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UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

Federal Center, Lakewood, Colorado 80225

HYDRAULIC TESTS IN HOLE UAe-6h, AMCHITKA ISLAND, ALASKA

(Amchitka-13)
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By

Wilbur C. Ballance

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ABSTRACT

Inflatable straddle packers were used to isolate and test 14 intervals ranging from 39 to 258 meters (127 to 846 feet) each in hole UAe-6h. Packer seats were poor in part of the hole because of unstable wall conditions. Thus, some zones had to be tested several times.

The static water levels in the intervals tested ranged from about 23 meters (71 feet) below land surface in the upper interval to an estimated 90 meters (295 feet) below land surface in the lower intervals, indicating a decreasing head with depth.

The specific capacity of the hole from 85.0 to 2,133.6 meters (279 to 7,000 feet) was 1.94 cubic meters per day per meter (0.11 gallon per minute per foot) of drawdown after the hole had been jetted at an average rate of 327 cubic meters per day (60 gallons per minute) for about 23 hours. Transmissivity computed from the recovery of water level after jetting stopped was 0.60 cubic meter per day per meter (48.3 gallons per day per foot).

The relative specific capacities of isolated intervals ranged from 0.004 cubic meter per day per meter (less than 0.001 gallon per minute per foot) of drawdown to 0.430 cubic meter per day per meter (0.024 gallon per minute per foot) of drawdown.

INTRODUCTION

Near "D" site

Hole UAe-6h is located at coordinates N. 5,708,874.67 m; E. 640,517.24 m, Universal Transverse Mercator Grid, Zone 60. Land surface at this site is 96.09 m (315.25 ft) above mean sea level.

Hydraulic tests were made in hole UAe-6h during April and May 1968. The objectives of the tests were to obtain hydraulic information for interpreting the hydrologic system of the island and to obtain samples of water for chemical and radiochemical analysis. Discussion of chemical data and significance of water quality will be presented in a later report.

The scope of this report is limited to presentation of well construction, hydraulic-testing procedures, and hydraulic-testing data. Geologic information was obtained from a previously drilled test hole, UAe-6c, at this site (Morris, 1969).

Drilling and Construction of Hole UAe-6h

Drilling of hole UAe-6h began on April 7, 1968. The drilling method was reverse circulation using clear water as the drilling fluid. The casing record is as follows:

50.8-cm (20-in.), 0 to 9.1 m (30 ft), cemented.

34.0-cm (13$\frac{3}{8}$-in.), 0 to 85.0 m (279 ft), cemented.

The hole was drilled with a 25.1-cm (9$\frac{7}{8}$-in.) bit from the bottom of the casing to 2,133.6 m (7,000 ft), and left open. Caving of the hole wall became a problem from 1,494.8 m (4,904 ft) to 2,133.6 m (7,000 ft). Drilling was interrupted two times so that hydraulic testing could be conducted. Further drilling would have eroded the walls of the hole

beyond the expansion capacity of the packers. During each cessation of drilling, the hole was hydraulically tested in the interval drilled since the previous test.

Procedure for Hydraulic Tests

The hydraulic-testing schedule usually begins with geophysical logging. After completion of the geophysical logging, a pumping test is made to clean suspended matter from the hole, to remove drilling fluid that may have penetrated the formations, and to measure the total discharge of water from the rocks exposed in the well bore. Pumping is generally with a submersible pump or by lifting water from the borehole by injecting large quantities of air below the water surface, commonly termed "jetting". During the pumping, radioactive tracer and temperature surveys are made to locate the zones of entry of water into the hole. After the pumping equipment has been removed from the hole, injection or swabbing tests are made by adding known volumes of water to, or withdrawing known volumes of water from, intervals that are isolated with straddle packers. The rate of decline or rise in water level resulting from this injection or withdrawal of water is recorded. From the rate of change in water levels with time, hydraulic characteristics of the rocks within the interval can be computed. Samples of water are collected during pumping and swabbing for chemical, radiochemical, tritium, and carbon-14 analyses. A more detailed explanation of testing procedures has been presented by Blankennagel (1967).

Method of Analysis of Test Data

The following formula was used to compute the transmissivity (T) from recovery data obtained after jetting:

$$T = \frac{2.30Q}{4\pi s} \log_{10} \frac{t}{t'}$$

where

T = transmissivity of the formation, in m^3 pd per m (cubic meters per day per meter);

s = residual drawdown (meters);

t = time since jetting began (minutes);

t' = time since jetting stopped (minutes);

Q = pumping rate, in m^3 pd (cubic meters per day).

Over one log cycle, $\log_{10} t/t'$ becomes unity; then,

$$T = \frac{2.30Q}{4\pi \Delta s}$$

and Δs is the change in head in that log cycle.

Specific capacity of a well is yield per unit of drawdown during pumping, such as gallons per minute per foot of drawdown. Relative specific capacity (RSC) is similar to specific capcity, in that the units and 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 an entire well. The computation for relative specific capacity from slug-injection data is as follows:

$$RSC = \frac{Q}{(h-h')}$$

where

Q = volume of water accepted by an interval isolated with packers during a 1-minute time interval (the time interval 3 to 4 minutes after the tool is opened is commonly used);

h = static water level of the hole--or interval tested--in distance below land surface;

h' = average water level in the tubing, in distance below land surface in the 1-minute interval used for determining Q. Usually, the water level at 3.5 minutes is used.

The values for relative specific capacity determined by the preceding method are reasonably accurate for relatively impermeable intervals; they are too low in highly permeable intervals. A comparison of the specific capacity values derived from drill-stem tests of permeable intervals with those from pumping tests of the same intervals has shown that the injection or swabbing-test data for permeable zones may be low by a factor of as much as 50. For low-yielding zones--that is, those with relative specific capacity less than 0.083 m^3 pd per m or 0.05 gpm per ft (gallons per minute per foot) of drawdown--injection and swabbing-test data yield information which is comparable to that which could be obtained if these holes were pumped for a long period of time.

Hydraulic Tests in Hole UAe-6h

Hole UAe-6h was drilled, cased, and cemented to 85.0 m (279 ft) and then deepened to 2,133.6 m (7,000 ft). Fresh water rather than mud was used for all the drilling in order to keep the formations as free of clay as possible and prevent plugging of the formations.

Drilling was interrupted twice for hydraulic testing because of excessive erosion of the walls of the borehole. During each cessation of drilling, the hole was pumped or jetted to remove drilling fluid and cuttings from the borehole and formations prior to testing (by injection or swabbing methods) intervals isolated with straddle packers. During the pumping with packers removed, total discharge of water from the rocks exposed in the well bore was measured.

Analysis of data obtained during hydraulic tests in hole UAe-6h are presented in figures 1 through 15.

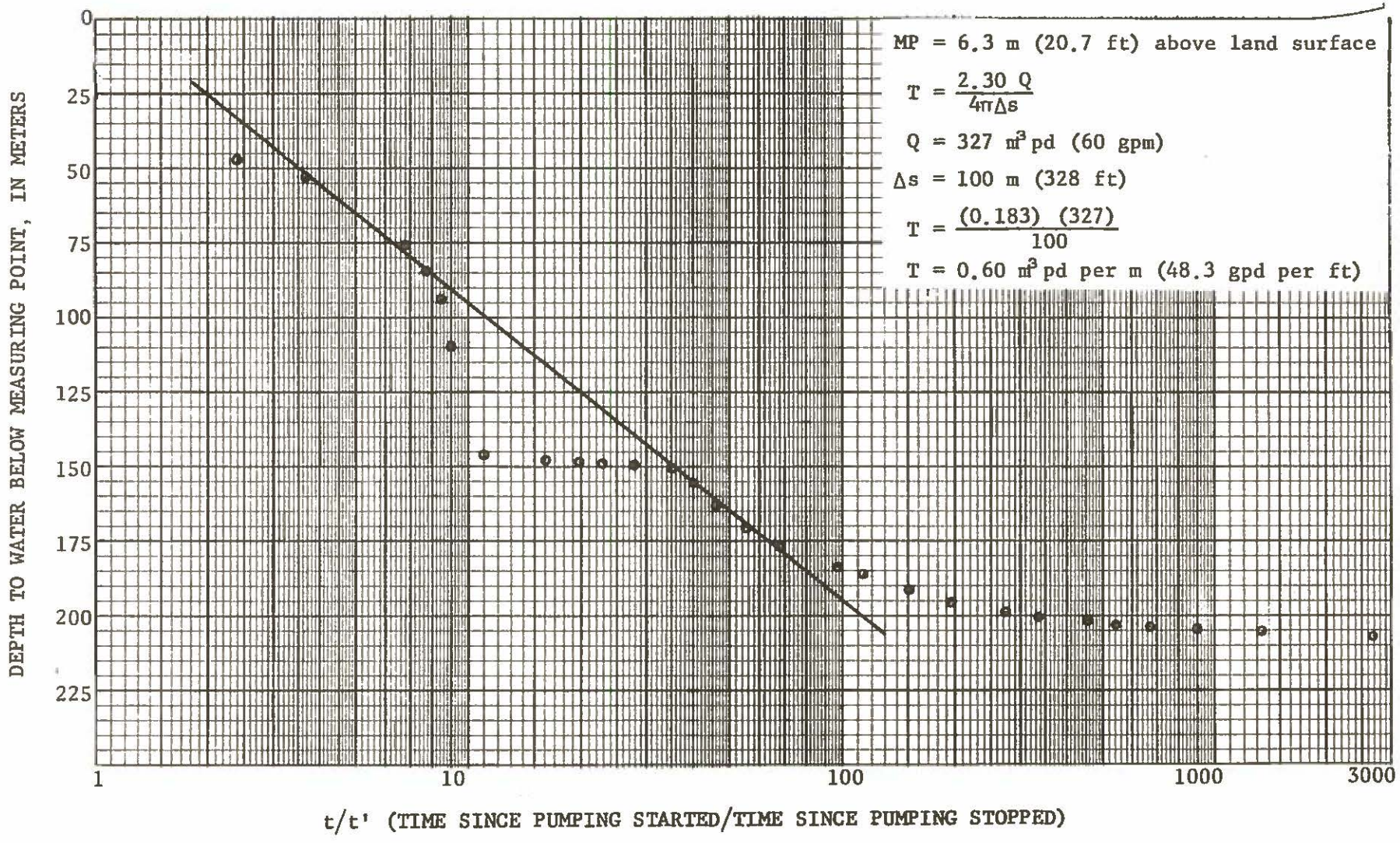

Figure 1.--Recovery of water level after jetting (air-lifting water from hole) from interval 85.0 to 2,133.6 m (279 to 7,000 ft), hole UAe-6h, Amchitka Island, Alaska, May 29, 1968.

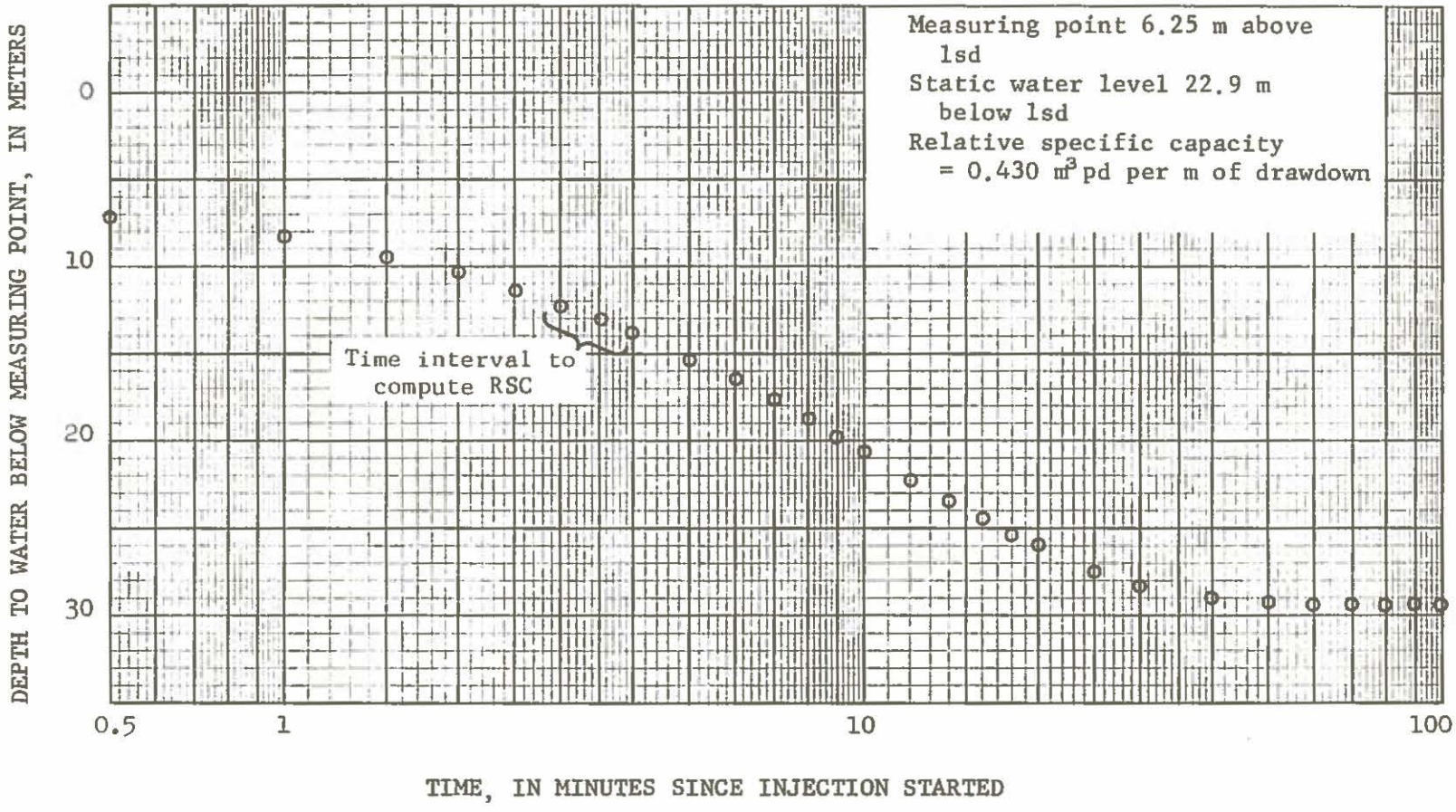

Figure 2.--Injection test of zone 85.0 to 123.8 m (279 to 406 ft), hole UAe-6h, Amchitka Island, Alaska, April 29, 1968.

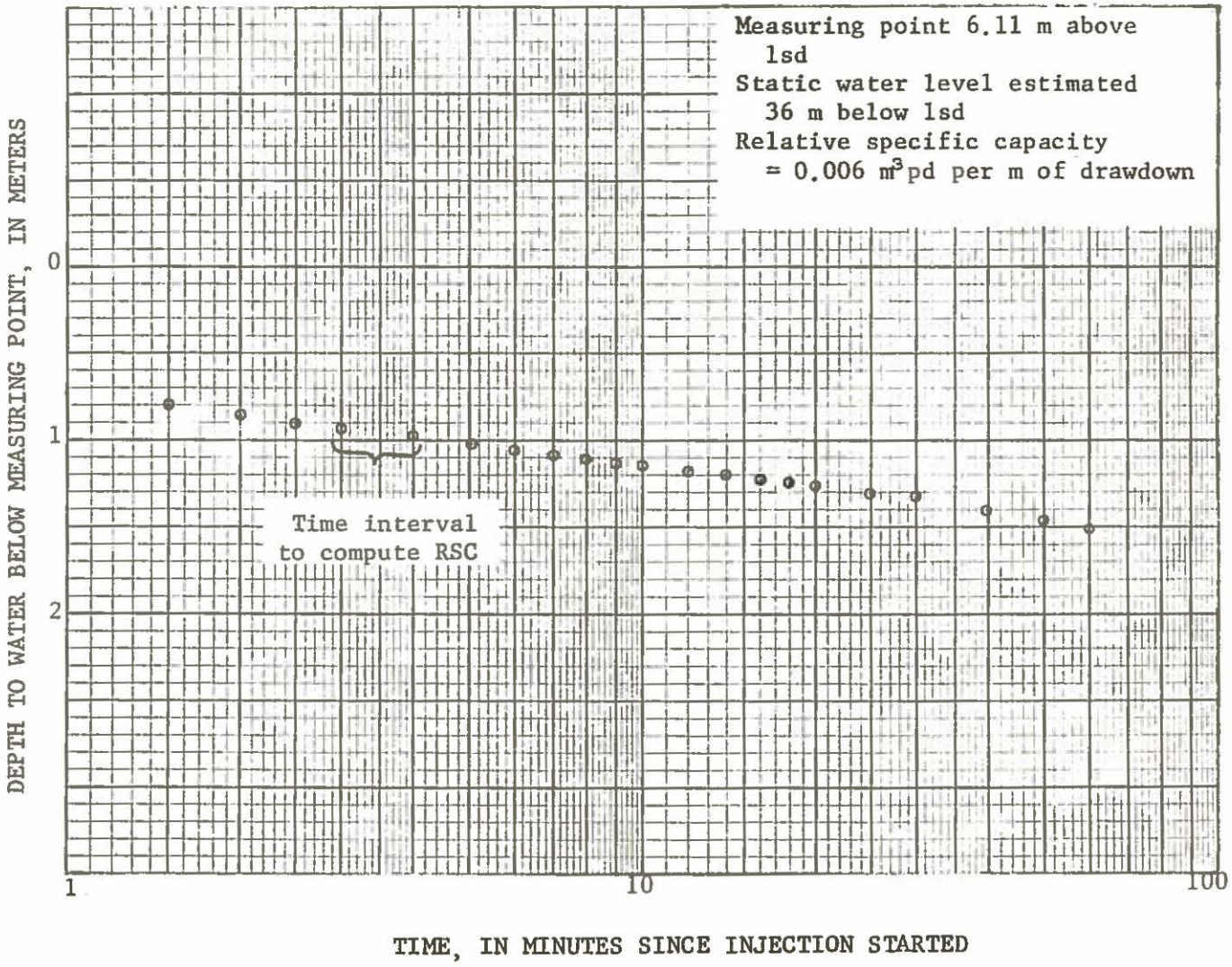

Figure 3.--Injection test of zone 777.2 to 840.6 m (2,550 to 2,758 ft), hole UAe-6h, Amchitka Island, Alaska, April 30, 1968.

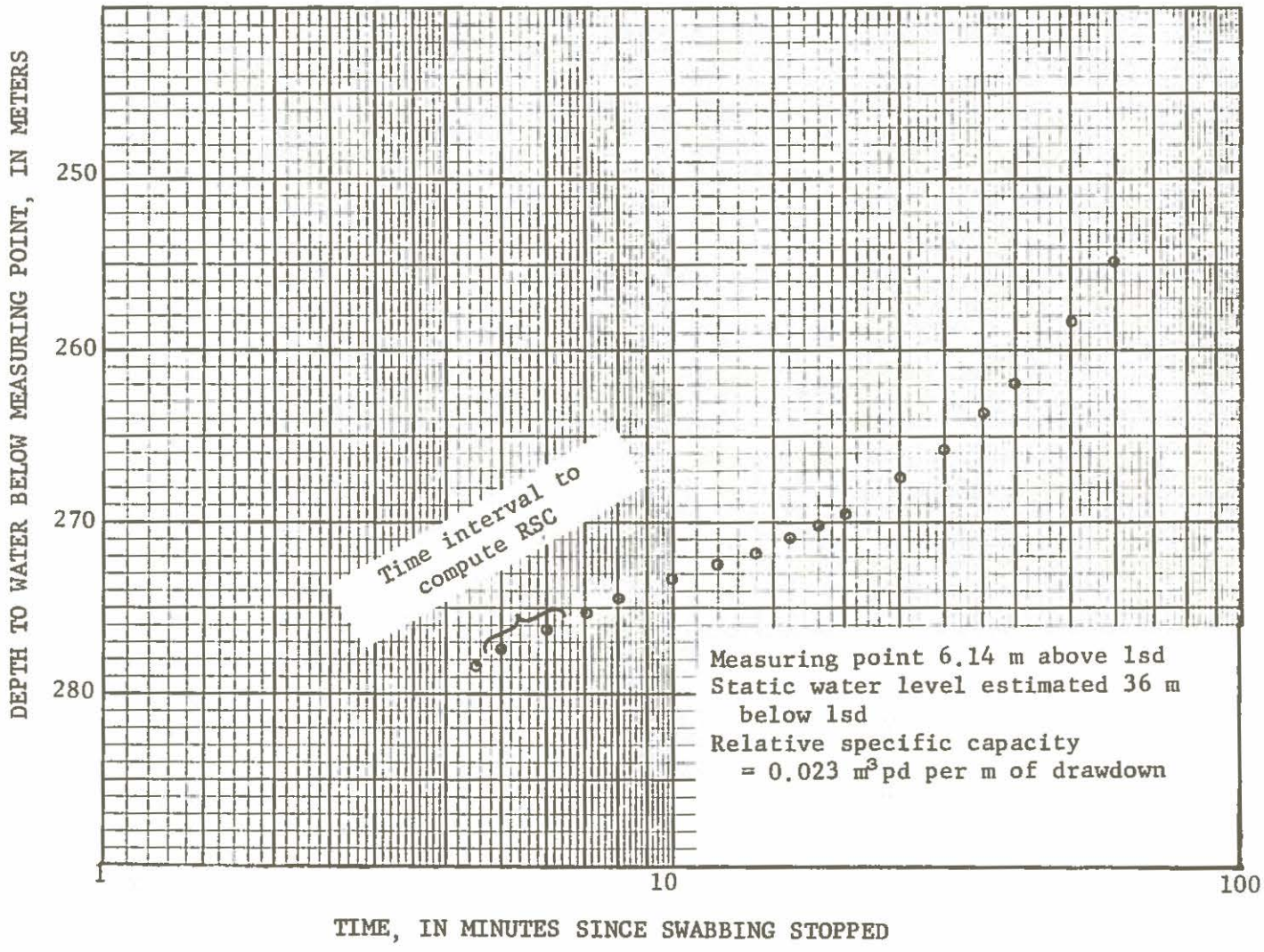

Figure 4.--Swabbing recovery test of zone 1,074.1 to 1,137.5 m (3,524 to 3,732 ft), hole UAe-6h, Amchitka Island, Alaska, April 30, 1968.

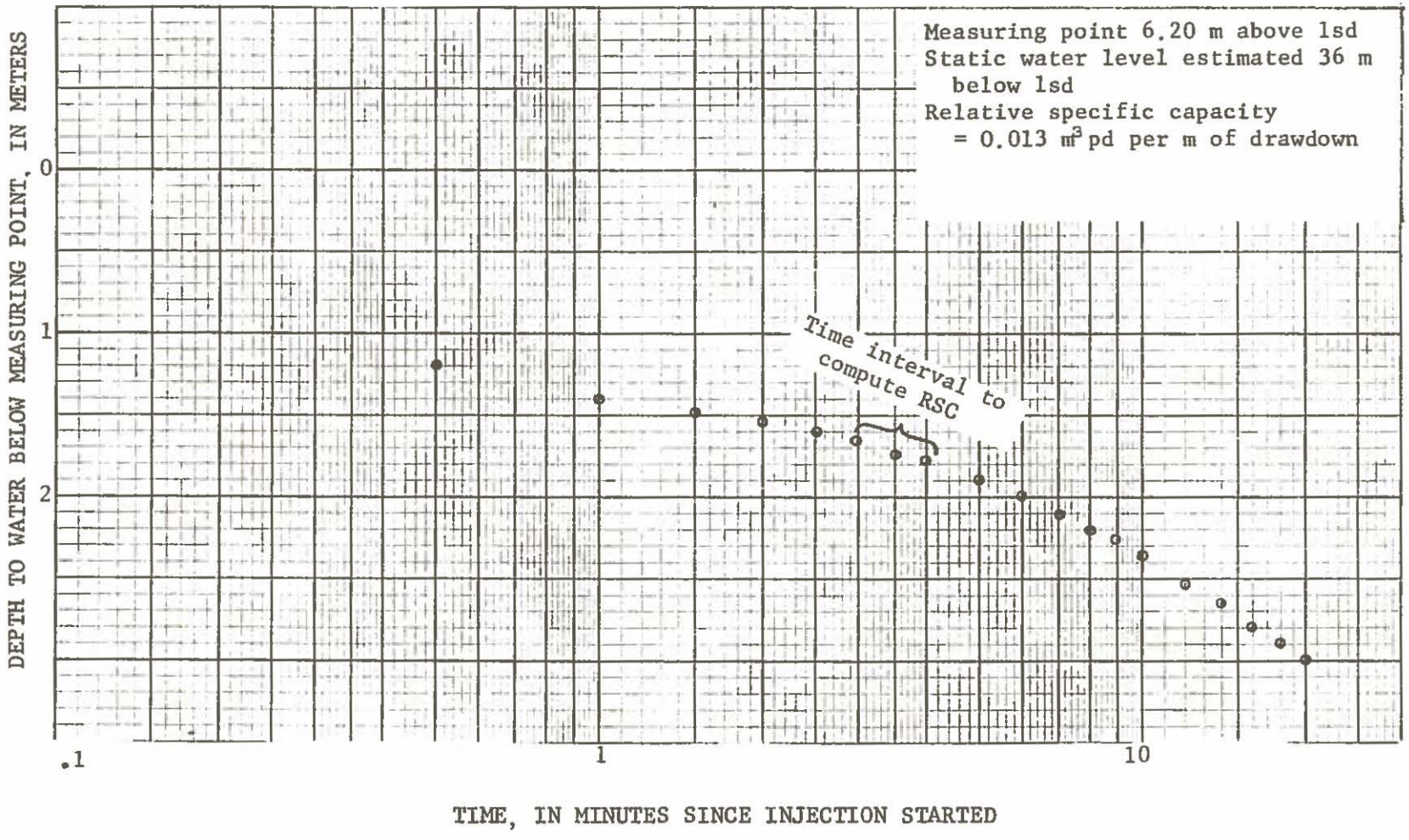

Figure 5.--Injection test of zone 1,170.4 to 1,233.8 m (3,840 to 4,048 ft), hole UAe-6h, Amchitka Island, Alaska, April 30, 1968.

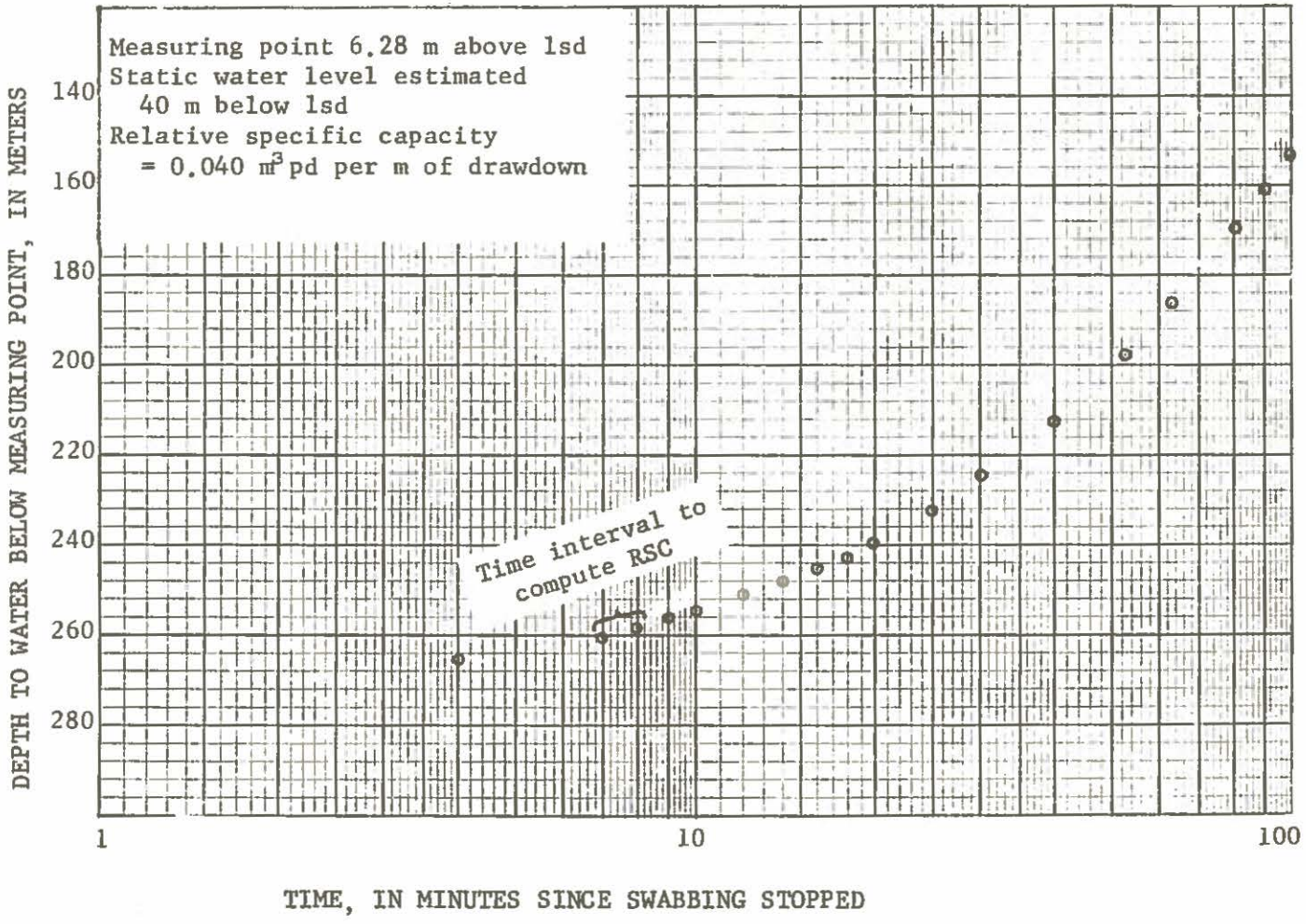

Figure 6.--Swabbing recovery test of zone 1,236.9 to 1,494.8 m (4,058 to 4,904 ft), hole UAe-6h, Amchitka Island, Alaska, April 30, 1968.

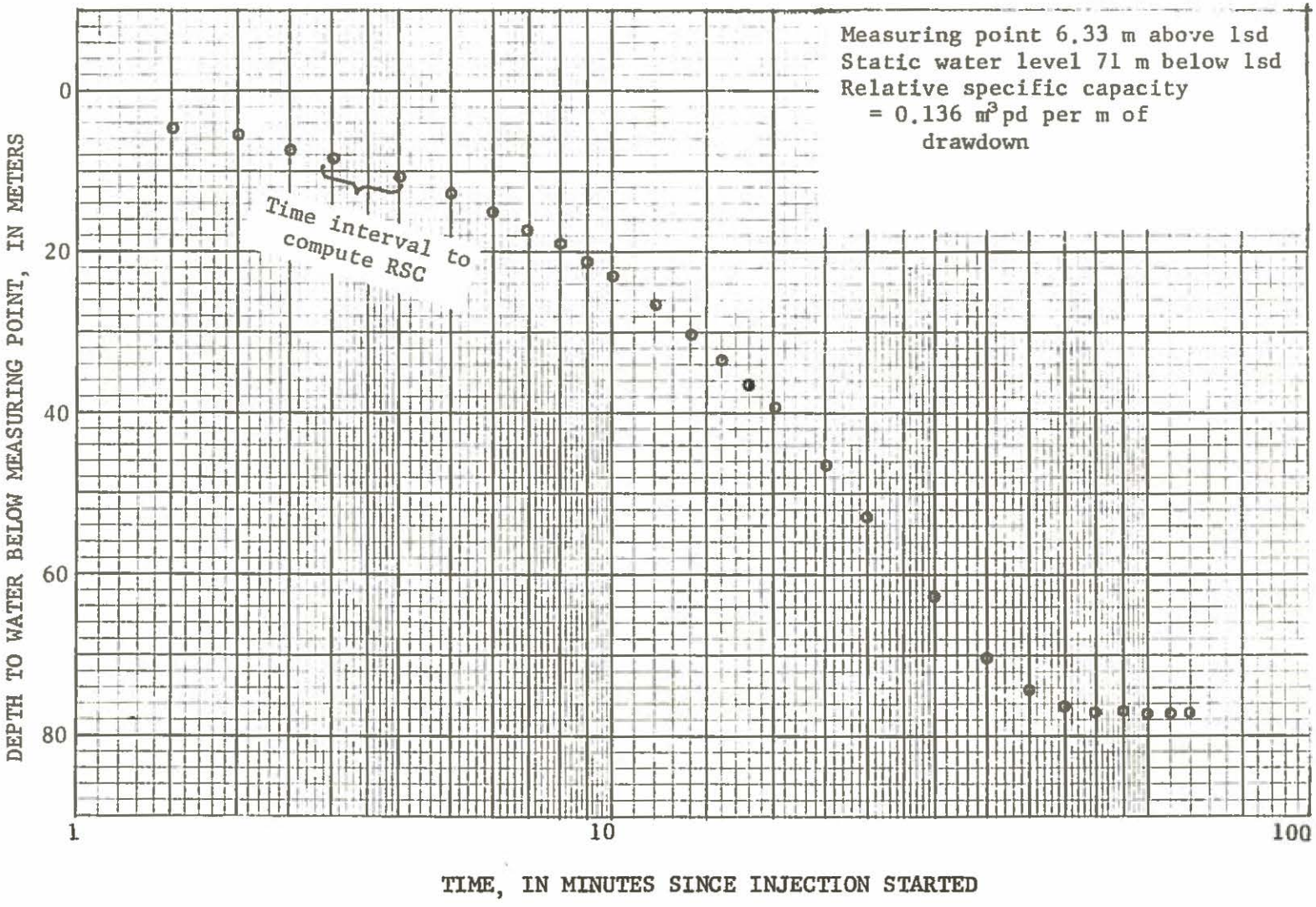

Figure 7.--Injection test of zone 1,498.7 to 1,589.2 m (4,917 to 5,214 ft), hole UAe-6h, Amchitka Island, Alaska, May 6, 1968.

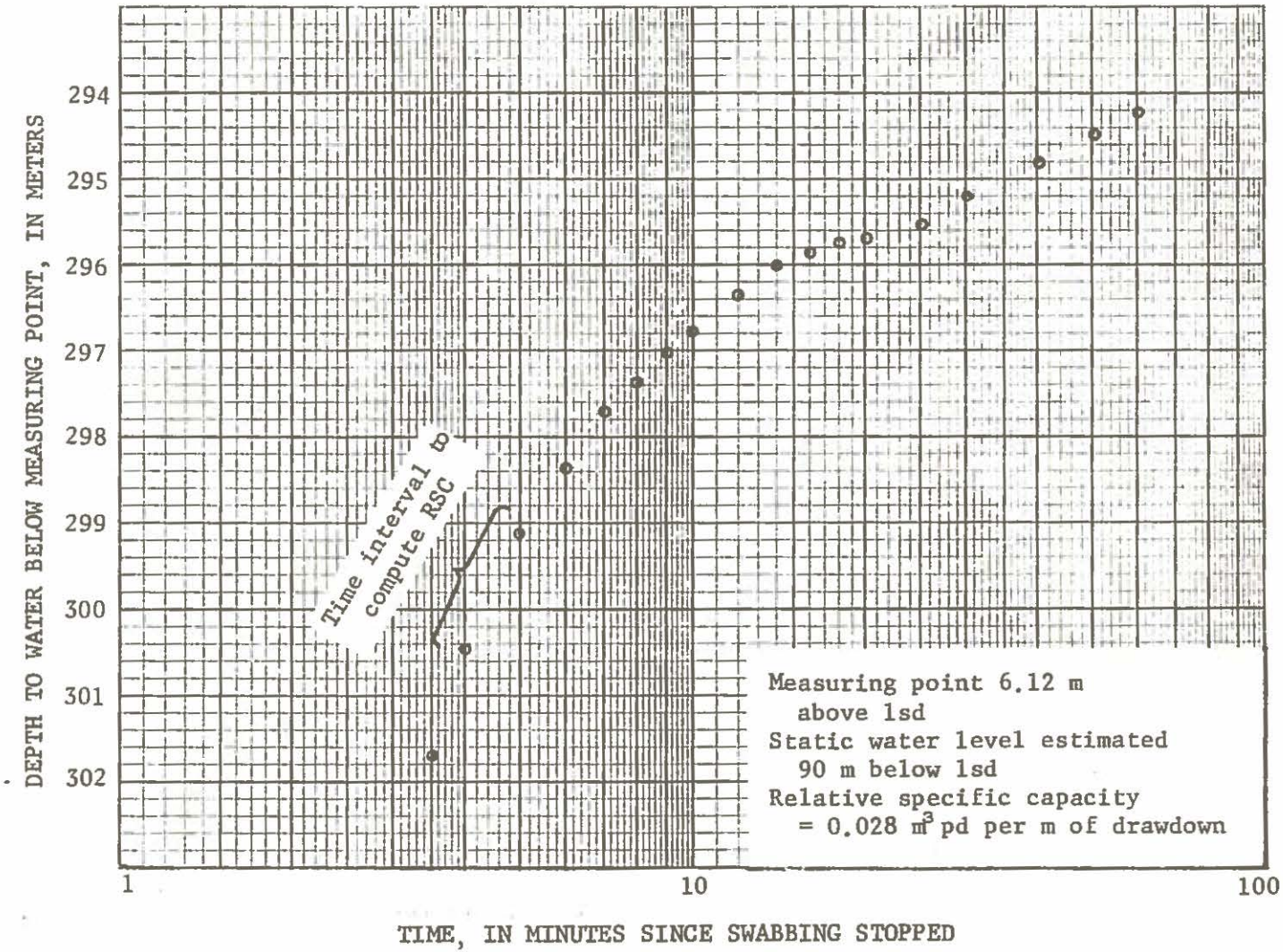

Figure 8.--Swabbing recovery test of zone 1,560.6 to 1,614.8 m (5,120 to 5,298 ft), hole UAe-6h, Amchitka Island, Alaska, May 10, 1968.

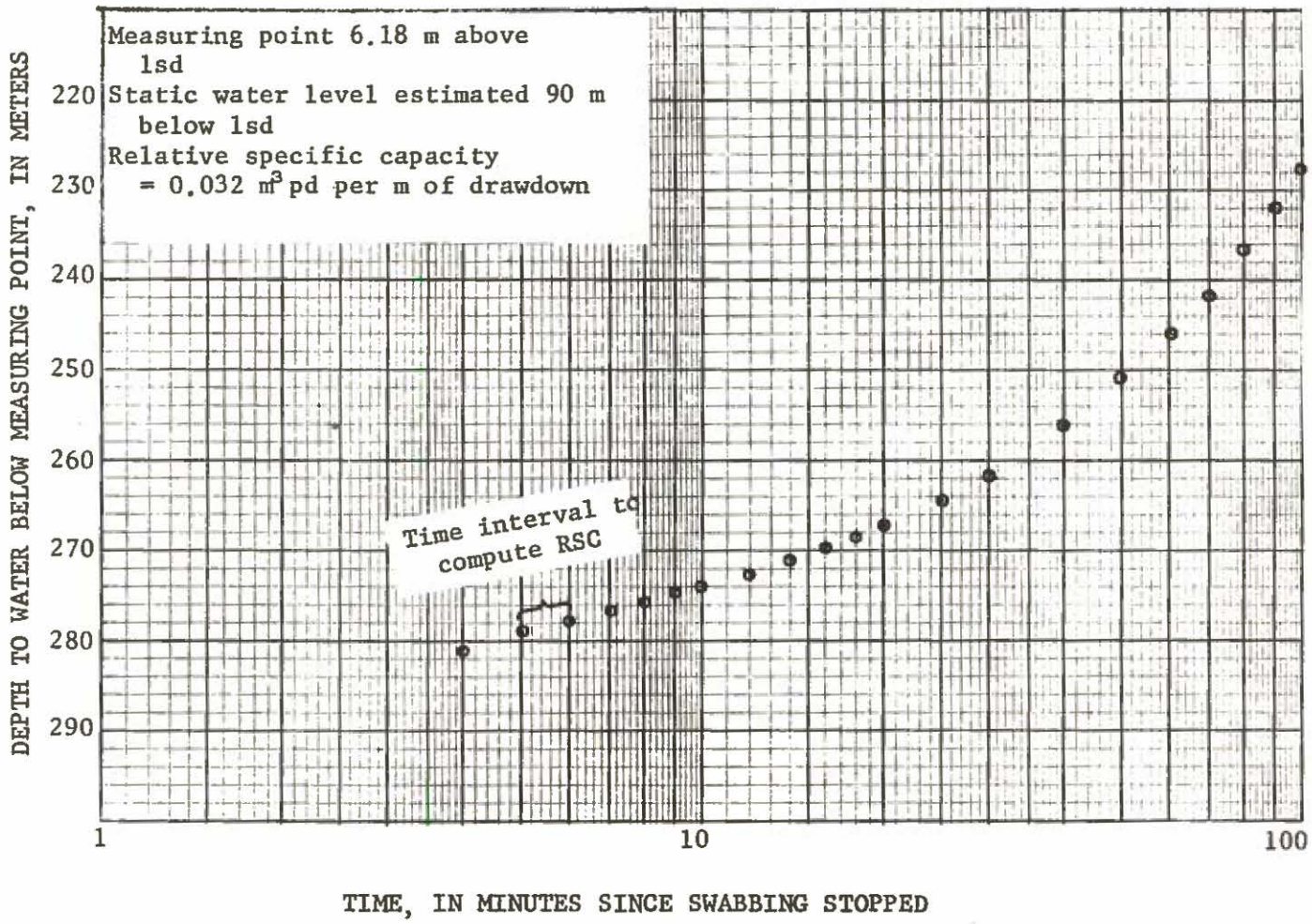

Figure 9.--Swabbing recovery test of zone 1,617.9 to 1,744.1 m (5,308 to 5,722 ft), hole UAe-6h, Amchitka Island, Alaska, May 10, 1968.

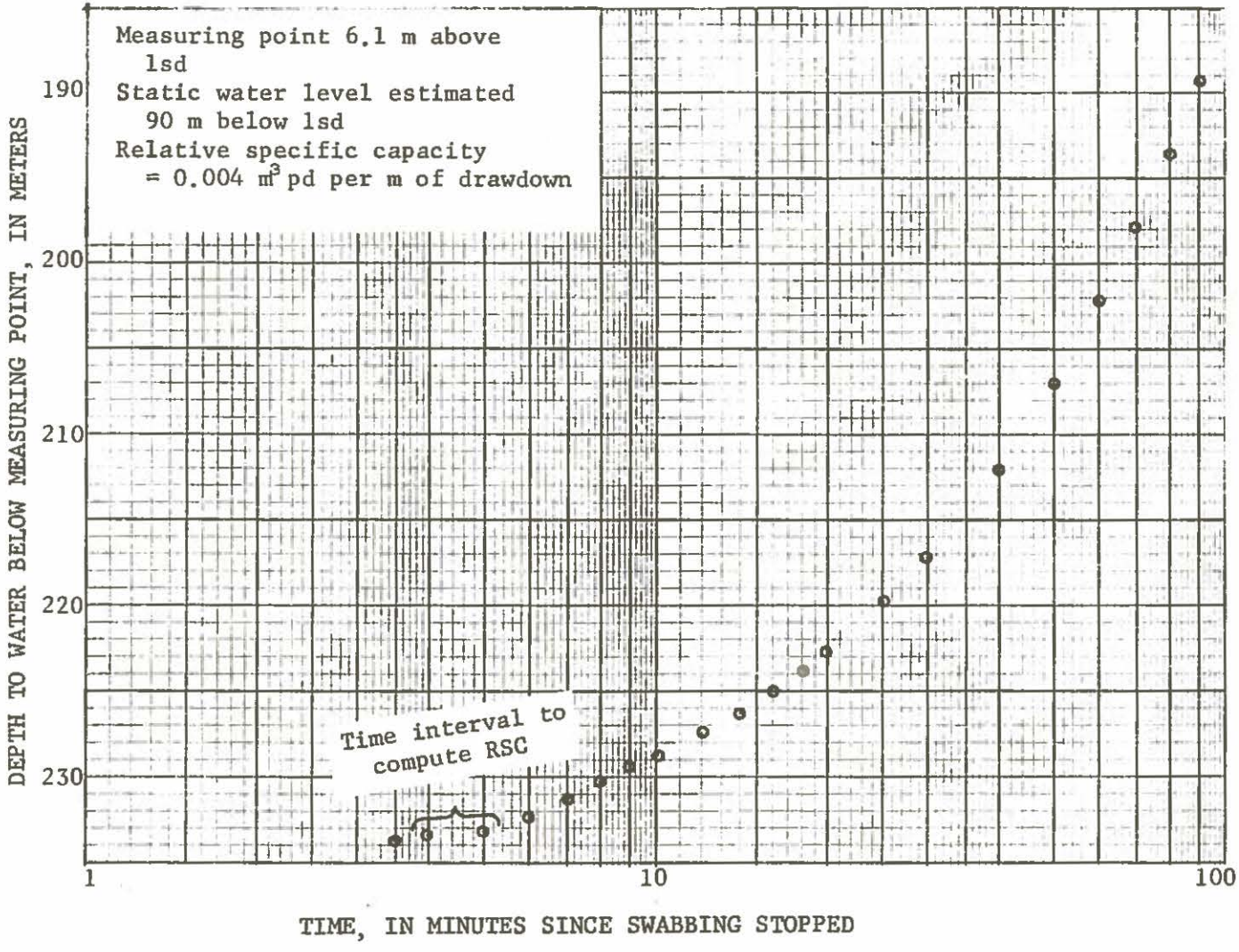

Figure 10.--Swabbing recovery test of zone 1,702.0 to 1,771.5 m (5,584 to 5,812 ft), hole UAe-6h, Amchitka Island, Alaska, May 16, 1968.

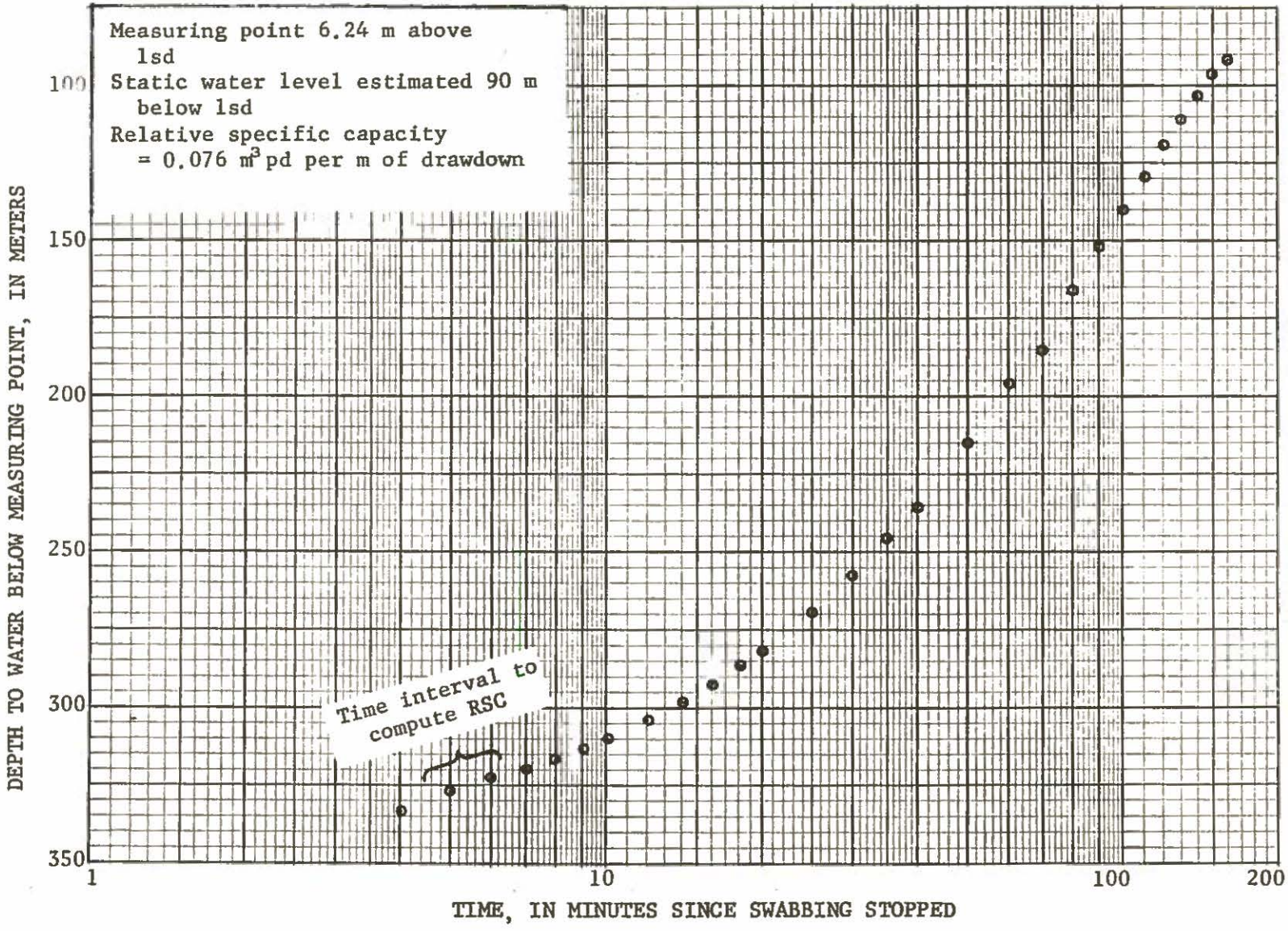

Figure 11.--Swabbing recovery test of zone 1,774.6 to 1,866.6 m (5,822 to 6,124 ft), hole UAe-6h, Amchitka Island, Alaska, May 17, 1968.

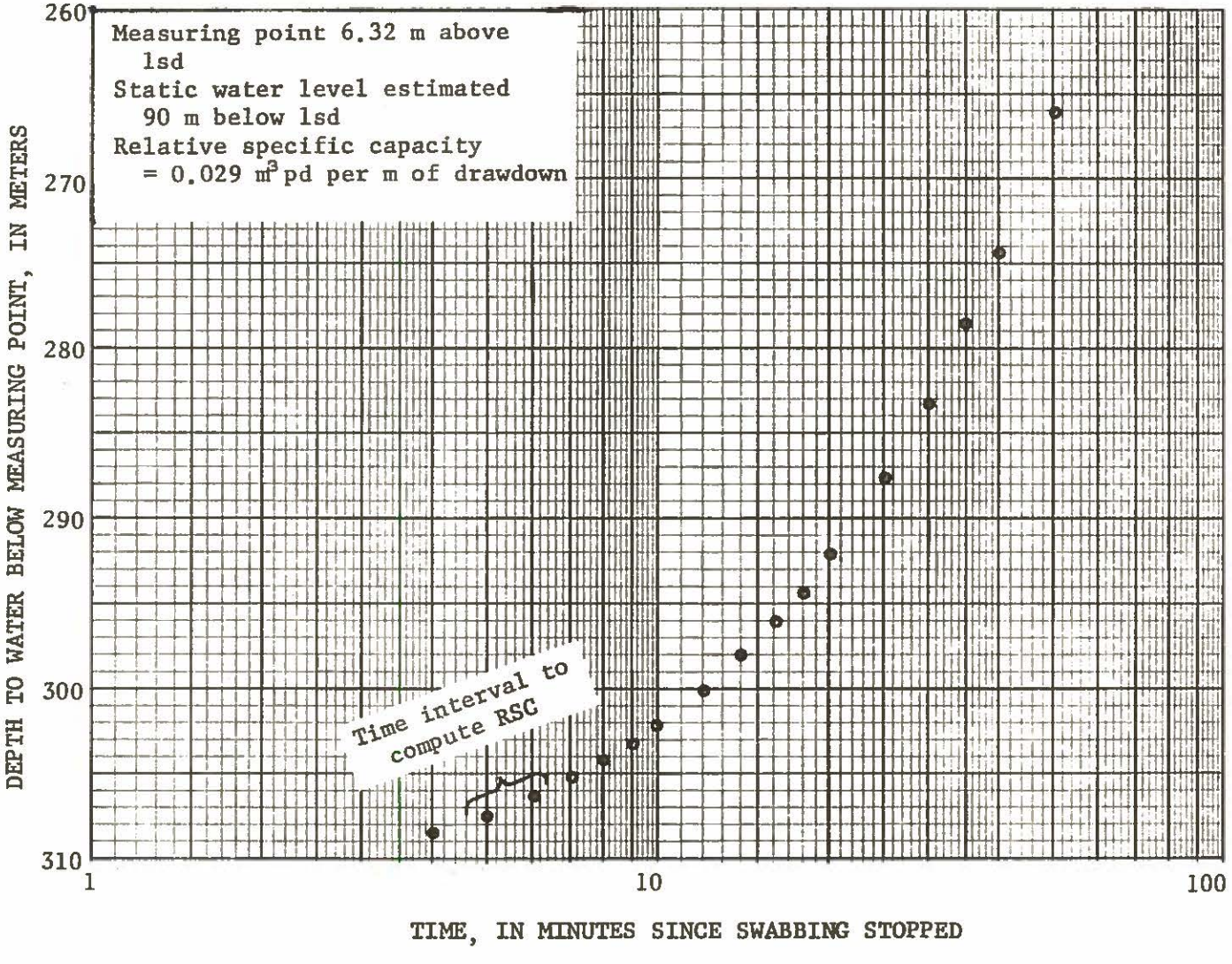

Figure 12.--Swabbing recovery test of zone 1,843.4 to 1,903.8 m (6,048 to 6,246 ft), hole UAe-6h, Amchitka Island, Alaska, May 30, 1968.

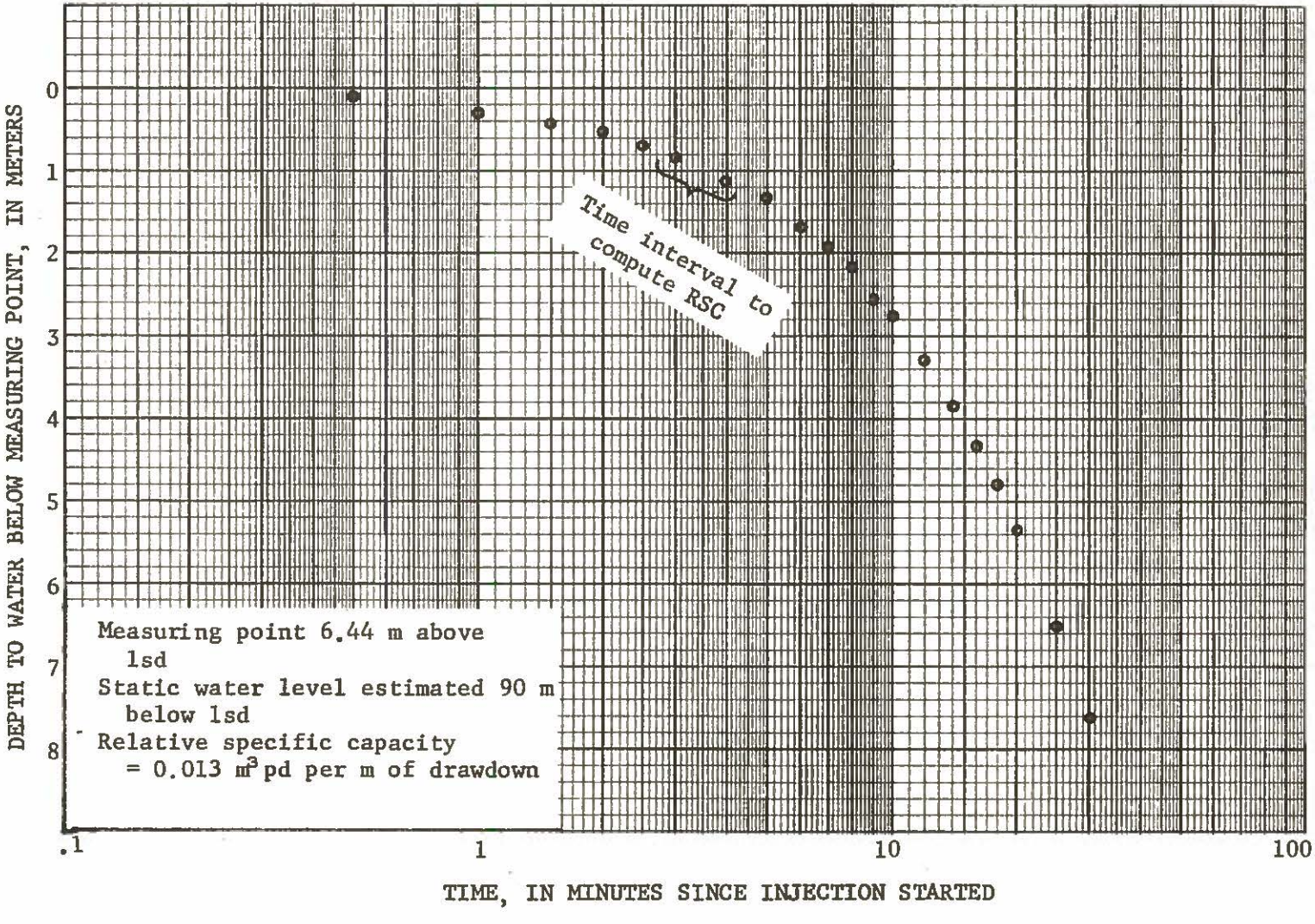

Figure 13.--Injection test of zone 1,892.8 to 1,953.2 m (6,210 to 6,408 ft), hole UAe-6h, Amchitka Island, Alaska, May 31, 1968.

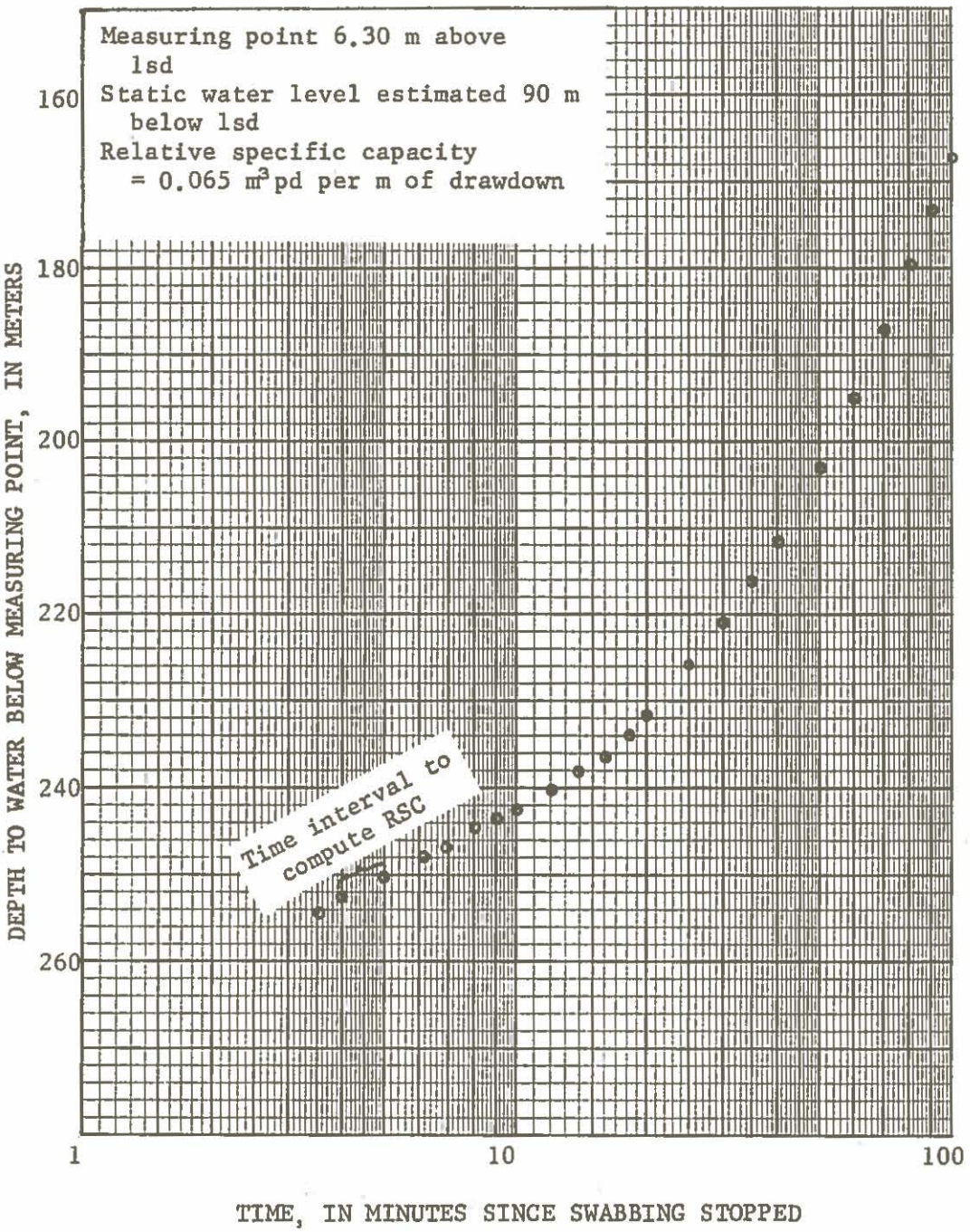

Figure 14.--Swabbing recovery test of zone 1,906.8 to 2,116.6 m (6,256 to 6,944 ft), hole UAe-6h, Amchitka Island, Alaska, May 31, 1968.

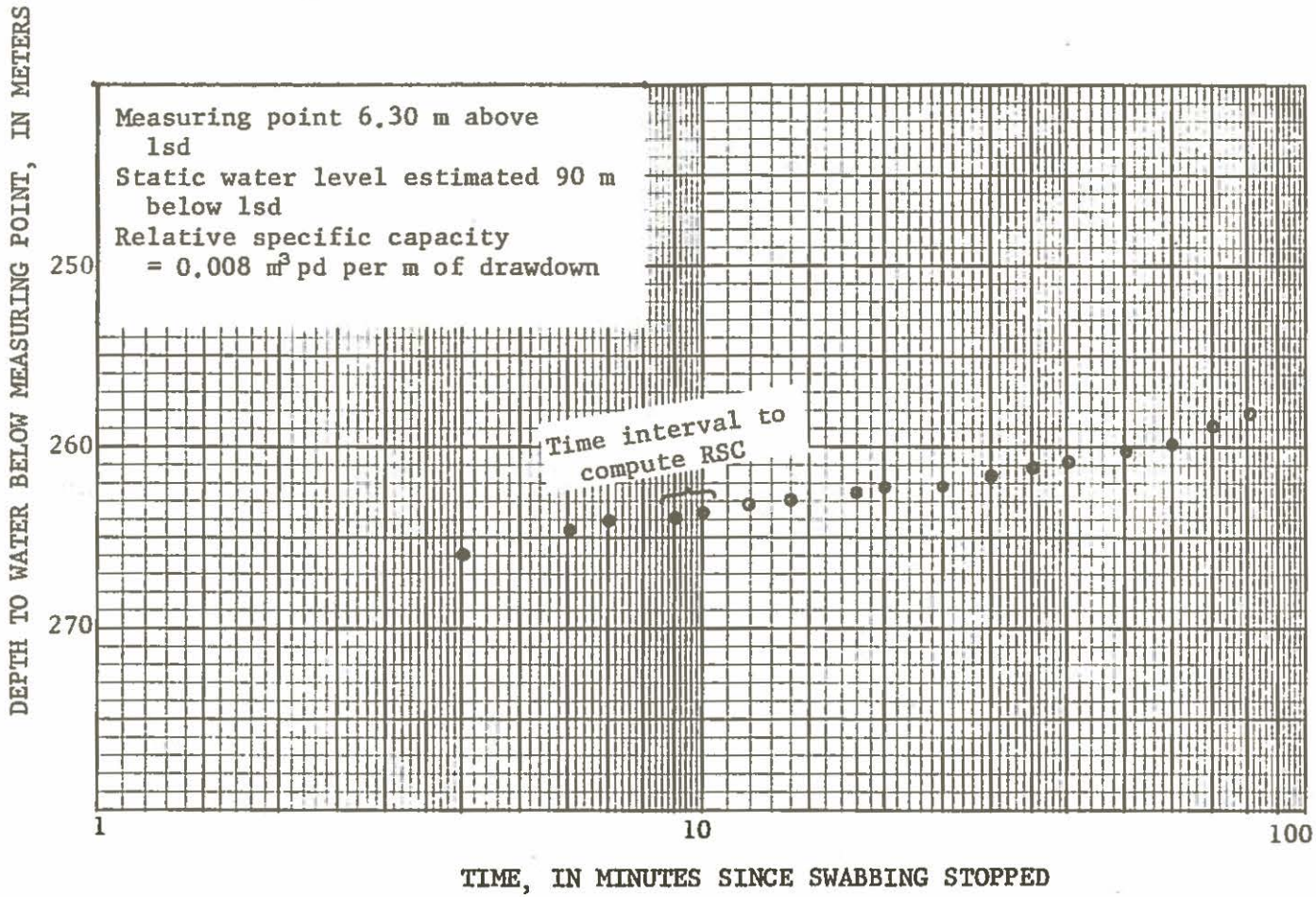

Figure 15.--Swabbing recovery test of zone 2,019.6 to 2,116.6 m (6,626 to 6,944 ft), hole UAe-6h, Amchitka Island, Alaska, May 31, 1968.

SUMMARY

Hole UAe-6h was drilled to 2,133.6 m (7,000 ft). The drilling fluid was clear water piped from a nearby lake. Reverse circulation of the drilling fluid was the method used to flush the drill cuttings to the surface. This method of drilling minimized but did not eliminate hole-wall erosion. After the hole was drilled to a depth of 1,493.5 m (4,900 ft), a caliper log was made and the hole was hydraulically tested to that depth. From 1,493.5 to 2,133.6 m (4,900 to 7,000 ft) drilling was interrupted every 76.2 m (250 ft) and a caliper log was made to assure that there was no excessive erosion.

Fourteen zones were tested in the hole; 10 were below 1,493.5 m (4,900 ft). Most intervals were tested by both injection and swabbing methods. There was leakage around the packers when testing some of the zones. When the leakage around the packers was considerable, the data were not included in this report because they cannot be used reliably for computation of hydraulic properties of the rock. Results of hydraulic tests are summarized in figure 16 and table 1.

The specific capacity of the hole 85.0 to 2,133.6 m (279 to 7,000 ft) was 1.94 m^3 pd per m (0.11 gpm per ft) of drawdown after the hole had been jetted at an average rate of 327 m^3 pd (60 gpm) for about 23 hours. Transmissivity computed from the recovery of water level after jetting stopped was 0.60 m^3 pd per m (48.3 gpd per ft).

The static water levels in the intervals tested ranged from about 30 m (98 ft) below land surface in the upper interval to an estimated 90 m (295 ft) below land surface in the lower intervals, indicating a decreasing head with depth. Most of the zones tested had rocks with very low permeabilities. Water levels for these zones were estimated because of the amount of time required for total recovery. The estimated water levels were based on water levels obtained from the more permeable zones.

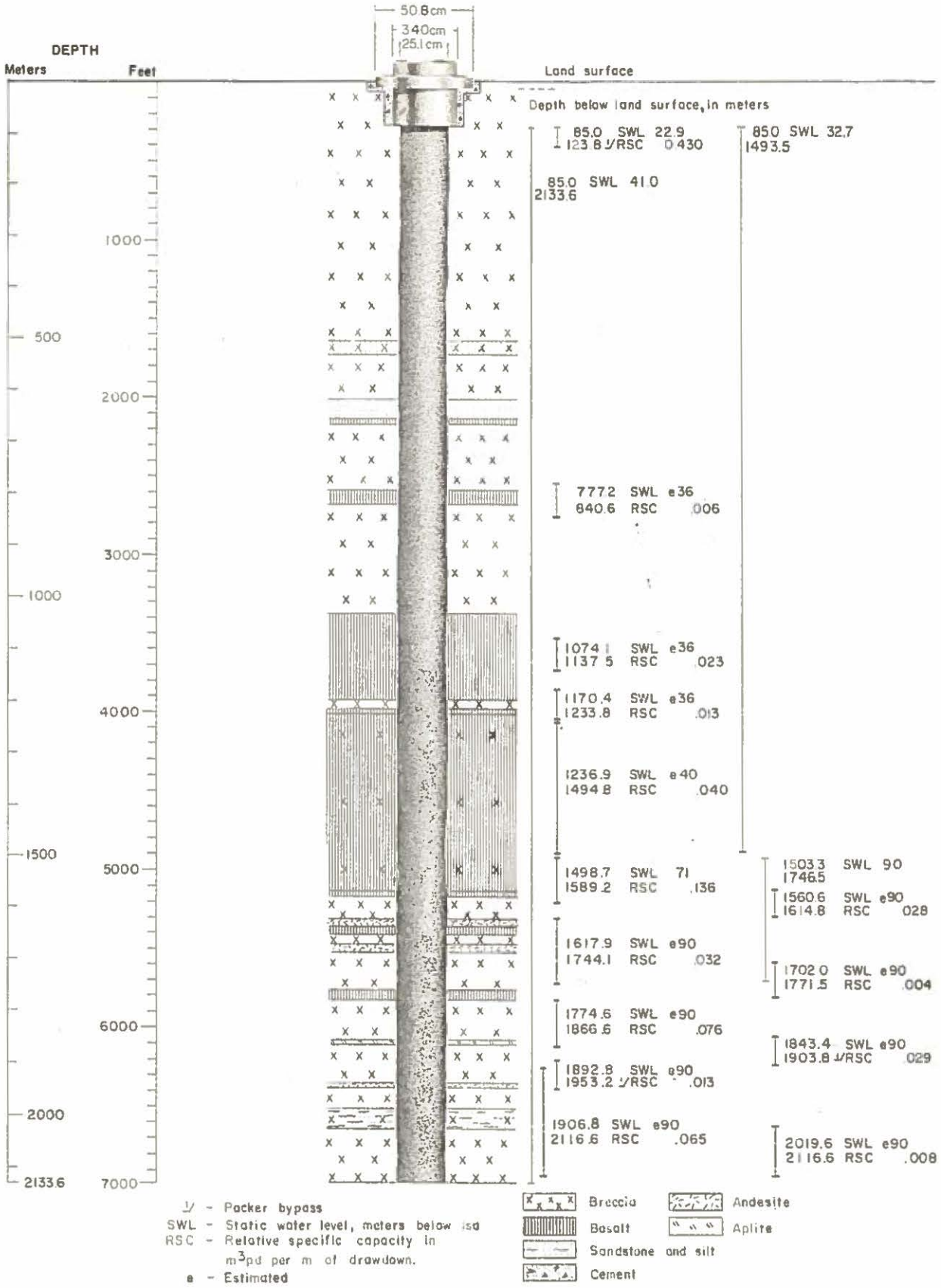

FIGURE 16.--CONSTRUCTION DIAGRAM, LITHOLOGIC LOG, AND SUMMARY OF HYDRAULIC TESTS, HOLE UAe-6h, AMCHITKA ISLAND, ALASKA.

Table 1.--Summary of hydraulic data obtained in hole UAe-6h, Amchitka Island, Alaska

Interval tested (depth below land surface)		Method of testing	Static water level below land surface		Relative specific capacity	
(m)	(ft)		(m)	(ft)	(m^3 pd per m)	(gpm per ft)
85 - 123.8	279 - 406	Injection	22.9	75.1	c0.430	c0.024
85 - 1,493.5	279 - 4,900	Jetting	32.7	107.3	--	--
85 - 2,133.6	279 - 7,000	Jetting	41.0	134.5	--	--
777.2 - 840.6	2,550 - 2,758	Injection	e36	e118	p.006	p<.001
1,074.1 - 1,137.5	3,524 - 3,732	Swabbing	e36	e118	.023	.001
1,170.4 - 1,233.8	3,840 - 4,048	Injection	e36	e118	.013	<.001
1,236.9 - 1,494.8	4,058 - 4,904	Swabbing	e40	e131	.040	.002
1,498.7 - 1,589.2	4,917 - 5,214	Injection	71.0	233.0	.136	.008
1,503.3 - 1,746.5	4,932 - 5,730	Swabbing	90.0	295.0	--	--
1,560.6 - 1,614.8	5,120 - 5,298	Swabbing	e90	e295	.028	.002
1,617.9 - 1,744.1	5,308 - 5,722	Swabbing	e90	e295	.032	.002
1,702.0 - 1,771.5	5,584 - 5,812	Swabbing	e90	e295	.004	.001
1,774.6 - 1,866.6	5,822 - 6,124	Swabbing	e90	e295	.076	.004
1,843.4 - 1,903.8	6,048 - 6,246	Swabbing	e90	e295	c.029	c.002

Table 1.--Summary of hydraulic data obtained in hole UAe-6h, Amchitka Island, Alaska--Continued

Interval tested (depth below land surface)		Method of testing	Static water level below land surface		Relative specific capacity	
(m)	(ft)		(m)	(ft)	(m^3 pd per m)	(gpm per ft)
1,892.8 - 1,953.2	6,210 - 6,408	Injection	e90	e295	c 0.013	c<0.001
1,906.8 - 2,116.6	6,256 - 6,944	Swabbing	e90	e295	.065	.004
2,019.6 - 2,116.6	6,626 - 6,944	Swabbing	e90	e295	.008	<.001

c Pressure records indicate leakage around lower packers.
e Estimated static level.
p Port may have been plugged.

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Morris, R. H., 1969, Preliminary lithologic log of drill hole UAe-6c from 0 to 6,999 feet, Amchitka Island, Alaska: U.S. Geol. Survey Rept., USGS-474-54, 4 p.; available only from U.S. Dept. Commerce, Natl. Tech. Inf. Service, Springfield, Va. 22151.

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