DESCRIPTION OF SCHNEBLY CREEK

TEST WELL #16 NEAR

ELLENSBURG, WASHINGTON

by Charles S. Cline

November 1980

Open-File Technical Report 80-01

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TABLE OF CONTENTS

ILLUSTRATIONS

LIST OF TABLES

DESCRIPTION OF SCHNEBLY CREEK TEST WELL #16

Abstract

Test-observation well #16 was drilled to 920 feet by the Washington State Department of Ecology near Schnebly Creek, approximately 10 miles northeast of Ellensburg, Washington. The well is the twelfth drilled to date under the Department's test-observation well drilling program, the purpose of which is to gain geologic and hydrologic data in areas where none are available.

The test well penetrated overburden of alluvium, sidestream facies of the Thorp Gravel, and interbedded gravels, sand, and clay of the Ellensburg and basalt of the Grande Ronde Formations. Water was encountered at various levels; the two primary aquifers were capable of producing from 1600 to 2400 gallons per minute (gpm).

Introduction

Farmland within the Kittitas Valley adjacent to Ellensburg is primarily irrigated by canal water either from the Highline, Cascade, or Town canals. The various creek waters draining the highlands are also appropriated for irrigation, but predominantly for lands south of the Highline Canal. Lands north of the Highline Canal are dependent on the creeks, direct precipitation, or on irrigation wells which are presently few in number. Drought conditions in the immediate past have awakened the need for more wells in this area.

Because few irrigation wells have been drilled to the east and northeast of Ellensburg, little information is available concerning the geology or hydrology of this area. Specific information required for the effective management and conservation of ground water includes data on the number and extent of good quality aquifers at moderate and greater depths, aquifer yields, water quality, and static water levels or pressures.

To add to the ground-water information in the area, a test-observation well was drilled 1,100 feet north and 550 feet west of the SE corner of Section 34, Township 19 North, Range 19 East Willamette Meridian at an elevation of 2,260 feet above mean sea level (Figures 1 and 2). Construction began in May and continued through December of 1978.

The purpose of this well was to explore the geology and water-bearing characteristics of the various aquifers that might be encountered and to provide for placement of piezometers to monitor ground-water levels in all major water-bearing zones within practical drilling depth. The aquifers would be pump-tested as each was encountered during the drilling of the well. Either a step-drawdown or continuous discharge test would be conducted and the water levels monitored during the drawdown and later during the recovery stages of each test. The well would be constructed to allow for placement of a turbine pump of a diameter capable of stressing the aquifers to the maximum.

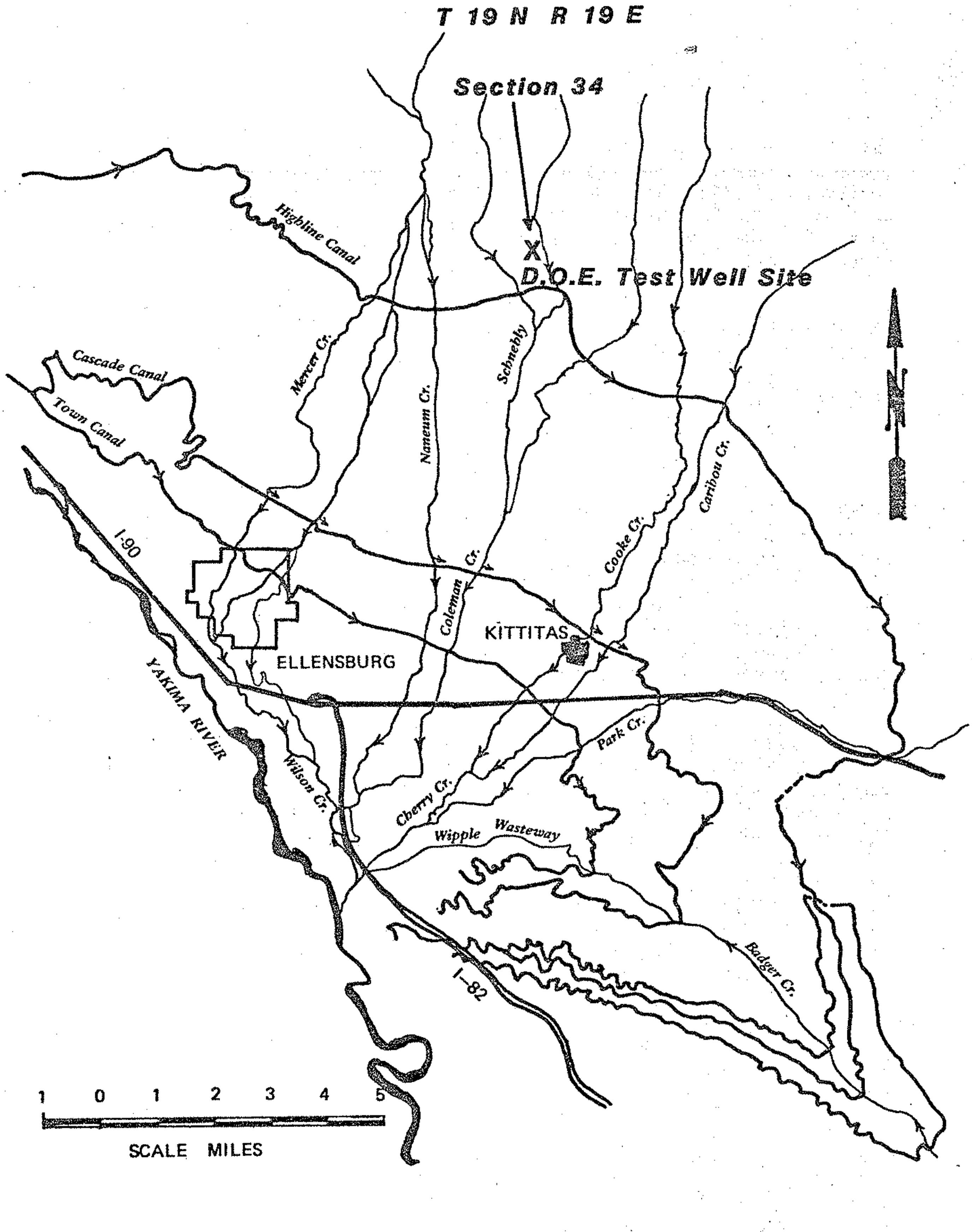


Figure 1. INDEX MAP SHOWING LOCATION OF SCHNEBLY CREEK (ELLENSBURG) TEST - OBSERVATION WELL AND SURROUNDING AREA.

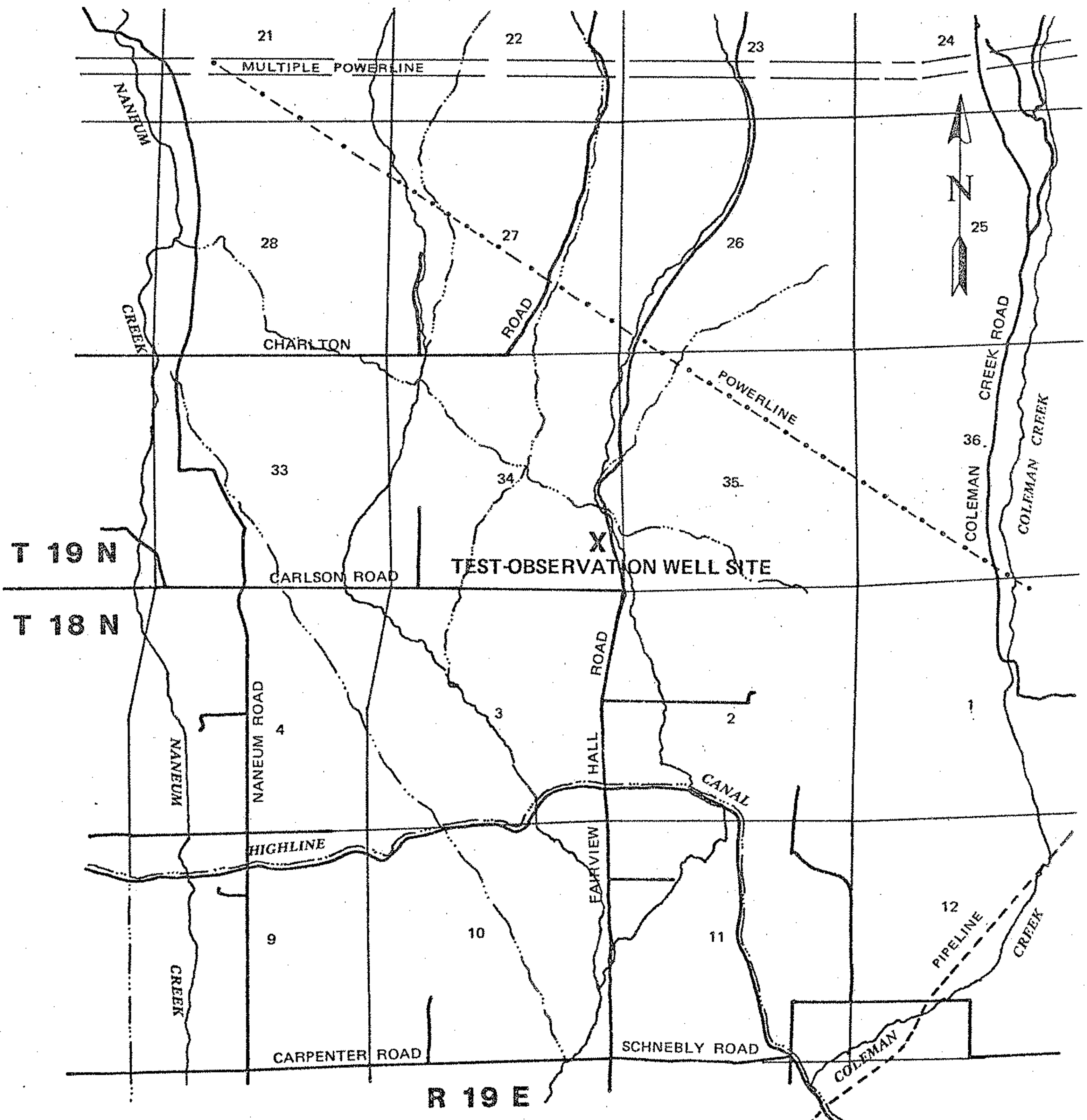


Figure 2 Detailed Map Showing Location of Schnebly Creek Test-Observation Well Site.

The work was part of the Department of Ecology Test-Observation Well Program for drilling, testing, and periodically collecting data from specially designed wells in the State of Washington. These wells are being drilled in areas where there is a critical need for ground-water data for water management purposes and where the data cannot be obtained from existing wells or by other means. This project is part of a continuing cooperative program between the Washington State Department of Ecology and the United States Geological Survey (USGS). The USGS provides the equipment and installs piezometers in the completed test holes so that periodic water-level soundings may be gathered over many years. The location of this well and of all test-observation wells completed to date under this program are shown in Figure 3.

Well Construction

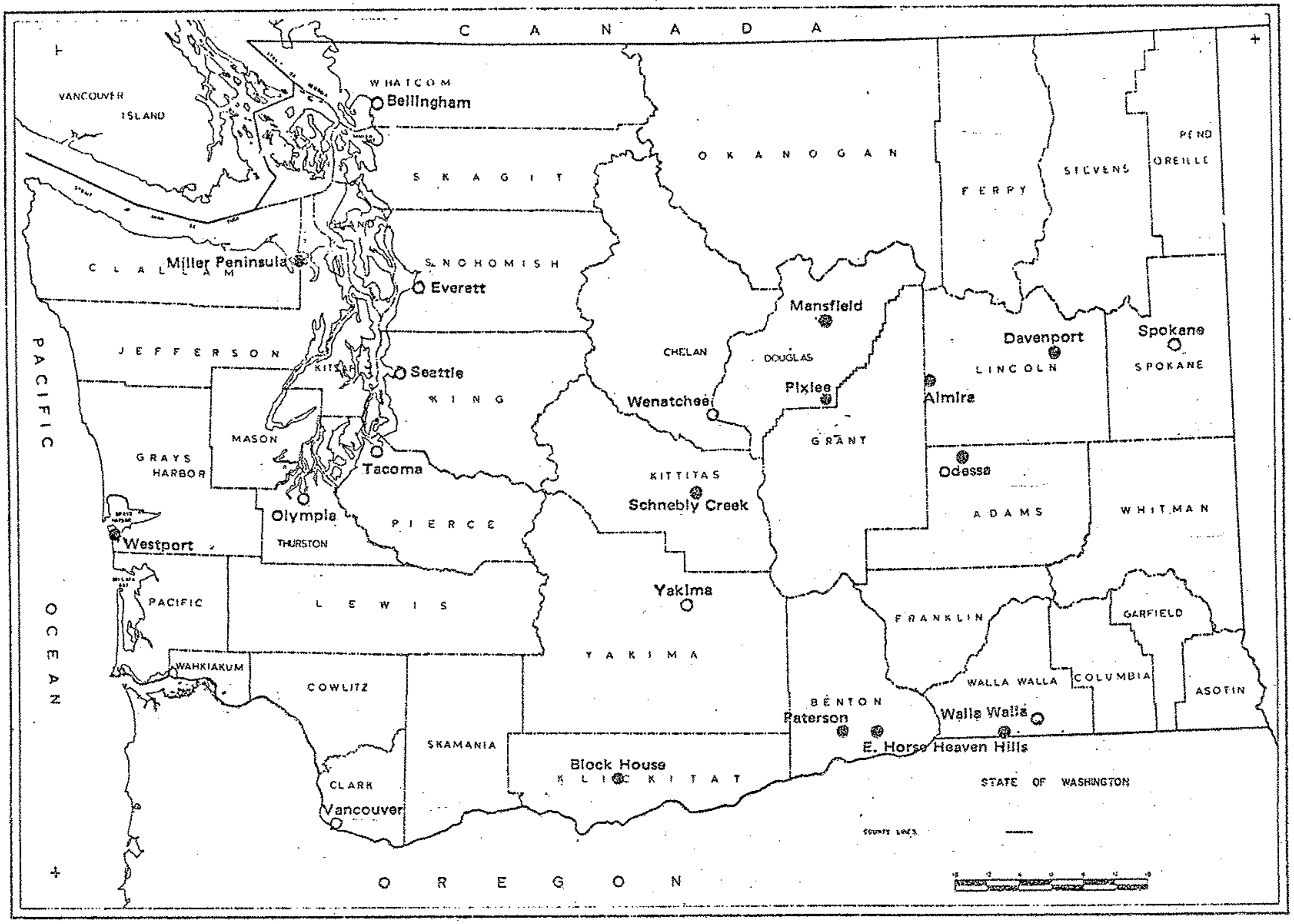
Work began on test-observation well #16 on May 17, 1978. Mike Ring of Bach Well Drilling Company based in Ellensburg, Washington, used a Bucyrus-Erie 22-W, Series 3 cable-tool drill rig for drilling the overburden. A temporary 20-inch surface casing was set and drilling proceeded just ahead of the placement of 16-inch (outer diameter) casing (Figure 4). Water was encountered within 17 feet of the surface.

By August 2, 1978, the hole was down to 405 feet, 30 feet into basalt. Basalt had been encountered at 376 feet and the 16-inch casing had been driven to 396 feet. The hole was extended to 420 feet and 10-inch (10.192" inner diameter, 10.750" outer diameter) casing was placed to this depth. The 20-inch surface casing was removed and a surface seal was grouted-in around the 16-inch and 10-inch casings. On August 17, the bottom of the 16- and 10-inch casings were pressure-grouted with 4.5 yards (175 sacks) of cement using a grout plug and 80 p.s.i. of water pressure to hold the cement. The static water level stood at 72 feet before the grout was placed.

A "Portadrill" rotary drill rig was positioned over the hole by the driller and owner, Mike Bach, on October 20, 1978. Within three hours, using a 10-inch percussion air hammer bit, water was encountered at a depth of 480 feet. By October 24, pump column and bowls had been set at 255 feet by Akland Irrigation, Inc. of Yakima, Washington. Static water level was 59.17 feet below the top of the casing.

On October 25, 1978, a step-drawdown test was conducted incorporating an 8-inch pipe with piezometer tube and a 6-inch orifice. Water levels were measured with an electric tape sounder with an air line and gauge as backup. The test is described in the Hydrology Section of this report.

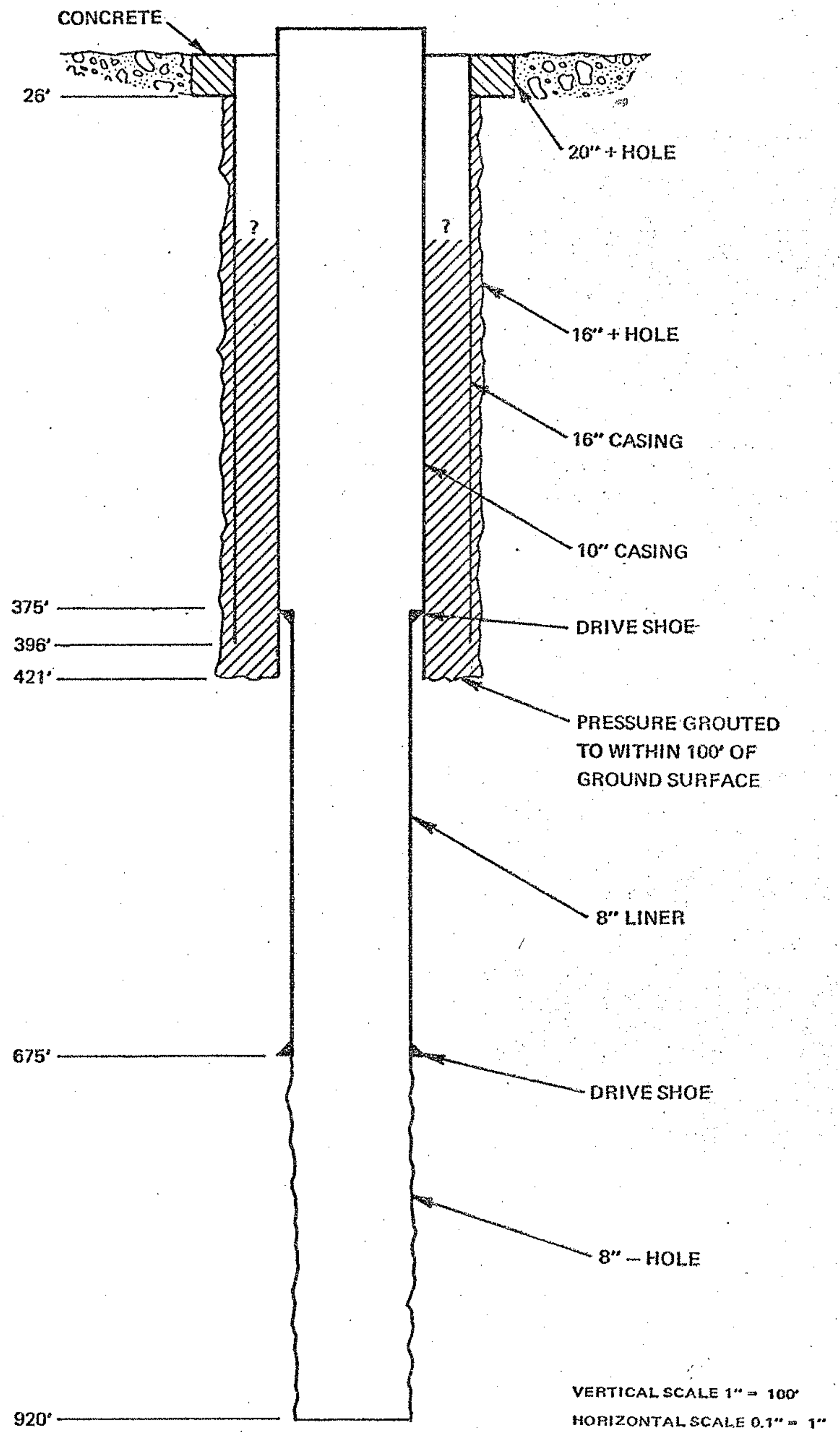
By November 1, 1978, the rotary drill rig was back on the site and the drillers had penetrated to 520 feet using drive collars and a 10-inch tricone roller bit. Drilling continued through hard basalt to 600 feet at the rates of 3 to 10 feet per hour. From 600 feet to approximately 680 feet, the drilling was much easier and then became more difficult again. The morning of November 7, the hole was down to 700 feet with water standing at 69.55 feet below land surface. The drillers had lost



EXPLANATION

Test Well and Name

FIGURE 3 — — LOCATIONS OF TEST–OBSERVATION WELLS IN WASHINGTON.



CONCRETE
26'
20" + HOLE
?
?
16" + HOLE
16" CASING
10" CASING
375'
396'
421'
DRIVE SHOE
PRESSURE GROUTED
TO WITHIN 100' OF
GROUND SURFACE
8" LINER
675'
DRIVE SHOE
8" – HOLE
920'
VERTICAL SCALE 1" = 100'
HORIZONTAL SCALE 0.1" = 1"

much of the air compression while drilling from 600 to 700 feet and during the next few days they circulated within the hole to get as many of the cuttings out as possible. The static water level on the morning of November 9, 1978 stood at 66.70 feet below land surface. Because of sloughing conditions, it was decided to case-off the zone from approximately 400 feet to 700 feet. A 300-foot, 8-in (8.071" interior diameter, 8.625" outer diameter) liner with inverted drive shoes at both ends was installed in the interval from 375 feet to 675 feet. The amount of water entering the hole from this zone was reduced considerably but was not completely closed off. However, the liner did prevent the sloughing of materials into the hole. The static water level on November 28, after the liner had been installed, was essentially the same as before, that is approximately 66 feet below land surface.

The hole had been drilled to 780 feet by the end of November 29 and more water had been encountered. The static water level the following morning was 47.7 feet below land surface. At approximately 820 feet, hard basalt slowed drilling considerably. At a depth approaching 870 feet, drilling became easier and at 900 to 920 feet fine sand (similar to beach sand) was encountered which stopped progress completely and prevented the completion of the hole to the specified contract depth of 1,200 feet. The drillers rented an additional air booster from Leach Well Drilling, Inc. of Moses Lake, Washington to maintain greater air pressure in an attempt to prevent sloughing while drilling; this was unsuccessful. It is possible that a conversion to mud rotary drilling would have allowed completion of the hole to 1,200 feet; however, the added expense was not warranted.

It was decided on December 16, 1978 to make a final pump test on the open interval from 675 to 920 feet, the total depth of the hole.

On December 27, 1978, a step-drawdown test was conducted at discharge rates ranging from 533 to 1,620 gallons per minute (gpm). A 10-inch pipe and piezometer with a 7-inch orifice were used to measure discharge. The results of this test are presented in detail in the Hydrology Section.

Geophysical Logs

Borehole logging of the well was done on March 24, 1980 by Jeff Brown of Washington State University, Geological Engineering Section. The suite of logs consisted of gamma gamma, neutron gamma, neutron neutron, natural gamma, flow meter, caliper, fluid temperature, fluid resistivity, and spontaneous potential.

The gamma gamma log is generated in response to back scattered gamma radiation from a Co^{60} source; it is a measure of formation density when corrected for borehole conditions.

The neutron gamma and neutron neutron logs provide much the same information. They are both affected by the presence of water and are basically porosity logs below the water table. Both use a Pu-Be or Am-Be source to produce neutrons which are captured by nuclei of atoms in the material through which it passes, recording emitted gamma rays in the case of the neutron neutron log. The neutron gamma log differs from the neutron neutron log in being affected somewhat by formation chemistry and therefore possible stratigraphic changes.

The natural gamma log measures the gamma photon emission from adjacent rocks usually related to the presence of potassium-40 or possibly uranium or thorium. The K^{40} concentrations are generally high in most clays while clean quartz sands are low in K^{40}.

The flowmeter log is the result of trolling a propeller sonde both down and up the hole (the log is actually a result of trolling up-hole). The amount and direction of vertical water movement may be determined by this log.

The caliper log is strictly a measure of the diameter of the borehole. Casing diameters and breaks are determined as well as various breakouts within the hole which might indicate aquifers or thief zones.

Fluid temperature and fluid resistivity both are indicators of water movement within the hole and areas of producing or thieving characteristics. The fluid temperature log is calibrated in degrees centigrade and is commonly used in conjunction with the flowmeter log to determine water movement and aquifer boundaries. The fluid resistivity log reflects the various dissolved solids present in ground water and can delineate possible aquifer boundaries.

The spontaneous potential log provides a continuous record of the natural potential within the borehole. It is useful in distinguishing sands from shales, and is primarily used for evaluating lithology and bed thickness. A report on *Geophysical Investigations of Washington's Ground Water Resources* by Barbara Seims, *et al.*, 1973, further explains the logging procedures of Washington State University.

Lithology and Stratigraphic Correlation

From the lithologic (see Appendix) and geophysical well logs and from geochemical analyses (see Table 1) made of four samples by the Washington State University through Rockwell International, Rockwell Hanford Operations, correlation with known formations is possible.

The four basalt samples collected from 510 to 520, 650 to 660, 770 to 780, and 870 to 880 feet, which were analyzed for various oxides, are correlative with the Grande Ronde Basalt Formation. This is consistent with information provided in the United States Geological Survey Professional Paper 1127 (Waitt, 1979) which correlates much of the Kittitas Valley surficial deposits and outcrops and provides a stratigraphic history of the area.

The sedimentary strata intercalated with and underlying the Grande Ronde Basalt, is apparently part of the Ellensburg Formation. Much of the interbedded, and especially the underlying materials, appear to be

Table 1

Schnebly Creek Test Well #16

Geochemical Analyses (in Percent)

Sample Number	Sample Interval	SiO_2	Al_2O_3	TiO_2	Fe_2O_3	FeO	MnO	CaO	MgO	K_2O	Na_2O	P_2O_5
C 8377	510-520 feet	55.04	15.96	1.85	2.00	9.01	0.17	8.24	4.02	1.11	2.25	0.34
C 8378	650-660 feet	54.68	15.71	1.85	2.00	10.09	0.22	8.08	3.96	0.93	2.16	0.32
C 8379	770-780 feet	53.96	15.23	1.85	2.00	9.96	0.20	8.75	4.48	0.98	2.28	0.31
C 8380	870-880 feet	54.06	15.40	1.90	2.00	9.82	0.19	8.47	4.16	1.03	2.66	0.32

All of the above samples are Grande Ronde Basalt.

silicic volcani-clastic sedimentary rock derived from the west or north rather than the south and east as is the Yakima Basalt Subgroup. It is indistinguishable from the overlying materials, more formally considered Ellensburg Formation; therefore, Waitt suggests that these interbedded sands, silts, and gravels be included in the Ellensburg. The deposition of "silicic volcanic debris" eastward from the Cascades was not confined to the latter part of the eruption of the Yakima Basalt Subgroup, but commenced before the earliest basalt flows reached the area" (Waitt, 1979). These sediments are described as ranging in size from siltstone to cobble conglomerate. Most of the material is moderately sorted, plane-bedded, and crossbedded alluvium with some massive diamictite units "as thick as 6 meters in the suprabasalt strata", which apparently originated as volcanic mudflows (Waitt, 1979). In the Ellensburg test well it is difficult to differentiate samples representing the Ellensburg Formation materials from those which perhaps contain more recent Thorp sidestream gravel facies or alluvium sidestream facies.

It is likely that the test well penetrated recent alluvium deposits as well as underlying Thorp gravels which overlie both the Ellensburg Formation and the Grande Ronde Basalt Formation. From the lithologic log, the location of the drill site, and the description provided by Waitt, it can be concluded that both the Thorp gravels and the overlying alluvium deposits are sidestream facies rather than mainstream facies. The sidestream facies of the Thorp Gravel is described, by Waitt, as angular to subrounded clasts up to 38 cm in intermediate diameter, entirely of Grande Ronde Basalt derived from the mountain front to the north. The type deposit is "thick bedded, comprising beds variously of small pebble to cobble gravel enclosed in a sandy granule basalt-clast matrix ranging from closely packed to meagerly openwork." It is "conspicuously cemented at the type locality to a depth of at least 10 m with alternating bands of reddish hematite and, verified by x-ray diffraction, pale-yellow montmorillonite." (Waitt, 1979) The Thorp Gravel probably correlates with the Ringold Formation of the Pasco Basin dating back approximately 3.5 million years (Waitt, 1979).

The sidestream alluvium grades to the mainstream deposits and is distinguished by its "monotonous content of subrounded to subangular basaltic gravel." (Waitt, 1979) The sidestream fans occur along the mountain front at the mouths of canyons, but merge upslope with fans of angular basaltic colluvium on interfluves. Sand and silt layers may occur as minor beds within and above mainstream deposits. Fine tephra also occurs as "rare discontinuous beds enclosed by alluvium and colluvium." (Waitt, 1979)

The process of drilling modifies the sample from that which is seen in surface exposures. Cable-tool and rotary drilling both break the larger clasts into smaller particles making the task of distinguishing between the various facies difficult. Is is therefore more practical to include the alluvium, Thorp Gravels, and perhaps the upper Ellensburg Formation as undifferentiated. For the purposes of this report and for an examination of the hydrologic characteristics, this is sufficient.

Results - Hydrology

Static water level measurements were made during drilling operations (Table 2). These, along with the geophysical logs, changes in drilling air pressure, and drill rates were used to analyze pump test data.

Two pump tests were conducted by Akland Irrigation, Inc. of Yakima, Washington, one beginning October 25, 1978 and the other starting December 27, 1978. The well at the time of the first test was cased and grouted to 421 feet (16-inch casing to 396 feet, 10-inch casing to 421 feet) and was open to 480 feet. A substantial amount of water was encountered at 480 feet, and the pump test was conducted to determine the characteristics of this aquifer.

The bottom of the pump bowls were set at 255 feet below land surface. A step-drawdown test (Table 3) was then conducted with incremental discharge rates of fixed duration. An 8-inch pipe and 6-inch orifice with piezometer tube were incorporated for discharge measurements. Water levels were measured with an electric tape sounder (Soil Test); an air line was used as backup. The initial pumping rate was established at 433 gpm for two hours; maximum drawdown was approximately 29 feet. The discharge for the second step was 800 gpm with a drawdown of nearly 81 feet. During the third and last step of the test, the well was pumped for 4-1/2 hours at a rate of 1,200 gpm with the resulting pumping water level at approximately 177 feet. Specific capacity decreased with each stage: from nearly 15 to 9.9 to 6.8 gpm per foot of drawdown. It is possible that boundary conditions were encountered during the last stage of pumping. Because it was necessary to place as large a pump and column within the 10-inch casing as possible to stress the aquifer, the amount of annular space for electrical tape measurement was small, thus limiting its use; many of the readings required the use of the air line.

A method for analyzing step-drawdown tests is presented by N.R. Brereton in *Step-Drawdown Pumping Tests for the Determination of Aquifer and Borehole Characteristics*. This method, although not the only one, is used here because of its ease of applicability and relevance to the test-well program where observation wells are not usually available. A transmissivity (T) is calculated for each of the pumping steps, as is an average T, for the overall test. Because no observation wells were available, it was not possible to determine the storage coefficient of the aquifer system. The transmissivity of the first step was approximately 57,000 gallons per day per foot (gpd/ft) and the T of the second step was nearly 28,000 gpd/ft and the T of the last step was approximately 14,000 gpd/ft. The average transmissivity of the first aquifer is approximately 22,000 gpd/ft; however, this may be biased if boundary conditions are present. Brereton (1979) suggests that from five to eight pumping increments should be run to establish good results; only three were conducted during this test. Tables 3 and 4 and Figures 5, 6, and 7 pertain to the initial drawdown test. Recovery to nearly 1.5 feet of initial static water level (Table 5) occurred in 24 hours. Figure 8 is the residual drawdown curve drawn from recovery data; an average discharge rate was established (917.8 gpm) and from the curve a transmissivity of 20,360 gpd/ft, was calculated. This transmissivity figure compares well with the 22,000 gpd/ft average T.

Table 2

Depth to Water During Drilling of Schnebly Creek Test-Observation Well

	Feet Below Land Surface Datum			
Date	Well Depth at Time of Measurement		Depth of Casing	Water Level
				(measurements generally made in morning before drilling)
05/22/78	17		17	17
06/16/78	155		155	20
08/17/78	420		420 (16" 396', 10" 420')	72 (before grouting)
10/25/78	480		420	59.3
10/26/78	480		420	60.7 (after test)
11/03/78	560		420	64.5
11/07/78	700		420	69.6
11/08/78	700		420	66.7
11/09/78	700		420	66.7
11/17/78	700		420	65.7
11/28/78	700	Setting liner 380-680'	420	66.7
11/28/78	700	(not sealed)	680	67.9
11/29/78	700		680 Water temp.	66.1 (56°F, 13°C)
11/30/78	780		680 Water temp.	47.7 (60°F, 15°C)
12/01/78	830		680 Water temp.	61.9 (61°F, 15+°C)
12/16/78	915		680	54.5
12/28/78	915		680	56.7

Table 3

Schnebly Creek Pumping Test #1 - Data

10/25/78
Measuring Equipment - Electric Tape (Soiltest)
Airline - length = 252 feet
1.1 ft. above top of casing
2.1 ft. above ground level
T/C = Top of Casing 1.0' above ground level
8" pipe, 6" orifice

Date	Hour	Airline PSI	T/C Airline Length Minus (PSI x 2.31)	E-Tape Measurement below T/C	Drawdown S (ft)	Time (min)	Comments
10/25/78	0823	82.5	60.33	59.33	0	0	433 gpm
	0825	73	82.27		21.94	2	7" piezometer
	0826	72	84.58		24.25	3	
	0827	71.5	85.74		25.41	4	
	0828	71.25	86.31		25.98	5	
	0829	71.25	86.31		25.98	6	
	0830	71	86.89		26.56	7	7" piezometer
	0831	71	86.89		26.56	8	= 433 gpm
	0832	70.75	87.47		27.14	9	
	0833	70.5	88.05		27.72	10	7.25"
	0838	71.25	86.31		25.98	15	6.5"-7.0" 421-433 gpm
	0845	70.75	87.47		27.14	22	427 gpm
	0850	70.25	88.62		28.29	27	
	0856	70	89.20		28.87	33	7.25"
	0901	70.25	88.62	87.1	28.29	38	6.5"-7.0"
	0910	70.5	88.05	87.63	27.72	47	6.5"-7.0"
	0920	70	89.2	88.60	28.87	57	7" = 433 gpm Water temp. = 58°F
	0930	70+	89.2	88.95	28.87	67	6.5"-7.0"
	0945	70.25	88.62	88.45	28.29	82	
	0955	70+	89.2	88.78	28.87	92	
	1010			89.25	28.92	107	6.5"-7.0"
	1015			88.88		112	
				88.86			
				89.07			
	1023			89.0		120	
				88.6			
	1030			88.86		127	

Table 3 - Continued

Date	Hour	Airline PSI	T/C Airline Length Minus (PSI x 2.31)	E-Tape Measurement below T/C	Drawdown S (ft)	Time (min)	Comments
10/25/78	1032 ~	Change of discharge rate					Q ≈ 800 gpm
	1035	50	135.4		75.07	(1)	
	1036	50	135.4		75.07	(2)	25.5" ± 0.5"
	1040	50	135.4		75.07	(6)	
	1045	49.5	136.56		76.23	(11)	26" ± 0.25" 800 gpm ± 3.5 gpm
	1050	49	137.71	140.0	77.38	(16)	
	1055	48.5	138.89	140.47	78.56	(21)	
	1100			140.45		157(26)	26" ± 0.25"
	1110	48.5	138.87	140.75	78.54	167(36)	
	1120	48	140.02	141.80	79.69	177(46)	26" ± 0.25"
	1133	47.5	141.18	142.35	80.85	190(59)	25.75" ± 0.25"
	1142	47.5	141.18	142.28	80.85	199(68)	25.5" ± 0.25"
	1153	47.5	141.18	142.63	80.85	210(79)	Water temp. = 55°F
	1215	47.5	141.18	143.9	80.85	232(101)	25" ± 0.5"
	1225			142.72		242(111)	
Change Pump Rate							
	1230	15+	216.25	155.92		247(116)	1200 gpm ± 5.0 gpm 61" ± 0.5"
	1235	14.5	217.41	157.08		252(5)	E-tape out - lost weights
	1240	13	220.87	160.54		257(10)	
	1246	12.5	222.03	161.7		(16)	61.5" ± 0.5"
	1257	12	223.18	162.85		274(27)	61" ± 0.5"
	1305	11.5	224.34	164.01		282(35)	61" ± 0.5"
	1320	11+	225.5	165.17		297(50)	61" ± 0.5"
	1342	10	227.8	167.47		319(72)	
	1400	9.5	228.95	168.62		(90)	61" ± 0.5"
	1420	9	230.10	169.77		(110)	60.5 ± 0.5"
	1430	8.25	231.84	171.51		367(120)	61" ± 0.5"
	1500	7.5	233.58	173.25		397(150)	61" ± 0.5"
	1530	7	234.73	174.4		(180)	60.5-61"
	1600	6.25	236.46	176.13		457(210)	61.5" ± 0.5"
	1630	6.25	236.46	176.13		(240)	
	1655	6	237.04	176.71		(265)	
						(270)	

Table 4

Schnebly Creek Test Well #16
First Pumping Test, October 25, 1978

Step	Pumping Rate (gpm)	Drawdown after 100 min. Sm (ft.)	Drawdown per Log Cycle ΔS_{os} (feet)
1	430	29	2.0
2	800	81	4.5
3	1200	171	10.5

Step	f (Q)	Dm	a	T	Sm-$\bar{a}$ Dm/Qm
1	430	0	4.65×10^{-3}	56,800	6.7×10^{-2}
2	473.3	129.4	9.51×10^{-3}	27,800	9.93×10^{-2}
3	547.6	316.5	1.92×10^{-2}	13,800	1.39×10^{-1}

$\bar{a} = .012 = 1.2 \times 10^{-2}$

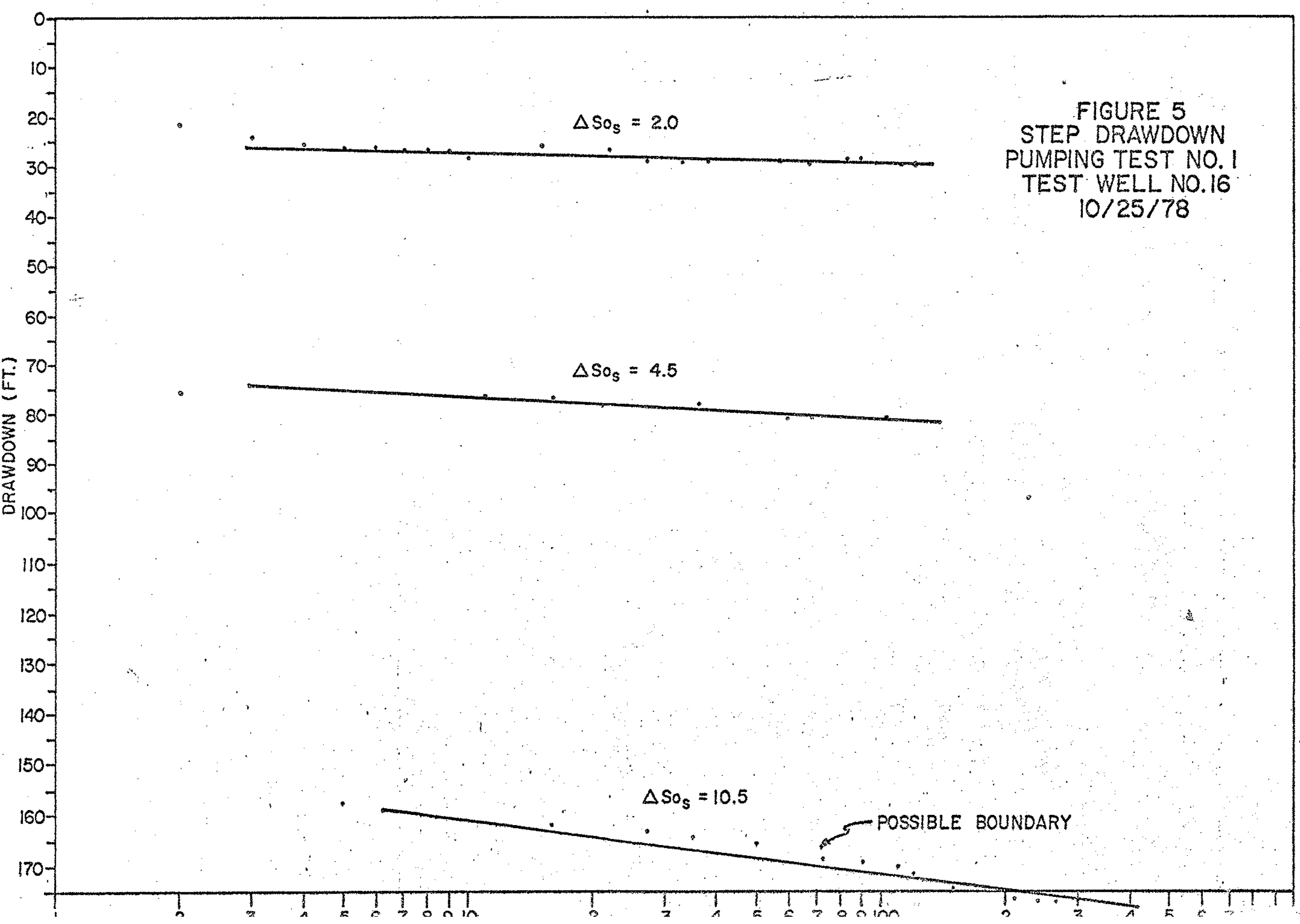


FIGURE 5
STEP DRAWDOWN
PUMPING TEST NO. 1
TEST WELL NO. 16
10/25/78
ΔSo_s = 2.0
ΔSo_s = 4.5
ΔSo_s = 10.5
POSSIBLE BOUNDARY
DRAWDOWN (FT.)
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170

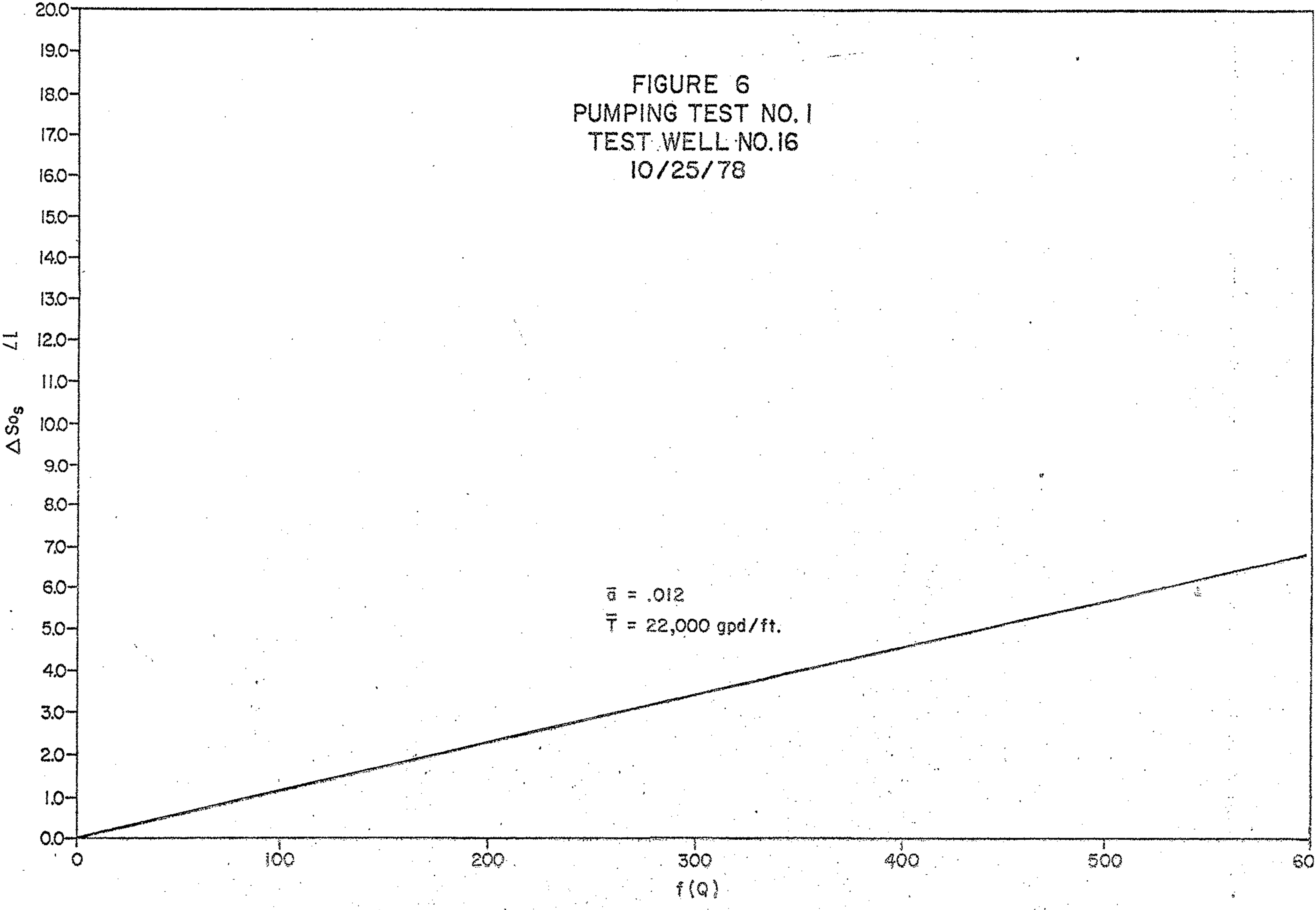


FIGURE 6
PUMPING TEST NO. 1
TEST WELL NO. 16
10/25/78

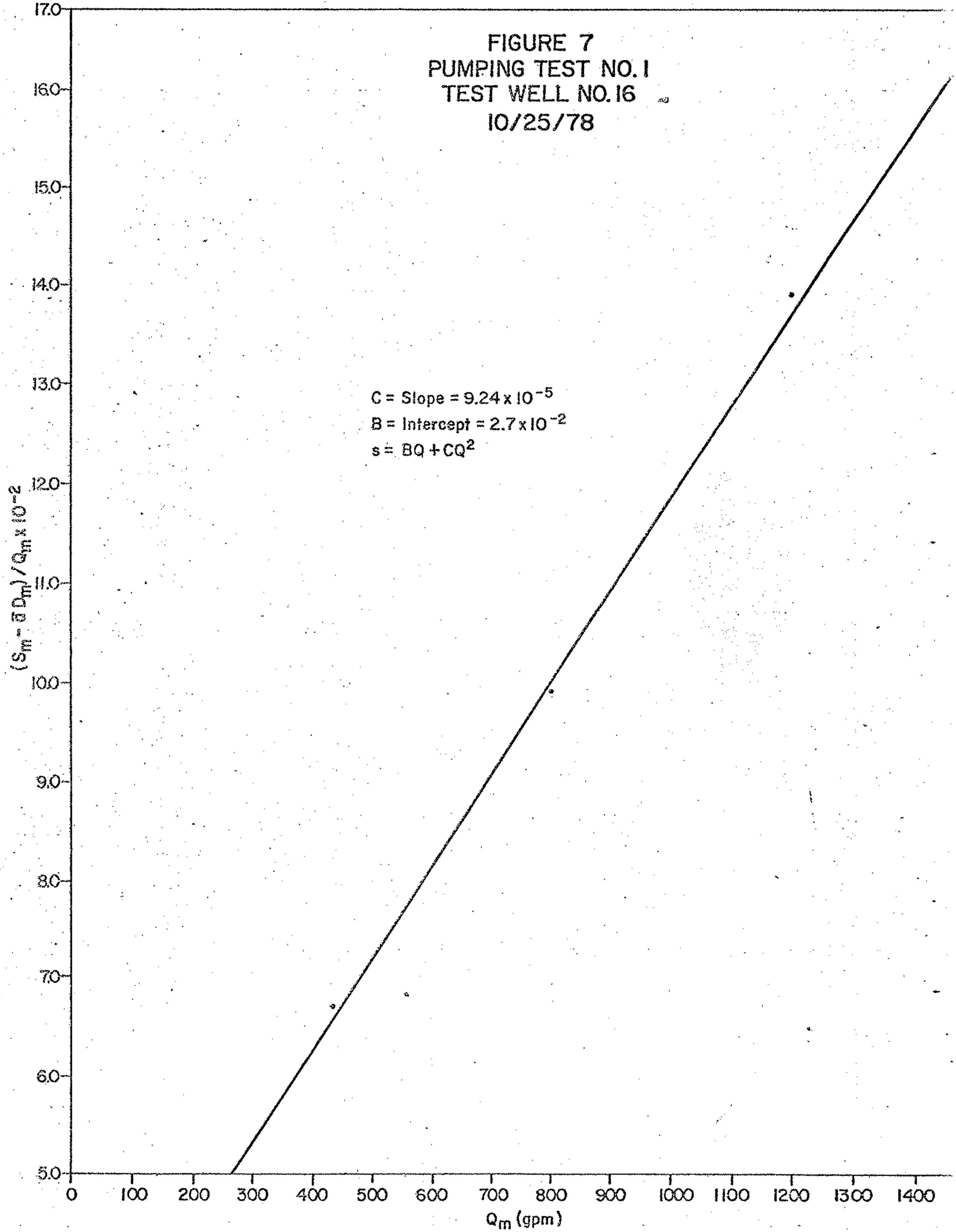


FIGURE 7
PUMPING TEST NO. I
TEST WELL NO. 16
10/25/78
C = Slope = 9.24 x 10^-5
B = Intercept = 2.7 x 10^-2
s = BQ + CQ^2
(Sm - ā Dm) / Qm x 10^-2
17.0
16.0
15.0
14.0
13.0
12.0
11.0
10.0
9.0
8.0
7.0
6.0
5.0
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
Qm (gpm)

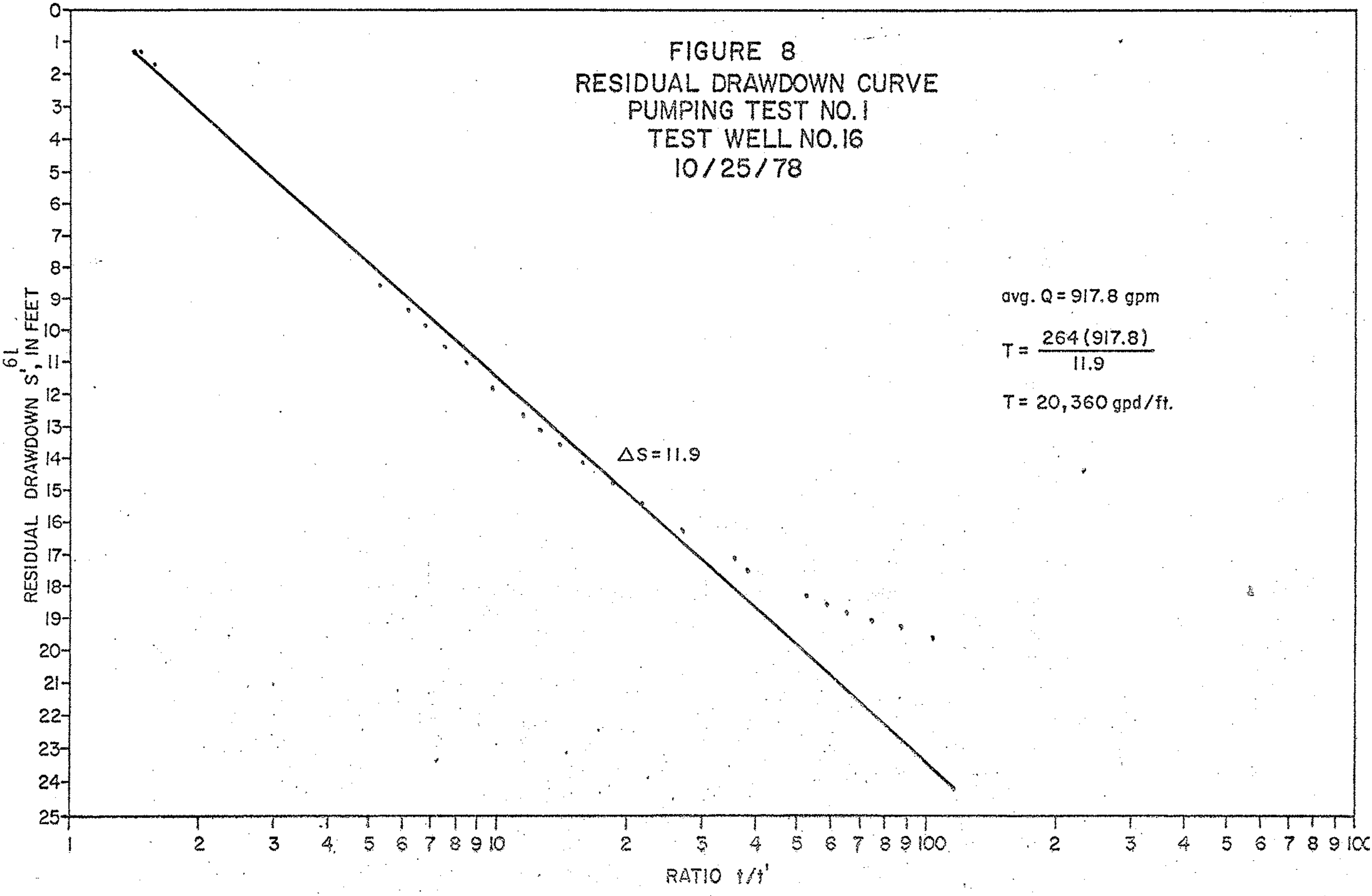


FIGURE 8
RESIDUAL DRAWDOWN CURVE
PUMPING TEST NO. 1
TEST WELL NO. 16
10/25/78
avg. Q = 917.8 gpm
T = 264 (917.8) / 11.9
T = 20,360 gpd/ft.
ΔS = 11.9
RESIDUAL DRAWDOWN S', IN FEET
RATIO t/t'

Table 5

Recovery

Static Water Level - 58.33 ft. below land surface
E-tape - 59.33 ft. below top of casing, T/C
Airline - 60.33 ft. below T/C

10/25/78	Time Since Pump Test Started t, (min)	Time Since Pump Stopped t' (min)	Ratio t/t'	Depth to Water (ft)	Residual Drawdown s' (ft)	
	516	0	--	237.62*	177.29	
	516.5	.5	1033	204.7*	144.37	avg. Q = 917.8 gpm
	517	1	517	200.1*	139.77	
	521	5	104.2	78.9	19.57	433 gpm/129 min.
	522	6	87	78.54	19.21	800 gpm/116 min.
	523	7	74.71	78.36	19.03	1200 gpm/270 min.
	524	8	65.5	78.12	18.79	
	525	9	58.33	77.82	18.49	433 x 129 = 55,857
	526	10	52.6	77.57	18.24	800 x 116 = 92,800
	530	14	37.86	76.80	17.47	1200 x 270 = 324,000
	531	15	35.4	76.45	17.12	472,657
	536	20	26.8	75.57	16.24	
	541	25	21.64	74.68	15.35	472,657 g/515 min.
	546	30	18.2	74.08	14.75	
	551	35	15.74	73.45	14.12	
	556	40	13.9	72.87	13.54	
	561	45	12.47	72.40	13.07	
	566	50	11.32	71.92	12.59	
	576	60	9.6	71.07	11.74	
	586	70	8.37	70.28	10.95	
	596	80	7.45	69.77	10.44	
	606	90	6.73	69.13	9.80	
	616	100	6.16	68.67	9.34	
	636	120	5.3	67.84	8.51	
10/26/78	1446	930	1.55	61.00	1.67	
	1666	1150	1.45	60.65	1.32	

*Airline measurement

The second pumping test was conducted when the well was 920 feet deep (total depth). An 8-inch liner had been installed from 380 to 675 feet. Apparently, as indicated by the geophysical logs, the liner had little effect in sealing off much of the water from the shallower aquifer. As in the first test, the bottom of the bowls was placed at 255 feet. The static water level at the beginning of the test was 53.0 feet as measured with the electric tape and 55.4 feet with air line, a discrepancy probably because of incorrect air line length, but which must be maintained for all measurements either with air line or with electric tape. Since all measurements are made relative to the initial water level, drawdown should be the same regardless of which method is used.

The test was again of the step-drawdown incremental type; however, as recharge was greater than in the first test, the initial pumping rate was 743 gpm. A 10-inch pipe with piezometer and 7-inch orifice were used for discharge measurements. Three pumping rates were again established for a period of approximately 120 minutes. Maximum drawdown during the first stage was nearly 30 feet; during the second period when the discharge rate had been increased to 1,215 gpm, maximum drawdown reached 67 feet; and at 1,620 gpm, total drawdown was over 122 feet (Table 6).

Again, calculations were made using the methods previously mentioned to determine some of the aquifer characteristics. Because the lower aquifer is not completely isolated, some of the coefficients may not be unique to that particular zone. Specific capacity decreased from nearly 25 gpm per foot of drawdown to 18.1 in the second stage to 13.3 gpm per foot of drawdown in the last step. The calculated transmissivity for the first step was 49,100 gpd/ft; for the second and third steps it was 21,800 and 20,500 gpd/ft, respectively (Table 7). The overall average transmissivity for the deeper aquifer (plus probably partial discharge from aquifer number 1) is 31,200 gpd/ft (Figure 9). Again, boundary conditions may be present and accuracy of the water level measurements is questionable because the air line was used during several stages of the test when it was not possible to make measurements with the electric tape. Figures 9 through 11 and Tables 6 and 7 are the graphs and figures for the second pumping test.

Recovery measurements were made. By 16 hours following the start of recovery, the water level was within 3.7 feet of complete recovery and after 20 hours it was within 3.5 feet (Table 8).

Figure 12 is the residual drawdown curve based on recovery data for the second pump test. From this curve a T of 34,200 gpd/ft is derived which compares quite well with the step-test curves. The transmissivity from the pumping curve, Figure 9, could have varied 10,000 gpd/ft, depending on the placement of the line drawn from the origin.

The fact that the transmissivities were similar for both aquifer tests suggests that the upper and lower aquifers are interconnected, not just through leakage along the liner, but within the aquifer itself. During drilling, no obvious water level changes were observed. The specific

Table 6

Schnebly Creek Pumping Test #2 - Data

12/27/78
Measuring Equipment - Electric Tape, Airline
Top of casing T/C = .9 ft. above land surface
Airline = 11.2 above T/C   11.2 + .9 = 12.1 ft. above LSD
10" pipe, 7" orifice
Airline length = 252 ft.

Date	Hour	Airline PSI	Depth to Water = Airline Length Minus (PSI x 2.31) (below land surface datum)	E-Tape Measurement (ft)	Drawdown s (ft)	Time (min.)	Comments
12/27/78	0915	79.9	55.4	53.0	0	0	Snowing
		71	75.89		20.49	1	533 gpm
		71	75.89		20.49	2	
		70.5	77.05		21.65	3	
		70.5	77.05		21.65	4	
		70.5	77.05		21.65	5	728 gpm
		70	78.20		22.80	6	
		69.5	79.36		23.96	7	
	0930					15	743 gpm
		69.5	79.36		23.96	20	
				78.90	25.90		
		69	80.51		25.1	25	
				79.65	26.65		
	0945	68.5	81.67		26.27	30	
				79.72	26.72		
		67	85.13(?)		29.73(?)	35	743 gpm
				80.10	27.10		
		68	82.82		27.42	40	
				80.42	27.42		
	1000	68	82.82		27.42	45	743 gpm
				81.60	27.60		
	1005	68	82.82		27.42	50	
				80.97	27.97		
	1015	67	85.13		29.73	60	743 gpm
				81.57	28.57		
	1025	67.5	83.98		28.58	70	757 gpm
				82.07	29.07		
	1035	67.5	83.98		28.58	80	
				81.90	28.90		
	1045	67.5	83.98		28.58	90	
				81.75	28.75		

Table 6 - Continued

Date	Hour	Airline PSI	Depth to Water = Airline Length Minus (PSI x 2.31) (below land surface datum)	E-Tape Measurement (ft)	Drawdown s (ft)	Time (min.)	Comments
12/27/78	1055	67.5	83.98		28.58	100	
				82.40	29.40		
	1105	67.5	83.98		28.58	110	740-750 gpm water temp. 62°F
				82.10	29.10		
		68	82.82		27.42	120	
				81.35	28.35		
		55	112.85		57.45	0	1209 gpm
		55	112.85		57.45	1	
		55.5	111.7		56.30	2	
		55.5	111.7		56.30	3	
		55.5	111.7		56.30	4	
		55.5	111.7		56.30	5	
		55	112.85		57.45	6	
		55.5	111.7		56.30	7	
		55.5	111.7		56.30	8	
		55.5	111.7		56.30	9	
		55	112.85		57.45	10	
		55	112.85		57.45	11	1218 gpm
		55	112.85		57.45	12	
		55	112.85		57.45	13	
		55	112.85		57.45	14	
		54.5	114.01		58.61	15	
		54.5	114.01		58.61	20	
		54.5	114.01		58.61	25	
		54	115.16		59.76	30	1218 gpm
				112.55	59.55		
		54	115.16		59.76	35	
				116.15	63.15		
		54	115.16		59.76	40	1215 gpm
				116.60	63.60		
		54	115.16		59.76	45	
				116.45	63.45		
		53.5	116.32		60.92	50	
				116.60	63.60		
		53.5	116.32		60.92	60	1215 gpm
				117.15	64.15		
		53.5	116.32		60.92	70	
				117.67	64.67		
		53.5	116.32		60.92	80	
				117.95	64.95		
		53	117.47		62.07	90	1215 gpm
				119.10	66.10		
		53	117.47		62.07	100	1209 gpm
				118.15	65.15		

Table 6 - Continued

Date	Hour	Airline PSI	Depth to Water = Airline Length Minus (PSI x 2.31) (below land surface datum)	E-Tape Measurement (ft)	Drawdown s (ft)	Time (min.)	Comments
12/27/78		53	117.47		62.07	110	
				118.80	65.80		
		53	117.47		62.07	120	
				119.40	66.40		
		52.5	118.63		63.23	130	1215 gpm
				120.0	67.0		
		52.5	118.63		63.23	140	
				119.6	66.60		
		52.5	118.63		63.23	150	
				119.95	66.95		
12/27/78		36	156.74		101.34	0	Change in Rate
		34.5	160.21		104.81	1	1620 gpm
		34.5	160.21		104.81	2	
		34	161.36		105.96	3	
		34	161.36		105.96	4	
		34	161.36		105.96	5	
		33.5	162.52		107.12	6	
		33.5	162.52		107.12	7	
		33.5	162.52		107.12	8	
		32.5	164.83		109.43	9	
		31	168.29		112.89	10	
		30.5	169.45		114.05	11	
		30	170.6		115.2	12	
		30	170.6		115.2	13	
		29.5	171.76		116.36	14	
		29.5	171.76		116.36	15	
		29	172.91		117.51	20	
		28.5	174.07		118.67	25	
		28.5	174.07		118.67	30	
		28	175.22		119.82	35	
		28	175.22		119.82	40	1620 gpm
		27.5	176.38		120.98	45	
		27.5	176.38		120.98	50	
		27	177.53		122.13	60	
		27	177.53		122.13	70	
		27	177.53		122.13	80	
		27	177.53		122.13	90	
		27	177.53		122.13	100	
		27	177.53		122.13	110	
		27	177.53		122.13	120	

Table 7

Schnebly Creek Test Well #16
Second Pumping Test, December 27, 1978

Step	Pumping Rate (gpm)	Drawdown after 100 min. Sm (ft.)	Drawdown per Log Cycle ΔS_{os} (feet)
1	743	28.1	4.0
2	1215	65.2	7.9
3	1620	122.0	8.0

Step	f (Q)	D_m	a	T	Sm-ā Dm/Qm
1	743	0	5.38×10^{-3}	49,100	3.78×10^{-2}
2	650.5	223.7	1.21×10^{-2}	21,800	5.17×10^{-2}
3	619.8	496.6	1.29×10^{-2}	20,500	7.20×10^{-2}

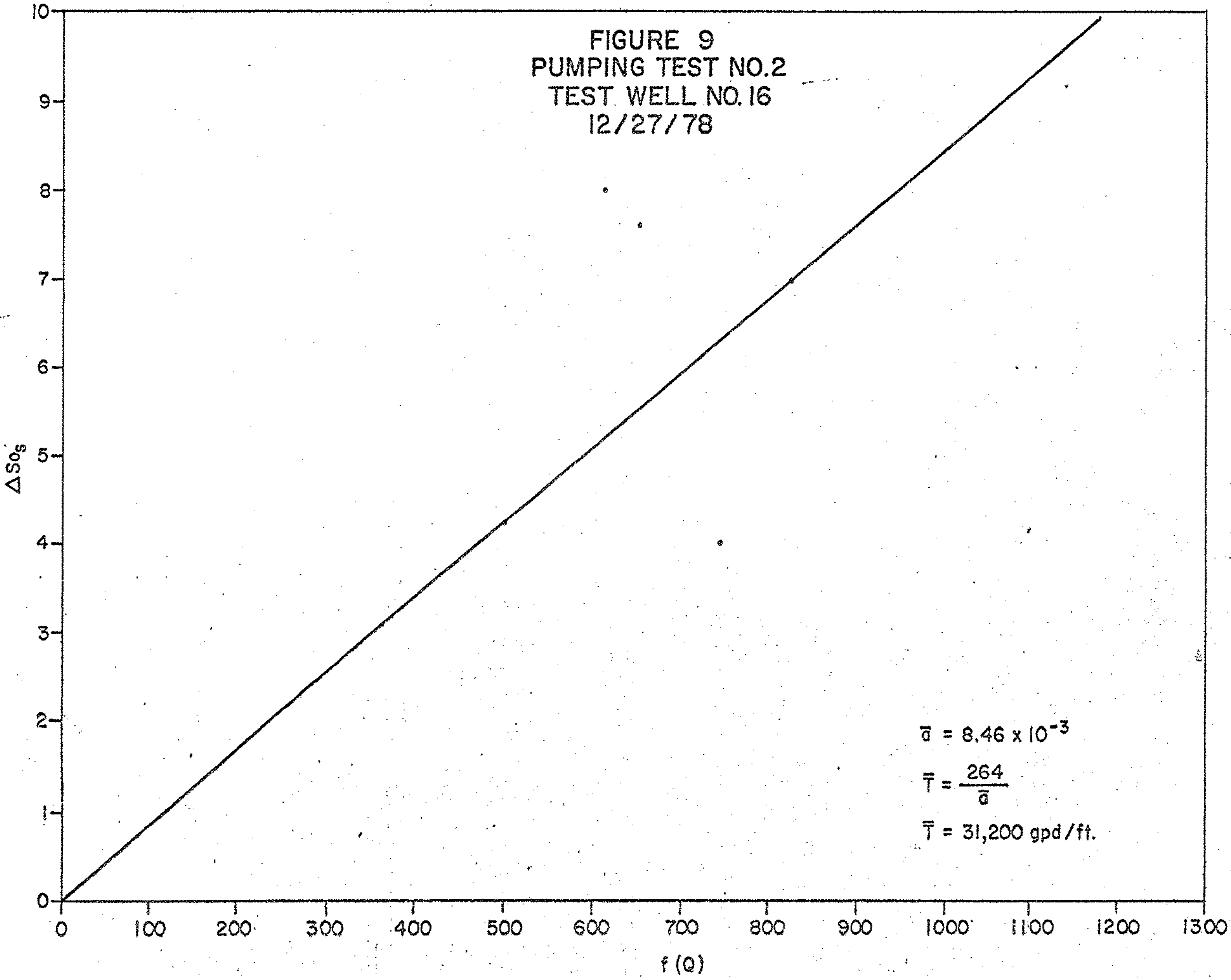


FIGURE 9
PUMPING TEST NO.2
TEST WELL NO.16
12/27/78

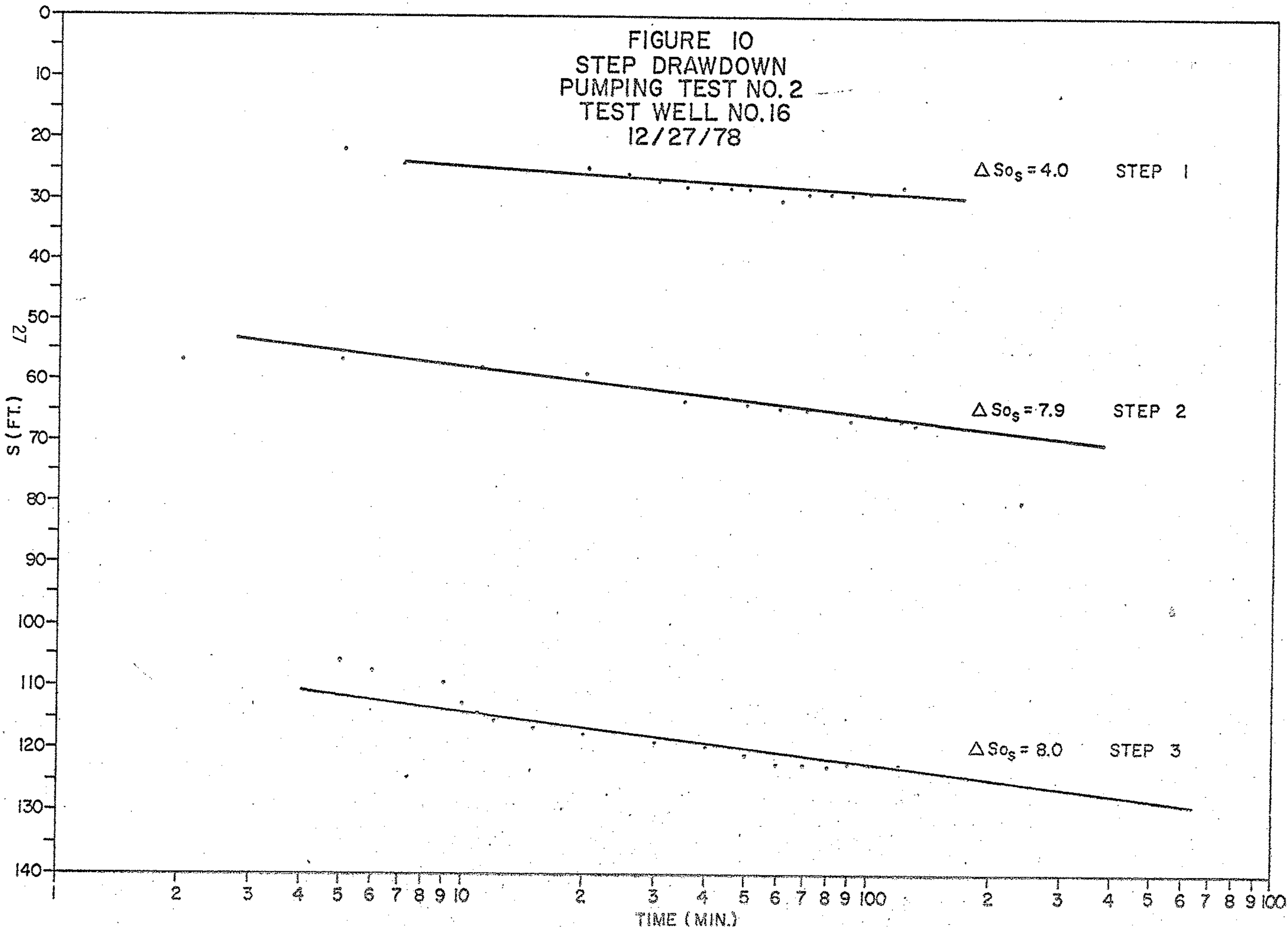


FIGURE 10
STEP DRAWDOWN
PUMPING TEST NO. 2
TEST WELL NO. 16
12/27/78
$\Delta So_s = 4.0$ STEP 1
$\Delta So_s = 7.9$ STEP 2
$\Delta So_s = 8.0$ STEP 3
S (FT.)
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
1
2
3
4
5
6
7
8
9
10
2
3
4
5
6
7
8
9
100
2
3
4
5
6
7
8
9
1000
TIME (MIN.)

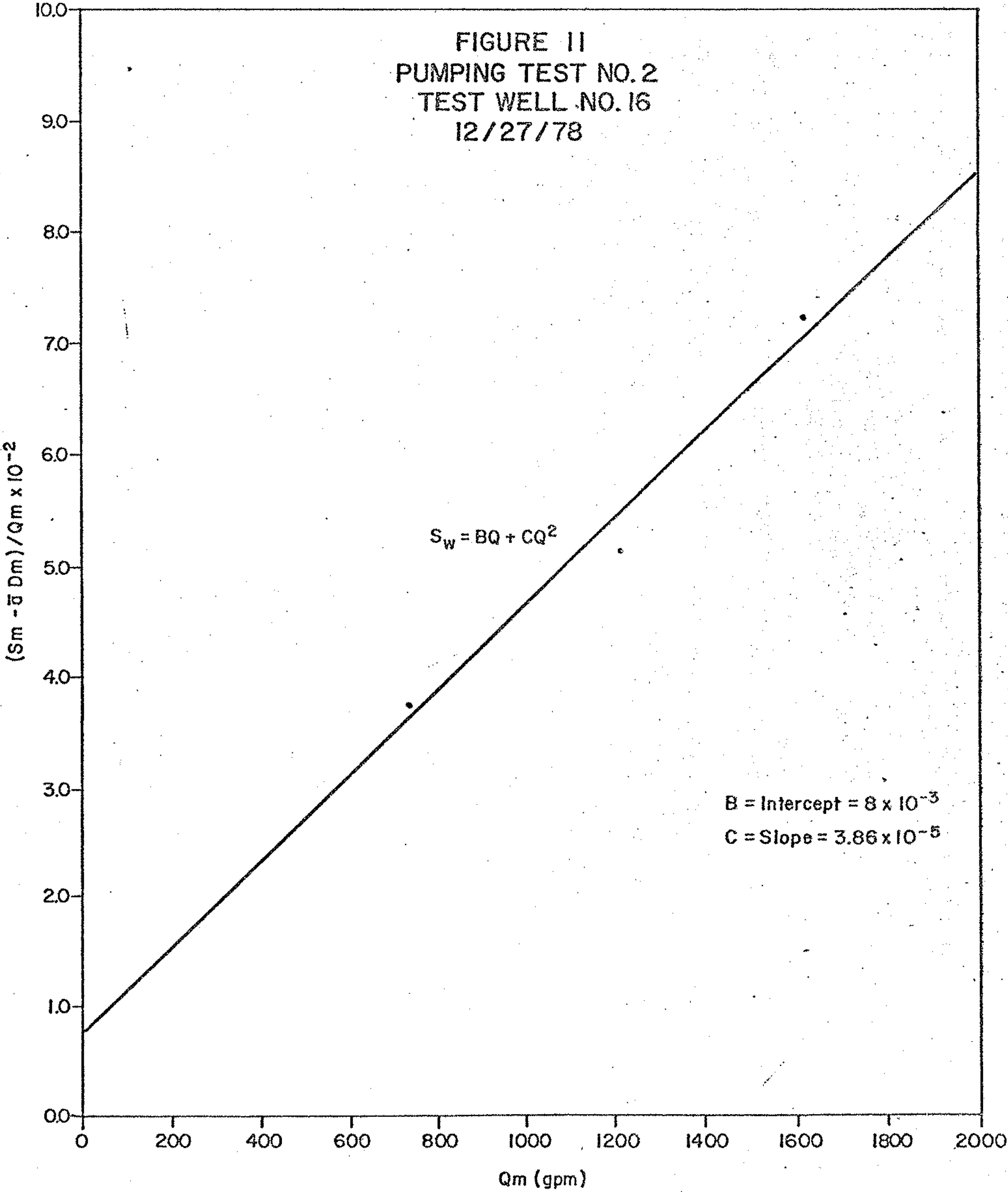


FIGURE 11
PUMPING TEST NO. 2
TEST WELL NO. 16
12/27/78
$S_W = BQ + CQ^2$
B = Intercept = 8×10^{-3}
C = Slope = 3.86×10^{-5}
$(Sm - \bar{a}\,Dm)/Qm \times 10^{-2}$
Qm (gpm)
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
0
200
400
600
800
1000
1200
1400
1600
1800
2000

Table 8

Recovery

Static Water Level - 53.0 ft. below land surface = E-Tape
55.4 ft. below land surface = Airline
Top of Casing, T/C = .9 ft. above land surface datum

12/27/78	Time Since Pump Test Started t, (min)	Time Since Pump Stopped t' (min)	Ratio t/t'	Depth to Water (ft)	Residual Drawdown s' (ft)
	390	0	--	177.53*	122.13*
	391	1	391	123.25*	67.85*
	392	2	196	110.54*	55.14*
	393	3	131	100.15*	44.75*
	394	4	98.5	81.67*	26.27*
	395	5	79	71.27*	15.87*
	396	6	66	71.27*	15.87*
	397	7	56.71	70.12*	14.72*
	398	8	49.75	70.12*	14.72*
	399	9	44.33	70.12*	14.72*
	400	10	40	69.75	16.75
	401	11	36.45	69.40	16.40
	402	12	33.5	69.30	16.30
	403	13	31	69.05	16.05
	404	14	28.86	68.77	15.77
	405	15	27	68.55	15.55
	410	20	20.5	68.05	15.05
	415	25	16.6	67.38	14.38
	420	30	14	66.65	13.68
	425	35	12.14	66.20	13.20
	430	40	10.75	65.70	12.70
	435	45	9.67	65.60	12.60
	440	50	8.80	65.50*	12.50
	450	60	7.50	59.6(?)	6.60(?)
12/28/78	1395	1005	1.39	56.68	3.68
	1535	1145	1.34	56.55	3.55

*Airline measurement

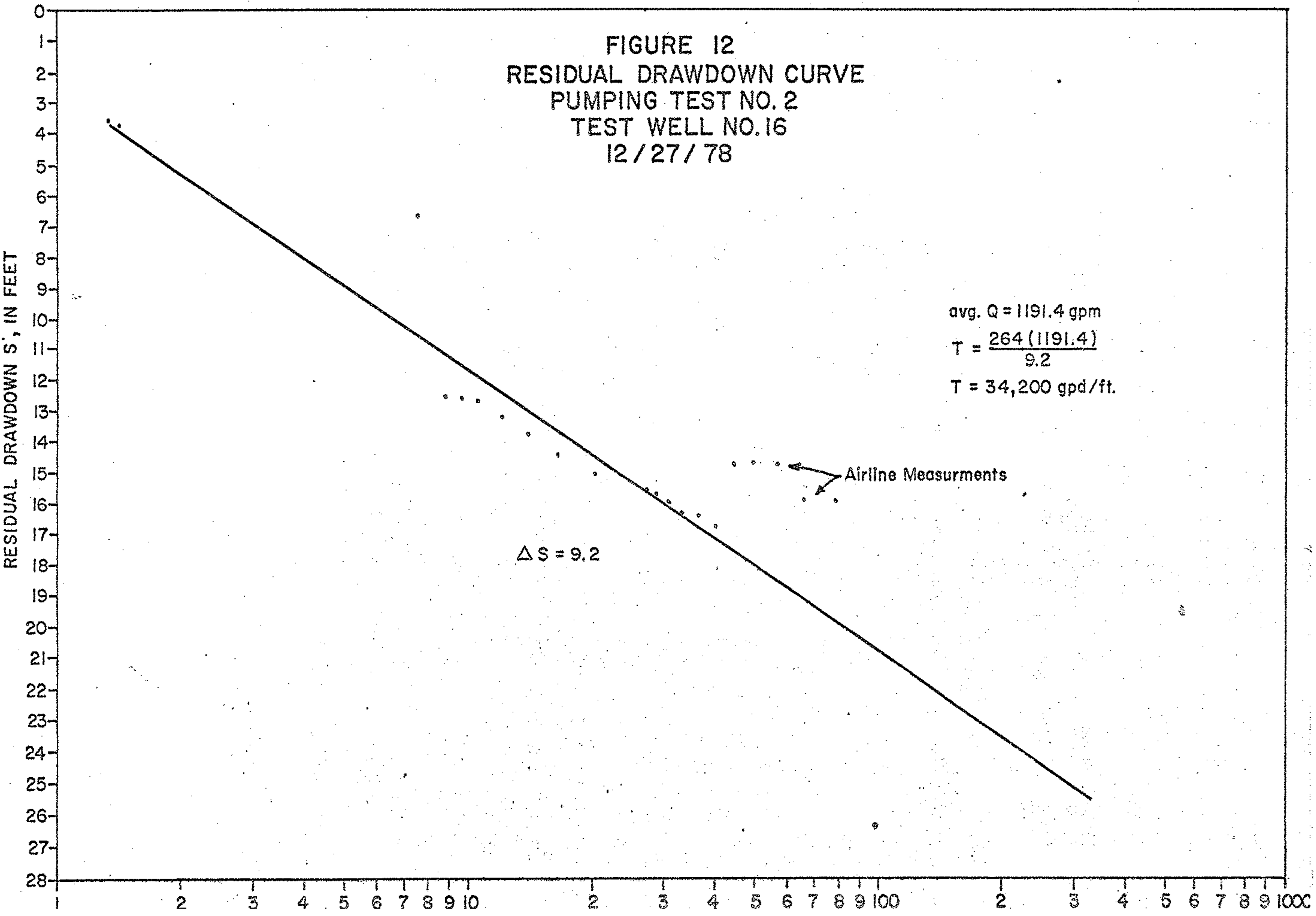


FIGURE 12
RESIDUAL DRAWDOWN CURVE
PUMPING TEST NO. 2
TEST WELL NO. 16
12/27/78
avg. Q = 1191.4 gpm
T = 264 (1191.4) / 9.2
T = 34,200 gpd/ft.
Airline Measurments
ΔS = 9.2
RESIDUAL DRAWDOWN S', IN FEET
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
1
2
3
4
5
6
7
8
9
10
2
3
4
5
6
7
8
9
100
2
3
4
5
6
7
8
9
1000

capacities increased, however, as more of the aquifer was exposed to the borehole, thus explaining the increased amount of water available. The lithologic and geophysical logs do not suggest any large dense basalt flows or confining clay layers which might isolate these aquifers either from each other or from above.

The evidence suggests one large aquifer, not quite unconfined but perhaps not completely confined either. Recharge may occur from the land surface directly as precipitation and perhaps along the basalt flows which dip quite steeply in this area. The lack of good pumping measurements as well as recovery data, the use of only three pumping steps rather than more, and the inability to adequately seal the liner from 380 to 680 feet, somewhat clouds the final conclusions. However, as more wells are drilled in this area and more data are made available, some of the missing picture may be completed.

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APPENDIX

LITHOLOGIC LOG

SCHNEBLY CREEK - TEST WELL #16

Log		Lithology	Comments
0- 10'	Sample #1	Sand, fine to medium, brown and tan, some silt, clay, loosely consolidated with black basaltic gravel and sand, brown silt, clay matrix	Cable tool Mike Ring Driller
10- 20'	Sample #2	Sand, fine to medium, brown, tan, loosely consolidated basaltic gravel with brown to tan silt and clay	
20- 30'	Sample #3	Sand (silt), fine, brown to tan silt clay matrix loosely consolidated with basaltic gravel and pebbles	
30- 40'	Sample #4	Gravel, basaltic, black to tan, loosely consolidated, silt, fine sand, some palagonite with gravels, basalt somewhat vesicular	
40- 50'	Sample #5	Sand (silt), fine, silt, clay, brown to tan matrix loosely consolidated with basaltic black gravel	Probably what drillers consider cemented gravel
50- 60'	Sample #6	Gravel, basaltic black to tan subangular to rounded, some silt and clay (probably matrix), some loosely consolidated fragments	
60- 70'	Sample #7	Sand, brown mixed with black basaltic gravel, silt, clay mostly as matrix, some consolidated fragments present, gravels weathered subrounded with some subangular pebbles	
70- 80'	Sample #8	Sand (silt), fine, tan, brown, silt loosely consolidated, some gravel	
85- 90'	Sample #9	Sand, fine to medium, loosely consolidated (crumbles easily), brown to tan silt matrix, some basaltic gravel	
90-100'	Sample #10	Gravel, basaltic, black to tan, subangular to rounded, weathered, some matrix of silt, fine sand, tan, crumbled under hand pressure	
100-110'	Sample #11	Sand, silty, fine to medium, tan to brown, some basaltic gravels loosely consolidated	
110-120'	Sample #12	Sand, fine to coarse, tan to brown, silt, dark to light basaltic gravel, loosely consolidated fragments breaks down easily under slight pressure	
120-130'	Sample #13	Same, however not as easily broken down, possibly more clay	

Log		Lithology	Comments
130-140'	Sample #14	Sand, fine to coarse, tan to brown, silt, very little gravel, some loosely consolidated sandstone fragments	
140-150'	Sample #15	Same	
150-160'	Sample #16	Sand, silty to coarse, tan to brown, black subrounded basaltic gravel, some loosely consolidated fragments	
160-170'	Sample #17	Sand, silty to coarse, tan to brown, black to light subrounded basaltic gravel, some loosely consolidated materials, some light clastics	
170-180'	Sample #18	Gravel, pea size, basaltic, dark, subrounded to angular, coarse basaltic sand dark to tan or brown, some fine sand, silt	
180-190'	Sample #19	Sand, silty to medium, tan to brown, some light clasts, dark to light tan basaltic gravel, silt, loosely consolidated fragments	
190-200'	Sample #20	Gravel, pea size, tan to dark, basaltic, subrounded, medium to coarse tan to brown sand, some light clasts, silt, sand/gravel ≈ 50/50	
200-210'	Sample #21	Sand, silty to coarse, tan to brown, some lighter clasts, basaltic gravel, light to black, angular to subrounded, loosely consolidated with silt	
210-220'	Sample #22	Sand, silty to coarse, tan to brown w/basalt gravel, black, brown, tan, angular to subrounded, some loosely consolidated fragments	
220-230'	Sample #23	Gravel, basaltic with medium to coarse tan, brown sand ≈ 50% with some silt	
230-240'	Sample #24	Sand, fine to coarse, tan, brown, tan and brown silt, rounded to subrounded black basaltic gravel, loosely consolidated	
240-250'	Sample #25	Gravel, coarse, large pebbles almost cobble size, dark to light, medium to coarse tan and brown sand loosely cemented by silt or clay	
245-250'	Sample #26	Sand, fine to medium, tan, brown with black to tan, subangular-subrounded basaltic gravel, silt, loosely consolidated	
250-260'	Sample #27	Sand, fine to medium, tan, brown, with brown and tan silt and highly weathered subrounded basaltic gravel, loosely consolidated	

Log		Lithology	Comments
260-270'	Sample #28	Sand, fine to medium, brown, tan, with brown and tan silt, a few small gravel clasts, loosely consolidated	
270-280'	Sample #29	Sand, fine to medium, tan, brown, with brown to tan silt and black basaltic gravel, a few pebbles, loosely consolidated	
280-290'	Sample #30	Sand, fine, brown to tan, with brown to tan silt, a few pebbles of black basaltic gravel, loosely consolidated	
290-300'	Sample #31	Sand, fine, brown to tan, with brown to tan silt, loosely consolidated	
300-310'	Sample #32	Sand, fine to medium, tan, brown, with brown to tan silt, weathered black and brown basaltic gravel, loosely consolidated	
310-320'	Sample #33	Sand, fine, tan, brown, with tan, brown silt, clay, very few coarse fragments, loosely consolidated	
320-330'	Sample #34	Sand, fine to medium, tan, with tan, brown silt, some dark to tan subrounded gravel, loosely consolidated	
330-340'	Sample #35	Sand, fine to coarse, brown, tan, with dark to brown, subrounded gravel, tan and brown silt, loosely consolidated	
340-350'	Sample #36	Tuff, volcanic ash, white, light coarse grained tephra	
350-360'	Sample #37	Gravel, basaltic, dark or black, subrounded to rounded, with brown to tan coarse sand	
360-370'	Sample #38	Gravel, basaltic, gray, subangular to subrounded, with gray to brown coarse sand	
370-430'	Samples # 39 - 43	These samples not logged	Beginning of basalt - samples placed in wax cups by drillers but not labeled. Cable tool rig off site. Rotary rig begins drilling using 10" roller bit.
430-440'	Sample #44	Basalt, black, gravel size to coarse gravel size fragments, fractured	
440-450'	Sample #45	Basalt, black, hard, smaller chips, broken, some olivine	

Log		Lithology	Comments
450-460'	Sample #46	Basalt, black, semi-hard, broken fragments, some olivine	
460-470'	Sample #47	Sand, basaltic, some black silt, clay, subangular to subrounded black gravel, some olivine	
470-480'	Sample #48	Sand, basaltic, black, silt, some green, red clay, some angular to subrounded gravel	
480-490'	Sample #49	Sand, basaltic, black, subrounded, appears clean; some silt, WATER	Pump test : SWL = 58.65' below land surface datum
490-500'	Sample #50	Basalt, black, vesicular, fractured, some silt, clay, sand, various colors, chlorophaeite weathered material	
500-510'	Sample #51	Basalt, black, some red, white, light green cuttings, hard to semi-hard	
510-520'	Sample #52	Basalt, black, red, green, white, hard (10'/hr w/10" roller bit); some clay, some larger pea gravel	
520-530'	Sample #53	Basalt, black, hard (5-6'/hr w/10" roller bit); some olivine, chlorophaeite, red, yellow, green colored	
530-540'	Sample #54	Basalt, black to brown, hard (5-6'/hr with 10" roller bit); some oxidation evident, green, red, yellow, olivine? chlorophaeite	
540-550'	Sample #55	Basalt, black, hard (3'/hr with 10" roller bit); some oxidation, broken larger pebbles, red, green, yellow angular to subrounded cobbles	Water Level = 64.45' below LSD
550-560'	Sample #56	Basalt, black, larger chips or fragments, hard (5'/hr with 10" roller bit); many pebbles, cobbles oxidized Fe, chlorophaeite, brown, red, yellow colors	
560-570'	Sample #57	Sand, basaltic cobbles, broken, angular to subrounded gravel fragments with some yellow, red, white, hard (3'/hr with 10" roller bit)	
570-580'	Sample #58	Sand, basaltic, black, yellow, white pea gravel, some angular to subrounded cobbles	
580-590'	Sample #59	Basalt, black, easier drilling (10'/hr with 10" roller bit); oxidized, larger yellow, red, angular to subangular cobbles	
590-600'	Sample #60	Basalt, black w/brown, broken, semi-hard to medium (12'/hr); some clay palagonite or claystone (soapstone)	

Log		Lithology	Comments
600-610'	Sample #61	Basalt, black, brown, soft (20'/hr with 10" roller bit); weathered, some larger fragments, brown clay	
610-620'	Sample #62	Basalt, black, brown, medium to soft (15'/hr with 10" roller bit); weathered to claystone and clay, some larger yellow, red cobbles, palagonite? present	
620-630'	Sample #63	Basalt, black, brown, medium to soft (17.5'/hr with 10" roller bit); cruddy, vesicular; pea gravel and larger fraction present, yellow, tan, claystone (palagonite?), soapstone present	
630-640'	Sample #64	Basalt, black, slightly harder (11'/hr with 10" roller bit); weathered; tan and yellow claystone (palagonite?) or soapstone	
640-650'	Sample #65	Basalt, black, brown, broken or fractured, weathered, soft (20'/hr); yellow, tan, brown claystone (palagonite?) (soapstone according to drillers)	Losing air pressure. Auxiliary compressor
650-660'	Sample #66	Basalt, black, broken, soft; brown, tan, and yellow claystone (soapstone)	
660-670'	Sample #67	Basalt, black, soft (20'/hr drilling rate with 10" roller bit); yellow, brown, white claystone	Pressure up.
670-680'	Sample #68	Basalt, black, brown, medium (12'/hr with 10" roller bit); greasy tan claystone (soapstone), red, green remnants of weathered basalt	
680-690'	Sample #69	Basalt, black, brown, hard (9'/hr with 10" roller bit); brown, tan greasy claystone (soapstone)	
690-700'	Sample #70	Basalt, black, soft (20'/hr w/10" roller bit); some claystone or soapstone present, tan, yellow, chlorophaeite, palagonite also present	Losing compression static water level = 66.7' below land surface. 8" liner placed 380-680' S.W.L. = 66.10' below LSD Water temp. = 56°F, 13°C Hole continued with 8" roller bit
700-710'	Sample #71	Sand, basaltic, black, some gravel, silt, claystone (soapstone) (20'/hr with 8" roller bit); probably from zone lined off	
710-720'	Sample #72	Basalt, black, lighter brown, yellow weathered fragments, soft (15'/hr with 8" roller bit); grey to brown claystone	

Log		Lithology	Comments
720-730'	Sample #73	Basalt, gravel, brown, black, some lighter fraction, fast drilling (60'/hr with 8" roller bit); angular to subrounded	
730-740'	Sample #74	Basalt, mostly of gravel fraction, black, brown, coarse sand, angular to subrounded, fast drilling (60'/hr with 8" roller bit)	
740-750'	Sample #75	Basalt, gravel, black, red, brown, tan, angular to subrounded, fast drilling (40'/hr with 8" roller bit); % gravel greater than clay, clay light tan, silt, sand	
750-760'	Sample #76	Basalt, black, getting harder (40'/hr with 8" roller bit); some angular to subrounded gravel and soapstone (clay) brown to tan color	
760-770	Sample #77	Basalt, black, brown, soft, larger gravel or small cobble size fraction, angular to subrounded	Water Temp. = 60°F, 15°C
770-780'	Sample #78	Gravel, basaltic, small cobbles, black with chlorophaeite, some red-brown, fractured (30'/hr drilling rate with 8" roller bit); angular to rounded, some sand	Water 720-780' S.W.L. below LSD = 47.7'
780-790'	Sample #79	Basalt, black some brown, soft (24'/hr with 8" roller bit); some brown, black, red, angular to rounded pea gravel	Water temp. = 60°F, 15°C
790-800'	Sample #80	Basalt, black, brown, soft (30'/hr with 8" roller bit); some sand, silt	
800-810'	Sample #81	Basalt, black, semi-hard to hard (12'/hr with 8" roller bit); some red, brown fragments larger gravel or small cobbles angular to subrounded, chlorophaeite	
810-820'	Sample #82	Basalt, black, soft (24'/hr with 8" roller bit); some red, brown colored larger broken cuttings	
820-830'	Sample #83	Basalt, black, hard (8'/hr with 8" roller bit); some brown, red cuttings	
830-840'	Sample #84	Basalt, black, hard (6'/hr with 8" roller bit); some softer basalt, green, red, brown cuttings	
840-850'	Sample #85	Basalt, black, hard (6-7'/hr with 8" roller bit); light colored cuttings, some silt size	
850-860'	Sample #86	Basalt, black, hard (5'/hr with 8" roller bit); some silt size, some olivine present, some rounded to subangular clastics present	

Log		Lithology	Comments
860-870'	Sample #87	Basalt, black, hard (6'/hr with 8" roller bit); a lot of fine sand and silt size materials some weathered materials some olivine or epidote?	
870-880'	Sample #88	Basalt gravel and sand, black, soft interbed (20'/hr with 8" roller bit); subrounded/rounded to subangular, various colored clasts	
880-890'	Sample #89	Sand, basaltic, black to light, hard drilling (10'/hr with 8" roller bit); some rounded to subangular gravel, silt	
890-900'	Sample #90	Sand, coarse basaltic to gravel, black to green, light medium-hard basalt (10'/hr with 8" roller bit); rounded to subangular gravel, epidote? olivine? some palagonite?	
900-910'	Sample #91	Sand, medium to fine, basaltic dark to light, some rounded gravel, some silt	
910-920'	Sample #92	Sand, fine, like beach sand, light to dark, some rounded basaltic gravel	Can't get past this point; drilling ended.