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Test wells in the Post Area, White Sands Missile Range, Dona Ana County, New Mexico

by

Gene C. Doty

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Gene C. Doty

Prepared in cooperation with the U. S. Army, White Sands Missile Range, New Mexico

U. S. Geological Survey open-file report
June 1968

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Dona Ana County, New Mexico

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Gene C. Doty

Introduction

Six test wells were drilled in the Post Area of the White Sands Missile Range in Dona Ana County, New Mexico (fig.1), between January 1966 and May 1967 as a part of the Water Master Plan of the Missile Range. The locations of the test wells drilled in the Post Area are shown on figure 2. The wells were drilled to increase the knowledge of the hydrology of the Post Area and to obtain data for long-range planning of water-resources development.

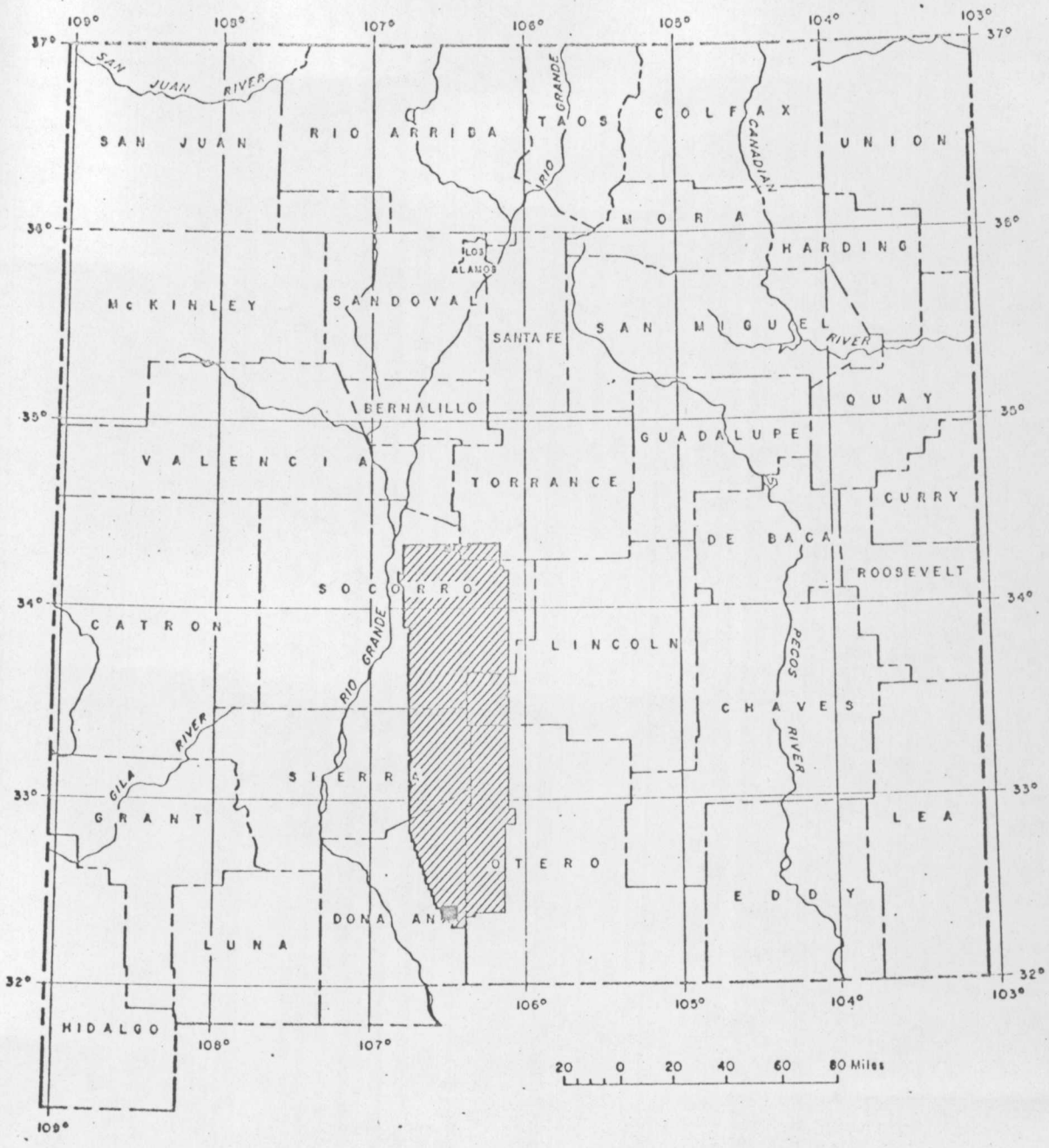
Specifically, the Post Area test wells were drilled to:

(1) Establish control points on the bedrock surface and hence further define the aquifer system.

(2) Establish control points on the saline-fresh water interface.

(3) Provide correlative subsurface information for geophysical-Survey data.

(4) Provide additional observation wells for monitoring water levels and saline-water encroachment in and near the Post Area well field.

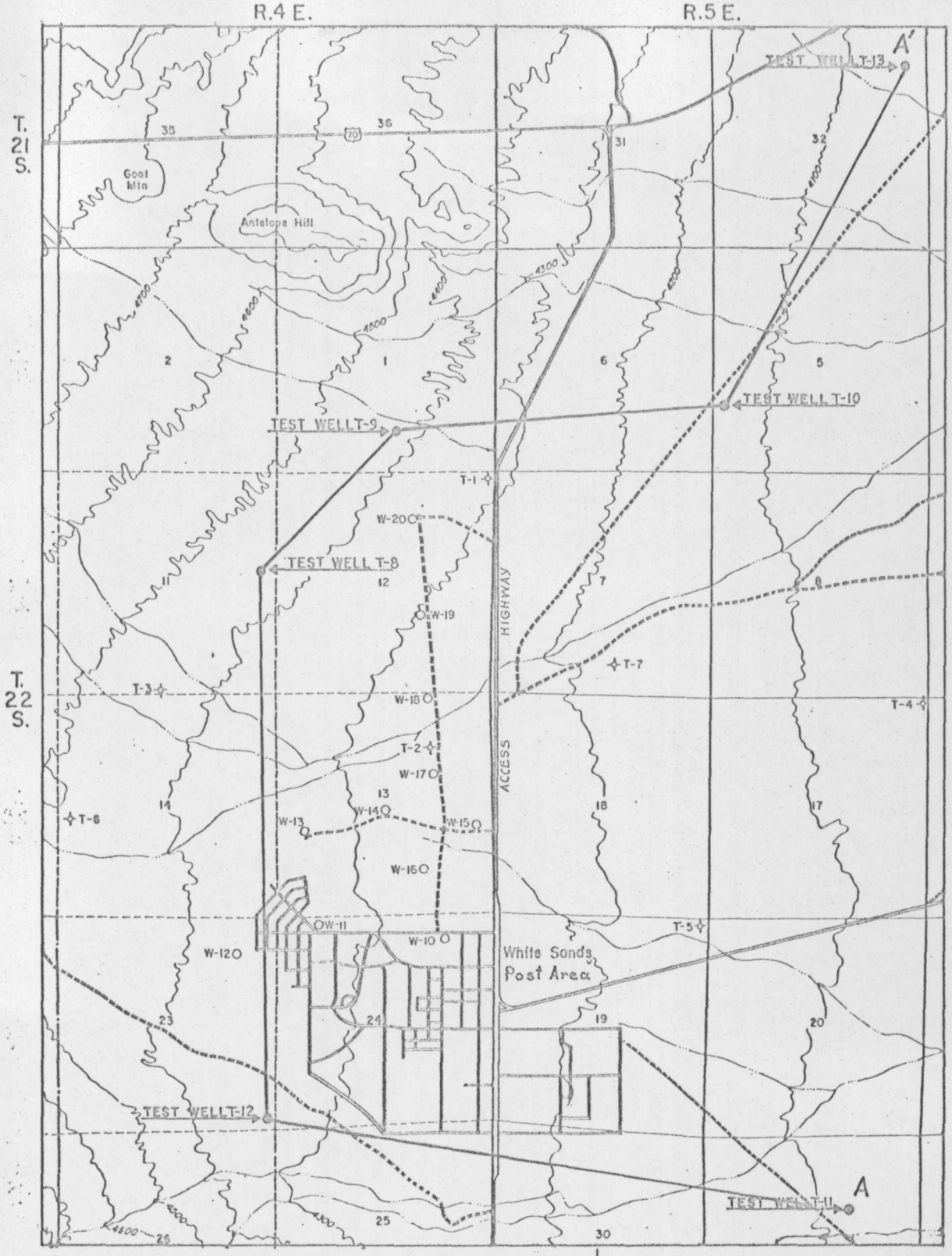


EXPLANATION

Project area

White Sands Missile Range

Figure 1.--White Sands Missile Range and project area, (Post Area), New Mexico.



Map from U.S. Army Corps of Engineers
Drawing 16-06-367

EXPLANATION

● New Test Well
⊹ Existing Test Well
o Existing Supply Well
A—A' Line of profile (fig. 16)

Figure 2.--Test wells in Post Area White Sands Missile Range, Dona Ana County, N. Mex.

The geography, geology and hydrology of the Post Area have been described by Herrick (1960), Hood (1968), and Davis and Busch (1968). The reader is referred to these sources for background material on the area. This report is a summary of the drilling of test wells T-8, T-9, T-10, T-11, T-12, and T-13 and is prepared as a part of the continuing cooperative agreement between White Sands Missile Range and the U. S. Geological Survey. The Geological Survey assisted in the selection of well sites and provided technical advice to the U. S. Army Corps of Engineers personnel administering the drilling contract, as well as observing the drilling and obtaining measurements and other data during development and testing of the wells. Geological Survey personnel involved in field-data collection included J. A. Basler, J. P. Borland, F. E. Busch, G. A. Dinwiddie, H. E. Lobley, and the writer, supervised by J. B. Cooper, Hydrologist, and W. E. Hale, District Chief, Water Resources Division, Albuquerque, New Mexico.

Methods and procedures

The test wells were drilled by conventional hydraulic rotary rigs operated by the Cass Drilling Company of El Paso, Texas. Drilling time was recorded by an automatic drilling-rate recorder. Samples of drill cuttings were collected from the return-flow sluice after each 5 feet of penetration and are not corrected for time lag; the samples were classified primarily for particle-size range. Water samples were collected as drilling progressed, using bottom-set or shoulder packers. A commercial logging company made electric logs when the wells had been drilled to total depth.

Electric logs, drilling-time logs, and drill cuttings were examined to determine where perforated casing should be placed. Mill-cut slots, 1/8-inch wide, were used in all perforated-casing sections. After the casing had been placed, each well was developed by bailing and surging with a tight-fitting bailer and, if needed, a closed-surge block. A test pump was installed after bailing and surging and the well was further developed by pumping and surging. The water level in the well was allowed to recover for several hours after pumping and surging; the well was then pumped for eight hours at a specified rate. Depth to water was measured with an electric tape during pumping and for several hours after pumping stopped. Upon completion all wells were fitted with removable caps and retained as water-level observation wells.

Results of drilling

Test well T-8 was expected to penetrate the full thickness of alluvial fan and bolson deposits of Quaternary-Tertiary age and to terminate in consolidated bedrock. The estimated depth of T-8 was based upon geophysical data (Herrick, 1960). An igneous intrusive rock was penetrated about 300 feet deeper than the estimated depth to bedrock (tables 2 and 3). Drilling became more difficult below 1,200 feet and the lower part of the well is believed to have penetrated cemented conglomerate (fig. 3) which yields but little water (see aquifer-test plots, figs. 4 and 5). Granitic bedrock was drilled in the interval from 1,891 to 1,896 feet, the total depth. The cemented conglomerate may be interpreted on some geophysical surveys as bedrock. Most of the material penetrated by the well was clay, sand, and gravel derived from igneous rocks. Water samples were collected at depths of 853; 1,348; and 1,820 feet; all samples were of potable quality. (table 1).

Test well T-9 was drilled for the dual purpose of prospecting the area north of the Post Area supply wells and of determining the depth to bedrock. Supply well 20, about 2,000 feet south of test well T-9, is one of the higher-yield wells in the well field; the extent of the high-transmissibility zone tapped by well 20 must be known for planning northward extension of the line of supply wells. Test well T-9 penetrated an igneous intrusive rock at a depth of 595 feet, about 200 feet shallower than expected (tables 4 and 5). The material above the bedrock was consolidated and unconsolidated clay, sand, and gravel of Quaternary-Tertiary age which was derived mostly from igneous rock. The well yielded so little water that a cylinder pump was used for test pumping (figs. 6 and 7). The well probably was drilled into the upthrown side of the fault bounding the high-transmissibility zone in which well 20 is completed. Water obtained from total depth was potable (table 1).

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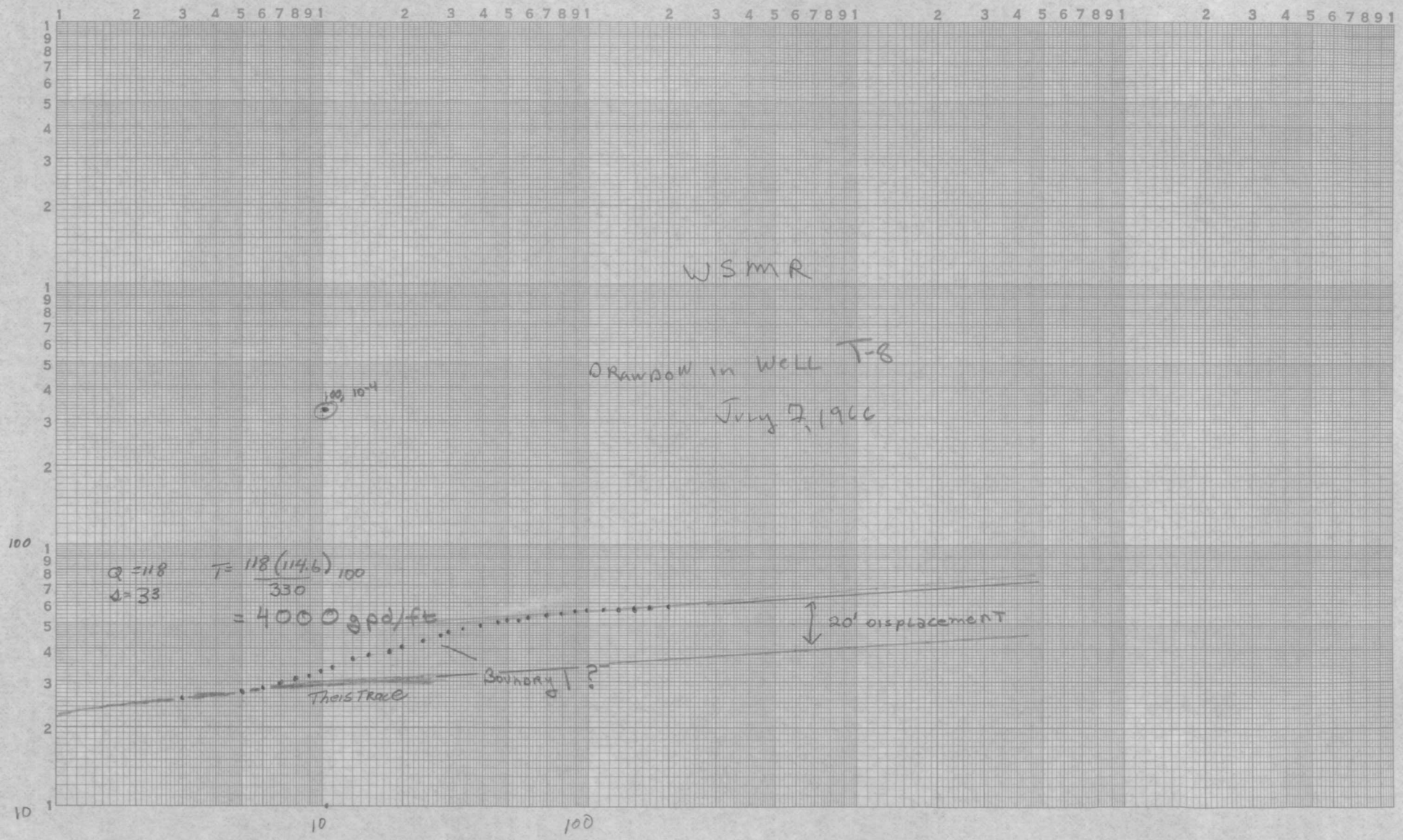

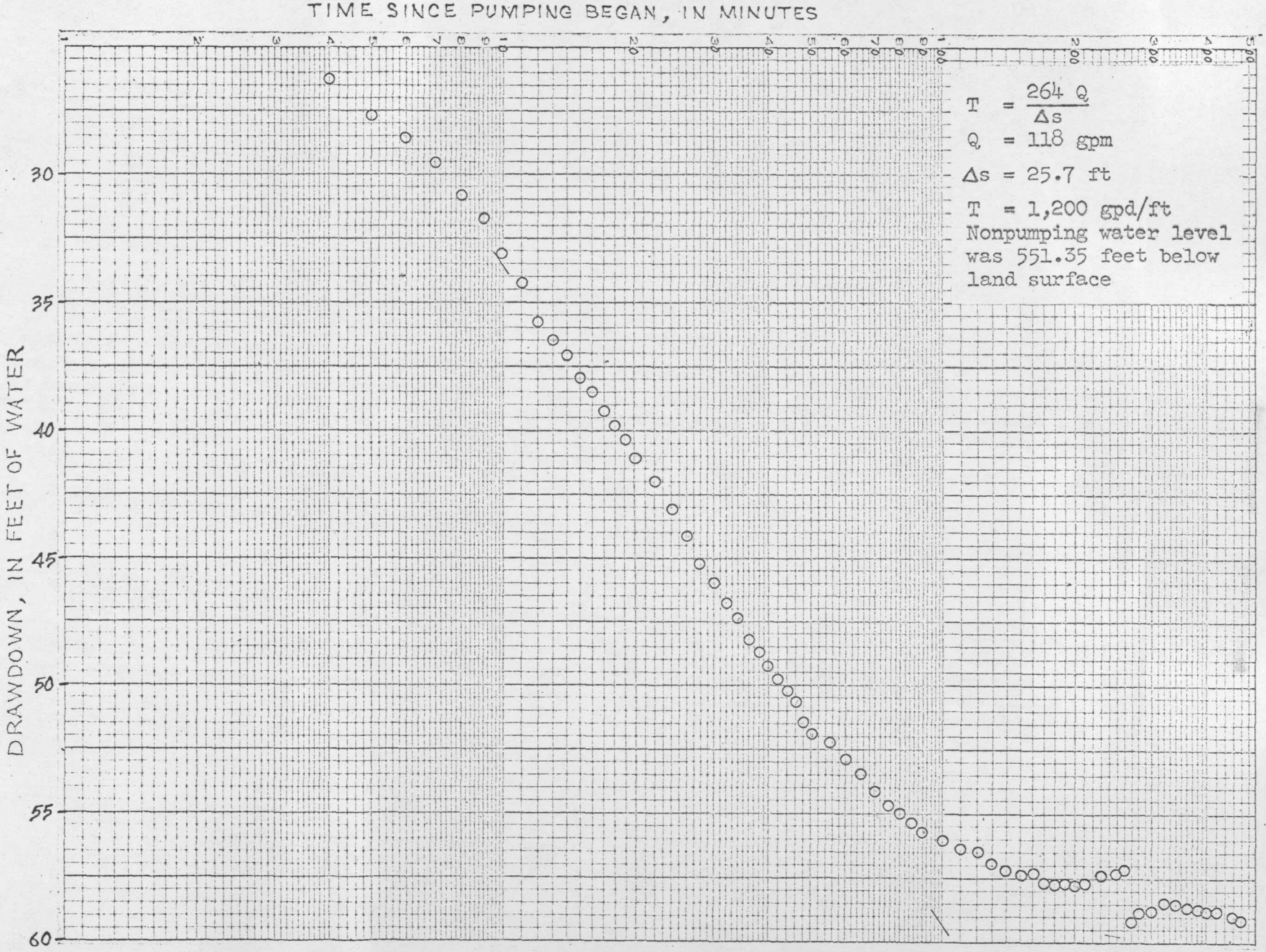

FIGURE 4.--DRAWDOWN IN WELL T-8, JULY 7, 1966

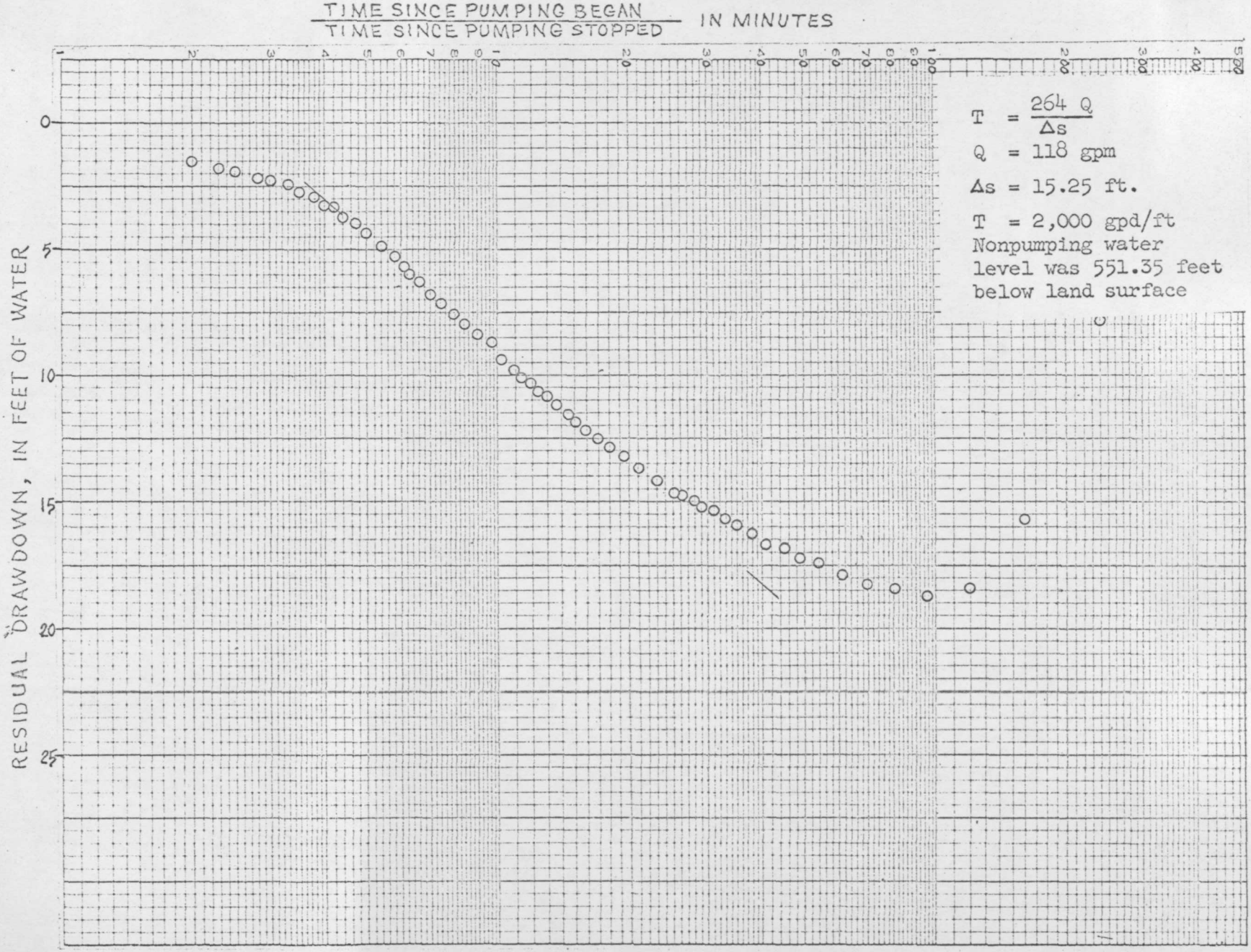

FIGURE 5.__ RESIDUAL DRAWDOWN IN WELL T-8, JULY 7, 1966

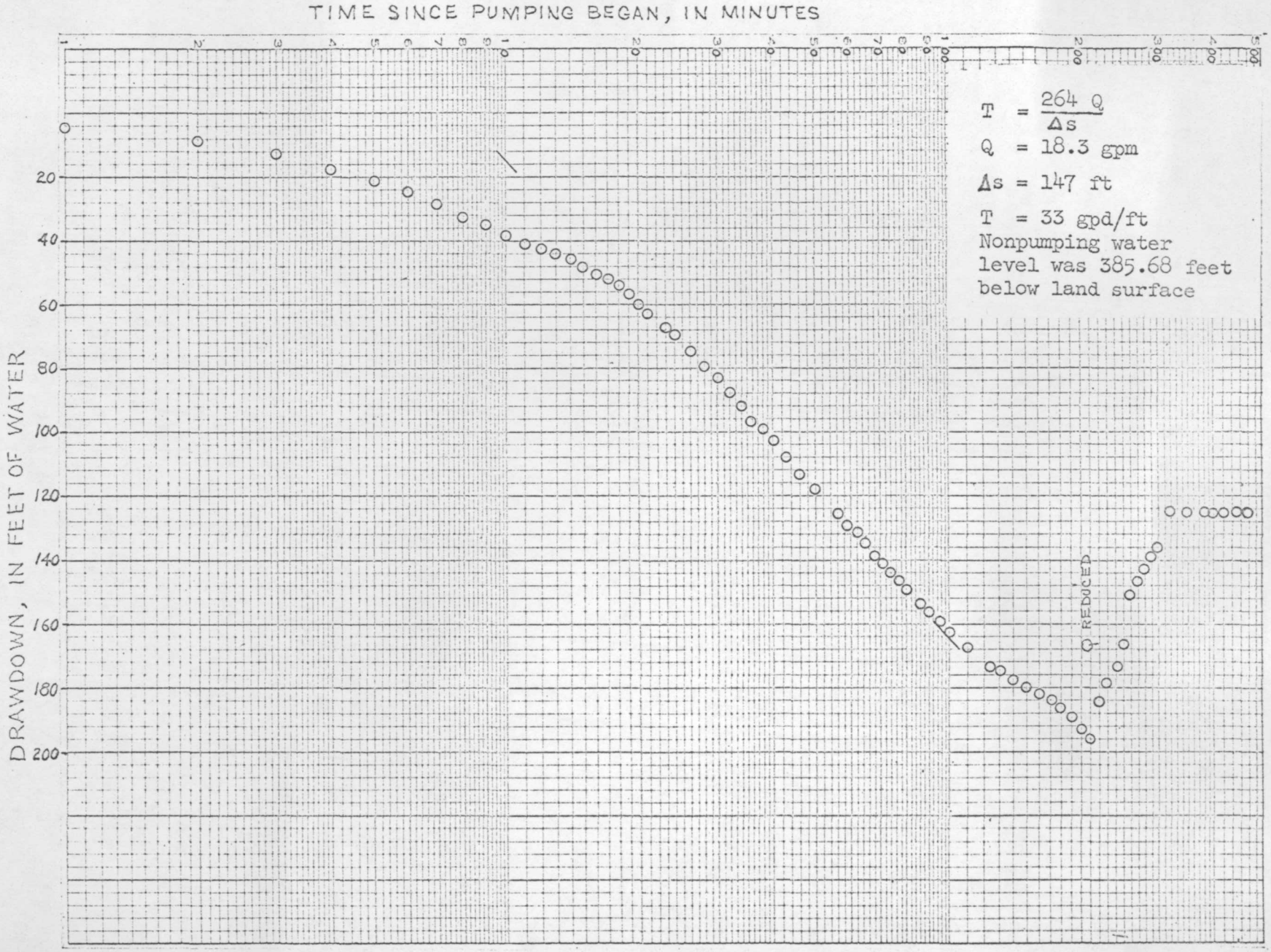

FIGURE 6.--DRAWDOWN IN WELL T-9, AUG. 4, 1966

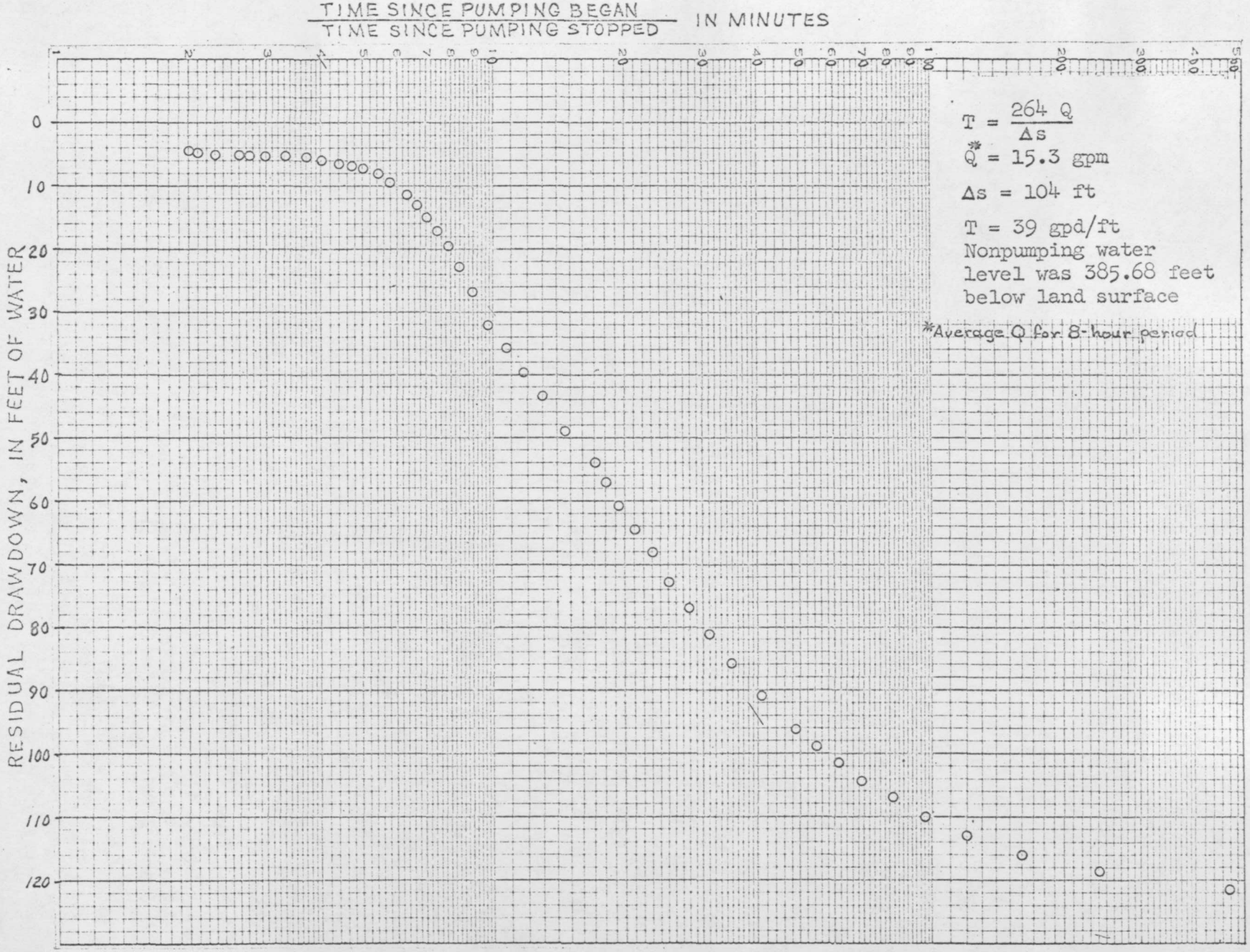

FIGURE 7.-- RESIDUAL DRAWDOWN IN WELL T-9 AUG.4, 1966

Test well T-10 was drilled to determine the interface between saline and fresh water and, possibly, as a bedrock-control point. The well was drilled about 100 feet deeper than originally planned in order to penetrate material permeable enough to yield water for a sample at total depth (tables 6 and 7). This sample, the lower sample of two collected as the well was drilled, was not potable (table 1). The well penetrated bolson deposits of Quaternary-Tertiary age consisting mostly of clay and sand. From a depth of about 560 feet to total depth of 1,365 feet the material penetrated was mostly clay with an occasional thin bed of sand. Bedrock was not reached. The well was completed at a depth of 555 feet in the fresh-water section of the aquifer. It will be sampled periodically in the future to monitor any saline-water encroachment of the fresh-water aquifer. The water-bearing materials adjacent to the lower perforated casing contain a high percentage of very fine sand and the well may in the future fill partially with sand as the slot size is too coarse to prevent sand from entering the casing. The transmissibility calculated from the aquifer test (figs. 8 and 9) is comparable to that of some of the low-yield wells in the well-field area.

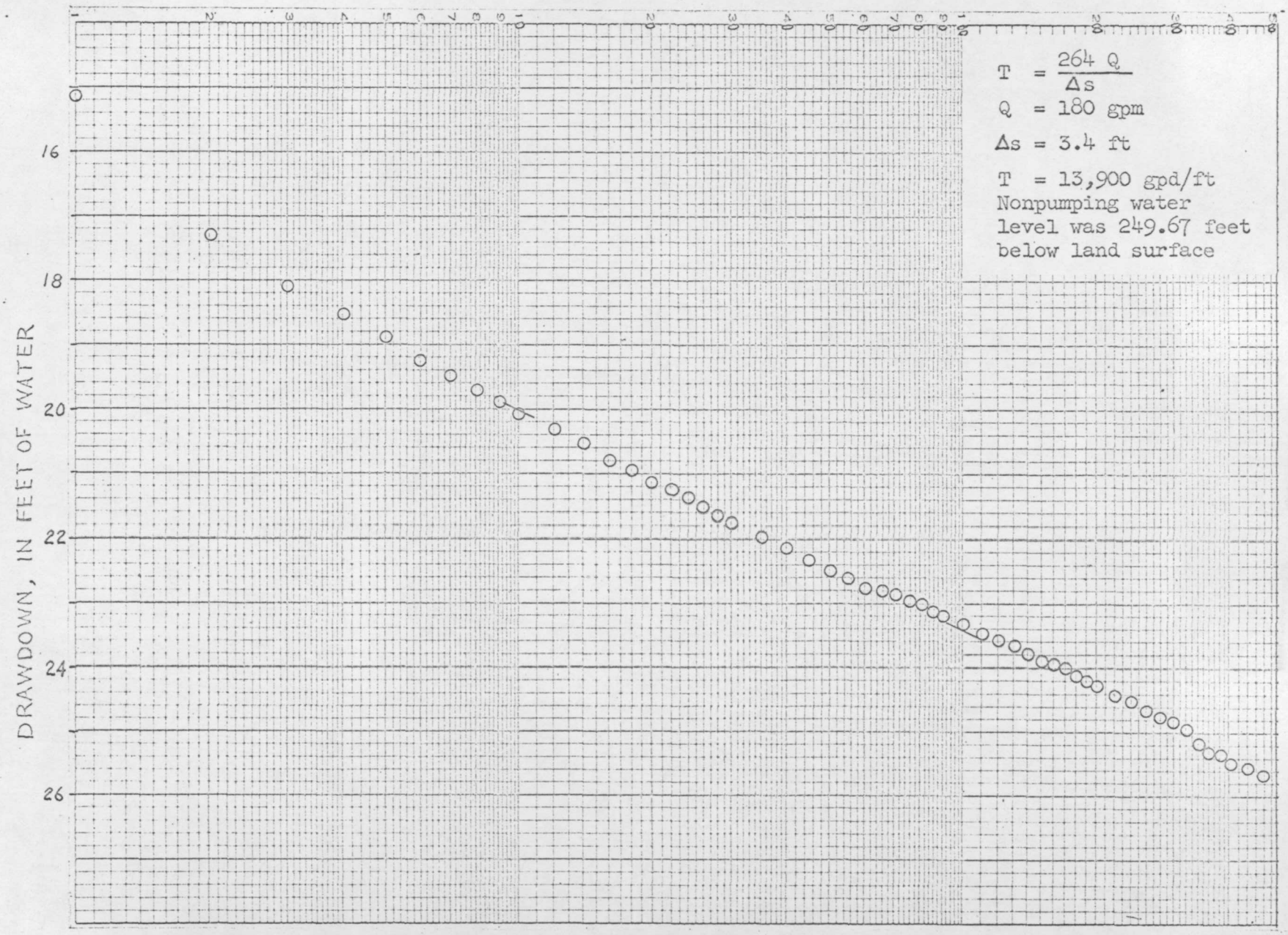

FIGURE 8.--DRAWDOWN IN WELL T-10, SEPT. 16, 1966

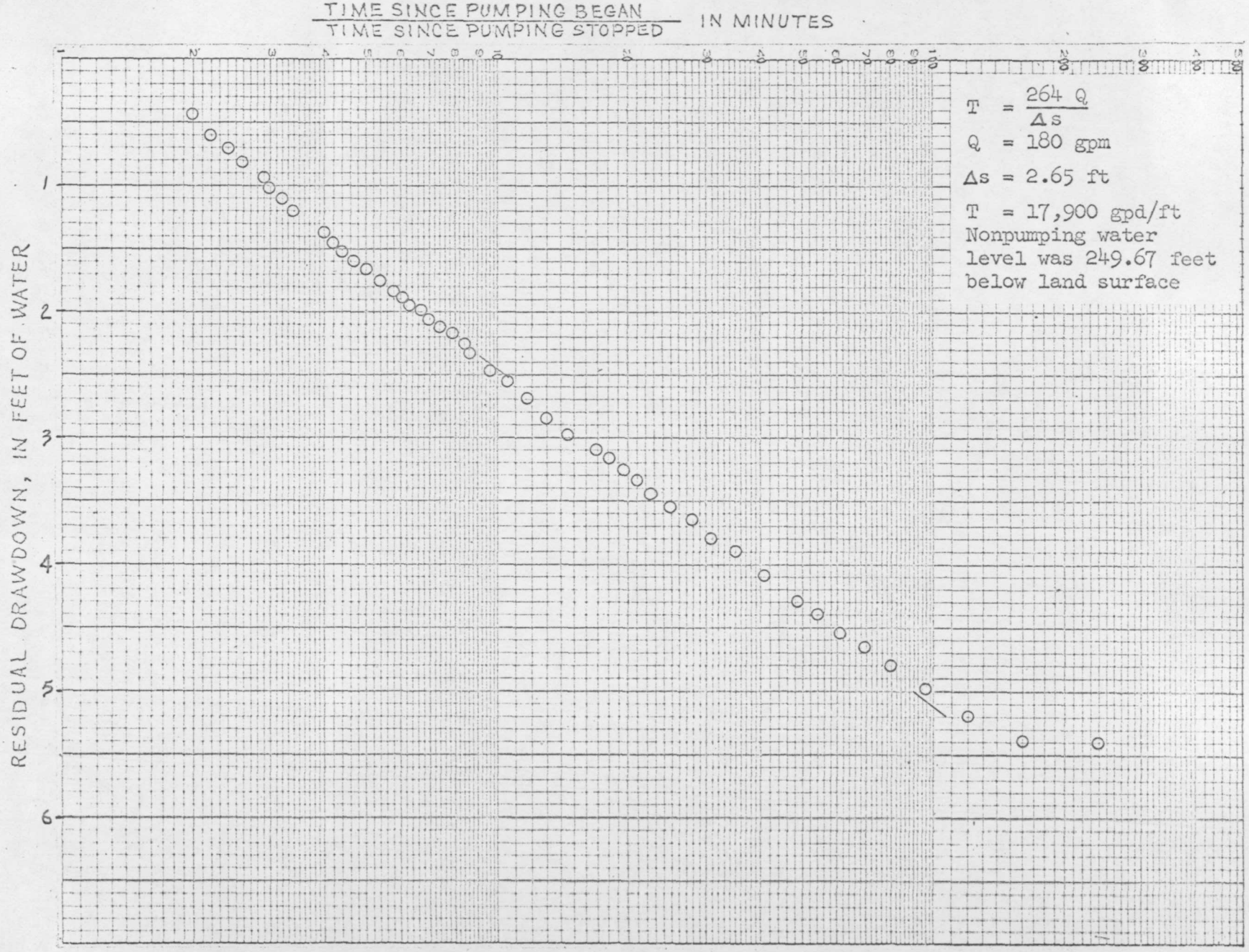

FIGURE 9.-- RESIDUAL DRAWDOWN IN WELL T-10, SEPT. 16-17, 1966

Test well T-11 was drilled to penetrate the saline-water fresh-water interface. The well was drilled 700 feet deeper than planned originally in order to penetrate the interface, which was a sequence of interfingering beds containing potable, brackish, and nonpotable water (Tables 8 and 9). Two sets of electric logs (fig. 3) were made, one when the well had been drilled to 1,265 feet and another when the well had been drilled to total depth of 1,808 feet. The well penetrated bolson deposits of Quaternary-Tertiary age, consisting mostly of clay and thin beds of sand, similar to the material penetrated by test well T-10. The water quality ranged from potable to nonpotable (table 1); the well was completed in the potable water zone at a depth of 780 feet. Sand entered the well so easily during development that bailing and surging was abandoned as a development procedure. The well produced a large amount of sand when the test pump was first operated and sand filled the lower section of the slotted casing and could not be removed with a bailer. Yield and drawdown characteristics of the well are similar to the lower-yield production wells in the well field (figs. 10 and 11).

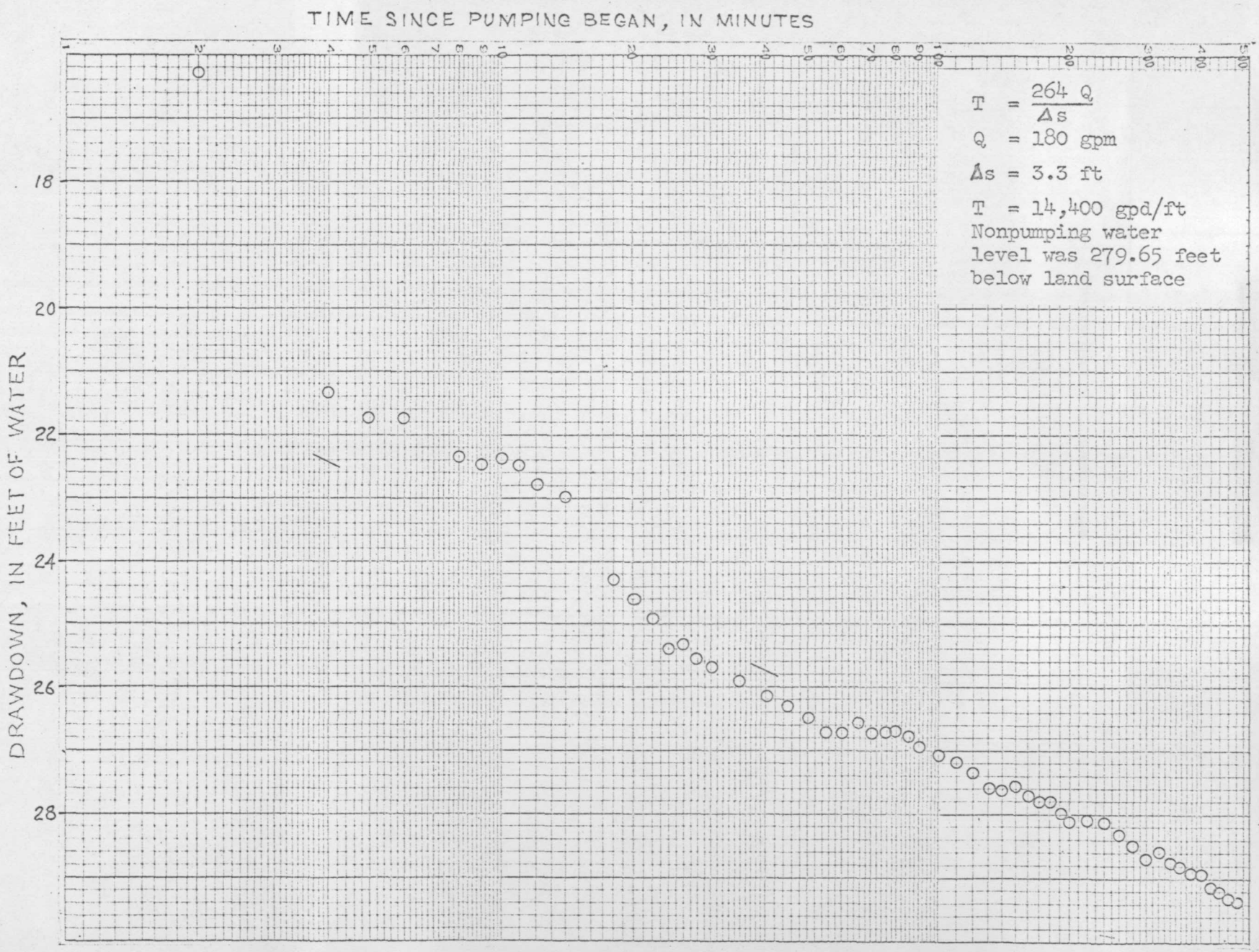

FIGURE 10.--DRAWDOWN IN WELL T-11, NOV. 16, 1966

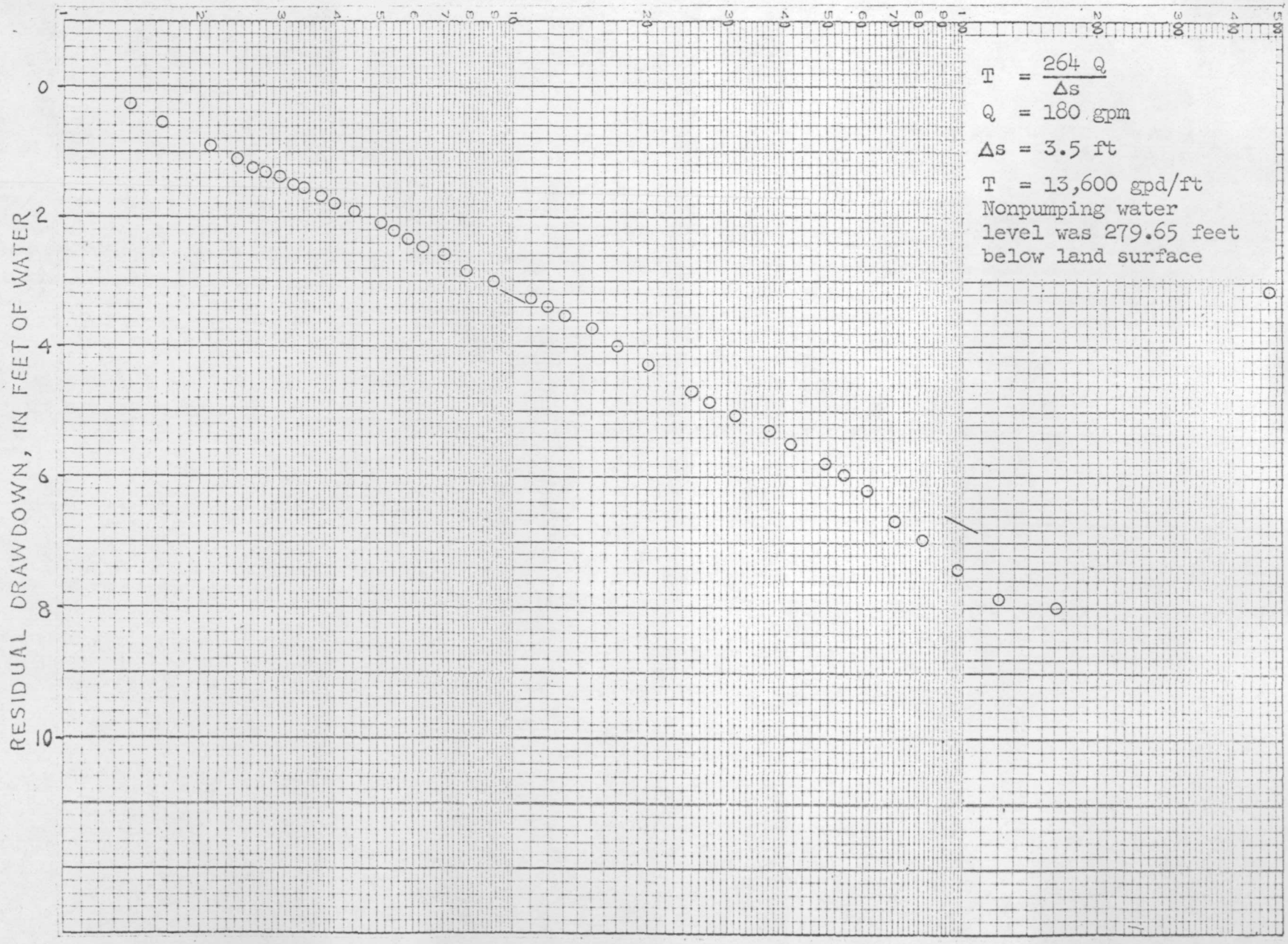

FIGURE 11.--RESIDUAL DRAWDOWN IN WELL T-11, NOV. 16-17, 1966

Test well T-12 was drilled to determine the depth to bedrock, thickness of the aquifer, and depth to saline water. The well was drilled to a depth of 2,000 feet which was 900 feet deeper than originally planned, in an attempt to fulfill the original objectives. (See tables 10 and 11). Sets of electric logs were made at depths of 1,600 feet and 2,000 feet. The well penetrated bolson deposits of Quaternary-Tertiary age consisting of sand, clay, and gravel, derived mostly from igneous intrusive rocks, and did not reach bedrock. The bolson deposits below 1,000 feet are semi-consolidated to consolidated; they probably are consolidated to a greater extent than similar materials penetrated in the lower part of test well T-8. Water samples were collected from depths of 734, 1,573, and 1,881 feet during drilling; all samples were potable (table 1). The well was cased with 8-inch casing to 450 feet and with 6-inch casing from 450 feet to 1,820 feet. During development, the size of particles removed suggested that the pipe had ruptured, probably where the two diameters of casing joined, and a sleeve swage with a minimum diameter of 5 inches was installed at the junction of the 6-and 8-inch casing. In all probability, if a rupture in the pipe did occur, it was in association with a collapse of the casing at a depth of about 1,794 feet; the bailer and sand pump could not be lowered past this depth when fill was being removed from the casing at the close of development. Extra effort was expended in attempting to develop this well, both in bailing and surging and in surging and pumping with the test pump. Yield was considerably less than expected (aquifer-test plots, figs. 12 and 13) from an examination of the electric logs (fig. 3); the possibility exists that, despite the additional effort expended in development, the aquifer or the slotted casing is plugged with a mixture of drilling mud and material from the formation.

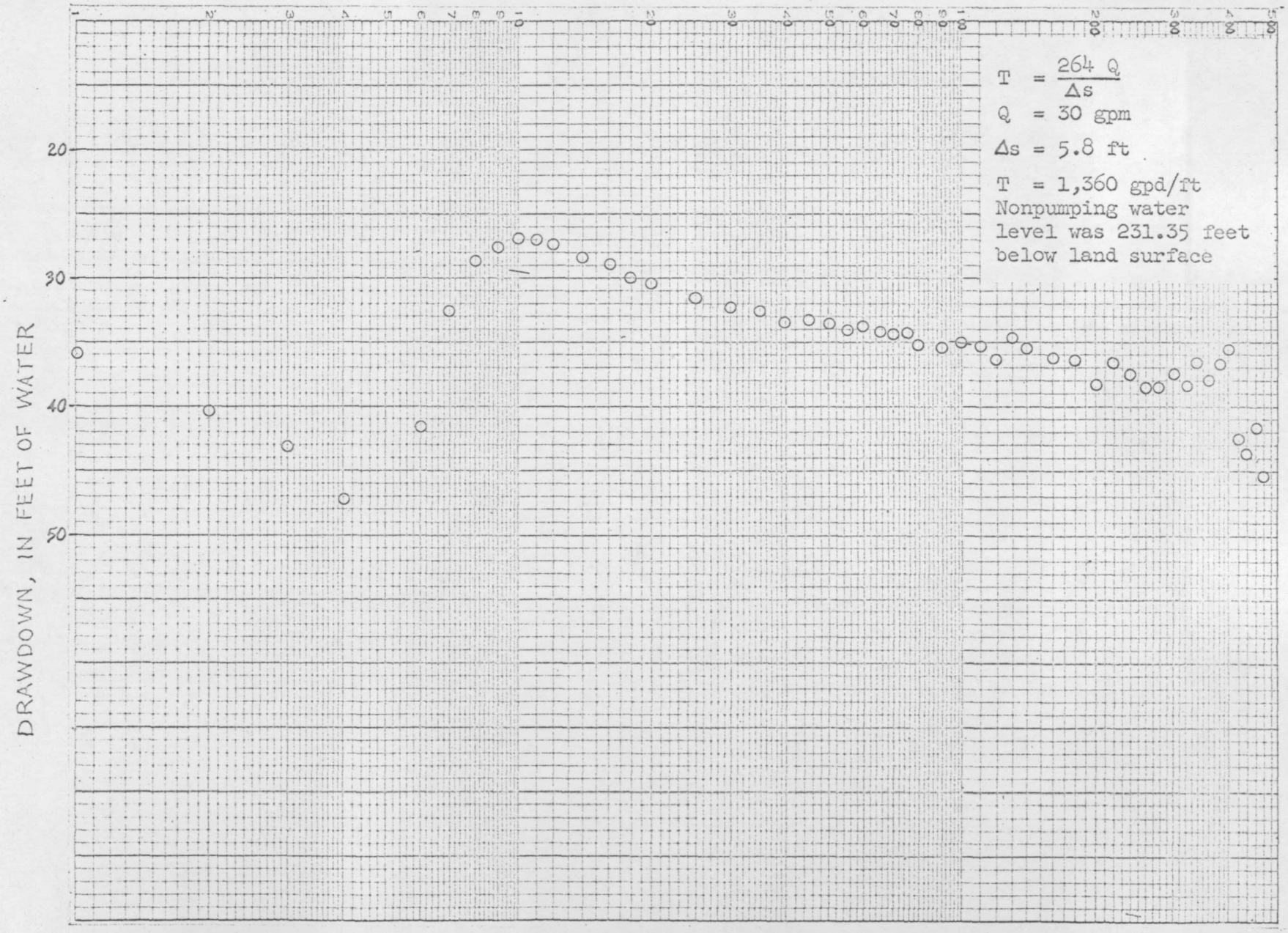

FIGURE 12.--DRAWDOWN IN WELL T-12, MAR. 30, 1967

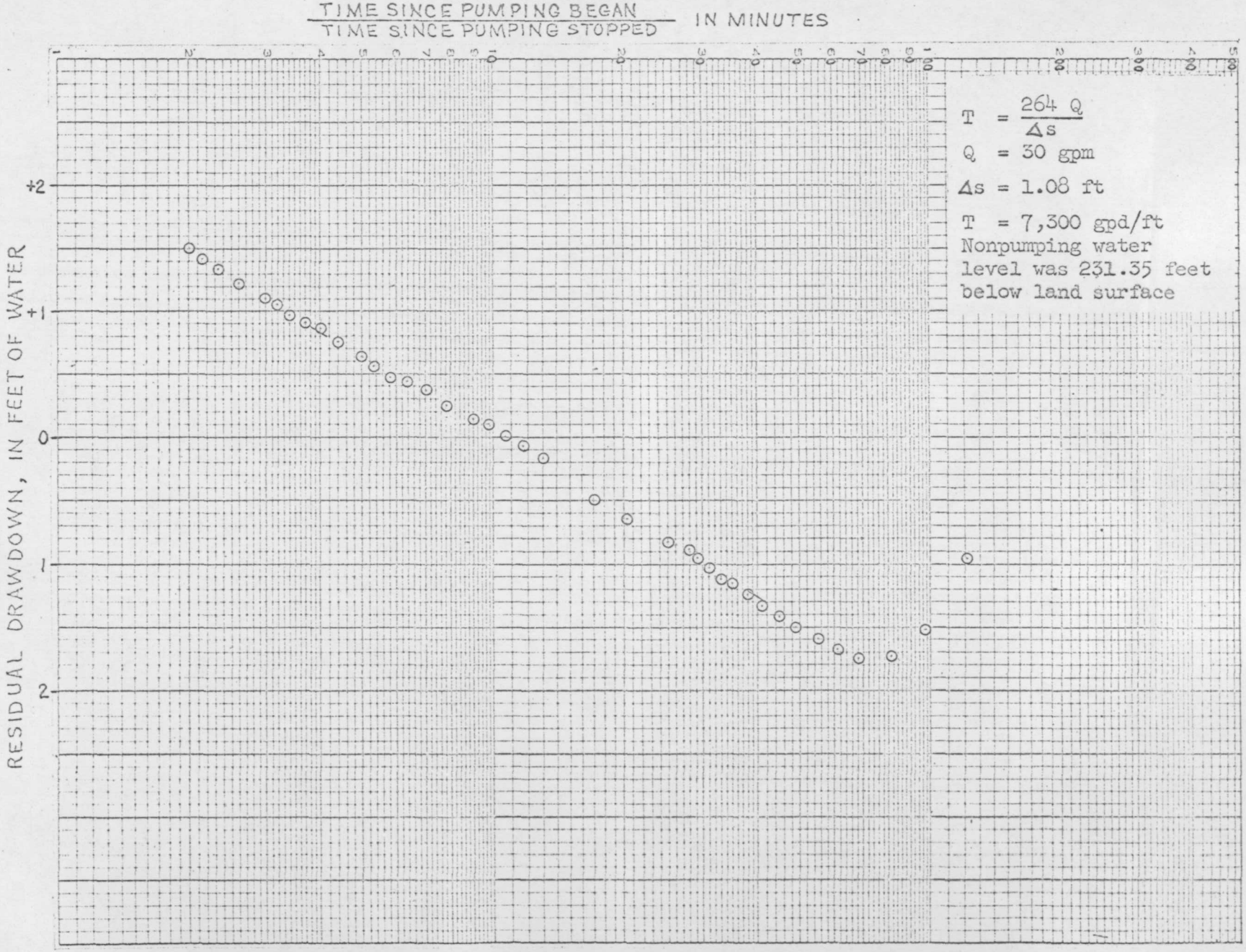

FIGURE 13.--RESIDUAL DRAWDOWN IN WELL T-12, MAR. 30, 1967

Test well T-13 was drilled to determine the fresh-water saline-water interface and to determine the thickness of the potable-water section. The well was drilled to 1,110 feet, about 300 feet deeper than originally planned, in an attempt to fulfill the original objectives. (tables 12 and 13). Two water samples were collected during drilling (table 1) and the well was completed in the potable-water section of the aquifer at a depth of 710 feet. The well penetrated bolson deposits of Quaternary-Tertiary age composed of unconsolidated sand and clay. The well produced a considerable amount of sand (see aquifer test plots, figs. 14 and 15) and the yield is less than that of either T-10 or T-11.

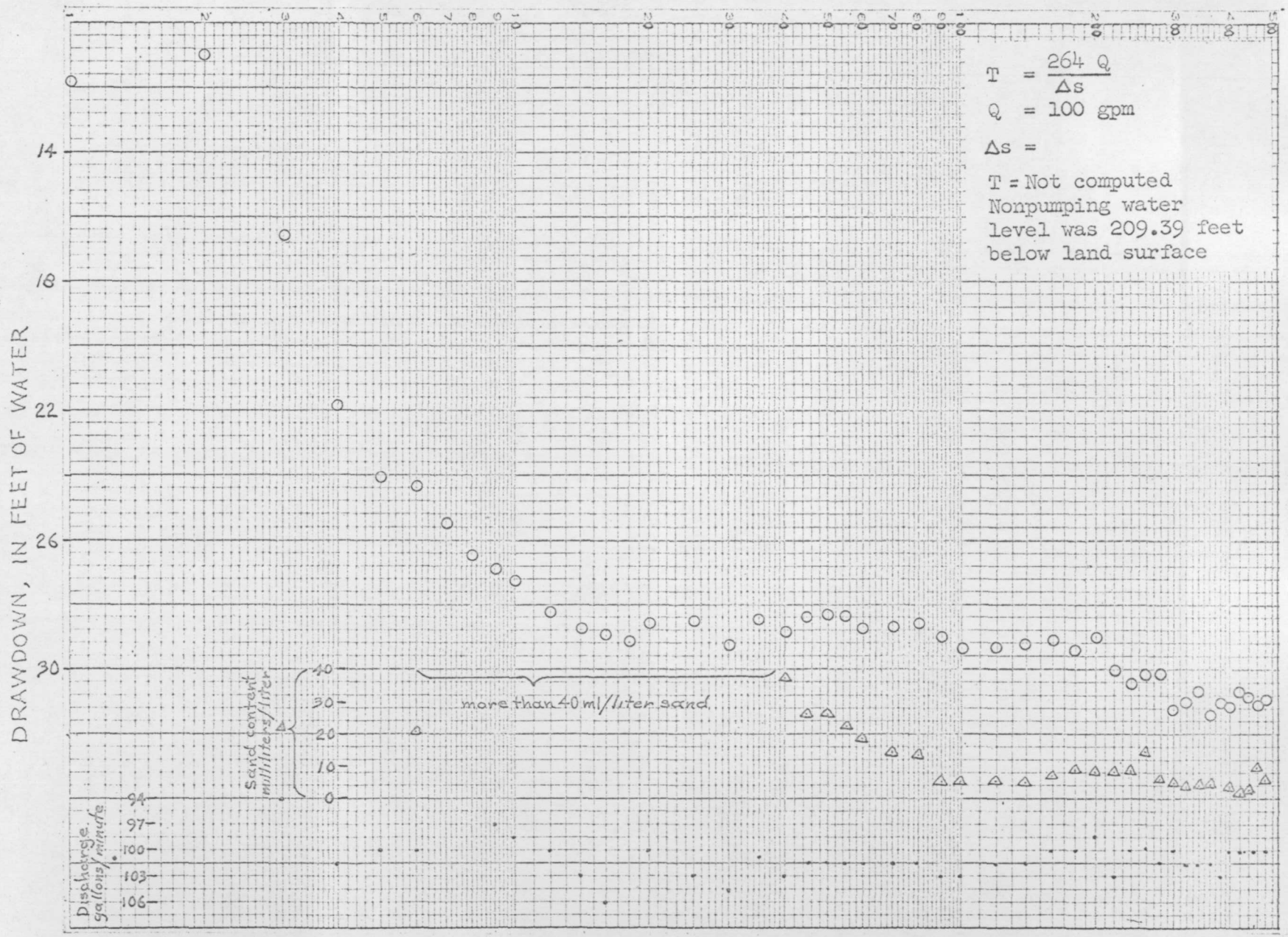

FIGURE 14.--DRAWDOWN IN WELL T-17, MAY 17, 1967

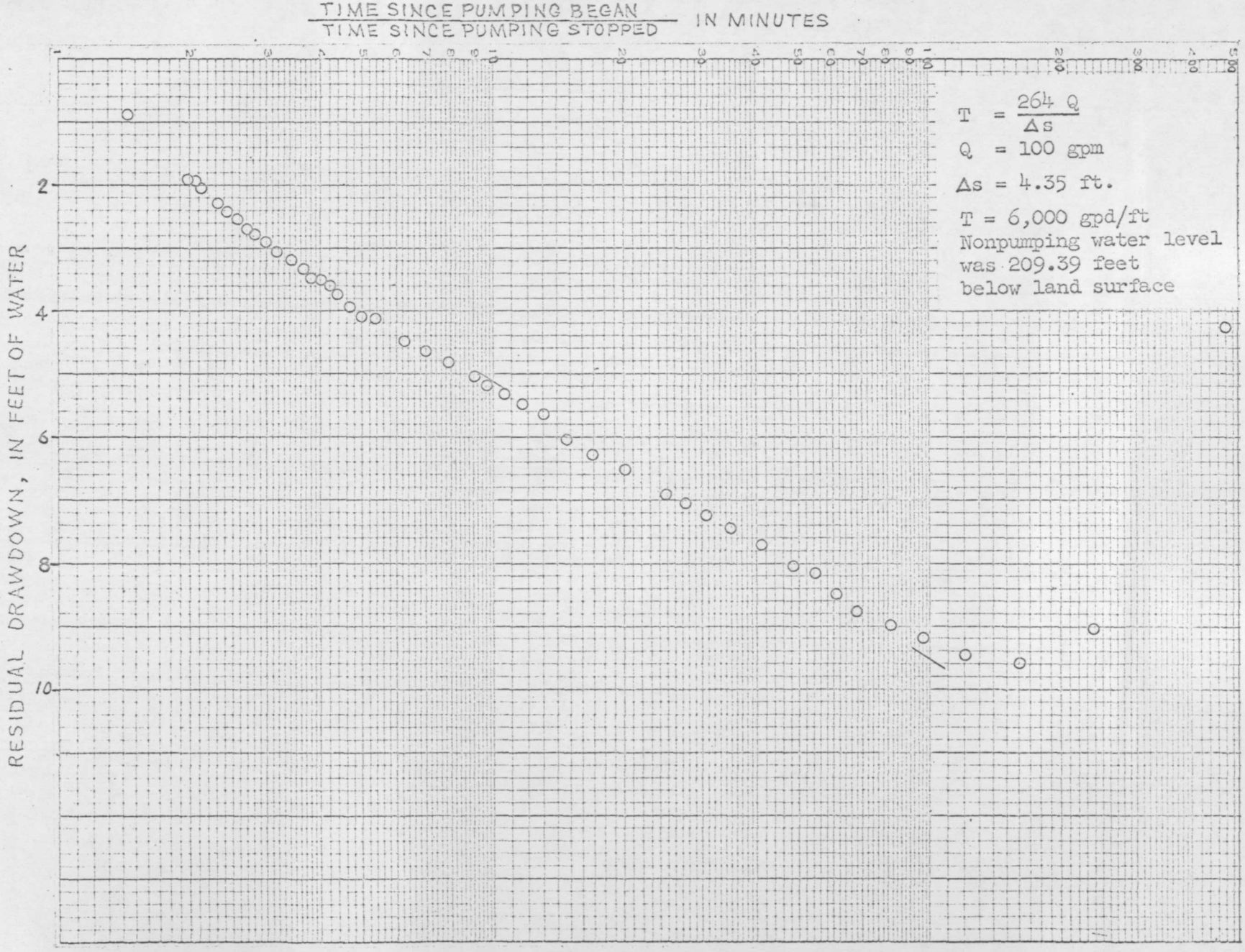

FIGURE 15.-- RESIDUAL DRAWDOWN IN WELL T-13, MAY 17, 1967

Conclusions and recommendations

The particle size of materials penetrated by the test wells was larger in wells west of the access highway to the Post Area than in wells to the east of the highway. The coarse fraction of samples from each well decreased with depth. The consolidated material penetrated by wells T-8, T-9, and T-12 may be associated with an older period of deposition prior to faulting; it does not appear to be a high-yield aquifer at depth. Present data indicate that only the upper unconsolidated material should be tapped by supply wells.

Test well T-9 probably was drilled on the north side of the fault bounding the well-field area to the north. The water-bearing materials penetrated by T-9 did not yield water readily and the zone of saturation is thin. Extension of the line of supply wells northward past well 20 is therefore considered inadvisable.

Test wells T-10, T-11, and T-13 produced water from materials as small as very fine sand. The 1/8-inch mill-cut slots used for the test-well screen were too large to prevent the fine sand from entering the wells and the particle-size range of the aquifer was not great enough in wells T-11 and T-13 to form a natural pack which would exclude the fine sand. If supply wells are drilled near these test wells they should be constructed so as to exclude the very fine sand either by proper-size screen openings or with an artificial gravel pack.

The electric log and water samples collected at depth from test well T-11 revealed that, in places, the transition zone from fresh-to saline-water-bearing beds was several hundred feet thick. Water of good quality underlies water of poor quality in the thick transition zone penetrated by test well T-11.

The depth to water in test well T-8 suggests that a trough in the ground-water surface extends westward from the line of production wells and that either the water-table contour maps made prior to the drilling of test well T-8 were inaccurate because of lack of data, or that the water level has declined considerably along a high permeability zone as the result of pumping of supply wells 18, 19, and 20. The depth to water in test well T-8 was 551.88 feet on January 11, 1967. On January 16, 1968 it was 557.51 feet; a water-level decline of 5.63 feet in a year. If this water-level decline continues at the present rate, or increases, the regimen of well-field pumping should be changed so as to prevent excessive water-level lowering in this locality and to distribute the declines over a larger area.

The well depths and construction details of the Post Area test wells are graphically summarized in figure 16, which is a profile from south to north along line A-A' on figure 2.

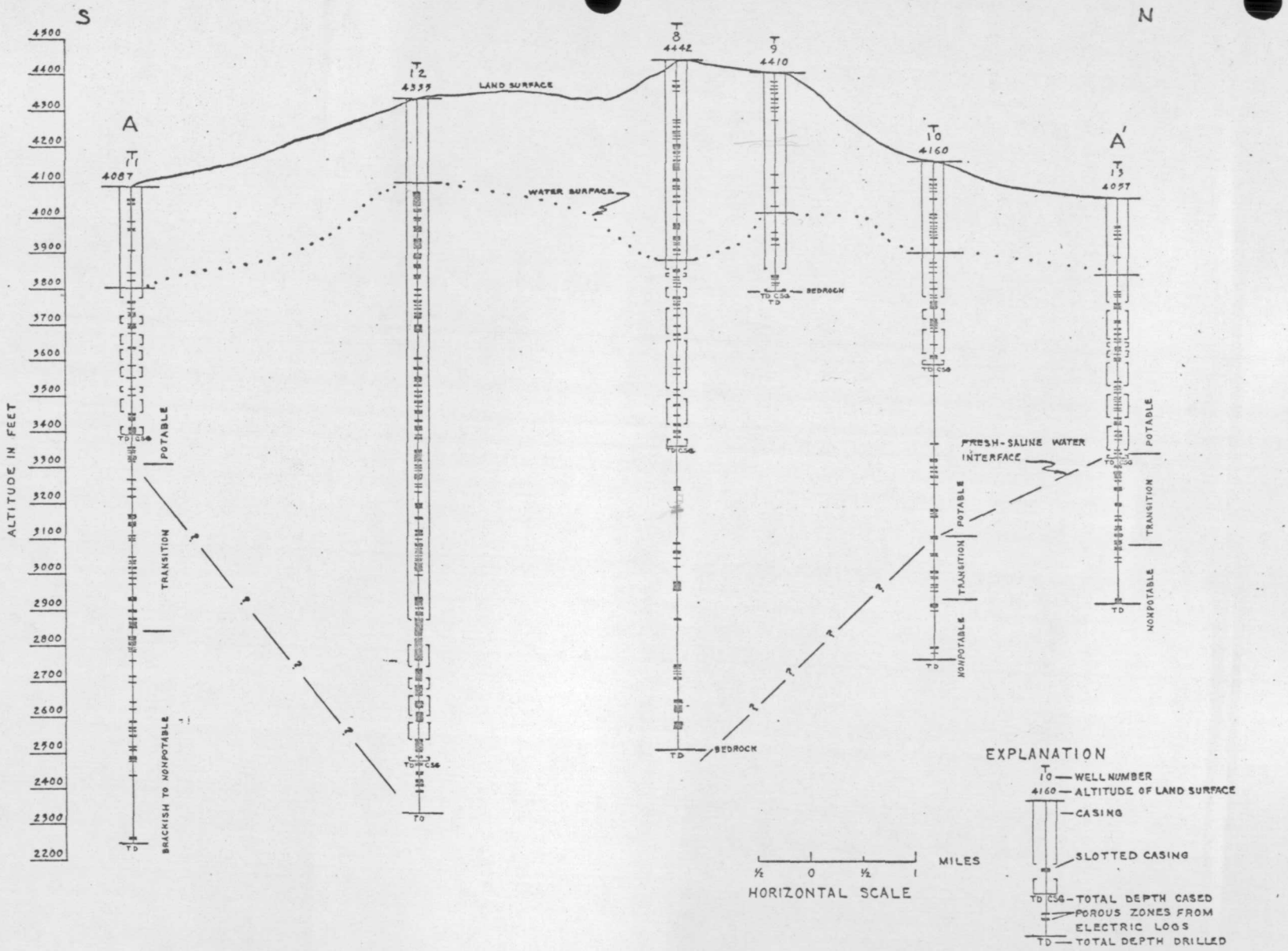

Figure 16.--Profile A-A' between Post Area test wells showing well depths and construction details. Location of test wells shown on figure 1.

References cited

Davis, L. V., and Busch, F. E., 1968, Summary of hydrologic investigations by the United States Geological Survey at White Sands Missile Range, New Mexico: U. S. Geol. Survey open-file rept., 146 p., 27 figs.

Herrick, E. H., 1960, Ground-water resources of the Headquarters (Cantonment) area, White Sands Proving Ground, Dona Ana County, N. Mex.: U. S. Geol. Survey open-file rept., 203 p., 33 figs.

Hood, J. W., 1968, Ground-water investigations at White Sands Missile Range, New Mexico, July 1960 - June 1962: U. S. Geol. Survey open-file rept., 153 p., 28 figs.

BASIC DATA

Table 1.--Results of chemical analysis of water samples collected from test wells in the Post Area, White Sands Missile Range

Analyses by Geological Survey, United States Department of the Interior
(parts per million)

Well number	T-8	T-8	T-8	T-8	T-9	T-9	T-10	T-10	T-10	T-11	T-11	T-11	T-12	T-12	T-12	T-12	T-13	T-13	T-13
Sample interval (feet)	853-895	1,348-1,370	1,880-1,897	total screen	TD 598	total screen	878-934	1,332-1,365	Total screen	1,220-1,268	1,701-1,806	Total Screen	734-800	1,573-1,600	1,681-1,950	Total screen	525-578	1,070-1,112	Total Screen
Date of collection	2/2/66	5/10/66	6/19/66	7/7/66	7/28/66	8/4/66	8/3/66	8/26/66	9/16/66	9/2/66	10/28/66	11/16/66	12/22/66	1/29/67	3/15/67	3/30/67	4/20/67	4/28/67	5/17/67
Silica (SiO_2)	-	-	13	37	-	30	-	-	41	-	-	36	-	-	-	35	-	-	38
Iron (Fe), dissolved 1/	-	-	-	.04		.24	-	-	.01	-	-	.12	-	-	-	.25	-	-	.02
Iron (Fe), total	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Manganese (Mn), dissolved 1/	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Manganese (Mn), total	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Calcium (Ca)	-	-	10	65	-	86	-	-	39	-	-	34	-	-	-	34	-	-	51
Magnesium (Mg)	-	-	1.2	19	-	17			8.4			5.6				6.3	-	-	10
Sodium (Na) + Potassium (K)	-	-	127	54	-	62	-	-	25	-	-	30	-	-	-	39	-	-	37
Bicarbonate (HCO_3)	-	-	174	158	-	148	-	-	144	-	-	118	-	-	-	126	-	-	148
Carbonate (CO_3)	-	-	6	0	-	0			0	-	-	0	-	-	-	0	-	-	0
Sulfate (SO_4)	123	159	91	158	190	186	104	2,890	44	136	910	54	95	81	67	73	105	459	64
Chloride (Cl)	36	39	24	38	50	58	32	12,400	13	890	2,240	12	22	19	17	10	28	4,940	24
Fluoride (F)	-	-	9.6	.8	-	2.7	-	-	.4	-	-	.4	-	-	-	.5	-	-	0.8
Nitrate (NO_3)	-	-	.8	13	-	21	-	-	3.9	-	-	3.8	-	-	-	.3	-	-	7.1
Dissolved solids Sum	-	-	369	463	-	536	-	-	239	-	-	234	-	-	-	272	-	-	325
Residue on evaporation at 180°C	-	-	368	460	-	564	-	-	246	-	-	232	-	-	-	260	-	-	329
Hardness as $CaCO_3$	-	-	30	242	-	286	-	-	132	-	-	106	-	-	-	111	-	-	170
Non-carbonate	-	-	0	112	-	164	-	-	14	-	-	12	-	-	-	8	-	-	48
Specific conductance (micromhos at 25°C)	356	960	606	700	822	827	605	36,700	358	3,110	8,480	336	431	412	436	410	600	14,700	492
pH	-	-	8.4	7.6	-	7.4	8.2	-	-	-	-	-	-	-	-	7.4	-	-	8.2
Color	-	-	-	5	-	25	-	-	5	-	-	5	-	-	-	5	-	-	3
Temperature °F	-	-	-	80	80	80	82	82	80	80	83	81	77	77	-	76	76	-	85

1/In solution at time of analysis.

Table 2.--Record of test well T-8

Location: $SE\frac{1}{4}SE\frac{1}{4}NE\frac{1}{4}$ sec. 11, T. 22 S., R. 4 E.

Altitude: 4441.67 feet.

Depth (drilled): 1,896 feet (cased): 1,060 feet

Date completed: Test pumped 7-7-66

Drilling contractor: Cass Drilling Co., El Paso, Texas

Drilling method: Hydraulic rotary

Casing and well record: Eight-inch casing to 1,060 feet, 1/8-inch wide, mill-cut slots from 574-584, 595-625, 650-680, 750-770, 900-930, and 1,000-1,040 feet.

Well-completion record: Concrete well head set; retained for water-level observation.

Formation logs: Sample description (table 3) and electric logs (fig. 3).

Geologic source: Bolson fill of Quaternary-Tertiary age. Granitic bedrock penetrated from 1891-1896 feet.

Yield: Well test pumped at 120 gpm (gallons per minute) for 8 hours with 59 feet of drawdown.

Nonpumping water level: 551.35 feet below land surface on 7-7-66.

Water quality: Potable; see table 1.

Table 3.--Sample description log of test well T-8

Material	Depth Interval (feet)	
Soil, dark brown, sandy	0	5
Clay, tan, and medium to coarse sand	5	10
Sand, pebble gravel, and clay	10	15
Gravel, granule to pebble, and coarse sand	15	30
Gravel, granule to pebble, coarse sand, and clay	30	110
Clay, tan, very fine sand, and granule to pebble gravel	110	115
Gravel, granule to pebble, some coarse sand and clay	115	145
Clay, tan, sandy with some gravel	145	160
Sand, gravel, and little clay	160	205
Gravel, granule to pebble size bit-cut rock fragments of mixed composition and some sand and clay	205	255
Sand, very coarse to coarse, granule to pebble gravel, and some clay	255	350
Clay, tan, sand and some granule gravel	350	375
Sand, gravel, and clay	375	400
Clay, sandy, and gravel	400	405
Sand, gravel, and clay	405	415
Clay, sand, and gravel	415	430
Sand, some gravel and clay	430	490
Sand, some gravel, and trace of clay	490	510
Sand, and clay	510	530
Sand, and some gravel and clay	530	560
Sand, clay, and some gravel	560	605

Table 3.--Sample description log of test well T-8-(Continued)

Material	Depth Interval (feet)	
Sand, some gravel and clay	605	620
Sand, clay, and some gravel	620	690
Sand, and some gravel and clay	690	730
Sand, clay, and some gravel	730	750
Sand, some gravel and clay	750	770
Sand, clay and gravel	770	780
Sand, gravel, and some clay	780	800
Sand, some clay and gravel	800	880
Clay, tan sandy and some gravel	880	885
Sand, some gravel and clay	885	895
Sand, clay, and gravel	895	910
Clay, sand, and gravel	910	925
Sand, some gravel and clay	925	940
Clay, sand, and gravel	940	985
Sand and gravel; little clay	985	1,000
Sand; little clay	1,000	1,010
Sand gravel and clay	1,010	1,025
Sand and gravel; little clay	1,025	1,035
Clay, sand and gravel	1,035	1,040
Sand, gravel and some clay	1,040	1,050
Sand, some gravel and clay	1,050	1,100
Sand, little gravel or clay	1,100	1,155
Sand, clay, and few particles of gravel	1,155	1,200
Sand, little gravel or clay	1,200	1,370
Sand and clay	1,370	1,380

Table 3.--Sample description log of test well T-8 (Concluded)

Material	Depth Interval (feet)	
Clay and sand	1,380	1,385
Sand, some clay and gravel	1,385	1,405
Sand	1,405	1,420
Sand, some gravel and clay	1,420	1,600
Sand and gravel	1,600	1,605
Sand, some gravel and clay	1,605	1,730
Sand, gravel and some clay	1,730	1,840
Sand, little gravel or clay	1,840	1,891
Rock, granitic	1,891	1,896

Table 4.--Record of test well T-9

Location: NW¼SW¼SE¼ sec. 1, T. 22 S., R. 4 E

Altitude: 4410.31 feet

Depth (drilled): 598 feet (cased): 598 feet

Date completed: Test pumped 8-4-66

Drilling contractor: Cass Drilling Co., El Paso, Texas

Drilling method: Hydraulic rotary

Casing and well record: Eight-inch casing to 598 feet, 1/8-inch mill-cut slots from 538-595 feet.

Well-completion record: Concrete well head set; retained for water-level observation

Formation logs: Sample description (table 5) and electric logs (fig. 3)

Geologic source: Bolson fill of Quaternary-Tertiary age. Granitic bedrock penetrated from 595-598 feet.

Yield: Well test pumped at 14 gpm for 8 hours with 125 feet of drawdown.

Nonpumping water level: 385.68 feet below land surface on 8-4-66

Water quality: Potable; see table 1.

Table 5.--Sample description log of test well T-9

Material	Depth interval (feet)	
Gravel, some sand and finer material	0	45
Sand and some gravel	45	60
Sand, some gravel and clay	60	95
Sand and gravel, some clay	95	115
Sand, clay, and some gravel	115	120
Sand, some gravel and clay	120	150
Sand and some gravel	150	185
Sand, some gravel and clay	185	290
Sand and some clay	290	325
Sand	325	335
Sand and clay	335	360
Sand	360	385
Sand and some clay	385	410
Sand, some clay and gravel	410	420
No sample	420	425
Sand and gravel	425	430
Sand, some gravel and clay	430	445
Sand	445	455
Sand, some gravel and clay	455	500
Sand	500	510
Sand, some clay	510	515
Sand and some gravel	515	535
Sand, some gravel, little clay	535	575
Sand and gravel	575	595
Rock, granitic	595	598

Table 6.--Record of test well T-10

Location: SW¼NW¼SW¼ sec. 5, T. 22 S., R. 5 E

Altitude: 4,159.84 feet

Depth (drilled) 1,365 feet (cased): 555 feet

Date completed: Test pumped 9-16-66

Drilling contractor: Cass Drilling Co., El Paso, Texas

Drilling method: Hydraulic rotary

Casing and well record: Eight-inch casing to 555 feet, 1/8-inch mill-cut slots from 370-405, 430-460, and 525-545 feet

Well completion record: Concrete well head set; retained for water level observation.

Formation logs: Sample description (table 7.) and electric logs (fig. 3)

Geologic source: Bolson fill of Quaternary-Tertiary age.

Yield: Well pumped at 180 gpm for 8 hours with 26 feet of drawdown.

Nonpumping water level: 249.67 feet below land surface on 9-16-66

Water quality: Potable in upper section, nonpotable at depth; see table 1.

Table 7.--Sample description log of test well T-10

Material	Depth interval (feet)	
Soil, sandy	0	5
Clay, sandy, red, and gravel	5	10
Sand and gravel	10	15
Gravel, sandy	15	30
Sand and gravel	30	85
Sand, some gravel	85	100
Sand, some clay and gravel	100	110
Gravel, sand and some clay	110	130
Sand and gravel	130	155
Gravel and sand	155	165
Sand, gravel, and some clay	165	215
Clay, sand, and some gravel	215	250
Sand, some clay and gravel	250	265
Clay and sand, some gravel	265	275
Sand, some gravel and clay	275	315
Clay, sandy	315	375
Sand and gravel with some clay	375	415
Clay, sand, and some gravel	415	435
Sand, clay, and some gravel	435	460
Clay, sandy with some streaks of sand and gravel	460	915
Gravel, sand and clay	915	930
Clay, sandy	930	1,005
Sand and clay	1,005	1,025

Table 7.--Sample description log of test well T-10(Continued)

Material	Depth interval (feet)	
Clay, sandy with streaks of sand	1,025	1,225
Sand and clay	1,225	1,230
Clay and sand	1,230	1,265
Sand and some clay	1,265	1,270
Clay and sand	1,270	1,350
Sand, clay, and some gravel	1,350	1,365

Table 8.--Record of test well T-11

Location: NE¼SW¼NE¼ sec 29, T. 22 S., R. 5 E

Altitude: 4087.21 feet

Depth: (drilled): 1,808 feet (cased): 780 feet

Date completed: Test pumped 11-16-66

Drilling contractor: Cass Drilling Co., El Paso, Texas

Drilling method: Hydraulic rotary

Casing and well record: Eight-inch casing to 780 feet, 1/8-inch mill-cut slots from 306-356, 375-406, 434-448, 574-596, 625-650, 662-684 and 718-760 feet.

Well-completion record: Concrete well head set; retained for water-level observation.

Formation logs: Sample description (table 9) and electric logs (fig. 3)

Geologic source: Bolson fill of Quaternary - Tertiary age.

Yield: Well pumped at 179 gpm for 8 hours with 29 feet of drawdown.

Nonpumping water level: 279.65 feet below land surface on 11-16-66

Water quality: Potable in upper section, nonpotable at depth; see table 1.

Table 9.--Sample description log of test well T-11

Material	Depth interval (feet)	
Sand, some granule gravel, little clay	0	35
Gravel, some sand	35	65
Sand and gravel	65	90
Gravel and sand	90	100
Sand, some gravel and clay	100	170
Gravel, and sand	170	185
Sand, gravel, and clay	185	225
Gravel, sand, and clay	225	235
Sand, clay and gravel	235	250
Sand and gravel, little clay	250	290
Sand, some clay	290	380
clay, sandy	380	400
Sand and silty clay	400	435
Clay and some sand	435	585
Sand and clay	585	760
Clay and some sand	760	1,125
Clay, sand, and some gravel	1,125	1,210
Sand and clay	1,210	1,235
Clay and sand	1,235	1,295
Clay, sand, and gravel	1,295	1,330
Gravel, sand and clay	1,330	1,350
Clay, sand and gravel	1,350	1,370
Clay and some sand	1,370	1,610
Sand and gravel	1,610	1,625
Sand, gravel, and clay	1,625	1,650
Clay, some sand and gravel	1,650	1,800

Table 10.--Record of test well T-12

Location: SE¼SE¼SE¼ sec. 23, T. 22 S., R. 4 E.

Altitude: 4334.65 feet

Depth: (drilled): 2,000 feet (cased): 1,820 feet

Date completed: Test pumped 3-30-67

Drilling contractor: Cass Drilling Co., El Paso, Texas

Drilling method: Hydraulic rotary

Casing and well record: Eight-inch casing to 450 feet, 6-inch casing to 1,820 feet; 1/8-inch wide mill-cut slots from 1,430-1,500, 1,560-1,590, 1,620-1,640, 1,695-1,715, and 1,760-1,810 feet

Well-completion record: Concrete well head set well retained for water level observation.

Formation logs: Sample description (table 11) and electric logs (fig. 3).

Geologic source: Bolson fill of Quaternary-Tertiary age.

Yields: Well pumped at 30 gpm for 8 hours with 45.24 feet of drawdown.

Nonpumping water level: 231.35 feet below land surface datum on 3-30-67

Water quality: Potable; see table 1

Table 11.--Sample description log of test well T-12

Material	Depth interval (feet)	
Gravel and sand	0	55
Sand, some gravel, and trace of clay	55	185
Sand and clay	185	200
Sand, some gravel and clay	200	265
Sand, and gravel, some clay	265	295
Clay, sand, and gravel	295	300
Sand, clay and some gravel	300	325
Clay and sand, some gravel	325	345
Sand and clay, some gravel	345	400
Sand and gravel, trace of clay	400	555
Sand, gravel, and some clay	555	675
Sand and gravel, trace of clay	675	730
Sand, some gravel and clay	730	755
Sand and gravel	755	775
Sand, some gravel and clay	775	800
Sand and gravel, some clay	800	880
Clay and sand, some gravel	880	895
Sand, some gravel and clay	895	925
Sand, some clay, and trace of gravel	925	985
Sand, trace of clay and gravel	985	1,000
Clay and sand	1,000	1,005
Sand and some gravel	1,005	1,015
Clay, sand, and some gravel	1,015	1,020
Sand and some gravel	1,020	1,035

Table 11.--Sample description log of test well T-12 (continued)

Material	Depth interval (feet)	
Clay, sand, and some gravel	1,035	1,045
Sand and clay	1,045	1,170
Sand, clay, and some gravel	1,170	1,200
Sand and clay	1,200	1,235
Sand, clay, and some gravel	1,235	1,250
Sand, clay, and gravel	1,250	1,305
Sand, clay, and some gravel	1,305	1,325
Sand, clay, and some gravel	1,325	1,370
Sand, some clay, and trace of gravel	1,370	1,425
Sand, gravel, and trace of clay	1,425	1,485
Sand, some clay and gravel	1,485	1,520
Sand, gravel, and clay	1,520	1,545
Sand	1,545	1,550
Sand, gravel, and some clay	1,550	1,590
Sand and some clay	1,590	1,600
No sample	1,600	1,610
Gravel, some sand and clay	1,610	1,615
Sand, some clay	1,615	1,630
Clay, some sand	1,630	1,635
Sand, some clay and gravel	1,635	1,650
Clay, some sand and gravel	1,650	1,655
Sand, gravel, and some clay	1,655	1,675

Table 11.--Sample description log of test well T-12 (concluded)

Material	Depth interval (feet)	
Clay, sand, and gravel	1,675	1,680
Sand, some clay and gravel	1,680	1,710
Sand, some gravel and clay	1,710	1,725
No sample	1,725	1,730
Clay, gravel, and sand	1,730	1,735
Sand, some gravel and clay	1,735	1,740
Clay, sand, and gravel	1,740	1,755
Sand, some gravel and clay	1,755	1,770
Clay, sand, and some gravel	1,770	1,775
Sand, gravel, and clay	1,775	1,855
Sand and clay	1,855	1,885
Sand, gravel and clay	1,885	2,000

Table 12.-- Record of test well T-13

Location: NE¼NE¼NE¼ sec. 32, T. 21 S., R. 5 E.

Altitude: 4056.63 feet

Depth (drilled): 1,110 feet (cased): 710 feet

Date completed: Test pumped 5-17-67

Drilling contractor: Cass Drilling Co., El Paso, Texas

Drilling method: Hydraulic rotary

Casing and well record: Eight-inch casing to 710 feet; 1/8-inch wide mill-cut slots from 285-305, 386-392, 408-416, 434-450, 512-536, 600-622, and 688-702 feet.

Well completion record: Concrete well head set; well retained for water-level observation.

Formation logs: Sample description (table 13) and electric logs (fig. 3)

Geologic source: Bolson fill of Quaternary-Tertiary age.

Yield: Well pumped at 100 gpm for 8 hours with 31.48 feet of drawdown.

Nonpumping water level: 209.39 feet below land surface datum 5-17-67.

Water quality: Potable in upper section, nonpotable at depth; see table 1.

Table 13.--Sample description log of test well T-13

Material	Depth interval (feet)	
Sand and gravel, trace of clay	0	15
Gravel and sand, some clay	15	30
Sand and gravel	30	70
Sand, clay and gravel	70	110
Clay, sand, and gravel	110	120
Gravel, sand, and clay	120	125
Clay, sand, and some gravel	125	300
Clay, sand and gravel	300	310
Clay	310	400
Clay and some sand	400	475
Clay and sand	475	485
Sand, clay, and some gravel	485	500
Clay and sand	500	535
Sand, gravel, and clay	535	545
Clay, sand, and some gravel	545	570
Sand, clay, and some gravel	570	595
Clay and sand	595	830
Gravel, clay, and sand	830	835
Clay and sand	835	955
Clay, sand, and some gravel	955	1,005
Clay and sand	1,005	1,015
Clay, sand, and gravel	1,015	1,040
Clay, sand, and trace of gravel	1,040	1,050
Clay and some sand	1,050	1,055

Table 13.--Sample description log of test well T-13 (concluded)

Material	Depth interval (feet)	
Clay, sand, and some gravel	1,055	1,075
Sand, gravel, and clay	1,075	1,085
Gravel, clay, and sand	1,085	1,100
Clay, sand and some gravel	1,100	1,110.