Central Nevada-40 USGS-474-90

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

Federal Center, Denver, Colorado 80225

SUMMARY OF HYDRAULIC TESTING IN AND CHEMICAL ANALYSES OF WATER SAMPLES FROM DEEP EXPLORATORY HOLES IN LITTLE FISH LAKE, MONITOR, HOT CREEK, AND LITTLE SMOKY VALLEYS, NEVADA

By

George A. Dinwiddie and LeRoy J. Schroder

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ABSTRACT

This report, prepared in support of the U.S. Atomic Energy Commission's underground nuclear testing program, summarizes hydraulic-test data obtained in deep exploratory holes in central Nevada. The tests were designed to determine vertical variations in head, transmissivity, hydraulic conductivity, storage coefficient, velocity of ground-water movement, and chemical quality of water in selected intervals of the boreholes.

Valley fill of Quaternary and Tertiary age, volcanic rock (tuff and rhyolite) of Tertiary age, and carbonate rock (dolomite) of Paleozoic age are penetrated by the boreholes which range in depth from 2,963 feet (903.1 meters) to 7,978 feet (2,432 meters). Hydraulic tests were not made in carbonate rock. In those tested intervals from which the data were adequate for analysis, transmissivity ranged from 3.53×10^{3} to an estimated 1.1×10^{-3} gallons per day per foot or 4.38×10^{1} to 1.4×10^{-5} cubic meters per day per meter; relative specific capacity ranged from 0.67 to an estimated 3×10^{-6} gallons per minute per foot of drawdown or 12.0 to 6×10^{-5} cubic meters per day per meter of drawdown; hydraulic conductivity ranged from an estimated 50.2 to an estimated 3.7×10^{-6} gallons per day per square foot or 2.05 to 1.5×10^{-7} cubic meters per day per square meter; and velocity ranged from an estimated 3.3×10^{-1} to an estimated 1.5×10^{-8} feet per day or 1.0×10^{-1} to 4.5×10^{-9} meters per day. Velocities of ground-water movement through some intervals, however, might be significantly greater, depending on the thickness and the effective porosities of the water-contributing fracture systems.

Results of interpretation of both the areal and the vertical distribution of head indicate an area of recharge (decreasing head with depth) in the northern part of the Hot Creek-Little Smoky Valley's ground-water flow system and an area of discharge (increasing head with depth)in the southern part of the system.

INTRODUCTION

Hydraulic testing and sampling in wells in central Nevada are done to: 1) increase knowledge of the general hydrologic environment of the area and improve ability to predict direction and velocity of ground-water movement, 2) determine the water/rock chemistry and the radiochemistry for improved understanding of radionuclide transport characteristics and for evaluation of the effect and the distribution of shot-produced contaminants, 3) determine certain hydraulic characteristics for use in engineering of chambers in specific lithologic zones, and 4) provide information about water supplies for drilling, construction projects, and camp sites. This report presents an analysis of the basic data obtained during hydraulic tests in Little Fish Lake, Monitor, Hot Creek, and Little Smoky Valleys (fig. 1). The analysis consists of determining head and water-quality distributions in the vertical section and the transmissivity, hydraulic conductivity, storage coefficients, and velocity of ground-water movement in selected intervals.

Inflatable straddle packers were used to isolate specific intervals of the holes. Intervals were tested by injecting or swabbing water through tubing and observing the rate of reaction of

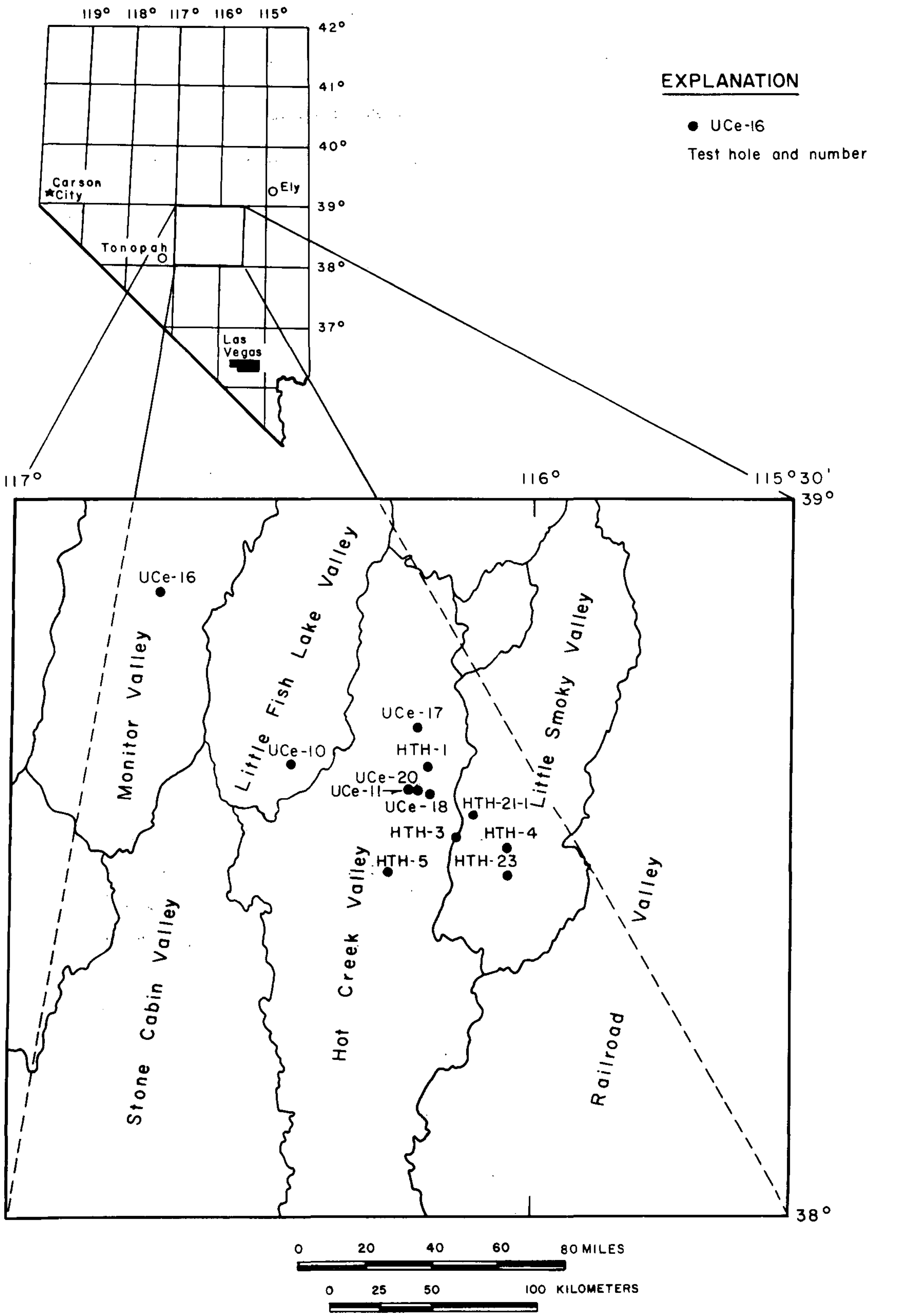


Figure 1.--General locations of test holes described in this report.

the water level. Intervals were selected according to apparent characteristics of hydrology, lithology, and hole conditions as interpreted from geologic reports and geophysical logs.

Water samples from the test holes were obtained by swabbing or pumping whenever feasible. The chemical data, not including radio-chemical and isotopic data, from analyses of the water samples are summarized in this report and will be used in interpreting the ground-water flow system in a later report.

The rate of reaction of water level to injection into some highly permeable zones was quite fast. As a result, the rate of reaction could not always be measured. Determination of relative specific capacity is time-interval dependent; therefore, some values of relative specific capacity when time-interval measurements of water level were not obtained are reported merely as "high". Determination of transmissivity, however, is based on position of plotted points relative to a family of type curves. Therefore, with even one point it is sometimes possible to reasonably estimate a value of trans-missivity for a highly permeable zone in which relative specific capacity could not be determined. Refined techniques of testing have minimized the possibility of not obtaining at least some measurements in future work.

ACKNOWLEDGMENTS

Particular thanks are due to the following personnel who cooperated within the Hydrologic Task Force: A. E. Peckham, Assistant Task Force leader, G. W. Fiero, Jr., A. L. Illian, Alan McClain, and A. L. Mindling of the Desert Research Institute, University of Nevada; Daniel Sokol and Paul Hackenberry of Teledyne Isotopes, Palo Alto Laboratories.

GENERAL LITHOLOGY

The three major rock types in central Nevada are valley fill of Quaternary and Tertiary age, volcanic rocks of Tertiary age, and carbonate rocks of Paleozoic age. The sequence of volcanic and carbonate rocks has been displaced by high-angle faults to form a series of nearly parallel mountain ranges and valleys. Valley fill has accumulated to a thickness of more than 4,000 feet at places. Carbonate rocks underlie virtually all the area (fig. 2).

The alluvium and the volcanic tuff generally have low permeability except for thin beds of sand and gravel in the alluvium and for zones of high-angle fractures associated with faults in the volcanic rock. Of the three rock types, the carbonate rock presumably has the highest permeability because it has a greater number of interconnected open fractures.

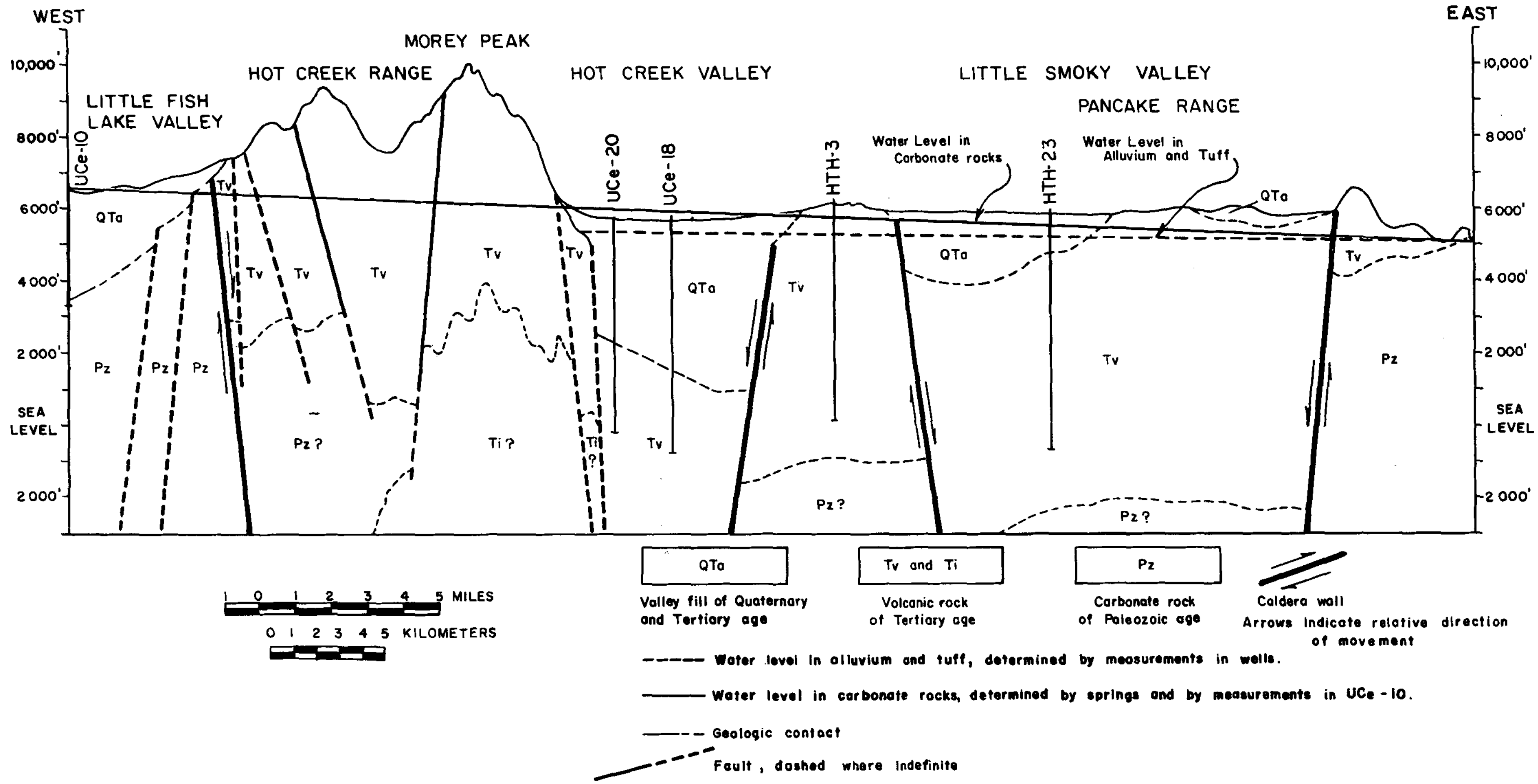


Figure 2.--Generalized section through Hot Creek Valley and vicinity, central Nevada.

INTERVALLEY FLOW OF GROUND WATER

In central Nevada, the water table generally is less than 600 feet below land surface. Strata beneath most of the valleys are filled to the extent that they discharge in their lowest parts where the water table intercepts or nearly intercepts the land surface. The head may increase or decrease with depth, depending on the location within the geohydrologic system.

Water-level contours, an indication of the flow pattern, indicate a possibility for ground-water flow from Little Fish Lake Valley, Hot Creek Valley, and Little Smoky Valley into Railroad Valley. In general, the major topographic divides coincide with ground-water divides. Thus, much of the ground-water flow from one valley to another is limited to narrow, interconnecting canyons containing alluvium.

METHOD OF ANALYSIS OF TEST DATA

Specific capacity of a well is yield per unit of drawdown after pumping for some time; for example, gallons per minute per foot of drawdown at time, t. Relative specific capacity is similar to specific capacity in that the units and the implications are similar. However, relative specific capacity is different in that it is derived from a short test of a defined interval rather than from a long test of a well penetrating the full saturated thickness of an aquifer. Relative specific capacity, as defined in this study, is discharge (determined by the volume change of water in tubing for a 1-minute interval of time) per unit of drawdown (the departure of the water level from the static conditions during this time).

A type-curve method for determining the transmissivity of an aquifer (Cooper and others, 1967) is applicable to testing of selected intervals in deep wells. This analysis involves an instantaneous charge of water to a well. The type curves (fig. 3) are derived by plotting H/H_o versus $\beta = Tt/r_c^2$ (a dimensionless time parameter) for values of $\alpha = r_s^2S/r_c^2$ where

H_o = water level in tubing above initial head in aquifer immediately after injection, in meters

H = water level in tubing above initial head in aquifer, in meters, at time, t, in days

T = transmissivity, in cubic meters per day per meter

r_c = radius of injection tubing, in meters

r_s = radius of open hole, in meters

S = storage coefficient.

Once a value of T is obtained, hydraulic conductivity, K, can be calculated by the equation

$$K = T/b$$

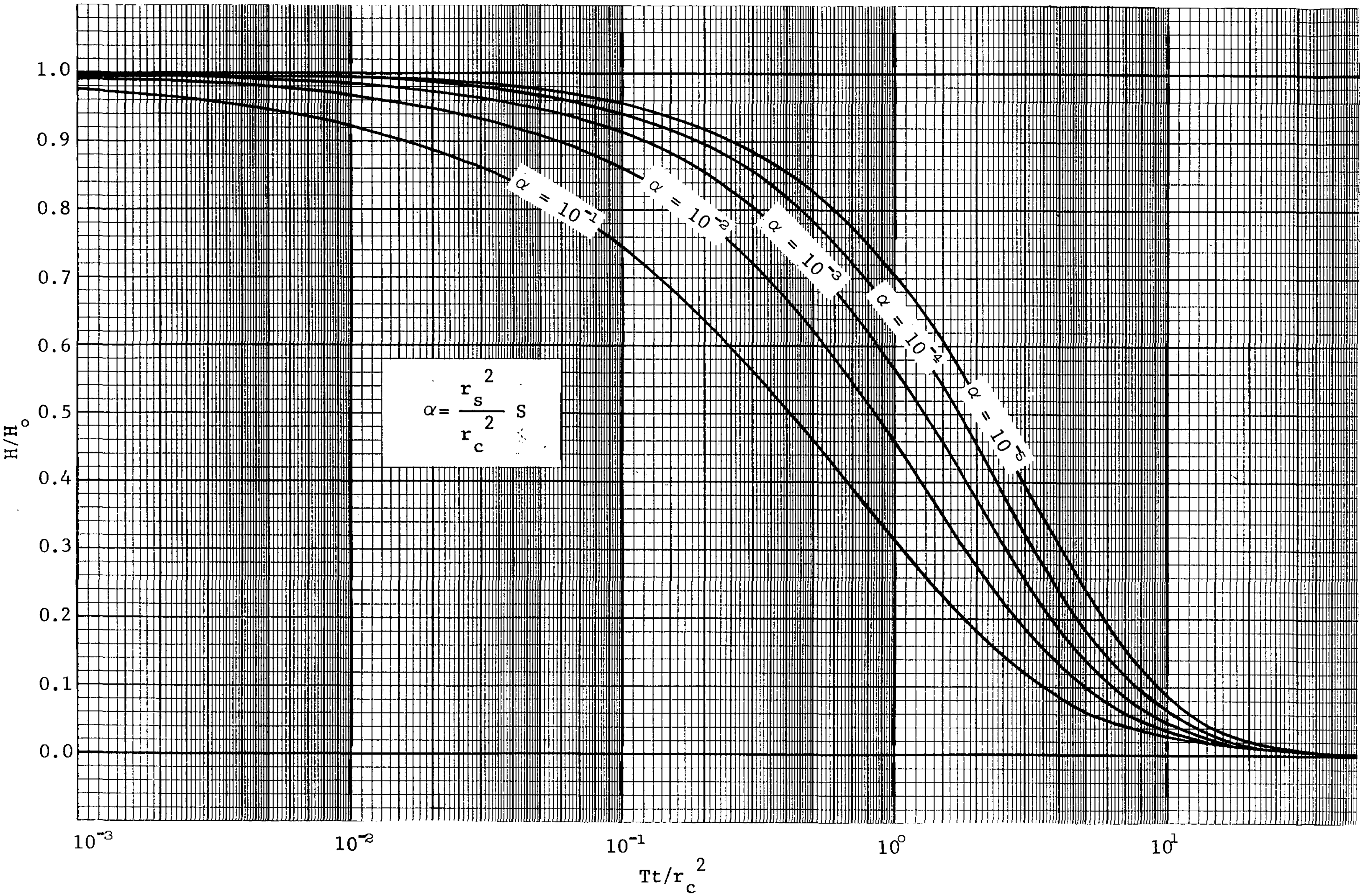


Figure 3.-- Type curves for instantaneous charge in well of finite diameter.

where K is in cubic meters per day per square meter and b = thickness of the tested interval, in meters. Velocity of ground-water movement (v) can then be calculated by the equation

$$v = KI/\theta$$

where v is in meters per day

I = ground-water gradient, in meters per meter, and

θ = effective porosity (fractional).

Measurements and calculations are made in metric units, and conversions are then made to English equivalents. Potentiometric maps using data from both shallow and deep systems were constructed, and some hydraulic gradients were obtained from interpretation of these maps. Other hydraulic gradients were obtained by 3-point solutions using known potential values. Much of the hydraulic conductivity in the zones tested is dependent upon the extent of fracturing of the strata; therefore, effective porosity has been estimated for calculations. Effective porosity in a fracture system probably is less than the estimated values, and the actual velocities would be correspondingly greater than those estimated. Effective porosity, for purposes of calculation is estimated between 5 and 25 percent. Also, calculation of ground-water velocity is based on the assumption that the entire isolated interval tested contributes water equally. This assumption probably is wrong when applied to any material other than alluvium. For example, most of the hydraulic conductivity of a packed-off interval of fractured, welded tuff probably is due to fractures. Therefore, it might be more reasonable to use the thickness of the fracture interval rather than the thickness of the tested interval for calculating hydraulic conductivity and velocity. However, it was not always possible to determine what part of a test interval was fractured. The values reported in the tables summarizing hydraulic-testing data should be considered as good first approximations.

SAMPLE TREATMENT AND ANALYSIS

A description of the sample treatment at field locations and laboratory procedures on samples are given so that the data in this report can be compared meaningfully to data published in other reports.

The water samples collected for determination of dissolved chemical constituents and physical parameters were filtered at field locations using a cellulose membrane having a pore size of 0.45 micron. A filtered, 4-ounce part of the sample was acidified for determination of cations. The cations--sodium, potassium, magnesium, calcium, lithium, strontium, iron, and manganese were determined using techniques described by Fishman and Downs (1966). An atomic-absorption spectrophotometer was used.

Another portion was acidified after filtration for later spectrographic analyses. Acidification minimizes adsorption of cations on the walls of the containers and prevents precipitation during sample transport to the laboratories. For an estimated dissolved-solids content less than 1,000 mg/l (milligrams per liter), based on 0.65 times the specific conductance of the water, nitric acid (HNO_3) was used. For an estimated dissolved-solids content greater than 1,000 mg/l, hydrochloric acid (HCl) was used.

Concentrations of minor elements, those elements whose normal concentration is low in relation to the concentrations of calcium, magnesium, or sodium, were determined using a 3-meter spectrograph. The concave grating of the spectrograph has 15,000 lines per inch and a reciprocal linear dispersion of 2.7 angstroms per millimeter. In preparation for analysis, each sample, which had been acidified in the field, was evaporated to dryness if the dissolved-solids content was less than 1,000 mg/l. If the dissolved-solids content was greater than 1,000 mg/l, the sought species were precipitated (Mallory, 1968).

Another part of the filtered sample was analyzed using titrametric, photometric, or potentiometric methods (Rainwater and Thatcher, 1960). Bicarbonate and carbonate were determined by titration with dilute sulfuric acid (H_2SO_4). The concentrations of sulfate, nitrate, fluoride, and complexes of aluminum, arsenic, selenium, boron, and zinc were determined with a spectrophotometer. The concentration of chloride was determined by volumetric tritration with mercuric nitrate, and the end point was determined with a spectrophotometer at a wavelength of 530 mμ (millimicrons).

Physical characteristics, such as the dissolved-solids content and specific conductance, were determined using methods described in Rainwater and Thatcher (1960). The dissolved-solids content is the residue on evaporation at 180°C, and the specific conductance is in micromhos per centimeter at 25°C.

Certain other characteristics were calculated from the determined constituents. These include total and noncarbonate hardness as $CaCO_3$, percent sodium, and SAR (sodium-adsorption ratio). The percent sodium is calculated by dividing the milliequivalents of sodium by the total milliequivalents of cations determined and the ratio multiplied by 100 to express it as a percentage. The sodium-adsorption ratio is equal to $(Na^+)/\sqrt{(Ca^{++} + Mg^{++})/2}$, where (Na^+), (Ca^{++}), and (Mg^{++}) represent the milliequivalents per liter of the respective ions. This ratio was defined by Richards (1959) as an index of sodium or alkali hazard of the water. The total hardness as $CaCO_3$ is obtained by summing the individual determinations of the alkaline earths expressed in milliequivalents per liter and then converting the sum to the equivalent of $CaCO_3$ in milligrams per liter. The noncarbonate hardness as $CaCO_3$ is obtained by multiplying the difference between the milliequivalents per liter of alkaline earth hardness and milliequivalents per liter of alkalinity times 50.05. Negative noncarbonate hardness is reported as zero.

Each suite of samples was analyzed for nearly 50 chemical constituents and physical parameters. Both the general-chemical and minor-elements analyses were made by the water chemistry laboratory of the U.S. Geological Survey, Denver Federal Center, Denver, Colorado.

HOLE UCe-10

Hole UCe-10, at coordinates N. 1,433,560 ft and E. 558,295 ft, Nevada coordinate system, central zone, Nye County, Nevada, is 2,963 ft (903.1 m) deep and penetrates alluvium and dolomite. The land-surface elevation at this site is 6,499 ft (1,981 m) above mean sea level. Although hydraulic tests were not made in this hole, the head of water in the producing zone was about 20 ft (6.1 m) above land surface, and a sustained rate of flow of approximately 10 gpm (gallons per minute) or 55 m^3 pd (cubic meters per day) was observed. Analyses of the water are presented in table 1.

Although both alluvium and dolomite are open to the borehole and can contribute water, chemical analysis indicates that the water is a calcium bicarbonate type. This type of water and the relatively high temperatures (46°C and 48°C) indicate that most of the water

Table 1.--Analyses of water from hole UCe-10, Little Fish Lake Valley, Nevada

Interval: That part of the test hole that was not cased.
Temperature: Thermometers used were accurate to ± 0.5°C.

Aquifer: Pc (Valley fill of Quaternary age and carbonate rocks of Paleozoic age.)

Chemical analyses

(In milligrams per liter. <, less than)

Interval, Feet	Interval, Meters	Date of sample collection	Temperature (°C)	Silica (SiO_2)	Aluminum (Al)	Iron (Fe)	Manganese (Mn)	Magnesium (Mg)	Calcium (Ca)	Strontium (Sr)	Lithium (Li)	Sodium (Na)	Potassium (K)	Copper (Cu)	Selenium (Se)	Zinc (Zn)	Carbonate (CO_3)	Bicarbonate (HCO_3)	Fluoride (F)	Chloride (Cl)	Sulfate (SO_4)	Nitrate (NO_3)	Phosphate (PO_4)	Boron (B)	Hardness as $CaCO_3$: Calcium, magnesium	Hardness as $CaCO_3$: Noncarbonate	Dissolved solids (residue at 180°C)	Specific conductance (micromhos/cm at 25°C)	pH	Percent sodium	Sodium adsorption ratio	Aquifer
2,710-2,963	826.0-903.1	5-10-67	46.0	30	<0.1	0.10	0.02	11	43	0.41	0.02	18	5.9	--	0.03	0.01	0	160	0.4	5.0	64	<0.1	0.02	0.06	153	22	274	397	8.0	20	0.6	Pc
2,710-2,963	826.0-903.1	8- 3-67	48.0	31	.2	.07	<.01	11	45	.42	.02	17	5.8	<0.01	.01	.20	0	158	.4	4.8	64	<.1	.01	.04	158	29	269	391	7.8	18	.6	Pc

Spectrographic analyses

(In micrograms per liter. <, less than. ND, sought but not detected)

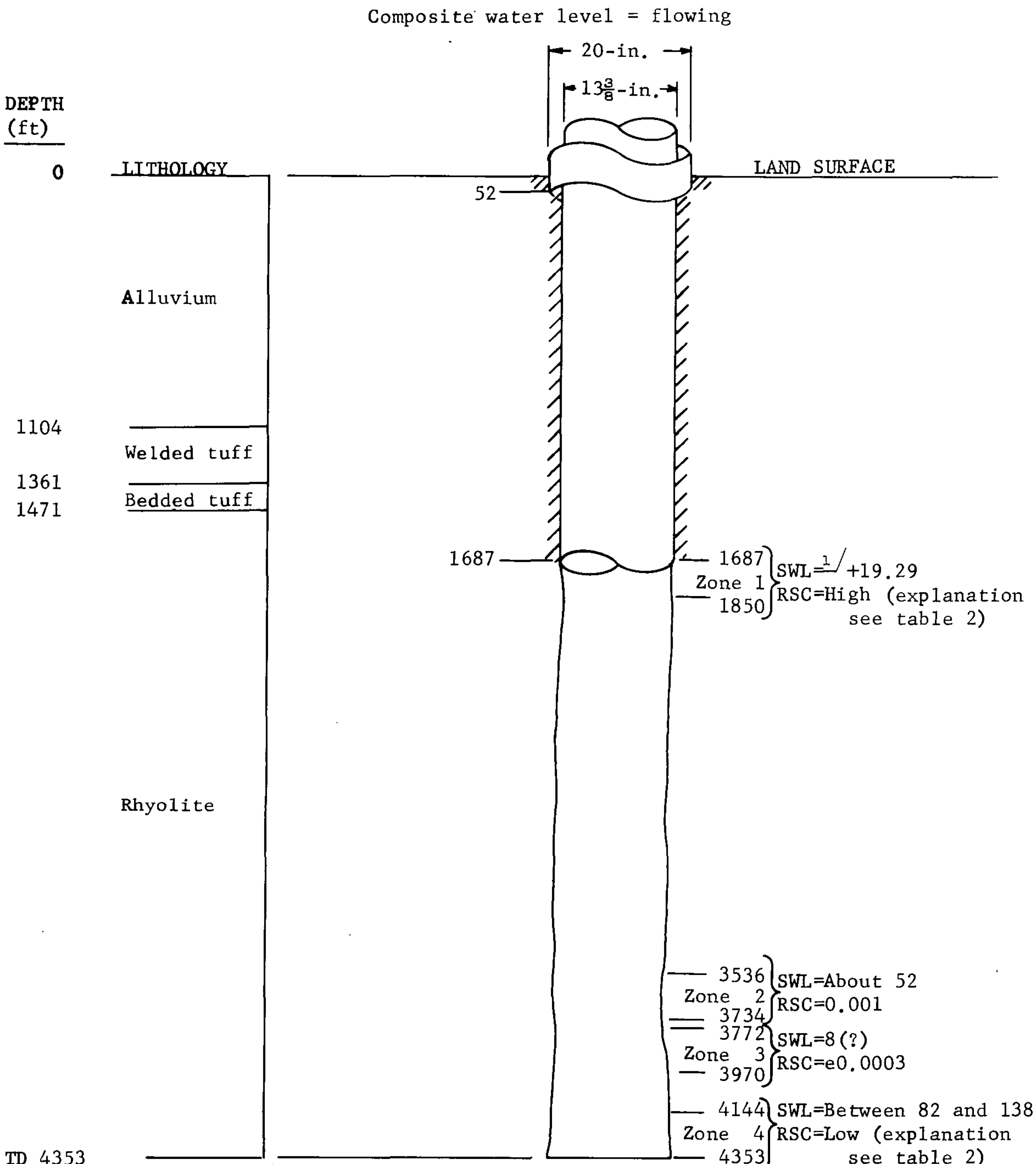
Interval, Feet	Interval, Meters	Date of sample collection	Temperature (°C)	Aluminum (Al)	Barium (Ba)	Beryllium (Be)	Bismuth (Bi)	Boron (B)	Cadmium (Cd)	Chromium (Cr)	Cobalt (Co)	Gallium (Ga)	Germanium (Ge)	Iron (Fe)	Lead (Pb)	Manganese (Mn)	Molybdenum (Mo)	Nickel (Ni)	Silver (Ag)	Strontium (Sr)	Tin (Sn)	Titanium (Ti)	Vanadium (V)	Zinc (Zn)	Zirconium (Zr)
2,710-2,963	826.0-903.1	5-10-67	46.0	5	120	<0.2	ND	50	ND	<2	<2	ND	ND	110	2	35	0.4	<2	<0.2	350	<2	<2	<2	--	ND
2,710-2,963	826.0-903.1	8- 3-67	48.0	120	130	<.2	<.4	45	<20	<.4	<2	<2	<3	150	<2	25	3	<.8	.2	380	<4	<2	<4	--	ND

probably comes from the dolomite, the top of which is at a depth of 2,660 ft (811 m) below land surface.

HOLE UCe-16

Hole UCe-16, at N. 1,499,400 ft and E. 487,000 ft, Nevada coordinate system, central zone, Nye County, Nevada, penetrates alluvium, welded tuff, bedded tuff, and rhyolite. The land-surface elevation at this site is 6,875 $\pm$ 25 ft (2,095 $\pm$ 7.6 m) above mean sea level. A summary of hydraulic-test results is presented in table 2, analyses of water are presented in table 3, and a generalized summary of hydrology, lithology, and construction is presented in figure 4.

Water in hole UCe-16 was first tapped at a depth of 48 ft (15 m) below land surface. UCe-16 was drilled with mud to 1,688 ft (514.5 m) and the water inflow therefore was controlled; however, after the cement had been drilled out and the hole had been cleaned to 1,688 ft (514.5 m), water began to flow at the surface. The initial shut-in pressure,measured just above ground level, was about 14 psi (pounds per square inch) when the hole was 1,956 ft (596.2 m) deep, but the pressure declined to such a low level it was not measurable after 3 hours. The flow rate was 745 gpm (4,060 m^3 pd) when the hole was 4,048 ft (1,234 m) deep. Four zones of increased flow were reported as the hole was drilled at depths of 1,706; 1,742; 1,773; and 1835 ft (520.0; 530.9; 540.4; and 559.3 m). Four zones of decreased flow were reported as the hole was drilled at depths of 3,726; 3,960; 4,065; and 4,322 ft (1,136; 1,207; 1,239; and 1,317 m). While the



1/ Water level is above lsd.
//, Cemented.
e Estimated.
SWL Static water level, ft below lsd.
RSC Relative specific capacity, gpm per ft of drawdown.

Figure 4.--Hydrology and lithology in hole UCe-16, Monitor Valley, Nevada.

Table 2.--Summary of hydraulic testing in hole UCe-16, Monitor Valley, Nevada

Zone	Interval tested: ft below lsd	Interval tested: m below lsd	Static water level: ft above (+) or below (-) lsd	Static water level: m above (+) or below (-) lsd	Relative specific capacity: gpm per ft of dd	Relative specific capacity: m^3pd per m of dd	Specific conductance (micromhos per cm at 25°C)	Maximum temperature[1] °F	Maximum temperature[1] °C	Packer bypass[2]	Rock type	Remarks
1[3]	1,687-1,850	514.2- 563.9	+19.29	+5.88	High[4]	High[4]	800	118	47.8	No No	Rhyolite	Flowing.
2	3,536-3,734	1,078 -1,138	-52	-16	0.001	0.018	660	128	53.3	No Yes	do.	--
3	3,772-3,970	1,150 -1,210	-8(?)	-2(?)	e .0003	e .0054	--	--	--	No Yes	do.	--
4[3]	4,144-4,353	1,263 -1,327	Between -82 and -138	Between -25 and -42	Low[5]	Low[5]	750	124	51.1	No Yes	do.	--

1/ Maximum temperature measured during swabbing or during flow.

2/ Upper: fluid bypass around top packer; lower: fluid bypass around bottom packer.

3/ Sampled for chemical analysis.

4/ High: water-level reaction too rapid to measure.

5/ Low: time-interval measurements of water-level change too small to allow accurate interpretation.

Explanation:

- ft - feet
- lsd - land-surface datum
- m - meters
- gpm - gallons per minute
- dd - drawdown
- m^3pd - cubic meters per day
- cm - centimeter
- °F - degrees Fahrenheit
- °C - degrees Celsius
- e - estimated

Table 3.--Analyses of water from hole UCe-16, Monitor Valley, Nevada

Interval: That part of the test hole that was open to the aquifer. Aquifer: Tv (Volcanic rocks of Tertiary age).
Temperature: Thermometers used were accurate to ±0.5°C.

Chemical analyses

(In milligrams per liter. <, less than)

Interval		Date of sample collection	Temperature (°C)	Silica (SiO_2)	Aluminum (Al)	Iron (Fe)	Manganese (Mn)	Magnesium (Mg)	Calcium (Ca)	Strontium (Sr)	Lithium (Li)	Sodium (Na)	Potassium (K)	Copper (Cu)	Selenium (Se)	Zinc (Zn)	Carbonate (CO_3)	Bicarbonate (HCO_3)	Fluoride (F)	Chloride (Cl)	Sulfate (SO_4)	Nitrate (NO_3)	Phosphate (PO_4)	Boron (B)	Hardness as $CaCO_3$		Dissolved solids (residue at 180°C)	Specific conductance (micromhos/cm at 25°C)	pH	Percent sodium	Sodium adsorption ratio	Aquifer
Feet	Meters																								Calcium, magnesium	Noncarbonate						
1,687-1,850	514.2- 563.9	3-26-67	48.0	52	<0.1	7.6	0.85	6.3	59	1.3	0.32	103	19	--	--	--	0	336	2.4	12	88	2.4	<0.01	--	175	0	495	650	8.0	53	3.4	Tv
1,687-4,353	514.2-1,327	6-27-68	54.0	63	.6	.57	.62	5.8	52	1.4	.34	114	33	0.01	0.01	0.01	5	276	2.5	11	81	<.1	<.01	0.38	87	0	455	672	8.4	55	4.0	Tv
1,687-4,353	514.2-1,327	6-28-68	54.0	63	.2	.09	.60	5.8	51	1.4	.32	115	33	--	--	--	0	411	2.6	11	67	.7	<.01	--	153	0	562	835	8.0	56	4.1	Tv
4,144-4,353	1,263 -1,327	3-29-67	51.0	23	.3	.05	.03	.3	6.3	.12	.26	172	9.6	--	--	--	6	345	3.9	12	87	2.9	<.01	--	17	0	507	692	8.5	92	18	Tv

Spectrographic analyses

(In micrograms per liter. <, less than. ND, sought but not detected)

Interval		Date of sample collection	Temperature (°C)	Aluminum (Al)	Barium (Ba)	Beryllium (Be)	Bismuth (Bi)	Boron (B)	Cadmium (Cd)	Chromium (Cr)	Cobalt (Co)	Gallium (Ga)	Germanium (Ge)	Iron (Fe)	Lead (Pb)	Manganese (Mn)	Molybdenum (Mo)	Nickel (Ni)	Silver (Ag)	Strontium (Sr)	Tin (Sn)	Titanium (Ti)	Vanadium (V)	Zinc (Zn)	Zirconium (Zr)
Feet	Meters																								
1,687-1,850	514.2- 563.9	3-26-67	48.0	13	120	<0.5	<9	360	<45	8	<5	<5	<7	12,000	<5	740	4	20	<0.5	1,200	<9	<3	<5	<45	ND
1,687-4,353	514.2-1,327	6-27-68	54.0	10	75	.4	<6	560	<30	<3	<6	<3	<4	24	<3	250	3	<3	<.3	1,100	<6	<2	<3	<20	--
1,687-4,353	514.2-1,327	6-28-68	54.0	14	120	1	<9	480	<45	<5	<9	<4	<6	9	<4	610	5	<4	<.5	1,400	<9	<3	<4	<30	--
4,144-4,353	1,263 -1,327	3-29-67	51.0	20	8	<.4	<8	590	<40	<3	<4	<3	<5	50	<4	15	35	<4	<.4	100	<8	<3	<4	<25	ND

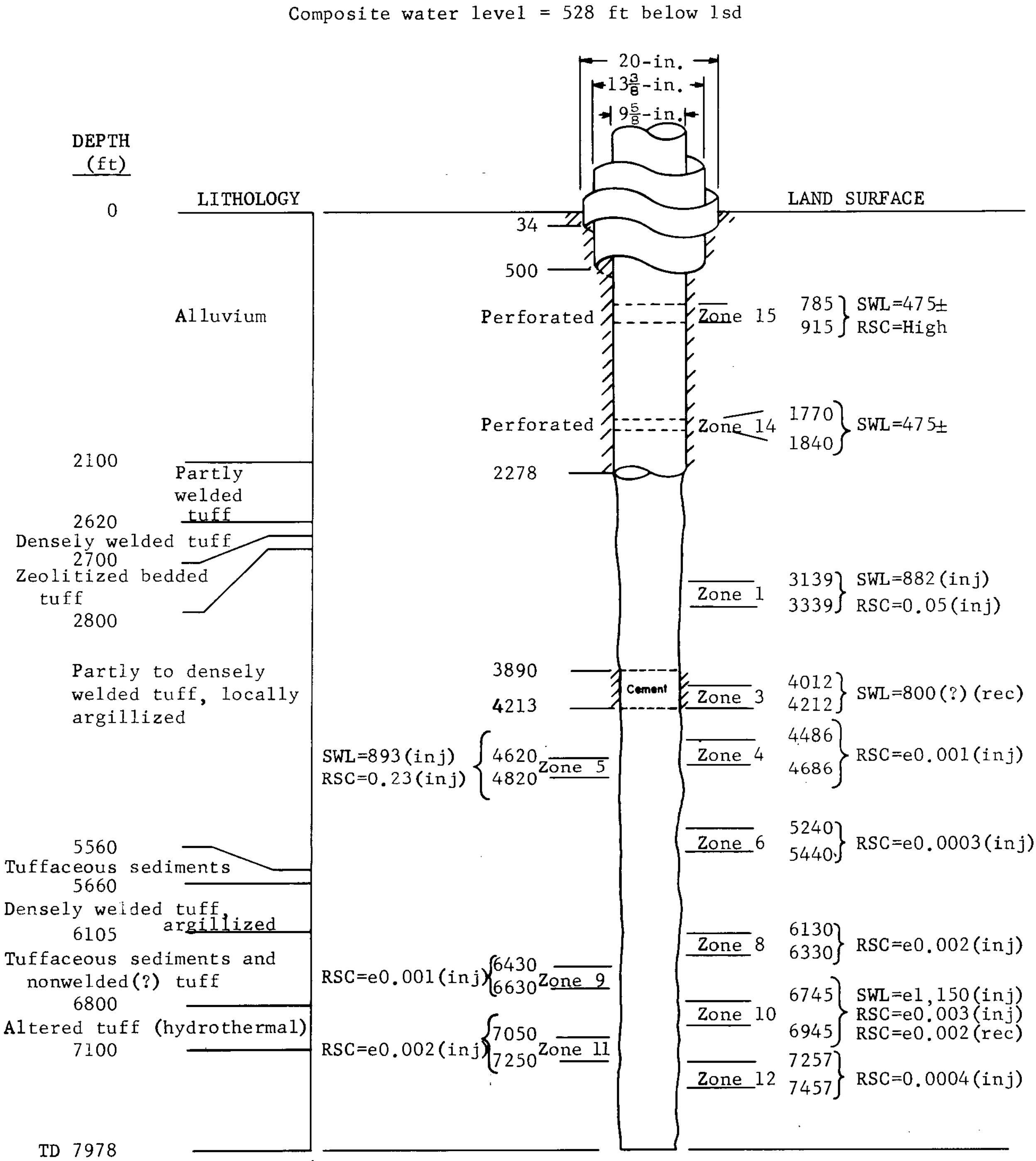
hole was being drilled at these depths, the water flow would stop for periods ranging from 1 to $1\frac{3}{4}$ hours and then would resume.

HOLE UCe-17

Hole UCe-17, at coordinates N. 1,430,622 ft and E. 628,172 ft, Nevada coordinate system, central zone, Nye County, Nevada, penetrated alluvium, welded tuff, zeolitized bedded tuff, and tuffaceous sediments. The land-surface elevation at this site is 6,545 ft (1,995 m) above mean sea level. A summary of hydraulic-test results is presented in table 4, analyses of water are presented in table 5, and a generalized summary of hydrology, lithology, and construction is presented in figure 5.

Tracejector Surveys

Significant results were obtained from tracejector surveys under both pumping and static conditions. The results indicate a definite possibility for downward flow. Under static conditions, vertical flow in the borehole was downward at a rate between 20 and 27 gpm (110 and 150 m^3pd) to a point at about 4,740 ft (1,445 m) below land-surface datum. At this depth, most of the flow went into the formation. Below this depth, some downward flow (less than 6.1 gpm or 33 m^3pd) and continual loss into the formation was observed. There was no measureable vertical flow in the borehole below a depth of 6,420 ft (1,957 m).



Cemented.
e Estimated.
SWL Static water level, ft below lsd.
RSC Relative specific capacity, gpm per ft of drawdown.
inj Injection.
rec Recovery.

Figure 5.--Hydrology and lithology in hole UCe-17, Hot Creek Valley, Nevada.

Table 4.--Summary of hydraulic testing in hole UCe-17, Hot Creek Valley, Nevada

Zone	Interval tested		Static water level[1]		Relative specific capacity[1]		Water swabbed		Specific conductance (micromhos per cm at 25°C)	Temperature		Packer bypass[2]	Storage coefficient	Transmissivity		Hydraulic conductivity		Velocity		Rock type
	ft below lsd	m below lsd	ft below lsd	m below lsd	gpm per ft of dd	m^3pd per m of dd	gal	m^3		°F	°C			gpd per ft	m^3pd per m	gpd per ft^2	m^3pd per m^2	ft pd	m pd	
15[3]	785- 915	239- 279	475± 475±	145± 145±	High[4] High[4]	High[4] High[4]	400	1.5	350	65	18.3	No No	--	--	--	--	--	--	--	Alluvium
14[3,5]	1,770- 1,840	539.5 560.8	475± 475±	145± 145±	-- --	-- --	8,000	30	450	74	23.3	Yes No	--	--	--	--	--	--	--	Do.
1[5]	3,139- 3,339	956.7- 1,018	882 --	269 --	.05 --	.89 --	10,000	38	430	98	36.6	Yes --	--	e2.12 x10^{2}	e2.63	e1.06	e4.31 x10^{2}	e5.64 x10^{-3}	e1.72 x10^{-3}	Welded tuff
2	3,800- 4,000	1,158- 1,219	-- --	-- --	-- --	-- --	--	--	--	--	--	No No	--	--	--	--	--	--	--	Do.
3[5]	4,012- 4,212	1,223- 1,284	-- 800(?)	-- 244(?)	--[6] --[6]	--[6] --[6]	6,000	23	360	93	33.9	Yes No	--	--	--	--	--	--	--	Do.
4	4,486- 4,686	1,367- 1,428	-- --	-- --	e.001 --	e.02 --	3,000	11	1,200	82	27.8	No --	--	e10.6	e1.31 x10^{-1}	e5.27 x10^{-2}	e2.15 x10^{-3}	e7.05 x10^{-4}	e2.15 x10^{-4}	Do.
5[5]	4,620- 4,820	1,408- 1,469	893 --	272 --	.23 --	4.1 --	5,000	19	900	95	35.0	Yes --	--	e7.06 x10^{2}	e8.76	e3.53	e1.44 x10^{-1}	e4.72 x10^{-2}	e1.44 x10^{-2}	Do.
6	5,240- 5,440	1,597- 1,658	-- --	-- --	e.0003 --	e.005 --	530	2.0	--	--	--	No --	--	e2.12 x10	e2.63 x10^{-3}	e1.06 x10^{-3}	e4.31 x10^{-5}	e2.83 x10^{-5}	e8.62 x10^{-6}	Do.
8	6,130- 6,330	1,868- 1,929	-- --	-- --	e.002 --	e.036 --	700	2.6	--	--	--	No --	5.65x10^{-3}	2.12 x10	2.63 x10^{-3}	1.06 x10^{-3}	4.31 x10^{-5}	9.42 x10^{-6}	2.87 x10^{-6}	Tuffaceous sediments
9	6,430- 6,630	1,960- 2,021	-- --	-- --	e.001 --	e.02 --	350	1.3	--	--	--	No --	5.65x10^{-3}	6.82 x10^{-2}	8.47 x10^{-4}	3.41 x10^{-4}	1.39 x10^{-5}	3.04 x10^{-6}	9.27 x10^{-7}	Do.
10[5]	6,745- 6,945	2,056- 2,117	e1,150 --	e351 --	e.003 e.002	e.05 e.04	1,500	5.7	610	83	28.3	No --	6.98x10^{-7}	5.29	6.57 x10^{-2}	2.65 x10^{-2}	1.08 x10^{-3}	2.36 x10^{-4}	7.2 x10^{-5}	Welded tuff
11	7,050- 7,250	2,149- 2,210	-- --	-- --	e.002 --	e.04 --	630	2.4	--	--	--	No --	6.26x10^{-7}	1.93	2.39 x10^{-2}	9.60 x10^{-3}	3.92 x10^{-4}	1.29 x10^{-4}	3.92 x10^{-5}	Do.
12	7,257- 7 457	2,212- 2,273	-- --	-- --	e.0004 --	e.007 --	--	--	--	--	--	No --	5.12x10^{-4}	1.41 x10^{-1}	1.75 x10^{-3}	7.03 x10^{-4}	2.87 x10^{-5}	6.27 x10^{-6}	1.91 x10^{-6}	Do.

1/Upper number from injection; lower number from recovery after swabbing.
2/Upper: fluid bypass around top packer; lower: fluid bypass around bottom packer.
3/Perforated casing and cement.
4/High: recovery too rapid to measure.
5/Sampled for chemical analysis.
6/Cemented zone.

NOTE: Composite water level = 528.2 ft (161.0 m) below lsd.

Well pumped at 170 gpm (925 m^3pd) for 13 hours (780 minutes) with 464.39 ft (141.54 m) of drawdown. Specific capacity = 0.36 gpm per ft (6.5 m^3pd per m).

Explanation:

m - meters
lsd - land-surface datum
ft - feet
gpm - gallons per minute
dd - drawdown
m^3pd - cubic meters per day
gal - gallons
cm - centimeters
°C - degrees Celsius
°F - degrees Fahrenheit
gpd - gallons per day
ft^2 - square feet
m^2 - square meters
ft pd - feet per day
mpd - meters per day
e - estimated

Table 5.--Analyses of water from hole UCe-17, Hot Creek Valley, Nevada

Interval: That part of the test hole that was open to the aquifer. Aquifer: Qal (Valley fill of Quaternary age),
Temperature: Thermometers used were accurate to $\pm 0.5^{\circ}C$. Tv (Volcanic rocks of Tertiary age)

Chemical analyses

(In milligrams per liter. <, less than)

Interval, Feet	Interval, Meters	Date of sample collection	Temperature (°C)	Silica (SiO_2)	Aluminum (Al)	Iron (Fe)	Manganese (Mn)	Magnesium (Mg)	Calcium (Ca)	Strontium (Sr)	Lithium (Li)	Sodium (Na)	Potassium (K)	Copper (Cu)	Selenium (Se)	Zinc (Zn)	Carbonate (CO_3)	Bicarbonate (HCO_3)	Fluoride (F)	Chloride (Cl)	Sulfate (SO_4)	Nitrate (NO_3)	Phosphate (PO_4)	Boron (B)	Hardness as $CaCO_3$: Calcium, magnesium	Hardness as $CaCO_3$: Noncarbonate	Dissolved solids (residue at 180°C)	Specific conductance (micromhos/cm at 25°C)	pH	Percent sodium	Sodium adsorption ratio	Aquifer
1,770-1,840	539.5- 560.8	6-27-67	--	69	<0.1	0.03	0.27	12	49	0.59	0.03	31	10	--	--	--	0	222	0.4	10	44	3.0	<0.01	--	173	0	335	405	8.1	27	1.0	Qal
3,139-3,339	956.7-1,018	6-25-67	--	50	.2	.02	.02	.6	7.6	.13	.14	96	4.2	--	--	--	3	185	2.7	16	44	2.4	<.01	--	22	0	333	398	8.3	88	9.0	Tv
4,012-4,212	1,223 -1,284	6-17-67	32.0	39	<.1	.22	.09	1.7	15	.26	.08	68	4.2	--	--	--	0	178	1.1	14	19	2.8	<.01	--	45	0	250	330	8.2	74	4.4	Tv
4,620-4,820	1,408 -1,469	6-26-67	--	13	.1	.07	.33	1.9	23	.53	.06	183	7.2	--	--	--	0	213	4.7	18	258	2.4	<.01	--	66	0	641	854	7.5	84	9.8	Tv
6,745-6,945	2,056 -2,117	6-23-67	--	16	.2	.03	.06	.6	11	.34	.19	132	7.4	--	--	--	0	208	5.8	15	100	2.2	<.01	--	31	0	425	588	8.0	87	10	Tv

Spectrographic analyses

(In micrograms per liter. <, less than. ND, sought but not detected)

Interval, Feet	Interval, Meters	Date of sample collection	Temperature (°C)	Aluminum (Al)	Barium (Ba)	Beryllium (Be)	Bismuth (Bi)	Boron (B)	Cadmium (Cd)	Chromium (Cr)	Cobalt (Co)	Gallium (Ga)	Germanium (Ge)	Iron (Fe)	Lead (Pb)	Manganese (Mn)	Molybdenum (Mo)	Nickel (Ni)	Silver (Ag)	Strontium (Sr)	Tin (Sn)	Titanium (Ti)	Vanadium (V)	Zinc (Zn)	Zirconium (Zr)
1,770-1,840	539.5- 560.8	6-27-67	--	16	65	<0.3	<5	100	<25	7	<3	<3	<4	260	7	330	4	10	<0.3	490	<5	<2	<4	15	ND
3,139-3,339	956.7-1,018	6-25-67	--	2,000	75	<.3	<5	500	<25	2	<3	<3	<4	8,000	18	150	20	12	<.3	140	<5	30	13	15	ND
4,012-4,212	1,223 -1,284	6-17-67	32.0	20	40	<.2	<4	130	<20	1	<2	<2	<3	160	<2	75	11	<2	<.2	270	<4	<2	<2	<15	ND
4,620-4,820	1,408 -1,469	6-26-67	--	16	22	<.4	<8	300	<40	<3	<4	<4	<6	22	<4	290	80	<4	<.4	510	<8	<4	<4	<25	ND
6,745-6,945	2,056 -2,117	6-23-67	--	35	35	<.3	<6	170	<30	<2	<3	<3	<4	65	<3	35	55	<3	<.3	310	<6	<3	<3	<20	ND

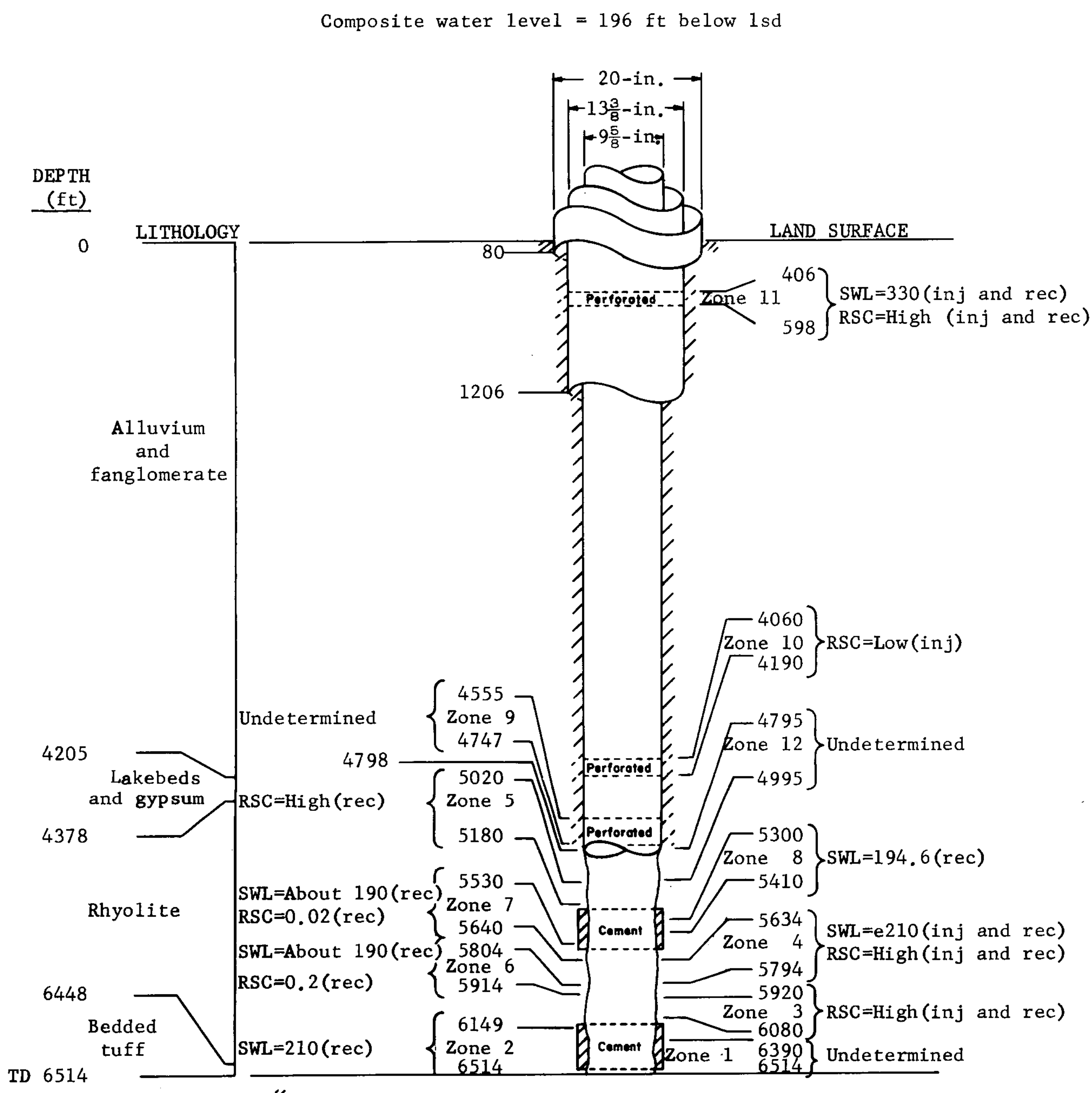
A tracejector survey made while pumping water at a rate of about 160 gpm (870 m^3 pd) indicates that most of the water came from the intervals 785 to 915 ft (239 to 279 m), 1,770 to 1,840 ft (539.5 to 560.8 m) and 4,740 to 4,750 ft (1,445 to 1,448 m).

HOLE UCe-18

Hole UCe-18, at coordinates N. 1,396,833 ft and E. 635,840 ft, Nevada coordinate system, central zone, Nye County, Nevada, penetrated alluvium, lakebeds and gypsum, rhyolite, and bedded tuff. The land-surface elevation at this site is 5,763 ft (1,756 m) above mean sea level. A summary of hydraulic-test results is presented in table 6, analyses of water are presented in table 7, and a generalized summary of hydrology, lithology, and construction is presented in figure 6.

Tracejector Surveys

The borehole was open to the formation from 4,798 to 6,335 ft (1,462 to 1,931 m) during the static-condition tracejector survey. The results of this survey indicate the possibility of downward flow in this interval of rhyolite. Vertical flow in the borehole was downward at a rate of about 6 gpm (33 m^3 pd) with inflow at a depth of 5,020 ft (1,530 m) and outflow at a depth of 5,685 ft (1,733 m). There was no measurable vertical flow in the borehole under static conditions either above 5,020 ft (1,530 m) or below 5,685 ft (1,733 m).



Cemented.
e Estimated.
SWL Static water level, ft below lsd.
RSC Relative specific capacity, gpm per ft of drawdown.
inj Injection.
rec Recovery.

Figure 6.--Hydrology and lithology in hole UCe-18, Hot Creek Valley, Nevada.

Table 6.--Summary of hydraulic testing in hole UCe-18, Hot Creek Valley, Nevada

Zone	Interval tested: ft below lsd	Interval tested: m below lsd	Static water level 1/: ft below lsd	Static water level 1/: m below lsd	Relative specific capacity 1/: gpm per ft of dd	Relative specific capacity 1/: m^3 pd per m of dd	Water swabbed: gal	Water swabbed: m^3	Specific conductance (micromhos per cm at 25°C)	Temperature: °F	Temperature: °C	Packer bypass 2/	Storage coefficient	Transmissivity: gpd per ft	Transmissivity: m^3 pd per m	Hydraulic conductivity: gpd per ft^2	Hydraulic conductivity: m^3 pd per m^2	Velocity: ft pd	Velocity: m pd	Rock type
11 3,4/	406- 598	124- 182	330 330	101 101	High 5/ High 5/	High 5/ High 5/	14,500	55	1,200	92	33.3	No Lost	--	--	--	--	--	--	--	Alluvium
10 3/	4,060- 4,190	1,237- 1,277	-- --	-- --	Low 5/ --	Low 5/ --	1,750	6.6	--	--	--	Yes Lost	e6x10^{-7}	e3 x10^{-1}	e4 x10^{-3}	e2 x10^{-3}	e1 x10^{-4}	e2 x10^{-5}	e5 x10^{-6}	Do.
9 3,4/	4,555- 4,747-	1,388- 1,447	-- --	-- --	-- --	-- --	28,000	106	1,400(?)	112(?)	44.5(?)	Yes Lost	--	--	--	--	--	--	--	Rhyolite
12 4/	4,795- 4,995	1,461- 1,522	-- --	-- --	-- --	-- --	22,000	83	1,800	99	37.2	Lost No	--	--	--	--	--	--	--	Do.
5 4/	5,020- 5,180	1,530- 1,579	-- --	-- --	-- High 5/	-- High 5/	17,500	66	3,000	107	41.7	Slight No	--	--	--	--	--	--	--	Do.
8 4/	5,300- 5,410	1,615- 1,649	-- 195	-- 59.3	-- 6/ -- 6/	-- 6/ -- 6/	27,000	102	3,000	130	54.4	Slight No	--	--	--	--	--	--	--	Do.
7 4/	5,530- 5,640	1,685- 1,719	-- e190	-- e58	-- 0.02	-- 0.36	20,500	78	3,000	120	48.9	Slight No	--	--	--	--	--	--	--	Do.
4	5,634- 5,794	1,717- 1,766	e210 e210	e64 e64	High 5/ High 5/	High 5/ High 5/	16,000	61	3,000	118	47.8	No No	--	--	--	--	--	--	--	Do.
6 4/	5,804- 5,914	1,769- 1,802	-- e190	-- e58	-- .2	-- 3.6	28,500	108	2,900	129	53.9	No No	--	--	--	--	--	--	--	Do.
3 4/	5,920- 6,080	1,804 1,853	-- --	-- --	-- e.001	-- e.018	9,000	34	3,000	105	40.6	No No	--	--	--	--	--	--	--	Do.
2 4/	6,149- 6,514	1,874- 1,985	-- 210	-- 64.0	-- 6/ -- 6/	-- 6/ -- 6/	18,000	68	2,950	118	47.8	-- No	--	--	--	--	--	--	--	Rhyolite and bedded tuff
1	6,390- 6,514	1,948- 1,985	-- --	-- --	-- 6/ -- 6/	-- 6/ -- 6/	1,400	5.3	--	--	--	-- No	--	--	--	--	--	--	--	Do.

1/Upper number from injection; lower number from recovery after swabbing.
2/Upper: fluid bypass around top packer; lower: fluid bypass around bottom packer; lost: recorder lost in borehole.
3/Perforated casing and cement.
4/Sampled for chemical analysis.
5/High: recovery too rapid to measure; low: time-interval measurement of water-level change too small to measure accurately.
6/Cemented zone.

NOTE: Composite water level = 196 ft (59.8 m) below lsd.
Well pumped at 170 gpm (925 m^3pd) for 9 hours (540 minutes) with 54.18 ft (16.51 m) of drawdown.
Specific capacity = 3.1 gpm per ft (55.5 m^3pd per m).

Explanation:

m - meters
lsd - land-surface datum
ft - feet
gpm - gallons per minute
dd - drawdown
m^3pd - cubic meters per day
gal - gallons
cm - centimeters
°C - degrees Celcius
°F - degrees Fahrenheit
gpd - gallons per day
ft^2 - square feet
m^2 - square meters
ft pd - feet per day
mpd - meters per day
e - estimated

Table 7.--Analyses of water from hole UCe-18, Hot Creek Valley, Nevada

Interval: That part of the test hole that was open to the aquifer. Aquifer: Qal (Valley fill of Quaternary age),
Temperature: Thermometers used were accurate to ±0.5°C. Tv (Volcanic rocks of Tertiary age).

Chemical analyses

(In milligrams per liter. <, less than)

Interval, Feet	Interval, Meters	Date of sample collection	Temperature (°C)	Silica (SiO_2)	Aluminum (Al)	Iron (Fe)	Manganese (Mn)	Magnesium (Mg)	Calcium (Ca)	Strontium (Sr)	Lithium (Li)	Sodium (Na)	Potassium (K)	Copper (Cu)	Selenium (Se)	Zinc (Zn)	Carbonate (CO_3)	Bicarbonate (HCO_3)	Fluoride (F)	Chloride (Cl)	Sulfate (SO_4)	Nitrate (NO_3)	Phosphate (PO_4)	Boron (B)	Hardness as $CaCO_3$: Calcium, magnesium	Hardness as $CaCO_3$: Noncarbonate	Dissolved solids (residue at 180°C)	Specific conductance (micromhos/cm at 25°C)	pH	Percent sodium	Sodium adsorption ratio	Aquifer
406- 598	124- 182	6- 7-67	33.5	54	<0.1	0.33	<0.01	1.0	4.2	0.05	0.12	325	5.7	0.01	0.02	<0.01	8	656	17	67	47	0.7	0.13	0.82	15	0	852	1,300	8.4	97	37	Qal
4,555-4,747	1,388-1,447	6- 7-67	40.5	58	.5	.47	.09	1.2	8.2	.09	.16	385	7.6	.03	.01	.06	16	790	19	64	47	.4	.20	2.3	26	0	950	1,510	8.4	96	33	Tv
4,795-4,995	1,461-1,522	6-12-67	37.0	60	.8	.82	.11	1.4	6.6	.10	.23	535	8.4	.03	.06	.05	26	1,110	27	82	55	.2	.17	1.1	23	0	1,340	2,070	8.4	97	49	Tv
5,020-5,180	1,530-1,579	6- 3-67	41.5	66	.9	.43	.09	.8	3.0	.10	.37	880	11	.06	.05	.29	81	1,860	39	76	73	.1	.28	3.0	11	0	2,180	3,230	8.7	99	115	Tv
5,300-5,410	1,615-1,649	6- 6-67	54.5	52	<.1	.09	.07	.2	2.6	.08	.39	875	9.0	.01	.02	.05	51	1,900	49	61	52	1.2	.13	3.0	8	0	2,180	3,220	8.5	99	139	Tv
5,530-5,640	1,685-1,719	6- 5-67	46.0	55	<.1	.75	.06	.2	2.2	.04	.40	890	9.2	.02	.03	.07	43	1,920	60	74	53	1.0	.07	2.9	7	0	2,150	3,250	8.5	99	152	Tv
5,804-5,914	1,769-1,802	6- 4-67	53.5	60	<.1	.37	.06	.2	1.8	.04	.38	880	8.7	.03	.03	.13	51	1,930	60	71	53	1.1	<.01	3.2	6	0	2,170	3,300	8.5	99	163	Tv
5,920-6,080	1,804-1,853	6- 1-67	--	46	<.1	.10	.18	.4	2.0	.04	.24	945	8.6	<.01	.02	.12	59	2,050	62	80	52	.2	<.01	2.3	7	0	2,250	3,470	8.6	99	161	Tv
6,149-6,514	1,874-1,985	6- 2-67	48.0	58	<.1	.45	.05	.6	1.2	.04	.36	875	8.5	.02	.03	.07	67	1,900	60	71	48	<.1	<.01	2.4	6	0	2,190	3,300	8.6	99	162	Tv

Spectrographic analyses

(In micrograms per liter. <, less than. ND, sought but not detected)

Interval, Feet	Interval, Meters	Date of sample collection	Temperature (°C)	Aluminum (Al)	Barium (Ba)	Beryllium (Be)	Bismuth (Bi)	Boron (B)	Cadmium (Cd)	Chromium (Cr)	Cobalt (Co)	Gallium (Ga)	Germanium (Ge)	Iron (Fe)	Lead (Pb)	Manganese (Mn)	Molybdenum (Mo)	Nickel (Ni)	Silver (Ag)	Strontium (Sr)	Tin (Sn)	Titanium (Ti)	Vanadium (V)	Zinc (Zn)	Zirconium (Zr)
406- 598	124- 182	6- 7-67	33.5	50	15	<0.7	<13	1,100	<70	6	<7	<7	<10	300	<5	1	35	<7	<0.7	40	<13	2	20	--	ND
4,555-4,747	1,388-1,447	6- 7-67	40.5	440	27	<.8	<16	1,600	<80	25	<8	<8	<11	450	<6	75	25	<8	<.8	100	<16	7	20	--	ND
4,795-4,995	1,461-1,522	6-12-67	37.0	970	35	<1	<25	2,500	<110	40	<11	<11	<15	750	<8	90	70	<5	<1	110	<25	35	13	--	ND
5,020-5,180	1,530-1,579	6- 3-67	41.5	--	25	1	ND	--	ND	70	<10	ND	ND	--	180	65	80	7	<.5	--	ND	85	20	--	<5
5,300-5,410	1,615-1,649	6- 6-67	54.5	60	8	.9	ND	--	ND	<5	<10	ND	ND	--	10	55	50	<5	<.5	--	ND	<5	ND	--	<5
5,530-5,640	1,685-1,719	6- 5-67	46.0	90	4	<1	ND	--	ND	<5	<10	ND	ND	--	20	35	65	<5	<.5	--	ND	<5	30	--	<5
5,804-5,914	1,769-1,802	6- 4-67	53.5	95	3	12	ND	--	ND	<5	<10	ND	ND	--	20	42	65	<5	<.5	--	ND	<5	200	--	<5
5,920-6,080	1,804-1,853	6- 1-67	--	65	5	.7	ND	--	ND	<5	<10	ND	ND	--	15	130	65	<5	<.5	--	ND	<5	20	--	<5
6,149-6,514	1,874-1,985	6- 2-67	48.0	90	2	16	ND	--	ND	<5	<10	ND	ND	--	20	35	65	<5	<.5	--	ND	<5	200	--	<5

A tracejector survey under dynamic conditions during pumping of water at a rate of 165 gpm (900 m^3 pd) indicates that most of the pumped water came from a depth of 5,685 ft (1,733 m) and from an interval in the alluvium from 406 to 598 ft (124 to 182 m). These two major contributing zones did not have the greatest head but they were two of the most permeable zones.

HOLE UCe-20

Hole UCe-20, at coordinates N. 1,399,868.46 ft and E. 628,092.75 ft, Nevada coordinate system, central zone, Nye County, Nevada, penetrated alluvium, zeolitized welded tuff, tuffaceous conglomerate, and partly to densely welded tuff. The land-surface elevation at this site is 5,759 ft (1,755 m) above mean sea level. A summary of hydraulic-test results is presented in table 8, analyses of water are presented in table 9, and a generalized summary of hydrology, lithology, and construction is presented in figure 7.

Tracejector Surveys

A tracejector survey run under static conditions indicated no measurable movement of water in the borehole. This lack of movement under static conditions indicates very little hydrostatic head difference in the vertical section, insufficient hydraulic conductivity for measurable exchange of water from one zone to another, or both.

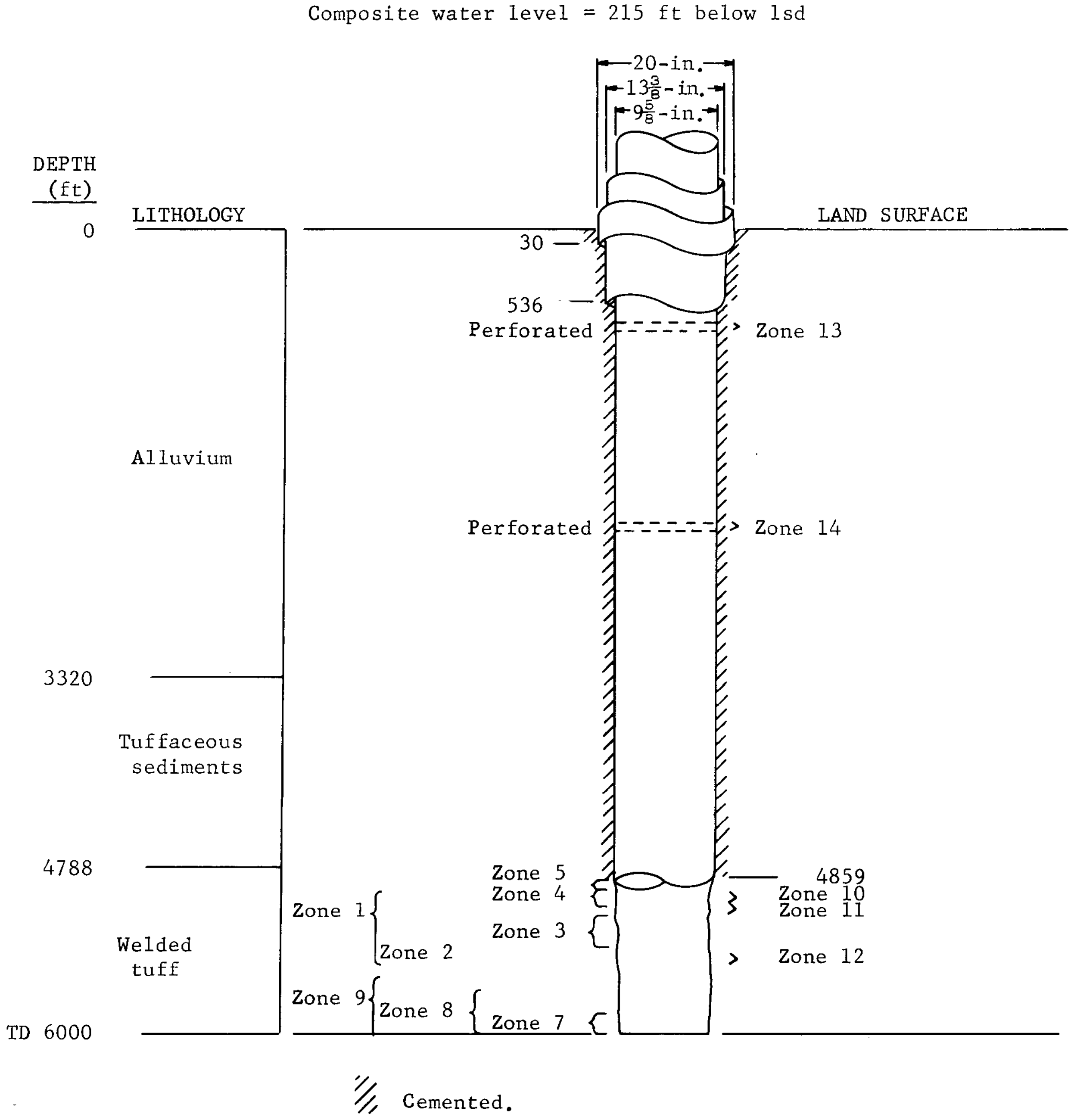


Figure 7.--Hydrology and lithology in hole UCe-20, Hot Creek Valley, Nevada.

Table 8.--Summary of hydraulic testing in hole UCe-20, Hot Creek Valley, Nevada

Zone	Interval tested		Static water level[1]		Relative specific capacity[1]		Water swabbed		Specific conductance (micromhos per cm at 25°C)	Temperature		Packer bypass[2]	Storage coefficient	Transmissivity		Hydraulic conductivity		Velocity		Rock type
	ft below lsd	m below lsd	ft below lsd	m below lsd	gpm per ft of dd	m^3pd per m of dd	gal	m^3		°F	°C			gpd per ft	m^3pd per m	gpd per ft^2	m^3pd per m^2	ft pd	m pd	
13[3]	700- 720	213- 219	340± --	104± --	0.005 --	0.089 --	--	--	--	--	--	No No	6.10×10^{-3}	6.23×10^{-1}	7.73×10^{-3}	3.11×10^{-2}	1.27×10^{-3}	8.2×10^{-4}	2.5×10^{-4}	Alluvium
14[3]	2,200- 2,220	671- 677	-- --	-- --	e.00004 --	e.0007 --	--	--	--	--	--	No No	e6.10×10^{-6}	e5.03×10^{-2}	e6.25×10^{-4}	e2.50×10^{-3}	e1.02×10^{-4}	e6.6×10^{-5}	e2×10^{-5}	Do.
5	4,860- 4,930	1,481- 1,503	-- --	-- --	e.0001 --	e.002 --	--	--	--	--	--	No No	e3.35×10^{-4}	e2.0×10^{-2}	e2.48×10^{-4}	e2.89×10^{-4}	e1.18×10^{-5}	e1.9×10^{-6}	e5.9×10^{-7}	Welded tuff
1	4,860- 5,308	1,481- 1,618	-- --	-- --	e.071 --	e1.27 --	--	--	--	--	--	-- No	4.67×10^{-3}	10.9	1.35×10^{-1}	2.43×10^{-2}	9.9×10^{-4}	1.62×10^{-4}	4.9×10^{-5}	Do.
4	4,930- 5,047	1,503- 1,538	-- --	-- --	e.0005 --	e.009 --	--	--	--	--	--	No No	4.89×10^{-5}	3.53×10^{-1}	4.38×10^{-3}	2.99×10^{-3}	1.22×10^{-4}	2.0×10^{-5}	6.1×10^{-6}	Do.
10	4,991- 5,051	1,521- 1,539	-- --	-- --	e.0003 --	e.005 --	--	--	--	--	--	No No	5.12×10^{-5}	1.76×10^{-1}	2.19×10^{-3}	2.94×10^{-3}	1.20×10^{-4}	1.97×10^{-5}	6.0×10^{-6}	Do.
11	5,051- 5,111	1,539- 1,558	228 219	69.5 66.8	.018 .022	.32 .39	--	--	--	--	--	No No	2.51×10^{-3}	10.6	1.31×10^{-1}	1.75×10^{-1}	7.16×10^{-3}	1.18×10^{-3}	3.6×10^{-4}	Do.
3	5,051- 5,308	1,539- 1,618	-- --	-- --	e.01 --	e.2 --	--	--	--	--	--	-- No	4.67×10^{-3}	7.56	9.38×10^{-2}	2.9×10^{-2}	1.2×10^{-3}	1.97×10^{-4}	6.0×10^{-5}	Do.
2	5,181- 5,308	1,579- 1,618	-- --	-- --	e.00002 --	e.0003 --	--	--	--	--	--	-- No	e4.67×10^{-7}	e7.05×10^{-2}	e8.75×10^{-4}	e5.54×10^{-4}	e2.26×10^{-5}	e5.71×10^{-6}	e1.74×10^{-6}	Do.
9	5,332- 6,002	1,625- 1,829	271 262	82.6 79.9	.36 --	6.44 --	--	--	--	--	--	-- No	--	e3.53×10^{3}	e43.8	e5.1	e2.1×10^{-1}	e3.6×10^{-2}	e1.1×10^{-2}	Do.
12[4]	5,422- 5,482	1,653- 1,671	215 215	65.5 65.5	High[5] High[5]	High[5] High[5]	9,000	34	800	93	34	No Slight	--	e3.02×10^{3}	e37.5	e50.2	e2.05	e3.3×10^{-1}	e1.0×10^{-1}	Do.
8	5,512- 6,002	1,680- 1,829	277 272	84.5 82.9	-- .008	-- .14	--	--	--	--	--	-- No	--	e2.12×10^{3}	e26.3	e4.31	e1.76×10^{-1}	e2.9×10^{-2}	e8.8×10^{-3}	Do.
7	5,902- 6,002	1,799- 1,829	-- --	-- --	e.002 --	e.04 --	--	--	--	--	--	-- No	6.26×10^{-4}	1.39	1.73×10^{-2}	1.39×10^{-2}	5.67×10^{-4}	9.19×10^{-5}	2.8×10^{-5}	Do.

1/Upper number from injection; lower number from recovery after swabbing.
2/Upper: bypass around top packer; lower: bypass around bottom packer.
3/Perforated casing and cement (two shots per foot).
4/Sampled for chemical analysis.
5/High: recovery too rapid to measure.

NOTE: Composite water level = 215 ft (65.5 m) below lsd.

Explanation:

m - meters
lsd - land-surface datum
ft - feet
gpm - gallons per minute
dd - drawdown
m^3pd - cubic meters per day
gal - gallons
cm - centimeters
°C - degrees Celsius
°F - degrees Fahrenheit
gpd - gallons per day
ft^2 - square feet
m^2 - square meters
ft pd - feet per day
mpd - meters per day
e - estimated

Table 9.--Analyses of water from hole UCe-20, Hot Creek Valley, Nevada

Interval: That part of the test hole that was open to the aquifer. Aquifer: Tv (Volcanic rocks of Tertiary age).
Temperature: Thermometers used were accurate to ±0.5°C.

Chemical analysis

(In milligrams per liter. <, less than)

Interval		Date of sample collection	Temperature (°C)	Silica (SiO_2)	Aluminum (Al)	Iron (Fe)	Manganese (Mn)	Magnesium (Mg)	Calcium (Ca)	Strontium (Sr)	Lithium (Li)	Sodium (Na)	Potassium (K)	Copper (Cu)	Selenium (Se)	Zinc (Zn)	Carbonate (CO_3)	Bicarbonate (HCO_3)	Fluoride (F)	Chloride (Cl)	Sulfate (SO_4)	Nitrate (NO_3)	Phosphate (PO_4)	Boron (B)	Hardness as $CaCO_3$		Dissolved solids (residue at 180°C)	Specific conductance (micromhos/cm at 25°C)	pH	Percent sodium	Sodium adsorption ratio	Aquifer
Feet	Meters																								Calcium, magnesium	Noncarbonate						
5,422-5,482	1,653-1,671	1-6-68	34.0	50	<0.1	0.14	0.03	0.1	5.8	0.08	0.04	162	1.4	0.02	--	<0.01	0	112	26	93	95	<0.1	0.45	--	15	0	470	791	7.6	95	18	Tv

Spectrographic analysis

(In micrograms per liter. <, less than. ND, sought but not detected)

Interval		Date of sample collection	Temperature (°C)	Aluminum (Al)	Barium (Ba)	Beryllium (Be)	Bismuth (Bi)	Boron (B)	Cadmium (Cd)	Chromium (Cr)	Cobalt (Co)	Gallium (Ga)	Germanium (Ge)	Iron (Fe)	Lead (Pb)	Manganese (Mn)	Molybdenum (Mo)	Nickel (Ni)	Silver (Ag)	Strontium (Sr)	Tin (Sn)	Titanium (Ti)	Vanadium (V)	Zinc (Zn)	Zirconium (Zr)
Feet	Meters																								
5,422-5,482	1,653-1,671	1-6-68	34.0	20	8	<0.4	<7	1,600	<35	<2	<4	<4	<5	370	<4	30	300	10	<4	30	<7	<3	6	<20	ND

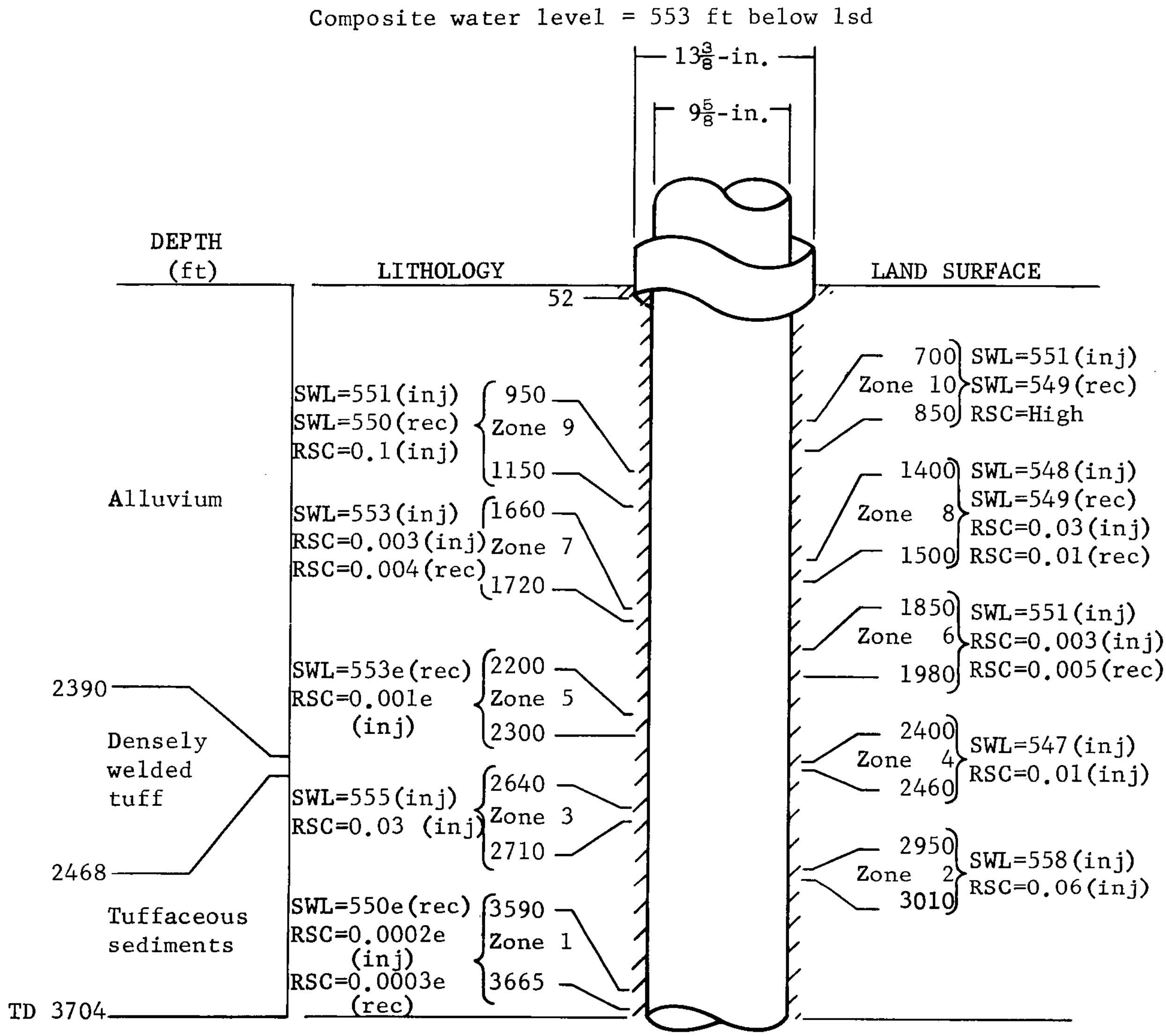
A tracejector survey under dynamic conditions during jetting of water at a rate of about 150 gpm (818 m^3pd) indicates that most of the jetted water came from a depth of about 5,440 ft (1,658 m). This depth is within the interval 5,422 to 5,482 ft (1,653 to 1,671 m) which had the greatest measured head and which was one of the most permeable zones.

HOLE HTH-1

Hole HTH-1, at coordinates N. 1,411,443 ft and E. 629,720 ft, Nevada coordinate system, central zone, Nye County, Nevada, penetrated alluvium, densely welded tuff, and tuffaceous sediments. The land-surface elevation at this site is 6,011 ft (1,832 m) above mean sea level. A summary of hydraulic-test results is presented in table 10, analyses of water are presented in table 11, and a generalized summary of hydrology, lithology, and construction is presented in figure 8.

Tracejector Surveys

Significant results were obtained from tracejector surveys under both pumping and static conditions. The survey under static conditions indicates that hydrostatic pressure in an interval of densely welded tuff from 2,400 to 2,460 ft (731.4 to 749.8 m) was greater than in the strata above and below; the flow therefore is primarily lateral. However, vertical flow from this interval both upward into the alluvium and downward into the tuffaceous sediments is possible.



/// Cemented areas. Tested intervals are shot perforated.
e Estimated.
SWL Static water level, ft below lsd.
RSC Relative specific capacity, gpm per ft of drawdown.
inj Injection.
rec Recovery.

Figure 8.--Hydrology and lithology in hole HTH-1, Hot Creek Valley, Nevada.

Table 10.--Summary of hydraulic testing in hole HTH-1, Hot Creek Valley, Nevada

Zone	Interval tested		Static water level[1]		Relative specific capacity[1]		Water swabbed		Specific conductance (micromhos per cm at 25°C)	Temperature		Packer bypass[2]	Storage coefficient	Transmissivity		Hydraulic conductivity		Velocity		Rock type
	ft below lsd	m below lsd	ft below lsd	m below lsd	gpm per ft of dd	m^3pd per ft of dd	gal	m^3		°F	°C			gpd per ft	m^3pd per m	gpd per ft^2	m^3pd per m^2	ft pd	mpd	
10[3,4]	700- 850	213- 259	551 549	168.0 167.4	High[5] High[5]	High[5] High[5]	875	3.3	285	72	22.2	No No	--	e1.3 x10^{3}	e16.4	e8.8	e3.6 x10^{-1}	e2.4 x10^{-1}	e7.2 x10^{-2}	Alluvium
9[3,4]	950- 1,150	290- 350.5	551 550	168.0 167.7	0.1 --	1.79 --	5,300	20	220	76	24.4	No No	6.1 x 10^{-7}	2.5 x10^{2}	3.1	1.3	5.1 x10^{-2}	3.3 x10^{-2}	1.0 x10^{-2}	Do.
8[3]	1,400- 1,500	426.7- 457.2	548 549	167.1 167.4	.03 .01	.54 .18	1,100	4.2	440	77	25.0	No No	6.1 x 10^{-6}	48	6.0 x10^{-1}	4.9 x10^{-1}	2.0 x10^{-2}	1.3 x10^{-2}	4.0 x10^{-3}	Do.
7[3]	1,660- 1,720	506.0- 524.2	553 --	168.6 --	.003 .004	.054 .072	200	.76	610	84	28.9	No No	6.1 x 10^{-7}	5.9	7.3 x10^{-2}	9.8 x10^{-2}	4.0 x10^{-3}	2.6 x10^{-3}	8.0 x10^{-4}	Do.
6[3]	1,850- 1,980	563.9- 603.5	551 --	168.0 --	.003 .005	.054 .089	530	2.0	660	83	28.3	No No	6.1 x 10^{-7}	6.6	8.2 x10^{-2}	5.1 x10^{-2}	2.1 x10^{-3}	1.4 x10^{-3}	4.2 x10^{-4}	Do.
5[3]	2,200- 2,300	670.6- 701.0	-- e550	-- e168	e.001 --	e.018 --	300	1.1	--	--	--	No No	6.1 x 10^{-3}	1.5 x10^{-1}	1.9 x10^{-3}	1.5 x10^{-3}	6.2 x10^{-5}	3.9 x10^{-5}	1.2 x10^{-5}	Do.
4[3,4]	2,400- 2,460	731.4- 749.8	547 --	166.8 --	.01 --	.18 --	1,550	5.9	730	81	27.2	No No	6.1 x 10^{-7}	27	3.3 x10^{-1}	4.4 x10^{-1}	1.8 x10^{-2}	3.9 x10^{-3}	1.2 x10^{-3}	Welded tuff
3[3,4]	2,640- 2,710	804.7- 826.0	555 --	169.2 --	.03 --	.54 --	7,700	29	500	91	32.8	No Yes	6.1 x 10^{-7}	96	1.2	1.4	5.6 x10^{-2}	1.2 x10^{-2}	3.7 x10^{-3}	Tuffaceous sediments
2[3,4]	2,950- 3,010	899.2- 917.4	558 --	170.1 --	.06 --	1.07 --	3,400	13	570	91	32.8	No No	6.1 x 10^{-4}	3.9 x10^{2}	4.9	6.5	2.7 x10^{-1}	5.9 x10^{-2}	1.8 x10^{-2}	Do.
1[3]	3,590- 3,665	1,094- 1,117	-- e550	-- e168	e.0002[6] e.0003[6]	e.0036[6] e.0054[6]	200	.76	--	--	--	No No	--	--	--	--	--	--	--	Do.

1/Upper number from injection; lower number from recovery after swabbing.
2/Upper: fluid bypass around top packer; lower: fluid bypass around bottom packer.
3/Perforated casing and cement.
4/Sampled for chemical analysis.
5/High: recovery too rapid to measure.
6/Sand may have plugged ports.

NOTE: Composite water level = 553 ft (168.5 m) below lsd.

Zones 9 and 10 pumped at 122 gpm (665 m^3pd) for about 7 days (10,000 minutes) with 18 ft (5.5 m) of drawdown. Specific capacity = 6.8 gpm per ft (1.2 x 10^2 m^3pd per m).

Explanation:

m - meters
lsd - land-surface datum
ft - feet
gpm - gallons per minute
dd - drawdown
m^3pd - cubic meters per day
gal - gallons
cm - centimeters
°C - degrees Celsius
°F - degrees Fahrenheit
gpd - gallons per day
ft^2 - square feet
m^2 - square meters
ft pd - feet per day
mpd - meters per day
e - estimated

Table 11.--Analyses of water from hole HTH-1, Hot Creek Valley, Nevada

Interval: That part of the test hole that was open to the aquifer. Aquifer: Qal (Valley fill of Quaternary age),
Temperature: Thermometers used were accurate to ±0.5°C. Tv (Volcanic rocks of Tertiary age).

Chemical analyses

(In milligrams per liter. <, less than)

Interval		Date of sample collection	Temperature (°C)	Silica (SiO_2)	Aluminum (Al)	Iron (Fe)	Manganese (Mn)	Magnesium (Mg)	Calcium (Ca)	Strontium (Sr)	Lithium (Li)	Sodium (Na)	Potassium (K)	Copper (Cu)	Selenium (Se)	Zinc (Zn)	Carbonate (CO_3)	Bicarbonate (HCO_3)	Fluoride (F)	Chloride (Cl)	Sulfate (SO_4)	Nitrate (NO_3)	Phosphate (PO_4)	Boron (B)	Hardness as $CaCO_3$		Dissolved solids (residue at 180°C)	Specific conductance (micromhos/cm at 25°C)	pH	Percent sodium	Sodium adsorption ratio	Aquifer
Feet	Meters																								Calcium, magnesium	Noncarbonate						
700- 850	213 -259	8- 5-67	22.0	18	0.2	1.2	0.02	0.9	5.9	0.16	0.08	58	6.7	--	<0.01	--	0	137	1.4	7.5	18	0.1	<0.01	0.24	18	0	198	285	7.9	82	5.9	Qal
950-1,150	290 -350.5	8- 5-67	24.5	25	.1	.42	.02	.6	8.7	.23	.05	39	3.9	--	<.01	--	0	116	.9	4.4	11	.1	<.01	.1	25	0	172	218	7.7	74	3.4	Qal
2,400-2,460	731.4-749.8	8- 2-67	27.0	44	3.9	3.0	.11	.8	3.7	.14	.15	144	7.9	--	<.01	--	122	47	12	13	44	.1	<.01	1.1	13	0	426	663	10.2	93	18	Tv
2,640-2,710	804.7-826.0	8- 1-67	33.0	42	<.1	1.1	.02	2.0	4.7	.12	.11	107	2.7	--	<.01	--	1	225	8.2	15	36	<.1	<.01	1.4	20	0	324	482	8.7	91	11	Tv
2,950-3,010	899.2-917.4	7-31-67	33.0	68	.1	.29	<.01	.4	12	.33	.16	110	1.2	--	<.01	--	5	247	2.6	20	34	<.1	<.01	1.9	32	0	402	567	8.4	87	9	Tv

Spectrographic analyses

(In micrograms per liter. <, less than. ND, sought but not detected)

Interval		Date of sample collection	Temperature (°C)	Aluminum (Al)	Barium (Ba)	Beryllium (Be)	Bismuth (Bi)	Boron (B)	Cadmium (Cd)	Chromium (Cr)	Cobalt (Co)	Gallium (Ga)	Germanium (Ge)	Iron (Fe)	Lead (Pb)	Manganese (Mn)	Molybdenum (Mo)	Nickel (Ni)	Silver (Ag)	Strontium (Sr)	Tin (Sn)	Titanium (Ti)	Vanadium (V)	Zinc (Zn)	Zirconium (Zr)
Feet	Meters																								
700- 850	213 -259	8- 5-67	22.0	150	15	<0.1	<3	210	<15	22	<2	<2	<2	1,300	<2	12	12	1	<0.2	110	<3	2	<1	<10	ND
950-1,150	290 -350.5	8- 5-67	24.5	60	34	<.1	<3	100	<15	25	<2	<2	<2	470	<2	7	5	.8	<.2	170	<3	<2	2	<7	ND
2,400-2,460	731.4-749.8	8- 2-67	27.0	3,000	95	.4	<8	820	<40	340	<4	<4	<6	6,500	20	190	90	4	.4	170	<8	200	20	<25	ND
2,640-2,710	804.7-826.0	8- 1-67	33.0	220	6	<.2	<6	730	<30	65	<3	<3	ND	680	<3	20	50	<1	<.3	30	<6	5	22	<20	ND
2,950-3,010	899.2-917.4	7-31-67	33.0	140	10	<.2	<6	1,200	<30	35	<3	<3	ND	220	<3	20	85	<2	<.3	170	<6	<3	21	<20	ND

During the survey, flow in the borehole from this interval was upward at a rate of more than 3 gpm (15 m^3pd) and downward at a rate of more than 4 gpm (20 m^3pd).

A tracejector survey made while pumping water at a rate of about 50 gpm (272 m^3pd) indicates that most of the water came from the intervals 700 to 850 ft (213 to 259 m) and 950 to 1,150 ft (290 to 350.5 m). There was no measurable contribution from deeper than 3,000 ft (915 m).

Aquifer-Performance Test in Holes HTH-1 and HTH-2

Physical Conditions

Hole HTH-1, the pumped well, was drilled to a depth of 3,704 ft (1,129 m) and penetrated alluvium from 0 to 2,390 ft (728.5 m), densely welded tuff from 2,390 to 2,468 ft (728.5 to 752.1 m), and tuffaceous sediments from 2,468 to 3,704 ft (752.2 to 1,129 m). The well was cased and cemented throughout its entire depth, after which specific intervals were shot perforated. The perforated intervals were selected as being the most permeable as inferred by the geophysical logs. Isolated tests of hydraulic characteristics showed that the intervals 700 to 850 ft (213 to 259 m) and 950 to 1,150 ft (290 to 350.5 m) were the most permeable. These zones were isolated for testing by use of a retrievable bridge packer. A pump was then installed above the packer.

Hole HTH-2 is 505 ft (154 m) from HTH-1 and was used to observe the effects of pumping hole HTH-1. Drilled to a depth of 1,000 ft (304.7 m), it penetrated alluvium. The well was cased with blank casing from 0 to about 500 ft (152 m) and with slotted casing from about 500 to 1,000 ft (152 to 304.7 m).

Purpose of the Test

This aquifer-performance test was needed to determine important aquifer characteristics such as transmissivity and hydraulic conductivity from which rate of ground-water and contaminant movement could be predicted near this location.

Type of Test and Conditions

The aquifer-performance test consisted of pumping well HTH-1 for a period of 10,008 minutes and measuring water-level change in wells HTH-1 and HTH-2 during both pumping and recovery after pumping. The conditions of the test were variable drawdown, with time, at a constant discharge. The average pumping rate was 122 gpm (665 m^3 pd). Some difficulties arose toward the end of the test when the rate of discharge fluctuated slightly. The fluctuation was particularly critical because the maximum drawdown in HTH-2 was only 0.56 ft (0.17 m).

Analysis of Aquifer-Test Data

Preliminary inspection of the test data indicated that a mathematical analysis concerned with leaky artesian conditions (fig. 9) would be the best means of evaluating the data.

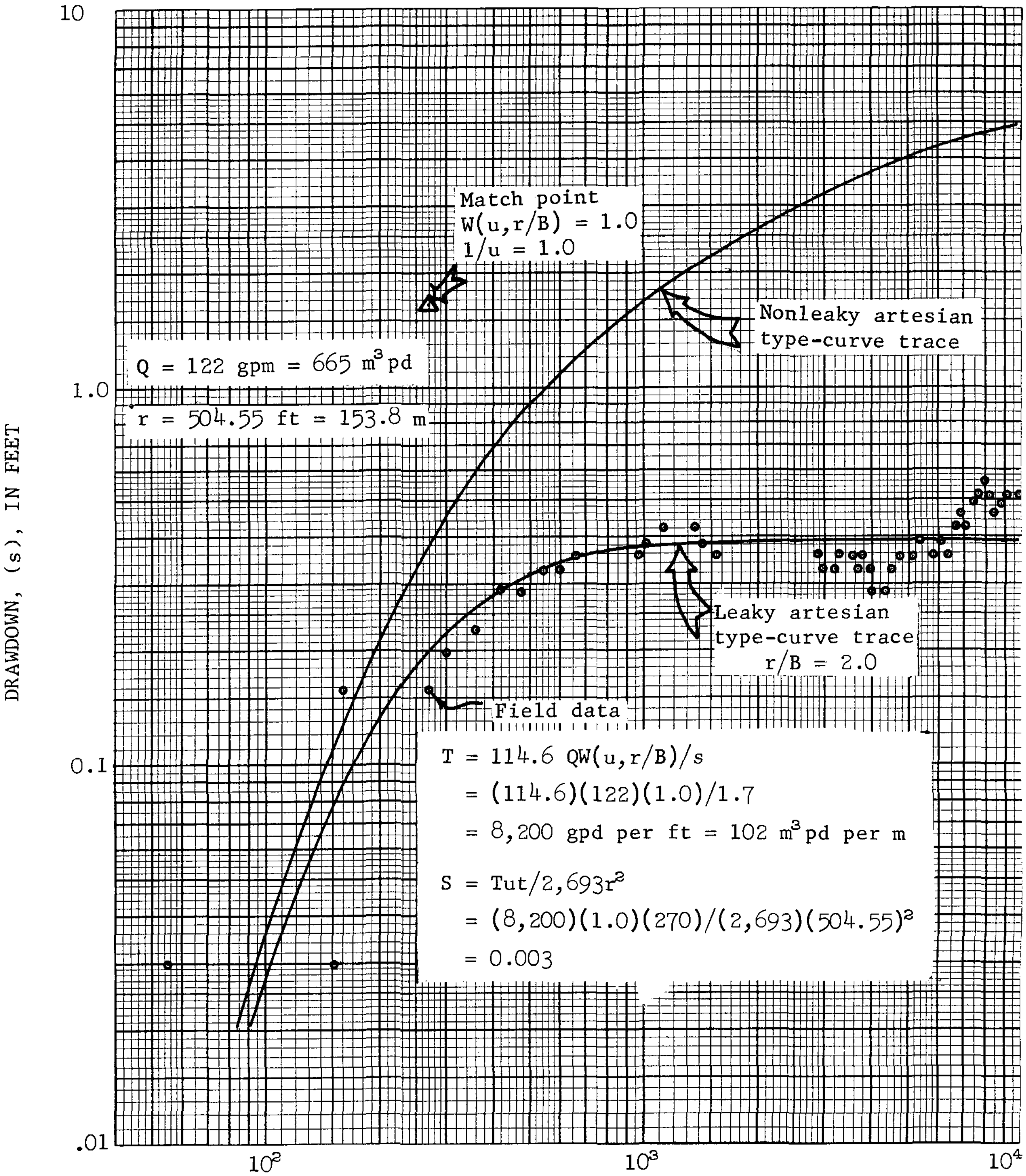


Figure 9.--Time-drawdown graph for observation well HTH-2, Hot Creek Valley, Nevada.

Equations applied to leaky-artesian conditions (Walton, 1962) are as follows:

$$T = 114.6QW(u, r/B)/s \quad \text{and}$$

$$u = 2693r^2S/Tt, \quad \text{or} \quad S = Tut/2693r^2$$

where:

s = drawdown in observation well, in feet

r = distance from pumped well to observation well, in feet

Q = discharge, in gallons per minute

t = time after pumping started, in minutes

T = coefficient of transmissivity, in gallons per day per foot

S = coefficient of storage of aquifer

W(u,r/B) = well function for leaky artesian aquifers

where:

$$r/B = r/\sqrt{T/(P'/m')}$$

P' = hydraulic conductivity of confining bed, in gallons per day per square foot

m' = thickness of confining bed through which leakage occurs.

When the equations are applied to the drawdown data from HTH-2, the observation well, the transmissivity of the aquifer is 8,200 gpd per ft (102 m^3pd per m) and the coefficient of storage of the aquifer is 3×10^{-3}. Converting transmissivity to hydraulic conductivity (K) is simply a matter of dividing the transmissivity (T) by the aquifer thickness (b):

$$K = T/b.$$

However, the complexity of the hydraulic system that was penetrated by HTH-1 results in a range of values for aquifer thickness. The aquifer thickness may be considered to be the combined thickness of the most permeable beds, intervals 700 to 850 ft and 950 to 1,150 ft (213 to 259 m and 290 to 350.5 m), or the entire saturated thickness from the static water level to the bottom of perforations, 1,150 ft (350.5 m). Therefore, this range in aquifer thickness, 350 to 597 ft (107 to 182 m) results in a range of hydraulic conductivity from 13.7 to 23.5 gpd per ft^2 (0.56 to 0.96 m^3pd per m^2):

$$K = T/b = 8{,}200/350 = 102/106.7 = 23.5 \text{ gpd per ft}^2 \; (0.96 \text{ m}^3\text{pd per m}^2)$$

and $$K = T/b = 8{,}200/597 = 102/182.0 = 13.7 \text{ gpd per ft}^2 \; (0.56 \text{ m}^3\text{pd per m}^2)$$

The average interstitial velocity of ground-water movement is computed from the following equation, using Darcy's law:

$$v = KI/\theta$$

where:

v = velocity, in feet per day

I = hydraulic gradient

θ = effective porosity (fractional).

The hydraulic gradient was determined by using elevations of water levels in holes UCe-11, HTH-1, and UCe-17. The unit gradient is about 0.04 from northwest to southeast, toward the principal drainage in the area. Assuming an effective porosity of 20 percent, considered a reasonable estimate in the type of material tested, the range of velocity of ground-water movement downgradient would be from 0.37 to 0.63 ft per day (0.11 to 0.19 m per day).

$$v = KI/\theta = (13.7)\ (0.04)\ (0.1337)/0.20 = 0.37 \text{ ft per day } (0.11 \text{ mpd})$$

$$v = KI/\theta = (23.5)\ (0.04)\ (0.1337)/0.20 = 0.63 \text{ ft per day } (0.19 \text{ mpd}).$$

A discrepancy appears between values of transmissivity of the two uppermost intervals from the pumping test (8,200 gpd per ft) and from injection tests (1,550 gpd per ft). The difference is considerably less than an order of magnitude and probably is due in large part to the following: 1) the pumping test was of long duration and a much larger volume of the aquifer was tested than during the short-duration injection tests and 2) much of the drilling mud was cleaned from the formation and the aquifer probably was developed during the pumping test but not during the injection tests.

HOLE HTH-3

Hole HTH-3, at coordinates N. 1,385,943.94 ft and E. 657,118.89 ft, Nevada coordinate system, central zone, Nye County, Nevada, penetrated alluvium, densely welded tuff, and tuffaceous sandstone and claystone. The land-surface elevation at this site is 5,915 ft (1,803 m) above mean sea level. A summary of hydraulic-tes results is presented in table 12, analyses of water are presented in table 13, and a generalized summary of hydrology, lithology, and construction is presented in figure 10.

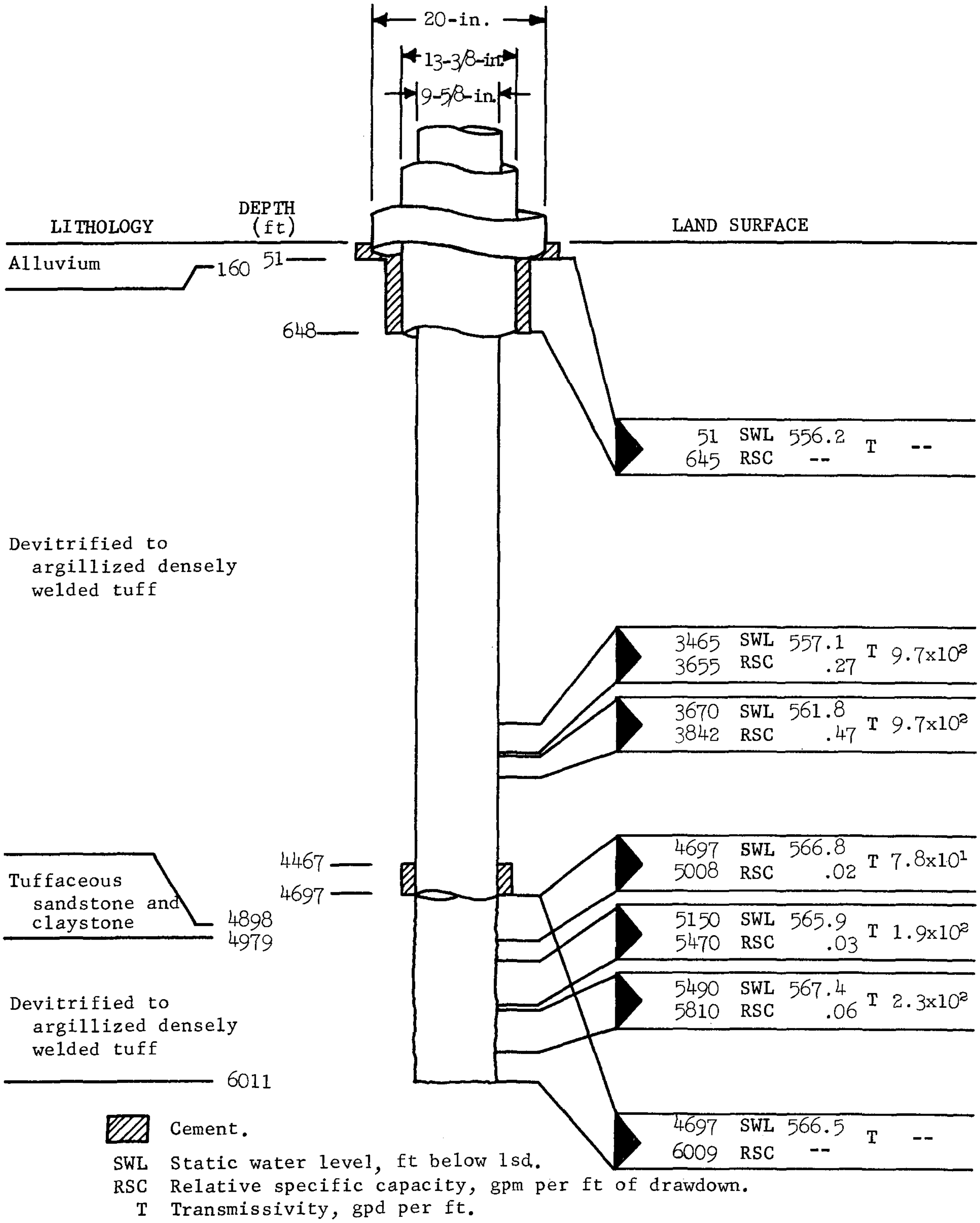


Figure 10.--Hydrology and lithology in hole HTH-3, Little Smoky Valley, Nevada.

Table 12.--Summary of hydraulic testing in hole HTH-3, Little Smoky Valley, Nevada

Test	Interval tested		Static water level		Relative specific capacity		Packer bypass[1]	Storage coefficient	Transmissivity		Hydraulic conductivity		Velocity[2]		Rock type	Remarks
	ft below lsd	m below lsd	ft below lsd	m below lsd	gpm per ft of dd	m^3 pd per m of dd			gpd per ft	m^3 pd per m	gpd per ft^2	m^3 pd per m^2	ft pd	mpd		
1	51- 645	16- 197	556.2	169.5	--	--	-- --	--	--	--	--	--	--	--	Welded tuff	Measured in open hole.
3	3,465-3,655	1,056-1,114	557.1	169.8	0.27	4.8	No No	--	9.7×10^{2}	1.2×10^{1}	5.1	2.1×10^{-1}	1.4×10^{-1}	4.2×10^{-2}	do.	--
2	3,670-3,842	1,119-1,171	561.8	171.2	.47	8.4	No No	--	9.7×10^{2}	1.2×10^{1}	5.6	2.3×10^{-1}	1.5×10^{-1}	4.6×10^{-2}	do.	--
6	4,697-5,008	1,432-1,526	566.8	172.8	.02	.34	No No	--	7.8×10^{1}	9.7×10^{-1}	2.4×10^{-1}	1.0×10^{-2}	6.6×10^{-3}	2.0×10^{-3}	Welded tuff and tuff-aceous sandstone and claystone	--
5	5,150-5,470	1,570-1,667	565.9	172.5	.03	.61	? ?	--	1.9×10^{2}	2.4	6.1×10^{-1}	2.5×10^{-2}	1.6×10^{-2}	5.0×10^{-3}	Welded tuff	Tool may have malfunctioned after 3 minutes.
4	5,490-5,810	1,673-1,771	567.4	172.9	.06	1.1	No No	--	2.3×10^{2}	2.9	7.4×10^{-1}	3.0×10^{-2}	2.0×10^{-2}	6.0×10^{-3}	do.	--
7	4,697-6,009	1,432-1,831	566.5	172.7	--	--	-- --	--	--	--	--	--	--	--	Welded tuff and tuff-aceous sandstone and claystone	Measured in open hole.

1/ Upper: fluid bypass around top packer; lower: fluid bypass around bottom packer.

2/ Velocity calculated as if entire straddled interval contributed evenly.

NOTE: Composite water level = 566.5 ft (172.7 m) below lsd in open hole from 4,697 to 6,009 ft (1,432 to 1,832 m).

Well pumped at about 22 gpm (120 m^3 pd) for about 44 hours (2,650 minutes) with 128.5 ft (39.2 m) of drawdown. Specific capacity = 0.17 gpm per ft (3.0 m^3 pd per m).

Explanation:

ft - feet
lsd - land-surface datum
m - meters
gpm - gallons per minute
dd - drawdown
m^3 pd - cubic meters per day
gpd - gallons per day
ft^2 - square feet
m^2 - square meters
ft pd - feet per day
mpd - meters per day

Table 13.--Analyses of water from hole HTH-3, Little Smoky Valley, Nevada

Interval: That part of the test hole that was open to the aquifer. Aquifer: Tv (Volcanic rocks of Tertiary age).
Temperature: Thermometers used were accurate to $\pm 0.5^{\circ}C$.

Chemical analyses

(In milligrams per liter. <, less than)

Interval: Feet	Interval: Meters	Date of sample collection	Temperature (°C)	Silica (SiO_2)	Aluminum (Al)	Iron (Fe)	Manganese (Mn)	Magnesium (Mg)	Calcium (Ca)	Strontium (Sr)	Lithium (Li)	Sodium (Na)	Potassium (K)	Copper (Cu)	Selenium (Se)	Zinc (Zn)
3,670-3,842	1,119-1,171	8-28-68	30.0	28	1.5	4.2	0.06	1.4	6.6	0.16	0.07	115	2.2	0.03	0.04	0.04
4,697-6,009	1,432-1,831	10-28-68	53.0	39	<.1	.73	.02	.6	4.4	.08	.07	94	2.0	.06	<.01	.06
5,490-5,810	1,673-1,771	10-29-68	33.0	36	<.1	.30	.02	.6	4.8	.13	.08	99	2.2	.03	<.01	.06

Interval: Feet	Carbonate (CO_3)	Bicarbonate (HCO_3)	Fluoride (F)	Chloride (Cl)	Sulfate (SO_4)	Nitrate (NO_3)	Phosphate (PO_4)	Boron (B)	Hardness as $CaCO_3$: Calcium, magnesium	Hardness as $CaCO_3$: Noncarbonate	Dissolved solids (residue at 180°C)	Specific conductance (micromhos/cm at 25°C)	pH	Percent sodium	Sodium adsorption ratio	Aquifer
3,670-3,842	0	245	6.4	10	39	0.5	0.12	0.38	23	0	452	494	7.4	91	11	Tv
4,697-6,009	0	201	5.2	12	24	<.1	<.01	.26	14	0	278	420	7.5	93	11	Tv
5,490-5,810	0	214	5.8	14	24	<.1	<.01	.26	15	0	293	434	7.5	92	11	Tv

Spectrographic analyses

(In micrograms per liter. <, less than. ND, sought but not detected)

Interval: Feet	Interval: Meters	Date of sample collection	Temperature (°C)	Aluminum (Al)	Barium (Ba)	Beryllium (Be)	Bismuth (Bi)	Boron (B)	Cadmium (Cd)	Chromium (Cr)	Cobalt (Co)	Gallium (Ga)
3,670-3,842	1,119-1,171	8-28-68	30.0	4,200	33	0.3	<6	370	<40	130	<7	--
4,697-6,009	1,432-1,831	10-28-68	53.0	190	10	<.3	<2	150	<20	<5	<2	--
5,490-5,810	1,673-1,771	10-29-68	33.0	240	10	<.3	<3	210	<25	<5	<3	--

Interval: Feet	Germanium (Ge)	Iron (Fe)	Lead (Pb)	Manganese (Mn)	Molybdenum (Mo)	Nickel (Ni)	Silver (Ag)	Strontium (Sr)	Tin (Sn)	Titanium (Ti)	Vanadium (V)	Zinc (Zn)	Zirconium (Zr)
3,670-3,842	<7	4,300	50	80	35	50	<0.4	160	<7	25	<7	<35	--
4,697-6,009	<2	55	<5	6	25	3	<.3	100	<5	<2	<5	<20	--
5,490-5,810	<3	75	12	15	28	<3	<.3	140	<5	<3	<5	<25	--

Tracejector Surveys

A tracejector survey run under static conditions in open hole from 4,697 to 6,009 ft (1,432 to 1,831 m) indicated no measurable flow in this interval of the borehole.

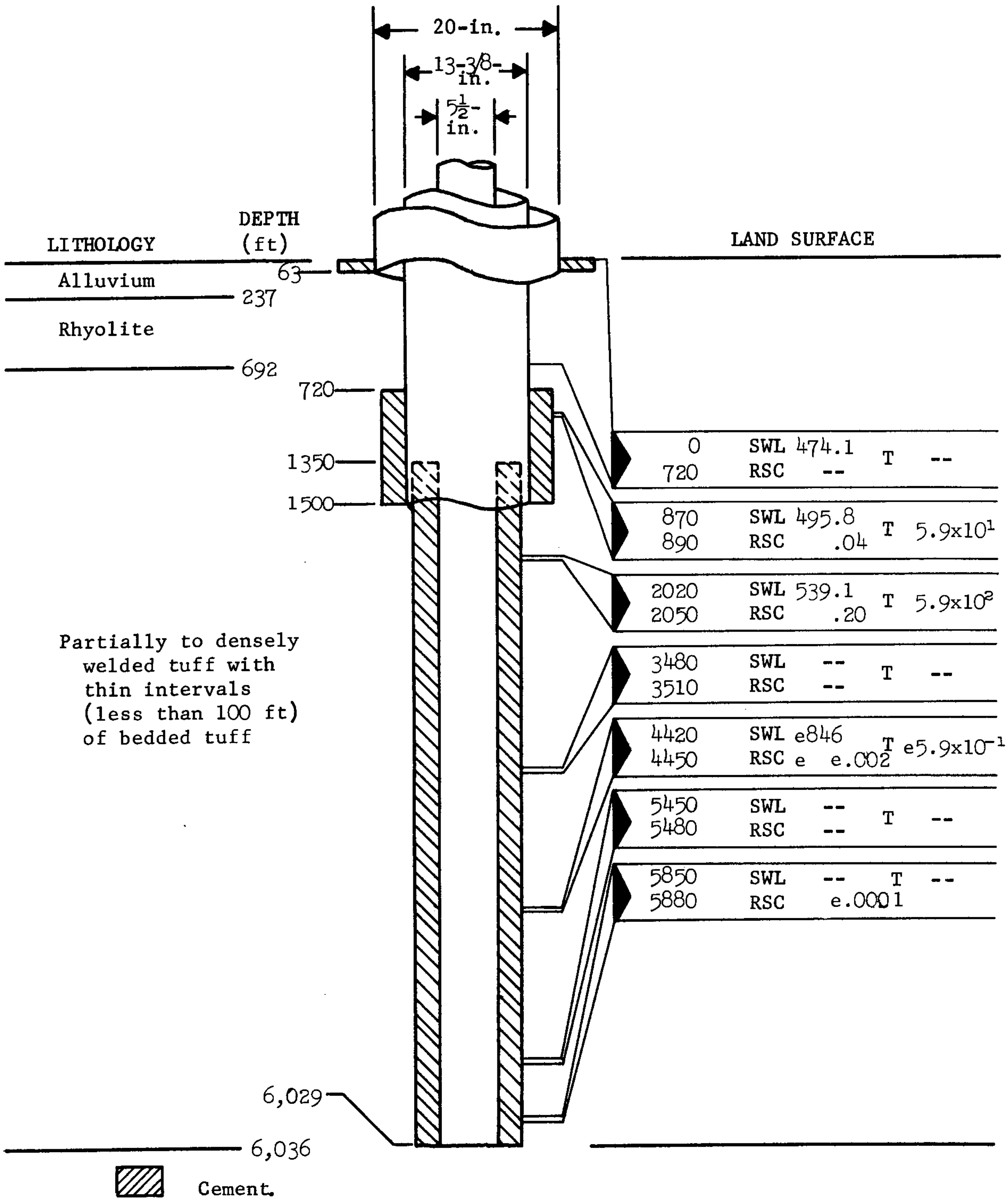
Results of a tracejector survey run under dynamic conditions while pumping water at a rate of about 22 gpm (120 m^3 pd) from the same interval of open hole indicate that most of the pumped water came from a depth of about 5,670 ft (1,728 m) and that some of the water came from a depth of about 5,720 ft (1,743 m). These contributing zones are in the most permeable tested interval below a depth of 4,697 ft (1,432 m).

HOLE HTH-4

Hole HTH-4, at coordinates N. 1,379,469.45 ft and E. 683,276.08 ft, Nevada coordinate system, central zone, Nye County, Nevada, penetrated alluvium, rhyolite, and partially to densely welded tuff. The land-surface elevation at this site is 5,828 ft (1,776 m) above mean sea level. A summary of hydraulic-test results is presented in table 14, analyses of water are presented in table 15, and a generalized summary of hydrology, lithology, and construction is presented in figure 11.

Tracejector Survey

A tracejector survey under dynamic conditions during injection of water at a constant rate of about 50 gpm (272 m^3 pd) indicates that most of the injected water was accepted into the perforated



Cement.
SWL Static water level, ft below lsd.
RSC Relative specific capacity, gpm per ft of drawdown.
T Transmissivity, gpd per ft.
e Estimated.

Figure 11.--Hydrology and lithology in hole HTH-4, Little Smoky Valley, Nevada.

Table 14. --Summary of hydraulic testing in hole HTH-4, Little Smoky Valley, Nevada

Test	Interval tested: ft below lsd	Interval tested: m below lsd	Static water level: ft below lsd	Static water level: m below lsd	Relative specific capacity: gpm per ft of dd	Relative specific capacity: m^3 pd per m of dd	Packer bypass[1]	Storage coefficient	Transmissivity: gpd per ft	Transmissivity: m^3 pd per m	Hydraulic conductivity: gpd per ft^2	Hydraulic conductivity: m^3 pd per m^2	Velocity[2]: ft pd	Velocity[2]: mpd	Rock type	Remarks
2	0- 720	0- 219	474.1	144.5	--	--	No No	--	--	--	--	--	--	--	Alluvium and rhyolite	Test for static water level only.
1	870- 890	265 - 271	495.8	151.1	0.04	0.75	No No	$3.5x10^{-6}$	$5.9x10^{1}$	$7.3x10^{-1}$	2.9	$1.2x10^{-1}$	$9.5x10^{-3}$	$2.9x10^{-3}$	Partially to densely welded tuff	--
3	2,020-2,050	615.7- 624.8	539.1	164.3	.20	3.6	No No	--	$5.9x10^{2}$	7.3	$2.0x10^{1}$	$8.0x10^{-1}$	$6.2x10^{-2}$	$1.9x10^{-2}$	do.	--
7	3,480-3,510	1,061 -1,070	--	--	--	--	No No	--	--	--	--	--	--	--	do.	Fractures cemented, no test.
6	4,420-4,450	1,347- -1,356	e846	e258	e .002	e .036	No No	e$2.1x10^{-3}$	e$5.9x10^{-1}$	e$7.3x10^{-3}$	e$2.0x10^{-2}$	e$8.0x10^{-4}$	e$1.0x10^{-3}$	e$3.2x10^{-4}$	do.	Static water level is $\pm$3.2 ft (1.0 m).
5	5,450-5,480	1,661 -1,670	--	--	--	--	No No	--	--	--	--	--	--	--	do.	Fractures cemented, no test.
4	5,850-5,880	1,783 -1,792	--	--	e .0001	e .002	No No	--	--	--	--	--	--	--	do.	Fractures at least partly cemented.

1/ Upper: fluid bypass around top packer; lower: fluid bypass around bottom packer.

2/ Velocity calculated as if entire straddled interval contributed evenly.

NOTE: Fractures in all tested intervals are assumed to be at least partly cemented; therefore, all values of T, K, v, and RSC are assumed to be too low.

Composite water level (measured in perforated 5½-inch casing) = 516.8 ft (157.5 m below lsd). Water was injected into the well through the perforated 5½-inch casing at a rate of about 50 gpm (270 m^3pd) for 140 minutes with 346.1 ft (105.5 m) of buildup. Specific capacity = 0.14 gpm per ft (2.5 m^3pd per m).

Explanation:

- ft - feet
- lsd - land-surface datum
- m - meters
- gpm - gallons per minute
- dd - drawdown
- m^3pd - cubic meters per day
- gpd - gallons per day
- ft^2 - square feet
- m^2 - square meters
- ft pd - feet per day
- mpd - meters per day
- e - estimated
- T - transmissivity
- K - hydraulic conductivity
- v - velocity
- RSC - relative specific capacity

Table 15.- Analyses of water from hole HTH-4, Little Smoky Valley, Nevada

Interval: That part of the test hole that was open to the aquifer. Aquifer: Tv (Volcanic rocks of Tertiary age).
Temperature: Thermometers used were accurate to ±0.5°C.

Chemical analyses

(In milligrams per liter. <, less than)

Interval: Feet	Interval: Meters	Date of sample collection	Temperature (°C)	Silica (SiO_2)	Aluminum (Al)	Iron (Fe)	Manganese (Mn)	Magnesium (Mg)	Calcium (Ca)	Strontium (Sr)	Lithium (Li)	Sodium (Na)	Potassium (K)	Copper (Cu)	Selenium (Se)	Zinc (Zn)	Carbonate (CO_3)
870- 890	265 -271	1-31-69	22.0	81	0.2	0.45	0.04	0.6	19	0.21	0.03	46	5.6	0.01	<0.01	0.03	0
2,020-2,050	615.7-624.8	1-20-69	38.0	44	<.1	.67	.02	.1	3.7	.06	.03	87	1.4	<.01	.02	<.01	33

Interval: Feet	Interval: Meters	Bicarbonate (HCO_3)	Fluoride (F)	Chloride (Cl)	Sulfate (SO_4)	Nitrate (NO_3)	Phosphate (PO_4)	Boron (B)	Hardness as $CaCO_3$: Calcium, magnesium	Hardness as $CaCO_3$: Noncarbonate	Dissolved solids (residue at 180°C)	Specific conductance (micromhos/cm at 25°C)	pH	Percent sodium	Sodium adsorption ratio	Aquifer
870- 890	265 -271	135	1.0	8.8	29	6.6	<0.01	0.25	50	0	266	315	8.2	64	2.8	Tv
2,020-2,050	615.7-624.8	116	1.4	8.3	24	2.2	<.01	.25	10	0	263	373	9.5	94	12	Tv

Spectrographic analyses

(In micrograms per liter. <, less than. ND, sought but not detected)

Interval: Feet	Interval: Meters	Date of sample collection	Temperature (°C)	Aluminum (Al)	Barium (Ba)	Beryllium (Be)	Bismuth (Bi)	Boron (B)	Cadmium (Cd)	Chromium (Cr)	Cobalt (Co)	Gallium (Ga)
870- 890	265 -271	1-31-69	22.0	40	50	<2	<6	240	<55	25	<6	--
2,020-2,050	615.7-624.8	1-20-69	38.0	210	27	<2	<6	130	<60	140	<6	--

Interval: Feet	Interval: Meters	Germanium (Ge)	Iron (Fe)	Lead (Pb)	Manganese (Mn)	Molybdenum (Mo)	Nickel (Ni)	Silver (Ag)	Strontium (Sr)	Tin (Sn)	Titanium (Ti)	Vanadium (V)	Zinc (Zn)	Zirconium (Zr)
870- 890	265 -271	<6	360	8	30	6	4	<0.6	200	<6	4	<6	<320	--
2,020-2,050	615.7-624.8	<6	550	7	12	7	4	<.6	65	<6	6	<6	<360	--

interval from 2,020 to 2,050 ft (615.7 to 624.8 m) and that there was no movement of water below the next lowest perforated interval from 3,480 to 3,510 ft (1,061 to 1,070 m). Because of construction difficulties, these results do not necessarily indicate the most permeable intervals penetrated by the borehole but probably do indicate the perforated intervals with the best hydraulic connections to the penetrated fracture systems.

HOLE HTH-5

Hole HTH-5, at coordinates N. 1,368,424.47 ft and E. 625,928.65 ft, Nevada coordinate system, central zone, Nye County, Nevada, penetrated alluvium, tuffaceous sandstone and siltstone, and slightly to densely welded tuff. The land-surface elevation at this site is 5,496 ft (1,675 m) above mean sea level. A summary of hydraulic-test results is presented in table 16, analyses of water are presented in table 17, and a generalized summary of hydrology, lithology, and construction is presented in figure 12.

Tracejector Survey

A tracejector survey run under dynamic conditions while pumping water at a rate of about 20 gpm (110 m^3pd) indicated that the pumped water came from the perforated interval from 570 to 590 ft (174 to 180 m). The survey indicated that there was no movement of water below the pump which was set at a depth of 1,504 ft (458.4 m).

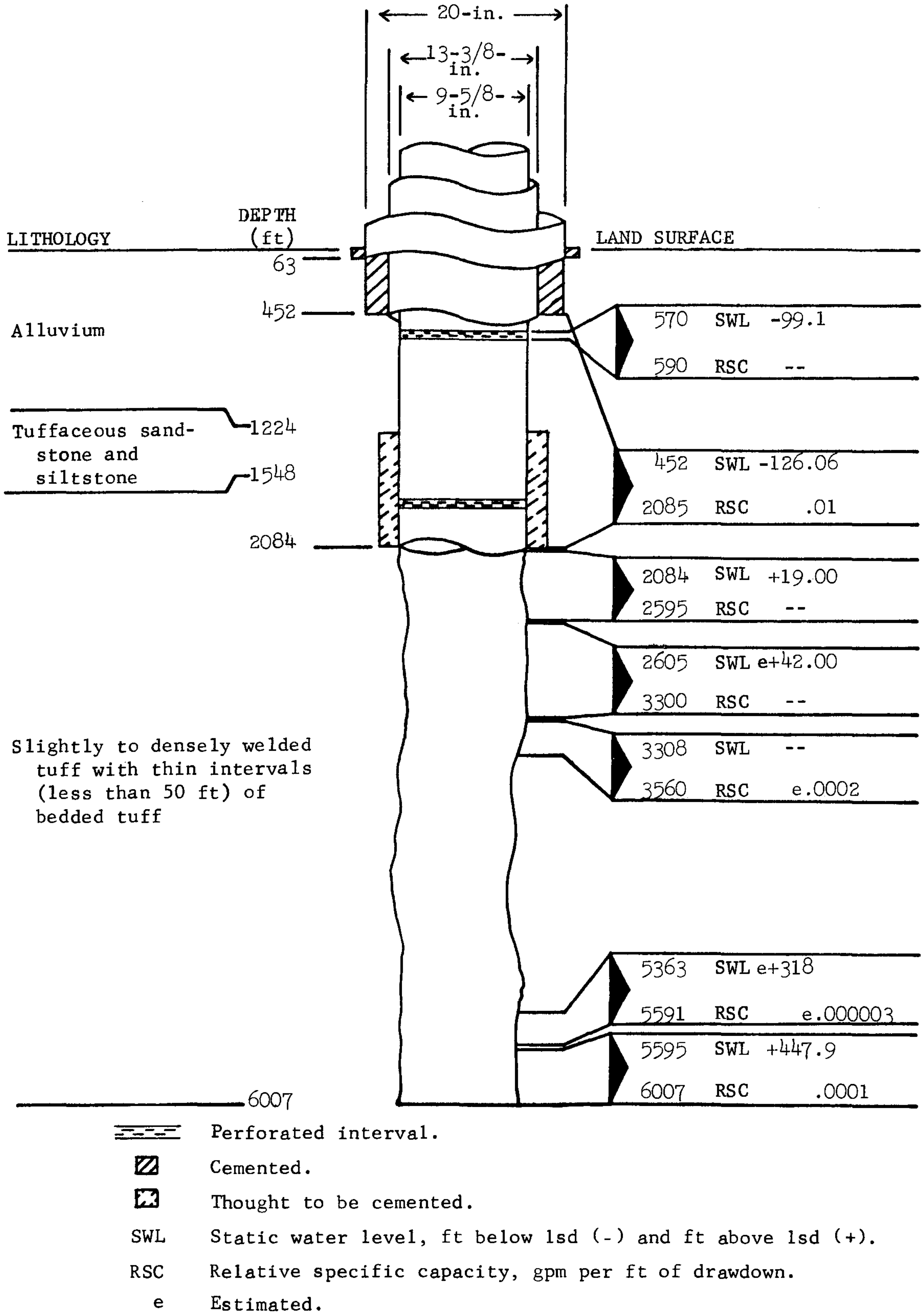


Figure 12.--Hydrology and lithology in hole HTH-5, Hot Creek Valley, Nevada.

Table 16.--Summary of hydraulic testing in hole HTH-5, Hot Creek Valley, Nevada

Test	Interval tested: ft below lsd	Interval tested: m below lsd	Static water level: ft above (+) or below (-) lsd	Static water level: m above (+) or below (-) lsd	Relative specific capacity: gpm per ft of dd	Relative specific capacity: m^3pd per m of dd	Packer bypass[1]	Rock type	Remarks
7	570- 590	174 - 180	-99.1	-30.2	--	--	No No	Alluvium	Casing is perforated but probably not cemented.
1	452-2,085	138 - 635.5	-126.06	-38.42	0.01	0.18	-- No	Alluvium, tuffaceous sandstone and siltstone, and welded tuff	--
3	2,084-2,595	635.2- 791.0	+19.00	+5.79	--	--	-- --	Welded tuff with thin intervals of bedded tuff	Measured in open hole.
2	2,605-3,300	794.0-1,006	e +42.00	e +13	--	--	No No	do.	Reaction of water level indicates hydraulic conductivity is low.
4	3,308-3,560	1,008 -1,085	--	--	e .0002	e.004	No No	do.	Do.
6	5,363-5,591	1,635 -1,704	e +318	e +97	e .000003	e.00006	No No	do.	Do.
5	5,595-6,007	1,705 -1,831	+447.9	+136.5	.0001	.002	No No	do.	Do.

[1] Upper: fluid bypass around top packer; lower: fluid bypass around bottom packer.

NOTE: Composite water level = 115.2 ft (35.1 m) below lsd after pumping test with hole open from 2,084 to 6,007 ft (635.2 to 1,831 m) and with casing perforated in two intervals from 570 to 590 ft (174 to 180 m) and from 1,760 to 1,810 ft (536.4 to 551.7 m). Well pumped at about 20 gpm (110 m^3pd) for 14 hours (840 minutes with 42.8 ft (13.03 m) of drawdown. Specific capacity = 0.5 gpm per ft (8.9 m^3pd per m).

Explanation:

ft - feet
lsd - land-surface datum
m - meters
dd - drawdown
gpm - gallons per minute
m^3pd - cubic meters per day
e - estimated

Table 17.--Analyses of water from hole HTH-5, Hot Creek Valley, Nevada

Interval: That part of the test hole that was open to the aquifer. Aquifer: Qal (Valley fill of Quaternary age).
Temperature: Thermometers used were accurate to $\pm 0.5^{\circ}C$.

Chemical analysis

(In milligrams per liter. <, less than)

Interval		Date of sample collection	Temperature (°C)	Silica (SiO_2)	Aluminum (Al)	Iron (Fe)	Manganese (Mn)	Magnesium (Mg)	Calcium (Ca)	Strontium (Sr)	Lithium (Li)	Sodium (Na)	Potassium (K)	Copper (Cu)	Selenium (Se)	Zinc (Zn)	Carbonate (CO_3)	Bicarbonate (HCO_3)	Fluoride (F)	Chloride (Cl)	Sulfate (SO_4)	Nitrate (NO_3)	Phosphate (PO_4)	Boron (B)	Hardness as $CaCO_3$		Dissolved solids (residue at 180°C)	Specific conductance (micromhos/cm at 25°C)	pH	Percent sodium	Sodium adsorption ratio	Aquifer
Feet	Meters																								Calcium, magnesium	Noncarbonate						
570-590	174-180	3-30-69	28.0	59	4.2	11	0.32	3.5	29	0.38	0.02	33	11	0.04	<0.01	0.45	0	163	1.0	5.4	18	8.3	<0.01	--	88	0	301	314	7.5	41	1.5	Qal

Spectrographic analyses

(In micrograms per liter. <, less than. ND, sought but not detected)

Interval		Date of sample collection	Temperature (°C)	Aluminum (Al)	Barium (Ba)	Beryllium (Be)	Bismuth (Bi)	Boron (B)	Cadmium (Cd)	Chromium (Cr)	Cobalt (Co)	Gallium (Ga)	Germanium (Ge)	Iron (Fe)	Lead (Pb)	Manganese (Mn)	Molybdenum (Mo)	Nickel (Ni)	Silver (Ag)	Strontium (Sr)	Tin (Sn)	Titanium (Ti)	Vanadium (V)	Zinc (Zn)	Zirconium (Zr)
Feet	Meters																								
570-590	174-180	3-30-69	28.0	4,200	110	<2	<15	140	<30	130	<8	ND	<15	4,500	20	250	3	45	<0.8	270	<8	100	12	340	<15

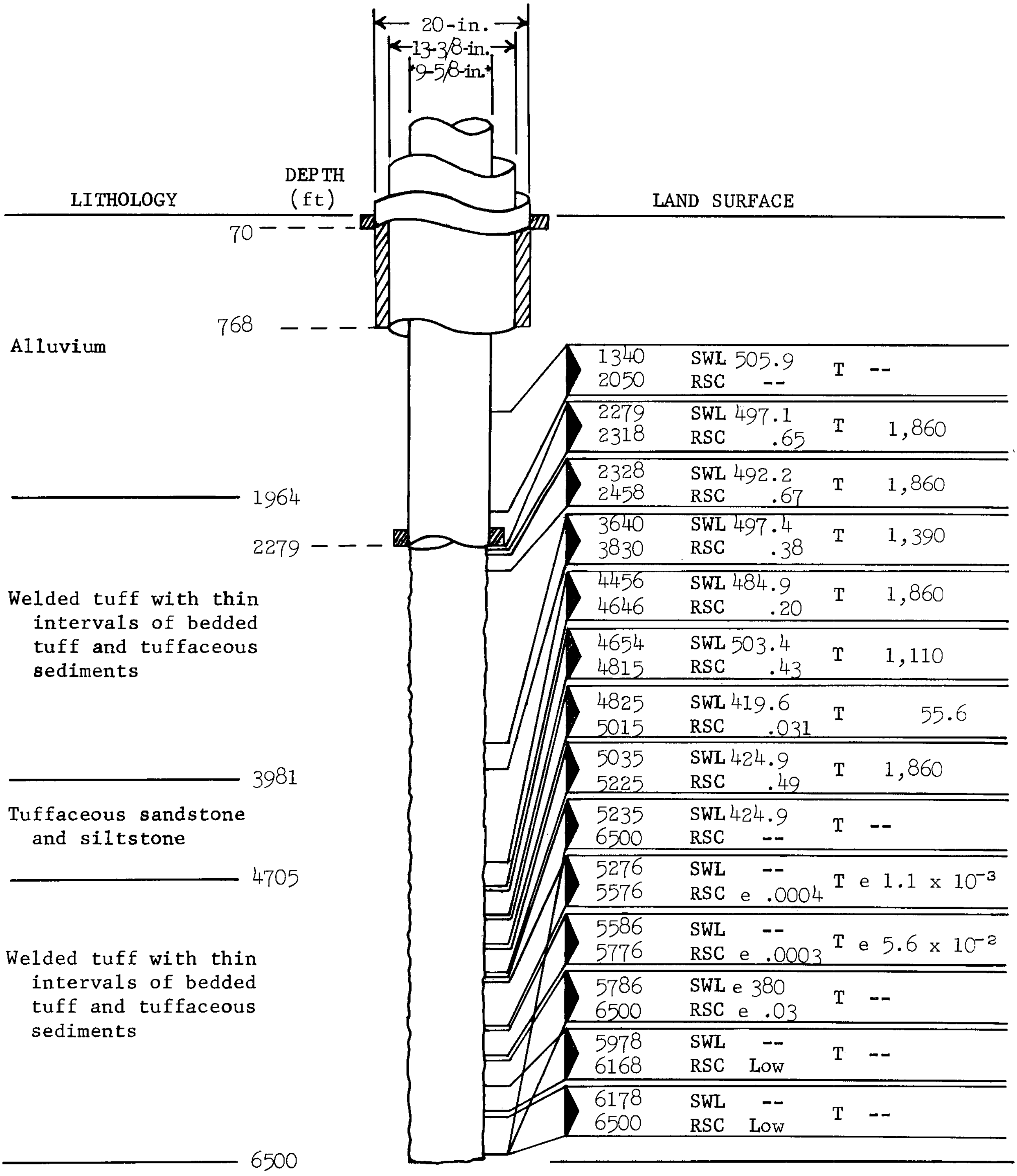
HOLE HTH-21-1

Hole HTH-21-1, at coordinates N. 1,397,250.13 ft and E. 668,505.56 ft, Nevada coordinate system, central zone, Nye County, Nevada, penetrated alluvium, welded tuff, and tuffaceous sandstone and siltstone. The land-surface elevation at this site is 5,863 ft (1,787 m) above mean sea level. A summary of hydraulic-test results is presented in table 18, analyses of water are presented in table 19, and a generalized summary of hydrology, lithology, and construction is presented in figure 13.

Tracejector Surveys

A tracejector survey run under static conditions indicated that there was inflow to the borehole from the interval 5,170 to 5,180 ft (1,576 to 1,579 m) below land surface. There was no measurable flow below this interval. However, water flowed upward from this interval and out through a permeable zone just below the casing at 2,279 ft (694.6 m) below land surface. This flow pattern under static conditions correlates well with the known hydrostatic head distribution in the vertical section and with the known zones of high permeability.

A tracejector survey under dynamic conditions during pumping of water at a rate of about 240 gpm (1,310 m^3pd) indicates that most of the pumped water came from a depth of 5,177 ft (1,578 m). This depth is within a tested interval that had one of the greatest measured heads and was also one of the most permeable.



SWL Static water level, ft below lsd.
RSC Relative specific capacity, gpm per ft of drawdown.
T Transmissivity, gpd per ft.
e Estimated.

Figure 13.--Hydrology and lithology in hole HTH-21-1, Little Smoky Valley, Nevada.

Table 18.--Summary of hydraulic testing in hole HTH-21-1, Little Smoky Valley, Nevada

Test	Interval tested: ft below lsd	Interval tested: m below lsd	Static water level: ft below lsd	Static water level: m below lsd	Relative specific capacity: gpm per ft of dd	Relative specific capacity: m^3pd per m of dd	Water swabbed: gal	Water swabbed: m^3	Specific conductance (micromhos per cm at 25°C)	Temperature: °F	Temperature: °C	Packer bypass[1]	Storage coefficient	Transmissivity: gpd per ft	Transmissivity: m^3pd per m	Hydraulic conductivity: gpd per ft^2	Hydraulic conductivity: m^3pd per m^2	Velocity[2]: ft pd	Velocity[2]: m pd	Rock type
14[3]	1,340-2,050	408.4-624.8	505.9	154.2	--	--	17,000	64.3	370	93	34	No / No	--	--	--	--	--	--	--	Alluvium
12	2,279-2,318	694.6-706.5	497.1	151.5	0.65	12	--	--	--	--	--	No / No	--	$1.86x10^3$	23.1	47.5	1.94	0.190	0.058	Welded tuff
13	2,328-2,458	709.6-749.2	492.2	150.0	.67	12	--	--	--	--	--	No / No	--	$1.86x10^3$	23.1	14.2	.58	.056	.017	Do.
9	3,640-3,830	1,109-1,167	497.4	151.6	.38	6.8	--	--	--	--	--	No / No	--	$1.39x10^3$	17.3	7.4	.30	.030	.009	Do.
8	4,456-4,646	1,358-1,416	484.9	147.8	.20	3.6	--	--	--	--	--	No / No	--	$1.86x10^3$	23.1	9.8	.40	.039	.012	Tuffaceous sediment
10	4,654-4,815	1,418-1,468	503.4	153.4	.43	7.7	--	--	--	--	--	No / No	--	$1.11x10^3$	13.8	6.9	.28	.026	.008	Welded tuff
7	4,825-5,015	1,471-1,528	419.6	127.9	.031	.55	--	--	--	--	--	No / No	$3 x10^{-7}$	55.6	.69	.29	.012	.0013	.0004	Do.
5[4]	5,035-5,225	1,535-1,593	424.9	129.5	.49	8.8	1,000	3.8	490	97	36	No / No	--	$1.86x10^3$	23.1	9.8	.40	.039	.012	Do.
6	5,235-6,500	1,596-1,981	424.9	129.5	--	--	--	--	--	--	--	No / No	--	--	--	--	--	--	--	Do.
11	5,276-5,576	1,608-1,699	--	--	e .0004	e .007	--	--	--	--	--	No / No	--	$e1.1x10^{-3}$	$e1.4x10^{-5}$	$e3.7x10^{-6}$	$e1.5x10^{-7}$	$e1.5x10^{-8}$	$e4.5x10^{-9}$	Do.
3	5,586-5,776	1,703-1,760	--	--	e .0003	e .006	--	--	--	--	--	No / No	--	$e5.6x10^{-2}$	$e6.9x10^{-4}$	$e2.9x10^{-4}$	$e1.2x10^{-5}$	$e1.2x10^{-6}$	$e3.6x10^{-7}$	Do.
4	5,786-6,500	1,763-1,981	e380	e115	e .03	e .5	--	--	--	--	--	No / Yes	--	--	--	--	--	--	--	Do.
1	5,978-6,168	1,822-1,880	--	--	Low[5]	Low[5]	--	--	--	--	--	No / No	--	--	--	--	--	--	--	Do.
2	6,178-6,500	1,883-1,981	--	--	Low[5]	Low[5]	--	--	--	--	--	No / Yes	--	--	--	--	--	--	--	Do.

[1] Upper: fluid bypass around top packer; lower: fluid bypass around bottom packer.
[2] Velocity calculated as if entire straddled interval contributed evenly.
[3] Tested for static water level through perforated casing above bridge plug.
[4] Sampled for chemical analysis.
[5] Low: time-interval measurement of water-level change too small to measure accurately.

NOTE: Composite water level = 497.3 ft (151.56 m) below lsd.

Well pumped at 250 gpm (1,360 m^3pd) for 50 hours (3,000 minutes) with 18.4 ft (5.6 m) of drawdown. Specific capacity = 13.6 gpm per ft (243 m^3pd per m). Open hole from 2,279 to 6,500 ft (694.6 to 1,981 m).

Explanation:

- ft - feet
- lsd - land-surface datum
- m - meters
- gpm - gallons per minute
- dd - drawdown
- m^3pd - cubic meters per day
- gal - gallons
- cm - centimeters
- °F - degrees Fahrenheit
- °C - degrees Celsius
- gpd - gallons per day
- ft^2 - square feet
- m^2 - square meters
- ft pd - feet per day
- mpd - meters per day
- e - estimated

Table 19.--Analyses of water from hole HTH-21-1, Little Smoky Valley, Nevada

Interval: That part of the test hole that was open to the aquifer. Aquifer: Tv (Volcanic rocks of Tertiary age).
Temperature: Thermometers used were accurate to ±0.5°C.

Chemical analyses

(In milligrams per liter. <, less than)

Interval		Date of sample collection	Temperature (°C)	Silica (SiO_2)	Aluminum (Al)	Iron (Fe)	Manganese (Mn)	Magnesium (Mg)	Calcium (Ca)	Strontium (Sr)	Lithium (Li)	Sodium (Na)	Potassium (K)	Copper (Cu)	Selenium (Se)	Zinc (Zn)	Carbonate (CO_3)	Bicarbonate (HCO_3)	Fluoride (F)	Chloride (Cl)	Sulfate (SO_4)	Nitrate (NO_3)	Phosphate (PO_4)	Boron (B)	Hardness as $CaCO_3$		Dissolved solids (residue at 180°C)	Specific conductance (micromhos/cm at 25°C)	pH	Percent sodium	Sodium adsorption ratio	Aquifer
Feet	Meters																								Calcium, magnesium	Noncarbonate						
2,279-6,500	694.6-1,981	8-22-68	56.0	47	1.7	0.50	0.03	0.2	3.6	0.02	0.05	197	5.8	<0.01	0.01	<0.01	6	396	12	21	35	0.7	0.06	0.57	10	0	587	773	8.4	96	27	Tv
2,279-6,500	694.6-1,981	8-27-68	36.0	44	<.1	.46	.04	.4	3.4	.04	.06	204	1.6	.02	.08	.08	9	554	18	25	37	.4	.08	.57	10	0	707	1,020	8.3	98	36	Tv
5,035-5,225	1,535- 1,593	9- 8-68	34.0	66	<.1	.20	.02	.8	14	.16	.04	57	12	.02	--	.01	0	162	1.4	7.7	22	5.7	.01	--	39	0	331	338	7.7	69	4.0	Tv

Spectrographic analyses

(In micrograms per liter. <, less than. ND, sought but not detected)

Interval		Date of sample collection	Temperature (°C)	Aluminum (Al)	Barium (Ba)	Beryllium (Be)	Bismuth (Bi)	Boron (B)	Cadmium (Cd)	Chromium (Cr)	Cobalt (Co)	Gallium (Ga)	Germanium (Ge)	Iron (Fe)	Lead (Pb)	Manganese (Mn)	Molybdenum (Mo)	Nickel (Ni)	Silver (Ag)	Strontium (Sr)	Tin (Sn)	Titanium (Ti)	Vanadium (V)	Zinc (Zn)	Zirconium (Zr)
Feet	Meters																								
2,279-6,500	694.6-1,981	8-22-68	56.0	2,800	12	<0.5	<7	370	<50	<50	<9	--	<9	820	<9	35	25	<9	<0.5	35	<9	15	13	<45	--
2,279-6,500	694.6-1,981	8-27-68	36.0	120	12	<.6	<9	510	<60	<11	<11	--	<11	270	40	25	30	<11	<.6	65	<11	<4	<11	<55	--
5,035-5,225	1,535- 1,593	9- 8-68	34.0	960	24	<.3	<4	250	ND	15	<5	--	<5	1,800	6	75	5	15	<.3	150	<5	10	17	<25	--

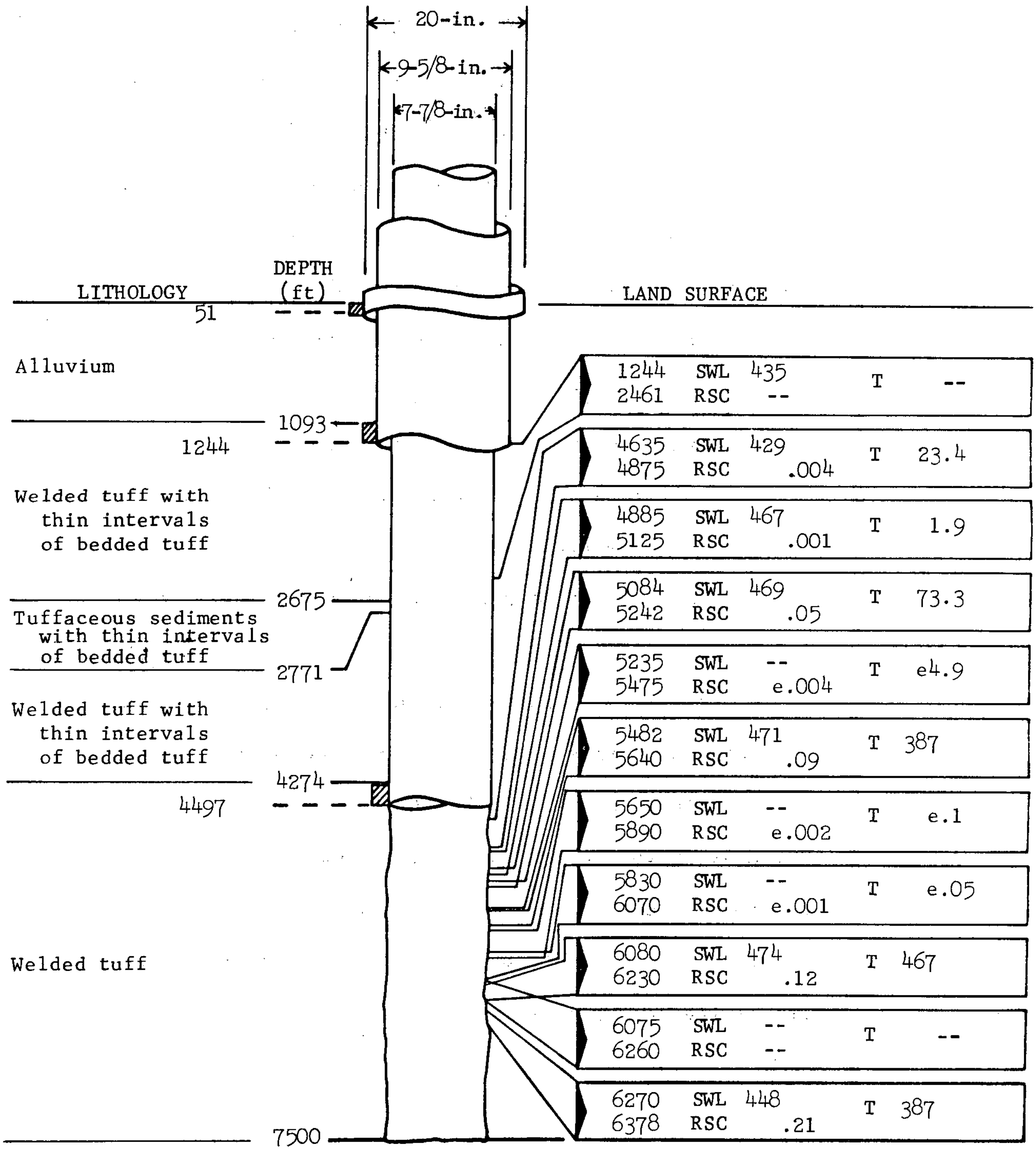
HOLE HTH-23

Hole HTH-23, at coordinates N. 1,368,087.00 ft and E. 684,237.00 ft, Nevada coordinate system, central zone, Nye County, Nevada, penetrated alluvium, welded tuff, and tuffaceous sediments. The land-surface elevation at this site is 5,795 ft (1,766 m) above mean sea level. A summary of hydraulic-test results is presented in table 20, analyses of water are presented in table 21, and a generalized summary of hydrology, lithology, and construction is presented in figure 14.

Tracejector Surveys

Results of a tracejector survey run under dynamic conditions while jetting water at a rate of about 27 gpm (150 m^3 pd) from an interval of open hole from 1,243 ft (378.8 m) to 2,461 ft (750.1 m) indicate that most of the jetted water came from somewhere below 2,337 ft (712.3 m).

Results of a tracejector survey run under dynamic conditions while pumping water at a rate of about 90 gpm (490 m^3 pd) from an interval of open hole from 4,520 ft (1,378 m) to 6,378 ft (1,944 m) indicate that most of the pumped water came from a depth of 6,136 ft (1,870 m) and that some of the water came from a depth of about 6,220 ft (1,896 m). These contributing zones are within an interval which was one of the most permeable of those tested.



▨ - Cement.
SWL - Static water level, ft below lsd.
RSC - Relative specific capacity, gpm per ft of drawdown.
T - Transmissivity, gpd per ft.
e - Estimated.

Figure 14.--Hydrology and lithology in hole HTH-23, Little Smoky Valley, Nevada.

Table 20.--Summary of hydraulic testing in hole HTH-23, Little Smoky Valley, Nevada

Test	Interval tested		Static water level		Relative specific capacity		Packer bypass[1] (upper / lower)	Storage coefficient	Transmissivity		Hydraulic conductivity		Velocity[2]		Rock type
	ft below lsd	m below lsd	ft below lsd	m below lsd	gpm per ft of dd	m^3 pd per m of dd			gpd per ft	m^3 pd per m	gpd per ft^2	m^3 pd per m^2	ft pd	m pd	
1	1,244-2,461	379.2- 750.1	435	132.5	--	--	-- / --	--	--	--	--	--	--	--	Welded tuff
6	4,635-4,875	1,413 -1,486	429	130.7	0.004	0.07	(?) / No	--	23	$2.9x10^{-1}$	$9.8x10^{-2}$	$4.0x10^{-3}$	$3.9x10^{-4}$	$1.2x10^{-4}$	Do.
5	4,885-5,125	1,489 -1,562	467	142.3	.001	.02	(?) / No	--	1.9	$2.4x10^{-2}$	$8.1x10^{-3}$	$3.3x10^{-4}$	$3.2x10^{-5}$	$9.9x10^{-6}$	Do.
7	5,084-5,242	1,550 -1,598	469	142.8	.05	.89	No / No	$1.1x10^{-6}$	73	$9.1x10^{-1}$	$4.7x10^{-1}$	$1.9x10^{-2}$	$1.9x10^{-3}$	$5.7x10^{-4}$	Do.
4	5,235-5,475	1,596 -1,669	--	--	e .004	e .07	(?) / No	$6.3x10^{-7}$	e 4.9	e$6.1x10^{-2}$	e$2.0x10^{-2}$	e$8.3x10^{-4}$	e$8.2x10^{-5}$	e$2.5x10^{-5}$	Do.
8	5,482-5,640	1,671 -1,719	471	143.6	.09	1.6	No / No	--	390	4.8	2.4	$1.0x10^{-1}$	$9.8x10^{-3}$	$3.0x10^{-3}$	Do.
9	5,650-5,890	1,722 -1,795	--	--	e .002	e .04	(?) / (?)	$7.0x10^{-3}$	e .1	e$1.0x10^{-3}$	e$3.4x10^{-4}$	e$1.4x10^{-5}$	e$1.3x10^{-6}$	e$4.0x10^{-7}$	Do.
3	5,830-6,070	1,777 -1,850	--	--	e .001	e .02	(?) / (?)	$1.3x10^{-2}$	e .05	e$6.2x10^{-4}$	e$2.1x10^{-4}$	e$8.4x10^{-6}$	e$8.2x10^{-7}$	$2.5x10^{-7}$	Do.
2	6,080-6,230	1,853 -1,899	474	144.6	.12	2.1	(?) / (?)	--	470	5.8	3.2	$1.3x10^{-1}$	$1.3x10^{-2}$	$3.9x10^{-3}$	Do.
11	6,075-6,260	1,852 -1,908	448	136.6	--	--	No / Yes	--	--	--	--	--	--	--	Do.
10	6,270-6,378	1,911 -1,944	448	136.6	.21	3.8	No / No	--	390	4.8	3.7	$1.5x10^{-1}$	$1.5x10^{-2}$	$4.5x10^{-3}$	Do.

[1]/ Upper: fluid bypass around top packer; lower: fluid bypass around bottom packer.

[2]/ Velocity calculated as if entire straddled interval contributed evenly.

NOTE: Composite water level = 455.4 ft (138.8 m) below lsd.

Well pumped at about 60 gpm (330 m^3 pd) for about 25 hours (1,480 minutes) with 411.8 ft (125.5 m) of drawdown. Specific capacity = 0.15 gpm per ft (2.7 m^3 pd per m). Open hole from 4,520 to 7,500 ft (1,378 to 2,286 m).

Explanation:

ft - feet
lsd - land-surface datum
m - meters
gpm - gallons per minute
dd - drawdown
m^3 pd - cubic meters per day
gpd - gallons per day
ft^2 - square feet
m^2 - square meters
ft pd - feet per day
m pd - meters per day
e - estimated

Table 21.--Analyses of water from hole HTH-23, Little Smoky Valley, Nevada

Interval: That part of the test hole that was open to the aquifer. Aquifer: Tv (Volcanic rocks of Tertiary age).
Temperature: Thermometers used were accurate to ±0.5°C.

Chemical analyses

(In milligrams per liter. <, less than)

Interval		Date of sample collection	Temperature (°C)	Silica (SiO_2)	Aluminum (Al)	Iron (Fe)	Manganese (Mn)	Magnesium (Mg)	Calcium (Ca)	Strontium (Sr)	Lithium (Li)	Sodium (Na)	Potassium (K)	Copper (Cu)	Selenium (Se)	Zinc (Zn)	Carbonate (CO_3)	Bicarbonate (HCO_3)	Fluoride (F)	Chloride (Cl)	Sulfate (SO_4)	Nitrate (NO_3)	Phosphate (PO_4)	Boron (B)	Hardness as $CaCO_3$		Dissolved solids (residue at 180°C)	Specific conductance (micromhos/cm at 25°C)	pH	Percent sodium	Sodium adsorption ratio	Aquifer
Feet	Meters																								Calcium, magnesium	Noncarbonate						
1,244-2,461	379.2- 750.1	10- 3-68	16.0	38	1.0	0.19	0.05	2.7	26	0.30	0.03	27	5.2	<0.01	0.06	0.01	--	--	0.7	9.5	19	--	0.03	0.14	77	--	300	--	--	41	1.3	Tv
4,520-6,205	1,378 -1,891	11-22-68	16.0	37	.8	14	.80	6.3	25	.90	.10	185	8.8	.08	<.01	.18	0	379	5.4	51	48	0.3	<.01	.02	90	0	1,340	806	7.9	80	8.6	Tv
4,520-7,500	1,378 -2,286	12-18-68	32.5	32	.8	3.6	.19	1.1	8.2	.20	.07	154	3.0	.03	<.01	.04	0	324	8.6	29	34	.2	<.01	.55	25	0	495	648	7.8	92	13	Tv

Spectrographic analyses

(In micrograms per liter. <, less than. ND, sought but not detected)

Interval		Date of sample collection	Temperature (°C)	Aluminum (Al)	Barium (Ba)	Beryllium (Be)	Bismuth (Bi)	Boron (B)	Cadmium (Cd)	Chromium (Cr)	Cobalt (Co)	Gallium (Ga)	Germanium (Ge)	Iron (Fe)	Lead (Pb)	Manganese (Mn)	Molybdenum (Mo)	Nickel (Ni)	Silver (Ag)	Strontium (Sr)	Tin (Sn)	Titanium (Ti)	Vanadium (V)	Zinc (Zn)	Zirconium (Zr)
Feet	Meters																								
1,244-2,461	379.2- 750.1	10- 3-68	16.0	10	4	<0.1	<3	200	<10	<3	<3	--	<2	140	<3	45	3	1	<0.1	190	<3	0.5	10	<11	--
4,520-6,205 [1]	1,378 -1,891																								
4,520-7,500 [1]	1,378 -2,286																								

[1] Not analyzed because of precipitate in sample.

GENERALIZED FLOW SYSTEM IN HOT CREEK AND LITTLE SMOKY VALLEYS

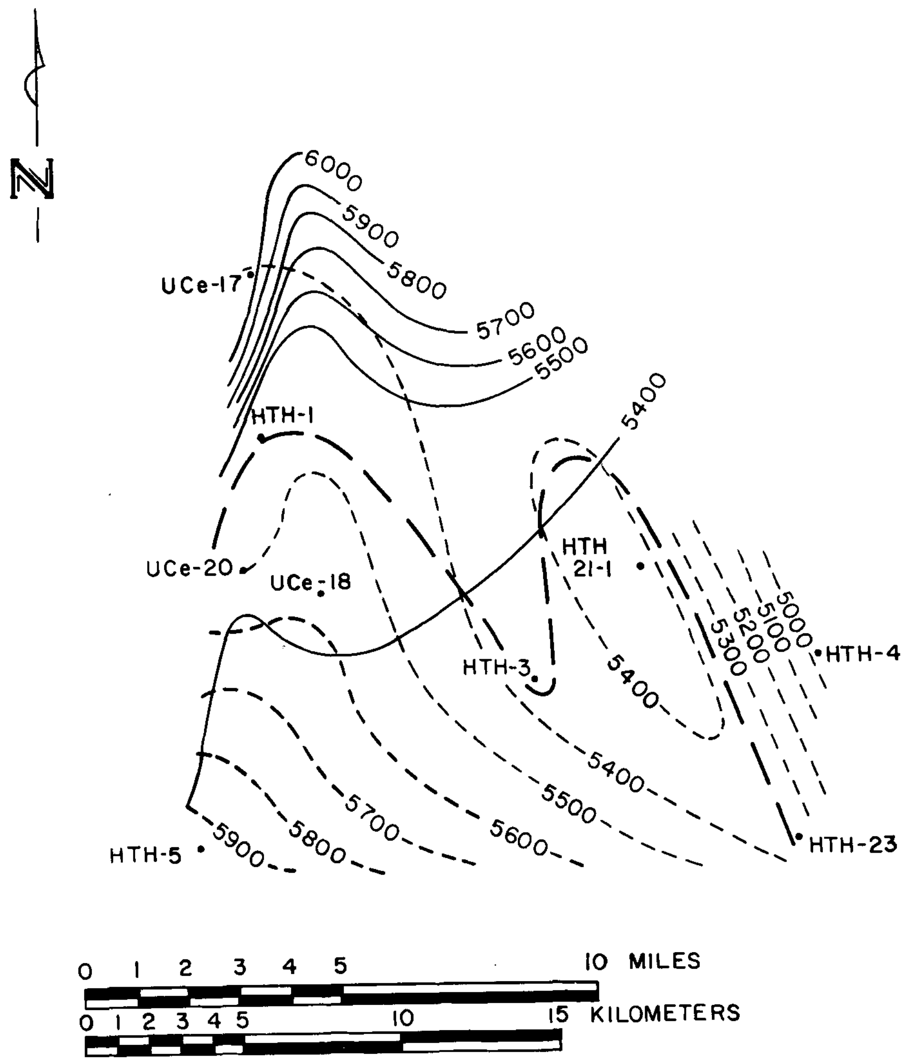
Hydrologic flow patterns can be, and frequently are, complex system. The flow system in Hot Creek and Little Smoky Valleys is no exception; it is herein discussed as a simplified, two-component system for ease of presentation and illustration. This simplification does not invalidate the basic concepts of the real, more complex flow system.

Shallow Component

The shallow potentiometric surface is, by definition, the surface indicated by the static heads that were measured near land surface in the exploratory holes. Generally, these heads were measured in isolated intervals in the upper 1,000 ft of the boreholes. The solid-line contours in figure 15 are on the shallow potentiometric surface, and they indicate that water in the shallow component of the flow system moves generally southward and southeastward. The solid-line contours in figure 16 indicate the same potentiometric surface in diagrammatic, three-dimensional view.

Deep Component

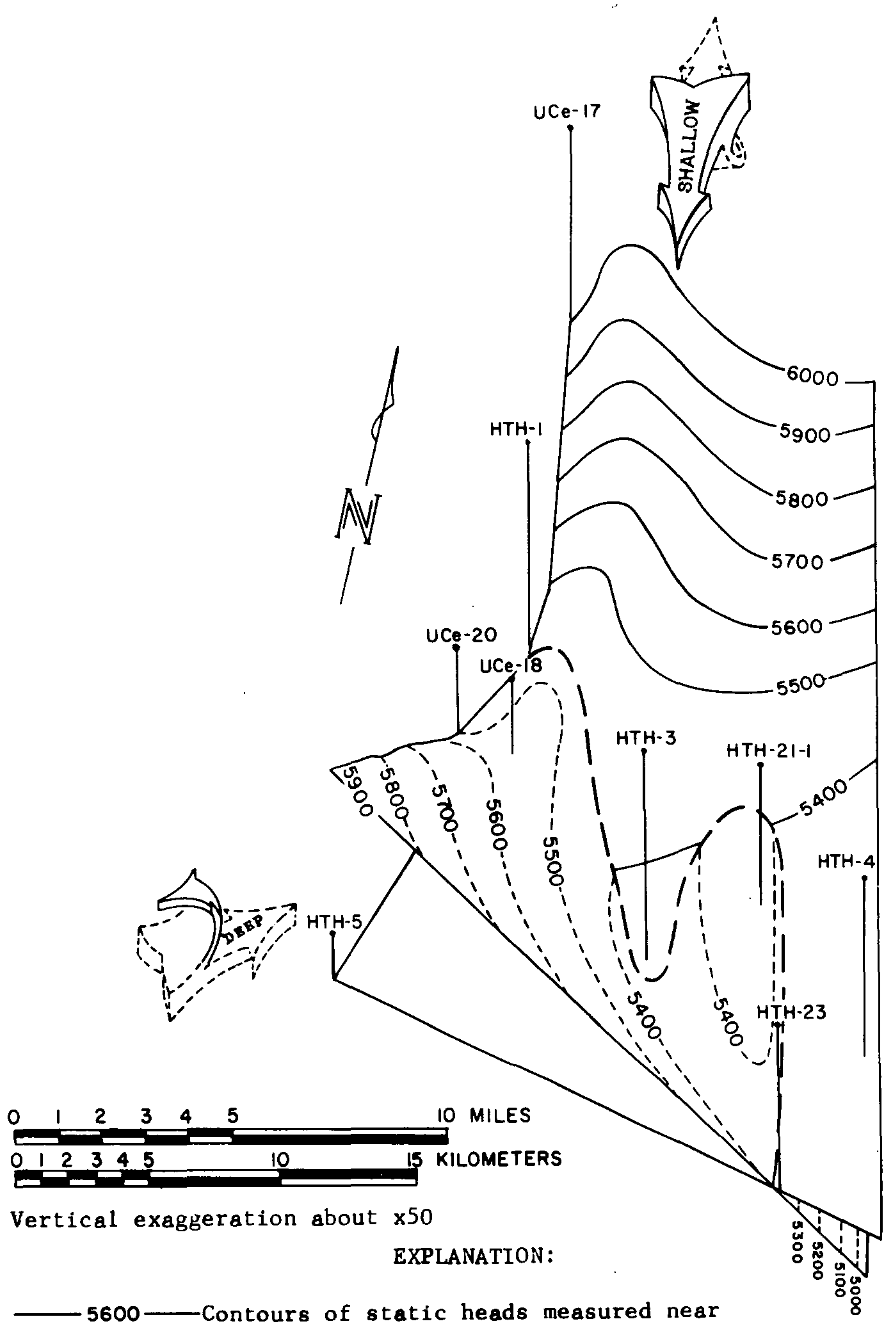
The deep potentiometric surface is, by definition, the surface indicated by static heads measured generally in isolated intervals at depths of from 5,000 to 7,000 ft in boreholes. This depth range was selected for two reasons: 1) there would be at least a



EXPLANATION:

———— 5600 ———	Contours of static heads measured near land surface (generally within 100 feet) in exploratory drill holes.
------ 5600 ---	Contours of static heads measured at depth (generally from 5000 to 7000 feet below land surface) in exploratory drill holes. Contour interval, 100 feet. Datum is mean sea level.
— — — — —	Intersection of the two contoured surfaces.
• HTH-23 • UCe-20	Exploratory drill holes and numbers.

Figure 15.--Generalized distribution of static heads in Hot Creek and Little Smoky Valleys, central Nevada.



EXPLANATION:

——5600—— Contours of static heads measured near land surface (generally within 100 feet) in exploratory drill holes.

---- 5600 --- Contours of static heads measured at depth (generally from 5000 to 7000 feet below land surface) in exploratory drill holes.

Contour interval, 100 feet.
Datum is mean sea level.

— — — — Intersection of the two contoured surfaces.

HTH-23 UCe-20 Exploratory drill holes at approximately land-surface elevation.

Figure 16.--Diagrammatic view of generalized flow system in Hot Creek and Little Smoky Valleys, central Nevada.

4,000-foot depth difference between shallow and deep measurements, and the difference in head in a borehole would be obvious and definitive; and 2) the influence of the hydraulics of the underlying carbonate rocks might be reflected in the heads measured in the volcanic rocks at these depths. The dashed-line contours in figures 15 and 16 are on the deep potentiometric surface, and they indicate that water in the deep component of the penetrated flow system moves generally northeastward and eastward toward Railroad Valley.

Recharge-Discharge Relationship

The preceding discussion and study of figures 15 and 16 reveal that the shallow potentiometric surface intersects the deep potentiometric surface. The line of intersection is indicated by the long-dash lines in figures 15 and 16. North and east of this line is an area of ground-water recharge (head decreases with depth) where ground water has the potential to move downward in the system. South and west of this line is an area of ground-water discharge (head increases with depth) where ground water has the potential to move upward in the system. This concept is indicated by the large arrows in figure 16. If ground water moves at all upward or downward in the system, the movement is very slow relative to lateral movement. This is true because lateral permeability must be significantly greater than vertical permeability in the regional hydrologic system due to the stratification in alluvium and to the many different types of flow units in the section of volcanic rocks.

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NVOO Panel of Consultants:

Joseph Lintz, Univ. Nev., Reno, Nev.
L. K. Bustad, Univ. Calif., Davis, Calif.
D. U. Deere, Univ. Ill., Urbana, Ill.
L. S. Jacobsen, 267 Belgreen Pl., Oakmont, Santa Rosa, Calif.
Carl Kisslinger, St. Louis Univ., St. Louis, Mo.
N. M. Newmark, Univ. Ill., Urbana, Ill.
Vincent Schultz, Wash. State Univ., Pullman, Wash.
T. F. Thompson, 713 Crossway Rd., Burlingame, Calif.
W. G. VanDorn, Scripps Inst. Oceanography, La Jolla, Calif.
L. G. von Lossberg, Sheppard T. Powell & Assoc., Baltimore, Md.
J. T. Wilson, Univ. Mich., Ann Arbor, Mich.
S. D. Wilson, Shannon & Wilson, Inc., Seattle, Wash.
P. A. Witherspoon, Univ. Calif., Berkeley, Calif.

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