06	.13	1.6	<4.9	<2.2	1.2×10^7	.6	9.1	37.8	330
Do.	728	do.	1025	7.0	.1	73	.7	120		6.9	36	30	.06	.14	1.6	<5.7	<2.4	1.7×10^7	.5	9.1	38.8	330
Do.	744	do.	1215	6.0	.0	73	.8	120		6.9	35	29	.06	.14	1.6	<5.6	2.3	1.8×10^7	.6	9.1	40.6	337
Do.	774	do.	1410	4.0	.0	73	.7	120		6.9	35	29	.06	.12	1.6	<5.1	2.7	2.0×10^7	.5	9.1	47.7	325
Do.	789	do.	1527	2.7	.1	74	.7	120		6.8	35	29	.07	.13	1.6	<5.1	<2.3	1.8×10^7	.5	9.1	55.0	340
362	375	7-19-82	1000	2.4	.1	46	1.1	86		4.8	19	17	.05	.31	.8	<2.7	1.8	1.3×10^3		9.7	--	310
Do.	393	do.	1145	2.1	.1	46	1.1	80		5.3	19	17	.05	.31	.8	<2.9	2.4	1.5×10^3		9.8	--	310
Do.	424	do.	1300	2.1	.1	47	1.2	97		5.2	19	17	.05	.32	.8	<2.4	2.4	1.4×10^3		9.7	--	290
Do.	454	do.	1350	4.3	.1	48	1.4	93		6.6	19	17	.05	.31	.8	<2.4	<1.7	1.5×10^3		9.6		290
Do.	485	do.	1430	2.2	.1	47	1.1	86		5.2	19	17	.05	.32	.8	<2.5	<1.7	1.3×10^3	--	9.9	--	280
Do.	515	do.	1520	4.8	.1	48	1.1	86		5.2	19	17	.05	.31	.8	<3.1	<1.9	1.4×10^3	--	9.7	--	280
Do.	546	7-20-82	0905	2.3	.1	48	1.1	86		5.9	20	17	.05	.31	.8	<2.5	<1.7	1.6×10^3	--	9.5	--	310
Do.	576	do.	1000	2.2	.1	47	1.1	86		4.9	19	17	.05	.32	.8	<2.7	2.2	1.6×10^3	--	9.5	--	295
Do.	607	do.	1030	3.1	.0	61	1.0	112		6.7	26	22	.06	.24	1.2	<4.0	<2.2	2.3×10^4	--	9.1	--	350
Do.	637	do.	1115	2.7	.0	63	1.0	111		6.4	26	24	.06	.24	1.3	<4.0	<2.2	2.5×10^4	--	9.2	--	385
Do.	668	do.	1230	3.2	.0	73	.9	138		7.3	30	29	.07	.18	1.6	4.8	<2.5	6.3×10^4	--	8.9	--	420
Do.	698	do.	1320	3.0	.1	73	.9	139		7.6	32	28	.07	.17	1.7	<4.8	<2.5	6.0×10^5	--	9.0	--	400
Do.	728	do.	1405	2.7	.0	74	.9	115		8.2	34	28	.07	.15	1.8	7.8	9.8	2.5×10^7	--	8.9	--	435
Do.	759	7-21-82	0905	4.0	.1	73	.8	133		9.8	34	28	.07	.14	1.8	13	7.5	2.4×10^7	--	8.8	--	440
Do.	789	7-21-82	1000	3.2	.0	74	.8	127		12	34	28	.08	.14	1.8	<6.0	6.0	2.1×10^7	--	8.6	--	445
340	351	7-19-83	1445	3.5	.05	48	1.5	--		--	--	15	.06	.29	--	<3.3	1.6	--	--	8.8	--	225
Do.	363	do.	1545	3.0	.05	45	1.3	86		5.6	15	15	.05	.27	.7	<2.9	1.9	--	--	9.0	--	200
Do.	393	do.	1630	2.5	.03	46	1.2	91		4.7	16	15	.05	.29	.7	<3.2	2.3	--	--	9.9	--	210
Do.	424	7-20-83	0945	2.3	.03	46	1.3	91		4.9	15	15	.05	.30	.8	<3.1	<1.7	--	--	9.6	--	200
Do.	454	do.	1030	2.7	< .01	47	1.3	91		4.8	16	15	.06	.30	.8	<3.3	<1.7	--	--	9.4	--	215
Do.	485	do.	1115	2.3	.02	47	1.2	91		4.8	15	15	.05	.30	.8	<3.4	<1.9	--	--	9.3	--	225
Do.	515	do.	1200	2.3	.05	47	1.3	91		5.7	18	15	.06	.30	.7	<3.2	<1.7	--	--	9.5	--	225
Do.	546	do.	1245	2.4	.03	46	1.2	91		4.8	17	15	.05	.30	.7	<3.4	2.0	--	--	9.6	--	215
Do.	576	do.	1400	2.5	.05	48	1.4	91		4.5	15	15	.06	.31	.8	<3.0	<1.7	--	--	9.4	--	215

Table 13.--*Chemical and radiochemical analyses of water from reentry hole UC-1-P-2SR*--Continued

Depth (meters)		Sample		Ca	Mg	Na	K	Alkalinity		Cl	SO_4	SiO_2	Li	Sr	F	Gross alpha	Gross beta	Tritium	K_{40}	pH	Water Temp-erature	Specific Conduct-ance
Water	Sample	Date	Time					Lab-oratory	On-site													
340	607	do.	1445	2.9	<0.01	60	1.0	113		5.7	23	20	0.06	.26	1.2	<4.8	<2.2	--	--	9.2	--	240
Do.	637	do.	1530	2.9	< .01	62	1.0	117		6.0	24	21	.06	.22	1.3	<5.8	<2.2	--	--	9.2	--	240
Do.	668	7-21-83	1600	2.9	.03	69	.9	129		6.8	30	26	.07	.17	< .1	<7.0	<2.7	--	--	8.9	--	320
Do.	698	do.	1140	3.0	.02	74	.8	132		7.5	32	27	.07	.17	1.9	<5.3	2.7	--	--	9.0	--	350
Do.	728	do																				
Do.	759	do.	1345	2.9	.03	76	.9	130		7.7	32	27	.07	.15	1.9	8.8	4.3	--	--	8.9	--	345
Do.	789	do.	1430	2.5	.04	72	.8	130		7.9	33	26	.08	.14	1.9	<7.0	6.1	--	--	9.0	--	300

[1] CO_3 and HCO_3 (laboratory) before 1972, alkalinity after.

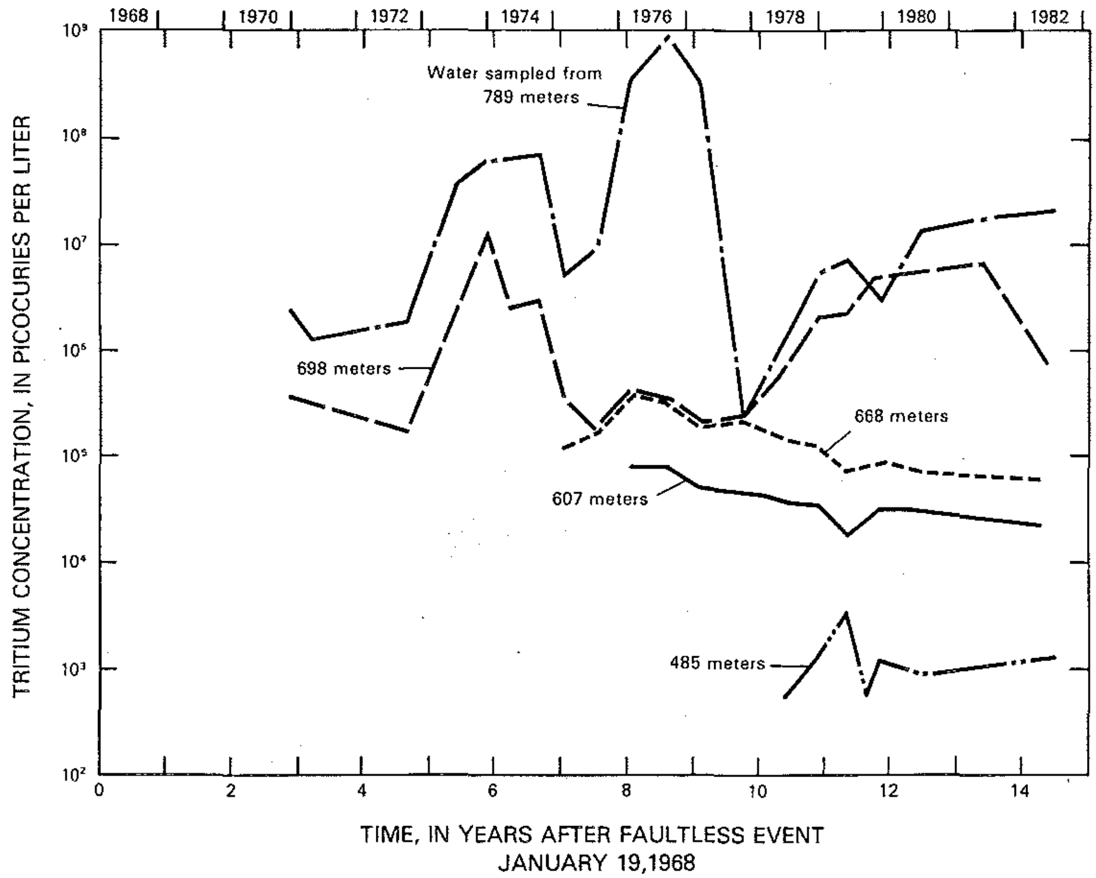

Figure 10.--Tritium concentrations in water from reentry hole UC-1-P-2SR, 1968-1982.

Dissolved gross-alpha concentrations in the water samples from reentry hole UC-1-P-2SR reached a maximum value of 45 μg/L as natural uranium in 1971, but has generally been less than 10 μg/L from 1975 to 1982. Small gross-alpha and gross-beta concentrations are similar to concentrations of these radiochemicals in the water from test hole HTH-1, and dissimilar to those in the water from test hole UCE-18, that was used to drill reentry hole UC-1-P-2SR.

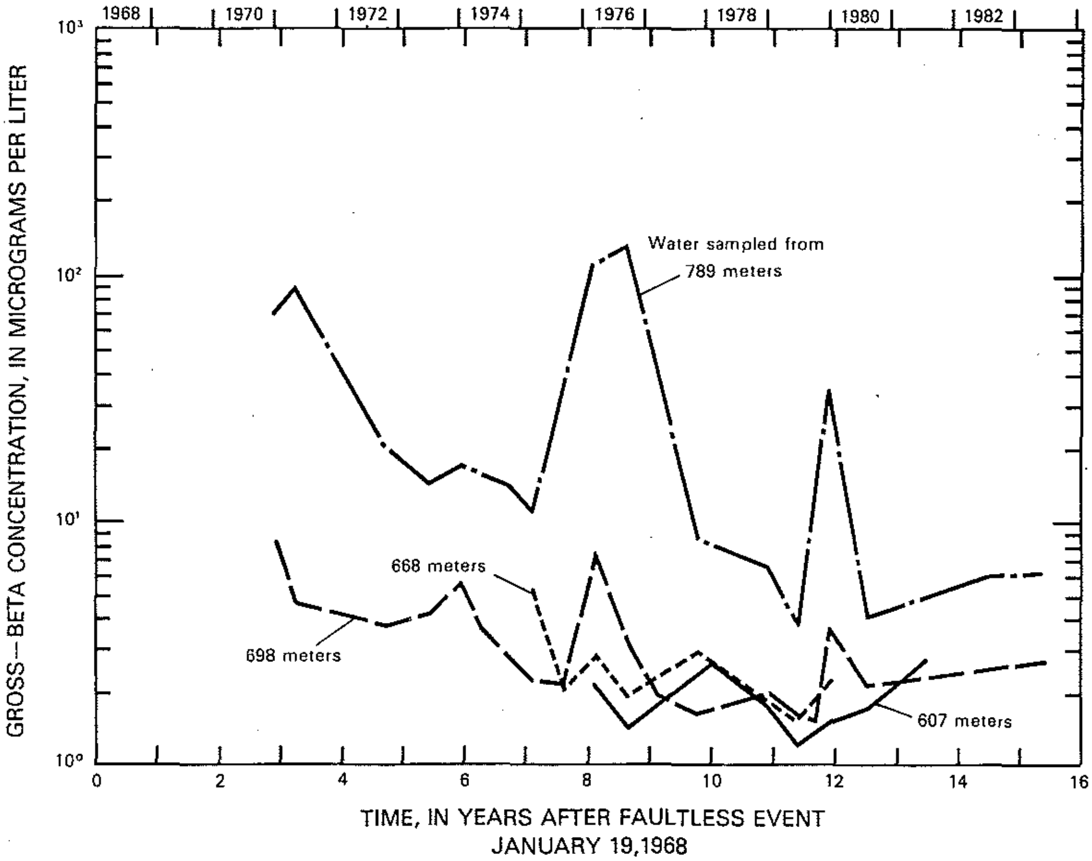

Figure 11.--Gross-beta concentrations in water from reentry hole UC-1-P-2SR, 1968-1983.

MONITORING PROGRAM

Since 1968, the monitoring program for reentry hole UC-1-P-2SR consisted of measurements of water level and water temperature, and collection of water samples for chemical and radiochemical analyses, generally on an annual or semiannual basis. Water samples were collected at various depth intervals, usually 17 to 30 m apart.

The present monitoring program requires quarterly measurements of depth to water and annual water sampling for chemical monitoring. Water samples are collected at points 17 to 30 meters apart; analyses of water include chemical analyses, dissolved and suspended gross-beta and gross-alpha activity, potassium-40, and tritium.

These water-level measurements and water samples have allowed the plotting of chemical time-series of the individual radiochemical constituents, as shown in figures 10 and 11. These plots show slow transient changes in the chemical time-series patterns (Keely, 1982; Keely and Wolf, 1983).

A continuation of the chemical-monitoring program would be needed to establish the shapes of the chemical time series. The patterns could be established by annually analyzing samples of water for the following: (1) Complete chemical analysis; (2) dissolved and suspended gross-alpha and gross-beta activity; (3) potassium-40; and (4) tritium.

For most efficient operations, and to make useful interpretations, sampling needs to be done at six depths: just below water level, and at 485 m, 607 m, 668 m, 698 m, and 789 m. These six depths probably are enough to characterize the chemical time-series pattern of the infilling water in the rubble chimney at reentry hole UC-1-P-2SR. In 1993 or so, when the water level has recovered fully, a pumping test at a very slow pumping rate might be attempted. Pumping tests would provide data on aquifer characteristics, skin effect, and well-entrance losses; water samples from a larger volume of rock also might be obtained.

The following procedure needs to be followed during future sampling:

1. Measure depth to water level.
2. Obtain the following at each depth, starting at the top:
   a. Measurement of maximum temperature;
   b. 250-mL sample for tritium analysis;
   c. 500-mL, filtered and acidified water sample, and 500-mL, filtered and unacidified water sample for general chemical analysis;
   d. 2-L sample for radiochemical analysis;
   e. Measurements of pH and specific conductance.
3. Measurement of depth to water level.

Water sampling and measurements of depth to water might be done on an annual basis, because the water level is changing slowly; unpredictable changes in water level or chemistry of the water are not expected for the remainder of infilling of the rubble chimney by water.

SUMMARY

Reentry hole UC-1-P-2SR, was drilled to a total depth of 1,097 m in the rubble chimney resulting from the Faultless event using rotary drilling equipment and mud as the circulating medium. The hole penetrated 732 m of alluvium and 365 m of tuffaceous sediments; it was cased to 851 m. An obstruction occurred at approximately 802 m.

Monitoring of the water level reentry hole UC-1-P-2SR, indicates that from 1970 to 1974, the water level was 694.9 m below land surface. From 1974 to 1983, the water level rose slowly to a depth of 335.1 m. The 1983 level was about 167 m below the preevent level. In test holes HTH-1 and HTH-2, the water level rose after the Faultless event. By 1976, the water level in the test HTH-1 had declined to a depth of 161.5 m, 6.7 m above the preevent level; the water level in test hole HTH-1 had declined to a depth of 169.5 m, 2.7 m above the preevent water-level.

The water sampled from reentry hole UC-1-P-2SR is a sodium bicarbonate water containing some sulfate and minor chloride, which resembles water from test hole HTH-1 and other ground water in the region, but very different from the water from test hole UCE-18, which was used to drill the reentry hole. Tritium concentrations have fluctuated from about 10^6 pCi/L in 1968 through 1972, to a maximum of 9.2×10^8 pCi/L in 1976, decreasing to about 10^5 pCi/L in 1977, followed by a gradual increase to about 10^7 pCi/L during 1980 to 1982. After 1971, gross-beta concentrations ranged between 1.2 and 130 pCi/L, but generally were less than 10 pCi/L. Gross-alpha concentrations generally were less than 10 μg/L from 1975 to 1982.

REFERENCES

Barnes, William and Hoover, D. L., 1977, Preliminary lithologic log of drill hole UCE-20, Hot Creek Valley, Nye County, Nevada: U.S. Geological Survey Report USGS-474-259, 13 p.

Claassen, H. C., 1973, Water quality and physical characteristics of Nevada Test Site water-supply wells: U.S. Geological Survey Report USGS-474-158, 141 p.

Corchary, G. S., 1969, Lithologic logs of six exploratory holes (UCE-9, -10, -11, -12a, -13, and -14) drilled in alluvium in central Nevada: U.S. Geological Survey Report USGS-474-2, 10 p.

Dinwiddie, G. A., and Schroder, L. J., 1971, Summary of hydraulic testing and sampling in deep exploratory holes in Little Fish Lake, Monitor, Hot Creek, and Little Smoky Valleys, Nevada: U.S. Geological Survey Report USGS-474-40, 66 p.

Dixon, G. L., and Snyder, R. P., 1977, Preliminary lithology and physical properties data, drill hole UCE-18, Hot Creek Valley, central Nevada: U.S. Geological Survey Report USGS-474-256, 5 p.

Fiero, G. W., Jr. Illiam, J. R., Dinwiddie, G. A., and Schroder, L. J., 1974, Use of hydrochemistry for interpreting ground-water flow systems in central Nevada: U.S. Geological Survey Report USGS-474-178, 40 p.

Hoover, D. L., 1977, Lithologic log of drill hole UCE-17, and general geology of the UCE-17 area, Hot Creek Valley, Nevada: U.S. Geological Survey Report USGS-474-258, 14 p.

Keely, J. F., 1982, Chemical time-series sampling: Ground Water Monitoring Review, v. 2, no. 4, p. 29-38.

Keely, J. F. and Wolf, Fred, 1983, Field applications of chemical time-series sampling: Ground Water Monitoring Review, v. 3, no. 4, p. 26-33.

McKeown, F. A., Dickey, D. D., and Ellis, W. L., 1970, Preliminary report on the geologic effects of the Faultless event: U.S. Geological Survey Report USGS-474-65, 20 p.

Robinson, B. P., Thordarson, William, and Beetem, W. A., 1967, Hydrologic and chemical data for wells, springs, and streams in central Nevada, Tps. 1-21 N. and Rs. 41-57 E.: U.S. Geological Survey Open-File Report TEI-871, 61 p.

Snyder, R. P., 1977, Preliminary lithologic report in drill hole UCE-18, Hot Creek Valley, Nye County, Nevada: U.S. Geological Survey Report USGS-474-257, 11 p.

Teller, Edward, Talley W. K., Higgins, G. H., and Johnson, G. W., 1968, The constructive uses of nuclear explosions: New York, McGraw-Hill, 320 p.

West, S. W., and Grove, D. B., 1969, Hydrologic Considerations, in Technical discussions of offsite safety programs for underground nuclear detonations: Denver, U.S. Geological Survey, U.S. Atomic Energy Commission Report NVO-40, Rev. 2, Chap. 6, p. 61-67.

Winograd, I. J., and Thordarson, William, 1975, Hydrogeologic and hydrochemical framework, south-central Great Basin, Nevada-California, with special reference to the Nevada Test Site: U.S. Geological Survey Professional Paper 712-C, 126 p.

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