USGS-474-103



USGS-474-103

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

Federal Center, Lakewood, Colorado 80225

# HYDRAULIC TESTS IN HOLE UAe-2, AMCHITKA ISLAND, ALASKA

(Amchitka-12)

Date Published: June 1973

Prepared Under
Agreement No. AT(29-2)-474

for the

Nevada Operations Office
U.S. Atomic Energy Commission

Available from
Department of Commerce, National
Technical Information Service,
Springfield, Virginia 22151

Price: Printed copy $4.00; Microfiche $0.95

Amchitka-12
1973

USGS-474-103

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

Federal Center, Lakewood, Colorado 80225

# HYDRAULIC TESTS IN HOLE UAe-2, AMCHITKA ISLAND, ALASKA

By

Wilbur C. Ballance

CONTENTS



ILLUSTRATIONS

CONTENTS--Continued

ILLUSTRATIONS--Continued

CONTENTS--Continued

ILLUSTRATIONS--Continued



TABLES

Amchitka-12
1973

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

USGS-474-103

Federal Center, Lakewood, Colorado 80225

# HYDRAULIC TESTS IN HOLE UAe-2, AMCHITKA ISLAND, ALASKA

By

Wilbur C. Ballance

## ABSTRACT

Inflatable straddle packers were used to isolate and test 19 intervals ranging from 56 to 747 meters (183 to 2,450 feet) each in hole UAe-2, Amchitka Island, Alaska. 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 14.2 meters (46.6 feet) below land surface in the upper interval to 33.7 meters (110.6 feet) below land surface in one of the intervals near a depth of 1,500 meters (4,900 feet).

The specific capacity of the open hole from 83.5 to 1,980.6 meters (274 to 6,498 feet) was 3.26 cubic meters per day per meter (0.182 gallon per minute per foot) of drawdown after the hole had been jetted at an average rate of 763 cubic meters per day (140 gallons per minute) for about 41 hours. Transmissivity computed from the recovery of water level after jetting stopped was 2.97 cubic meters per day per meter (239.2 gallons per day per foot).

The relative specific capacities of isolated intervals ranged from 0.001 cubic meter per day per meter (less than 0.001 gallon per minute per foot) of drawdown to 2.765 cubic meters per day per meter (0.155 gallon per minute per foot) of drawdown.

## INTRODUCTION

Hydraulic testing and water sampling in hole UAe-2 were done during November and December 1967 and January 1968 to supplement and improve knowledge of the hydrology of Amchitka Island. 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. A lithologic log of hole UAe-2 was prepared by Snyder (1969a, b).

### Drilling and Construction of Hole UAe-2

Hole UAe-2 is located at coordinates N. 5,698,166.48 m (meters), E. 651,716.53 m, Universal Transverse Mercator Grid, Zone 60. Land surface at this site is 39.47 m or 129.5 ft (feet) above mean sea level. The hole was drilled for obtaining geologic and hydrologic information.

Drilling of the hole began on October 11, 1967. 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 9.4 m (0 to 31 ft), cemented;

34.0-cm (13$\frac{3}{8}$-in.), 0 to 83.5 m (0 to 274 ft), cemented.

The hole was drilled with a 25.1-cm ($9\frac{7}{8}$-in.) bit from the bottom of the casing to 1,981.2 m (6,500 ft), and left open. Erosion of the hole wall became a problem from 1,127.8 m (3,700 ft) to 1,981.2 m (6,500 ft). Drilling was interrupted twice so that hydraulic testing could be conducted because 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. Rock lithology and qualitative data on hydrologic conditions in the borehole are obtained from the geophysical logs. After completion of the geophysical logging, the test hole is pumped to clean suspended matter from the hole, to remove drilling fluid that may have penetrated the formations, and to measure the gross yield of water of all the rocks exposed in the well bore. Pumping generally is accomplished with a submersible pump or by lifting water from the borehole by injecting large quantities of air below the water surface, commonly termed "air jetting". During 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, intervals in the drill hole are selected for a series of injection or swabbing tests. 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 and observing the rate of decline or rise in water level resulting from this injection or withdrawal of water. From the rate of change in water levels with time, the yield of the various intervals at maximum drawdown can be computed. For intervals of low permeability the rate of decline or rise of water level was very slow. Because of the high cost of rig time, the measurements frequently had to be discontinued before static conditions were achieved. 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).

## 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 $\Delta s$ 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 capacity 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;

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.

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 injection- or swabbing-test data of permeable intervals with those values from pumping tests of the same intervals show 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 0.005 gpm per ft (gallon 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-2

Hole UAe-2 was drilled, cased, and cemented to 83.5 m (274 ft) and then deepened to 1,981.2 m (6,500 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 to 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 this pumping, the gross yield of water from all rocks exposed in the well bore was measured. Erosion of the hole wall filled the hole to 1,980.6 m (6,498 ft) and the hole was tested to this depth.

Analyses of data obtained during hydraulic tests in hole UAe-2 are presented in figures 1 through 17.

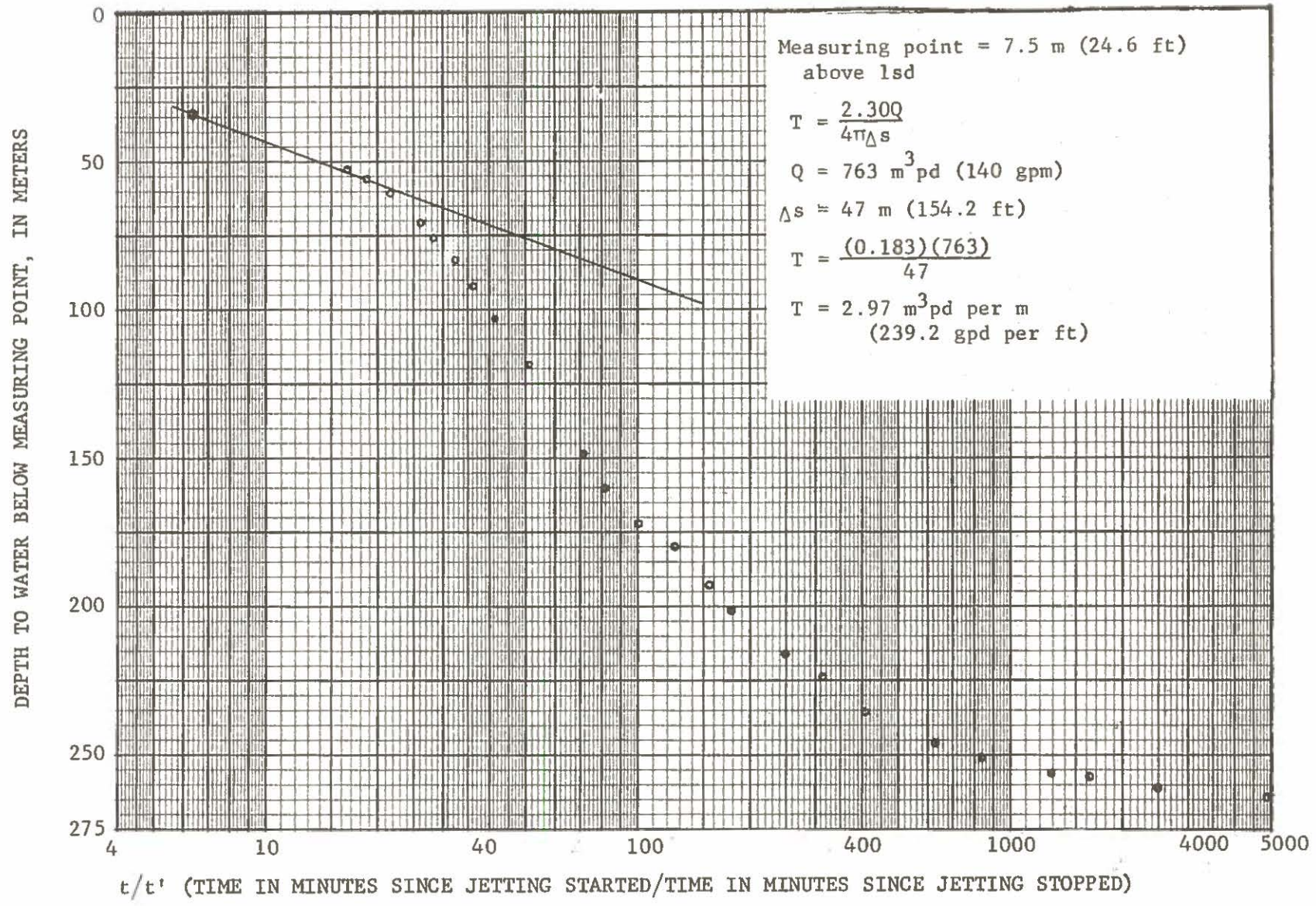


Figure 1.--Recovery of water level after jetting (air lifting water from hole) the interval from 83.5 to 1,980.6 m (274 to 6,498 ft), hole UAe-2, Amchitka Island, Alaska, January 17, 1968.

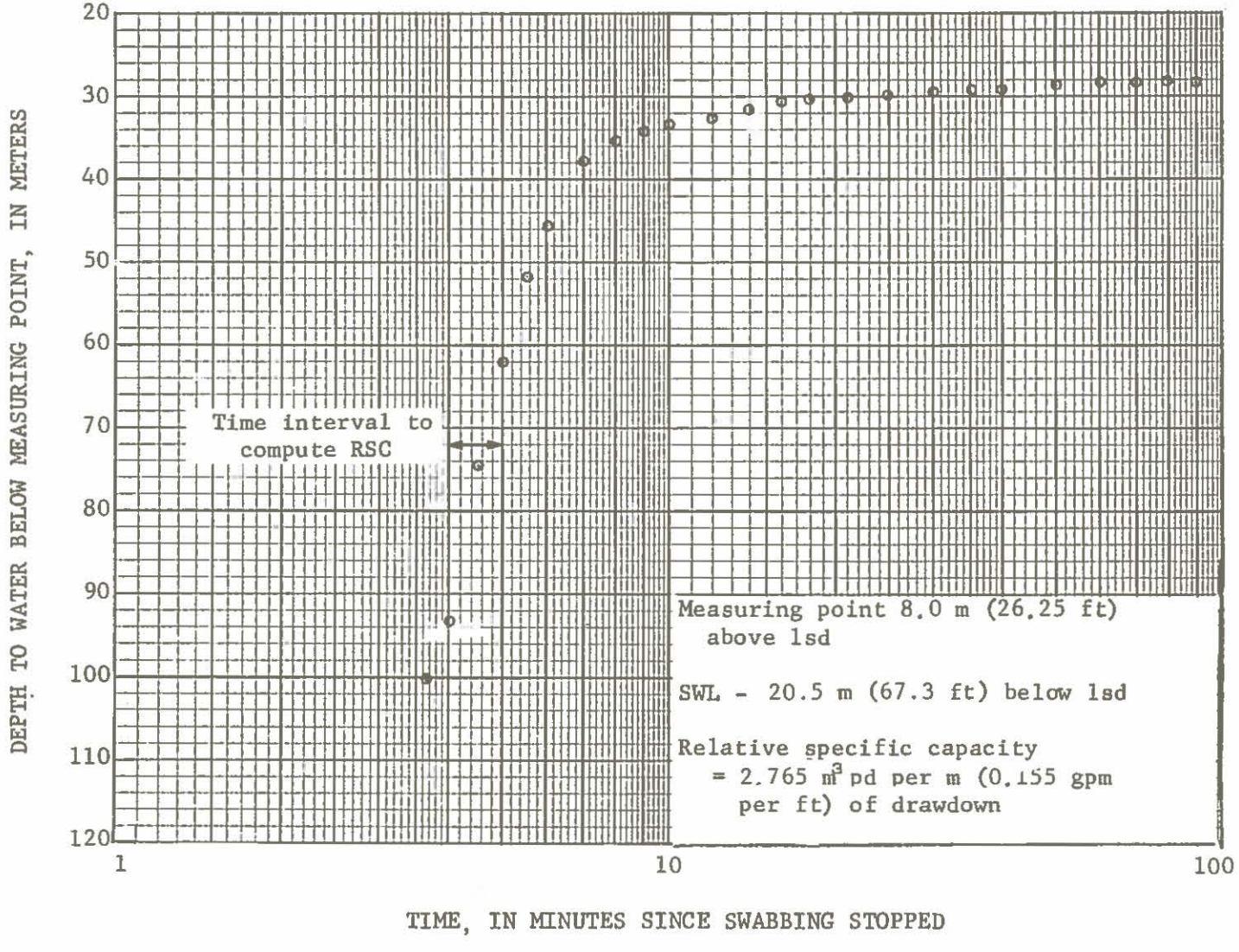


Figure 2.--Swabbing recovery test of zone 719.3 to 779.7 m (2,360 to 2,558 ft), hole UAe-2, Amchitka Island, Alaska, November 16, 1967.

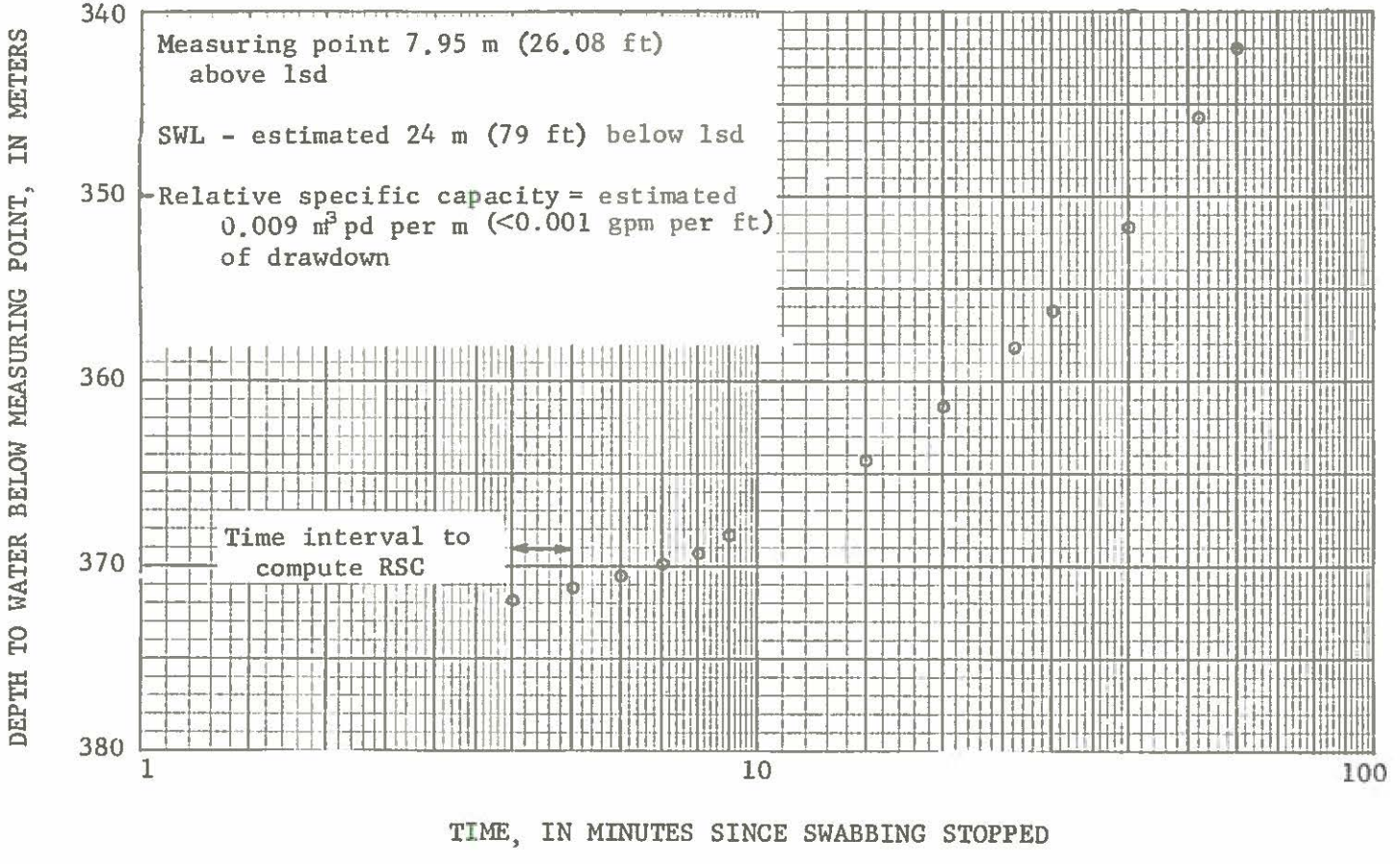


Figure 3.--Swabbing recovery test of zone 994.3 to 1,054.6 m (3,262 to 3,460 ft), hole UAe-2, Amchitka Island, Alaska, November 17, 1967.

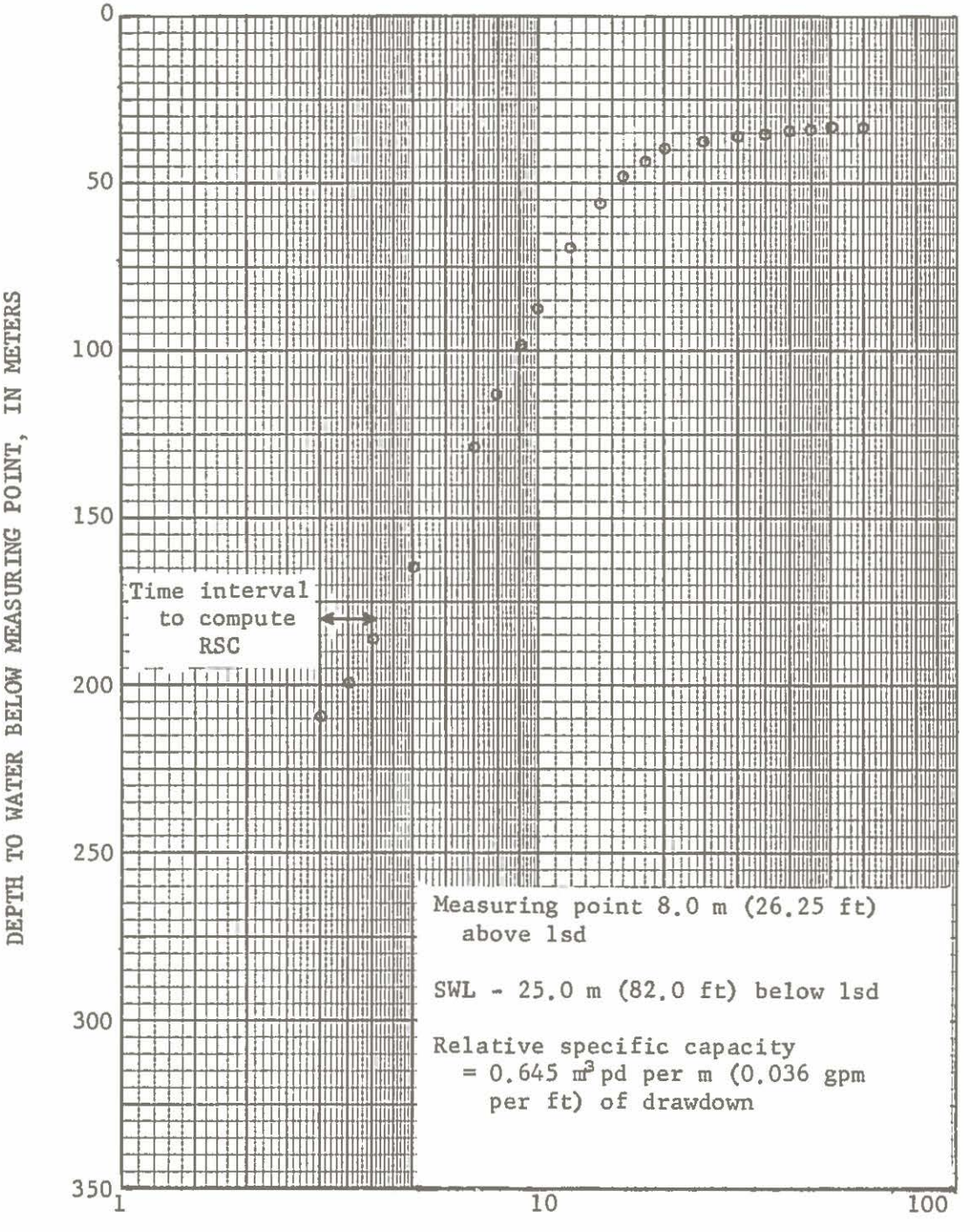


Figure 4.--Swabbing recovery test of zone 1,057.7 to 1,127.8 m (3,470 to 3,700 ft), hole UAe-2, Amchitka Island, Alaska, November 17, 1967.

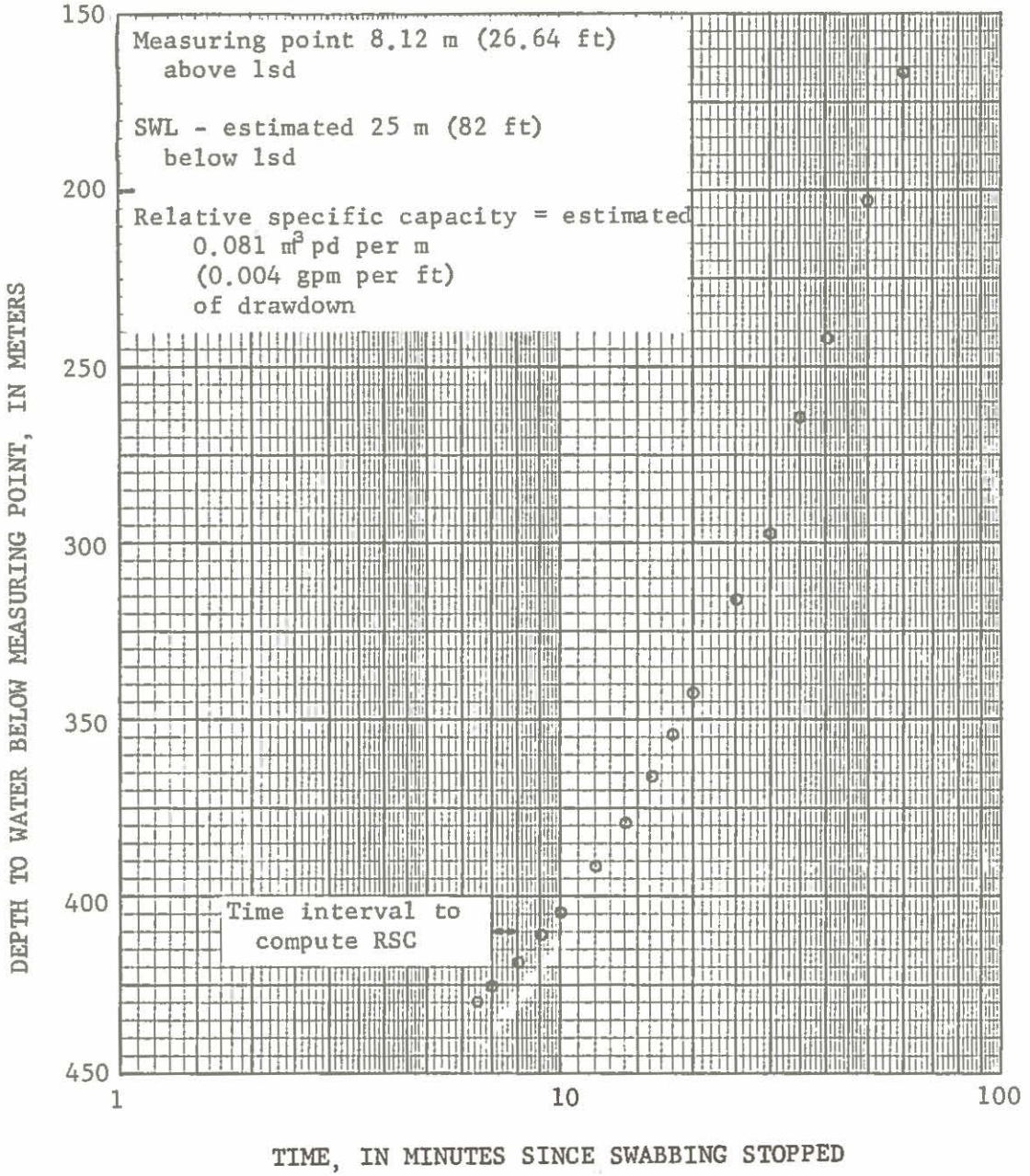


Figure 5.--Swabbing recovery test of zone 1,109.5 to 1,169.8 m (3,640 to 3,838 ft), hole UAe-2, Amchitka Island, Alaska, December 19, 1967.

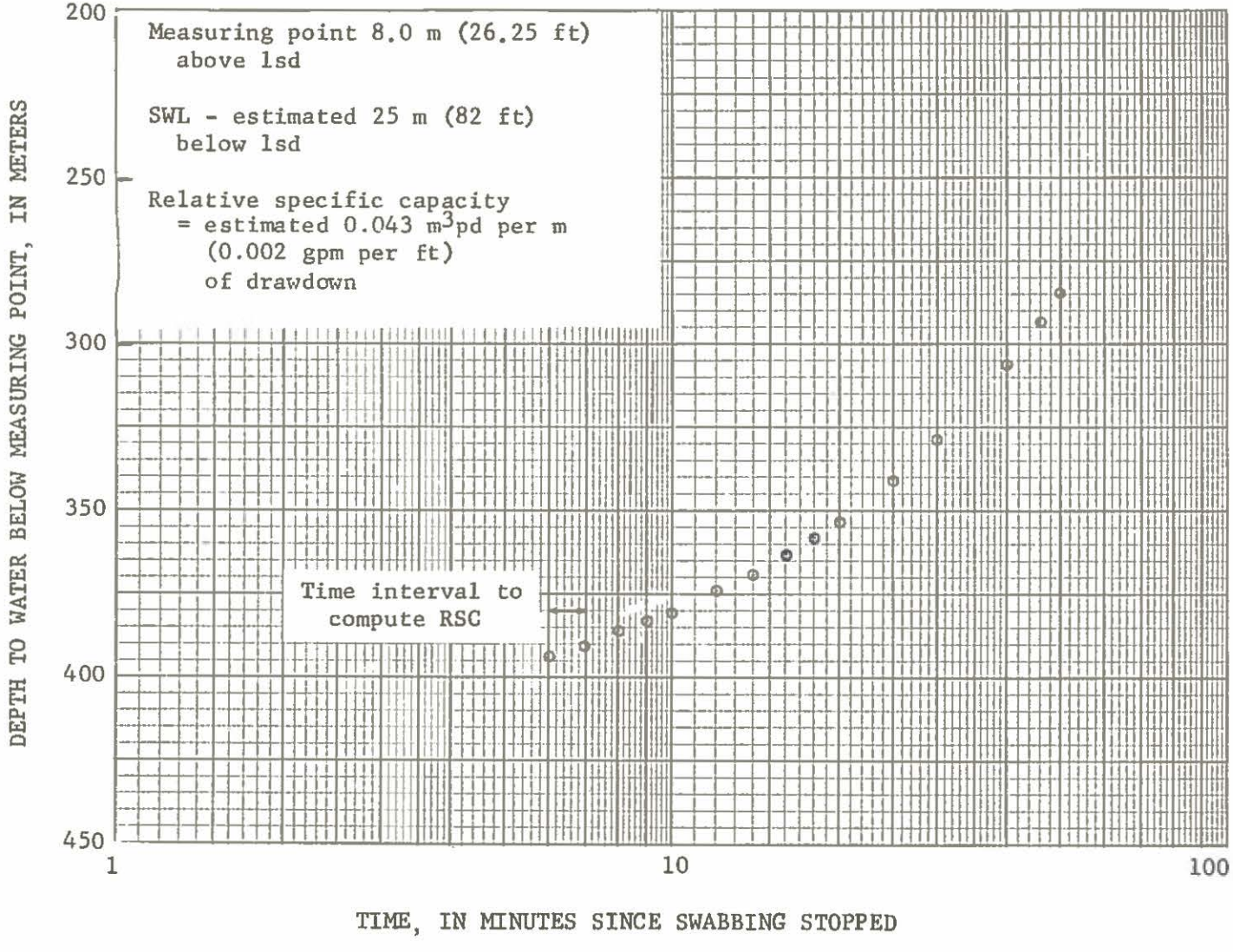


Figure 6.--Swabbing recovery test of zone 1,164.4 to 1,224.7 m (3,820 to 4,018 ft), hole UAe-2, Amchitka Island, Alaska, December 23, 1967.

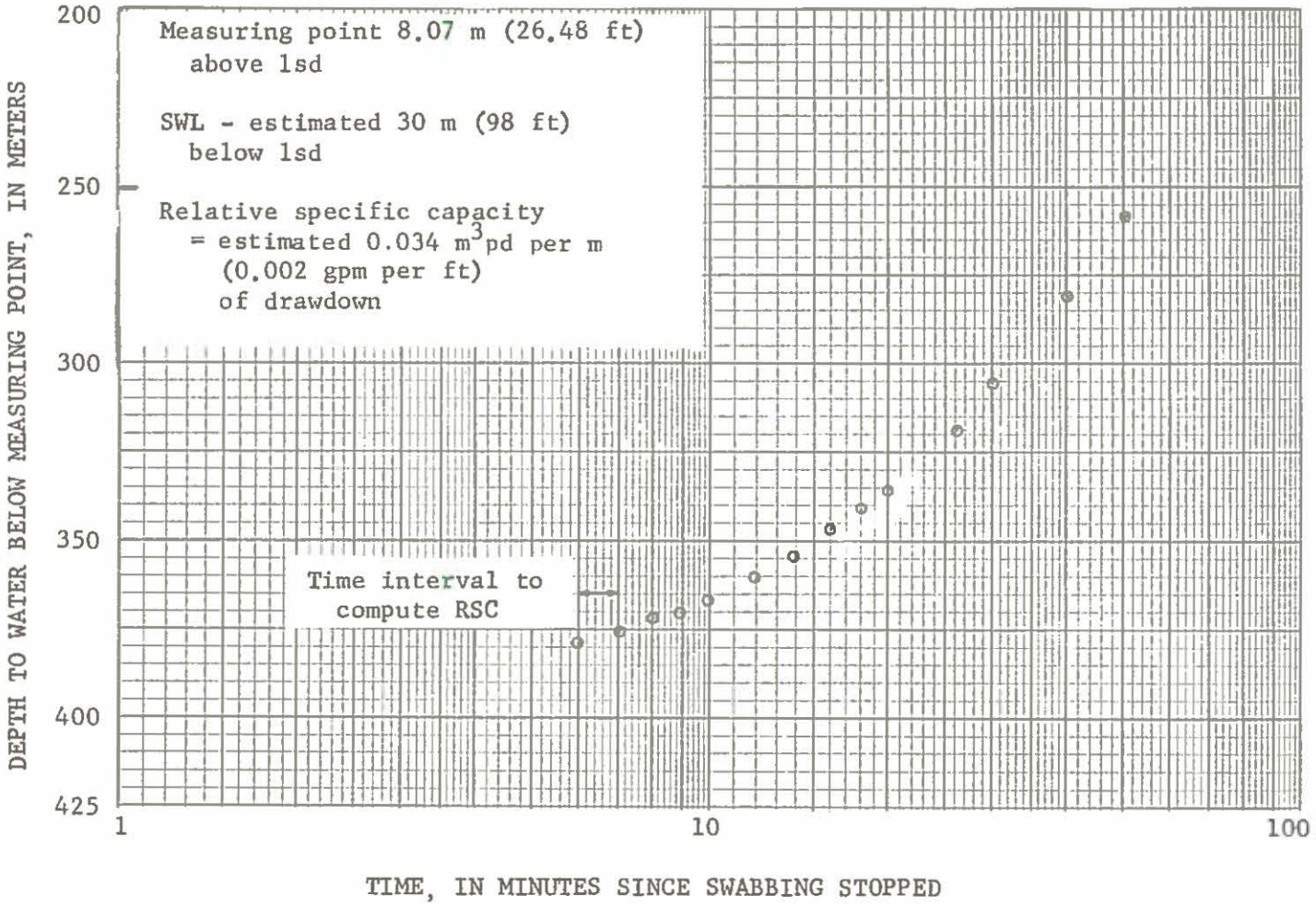


Figure 7.--Swabbing recovery test of zone 1,230.2 to 1,290.5 m (4,036 to 4,234 ft), hole UAe-2, Amchitka Island, Alaska, December 20, 1967.

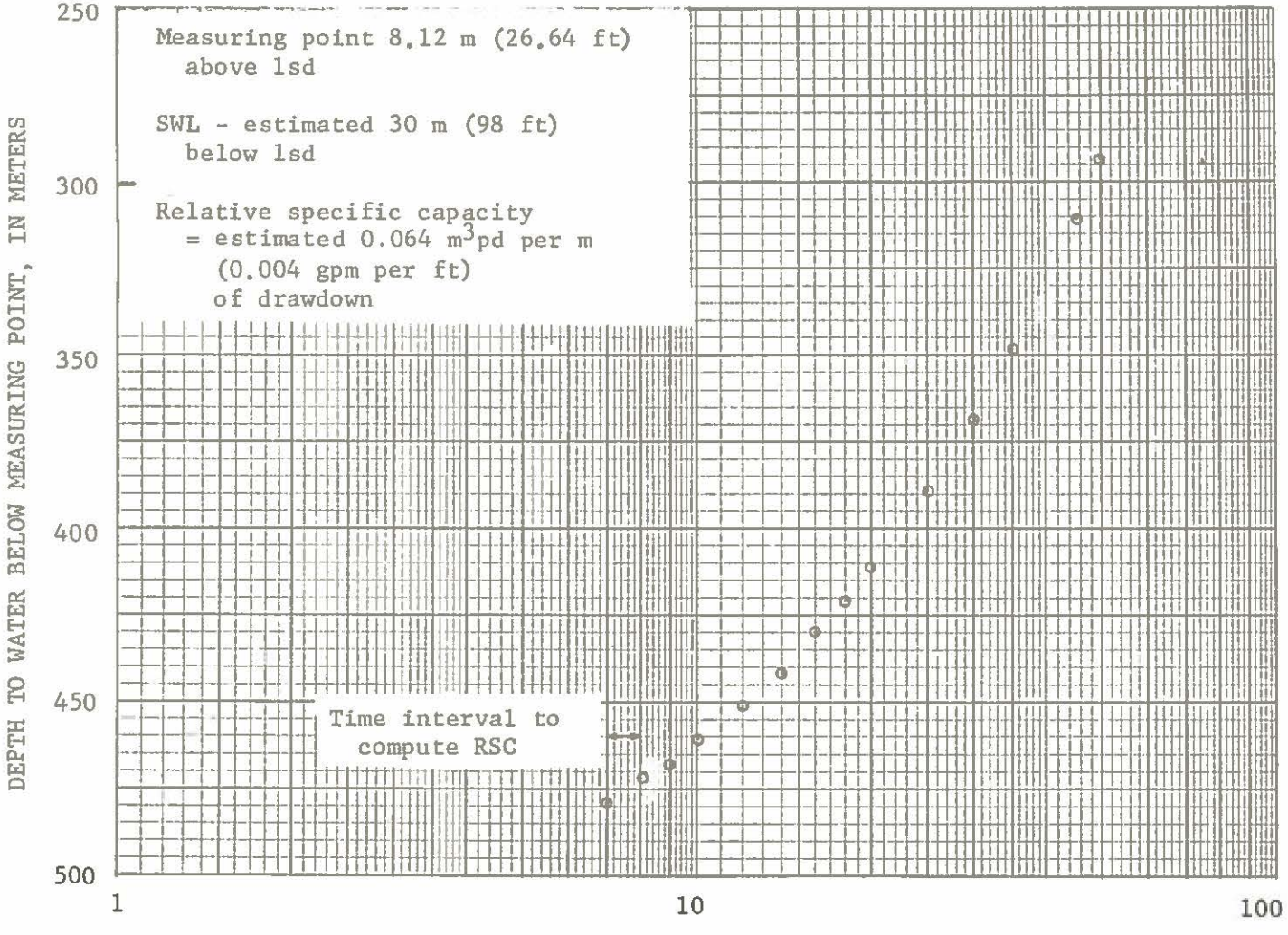


Figure 8.--Swabbing recovery test of zone 1,292.4 to 1,352.7 m (4,240 to 4,438 ft), hole UAe-2, Amchitka Island, Alaska, December 20, 1967.

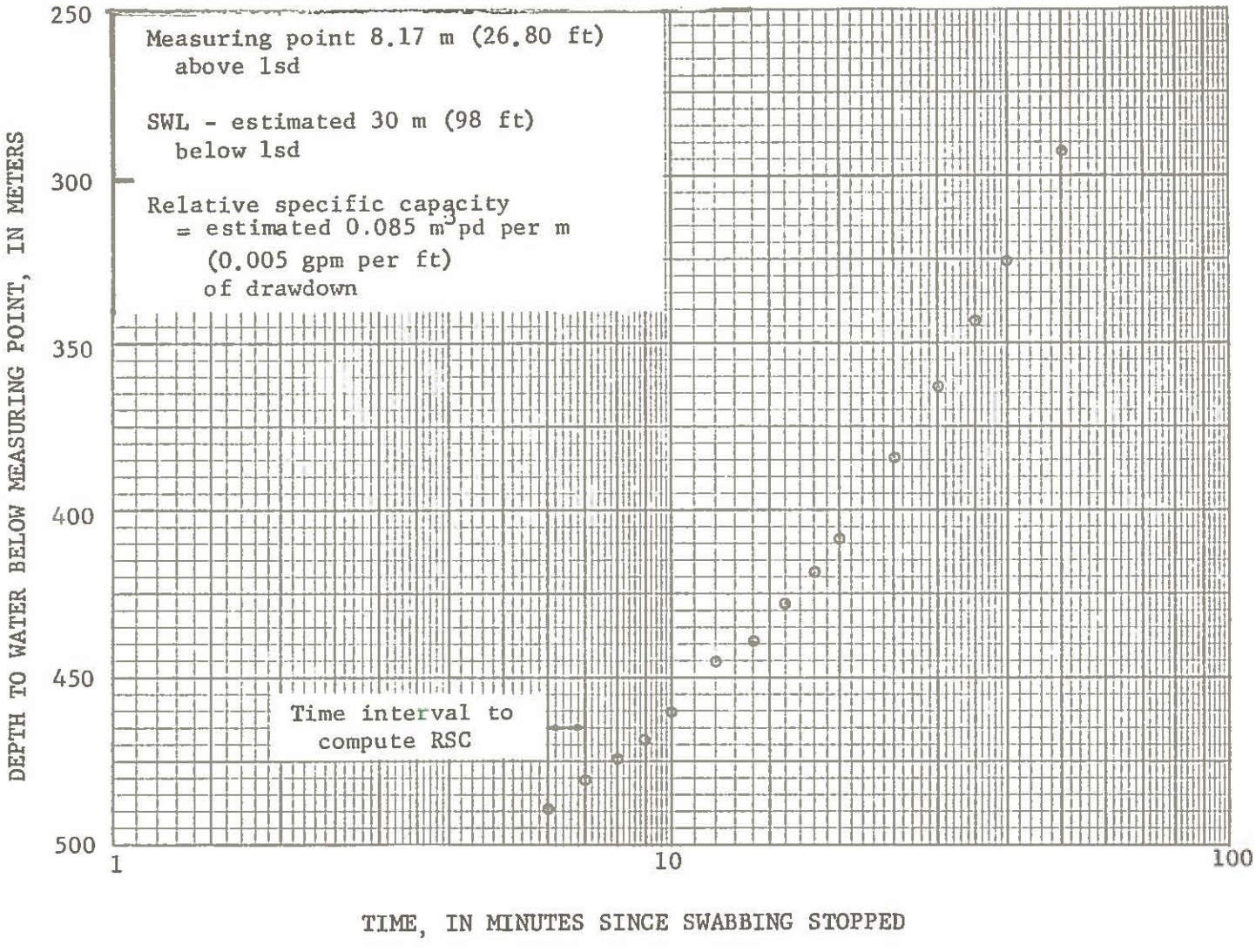


Figure 9.--Swabbing recovery test of zone 1,355.8 to 1,416.1 m (4,448 to 4,646 ft), hole UAe-2, Amchitka Island, Alaska, December 20, 1967.

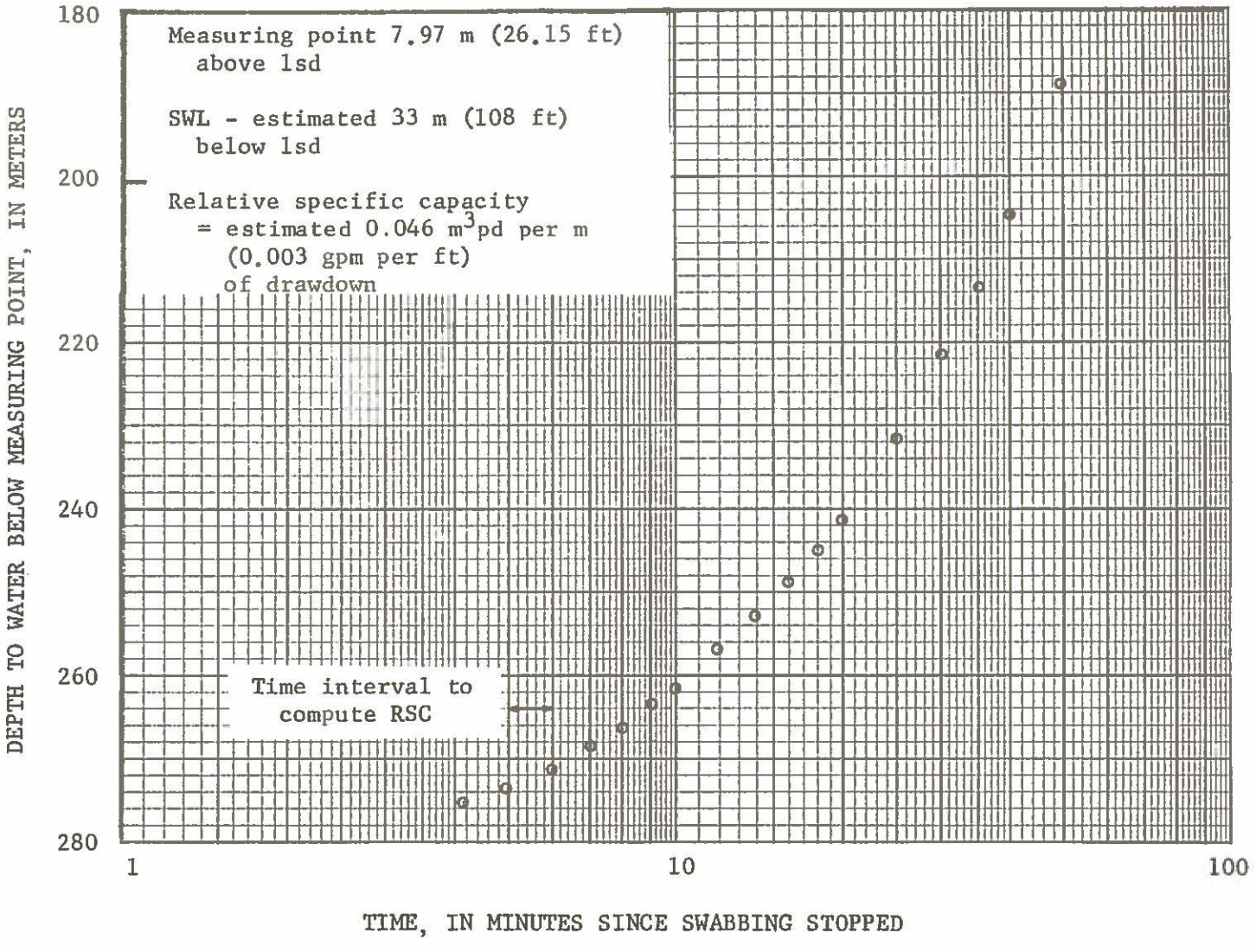


Figure 10.--Swabbing recovery test of zone 1,521.6 to 1,581.9 m (4,992 to 5,190 ft), hole UAe-2, Amchitka Island, Alaska, December 24, 1967.

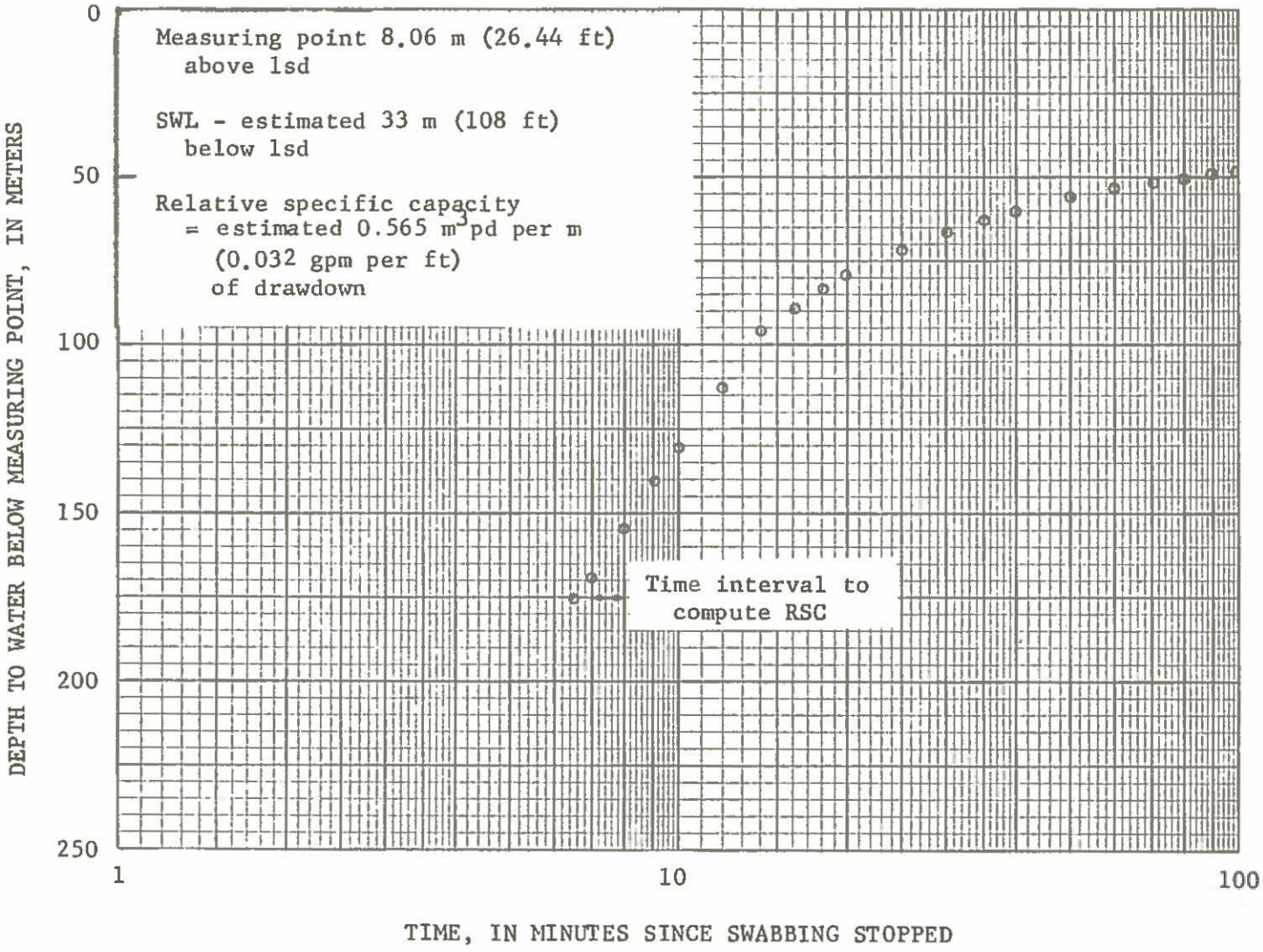


Figure 11.--Swabbing recovery test of zone 1,530.1 to 1,590.5 m (5,020 to 5,218 ft), hole UAe-2, Amchitka Island, Alaska, December 21, 1967.

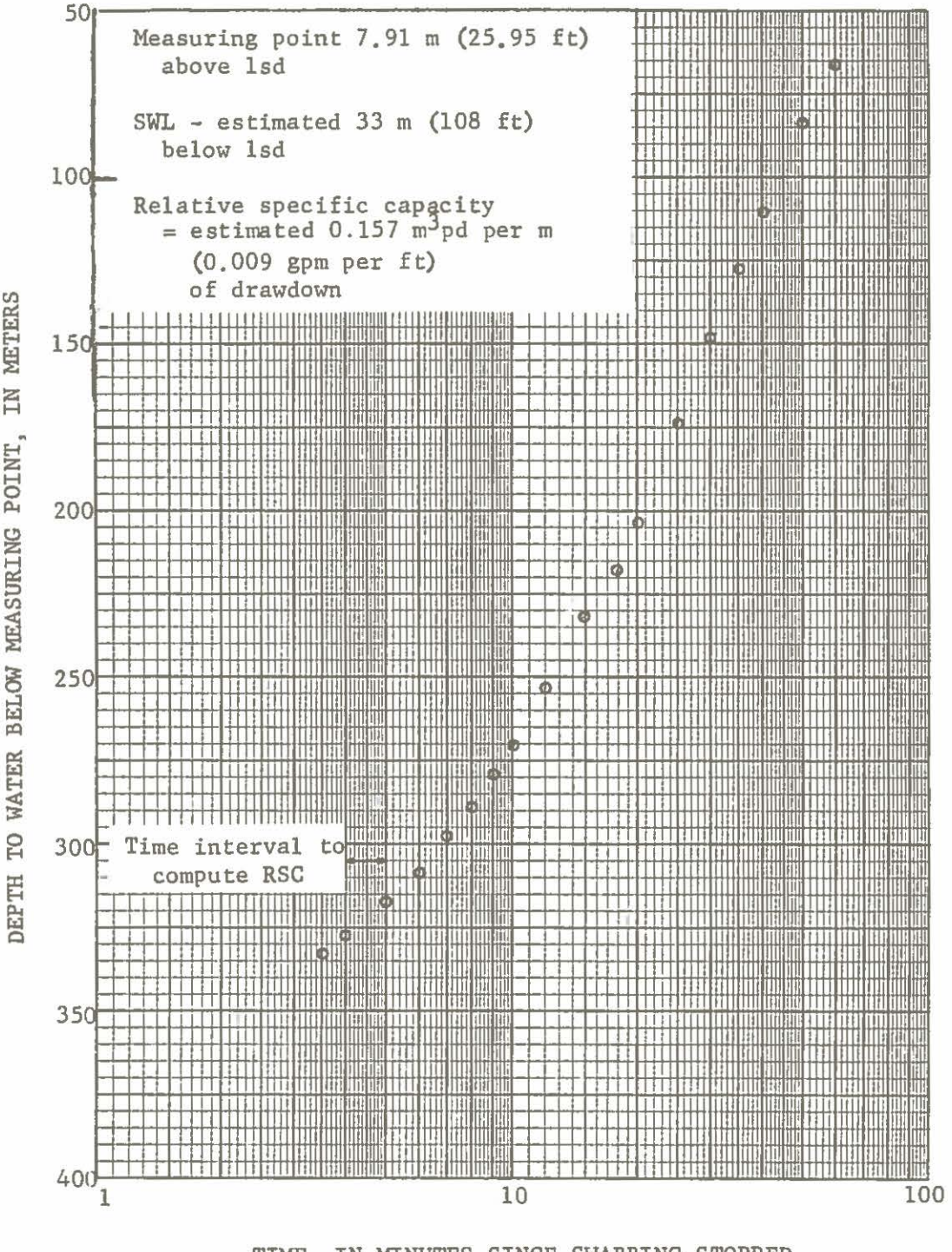


Figure 12.--Swabbing recovery test of zone 1,621.6 to 1,681.9 m (5,320 to 5,518 ft), hole UAe-2, Amchitka Island, Alaska, December 31, 1967.

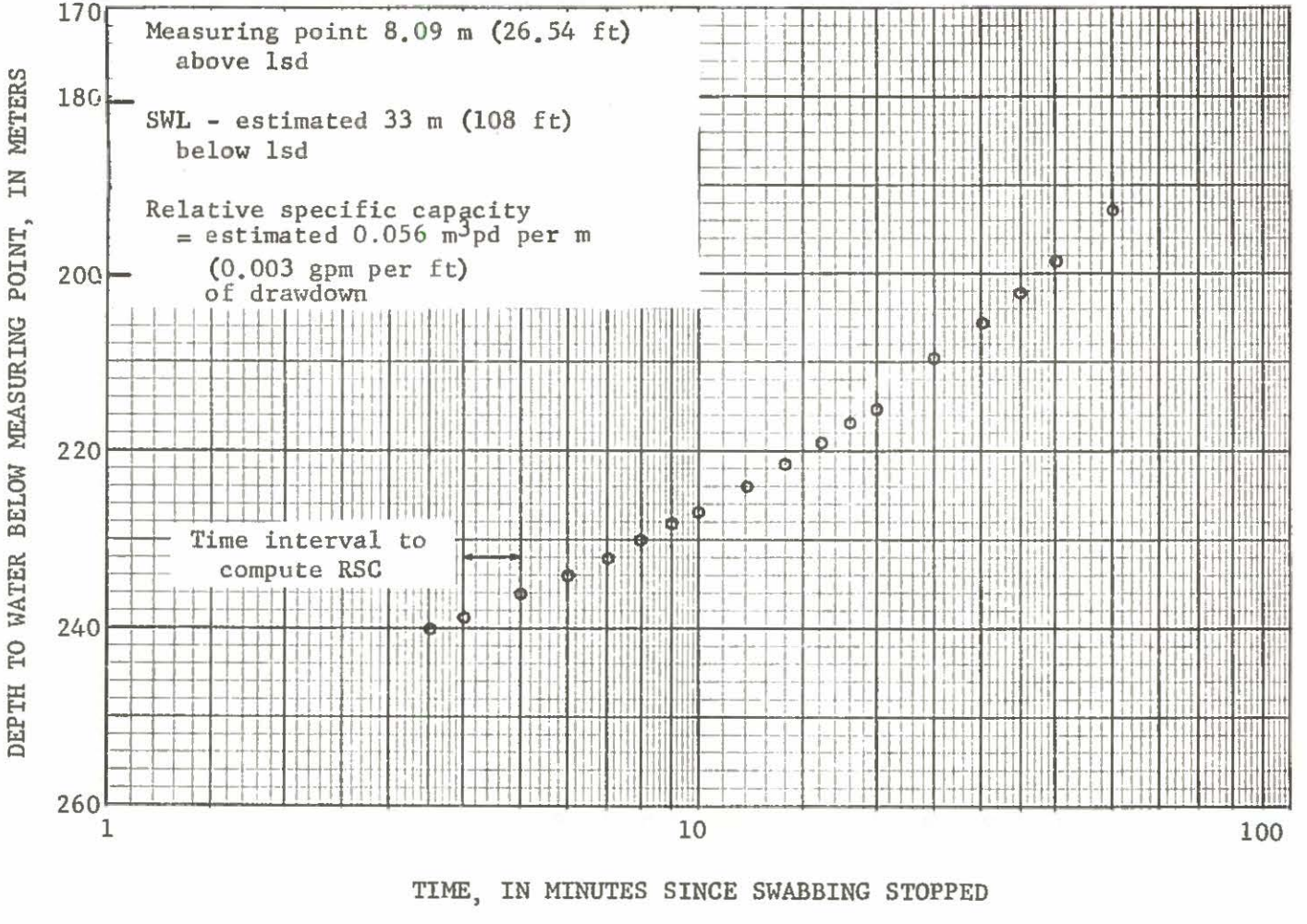


Figure 13.--Swabbing recovery test of zone 1,670.9 to 1,731.3 m (5,482 to 5,680 ft), hole UAe-2, Amchitka Island, Alaska, December 31, 1967.

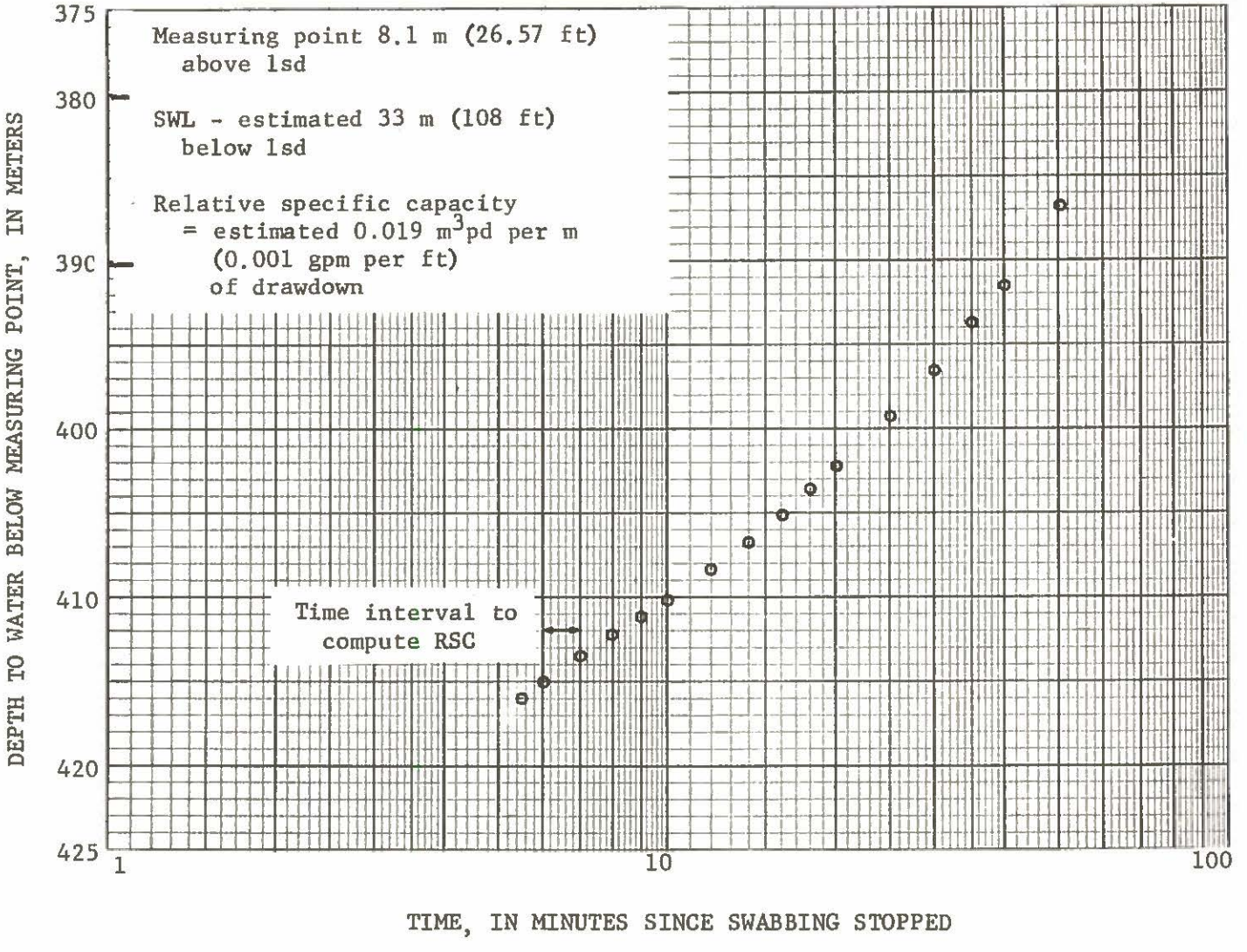


Figure 14.--Swabbing recovery test of zone 1,725.8 to 1,786.1 m (5,662 to 5,860 ft), hole UAe-2, Amchitka Island, Alaska, December 31, 1967.

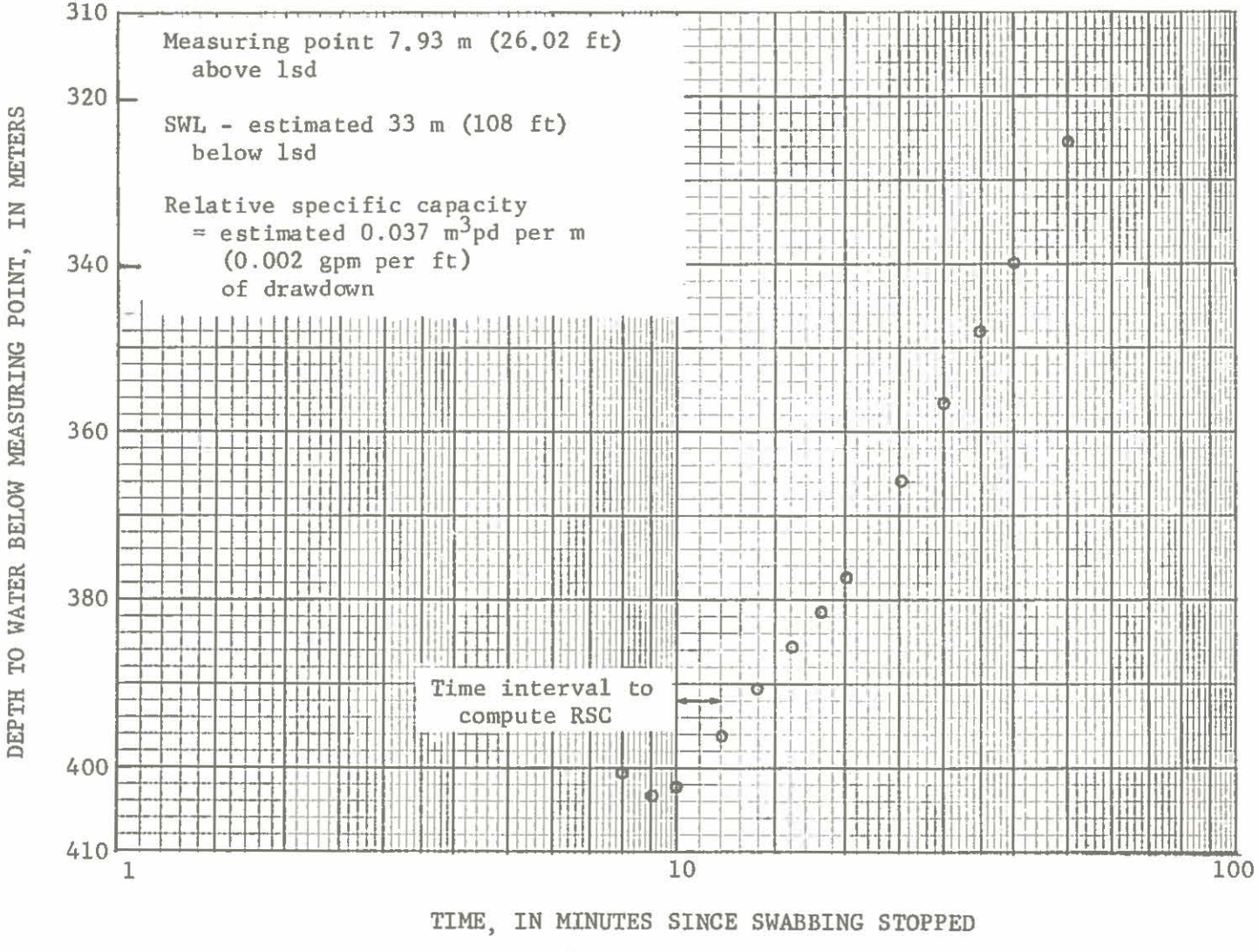


Figure 15.--Swabbing recovery test of zone 1,789.2 to 1,845.0 m (5,870 to 6,053 ft), hole UAe-2, Amchitka Island, Alaska, December 31, 1967.

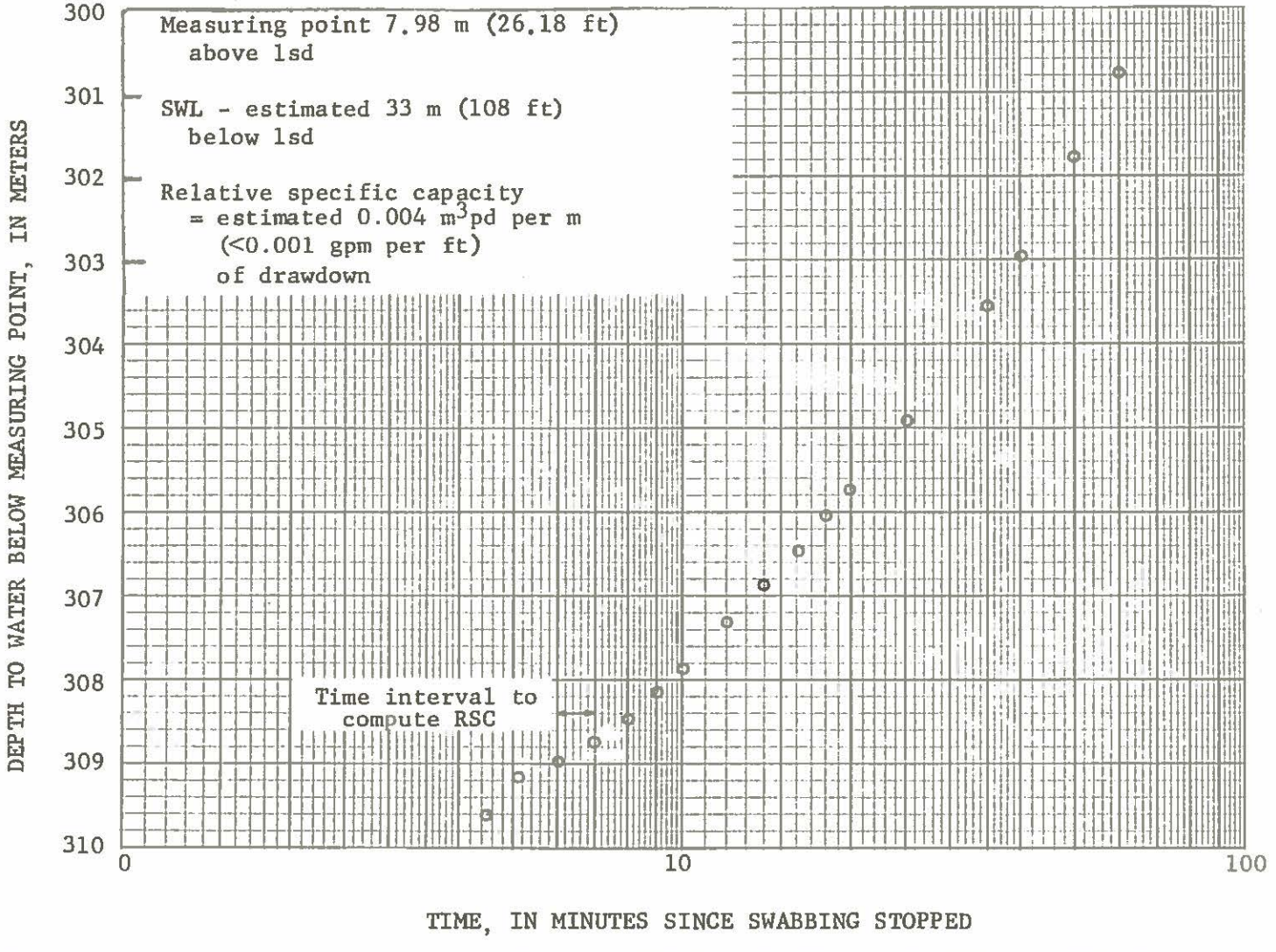


Figure 16.--Swabbing recovery test of zone 1,829.7 to 1,890.1 m (6,003 to 6,201 ft), hole UAe-2, Amchitka Island, Alaska, January 18, 1968.

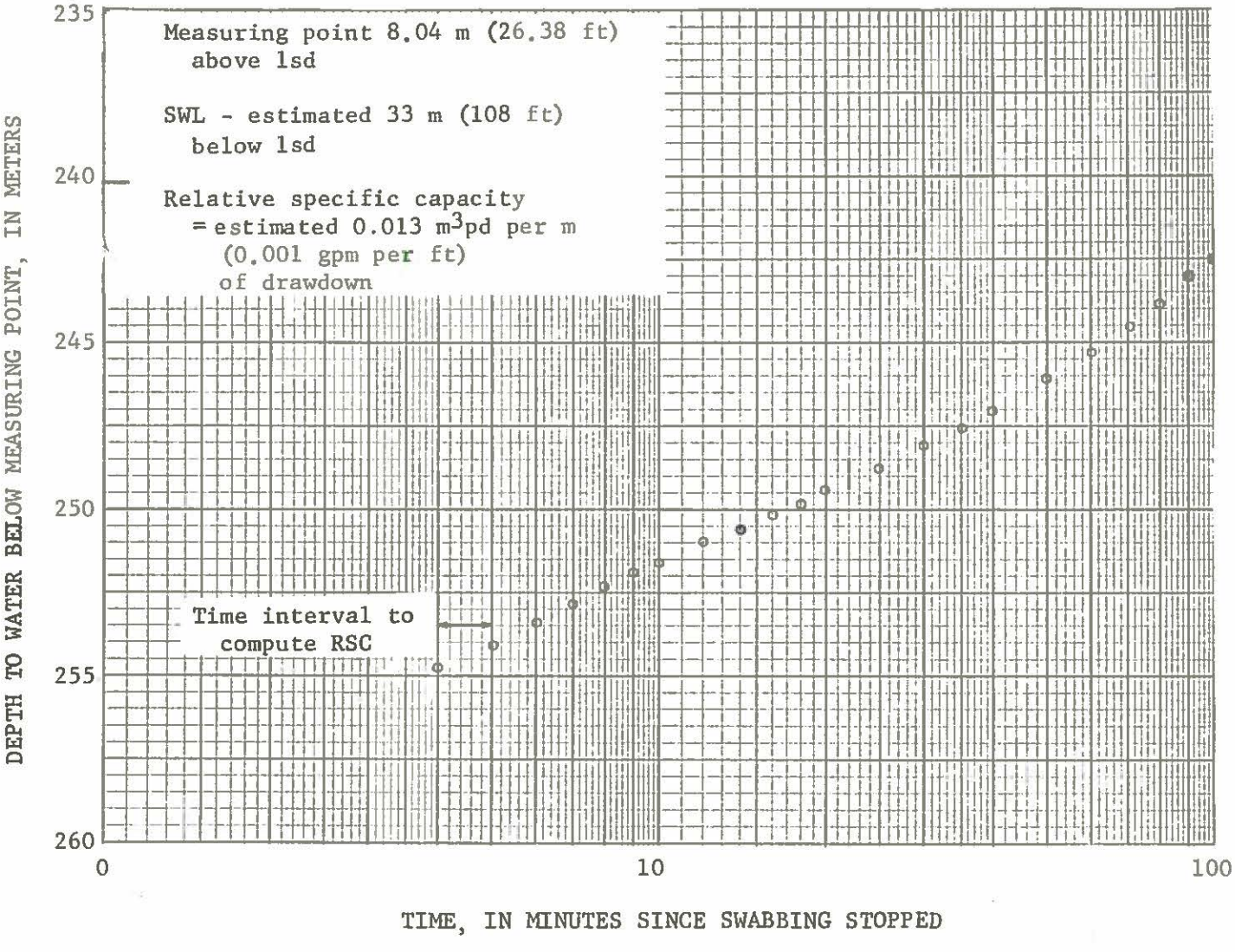


Figure 17.--Swabbing recovery test of zone 1,893.1 to 1,980.6 m (6,211 to 6,498 ft), hole UAe-2, Amchitka Island, Alaska, January 18, 1968.

## SUMMARY

Hole UAe-2 was drilled to 1,981.2 m (6,500 ft). Clear lake water was used as the drilling fluid. 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 1,127.8 m (3,700 ft), a caliper log was made and the hole was hydraulically tested to that depth. From 1,127.8 to 1,981.2 m (3,700 to 6,500 ft), drilling was interrupted every 152.4 m (500 ft) and a caliper log was made to assure that there was no excessive erosion.

Nineteen zones were tested in the hole. All zones were tested by the swabbing method. 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 18 and table 1.

The specific capacity of the hole from 83.5 to 1,980.6 m (274 to 6,498 ft) was 3.26 $m^3$pd per m (0.182 gpm per ft) of drawdown after the hole had been jetted at an average rate of 763 $m^3$pd (140 gpm) for about 41 hours. Transmissivity computed from the recovery of water level after jetting stopped was 2.97 $m^3$pd per m (239.2 gpd per ft).

The static water levels in the intervals tested ranged from 14.2 m (46.6 ft) below land surface in the upper interval tested to 33.7 m (110.6 ft) below land surface in one of the intervals near a depth of 1,500 m (4,900 ft). 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. These water levels were based on those water levels obtained from the more permeable zones. The water levels were not corrected for temperature and density of water in the hole.

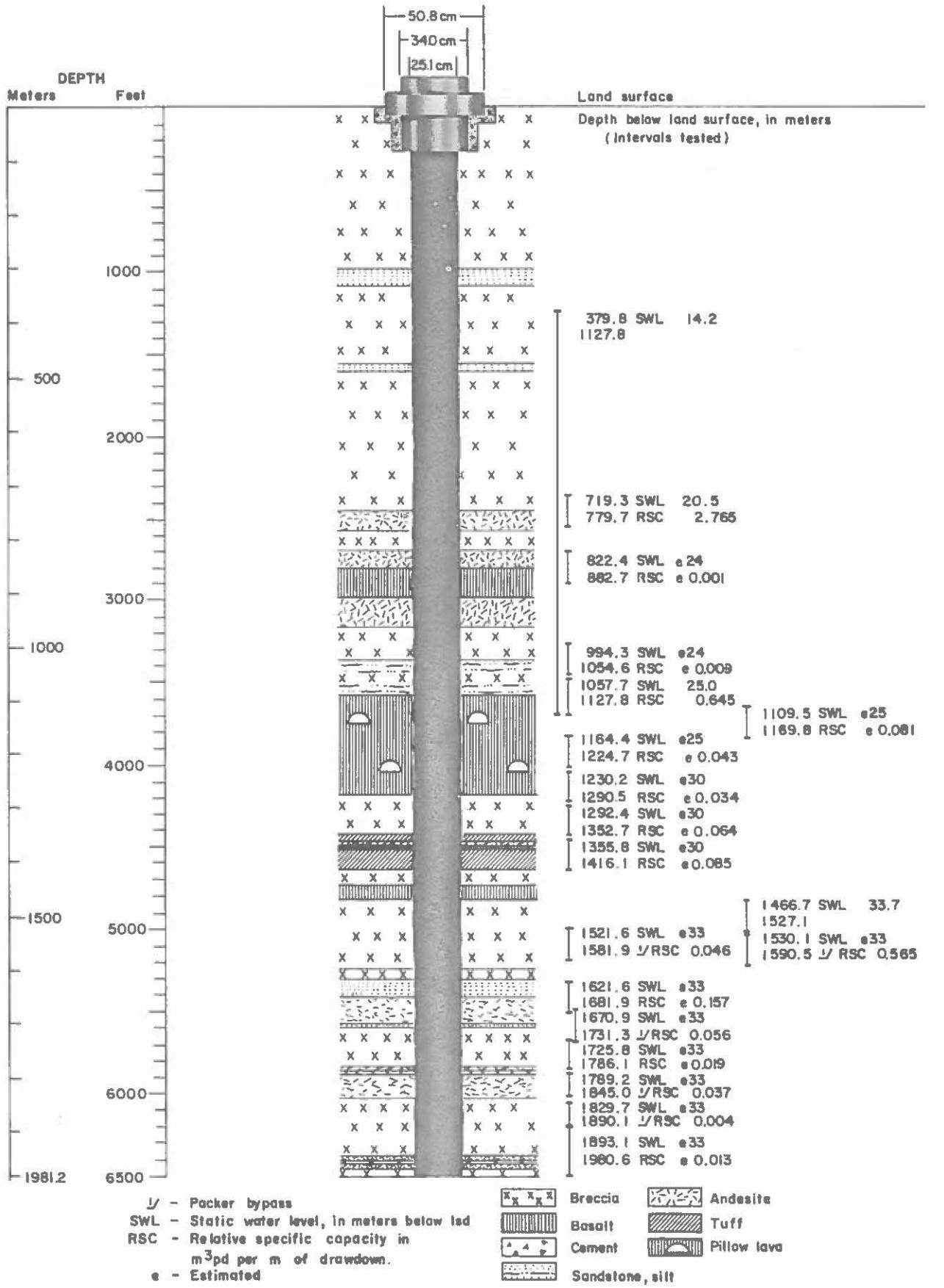


FIGURE 18.--CONSTRUCTION DIAGRAM, LITHOLOGIC LOG, AND SUMMARY OF HYDRAULIC TESTS, HOLE UAe-2, AMCHITKA ISLAND, ALASKA.

Table 1.--Summary of hydraulic data obtained in hole UAe-2, 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 of dd | gpm per ft of dd |
| 379.8-1,126.6 | 1,246-3,696 | Swabbing | 14.2 | 46.6 | -- | -- |
| 719.3-779.7 | 2,360-2,558 | Swabbing | 19.5 | 64.0 | 2.765 | 0.155 |
| 822.4-882.7 | 2,698-2,896 | Swabbing | e24 | e79.0 | .001 | <.001 |
| 994.3-1,054.6 | 3,262-3,460 | Swabbing | e24 | e79.0 | .009 | <.001 |
| 1,057.7-1,127.8 | 3,470-3700 | Swabbing | 25.0 | 82.0 | .645 | .036 |
| 1,109.5-1,169.8 | 3,640-3,838 | Swabbing | e25 | e82 | .081 | .004 |
| 1,164.4-1,224.7 | 3,820-4,018 | Swabbing | e25 | e82 | .043 | .002 |
| 1,230.2-1,290.5 | 4,036-4,234 | Swabbing | e30 | e98 | .034 | .002 |
| 1,292.4-1,352.7 | 4,240-4,438 | Swabbing | e30 | e98 | .064 | .004 |
| 1,355.8-1,416.1 | 4,448-4,646 | Swabbing | e30 | e98 | .085 | .005 |
| 1,466.7-1,527.1 | 4,812-5,010 | Swabbing | 33.7 | 110.6 | -- | -- |
| 1,521.6-1,581.9 | 4,992-5,190 | Swabbing | e33 | e108 | c.046 | c.003 |
| 1,530.1-1,590.5 | 5,020-5,218 | Swabbing | e33 | e108 | c.565 | c.031 |

Table 1.--Summary of hydraulic data obtained in hole UAe-2, 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 of dd | gpm per ft of dd |
| 1,621.6-1,681.9 | 5,320-5,518 | Swabbing | e33 | e108 | 0.157 | 0.009 |
| 1,670.9-1,731.3 | 5,482-5,680 | Swabbing | e33 | e108 | c.056 | c.003 |
| 1,725.8-1,786.1 | 5,662-5,860 | Swabbing | e33 | e108 | .019 | .001 |
| 1,789.2-1,845.0 | 5,870-6,053 | Swabbing | e33 | e108 | c.037 | c.002 |
| 1,829.7-1,890.1 | 6,003-6,201 | Swabbing | e33 | e108 | c.004 | c<.001 |
| 1,893.1-1,980.6 | 6,211-6,498 | Swabbing | e33 | e108 | .013 | .001 |

NOTE: Static water levels were not corrected for temperature and density of water in the hole.

EXPLANATION

m - meters
ft - feet
$m^3$ pd - cubic meters per day
dd - drawdown
gpm - gallons per minute
e - estimated
c - pressure records indicate leakage around lower packers

## REFERENCES

Blankennagel, R. K., 1967, Hydraulic testing techniques of deep drill holes at Pahute Mesa, Nevada Test Site: U.S. Geol. Survey open-file rept., 50 p.

Snyder, R. P., 1969a, Preliminary lithologic log of drill hole UAe-2 from 0 to 3,580 feet, Amchitka Island, Alaska: U.S. Geol. Survey Rept. USGS-474-52, 3 p.; available only from U.S. Dept. Commerce, Natl. Tech. Inf. Service, Springfield, Va. 22151.

_____1969b, Preliminary lithologic log of drill hole UAe-2 from 3,580 feet to 6,500 feet (T.D.): U.S. Geol. Survey Rept. USGS-474-53, 3 p ; available only from U.S. Dept. Commerce, Natl. Tech. Inf. Service, Springfield, Va. 22151.

Distribution:

U.S. Atomic Energy Commission, Nevada Operations Office, Las Vegas, Nevada:

W. R. Cooper
E. M. Douthett (3)
M. E. Gates, c/o R. R. Loux (2)
D. M. Hamel (3)
D. W. Hendricks
R. R. Loux (20)
Roger Ray
W. D. Smith, Jr.
R. H. Thalgott
H. G. Vermillion (3)

U.S. Atomic Energy Commission, Nevada Test Site Support Office, Mercury, Nevada:

D. T. Schueler

U.S. Atomic Energy Commission, Mercury, Nevada:

CETO Library

U.S. Atomic Energy Commission, Washington, D.C.:

M. B. Biles (2)
F. A. Camm (2)
R. J. Catlin
J. A. Harris, Jr.
G. W. Johnson
J. H. Rubin

U.S. Atomic Energy Commission, Technical Information Center, Oak Ridge, Tennessee: (2)

Defense Nuclear Agency:

Director (Attn: SPSS, John Lewis, Clifford McFarland), Washington, D.C.
Commander, Field Command (Attn: Dr. Benjamin Grote), Kirtland AFB, New Mexico
O-I-C Liaison Office, Las Vegas, Nevada

Los Alamos Scientific Laboratory, Los Alamos, New Mexico:

Robert Bradshaw
C. I. Browne
Robert Brownlee
E. A. Bryant
R. H. Campbell
R. W. Newman
R. R. Sharp, Jr.

Lawrence Livermore Laboratory, Livermore, California:

R. E. Batzel
J. E. Carothers
P. E. Coyle
D. O. Emerson
L. S. Germain
Alfred Holzer
A. E. Lewis
L. D. Ramspott
H. C. Rodean
D. L. Springer
Technical Information Division (3)
G. C. Werth

Lawrence Livermore Laboratory, Mercury, Nevada:

R. D. McArthur

Sandia Laboratories, Albuquerque, New Mexico:

J. R. Banister
C. D. Broyles
M. L. Merritt
W. C. Vollendorf
W. D. Weart

NVOO Panel of Consultants:

L. K. Bustad, University of California, Davis, California
Joseph Lintz, University of Nevada, Reno, Nevada
Vincent Schultz, Washington State University, Pullman, Washington
T. F. Thompson, 2845 Rivera Drive, Burlingame, California
L. G. von Lossberg, Sheppard T. Powell & Associates, Baltimore, Maryland
P. A. Witherspoon, University of California, Berkeley, California

Advanced Research Projects Agency, Arlington, Virginia:

S. J. Lukasik

Battelle Columbus Laboratories:

V. Q. Hale, Las Vegas, Nevada
J. B. Kirkwood, Columbus, Ohio

Desert Research Institute:

P. R. Fenske, Reno, Nevada
G. B. Maxey, Las Vegas, Nevada

Environmental Protection Agency, Office of Water Programs:

Regional Director, Portland, Oregon
R. C. Scott, San Francisco, California

Environmental Protection Agency, National Environmental Research Center, Las Vegas, Nevada:

D. S. Barth

Environmental Research Corporation, Las Vegas, Nevada:

M. C. Erikson

Fenix & Scisson, Inc.:

Grant Bruesch, Mercury, Nevada
M. H. May, Las Vegas, Nevada

Holmes & Narver, Inc., Las Vegas, Nevada:

F. M. Drake

National Oceanic and Atmospheric Administration, Air Resources Laboratory, Las Vegas, Nevada:

H. F. Mueller

National Oceanic and Atmospheric Administration, Earth Sciences Laboratory, Las Vegas, Nevada:

K. W. King

National Oceanic and Atmospheric Administration, Environmental Research Laboratories:

Don Tocher, San Francisco, California
E. R. Engdahl, Boulder, Colorado

National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Auke Bay, Alaska:

T. R. Merrell, Jr.

University of Washington, Seattle, Washington:

E. E. Held
J. S. Isakson

U.S. Army Corps of Engineers, Alaska District, Anchorage, Alaska:

District Engineer

U.S. Army Corps of Engineers, Waterways Experiment Station, Vicksburg, Mississippi:

Library

U.S. Bureau of Mines, Denver, Colorado:

P. L. Russell

U.S. Department of Interior, Bureau of Sport Fisheries and Wildlife, Anchorage, Alaska:

C. E. Abegglen

U.S. Geological Survey:

Library, Denver, Colorado
Library, Menlo Park, California
Library, Washington, D.C.

U.S. Geological Survey, Mercury, Nevada:

Geologic Data Center (15)

U.S. Geological Survey, Washington, D.C.:

Chief Hydrologist, WRD (Attn: Radiohydrology Section)
Military Geology Branch
R. B. Raup