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UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

Geohydrologic and Drill-Hole Data for Test Well USW H-1, Adjacent to Nevada Test Site, Nye County, Nevada

Open-File Report 83-141

1983

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JAMES G. WATT, Secretary

GEOLOGICAL SURVEY

Dallas L. Peck, Director

For additional information
write to:

Chief, Nuclear Hydrology Program
Water Resources Division, Central Region
U.S. Geological Survey
Box 25046, Mail Stop 416
Denver Federal Center
Lakewood, Colorado 80225

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METRIC CONVERSION TABLE

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

Metric unit	Multiply by	To obtain inch-pound unit
centimeter (cm)	3.937×10^{-1}	inch
millimeter (mm)	3.937×10^{-2}	inch
kilometer (km)	6.214×10^{-1}	mile
cubic meter (m^3)	3.531×10^{1}	cubic foot
meter (m)	3.281	foot
degree Celsius (°C)	1.8°C + 32	degree Fahrenheit
milligram per liter (mg/L)	1/ 1.0	part per million
microgram per liter (μg/L)	1/ 1.0	part per billion
liter per second (L/s)	1.585×10^{1}	gallon per minute
liter (L)	2.642×10^{-1}	gallon

1/ Approximate.

National Geodetic Vertical Datum of 1929 (NGVD)--a geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly called "Mean Sea Level"; it will be referred to as sea level in this report.

GEOHYDROLOGIC AND DRILL-HOLE DATA FOR TEST WELL USW H-1, ADJACENT TO NEVADA TEST SITE, NYE COUNTY, NEVADA

By F. E. Rush, William Thordarson, and Laura Bruckheimer

ABSTRACT

This report presents data collected to determine the hydraulic characteristics of rocks penetrated in test well USW H-1. The well is one of a series of test wells drilled in and near the southwestern part of the Nevada Test Site, Nye County, Nevada, in a program conducted on behalf of the U.S. Department of Energy. These investigations are part of the Nevada Nuclear Waste Storage Investigations to identify suitable sites for storage of high-level radioactive wastes. Data on drilling operations, lithology, borehole geophysics, hydrologic monitoring, core analysis, ground-water chemistry and pumping and injection tests for well USW H-1 are contained in this report.

INTRODUCTION

The U.S. Geological Survey has been conducting investigations at Yucca Mountain, Nevada, to evaluate the hydrologic and geologic suitability of this site for storing high-level nuclear waste in an underground mined repository. The investigations are part of the Nevada Nuclear Waste Storage Investigations being conducted on behalf of the U.S. Department of Energy, Nevada Operations Office. Test drilling has been a principal method of investigation. This report presents geohydrologic and drill-hole data from hydrologic test well USW H-1. All data tables presented were compiled by the authors except where otherwise noted.

Test well USW H-1 is located in Nye County, Nevada, approximately 140 km northwest of Las Vegas in the southern part of the State (fig. 1). It is in an easterly-draining canyon of Yucca Mountain, northwest of Jackass Flats (fig. 2). Location of the site is Nevada State Coordinate System Central Zone N 770,254 and E 562,388. Altitude of the land surface at the well site is 1,302.2 m above sea level.

DRILLING OPERATIONS

Drilling of well USW H-1 started on September 2, 1980; total depth of 1,829 m was reached on November 22, 1980. The rotary-drilling fluid was air foam consisting of air, detergent, and water. Well deviation was less than 3° from the vertical. Bit and casing data are listed in table 1. Detailed drilling history is contained in the files of the drilling contractor Fenix and Scisson, Inc., Las Vegas, Nevada.

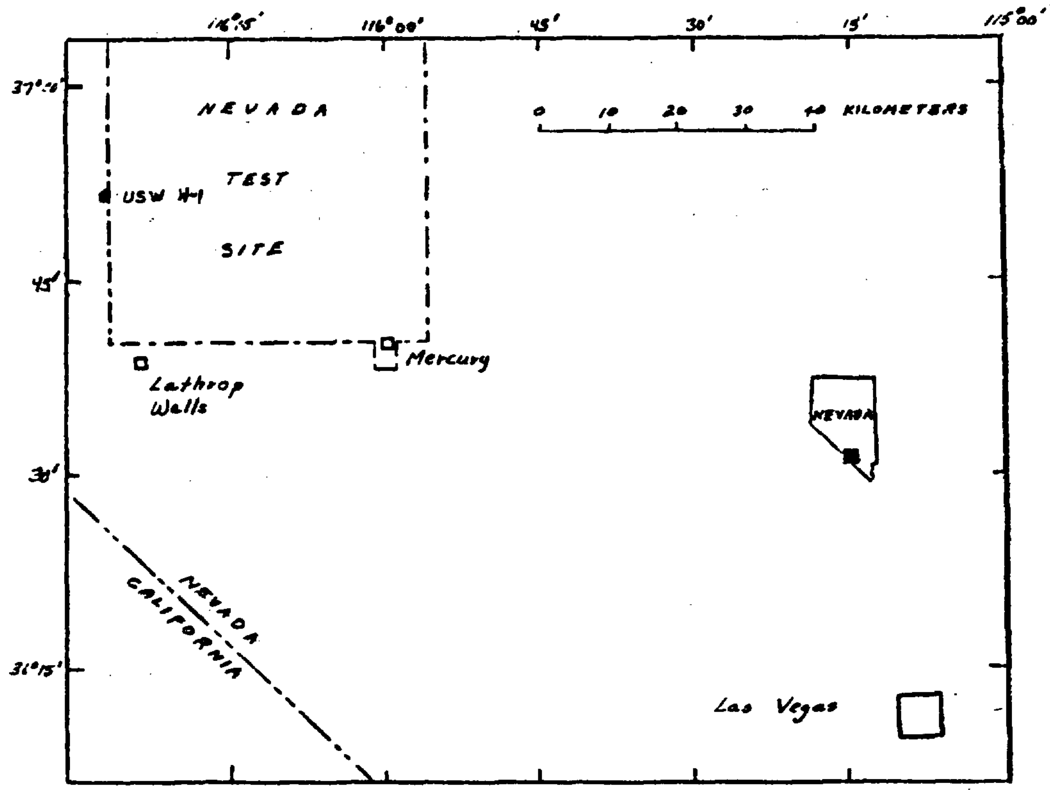

Figure 1.--Location of well USW H-1 in southern Nevada.

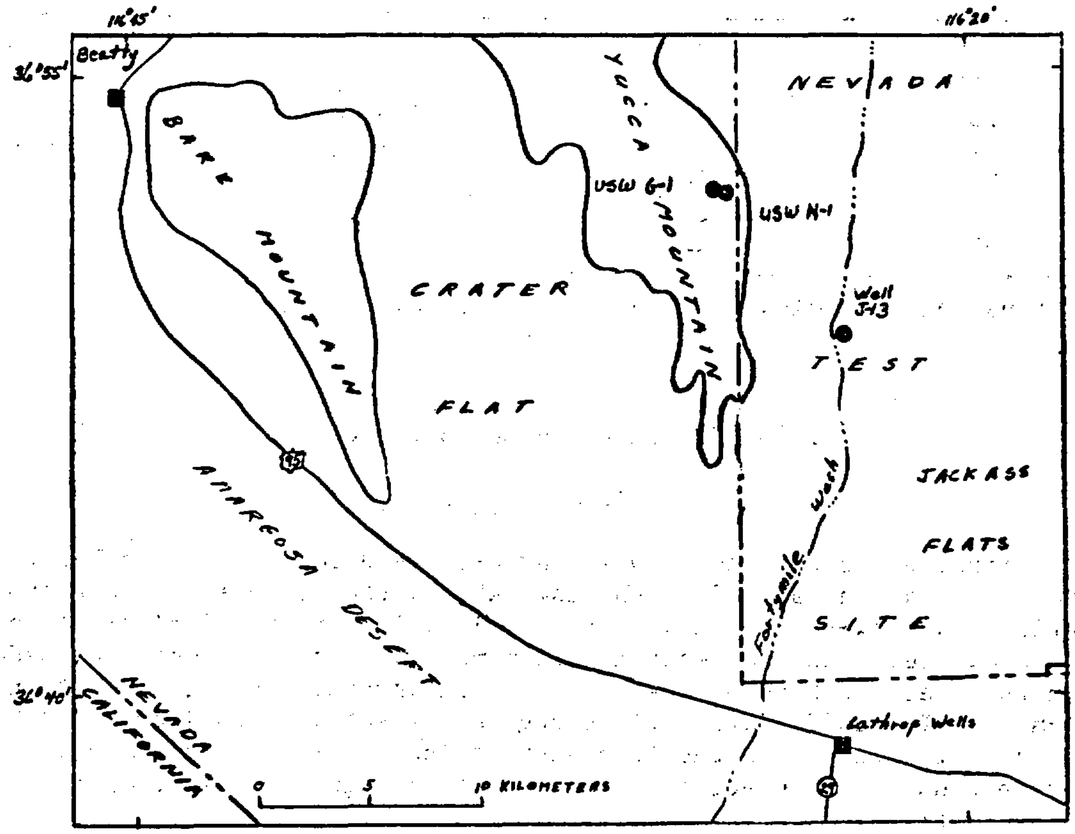

Figure 2.--Location of well USW H-1 and nearby geographic features.

Table 1.--*Bit and casing data*

Drilled interval (meters)	Bit diameter (centimeters)	Cased interval (meters)	Casing inside diameter (centimeters)
0 3	122	---	---
3 - 12	118	0 - 12	76
12 - 102	51	0 - 102	41
102 - 117	38	---	---
117 - 530	34	---	---
530 - 688	31	0 - 687	23
688 - 1,829	22	1/	---

1/ No casing set below a depth of 687 meters.

LITHOLOGIC SAMPLING AND WELL LOGGING

Lithologic Log

The lithology penetrated by well USW H-1, as determined by rock-bit cuttings and core, is shown in table 2. Ash-flow tuff is the predominant rock type in the section. A flow-breccia unit, 111 m thick, is the principal exception to the tuff sequence. Other exceptions are nine thin, poorly lithified, bedded or reworked tuffs at the base of most of the stratigraphic units, and within two of the units. The tuffs have various degrees of welding and induration, as summarized in figure 3. In the remainder of the report, shortened names of stratigraphic units are used; for the complete designation of formation and member, see table 2.

Hydrologic Properties of Core Samples

Hydrologic analyses of 48 core samples of rocks from both unsaturated and saturated zones were made. All samples were analyzed for density, matrix porosity, pore saturation, and pore-water content. Horizontal- and vertical-matrix hydraulic conductivities were measured in samples from the saturated zone. Laboratory analysis of these cores is presented in tables 3 and 4.

Geophysical Well Logs

Several types of well logs were run in well USW H-1 to obtain useful information for designing the hydraulic tests and sampling programs. The types of logs and the intervals they included are listed in table 5.

Table 2.--*Generalized lithologic log*
[Modified from Richard Spengler, U.S. Geological Survey, written commun., 1981]

Depth (meters)	Thickness (meters)	Stratigraphic unit	Lithology
0- 27	27	Paintbrush Tuff:	
		Tiva Canyon Member	Tuff, ash-flow, brown, partially welded to non-welded; pumice and glass shards.
27- 29	2		Tuff, bedded, light gray to white, vitric.
29- 49	20	Yucca Mountain Member	Tuff, ash-flow, light gray and light brown, partially welded to nonwelded, vitric; glass shards.
49- 58	9		Tuff, bedded, vitric.
58- 85	27	Pah Canyon Member	Tuff, ash-flow, pale-brown, nonwelded, vitric; pumice.
85- 454	369	Topopah Spring Member	Tuff, ash-flow, light brown and red, moderately to densely welded and devitrified; lithophysae and devitrified pumice.
454- 459	5		Tuff, bedded.
		Rhyolite lavas and tuffs of Calico Hills (undivided):	
459- 549	90	Tuffaceous beds of Calico Hills	Tuff, ash-flow, pink, nonwelded and zeolitized; pumice and volcanic lithic fragments common.
549- 566	17		Tuff, bedded, pink, slightly indurated, zeolitized.
		Crater Flat Tuff:	
566- 701	135	Prow Pass Member	Tuff, ash-flow, various colors, partially welded and devitrified; devitrified pumice throughout, mudstone lithic fragments common.

Table 2.--*Generalized lithologic log*--Continued

Depth (meters)	Thickness (meters)	Stratigraphic unit	Lithology
701- 707	6		Tuff, bedded, zeolitized.
707- 820	113	Bullfrog Member	Tuff, ash-flow, various colors, nonwelded to moderately welded, devitrified pumice and mudstone and volcanic, lithic fragments common.
820- 832	12		Tuff, bedded, zeolitized; pumice and biotite.
832-1,103	271	Tram unit	Tuff, ash-flow, upper part devitrified, lower part zeolitized mostly gray, nonwelded to partially welded, pumice and volcanic, lithic fragments throughout unit.
1,103-1,116	13		Tuff, bedded.
1,116-1,227	111	Lava flow and flow breccia:	Flow breccia; gray, devitrified, autoclastic; abundant hornblende.
1,227-1,235	8		Tuff, bedded, air-fall, moderately indurated, zeolitized.
1,235-1,500	265	Tuff of Lithic Ridge:	Tuff, ash-flow, gray and green, partially welded, zeolitized; pumice and volcanic, lithic fragments.
1,500-1,509	9		Tuff, bedded, pink, zeolitized.
1,509-1,829	320	Older tuffs:	Tuff, ash-flow, and bedded, gray, partially to moderately welded, devitrified, zeolitized; sparse rhyolitic and intermediate lithic fragments.

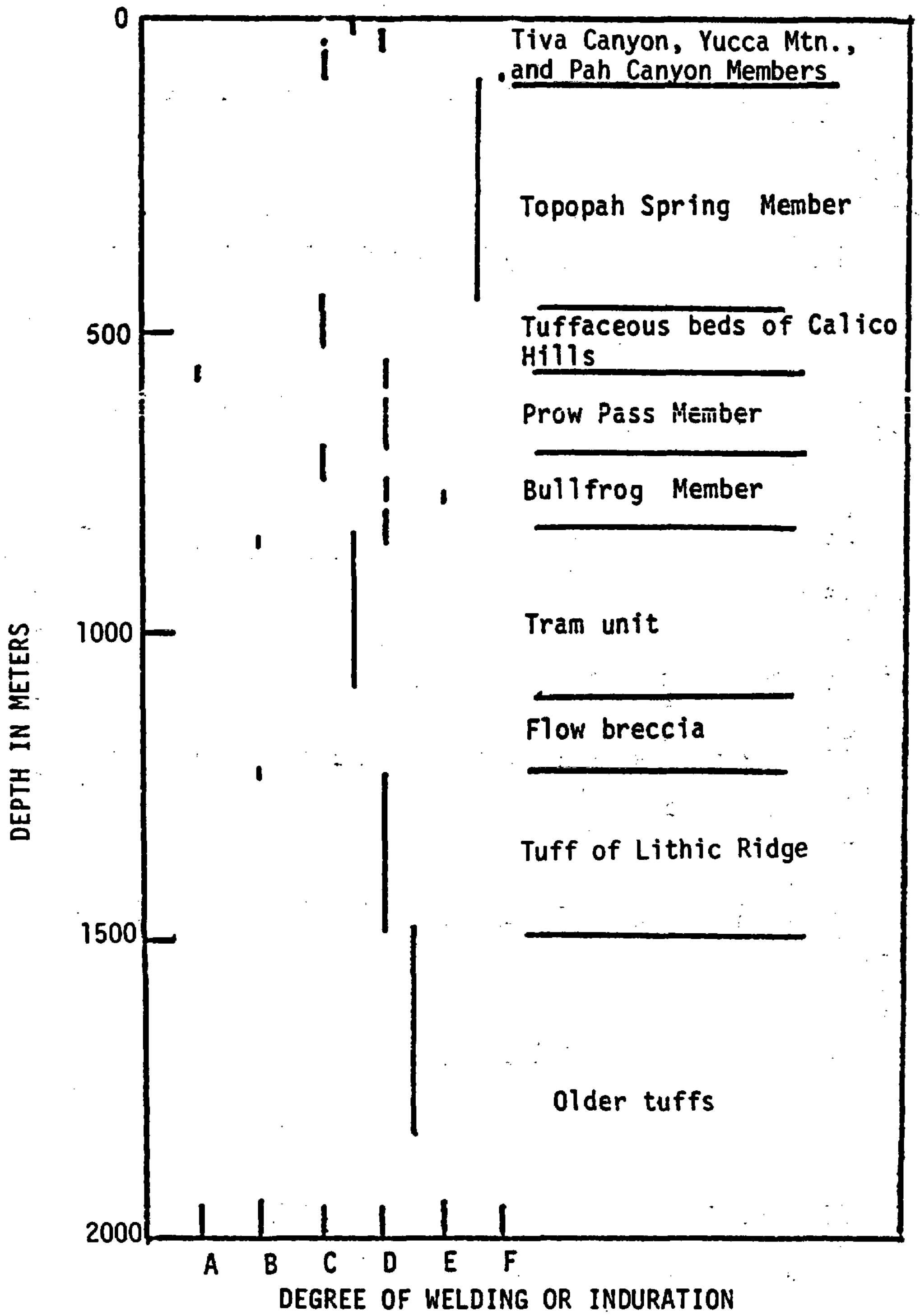

Figure 3.--Generalized distribution of welding and induration in rocks penetrated by well USW H-1. [Induration: A, slightly; B, moderately. Welding: C, nonwelded; D, partially; E, moderately; F, densely]

Table 3.--*Results of laboratory analyses of hydrologic properties of core samples from the unsaturated zone*
[Analyses by Holmes & Narrer, Inc.]

Depth (meters)	Density (grams per cubic centimeter)			Matrix porosity (percent)		Pore saturation (percent)	Natural-state pore-water content (percent)	
	Natural state	Dry bulk	Grain	From dry bulk and grain densities	From helium pychometer		weight	volume
				YUCCA MOUNTAIN MEMBER				
33.5	1.6	1.3	2.4	45	42	49	14	22
34.1	1.6	1.4	2.4	43	--	55	14	23
				PAH CANYON MEMBER				
76.9	1.4	1.3	2.4	48	--	34	11	--
				TOPOPAH SPRING MEMBER				
128	2.1	2.0	2.6	22	20	45	4.5	10
129	2.1	2.0	2.6	24	19	49	5.4	11
135	2.1	2.0	2.6	21	20	44	4.3	9.3
137	2.2	2.1	2.6	19	17	57	4.8	11
140	2.2	2.2	2.6	16	--	58	4.2	10
141	2.2	2.2	2.6	17	--	57	4.2	9.4
142	2.2	2.2	2.6	17	15	54	4.0	9.0
143	2.3	2.2	2.6	15	13	57	3.8	8.5
219	2.2	2.1	2.6	17	15	73	5.7	13
221	2.0	1.8	2.6	28	17	42	6.0	12
222	2.2	2.1	2.6	18	13	68	5.4	12
226	2.2	2.0	--	--	16	--	5.3	12
390	2.3	2.2	2.6	16	15	70	4.9	11
391	2.3	2.2	2.6	16	13	74	5.0	11
398	2.3	2.2	2.6	14	11	72	4.4	10
399	2.4	2.3	2.6	10	10	80	3.4	8.2
405	2.4	2.3	2.6	12	12	82	4.4	10
406	2.4	2.3	2.6	11	7.9	76	3.5	8.4
				TUFFACEOUS BEDS OF CALICO HILLS				
531	1.7	1.3	2.4	47	43	96	27	46
533	1.8	1.4	2.4	44	37	96	24	42

Table 4.—*Results of laboratory analyses of hydrologic properties of core samples from the saturated zone*
[Analyses by Holmes & Narrer, Inc.]

Depth (meters)	Density (grams per cubic centimeter)			Matrix porosity (percent)		Pore saturation (percent)	Natural-state pore-water content (percent)		Matrix hydraulic conductivity, K (meters per day)	
	Natural state	Dry bulk	Grain	From dry bulk and grain densities	From helium pycnometer		weight	volume	Horizontal	Vertical
					PROW PASS MEMBER					
640	2.0	1.7	2.5	33	28	97	16	32	1×10^{-4}	7×10^{-5}
641	2.0	1.7	2.5	31	29	96	15	30	7×10^{-5}	5×10^{-5}
641	2.0	1.7	2.5	32	29	95	16	31	6×10^{-5}	5×10^{-5}
					BULLFROG MEMBER					
709	2.0	1.6	2.5	33	27	92	16	31	3×10^{-5}	2×10^{-5}
709	2.0	1.6	2.5	33	32	95	16	32	3×10^{-4}	2×10^{-4}
710	1.9	1.6	2.5	38	34	92	18	35	8×10^{-4}	4×10^{-4}
713	2.3	2.1	2.6	19	20	82	6.8	15	1×10^{-4}	4×10^{-5}
764	2.1	1.9	2.6	28	—	87	11	24	1×10^{-3}	3×10^{-4}
772	2.2	2.0	2.6	25	25	94	10	23	6×10^{-4}	2×10^{-4}
790	2.3	2.1	2.6	19	19	89	7.5	17	4×10^{-5}	4×10^{-5}
791	2.3	2.1	2.6	19	20	84	6.9	16	6×10^{-5}	8×10^{-5}
792	2.2	2.1	2.6	21	22	89	8.4	19	7×10^{-5}	3×10^{-5}
830	2.1	1.8	2.6	27	25	91	12	25	4×10^{-5}	3×10^{-5}
					TRAM UNIT					
833	2.1	1.8	2.6	28	26	94	12	26	1×10^{-4}	1×10^{-4}
840	2.1	1.8	2.5	26	26	93	11	24	2×10^{-5}	8×10^{-6}
844	2.2	2.0	2.6	24	21	90	10	22	4×10^{-6}	2×10^{-6}
1,031	2.2	2.0	2.6	25	21	87	9.9	22	4×10^{-4}	5×10^{-4}
1,031	2.2	2.0	2.6	23	23	75	7.8	17	3×10^{-4}	2×10^{-4}
1,032	2.2	2.0	2.6	26	22	79	9.4	20	2×10^{-4}	3×10^{-4}
1,039	2.4	2.2	2.7	18	18	79	5.9	14	1×10^{-4}	1×10^{-4}
1,039	2.3	2.1	2.6	19	18	81	6.6	15	2×10^{-4}	7×10^{-5}
1,040	2.2	2.1	2.6	22	21	83	8.1	18	5×10^{-5}	1×10^{-5}
					FLOW BRECCIA					
1,201	2.6	2.5	2.7	7	7.3	77	2.2	5.5	8×10^{-7}	8×10^{-7}
					OLDER ASH-FLOW AND BEDDED TUFF					
1,569	2.3	2.2	2.6	16	17	50	3.6	8.2	6×10^{-5}	2×10^{-5}
1,820	2.5	2.4	2.7	10	8.8	87	3.3	8.3	3×10^{-4}	4×10^{-4}

Table 5.--*Geophysical well logs run*

Geophysical log	Depth interval (meters)	Geophysical log	Depth interval (meters)
Density	6-102	3-D Velocity	1/ 310-510
			1/ 563-687
Density, borehole-compensated	12-196		660-1,828
	91-688		671-1,827
	683-1,829		671-1,828
Neutron	253-511	Electric	67-1,829
	570-1,829		366-511
			584-688
Neutron-neutron	1/ 0-511		
	0-1,829		
Neutron, borehole-compensated	683-1,829		
		Induction	12-101
Epithermal neutron porosity	6-102		91-687
	90-688		
	101-688	Dual induction focused	102-512
Gamma ray-neutron	1/ 91-688	Fluid density for fluid location	76-102
	671-1,829		306-393
			1/ 566-578
Gamma ray	0-102		174-189
Magnetometer	104-688		189-204

Table 5.--*Geophysical well logs run*--Continued

Geophysical log	Depth interval (meters)	Geophysical log	Depth interval (meters)
Downhole seismic survey	107-685		152-167
	686-1,227		152-169
	1,227-1,821		549-565
Nuclear annulus investigation	572-686		552-582
			2/564-579
Temperature	0-688		3/522-583
	6-1,829		381-439
Caliper	0-99		351-427
			546-594
	85-688		564-576
	91-685	Radioactive-tracer survey	102-688
	671-1,829		687-1,829
Formation density	0-102	Acoustic televiewer	570-1,783
Television-camera videotape	0-570	Gyroscopic	0-1,783
		Spectral	0-1,829

1/Two logs run in this interval.

2/Five logs run in this interval.

3/Six logs run in this interval.

The acoustic televiewer log, an acoustic travel-time log, was made to record lithophysae and such linear features as fractures and bedding planes. Because the log was directionally oriented, inclined fractures and their attitude could be identified. Lineations observed in this log are shown in table 6.

Caliper logs were run to determine the open-hole diameter distribution with well depth. A summary of the hole gage is presented in table 7. Out-of-gage is defined for this report as a diameter 100 mm greater than the diameter of the bit used to drill the interval. Thick out-of-gage intervals commonly cannot be tested by inflatable packers because of the difficulty of seating packers, or because over-inflation results in packer rupture. Enlarged bore-hole zones resulting from rock fracturing also were identified from caliper logs (table 8). These are zones having irregular enlargements of a smaller diameter than the out-of-gage zones.

A television-camera videotape was made to a depth of 687 m to observe open-hole conditions. A description of the water seeps observed at various intervals is given in table 9. The source of water was not identified.

HYDROLOGIC TESTING AND WATER SAMPLING

Radioactive-Tracer Flow Surveys

Radioactive-tracer flow surveys were run to measure vertical flow in the well while water was pumped into or out of the well. The zones through which the water flowed were identified from this information. Surveys were made: (1) While the well was at a depth of 688 m; and (2) after the well had been cased to a depth of 687 m and after drilling to total depth. Results of these surveys are shown in figures 4 and 5.

Water Levels

Water-level observations and measurements in well USW H-1 were made during and after the drilling as part of hydraulic tests, for the purpose of: (1) Locating any perched-water zones above the water table; (2) identifying the depth at which ground-water saturation occurs; (3) determining the composite hydraulic head in the well; and (4) identifying hydraulic heads in various water-bearing zones. Water-level measurements are listed in table 10.

After the composite water-level measurement made on June 24, 1982, piezometers were installed in the well to measure water levels in four widely spaced intervals. Intervals were selected to obtain information on the relative position of the hydraulic head. Preliminary data from the piezometers are included in table 10.

Table 6.--*Lineations observed on acoustic-televiewer log*
[Log made in water-filled part of hole]

Stratigraphic unit	Depth below land surface (meters)	Orientation	Remarks for stratigraphic unit
Prow Pass Member	580	Dipping steeply westward	Lineations present throughout unit
	608	Dipping westward about 75°	
	635	Horizontal	
	657	Horizontal	
	676	Horizontal	
	688	Dipping westward	
Bullfrog Member	825	Horizontal	-----
	827	Horizontal	
	831	Horizontal	
Tram unit	874	Horizontal	Lineations only in upper part of unit
	877	Dipping westward about 70°	
	919	Horizontal	
Flow breccia	1,137	Dipping southeastward about 80°	Lineations only in upper part of unit
Older tuffs	1,635	Horizontal	-----
	1,636	Horizontal	
	1,665	Horizontal	

Table 7.--*Distribution of out-of-gage hole*

Stratigraphic unit	Part of unit out of gage (percent)	Location within stratigraphic unit
Tiva Canyon Member[1/]	39	In lower part of interval
Yucca Mountain Member	26	Mostly near base of unit
Pah Canyon Member	42	Throughout unit
Topopah Spring Member	16	Throughout unit
Tuffaceous beds of Calico Hills	13	Near base of unit
Prow Pass Member	19	In upper one-half of unit
Bullfrog Member	44	In upper one-half of unit
Tram unit	0.1	Near base of unit
Flow breccia	7	Near base of unit
Tuff of Lithic Ridge	2	In lower part of unit
Older tuffs	4	At mid-interval
Average for well	10	

[1/]Below a depth of 12 meters.

Table 8.--*Enlarged borehole intervals*
[Based on caliper-logs]

Stratigraphic unit	Depth interval (meters)	Interval thickness (meters)	Remarks for stratigraphic unit
Tiva Canyon Member	[1] 12-29	22	Interval continues into underlying unit
Yucca Mountain Member	29-34		Lower interval continues into underlying unit
	[2] 44-58	30	
Pah Canyon Member	58-74		Lower interval continues into underlying unit
	78-85	13	
Topopah Spring Member	85-91		
	123-139	16	
	150-327	177	
	332-406	74	
Tuffaceous beds of Calico Hills	-----	---	No intervals identified in stratigraphic unit
Prow Pass Member	-----	28	Ten zones occurring throughout unit with a combined thickness of 28 meters
Bullfrog Member	707-762	55	Interval is upper one-half of stratigraphic unit
Tram unit	-----	---	No intervals identified in stratigraphic unit
Flow breccia	1,116-1,120	4	Both intervals near top of stratigraphic unit
Tuff of Lithic Ridge	-----	---	No intervals identified in stratigraphic unit
Older tuffs	1,519-1,557	38	Enlargement may be the result of little lithification
	1,647-1,653	6	
	1,682-1,696	14	
	1,796-1,798	2	
	1,805-1,806	1	

[1] Well cased to 12 meters.

[2] Interval includes a thin interval of bedded and reworked tuff.

Table 9.--*Descriptions of water seeps above the zone of saturation, observed with a down-hole television camera*
[Well cased to 102 meters]

Depth (meters)	Description
	Topopah Spring Member
183	Rough walls; a few drops of water
261	Vertical fracture seeping water
343-344	Extensively fractured, hole enlarged; water
351-358	Fracture seeping water; hole enlarged
	Tuffaceous beds of Calico Hills
472-488	Lithic-rich tuff dripping small stream of water
488-495	Lithic-rich tuff yielding water running down side of hole
500-511	Stratiform beds dripping water
511-526	Lithic-rich tuff dripping water
526-533	Lithic-rich tuff yielding small stream of water
541-549	A few fractures; dripping water
549-566	Water on side of hole
564-566	Hole enlarged; dripping water
	Prow Pass Member
566-570	Dripping water
570	Large stream of water on side of hole

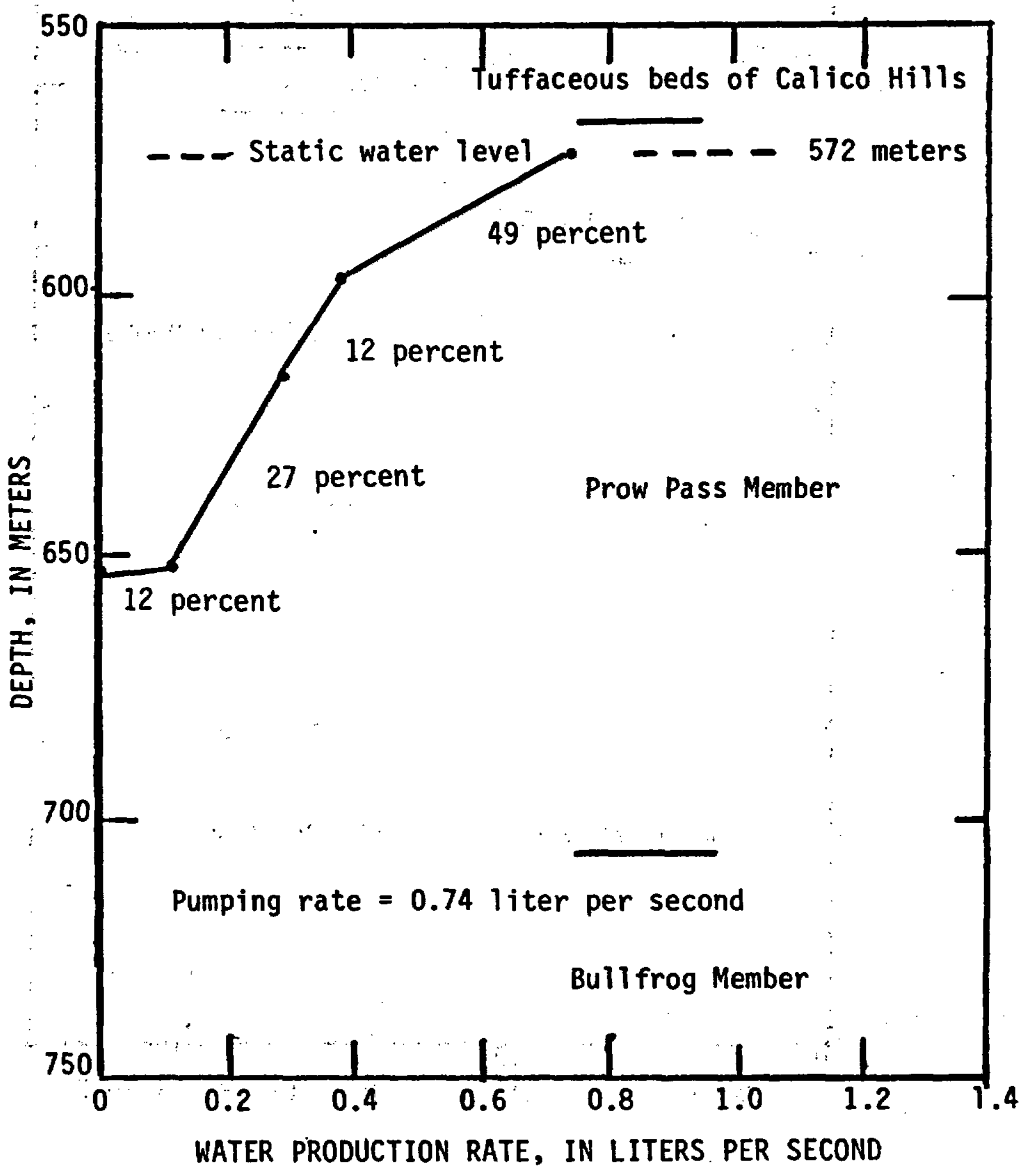

Figure 4.--Radioactive-tracer flow survey for depth interval from 572 to 688 meters, showing percent of pumping rate produced by intervals.

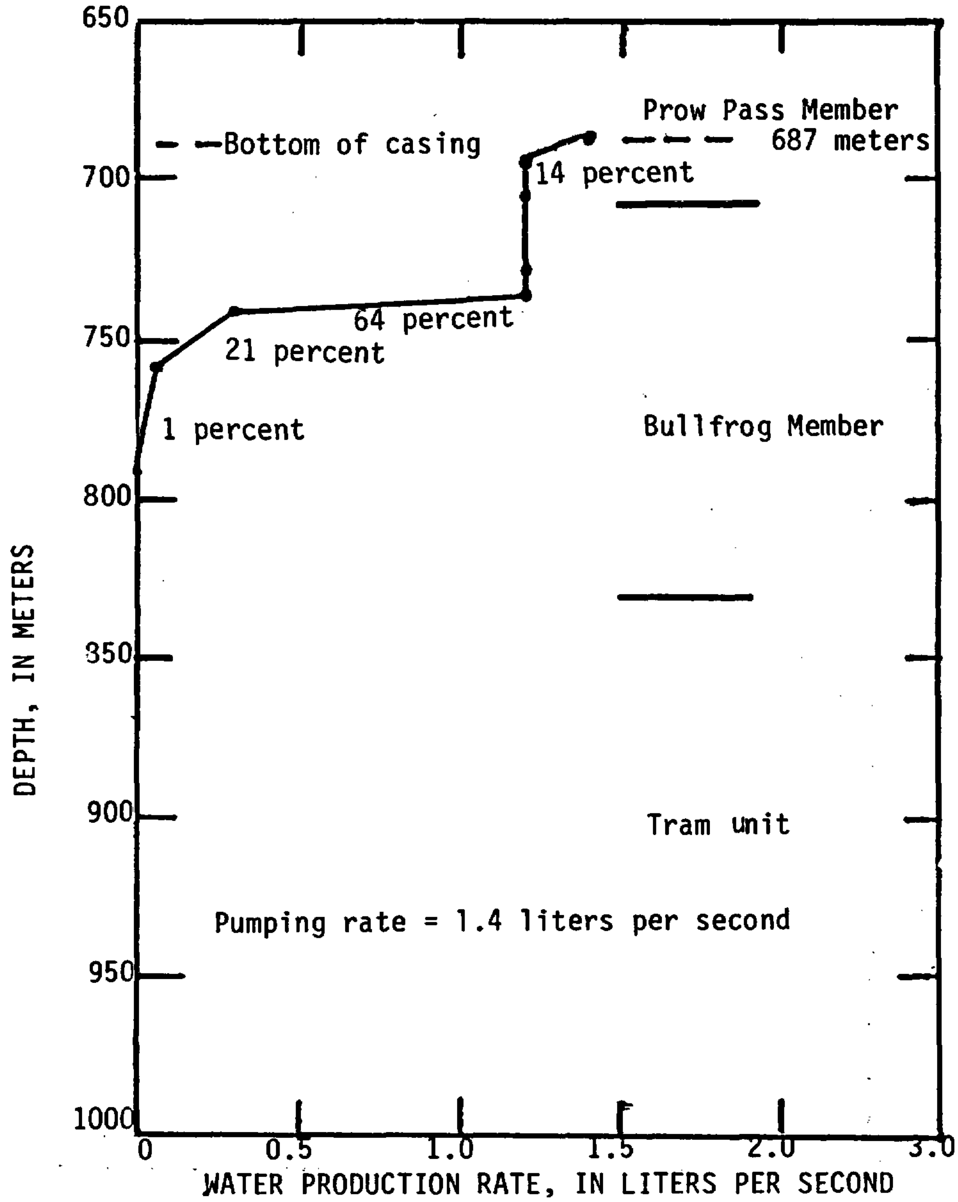

Figure 5.--Radioactive-tracer flow survey for depth interval from 687 to 1,829 meters, showing percent of pumping rate produced by intervals.

Table 10.--*Water levels*

[Altitude of land surface at well is 1,302.2 meters; water level in well accurate to ± 0.5 meter]

Date	Depth zone (meters)	Water level in well (meters)		Remarks
		Depth to water from land surface	Altitude of water surface above sea level	
10-05-80	448-458	448	854	Air lifted water at a rate of 1.3 to 1.6 liters per second for 45 minutes while the well was at a depth of 458 meters
10-07-80	--	564	738	Depth at which first water was reported by driller
10-22-80	572-688	572.3	729.9	Prow Pass Member, upper part
1-21-81	687-698	574.7	727.5	Prow Pass Member, lower part
1-21-81	687-698	574.3	727.9	Do.
2-26-81	687-1,829	572.4	729.8	-----
5-31-81	687-1,829	572.4	729.8	-----
10-09-81	687-1,829	572.0	730.2	-----
11-10-81	687-1,829	572.4	729.8	-----
12-09-81	687-1,829	572.0	730.2	-----
2-25-82	687-1,829	572.3	729.9	-----
6-24-82	687-1,829	572.0	730.2	-----
9-24-82	572-640	572.5	729.7	Piezometer
9-24-82	738-741	572.7	729.5	Piezometer
9-24-82	1,112-1,115	569.7	732.5	Water level continued to rise since installation of piezometer
9-24-82	1,803-1,806	521.4	780.8	Water level continued to rise since installation of piezometer

Drilling-Fluid Use

To minimize the invasion and plugging of fracture and matrix porosity while drilling the well, a drilling fluid of air-foam, consisting of small volumes of detergent and water and large volumes of air, was used. Approximately 14,300 L of detergent and 2,200,000 L of water were used during drilling. Variations in fluid use were recorded and are shown in figure 6. Fluid-use rate while drilling was used as an approximate index of permeability, because more permeable zones receive more infiltration and, thus, less drilling fluid, than less permeable zones. In figure 6, horizontal offsets at 400 m, 680 m, and 1,180 m correspond to periods when no drilling was in progress, rather than to fluid losses.

Pumping Tests

Drawdown and recovery tests were made in conjunction with two pumping periods: (1) At a depth of 688 m before casing was set, and (2) after the well had been cased to 687 m and drilled to a depth of 1,829 m. Pumping-test information for these intervals is presented in table 11. Data are given for one set of tests for the upper interval and two sets of tests for the lower interval. Data plots of these tests are shown in figures 7 through 12.

Drawdown-test data were plotted using drawdown versus time after start of pumping as the coordinates. Recovery-test data were plotted with residual drawdown (recovery) against time after pumping stopped as the coordinates.

Injection Tests

Injection tests were made using inflatable packers to isolate test zones. Intervals tested are shown in table 12. Data for six injection tests for the intervals between 687 and 1,829 m (total depth) are plotted in figures 13 through 18. The ratio of hydraulic head at a given time to initial hydraulic head is plotted against time since injection began.

Chemical Analyses of Water

Water samples were collected for chemical analyses near the end of pumping tests from depth intervals from 572 to 688 m and from 687 to 1,829 m. The chemical constituents found in the samples are shown in table 13. Carbon-14 determination indicates that the apparent age of the ground water is about 12,000 to 13,000 years before present.

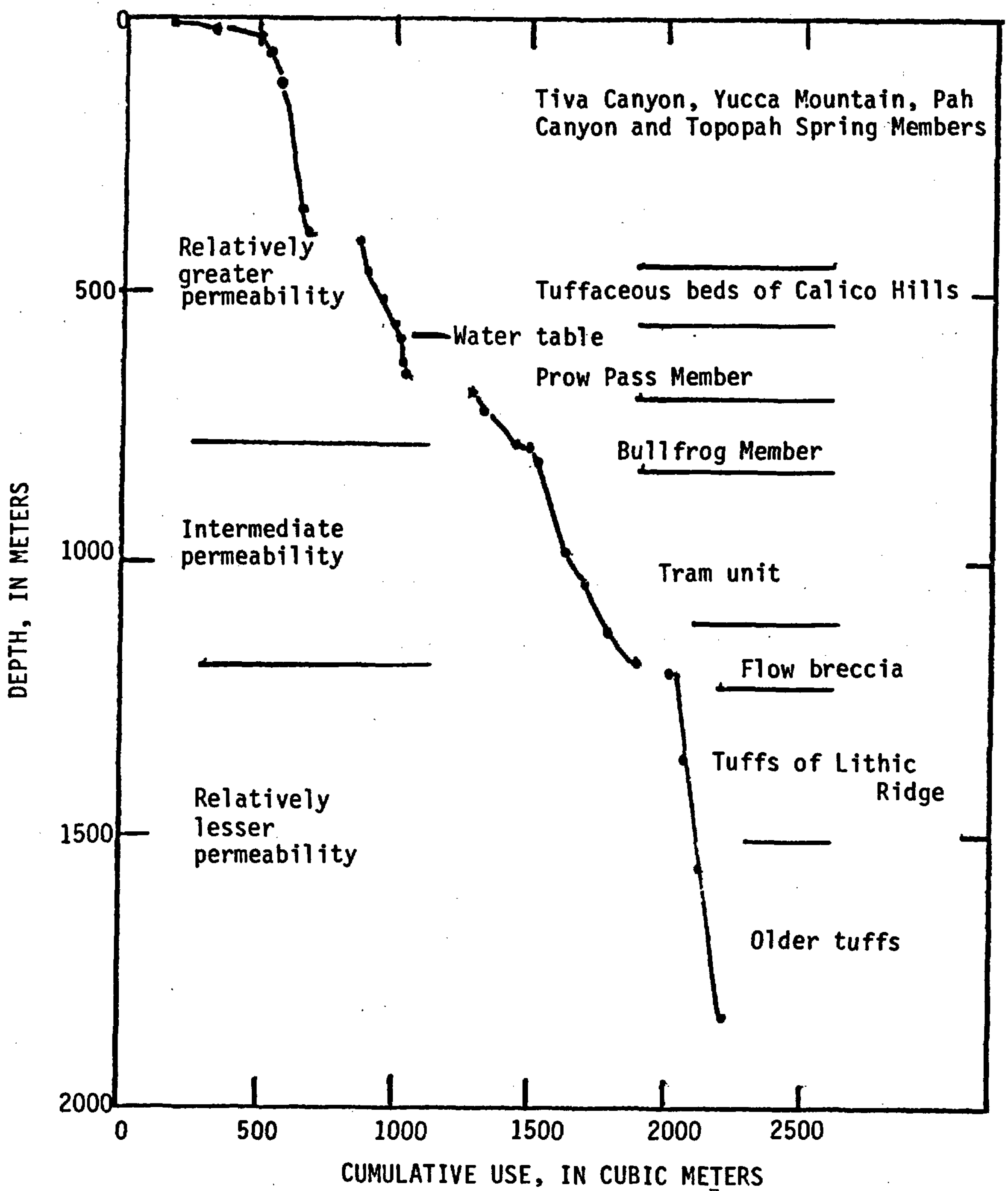

Figure 6.--Drilling-fluid use and estimates of relative permeability.

Table 11.--*Pumping-test data*

Test interval (meters)	Stratigraphic unit(s) tested	Type of test	Pumping rate, Q (liters per second)	Pumping period, t (minutes)
572-688	Prow Pass Member	Drawdown	3.4	2,880
572-688	Prow Pass Member	Recovery	1/ 3.4	1/ 2,880
687-1,829	Prow Pass Member and underlying penetrated units	Drawdown	2.3	3,383
687-1,829	do.	Recovery	1/ 2.3	1/ 3,383
687-1,829	do.	Drawdown	3.1	90
687-1,829	do.	Recovery	1/ 3.1	1/ 90

1/ For pumping prior to recovery test.

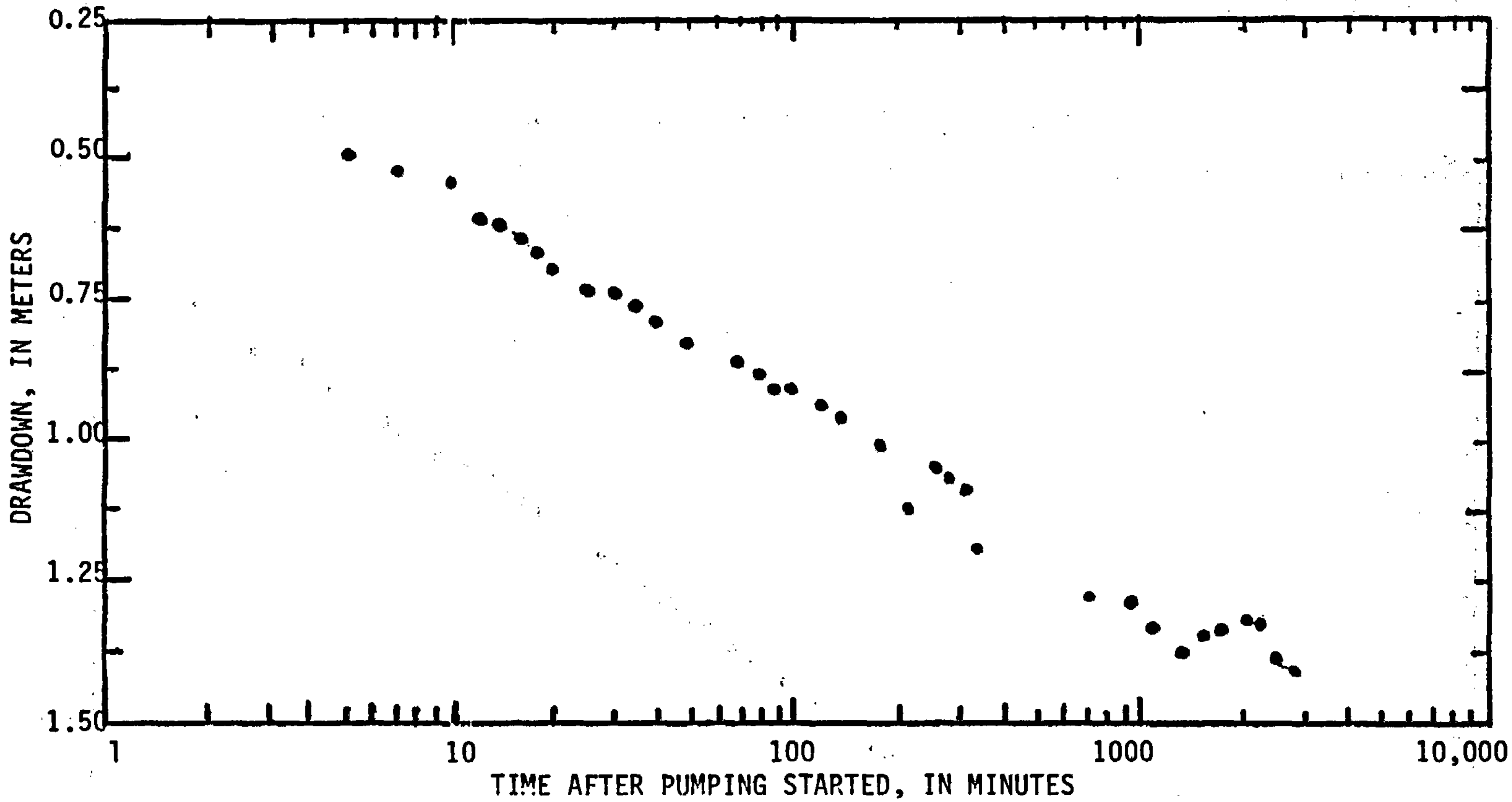

Figure 7.--Water-level drawdown, pumping test 1, depth interval from 572 to 688 meters.

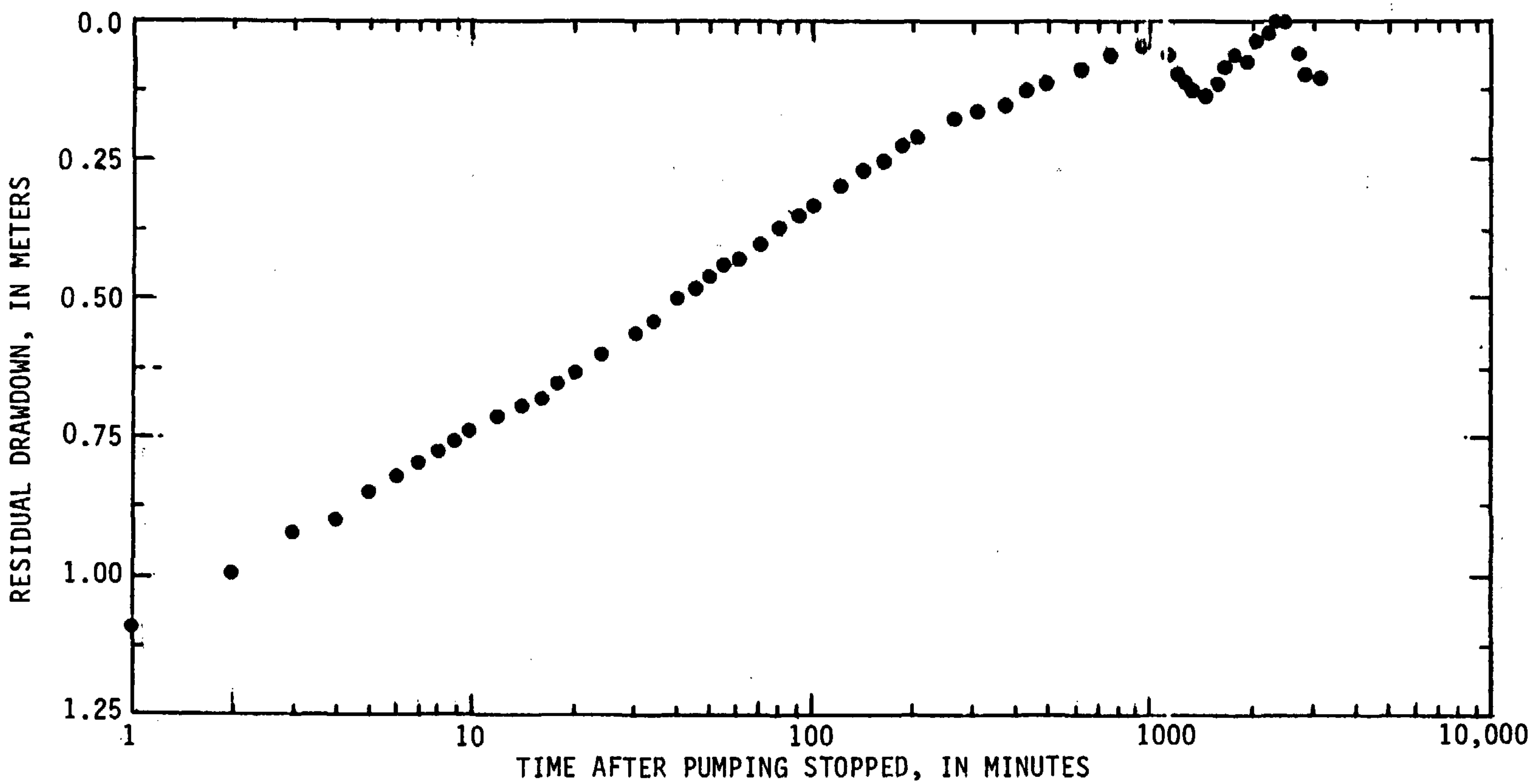

Figure 8.--Water-level recovery data, pumping test 1, depth interval from 572 to 688 meters.

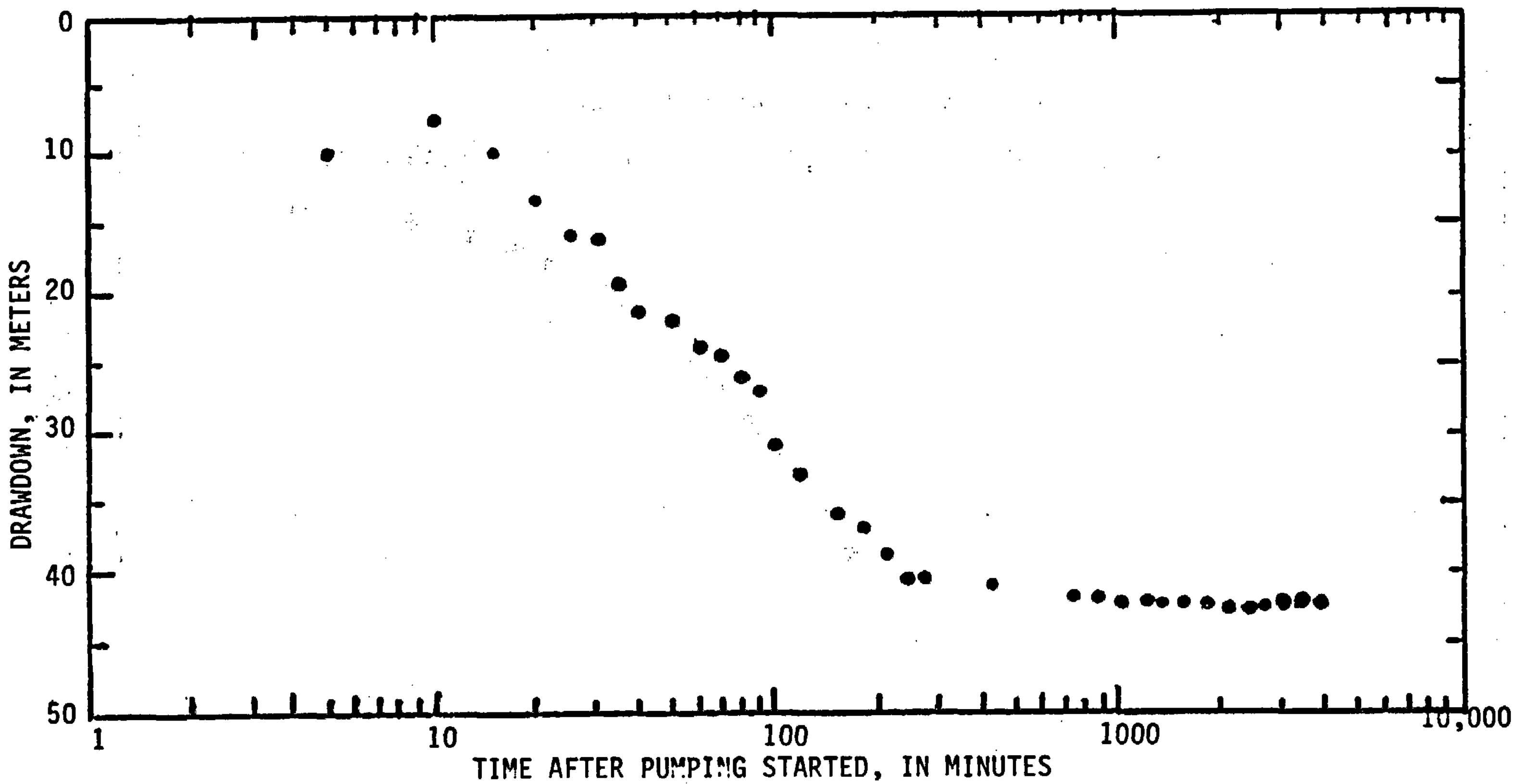

Figure 9.--Water-level drawdown data, pumping test 2, depth interval from 687 to 1,829 meters.

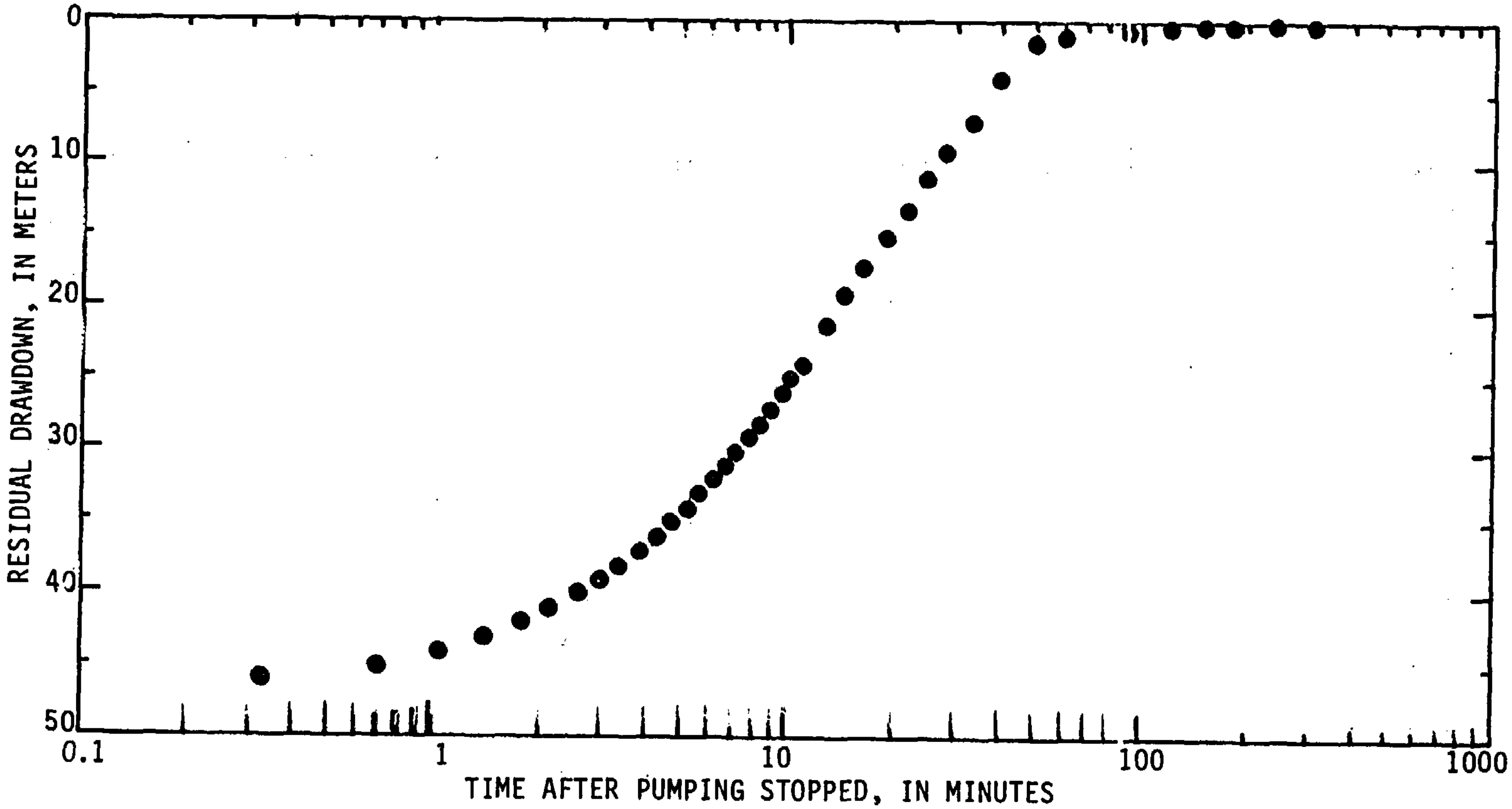

Figure 10.--Water-level recovery data, pumping test 2, depth interval from 687 to 1,829 meters.

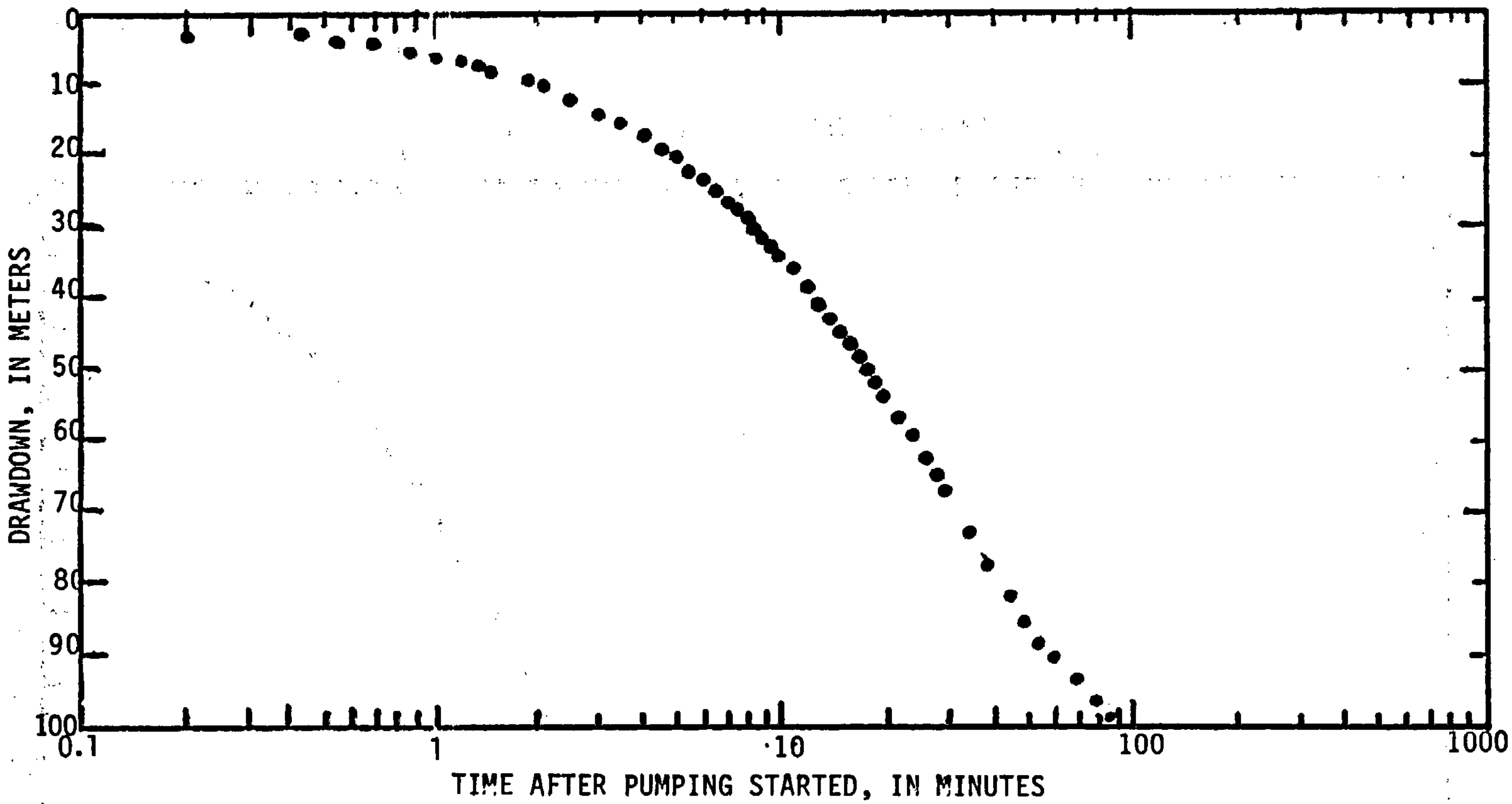

Figure 11.--Water-level drawdown data, pumping test 3, depth interval from 687 to 1,829 meters.

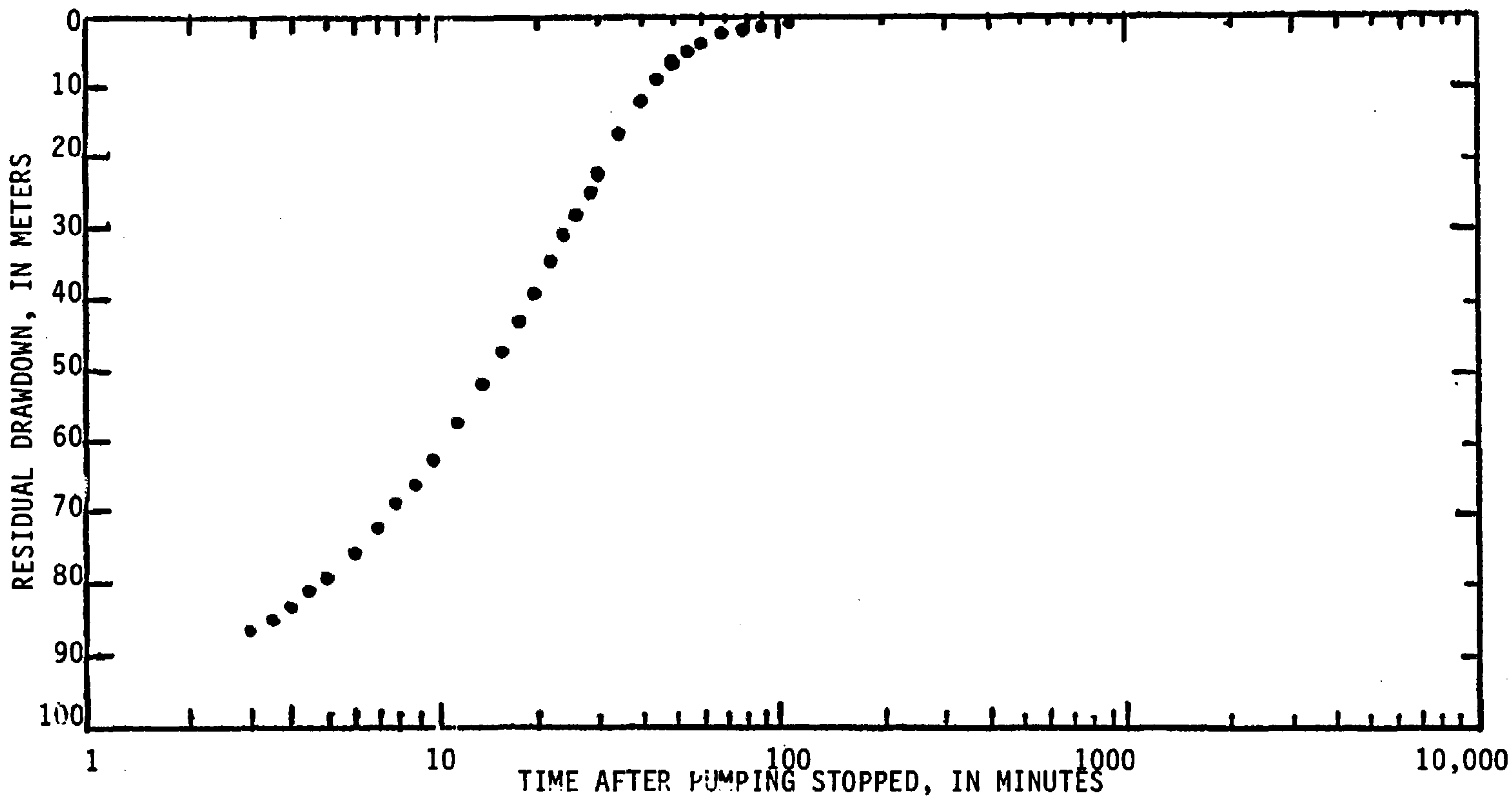

Figure 12.--Water-level recovery data, pumping test 3, depth interval from 687 to 1,829 meters.

Table 12.--*Injection-test data*

Test interval (meters)	Stratigraphic unit(s) tested	Length of injection period (minutes)
687-697	Prow Pass Member	60
811-1,829	Bullfrog Member and underlying penetrated units	910
926-1,829	Tram unit and underlying penetrated units	334
1,200-1,829	Flow breccia and underlying penetrated units	198
1,407-1,829	Tuff of Lithic Ridge and older tuffs	350
1,621-1,829	Older tuffs	273

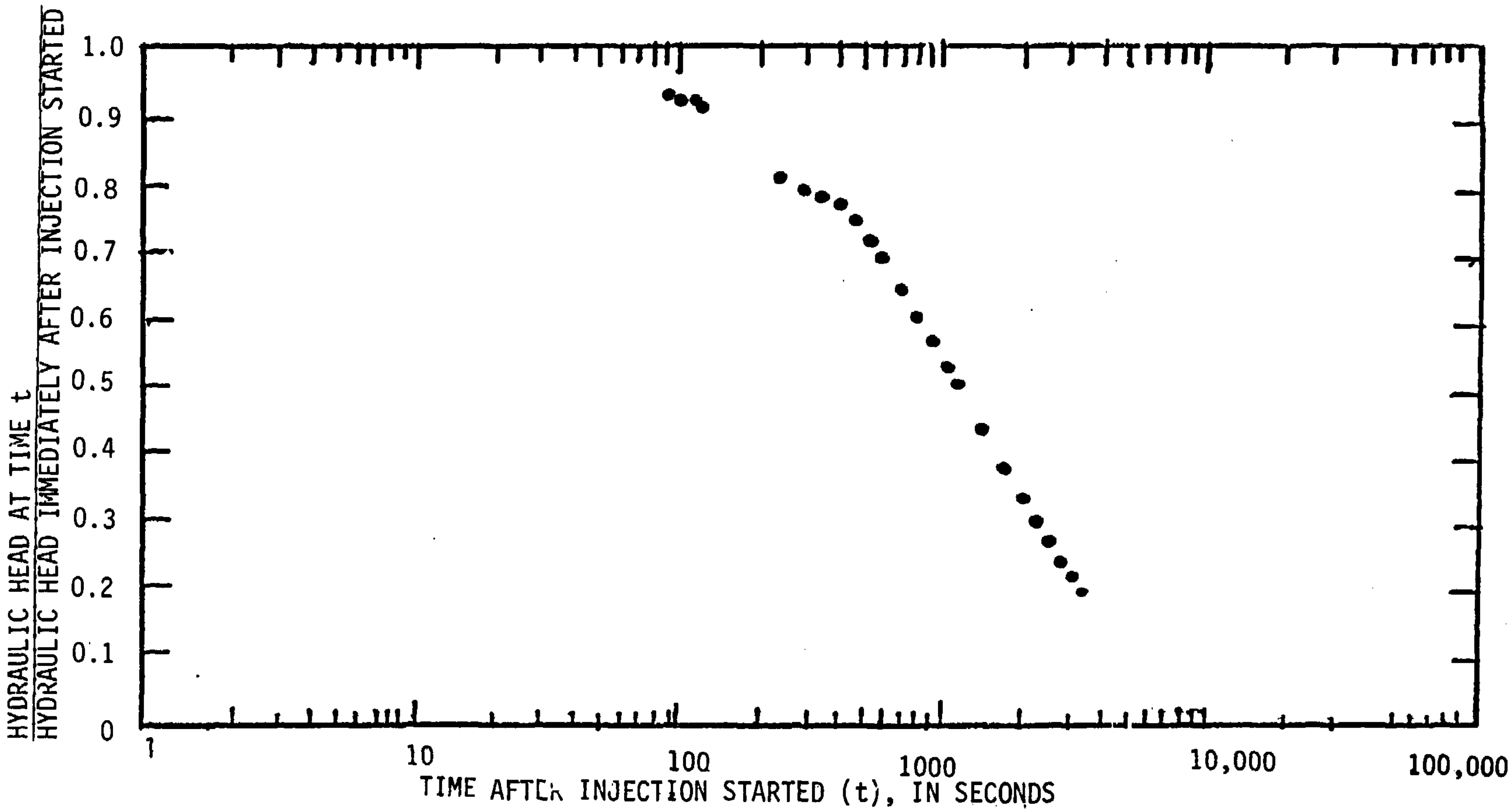

Figure 13.--Injection-test data for depth interval from 687 to 697 meters.

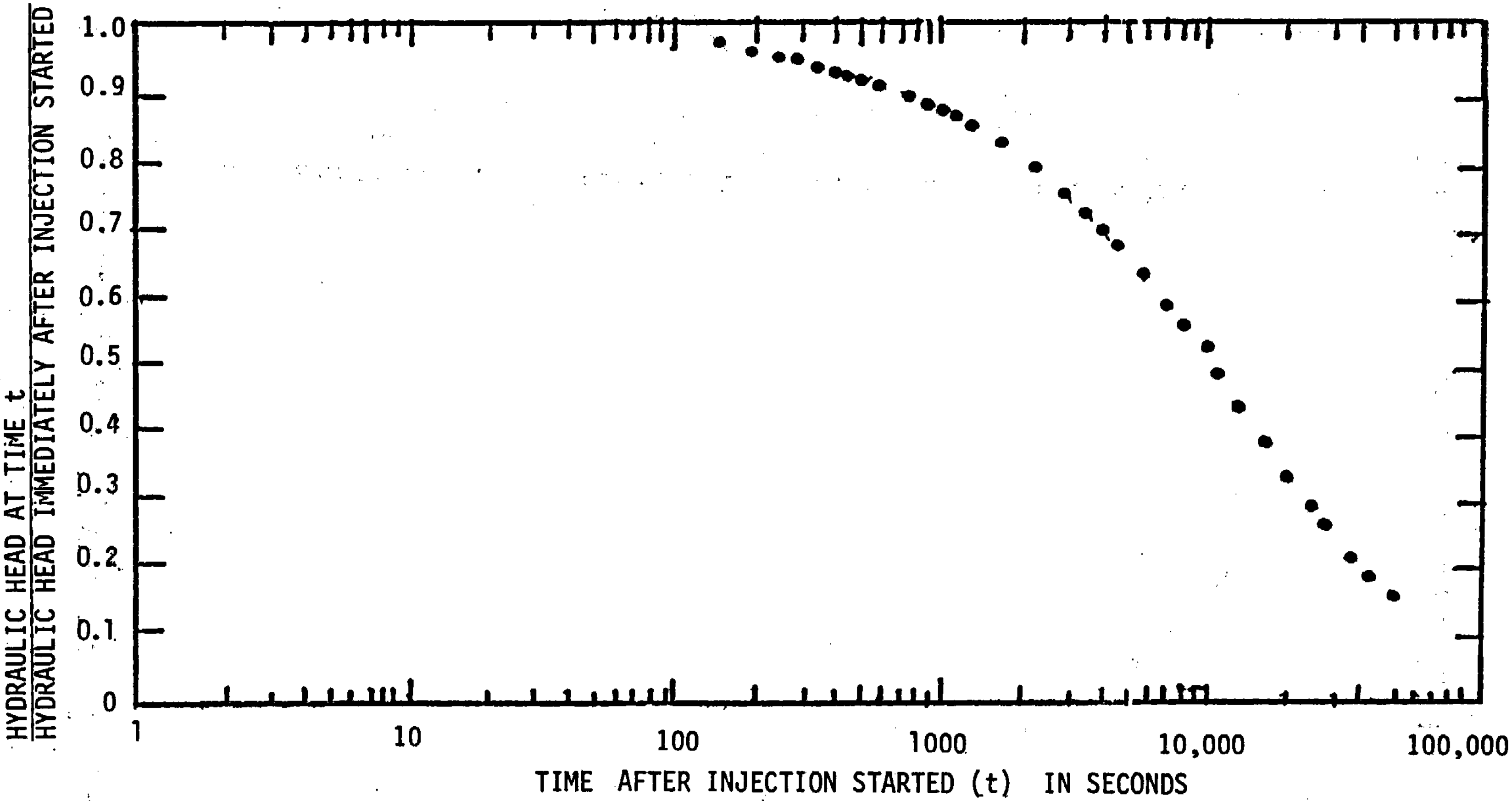

Figure 14.--Injection-test data for depth interval from 811 to 1,829 meters.

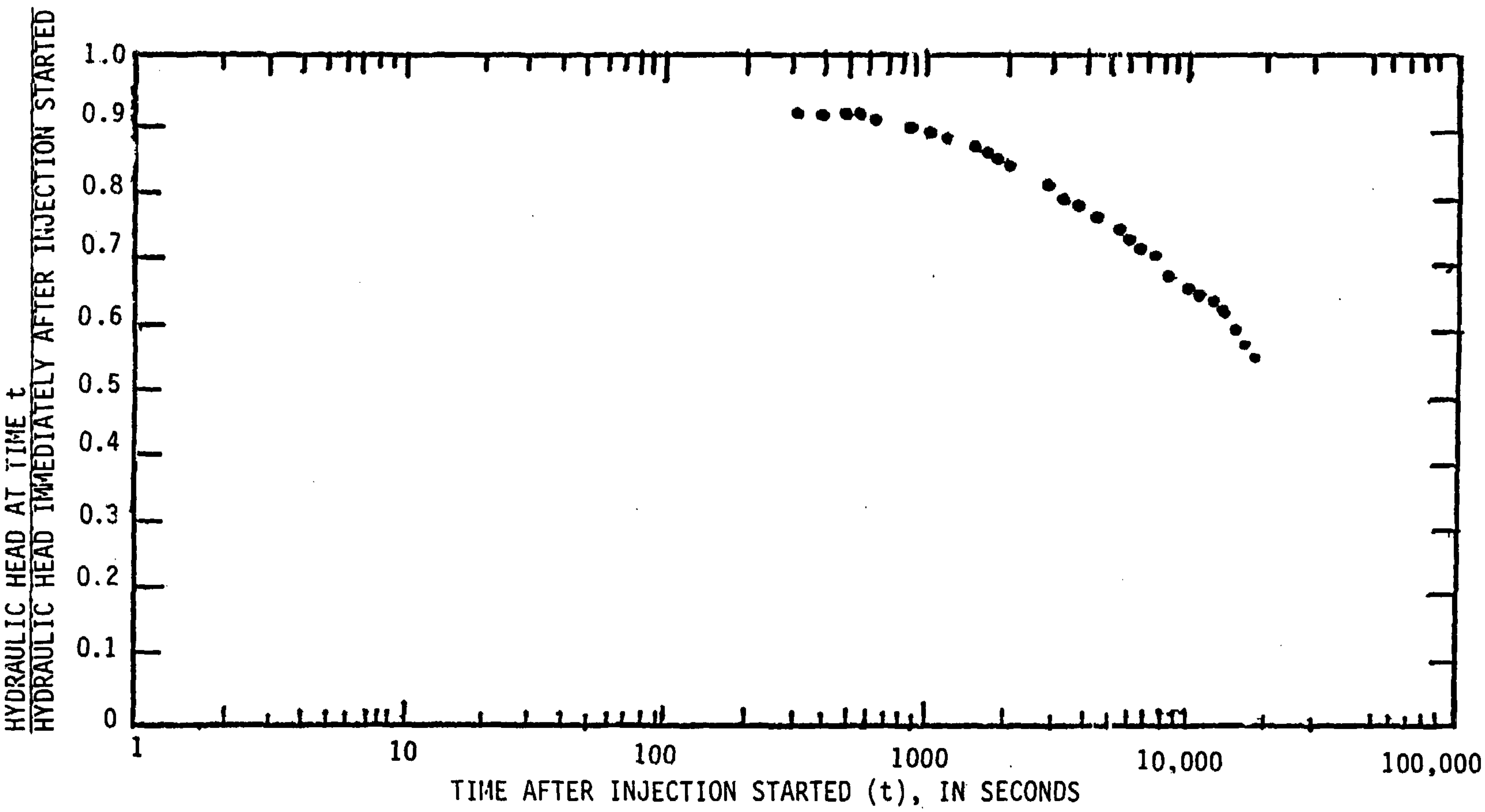

Figure 15.--Injection-test data for depth interval from 926 to 1,829 meters.

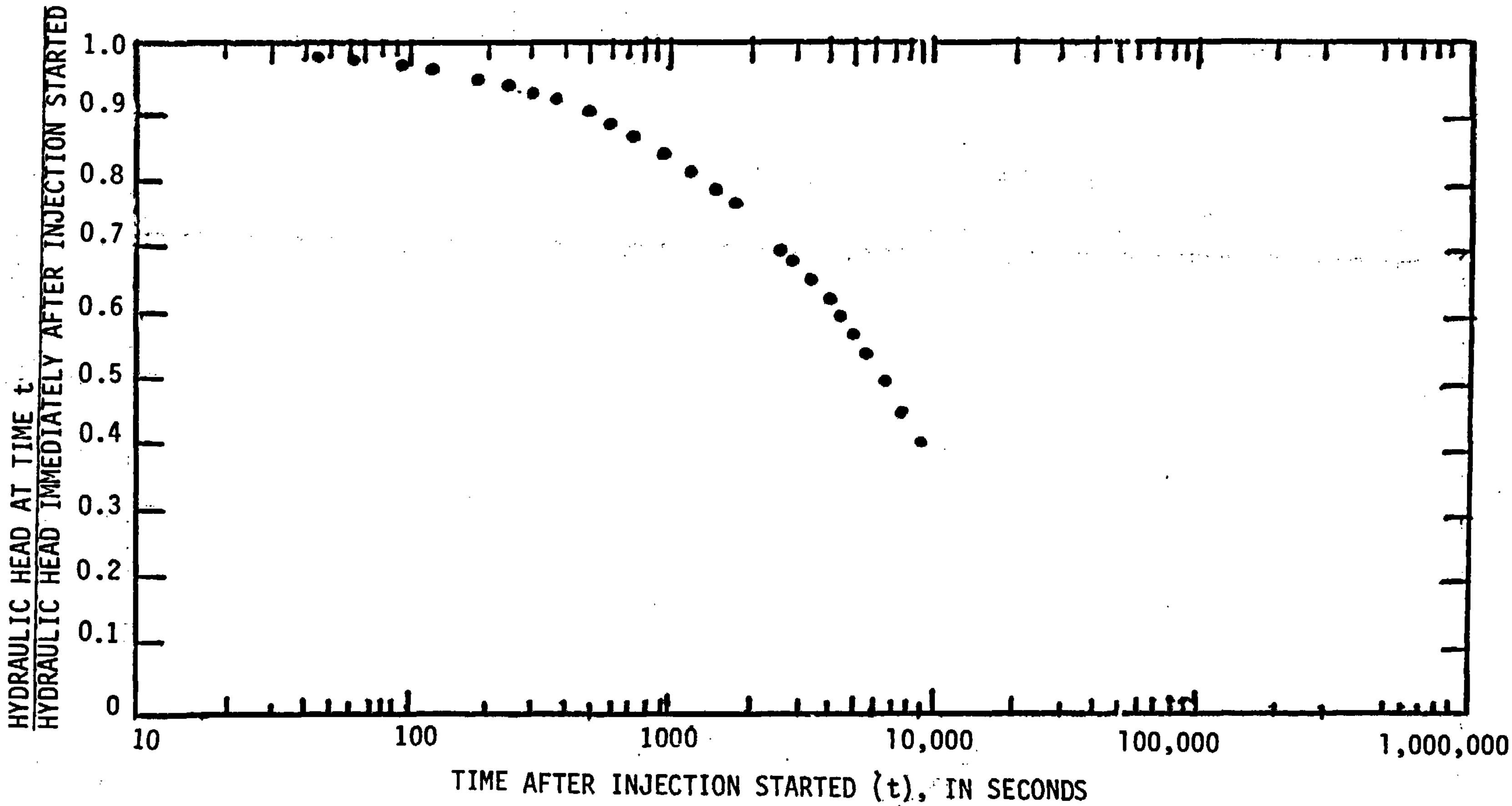

Figure 16.--Injection-test data for depth interval from 1,200 to 1,829 meters.

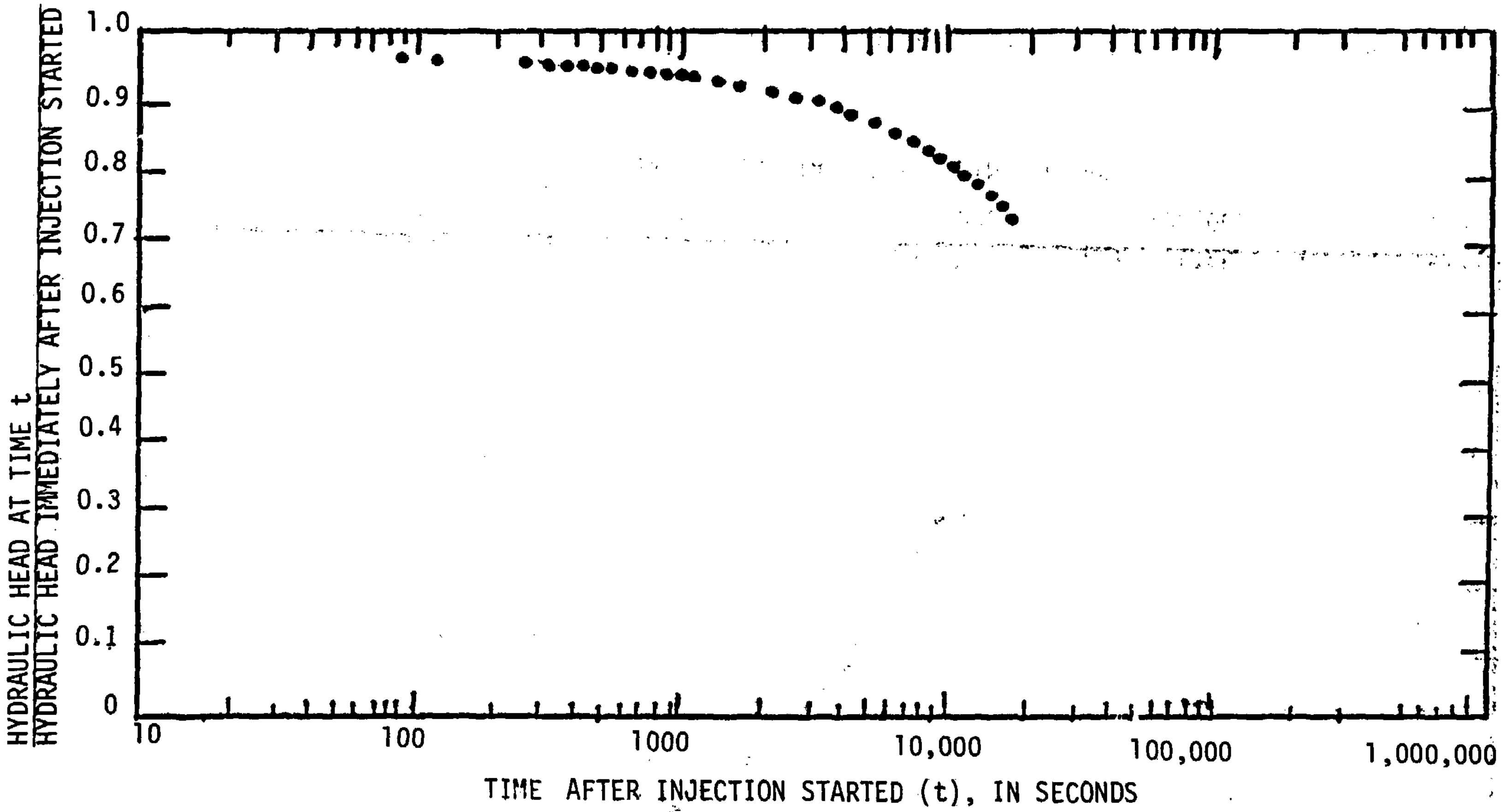

Figure 17.--Injection-test data for depth interval from 1,407 to 1,829 meters.

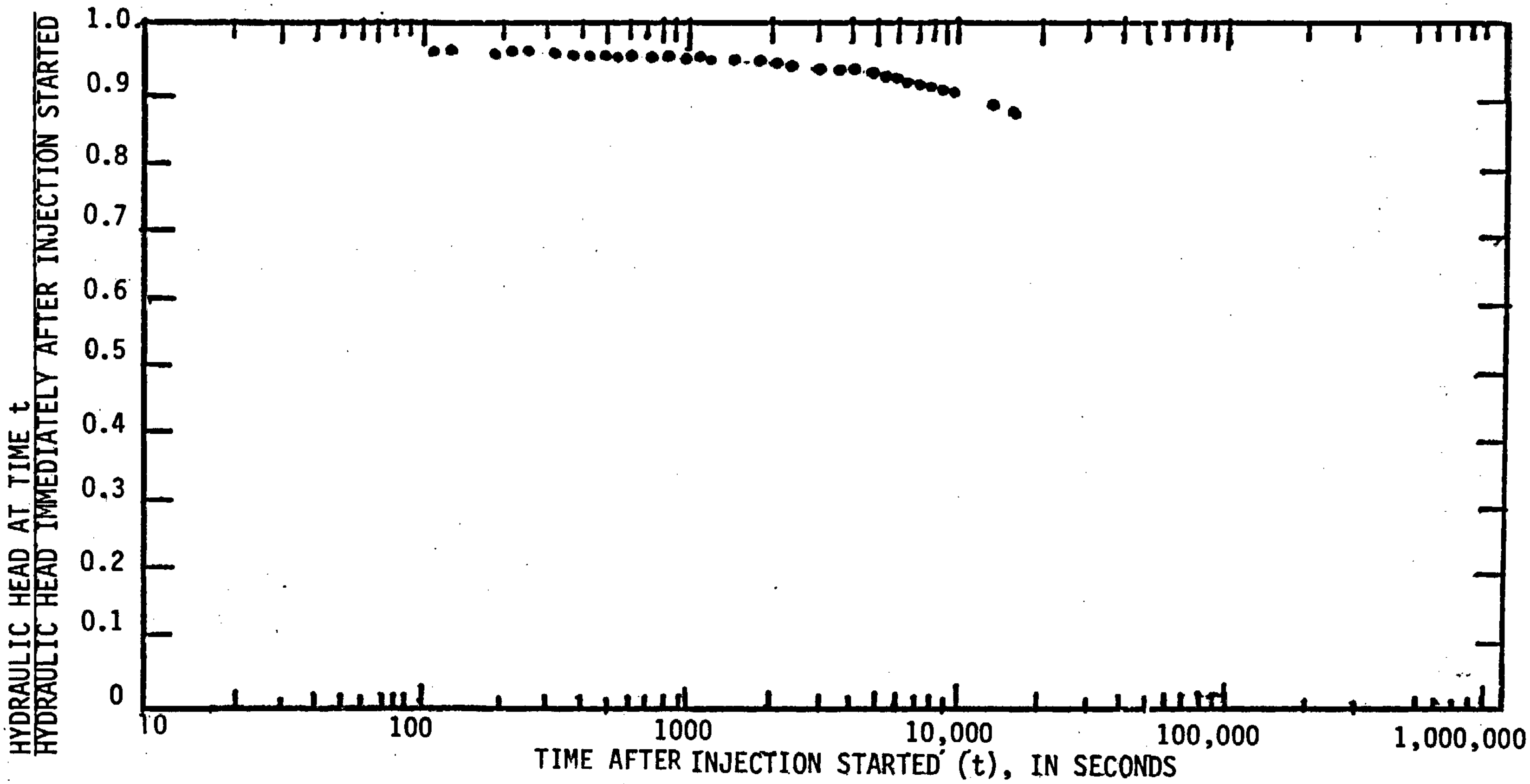

Figure 18.--Injection-test data for depth interval from 1,621 to 1,829 meters.

Table 13.--*Results of chemical analyses of water samples*[1]

[All units are milligrams per liter unless otherwise indicated]

Data collected	Sampled during pumping of depth interval from 572 to 688 meters	Sampled during pumping of depth interval from 687 to 1,829 meters
	10/20/80	12/08/80
Volume of water pumped from zone prior to sampling (liters)	580,000	420,000
Chemical constituents or physical properties		
Bicarbonate (HCO_3)	122	115
Calcium (Ca)	4.5	6.2
Carbon-13/carbon-12 ($\delta^{13}C$)[2]	---	-11.4
Carbon-14 (percent of modern standard)	19.8 ± 4	22.4 ± 1.5
Chloride (Cl)	5.7	5.8
Deuterium-hydrogen ($\delta^{2}H$)[3]	-103	-101
Fluoride (F)	1.2	1.0
Lithium (Li)	40	40
Magnesium (Mg)	0.0	0.0
Oxygen-18/oxygen-16 ($\delta^{18}O$)[4]	-13.4	-13.5
pH, laboratory	7.8	8.0
pH, field	7.7	7.5
Potassium-40 (picocuries per liter)	1.8	1.2
Potassium (K)	2.4	1.6
Residue on evaporation	176	188
Silica (SiO_2)	47	40
Sodium (Na)	51	51
Specific conductance, field (microseimens)[5]	255	247
Specific conductance, laboratory (microsiemens)	258	266
Strontium (Sr, micrograms per liter)	5	20
Sulfate (SO_4)	18	19
Temperature (degrees Celsius)	33	34.7
Tritium (picocuries per liter)	<20	<20

Table 13.--*Results of chemical analyses of water samples*--Continued[1/]

Data collected	Sampled during pumping of depth interval from 572 to 688 meters	Sampled during pumping of depth interval from 687 to 1,829 meters
	10/20/80	12/08/80
Chemical constituents or physical properties--Continued		
Cations (milliequivalents per liter)	2.50	2.57
Anions (milliequivalents per liter)	2.48	2.61
Difference (percent)	0.55	0.79

1/ Chemical analysis made by U.S. Geological Survey laboratory, Denver, Colorado.

2/ Deviation of carbon-13/carbon-12 ratio of sample from PeeDee Belemnite standard (PDB) relative to PDB, in parts per thousand.

3/ Deviation of deuterium/hydrogen ratio of sample from standard mean ocean water (SMOW) relative to SMOW, in parts per thousand.

4/ Deviation of oxygen-18/oxygen-16 ratio of sample from standard mean ocean water (SMOW) relative to SMOW, in parts per thousand.

5/ Equivalent to micromhos per centimeter at 25°C.

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