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Albuquerque, New Mexico

Test wells T-15, T-16, T-17, T-18, and RC-3, White Sands Missile Range, Dona Ana and Sierra Counties, New Mexico

By

Forest P. Lyford

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

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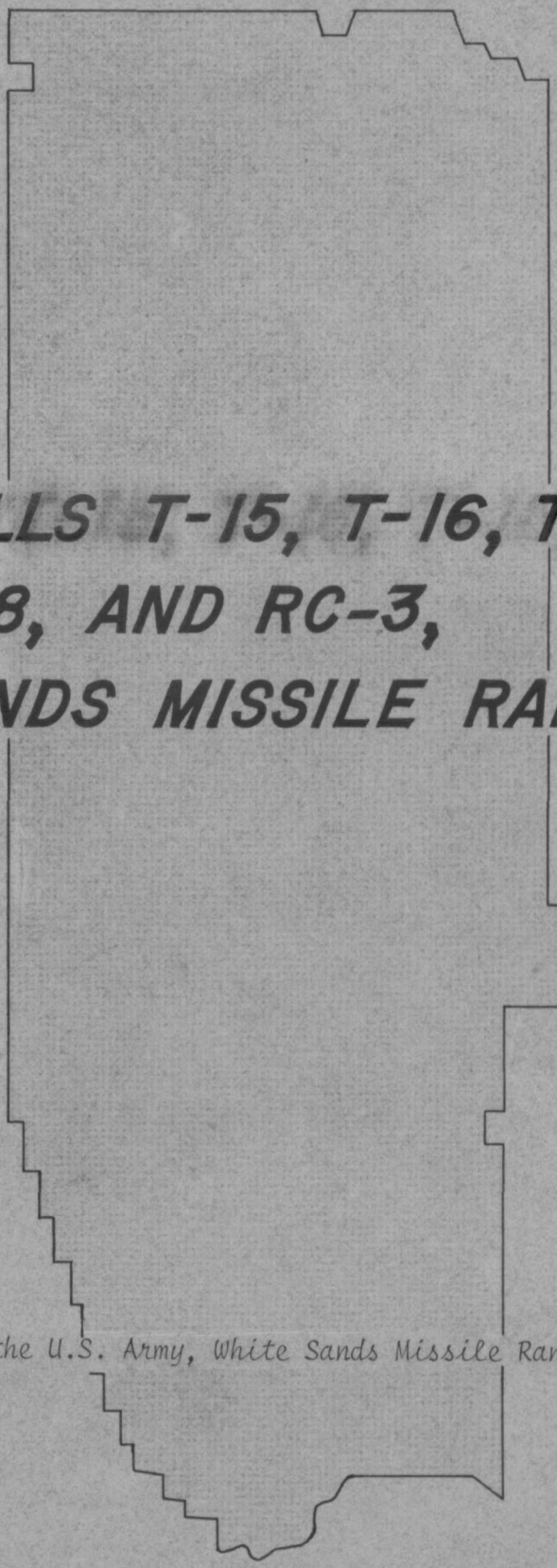

TEST WELLS T-15, T-16, T-17, T-18, AND RC-3, WHITE SANDS MISSILE RANGE

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Introduction

Test wells T-15, T-16, T-17, and T-18 were drilled between November 1968 and June 1969 as part of a continuing program by White Sands Missile Range to locate and evaluate potable water supplies in the area of Post Headquarters. These wells were drilled in bolson deposits southeast of Post Headquarters in Dona Ana County, New Mexico, on White Sands Missile Range and on Fort Bliss Military Reservation. Locations of the wells are shown in figures 1 and 2. Test well RC-3 was drilled during June of 1969 at Rhodes Canyon Range Center in Sierra County, New Mexico to investigate the availability of saline water to support a desalting plant. Rhodes Canyon Range Center is an isolated installation that occupies only a few acres of land. The purpose of this report is to present information retrieved during drilling and testing operations on each test well and to evaluate quality of water and aquifer properties in each locality.

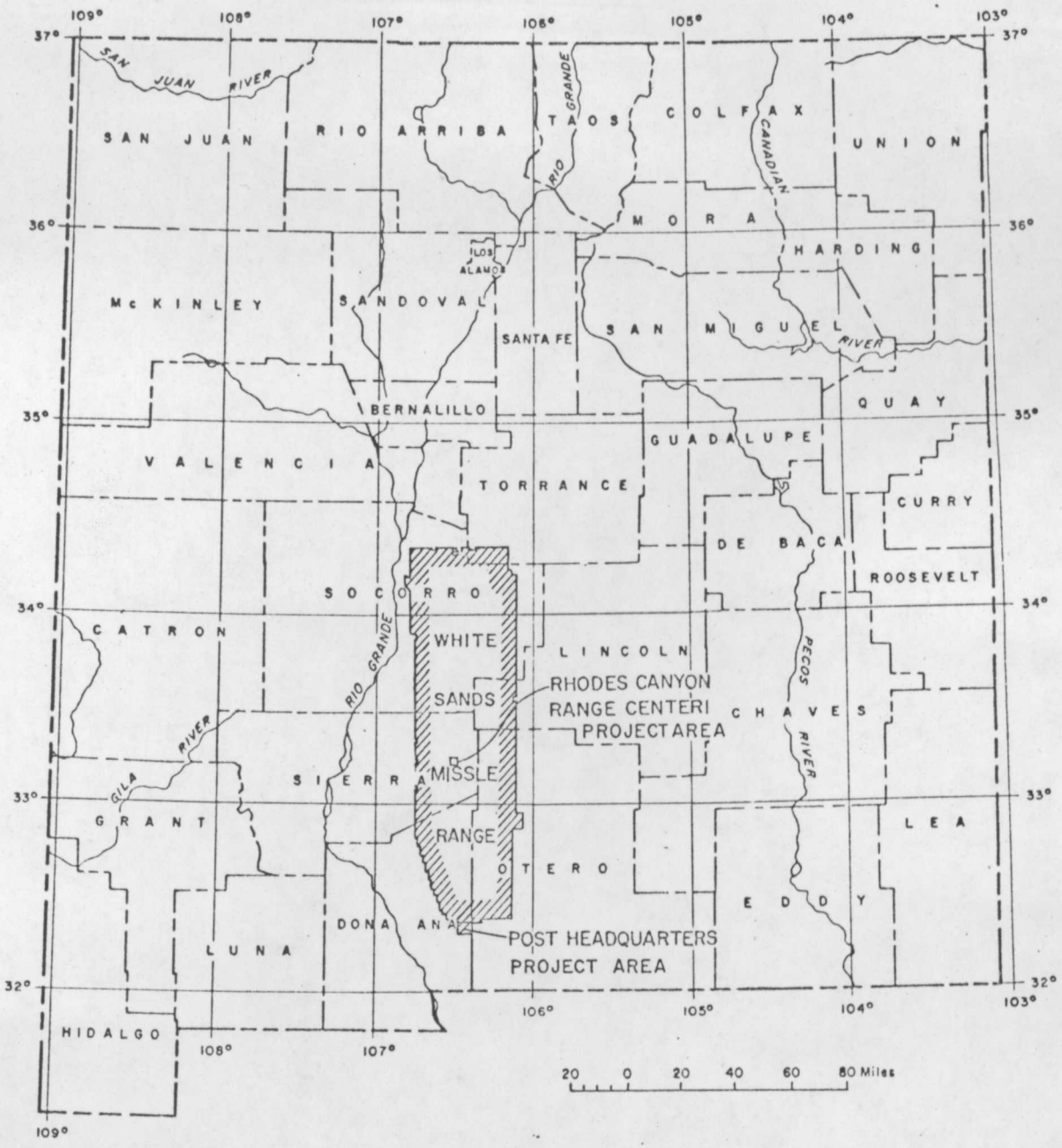
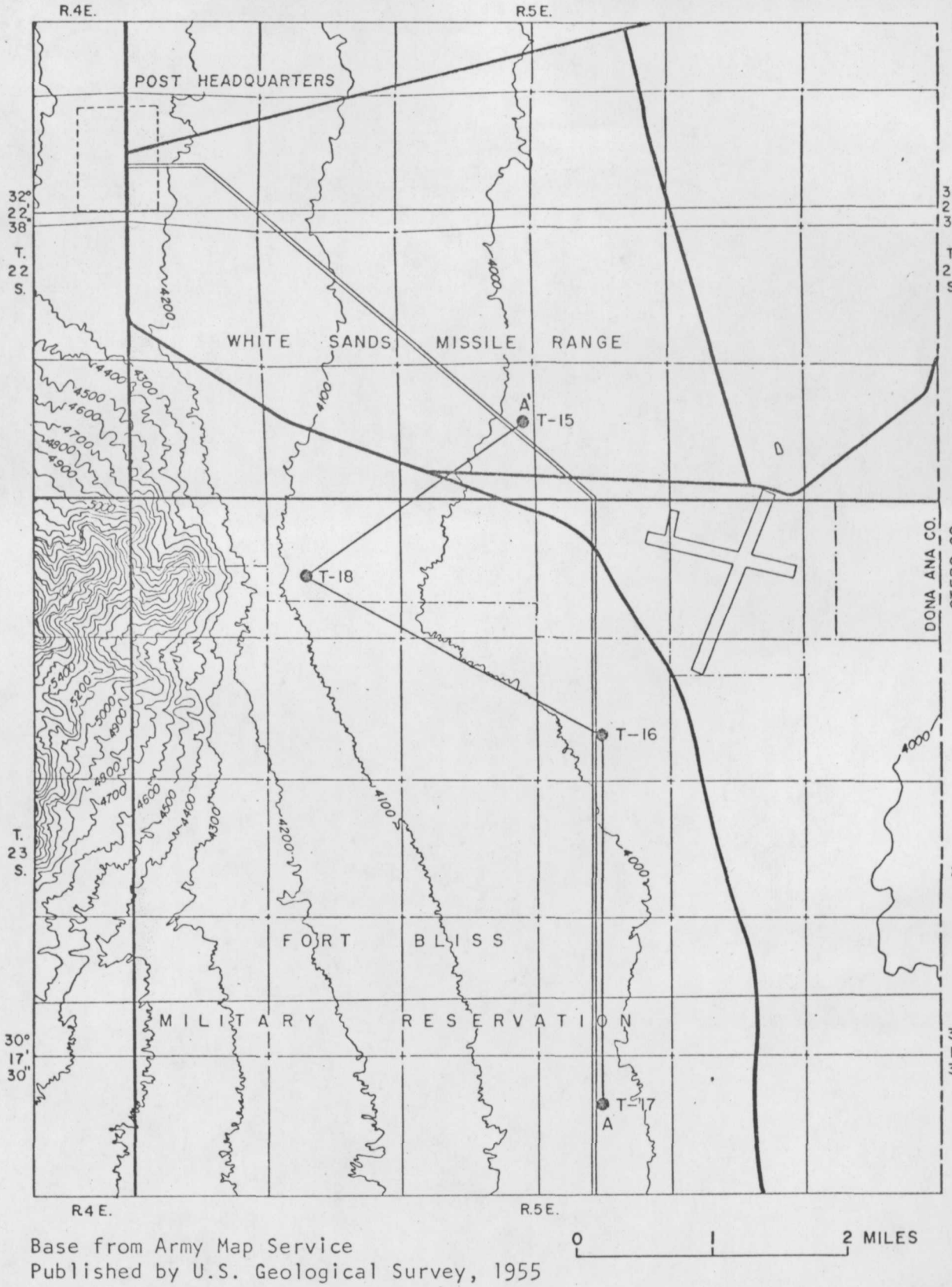


Figure 1.--White Sands Missile Range and project areas, New Mexico.



Base from Army Map Service
Published by U.S. Geological Survey, 1955

Figure 2.--Locations of test wells T-15, T-16, T-17, and T-18, Post Headquarters project area, White Sands Missile Range.

All test wells were drilled by the hydraulic-rotary method to depths ranging from 750 to 2,500 feet. Samples of drill cuttings were collected at 10-foot intervals. A drilling-rate recorder provided a continuous record of the rate of bit penetration.

Upon completion of drilling, geophysical well logs of the following types were made: 1) proximity log - microlog with caliper; 2) dual induction - laterolog.

Water samples were collected from one or more zones in each test well by airlifting water from below an expansion packer that isolated higher water-bearing zones in the open hole. After water samples were collected a decision was made whether to case, develop, test, and retain the well for observation purposes. Such wells were cased with 8 5/8-inch outer-diameter steel casing with slotted sections opposite water-bearing zones. The mill-cut slots in the casing were 1/8-inch wide and 2 inches in length, placed 12 slots around and 3 rounds per foot. Retained test wells were developed by surging and bailing, and by surging and pumping. An 8-hour pumping test, followed by an 8-hour recovery test, then was conducted to evaluate aquifer characteristics. These test wells then were retained for future water-level observations and water-sample collection.

Throughout this report all depths are referenced to the land-surface datum. Depths shown on geophysical well logs are referenced to the kelly bushing which was 10 feet above the ground.

The contract administration and supervision of construction of the test wells was under the direction of the U.S. Army Corps of Engineers. The U.S. Geological Survey, in cooperation with the U.S. Army Corps of Engineers and the White Sands Missile Range, provided technical assistance in well-site selection, contract-specification preparation, and hydrologic and geologic data collection. Geological Survey personnel involved in the collection of field data include G. C. Doty, Project Chief; F. E. Busch, J. A. Basler, and the writer, supervised by J. B. Cooper, Hydrologist and W. E. Hale, District Chief, Water Resources Division, Albuquerque, New Mexico.

Results of drilling and testing

Test well T-15

Test well T-15 was started November 24, 1968. The well was drilled with a 6 7/8-inch bit to a depth of 2,034 feet below the land surface. A description of well-cutting samples is given in table 1. Geophysical logs made in the well are shown in figures 3a, b. Two water samples were collected--the first from below a packer set at 1,620 feet, and the second from below a packer set at 714 feet. Results of chemical analyses of these samples are given in table 11, (p. 40).

After water samples were collected a cement plug was set from 670 to 690 feet and the well was reamed and cased to 670 feet. Slotted sections of pipe were placed from 446 to 476 feet, 507 to 522 feet, and from 595 to 650 feet. An attempt was made to develop the well by bailing but was discontinued because of the large quantities of sand bailed out with the water. No pumping test was conducted. The drilling and construction record of test well T-15 is given in table 2.

A cement platform was placed around the well casing and the well was retained for water-level and water-quality monitoring.

Water samples and resistivity values from geophysical well logs show a transition from potable to nonpotable water in test well T-15 between 850 to 1,000 feet below the land surface. Well depths, water sampling zones, water levels, construction details, and the approximate transition zone for test wells T-15, T-16, T-17, and T-18 are graphically summarized in figure 4, which is a profile drawn along the line A-A' of figure 2.

Table 1.--Sample-description log of test well T-15, White Sands Missile Range

Material	Thickness (feet)	Depth (feet)
Sand, very coarse to very fine, tan, angular to rounded, poorly sorted, arkosic; granule gravel -	10	10
Gravel, granule to pebble; sand as 0-10 ----------	10	20
Sand, as 0-10, fine gravel ----------	20	40
Sand, very coarse to very fine, mostly coarse, tan, angular to rounded, poorly sorted, arkosic; granule gravel ----------	10	50
Sand, very coarse to very fine, mostly medium, as 40-50; clay, granule gravel ----------	20	70
Sand, as 0-10; granule gravel ----------	30	100
Sand, as 40-50 ; gravel; clay ----------	20	120
Sand, as 0-10; tan, calcareous; granule gravel --------	30	150
Sand, as 0-10; granule gravel; trace of clay ---------	10	160
Sand, as 0-10; clay; granule gravel ----------	40	200
Sand, very coarse to very fine, mostly medium to fine, angular to rounded, poorly sorted, arkosic; clay, tan, calcareous; trace of granule gravel --------	160	360
Sand, as 200-360; trace of clay and granule gravel ---	90	450
Sand, as 200-360; clay; trace of granule gravel ------	100	550
Sand, as 200-360, mostly fine; clay ----------	130	680
Clay, tan, calcareous; sand, as 200-360 ----------	60	740

Table 1.--Sample-description log of test well T-15, White Sands Missile Range - Concluded

Material	Thickness (feet)	Depth (feet)
Clay; sand as 680-740; some pebbles	20	760
Clay; sand, as 200-360	40	800
Clay; sand, as 200-360; granule gravel	80	880
Clay; sand, as 200-360	20	900
Clay; sand, as 200-360; some granule to pebble gravel-	20	920
Sand, as 200-360; clay	20	940
Clay; tan, calcareous; sand as 200-360; some granule gravel	190	1,130
Clay, tan and white; sand as 200-360	90	1,220
Clay, tan, white and gray; sand as 200-360; granule to pebble gravel	120	1,340
Sand, as 200-360; clay; granule to pebble gravel	60	1,400
Clay, as 1,220-1,340; sand; granule to pebble gravel -	10	1,410
Sand, as 200-360; clay; granule to pebble gravel	30	1,440
Clay, as 1,220-1,340; sand; granule to pebble particles	80	1,520
Clay, mostly gray; sand; granule to pebble particles -	190	1,710
Sand, as 200-360; clay; granule to pebble particles --	40	1,750
Clay; sand; gravel; as 1,520-1,710	20	1,770
Sand, as 200-360; granule to pebble gravel; clay	30	1,800
Clay, dark gray; sand; gravel particles	110	1,910
Sand, as 200-360; clay; gravel particles	100	2,010
No samples	24	2,034
Total depth		2,034

Table 2.--Record of test well T-15, White Sands Missile Range

LOCATION: SE¼SE¼NE¼ sec. 33, T. 22 S., R. 5 E. USGS NO: 22.5.33.244

LATITUDE: 32°21'08" LONGITUDE: 106°25'47" ALTITUDE: 3,990 feet.

DEPTH: 2,034 feet.

DATE COMPLETED: 12-11-68 DRILLING METHOD: Hydraulic rotary.

DRILLING CONTRACTOR: Jerry Burgett Drilling Co.

CASING AND HOLE RECORD: Pilot hole drilled with 6 7/8-inch bit to 2,034 feet; reamed with 12 1/4-inch bit; concrete plug from 670 to 690 feet, cased with 8 5/8-inch O.D. steel casing to 670 feet; casing perforated with mill-cut slots 1/8" x 2", placed 12 slots around and 3 rounds per foot at depth intervals 446 to 476, 507 to 522, 595 to 650 feet.

YIELD: Not tested.

NONPUMPING WATER LEVEL: 179.25 feet on June 24, 1969.

CHEMICAL QUALITY:

Date	Depth interval (feet)	Specific conductance (micromhos at 25°C)	Sulfate (mg/l)	Chloride (mg/l)
1- 3-69	714-736	567	112	54
12-29-68	1,620-1,642	45,600	3,600	17,100

FORMATION LOGS: 1) Sample description; 2) Dual induction-laterlog; 3) Proximity log-microlog with caliper.

GEOLOGIC SOURCE: Bolson deposits of Quaternary and Tertiary age.

USE AND REMARKS: To be used as water level observation well. Well produced large amount of sand during development. No pumping test was conducted.

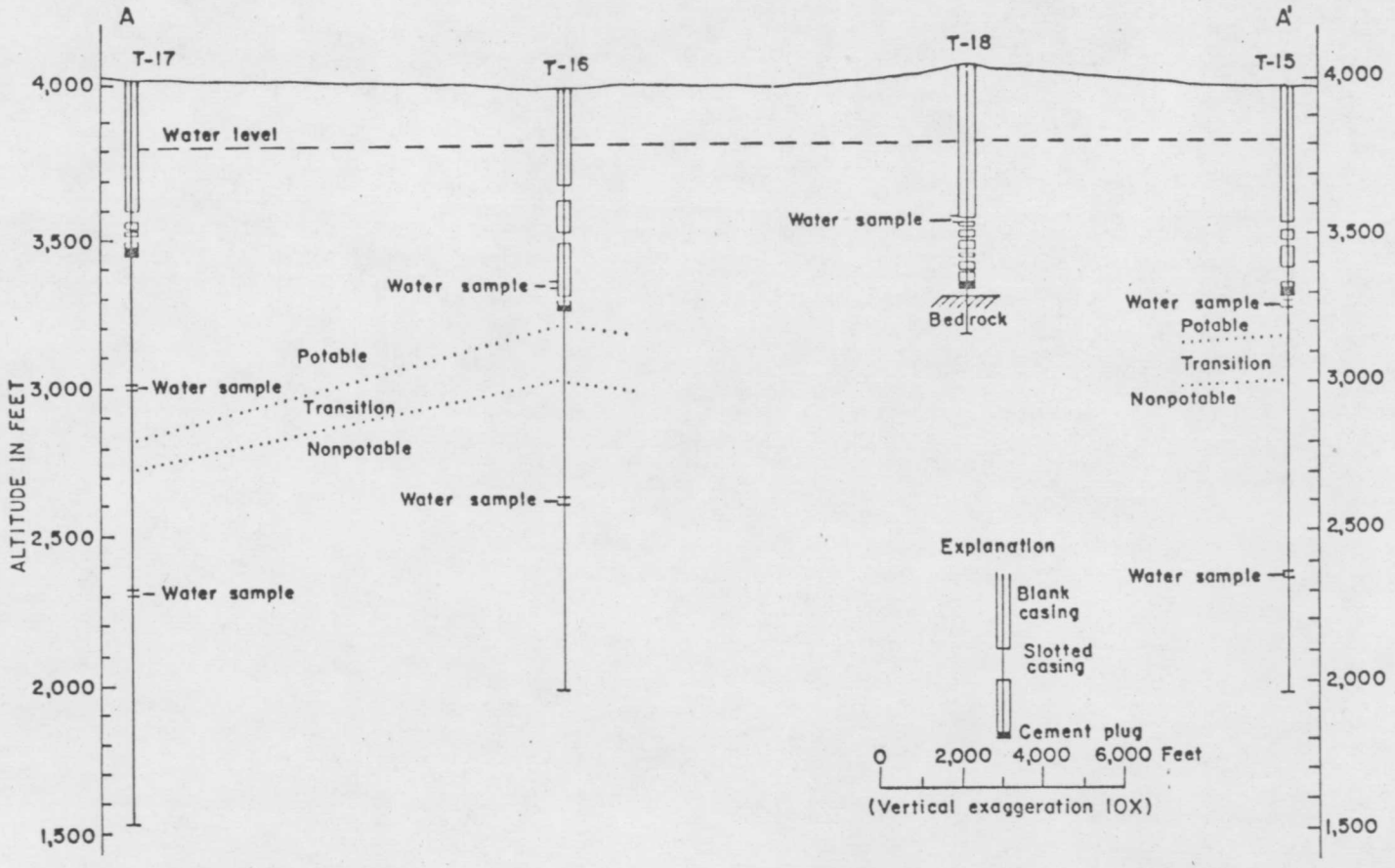


Figure 4.--Profile A-A' showing depths, water sampling zones, water levels, and construction details of test wells southeast of the Post Area, White Sands Missile Range.

Test well T-16

Drilling on test well T-16 began January 25, 1969. A 6 7/8-inch pilot hole was drilled to 2,007 feet below the land surface, geophysical well logs were made, and water samples were obtained by the airlift method from below a packer set at a depth of 628 feet and from below a packer set at a depth of 1,360 feet. Results of chemical analyses of water samples are given in table 11. A description of well-cutting samples collected from the test well is given in table 3 and geophysical logs with drilling time are shown in figures 5a, b.

A cement plug was set from 710 to 730 feet and the well was reamed to a diameter of 18 inches. Casing with slotted sections from 310 to 360 feet, 470 to 500 feet, and 680 to 700 feet was then placed in the well and surrounded by an envelope of 1/8- to 3/8-inch diameter gravel emplaced in the annulus between the casing and the wall of the well. After development by surging and bailing for 18 hours and by surging and pumping for 19 hours, the well was pumped at a mean rate of 175 gpm (gallons per minute) for 8 hours. During the pumping test the sand content of the water discharged ranged from 3.5 ml/l (milliliters per liter) at the start of pumping to 0.3 ml/l at the end of pumping. The drilling and construction record of test well T-16 is given in table 4.

Figure 6 is a graph of drawdown plotted against time since pumping began in well T-16. The transmissivity (T) of the aquifer was computed by the Jacob nonequilibrium method (Ferris and others, 1962, p. 98-100).

Table 3.--Sample-description log of test well T-16, White Sands Missile Range

Material	Thickness (feet)	Depth (feet)
Sand, very coarse, angular, well sorted	10	10
Sand, very coarse to very fine, angular to subrounded. poorly sorted	60	70
Sand, as 10-70; clay, tan calcareous, some granule to pebble gravel	60	130
Clay, tan calcareous; sand; some granule to pebble gravel	40	170
Sand, very coarse to very fine, mostly medium, angular to well rounded, poorly sorted; clay; some granule to pebble gravel	680	850
Sand, as 170-850; clay	50	900
Sand, mostly medium, well sorted	50	950
Clay, tan with white spots; sand, as 900-950; some granule gravel	220	1,170
Sand, as 170-850; tan clay; some granule gravel	60	1,230
Clay; sand, as 170-850; some granule gravel	40	1,270
Sand, as 170-850; and clay	90	1,360
Clay; sand, as 170-850	90	1,450
Sand, as 170-850; clay	70	1,520
Clay; sand, as 170-850	60	1,580
Sand, as 170-850; clay	180	1,760
Clay; sand, as 170-850	70	1,830
Sand, as 170-850; clay	10	1,840
Clay; sand as 170-850	100	1,940
Sand, as 170-850; clay	10	1,950
Clay; sand, as 170-850	50	2,000
Total depth		2,007

Table 4.--Record of test well T-16, White Sands Missile Range

LOCATION: SW¼NW¼SE¼ sec. 10, T. 23 S., R. 5 E. USGS NO: 23.5.10.413

LATITUDE: 32°19'10" LONGITUDE: 106°25'07" ALTITUDE: 3,980 feet.

DEPTH: 2,007 feet.

DATE COMPLETED: 2-28-69 DRILLING METHOD: Hydraulic rotary.

DRILLING CONTRACTOR: Jerry Burgett Drilling Co.

CASING AND HOLE RECORD: Pilot hole drilled with 6 7/8-inch bit to 2,007 feet; concrete plug from 710-730 feet, hole reamed with 18-inch bit, well cased with 8 5/8-inch O.D. steel casing to 710 feet; casing perforated with mill-cut slots 1/8" x 2", placed 12 slots around and 3 rounds per foot at depth intervals 310-360, 470-500, 680-700 feet; gravel 1/8-3/8-inch diameter placed in annulus as gravel pack; well developed by surging and bailing for 18 hours and by surging and pumping for 19 hours.

YIELD: Well was pumped for 8 hours at a mean rate of 175 gpm. Drawdown at the end of 8 hours was 16.20 feet.

NONPUMPING WATER LEVEL: 186.85 feet on June 24, 1969.

CHEMICAL QUALITY

Date	Depth interval (feet)	Specific conductance (micromhos at 25° C)	Sulfate (mg/1)	Chloride (mg/1)
3-28-69	300-690	355	48	16
3-12-69	628-650	354	59	20
3-11-69	1,360-1,382	36,700	3,360	13,200

FORMATION LOGS: 1) Sample description; 2) Drilling time: 3) Dual induction-laterlog; 4) Proximity log-microlog with caliper.

GEOLOGIC SOURCE: Bolson deposits of Quaternary and Tertiary age.

USE AND REMARKS: To be used as observation well.

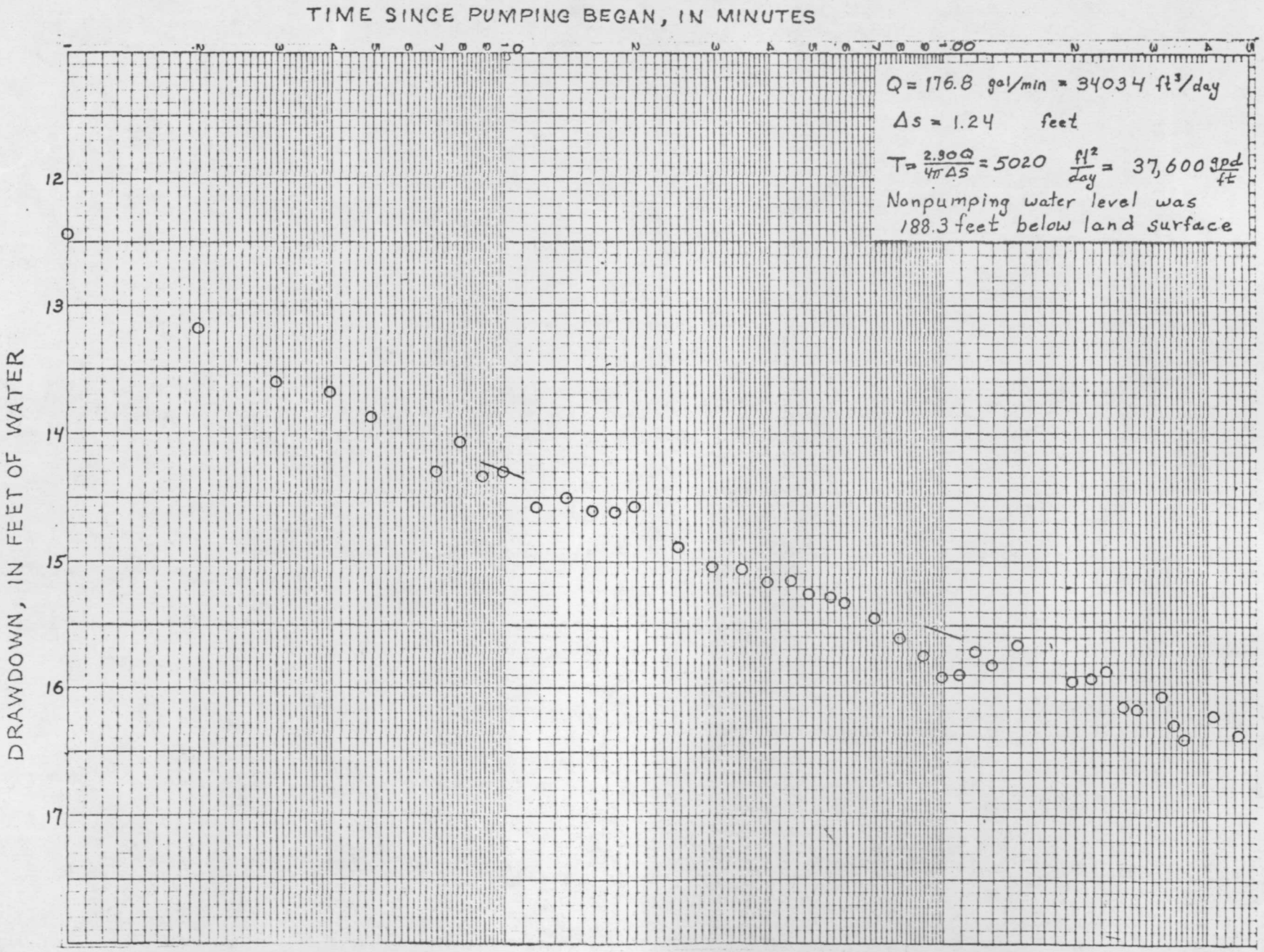


Figure 6.--Graph showing drawdown in test well T-16, March 28, 1969.

Figure 7 is a graph of drawdown plotted against the ratio of time since pumping began to time since pumping ended. The transmissivity of the aquifer was computed by the Theis recovery method (Ferris and others, 1962, p. 100-102). The values for transmissivity computed by the two methods agree well; the average value is 4,900 ft^2/day. Results of chemical analysis of a water sample collected during the pumping test are given in table 11.

After the pumping test, a concrete platform was placed around the well casing and the well was retained for water-level and water-quality monitoring.

Potable water in test well T-16 is present to a depth of about 800 feet. The water quality deteriorates rapidly between 800 and 1,000 feet, and then gradually worsens with increasing depth.

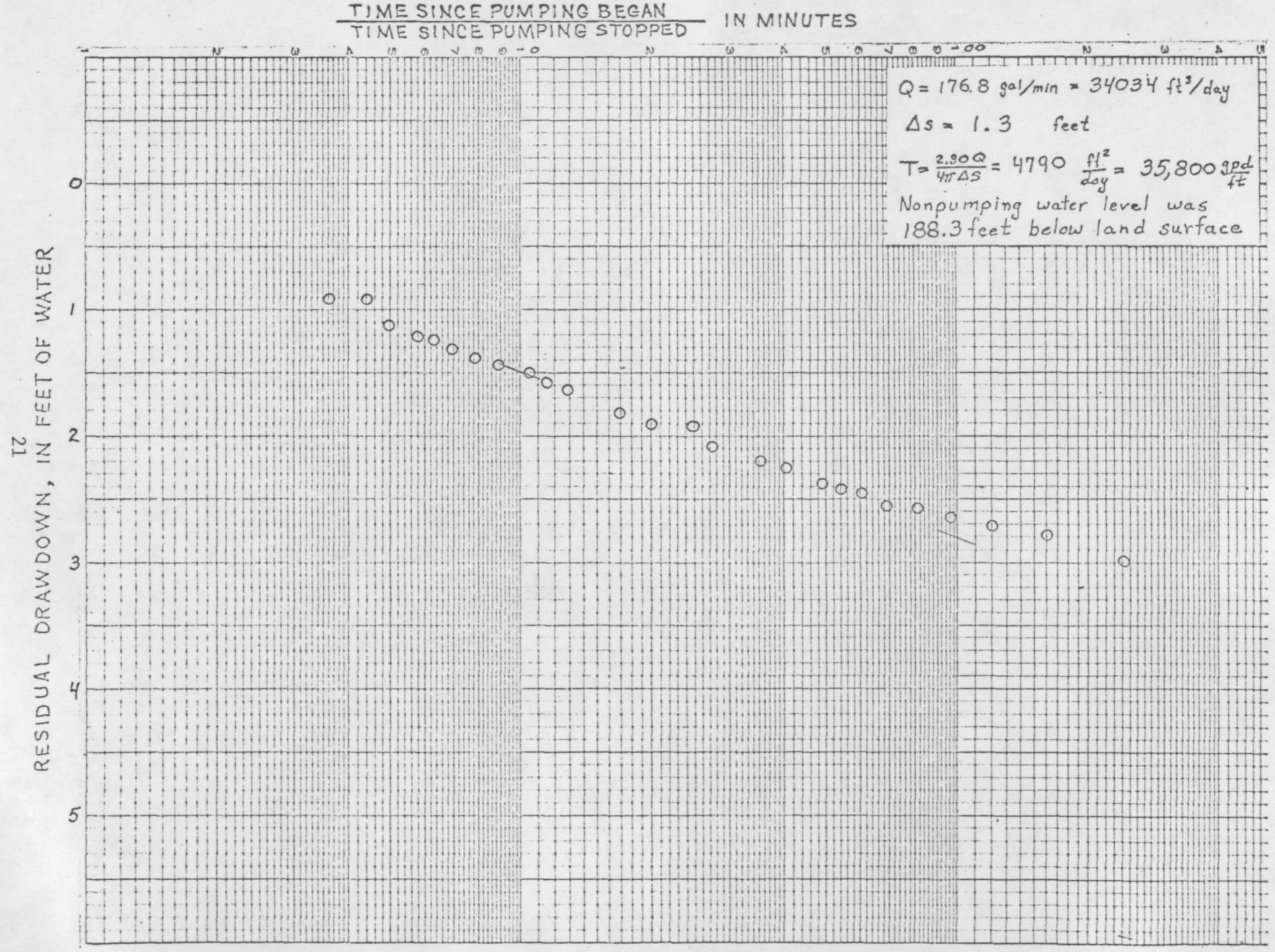


Figure 7.--Graph showing residual drawdown in test well T-16.

Test well T-17

Drilling of test well T-17 began April 7, 1969. A 6 7/8-inch pilot hole was drilled to 2,500 feet below the land surface, geophysical well logs were made, and water samples were obtained by the airlift method from below a packer set at 1,709 feet and from below a packer set at 1,023 feet. A description of well cutting samples collected from the test well is given in table 5 and geophysical logs, with drilling time, are shown in figures 8a, b.

After a concrete plug was set from 564 to 584 feet, the well was reamed to 18 inches and cased to 564 feet with slotted pipe from 440 to 472, from 492 to 504, and from 522 to 544 feet. The casing was centered by spacers welded to the casing every 200 feet. Gravel, 1/8- to 3/8-inch in diameter, was emplaced in the annulus, and the well was developed by surging and bailing for 24 hours and by surging and pumping for 24 hours. The drilling and construction record of test well T-17 is given in table 6.

Results of an 8-hour pumping test followed by a recovery test are shown with computed transmissivities in figures 9 and 10. The computed values of transmissivity are in close agreement and have an average value of 2,200 ft^2/day. The gravel envelope was apparently effective in restricting sand movement because the discharged water contained only a trace of sand during the pumping test.

Table 5.--Sample-description log of test well T-17, White Sands Missile Range

Material	Thickness (feet)	Depth (feet)
Sand, very coarse to very fine, mostly coarse, angular to well rounded, poorly sorted; granule to pebble gravel; some tan clay	10	10
Gravel, granule to pebble; sand, as 0-10; some tan clay	80	90
Sand, very coarse to very fine, mostly medium, angular to well rounded, poorly sorted; granule to pebble gravel	20	110
Gravel; sand, as 0-10	70	180
Sand, as 90-110; granule to pebble gravel; some clay	230	410
Sand, as 90-110; some granules	20	430
Sand, as 90-110; granule to pebble gravel; some clay	50	480
Sand, coarse to medium, well sorted, rounded; granule to pebble gravel	60	540
Sand, very coarse to very fine, mostly medium, fair sorting subangular; granule to pebble gravel; some clay	220	760
Sand, as 540-760; tan, calcareous clay	310	1,070
Clay, tan, calcareous; sand, as 540-760	20	1,090
Sand, very coarse to very fine, mostly coarse, well sorted; some granules	30	1,120
Sand, as 540-760; tan clay	30	1,150
Clay, tan; sand, as 540-760	20	1,170

Table 5.--Sample-description log of test well T-17, White Sands Missile Range - Concluded

Material	Thickness (feet)	Depth (feet)
Sand, as 540-760; tan clay	190	1,360
Sand, coarse to very fine, poorly sorted, fair rounding; tan clay	90	1,450
Clay, tan; sand, as 1,360-1,450	200	1,650
Sand, coarse to very fine, mostly medium, well sorted, angular; tan clay	50	1,700
Clay, tan; sand, as 1,650-1,700	20	1,720
Sand, as 1,650-1,700; tan clay	60	1,780
Clay, tan; sand, as 1,650-1,700	520	2,300
No samples	30	2,330
Sand, medium to very fine, poorly sorted, angular; some clay	170	2,500
Total depth		2,500

Table 6.--Record of test well T-17, White Sands Missile Range

LOCATION: NE¼SE¼NW¼ sec. 27, T. 23 S., R. 5 E. USGS NO: 23.5.27.142

LATITUDE: 32°16'47" LONGITUDE: 106°25'13" ALTITUDE: 4,020 feet.

DEPTH: 2,500 feet.

DATE COMPLETED: 5-11-69 DRILLING METHOD: Hydraulic rotary.

DRILLING CONTRACTOR: Jerry Burgett Drilling Co.

CASING AND HOLE RECORD: Pilot hole drilled with 6 7/8-inch bit to 2,500 feet; cement plug from 564 to 584 feet; pilot hole reamed with 18-inch bit; well cased with steel casing to 564 feet; 8 5/8" O.D. casing perforated with mill-cut slots 1/8"x2", placed 12 slots around and 3 rounds per foot at depth intervals 440-472, 492-504, 522-544 feet; gravel 1/8-3/8-inch diameter placed in annulus as gravel pack; well developed by surging and bailing for 24 hours and by surging and pumping for 24 hours.

YIELD: Well was pumped for 8 hours during pumping test at an average rate of 115 gpm. Drawdown at the end of 8 hours was 20.2 feet.

NONPUMPING WATER LEVEL: 242.16 feet on June 24, 1969.

CHEMICAL QUALITY:

Date	Depth interval (feet)	Specific conductance (micromhos at 25°C)	Sulfate (mg/l)	Chloride (mg/l)
4-25-69	1,709-1,731	11,200	720	3,540
4-26-69	1,023-1,045	450	66	26
5-10-69	440- 544	301	42	11

FORMATION LOGS: 1) Sample description; 2) Drilling time; 3) Dual induction-laterlog; 4) Proximity log-microlog with caliper.

GEOLOGIC SOURCE: Bolson deposits of Quaternary and Tertiary age.

USE AND REMARKS: To be used as observation well.

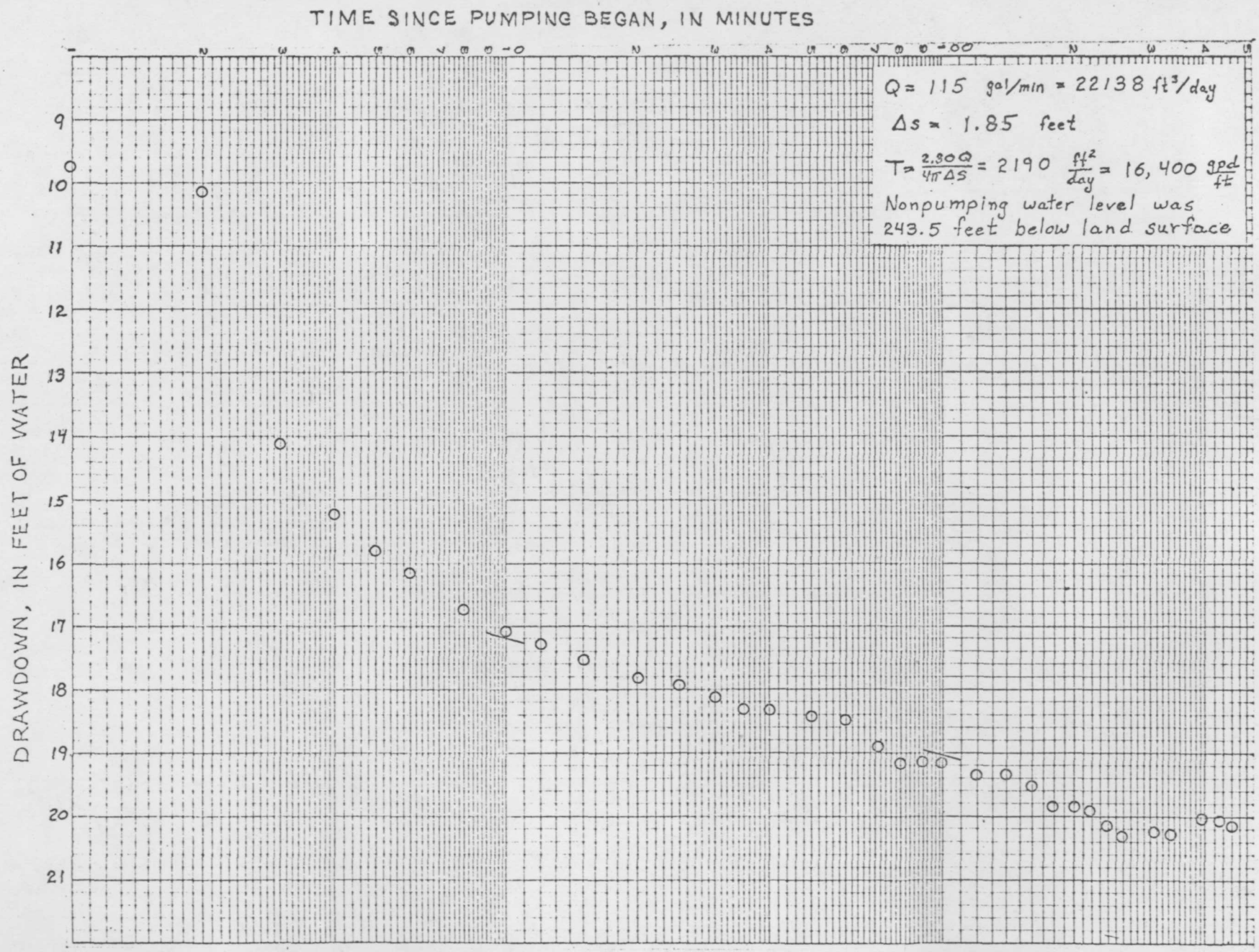


Figure 9.--Graph showing drawdown in test well T-17, May 10, 1969.

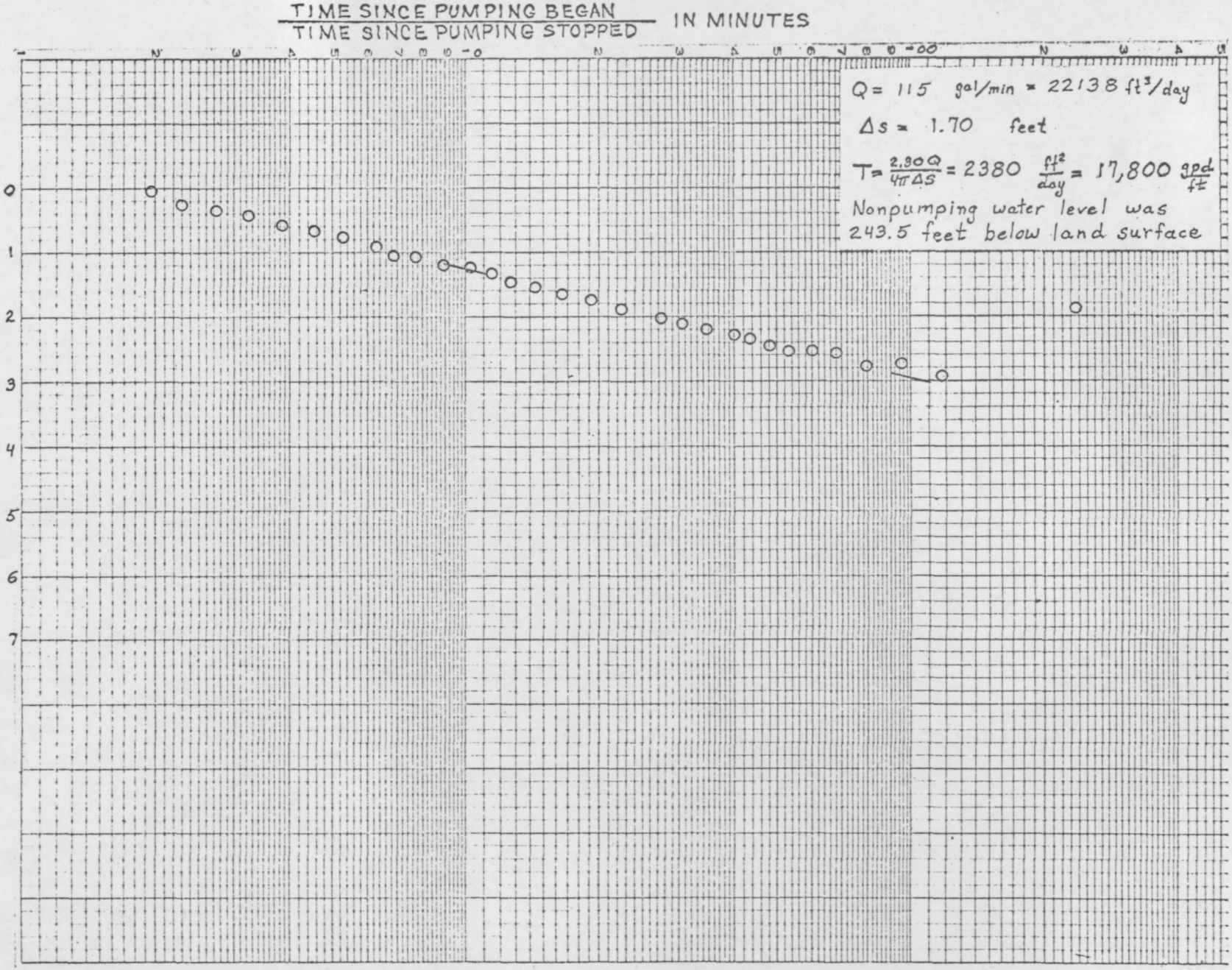


Figure 10.--Graph showing residual drawdown in test well T-17.

After the pumping test, a concrete platform was placed around the casing and the well was retained for water level and water-quality monitoring.

The transition zone between potable and nonpotable water in test well T-17 is not well defined but seems to occur between 1,200 and 1,300 feet as determined from geophysical well logs. The dissolved solids content of 7,320 mg/l in a water sample (table 11) collected below a packer set at 1,709 feet was considerably lower than dissolved solids in water samples collected from comparable depths in test wells T-15 and T-16 (table 11).

Test well T-18

Test well T-18 is located about 800 feet east of a fault scarp at the eastern edge of the Organ Mountains. Bedrock crops out about 200 feet west of the fault scarp. Drilling began May 19, 1969 and was to continue to a depth of 1,200 feet. Drilling rate decreased at a depth of 780 feet and remained low to 890 feet. At this depth a core run was made and about 4 feet of highly fractured monzonite fragments were recovered. Drilling was terminated at this point, geophysical well logs were run, and a water sample was obtained by the airlift method from below a packer set at 505 feet. A description of well cutting samples collected from the test well is given in table 7 and geophysical well logs, with drilling time are shown in figures 11a, b. Results of chemical analyses of water samples collected from the well are given in table 11.

A plug was set in the well from 704 to 724 feet, the well was reamed to a diameter of 9 inches, and casing was placed with slotted intervals from 506 to 524, 530 to 536, 572 to 580, 610 to 620, 632 to 652, and 676 to 684 feet. The well was then developed by surging and bailing for 24 hours and by surging and pumping 24 hours. A large volume of sand was removed during bailing and pumping. During the first three hours of pumping development approximately 30 percent of the discharge by volume was very fine to medium sand. Near the end of pumping development the sand content had decreased to about 0.2 ml/l. The water was still slightly milky in color. The drilling and construction record of test well T-18 is given in table 8.

Table 7.--Sample-description log of test well T-18, White Sands Missile Range

Material	Thickness (feet)	Depth (feet)
Gravel, pebble to granule; sand, very coarse to very fine, poorly sorted, angular; reddish-brown clay	20	20
Sand, as 0-20; gravel, as 0-20; reddish-brown clay	100	120
Sand and gravel, as 0-20; tan clay	20	140
Gravel and sand, as 0-20; some tan clay	10	150
Sand and gravel, as 0-10, tan clay	290	440
Sand, as 0-20; granules	300	740
Sand, as 0-20	40	780
Top of bedrock; mostly angular feldspar fragments with some white calcareous flecks	110	890
Core: Monzonite, fractured with calcium carbonate lining fractures	4	894
Total depth		894

Table 8.--Record of test well T-18, White Sands Missile Range

LOCATION: NW¼NE¼SW¼ sec. 5, T. 23 S., R. 5 E. USGS NO: 23.5.5.321

LATITUDE: 32°20'10" N LONGITUDE: 106°27'27 W ALTITUDE: 4,065 feet.

DEPTH: 890 feet.

DATE COMPLETED: 5-30-69 DRILLING METHOD: Hydraulic rotary.

DRILLING CONTRACTOR: Jerry Burgett Drilling Co.

CASING AND HOLE RECORD: Pilot hole drilled with 6 3/4-inch bit to 890 feet; cored (2 1/8-inch core) from 890 to 894 feet; reamed with 12 1/4-inch bit to 704 feet; concrete plug from 704-724 feet; well cased with 8 5/8-inch O.D. steel casing to 704 feet; casing perforated with mill-cut slots 1/8" x 2", placed 12 slots around and 3-rounds per foot at depth intervals 516-534, 530-536, 572-580, 610-620, 632-652, and 676-684 feet; well developed by surging and bailing for 24 hours and by surging and pumping for 24 hours.

YIELD: Well was pumped for 8 hours at an average rate of 51.5 gpm. Drawdown at the end of 8 hours was 56.2 feet.

NONPUMPING WATER LEVEL: 257.20 on July 24, 1969.

CHEMICAL QUALITY:

Date	Depth interval (feet)	Specific conductance (micromhos at 25°C)	Sulfate (mg/l)	Chloride (mg/l)
5-24-69	505-527	698	128	36
5-29-69	506-704	641	119	42

FORMATION LOGS: 1) Sample description; 2) Drilling time; 3) Dual induction-laterlog; 4) Proximity log-microlog with caliper.

GEOLOGIC SOURCE: Bolson deposits of Quaternary and Tertiary age. Igneous intrusive of Tertiary age.

USE AND REMARKS: To be used as observation well. Bedrock penetrated from about 780 to 894 feet.

Results of an 8-hour pumping test followed by an 8-hour recovery test are shown in figures 12 and 13. Results of these tests are difficult to interpret because of several complicating factors. During the first hour of the test the well was developing and appreciable quantities of sand were being discharged. After 3 hours, pumping was stopped for 10 minutes for minor repairs to the gear head. The surge of stopping and starting the pump resulted in further well development; about an hour was required for the water to clear. Other factors affecting results of the pumping test include delayed drainage from water-bearing materials, storage in the well bore, and an apparent impermeable boundary condition that affected the latter parts of both the drawdown and recovery curves.

The middle portion of the recovery curve of figure 13 probably is affected least by complicating factors. This section when analyzed by the Theis recovery method gives a transmissivity of 184 ft^2/day. The latter part of the drawdown curve of figure 12 can be used to compute transmissivity if the assumption is made that a vertical impermeable boundary affects this portion of the curve. In such a case the Jacob method can be used to compute transmissivity if the difference in drawdown in one log cycle (Δs) is divided by 2. This method gives a transmissivity of 153 ft^2/day. These values of transmissivity are considerably lower than values obtained for T-16 and T-17. Lower transmissivities can be expected in poorly sorted materials near the mountain front (Herrick, 1960).

After the pumping test a concrete platform was placed around the casing and the well was retained for water-level and water-quality monitoring.

Water in T-18 is potable to, and probably within, the bedrock as shown by the water samples and well logs. Results of chemical analyses of a water sample collected during the pumping test are shown in table 11.

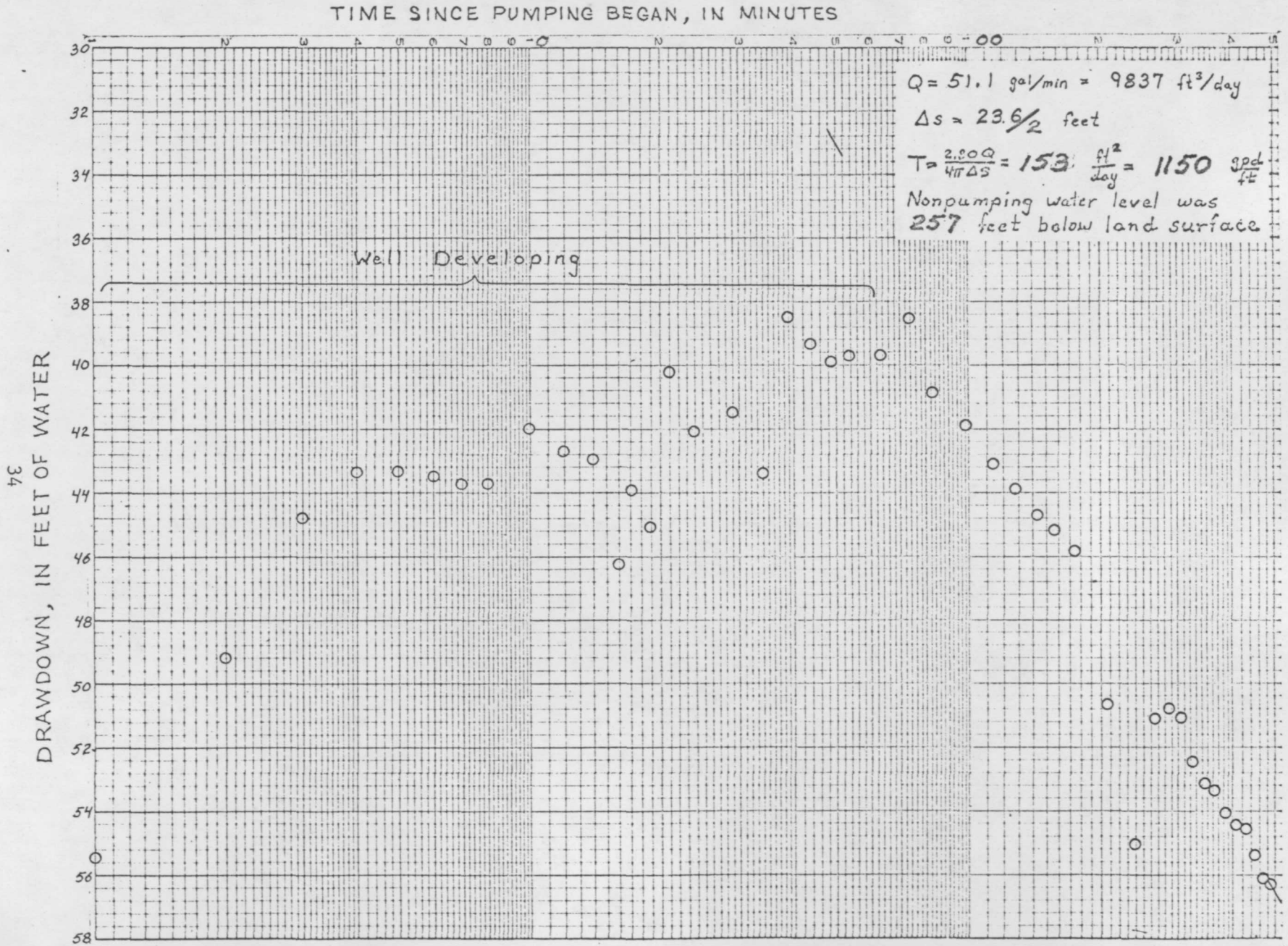


Figure 12.--Graph showing drawdown in test well T-18, May 29, 1969.

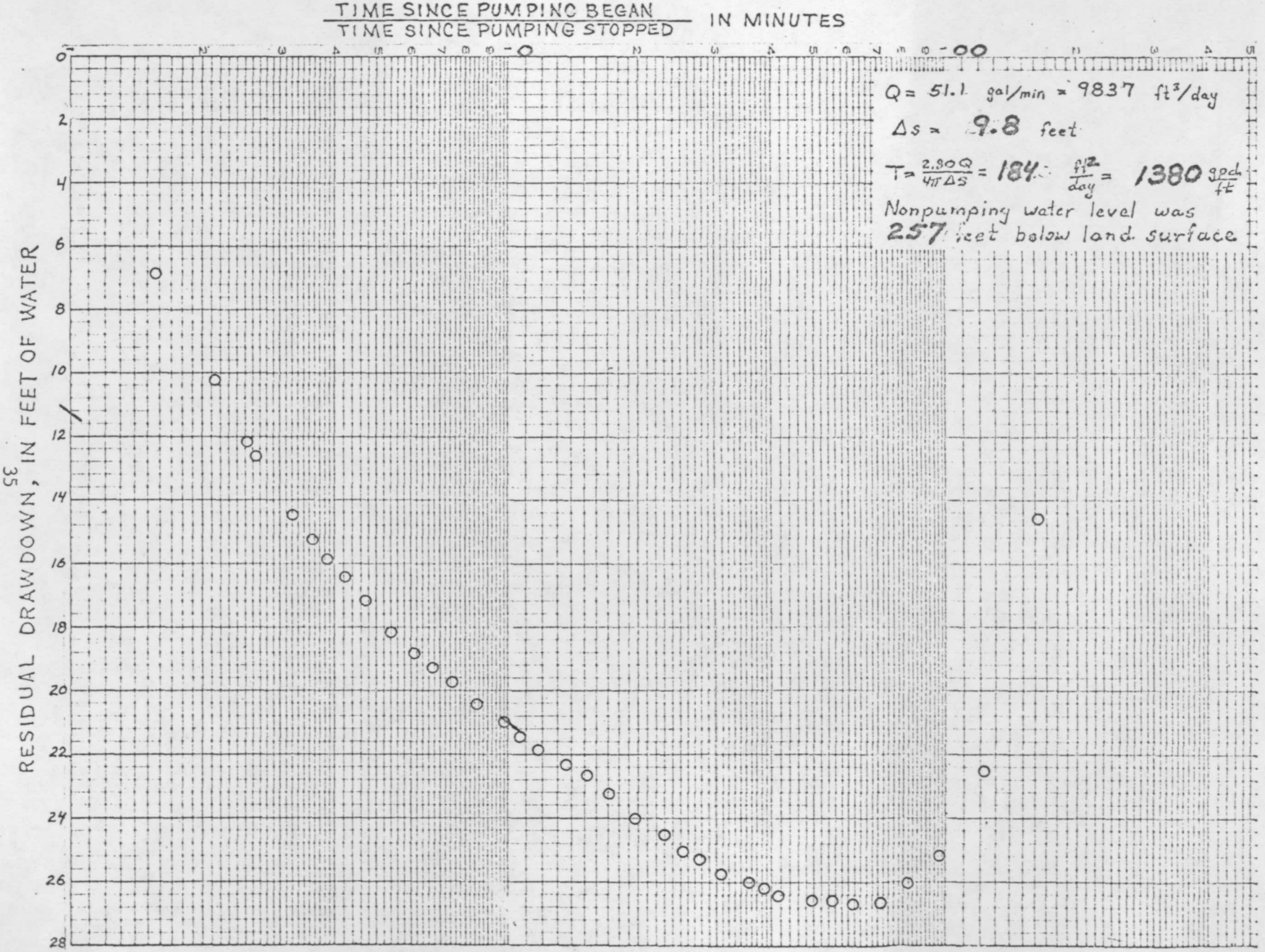


Figure 13.--Graph showing residual drawdown in test well T-18.

It should be noted that while the packer was set at 505 feet, water rose in the connecting pipe to 132 feet below the land surface after the well was pumped to obtain a water sample. Two months after the well had been reamed, plugged, cased, and tested, the water level stood at 257 feet below the land surface. This suggests that water in the fractured bedrock, or in some zone below the concrete plug set at 704 feet, is under a higher hydrostatic head than water above the zone. The possibility of higher pressure in the bedrock than in the unconsolidated materials is supported by water-level data collected from a nearby windmill well. This well is located about 1,000 feet west of T-18 at a slightly higher elevation. Bedrock can be seen at the surface only 180 feet west of the windmill well which would indicate the well is probably completed in bedrock. The water level in this well on May 29, 1969 was 132 feet below the land surface.

Test well RC-3

Test well RC-3 at Rhodes Canyon Range Center was started June 8, 1969 and drilled to a depth of 750 feet below the land surface. Nothing but clay, and clay with gypsum, was encountered during drilling (table 9).

Four zones were selected for water sampling using geophysical well-log information (figs. 14a,b). Water was obtained by the airlift method from below a packer set at the following depths: 560, 490, 390, and 253 feet. Maximum discharge from the lower three depths during pumping was 2 gpm and all sample zones produced muddy water that would not clear with continuous pumping. The uppermost sampling zone produced 10 gpm.

Pumping from the lower sampling zone was discontinued after eight hours when discharge increased and field specific conductance decreased appreciably. It was assumed that the packer became ineffective in separating upper zones of better water quality. Prior to the breakthrough, the field specific conductance was increasing with a maximum measurement of 25,500 micromhos. No sample was collected and no attempt was made to reset the packer at that depth because the hole had filled in below. Table 11 shows results of chemical analyses on water samples from the other three sampling zones.

It was decided, because of the poor quality of the water (table 11) and poor water-bearing properties of the material penetrated in test well RC-3, that a well drilled in this area would not meet production and desalting requirements. Therefore, development and further tests were not attempted and the well was sealed. The drilling and construction record is given in table 10.

Table 9.--Sample-description log of test well RC-3, Rhodes Canyon Range Center, White Sands Missile Range

Material	Thickness (feet)	Depth (feet)
Clay, reddish tan	30	30
Clay, tan	30	60
Clay, reddish tan	30	90
Clay, reddish tan, white calcareous particles; medium to very fine sand; gypsum and well rounded quartz	60	150
Clay, reddish tan, white calcareous particles; very fine sand; gypsum	60	210
Clay, red and blue, white calcareous particles; sand, as in interval 90-150; some large gypsum crystals	270	480
Sand, very fine; gypsum crystals; reddish brown clay	10	490
Clay, red and blue laminated fragments; sand, as in interval 90-150	260	750
Total depth		750

Table 10.--Record of test well RC-3, Rhodes Canyon Range Center, White Sands Missile Range

LOCATION: NW¼NE¼SE¼ sec. 27, T. 13 S., R. 5 E. USGS NO: 13.5.27.421

LATITUDE: 33°09'19" N LONGITUDE: 106°29'05" ALTITUDE: 4,014 feet.

DEPTH: 750 feet.

DATE COMPLETED: 6-8-69 DRILLING METHOD: Hydraulic rotary.

DRILLING CONTRACTOR: Jerry Burgett Drilling Co.

CASING AND HOLE RECORD: Pilot hole drilled with 6 3/4-bit to 750 feet; filled with clay.

YIELD: Upper water-sampling zone yielded 10 gpm. Lower zones yielded 1-2 gpm.

NONPUMPING WATER LEVEL: About 35 feet.

CHEMICAL QUALITY

Date	Depth interval (feet)	Specific conductance (micromhos at 25°C)	Sulfate (mg/l)	Chloride (mg/l)
6-11-69	490-512	159,000	6,120	84,500
6-12-69	390-412	181,000	5,940	103,000
6-12-69	257-269	38,500	5,280	11,950

FORMATION LOGS: 1) Sample description; 2) Drilling time; 3) Dual induction-laterlog; 4) Proximity log-microlog with caliper.

GEOLOGIC SOURCE: Bolson deposits of Tertiary and Quaternary age.

USE AND REMARKS: Hole sealed after collecting water samples.

Water quality

The results of chemical analyses of water samples collected from selected intervals from beneath packers and during aquifer pump-testing of all test wells discussed in this report are given in table 11.

The sample interval shown on table 11 for samples collected during aquifer pumping tests is from the top of the uppermost to the bottom of the lowermost slotted-pipe section in the well. The sample interval given for samples collected by the airlift method from below an open-hole packer is the interval from the bottom of the packer to the bottom of the perforated tail pipe.

Table 11.--Results of chemical analyses of water samples collected from test wells T-15, T-16, T-17, T-18, and RC-3

U.S. DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
WATER RESOURCES DIVISION

Analyses by Geological Survey, United States Department of the Interior
(milligrams per liter)

9-268 q

Well number	T-15	T-15	T-16	T-16	T-16
Sample interval (feet)	714-736	1,620-42	310-700	628-650	1,360-82
Date of collection	1/ 1-3-69	1/ 12-29-68	2/ 3-28-69	1/ 3-12-69	1/ 3-11-69
Silica (SiO_2)	26	13	38	28	33
Iron (Fe)	0.09	0.13	0.56	4	18
Manganese (Mn)	--	--	--	--	--
Calcium (Ca)	47	1,700	34	27	1,280
Magnesium (Mg)	4.7	379	5.6	1.8	683
Sodium (Na) + Potassium (K)	63	10,200	33	47	1,450
Bicarbonate (HCO_3)	93	43	127	104	102
Carbonate (CO_3)	0	0	0	0	0
Sulfate (SO_4)	112	3,600	48	59	3,360
Chloride (Cl)	54	17,100	16	20	13,300
Fluoride (F)	0.4	1.4	0.6	0.4	0.7
Nitrate (NO_3)	4.2	1.8	3.2	3.1	1.7
Dissolved solids					
Calculated	357	33,000	240	239	26,000
Residue on evaporation at 180°C	354	32,600	256	254	27,600
Hardness as $CaCO_3$	137	5,800	108	75	6,000
Noncarbonate hardness as $CaCO_3$	61	5,760	4	0	5,920
Alkalinity as $CaCO_3$					
Specific conductance (micromhos at 25°C)	567	45,600	355	354	36,700
pH	7.7	6.9	8.1	8.2	7.5
Color	0	0	5	100	5
Temperature °C	27.5	33	25	26	25

GPO 830-857

1/ Collected by airlift from below packer.
2/ Collected during aquifer pumping test.

Table 11.--Results of chemical analyses of water samples collected from test wells T-15, T-16, T-17, T-18, and RC-3 - Continued

U.S. DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
WATER RESOURCES DIVISION

Analyses by Geological Survey, United States Department of the Interior

9-268 q (milligrams per liter)

Well number	T-17	T-17	T-17	T-18	T-18
Sample interval (feet)	440-544	1,023-45	1,709-31	506-684	505-527
Date of collection	2/ 5-10-69	1/ 4-26-69	1/ 4-25-69	2/ 5-29-69	1/ 5-24-69
Silica (SiO_2)	28	27	29	32	23
Iron (Fe)	0.05	0.33	0.09	0.09	0.07
Manganese (Mn)	--	--	--	--	--
Calcium (Ca)	30	22	465	38	46
Magnesium (Mg)	1.7	0	83	1.9	5.1
Sodium (Na) + Potassium (K)	34	78	1,970	98	103
Bicarbonate (HCO_3)	113	141	57	153	201
Carbonate (CO_3)	0	0	0	0	0
Sulfate (SO_4)	42	66	720	119	128
Chloride (Cl)	11	26	3,540	42	36
Fluoride (F)	0.6	1.1	1.2	3.1	3.9
Nitrate (NO_3)	4	0.2	0.1	0.2	0
Dissolved solids					
Calculated	207	290	6,840	409	444
Residue on evaporation at 180°C	207	291	7,320	414	512
Hardness as $CaCO_3$	82	55	1,500	103	136
Noncarbonate hardness as $CaCO_3$	0	0	1,450	0	0
Alkalinity as $CaCO_3$					
Specific conductance (micromhos at 25°C)	301	450	11,200	641	698
pH	7.8	7.8	6.9	7.4	7.8
Color	0	35	3	5	10
Temperature °C	27	30	32	32	31

GPO 830-857

1/ Collected by airlift from below packer.
2/ Collected during aquifer pumping test.

Table 11.--Results of chemical analyses of water samples collected from test wells T-15, T-16, T-17, T-18, and RC-3 - Concluded

U.S. DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
WATER RESOURCES DIVISION

Analyses by Geological Survey, United States Department of the Interior

9-268 q (milligrams per liter)

Well number	RC--3	RC-3	RC-3			
Sample interval (feet)	490-512	390-412	257-269			
Date of collection	1/ 6-11-69	1/ 6-12-69	1/ 6-12-69			
Silica (SiO_2)	19	17	10			
Iron (Fe)	0.06	0.07	0.03			
Manganese (Mn)	-	-	-			
Calcium (Ca)	2,000	1,950	950			
Magnesium (Mg)	1,270	1,420	421			
Sodium (Na) + Potassium (K)	53,100	64,800	8,440			
Bicarbonate (HCO_3)	66	54	98			
Carbonate (CO_3)	0	0	0			
Sulfate (SO_4)	6,120	5,940	5,280			
Chloride (Cl)	84,500	103,000	11,950			
Fluoride (F)	1.6	1.9	1.7			
Nitrate (NO_3)	.4	.0	.0			
Dissolved solids						
Calculated	147,000	177,000	27,100			
Residue on evaporation at 180°C	151,000	183,000	28,100			
Hardness as $CaCO_3$	10,200	10,700	4,100			
Noncarbonate hardness as $CaCO_3$	10,100	10,700	4,020			
Alkalinity as $CaCO_3$						
Specific conductance (micromhos at 25°C)	159,000	181,000	38,500			
pH	7.1	7.1	7.6			
Color	7	5	5			
Temperature °C	25	25	23			

GPO 830-857

1/ Collected by airlift from below packer.
2/ Collected during aquifer pumping test.

Conclusions and recommendations

Data collected from test wells drilled southeast of Post Headquarters, White Sands Missile Range, show a fresh-water lens about 600 feet thick in the vicinity of T-15 and T-16. This lens thickens to about 1,000 feet near T-17. Supply wells completed near the sites of T-15, T-16, and T-17 should have yields in excess of 200 gallons per minute. Gravel packing should be considered as a means of minimizing sanding in future test and production wells in this locality.

Potable water in T-18 occurs to and probably within the bedrock that was encountered at a depth of 780 feet. The relatively low transmissivity measured in T-18 indicates that wells completed near the mountain front in unconsolidated materials will have lower yields than wells completed on fan deposits farther out in the basin.

The best quality of water measured in test well RC-3 at Rhodes Canyon Range Center apparently has a dissolved solids content in excess of 27,000 mg/l. Wells drilled in this area will encounter very fine-grained materials with poor water-bearing properties. Yields from such wells would probably not be greater than 15 or 20 gallons per minute.

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

Figure 3a.--Proximity log-microlog of test well T-15.

Figure 3b.--Dual induction laterolog of test well T-15.

Figure 5a.--Proximity log-microlog of test well T-16.

Figure 5b.--Dual induction-laterolog of test well T-16.

Figure 8a.--Proximity log-microlog of test well T-17.

Figure 8b.--Dual induction-laterolog of test well T-17.

Figure 11a.--Proximity log-microlog of test well T-18.

Figure 11b.--Dual induction-laterolog of test well T-18.

Figure 14a.--Proximity log-microlog of test well RC-3.

Figure 14b.--Dual induction-laterolog of test well RC-3.