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Albuquerque, New Mexico

Summary of production wells drilled for MAR site water supply, White Sands Missile Range, New Mexico

By

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Introduction

The water requirement, the geologic and topographic setting of the well field area, and the results of drilling to locate a suitable water supply for MAR site have been discussed in the report, "Summary of test wells drilled for MAR site water supply, White Sands Missile Range, New Mexico," by Gene C. Doty, and the reader is referred to that report for background information. MAR production wells 1 and 2 were drilled in accordance with the information obtained from the test drilling program and produced enough water to meet the water requirement for the facility. The location of the production wells in relation to MAR 1 test well is shown on figure 1. MAR 1 test well is in the

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Figure 1 (caption on next page) belongs near here.

SW¼SW¼SW¼ sec. 17, T. 19 S., R. 5 E.(19.5.17.333). MAR 1 production well is in the NW¼SW¼SW¼ sec. 17, T. 19 S., R. 5 E.(19.5.17.331) and MAR 2 production well is in the SE¼SW¼SW¼ sec. 17, T. 19 S., R. 5 E. (19.5.17.334). For convenience of reference in this test MAR 1 test refers to the test well; MAR 1 and MAR 2 refer to the production wells.

Figure 1.--Map of MAR well field area.

Drilling operations

The MAR production wells were drilled by the hydraulic rotary method by the Harold P. Doty Drilling Company of D. W. Falls, Inc., of Albuquerque, N. Mex. The general procedure for each well, summarized from the contract specifications, was as follows: a pilot hole was drilled to 650 feet, electric logs run, a bottom-hole water sample collected, the hole reamed to 20-inch diameter, the casing placed in the well, the gravel pack washed into place, and the well developed and test pumped. (See table 1.) Work on the project was supervised by an inspector of the Corps of Engineers with the advice of the Geological Survey.

MAR 1

Drilling of the pilot hole for MAR 1 began September 16, 1963, and was completed at a depth of 650 feet September 20, 1963. A water sample could not be obtained from the lower part of the hole during the period September 24-25, 1963. A critical examination of the cuttings sample log (table 2) and electric log (fig. 1a) indicated that the

Figure 1a (caption on next page) belongs near here.

lowermost 100 feet of the hole penetrated little permeable material so the finished depth of the well was decreased to 550 feet. The hole was reamed to 20-inch diameter to a depth of 550 feet by October 7, and 10-inch casing was installed October 8, 1963. The gravel pack was emplaced October 9, 1963. Development was completed October 21 and the well was test pumped October 22-23, 1963.

Figure 1a.--Electric logs of MAR wells.

Well MAR 1 (19.5.17.331) Electrical induction log.

Well MAR 1 (19.5.17.331) Microlog.

Well MAR 2 (19.5.17.334) Electrical induction log.

Well MAR 2 (19.5.17.334) Microlog.

Table 1.--Records of wells

Well 19.5.17.331 (MAR 1)

Location: NW¼SW¼SW¼ sec. 17, T. 19 S., R. 5 E., Dona Ana County, N. Mex.

Altitude: Land surface altitude 4,152 **feet, interpolated from USGS topographic maps.**

Depth: 650 feet below land surface.

Date test pumped: October [illegible], 196[illegible].

Drilling contractor: H. P. Doty Drilling Co., Albuquerque, N. Mex.

Casing and well record: Pilot hole drilled to 650 feet with 10¼-inch bit.

Pilot hole reamed to 30 feet with 30-inch bit and 30 feet of 24-inch surface casing cemented in place.

Pilot hole reamed to 20 inches from 30 feet to 550 feet and 10-inch casing perforated from 250 to 550 feet installed to 550 feet. Perforations are mill-cut slots 1/8 X 2¼ inches, 9 slots around, 3 rows per foot.

The void around the casing was gravel packed with 42 yards of rounded gravel, 1/8- to 3/8-inch diameter.

Well developed by bailing, surging with surge block, treating with 1,200 pounds of Wel[illegible]ene chemical, and surging and pumping with test pump.

Well completion record: Well equipped with turbine pump and 20-horsepower electric motor, enclosed in steel well house and connected to water supply main. Pump consists of 19-stage, 6-inch bowls set at 350 feet with 4-inch column pipe.

Table 1.--Records of wells - Continued

Well 19.5.17.331 (MAR 1) - Continued

Water-bearing formation: Bolson deposits. Well was pumped 114 gallons per minute for 24 hours with 37 feet of drawdown.

Formation logs: (1) Description of cuttings (2) Microlog and induction electrical logs. See tables 2 and 3.

Water sample: See table 4.

Summary of material penetrated: See table 2; 650 feet of bolson deposits.

Table 1.--Records of wells - Continued

Well 19.5.17.334 (MAR 2)

Location: SE$\frac{1}{4}$SW$\frac{1}{4}$SW$\frac{1}{4}$ sec. 17, T. 19 S., R. 5 W., Dona Ana County,

N. Mex.

Altitude: Land-surface altitude 4,158 feet,

interpolated from USGS topographic maps.

Depth: 650 feet below land surface

Date test pumped: November 28, 1963; test pumped again January 20-21, 1964 after redevelopment.

Drilling contractor: H. P. Doty Drilling Co., Albuquerque, N. Mex.

Casing and well record: Pilot hole drilled to 650 feet with $10\frac{1}{4}$-inch bit.

Pilot hole reamed to 30 feet with 30-inch bit and 30 feet of 24-inch surface casing cemented in place.

Pilot hole reamed to 20 inches from 30 feet to 650 feet and 16-inch casing perforated from 227 to 650 feet installed to 650 feet. Perforations are mill-cut slots 1/8 X $2\frac{1}{4}$ inches, 9 slots around, 3 rows per foot.

The hole around the casing was gravel packed with 50 yards of rounded gravel, 1/8- to 3/8-inch diameter.

Well developed by bailing, surging with surge block, treating with 1,200 pounds of Weltone chemical, and surging and pumping with test pump. Well redeveloped by same procedure in January, 1964. in an attempt to reduce drawdown. Well pumped to waste April 8-22, 1964 to reduce turbidity and sediment.

Table 1.--Records of wells - Concluded

Well [illegible].17.334 ([illegible]) - Concluded

Well completion and equipment: Well equipped with turbine pump and 20-horsepower electric motor, enclosed in steel well house and connected to water-supply main. Pump consists of [illegible]-stage, 6-inch bowls set at 300 feet with 4-inch column pipe.

Water-bearing formation: Bolson deposits. Well was pumped at 96 gallons per minute for 24 hours with 116 feet of drawdown on November 26-27, 196[illegible].

Formation logs: (1) Description of cuttings (2) Microlog and induction electrical logs. See tables 2 and 3.

Water sample: See table 4.

Summary of material penetrated: See table 2; 650 feet of bolson deposits.

Table 2.--Descriptions of cuttings from wells

Well [illegible] (MAR 1)

Material	Depth interval (feet)
Sand and gravel ----------------------------------	0-10
Gravel, 3/4 to 1 inch rounded to angular, some sand ------------------------------------	10-40
Gravel and rock fragments, rounded to angular, some sand and tan clay ----------------------	40-110
Clay, tan, and some gravel ---------------------	110-120
Gravel and rock fragments, as 40-110, tan clay and some sand --------------------------------	120-175
Clay, tan, and gravel -------------------------	175-190
Gravel, and rock fragments and tan clay ---------	190-205
Clay, tan, gravel, and some sand ---------------	205-230
Gravel and rock fragments, some sand and tan clay ------------------------------------	230-250
Clay, tan, and some gravel ---------------------	250-270
Gravel and rock fragments, some tan clay -------	270-290
Clay, tan and some gravel ---------------------	290-340
Gravel, granule, caliche cemented, rounded, and tan clay --------------------------------	340-345
Clay, tan, granule gravel ----------------------	345-370
Clay, tan --------------------------------------	370-380
Clay, tan, some granule gravel -----------------	380-420

Table 2.--Descriptions of cuttings from wells - Continued

Well 19.5.17.[illegible] (MAR 1) - Continued

Material	Depth interval (feet)
Gravel and clay	420-425
Clay, tan, some granule gravel	425-510
Gravel, granule, sand, and clay	510-515
Clay, tan, some granule gravel and sand	515-550
Clay, tan	550-555
Clay, tan, some very fine sand	555-580
Clay, tan	580-595
Clay, tan, some granule gravel	595-600
Clay, tan, some very fine sand	600-625
Clay, tan, some very fine sand and pebbles	625-630
Clay, tan, some very fine sand	630-650

Table 2.--Descriptions of cuttings from wells - Continued

Well 19.5.17.334 (MAR 2)

Material	Depth interval (feet)
Gravel, fine, angular to subangular, and sand ------	0- 10
Gravel, to ¼-inch, angular to subangular, some brown clay --	10- 30
Gravel, to ½-inch, angular to subangular, some brown clay --	30- 38
Silt, clay, light - brown, sandy --------------------	38- 39.5
Gravel and rock fragments, to ½ inch, black and gray limestone: trace of clay and sand ----------	39.5-58
Clay --	58- 60
Gravel and rock fragments, as 39.5-58 -------------	60- 80
Clay and gravel ------------------------------------	80- 90
Gravel, clay, and sand ------------------------------	90-100
Gravel and rock fragments --------------------------	100-106
Clay, light-brown, some gravel ---------------------	106-125
Clay --	125-130
Gravel and rock fragments, some sand --------------	130-145
Gravel and rock fragments, clay, some sand ---------	145-150
Clay and gravel ------------------------------------	150-160
Gravel and sand ------------------------------------	160-185
Clay, tan --	185-197
Rock fragments of gray to black dolomite and chert--	197-210
Clay, gravel, and sand -----------------------------	210-220

Well 19.5.17.334 (MAR 2) - Continued

Material	Depth interval (feet)
Sand --	220-235
Sand and gravel ------------------------------------	235-240
Clay, sand, and gravel -----------------------------	240-245
Gravel, compact ------------------------------------	245-250
Sand, clay, some fine gravel -----------------------	250-260
Gravel, clay, and sand -----------------------------	260-265
Clay, sticky, and gravel ---------------------------	265-270
Clay, sand, and fine gravel ------------------------	270-285
Rock fragments of black and gray dolomite ----------	285-298
Clay, brown, sandy, some granule gravel ------------	298-316
Gravel and clay ------------------------------------	316-325
Clay, gravel, and sand -----------------------------	325-330
Clay, some sand ------------------------------------	330-335
Gravel, clay, and some sand ------------------------	335-345
Gravel and rock fragments --------------------------	345-355
Clay, some gravel and sand -------------------------	355-390
Clay and gravel ------------------------------------	390-400
Clay, sand, and gravel -----------------------------	400-415
Gravel and sand, some clay -------------------------	415-420
Clay, gravel, and sand -----------------------------	420-445
Clay and gravel ------------------------------------	445-517
Gravel and rock fragments, and gray clay -----------	517-526
Clay, and some gravel ------------------------------	526-567
Clay, sand, and gravel -----------------------------	567-572

Table 2.--Descriptions of cuttings from wells - Concluded

Well 19.[illegible].[illegible]7.[illegible]34 (MAR [illegible]) - Concluded

Material	Depth interval (feet)
Clay, brown, some gravel ------------------------	5[illegible]-590
Gravel and clay ----------------------------------	590-600
Clay, very little gravel and trace of sand -------	600-620
Clay --	620-650

MAR 2

Drilling of the pilot hole for MAR 2 began October 3 and the electric logs were run October 28, 1963. A water sample was obtained by air jetting October 29, 1963. The hole was reamed to 20-inch diameter to a depth of 650 feet from October 31 to November 10, the casing was set by November 12, and the gravel pack was emplaced November 13, 1963. Development was completed November 26 and the well was test pumped November 27-28, 1963.

Redevelopment of MAR 2

The drawdown during test pumping of MAR 2 was more than expected and exceeded the drawdown in MAR 1 test and MAR 1 wells (fig. 2). To

Figure 2 (caption on next page) belongs near here.

make certain that the well was clean and open to the aquifer, the well was redeveloped by swabbing with a surge block, bailing, treatment with Weltone (chemical mud dispersant), and surging and pumping with a test pump.

Figure 2.--Drawdown and recovery of water level from test pumping MAR 1 test well and MAR 1 and 2 production wells and discharge of MAR 2 production well.

The well was swabbed with a closed surge block containing wash ports above and below the block. The swab was made from a small bailer fitted with six close-fitting gaskets, $\frac{1}{2}$-inch thick by 10-inch diameter, of rubberized belting material. The well was swabbed in 5 sections: 230 to 262, 280 to 355, 380 to 415, 484 to 520, and 564 to 600 feet. Each section was swabbed for 3 hours. The well was bailed to remove accumulated fill after each section was swabbed; about 4 cubic feet of fill material was removed from the well. Four hundred pounds of Weltone was mixed with water and poured in the well and the sections were swabbed again, using shorter lengths of swab travel within the sections. The accumulation of fill in the well was removed periodically, totaling about 6 cubic feet of material. Eight hundred pounds of Weltone was mixed, added to the well, and distributed throughout the length of the well by running a large bailer full depth of the well several times. The sections were swabbed for a total of 8 hours and the accumulated fill totaling about 4 cubic feet was removed from the well. A total of about 15 cubic feet of sand, silt, and under-gage gravel pack particles, was removed from the well. The gravel pack did not move throughout the swabbing or ensuing pumping operations.

A test pump was installed in the well with the bowls at 400 feet and with 20 feet of suction pipe below the bowls. The well was pumped and surged to remove material loosened by swabbing and then pumped at different rates to determine the capacity of the production pump (fig. 3).

Figure 3 (caption on next page) belongs near here.

Figure 3.--Drawdown and discharge in well MAR 2, January 20-21, 1964.

Pumping MAR 2 to reduce sediment

Water from the well was turbid and contained much sediment during redevelopment pumping. The sediment was very fine sand and silt. The well was pumped to waste April 8-22, 1964, to reduce the turbidity and sediment. The well was pumped 8 hours a day with alternate periods of steady pumping and surging. The surging consisted of stopping the pump for a few minutes, then pumping for a few minutes. This cycle of surging was repeated several times and then the well was pumped steadily to remove any sediment washed out by the surging. About one-half million gallons of water was discharged during the pumping. Figure 4 graphically summarizes the program of

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pumping MAR 2.

The volume of sediment was measured in a standard 1 liter Imhoff cone; note that the scale for sediment load is logarithmic and that peak load concentration was reduced by a factor of about 100.

Figure 4.--Depth to water, sediment content of water, and pumping rate during test of MAR 2 production well, April 8-22, 1964.

The pumped water contains the most sediment when the water level in the well declines through the interval 340-360 feet. The quantity of sediment decreases as the water level declines below this zone. An unstable bed of very fine sand, silt, and clay somewhere within this zone probably is the source of the sediment. Pumping continuously for periods of 2 hours or more significantly reduces the ratio of sediment to water and the regimen of pumping should be so arranged as to take advantage of this fact. As production pumping continues, the material from the unstable bed probably will stabilize or "clean up" and the sediment content of the pumped water will decrease.

The well was pumped until the volume of sediment decreased but slightly with each cycle of steady pumping; some sediment probably will be produced for several months after the well is in regular production. The volume of sediment produced by the well at the time pumping to waste was discontinued was calculated to represent no serious hazard to transmission or storage facilities. However, if the well is pumped only for short periods of time, or if the volume of sediment in the pumped water should increase, sediment may accumulate in the main storage tank at the facility. Therefore, the amount of sediment in the pumped water and the accumulation of sediment in the storage tank should be measured periodically.

Water obtained

The MAR production wells yield sufficient water for present use at the facility but not enough water for an increased demand. MAR 1 production well is expected to yield 100 gallons per minute and MAR 2 is expected to yield 90 gallons per minute. The drawdown and pumping rate of MAR 1 test and MAR 1 and 2 wells are shown by hydrographs of test pumping on figure 2. The production wells did not yield as much water as MAR 1 test well.

Aquifer tests indicate that all three wells tap the same aquifer and that pumping one of the production wells lowers the water level in the others (fig. 5). The drawdown and recovery data for the pumped

Figure 5 (caption on next page) belongs near here.

well and observation wells were analyzed to determine aquifer characteristics (fig. 6). Although the aquifer tests provided

Figure 6 (caption on next page) belongs near here.

sufficient data for pump installation, the data are not suitable for determination of long-term aquifer characteristics because the aquifer is inhomogenous and not areally extensive. Slow drainage from less permeable beds and possible boundary effects distort aquifer test-data plots. A wide range in coefficients of storage (S) and transmissibility (T) was obtained from the data. Probably none of the coefficients approximate long-term average conditions near enough to be useful in predicting water-level behavior in the well field.

Figure 5.--Water levels in observation wells during aquifer tests on October 22-23 and November 27-28, 1963, in MAR well field.

6.--Drawdown and recovery of water level in wells MAR 1 and MAR 2 for dates shown.

The hydrographs and semilogarithmic plots of aquifer-test data in figures 2, 3, 5, and 6 illustrate the difficulty in interpretation and provide the interested reader with the basis for futher computation and interpretation. Records of water level and pumpage for a period of several months or a few years will provide better data for the determination of aquifer characteristics and prediction of well-field life.

Quality of water

Water obtained from the MAR production wells is of satisfactory quality and within the limits of potability established by U.S. Public Health Service standards, although the water is very hard (table 3). The water is similar in quality to that from MAR 1 test well. Some encrustation of pipes may be expected and more than normal quantities of soap will be needed when this water is used for domestic purposes. Specific industrial requirements should be checked against the table of chemical analyses to determine whether or not treatment is required for a special use.

Water pumped from MAR 2 contains sediment and may be turbid for periods of a few minutes. The turbidity is not excessive, and probably will be unnoticed because the turbid water will be diluted with nonturbid water from MAR 1. Turbidity as well as sediment content of water from MAR 2 should be measured periodically.

Table 3.--Analyses of water samples from wells MAR 1 (19.5.17.551) and MAR 2 (19.5.17.[illegible]54).

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

Well	MAR 1	MAR 2	MAR 2	MAR 2
Date of collection	10-[illegible]-63	10-29-63	11-28-63	1-22-64
Silica (SiO_2) ----------	25	-	25	23
Iron (Fe), dissolved[1] --	-	-	-	-
Iron (Fe), total -------	-	-	-	0.54
Manganese (Mn), dissolved[1] -----------	-	-	-	0.00
Manganese (Mn), total---	-	-	-	-
Calcium (Ca)-----------	73	-	68	79
Magnesium (Mg)----------	41	-	40	42
Sodium (Na) ----------	43	-	52	37
Potassium (K)				2.3
Bicarbonate (HCO_3)------	256	-	259	254
Carbonate (CO_3)---------	0	-	0	0
Sulfate (SO_4)-----------	130	174	170	176
Chloride (Cl)-----------	56	57	56	36
Fluoride (F)-----------	1.4	-	1.2	.6
Nitrate (NO_3)-----------	6.0	-	5.7	6.4
Dissolved solids Sum-------------------	536	-	525	528
Residue on evaporation at 180°C---------	-	-	-	552
Hardness as $CaCO_3$ -------	364	-	356	368
Noncarbonate ---------	154	-	124	160
Specific conductance (micromhos at 25°C)---	816	807	805	817
pH---------------------	7.[illegible]	-	7.7	7.[illegible]
Color------------------	-	-	-	-

[1] In solution at time of analysis.

Conclusions and recommendations

The MAR production wells were drilled in accordance with findings from the test-drilling program and the contract specifications. Redevelopment and pumping to waste of MAR 2 was required in addition to the standard contract specifications. The MAR production wells will produce a supply of water adequate for the present needs of the facility, but inadequate for larger future water demands. The water is potable but very hard. Water pumped from the MAR wells is derived from permeable thin beds of sand and gravel in the bolson deposits, probably old channel deposits. The yield of the production wells was less, and the drawdown in MAR 2 much greater, than expected from the test drilling data. Inconsistent figures for coefficients of transmissibility and storage are obtained from aquifer-test data because of slow drainage from less permeable beds and possibly, boundary effect from clay beds in the bolson deposits.

Water-level and pumpage records for a long period of time are needed to determine average values for coefficient of transmissibility and coefficient of storage; these coefficients can be used to predict water-level changes in the well field. Water quality should be monitored by annual sampling for chemical analysis. Quarterly, or at least semiannual, measurements should be made of turbidity and sediment in the discharge from MAR 2, and in the storage tank at the facility. The regimen of pumping, except in emergency, should be such that both wells are not pumped simultaneously and MAR 2 well is pumped for 2 hours or longer in each cycle of pumping.

Test wells should be drilled 1,000-1,200 feet west or southwest of MAR 1 test well if the water demand at the facility increases and more wells are needed in the MAR well field. A water supply should be established prior to construction of pipelines and other facilities because the bolson deposits in the well-field area range widely in water yielding capability. Test wells constructed with 8- or 10-inch casing, selectively perforated adjacent to permeable zones, could be retained as production wells if the yield is adequate. Such construction probably would result in an overall cost saving, and permit exploration of the widest area at minimum cost.

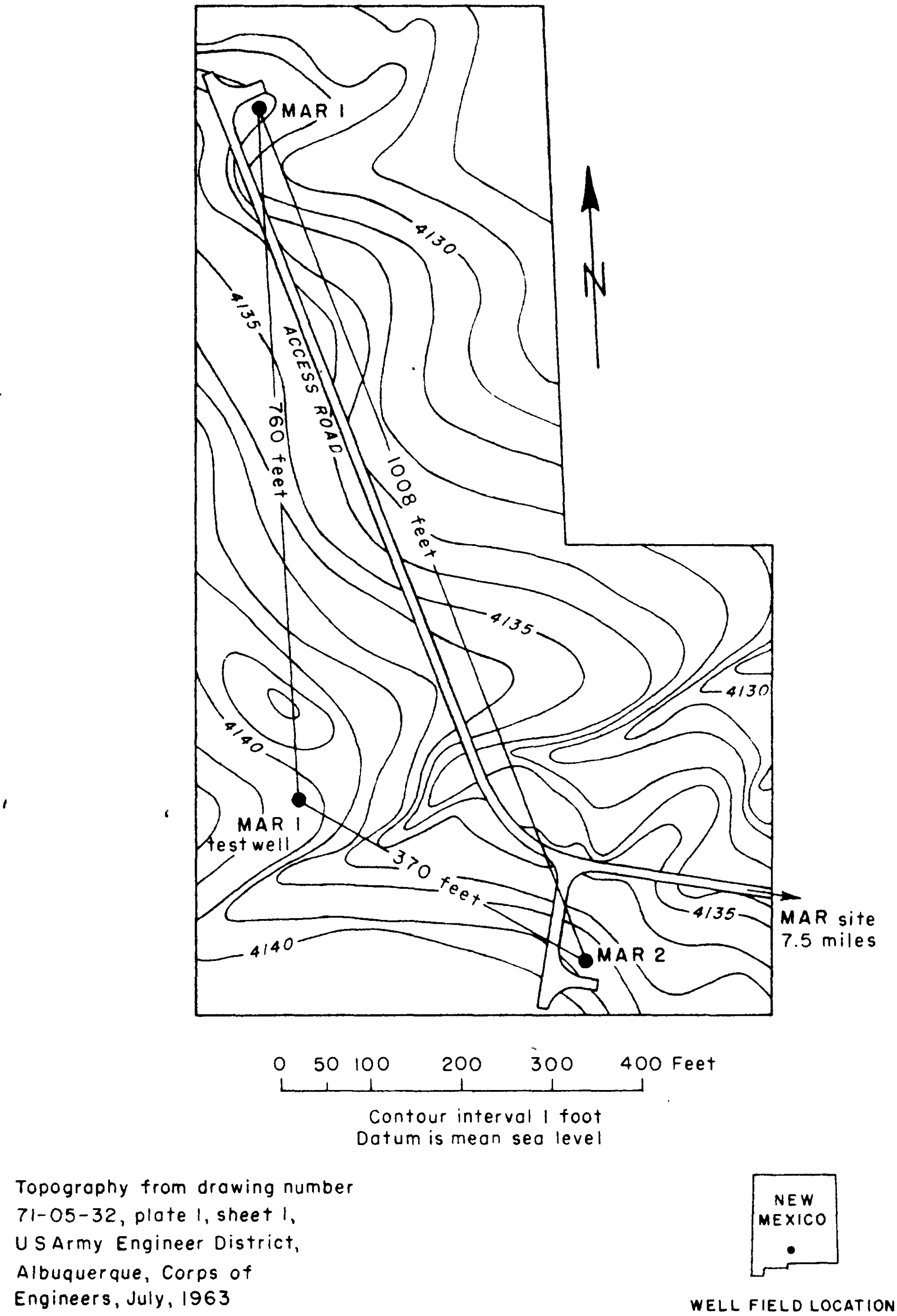

Figure 1.--Map of MAR well field area.

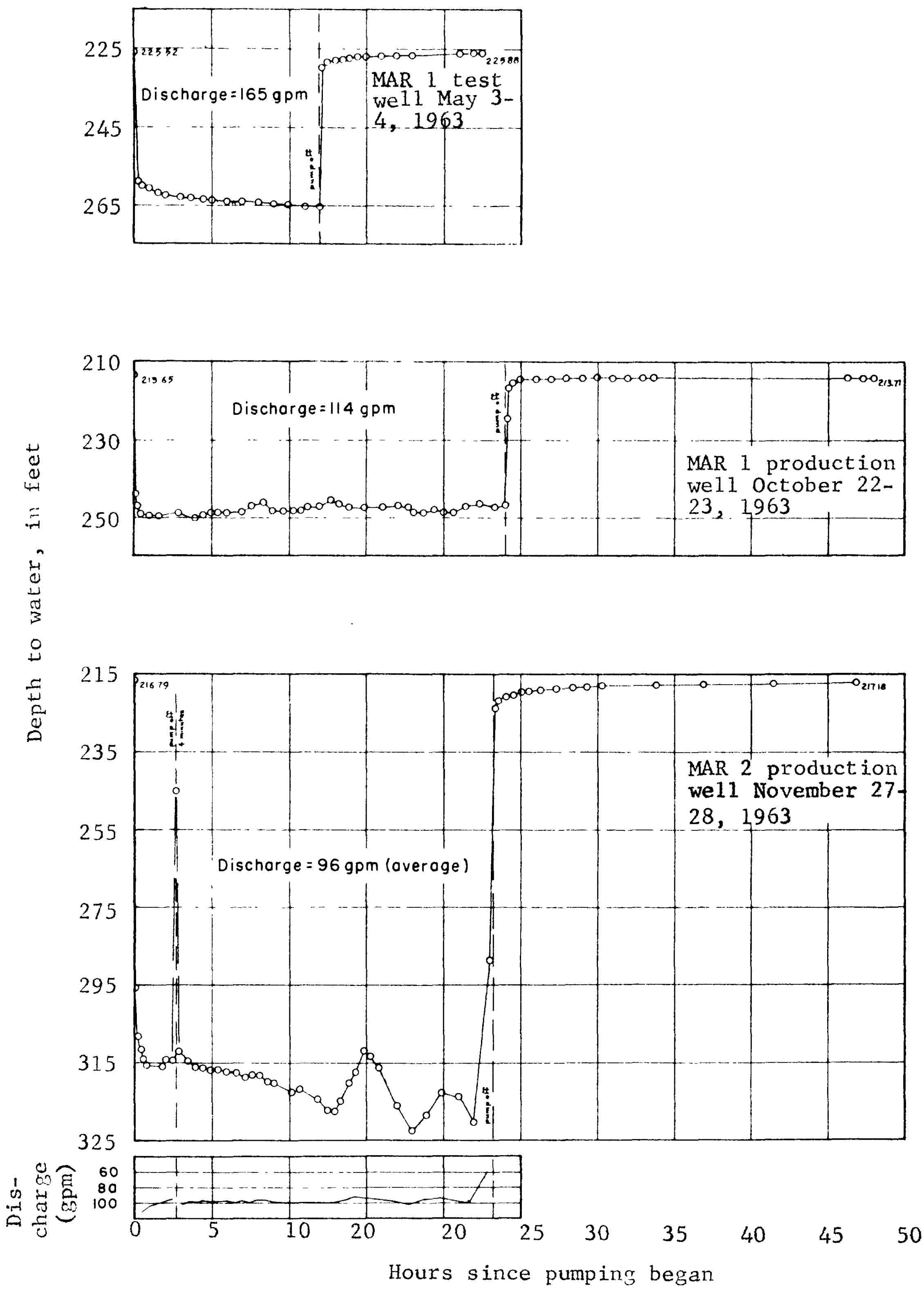

Figure 2.--Drawdown and recovery of water level from test pumping MAR 1 test well and MAR 1 and 2 production wells and discharge of MAR 2 production well

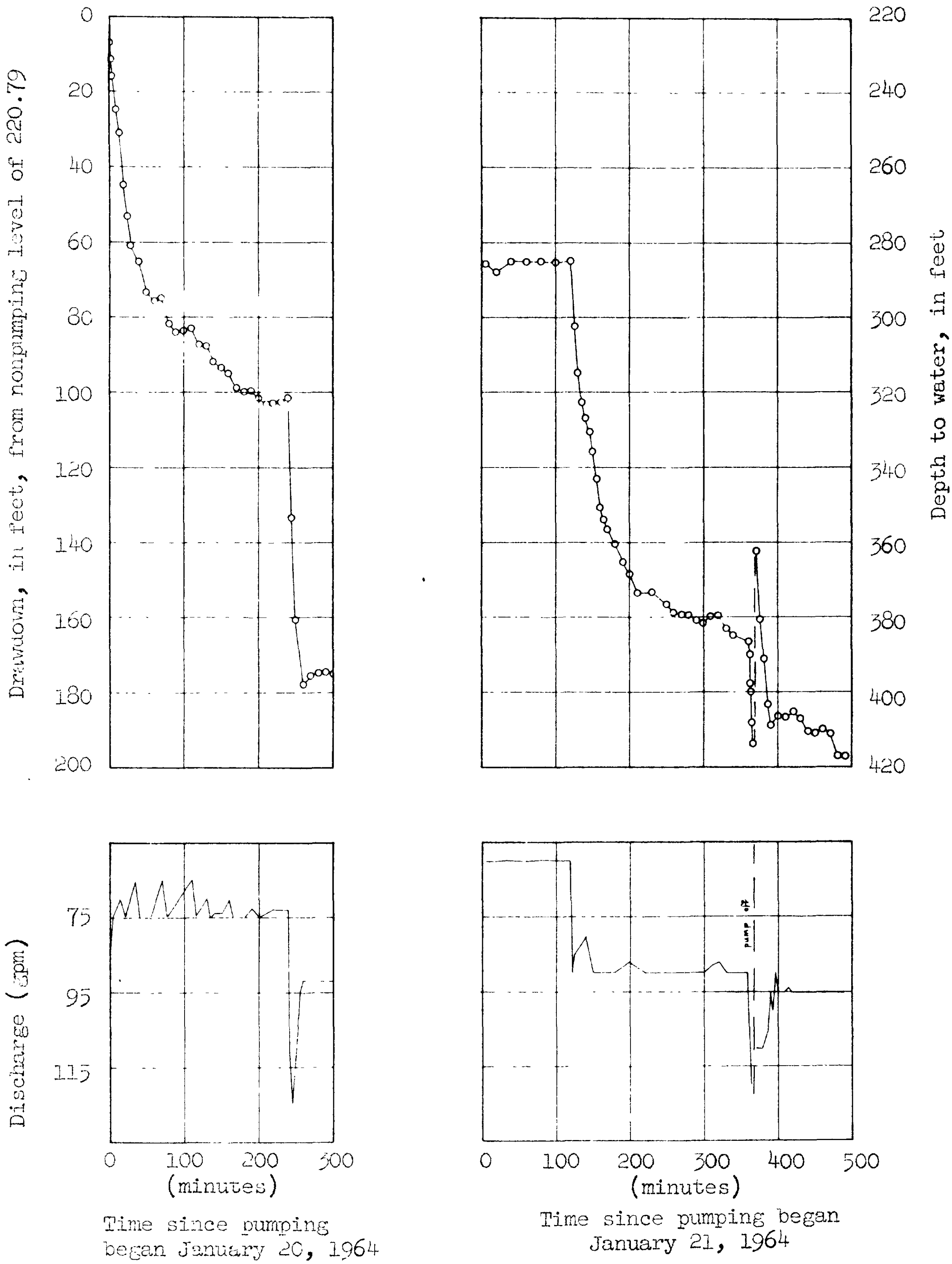

Figure 3.--Drawdown and discharge in well MAR 2, January 20-21, 1964

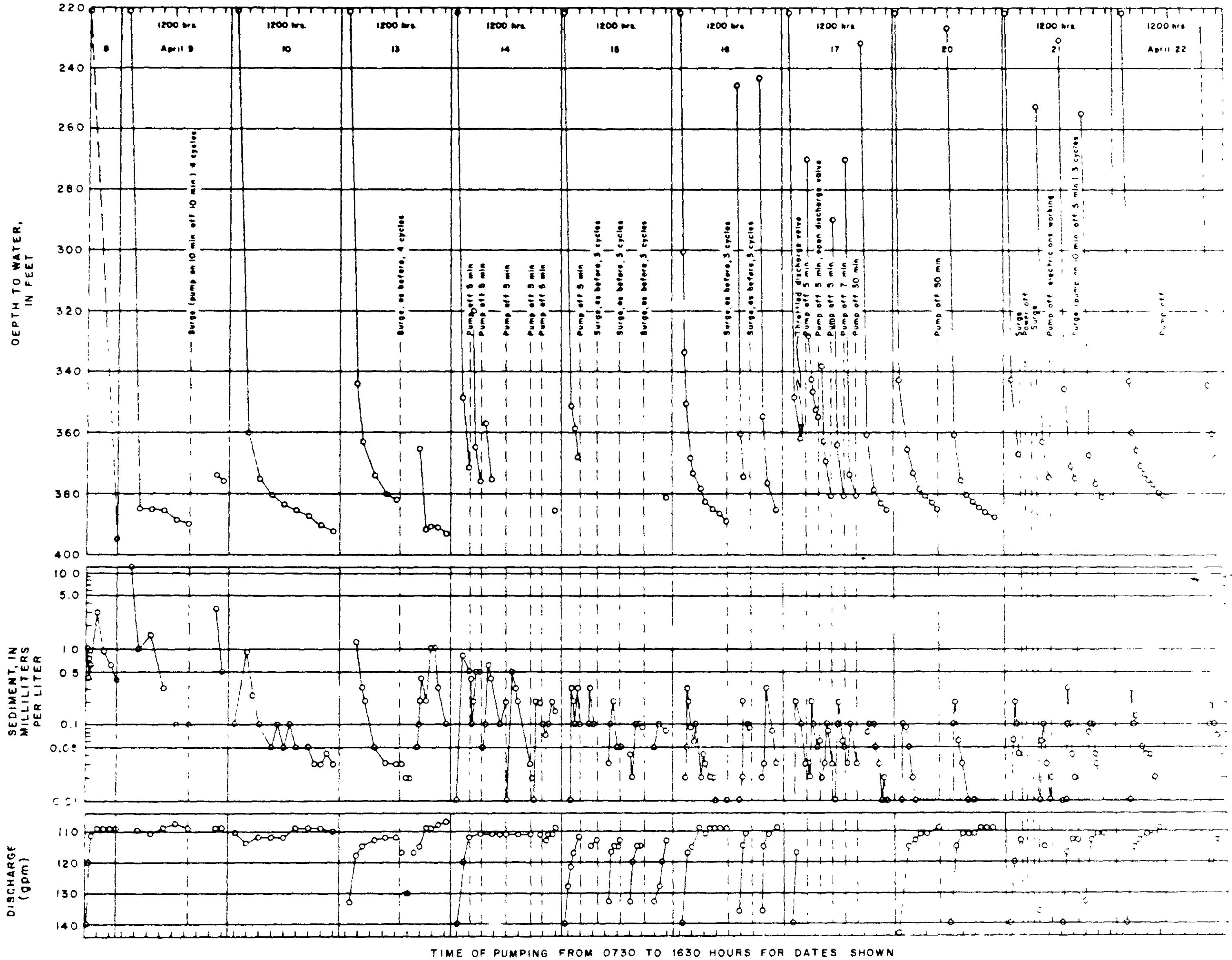

Figure 4.--Depth to water, sediment content of water, and pumping rate during test of MAR 2 production well, April 8-22, 1964.

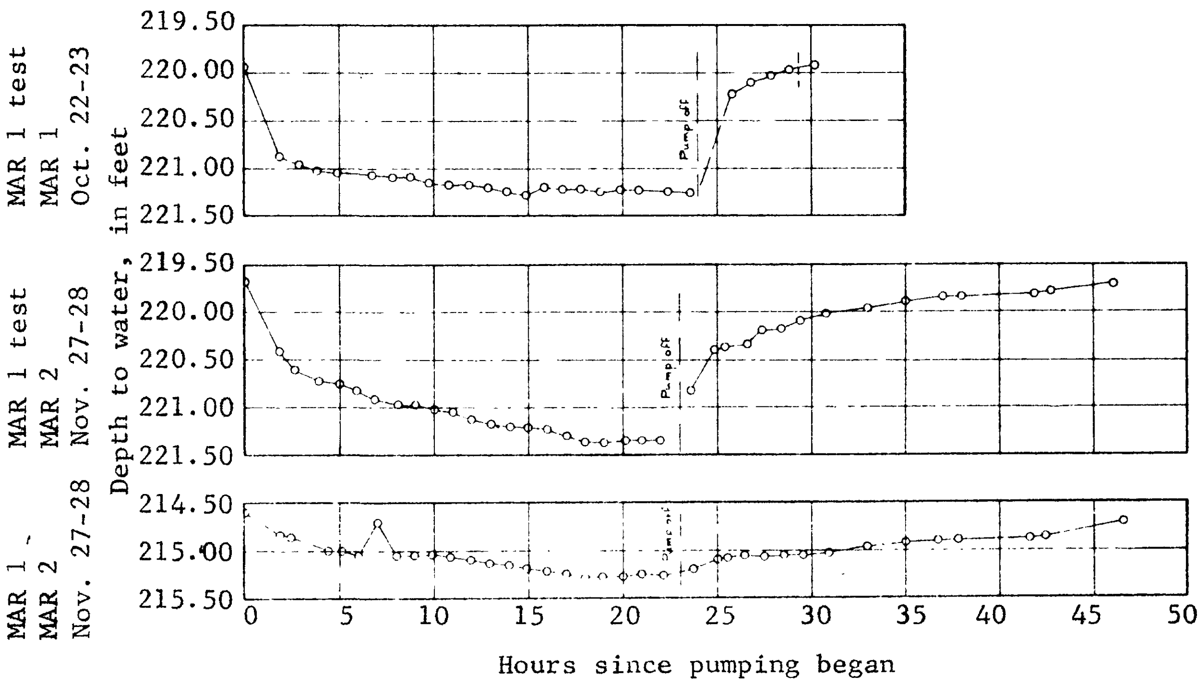

Figure 5.--Water levels in observation wells during aquifer tests on October 22-23 and November 27-28, 1963, in MAR well field.

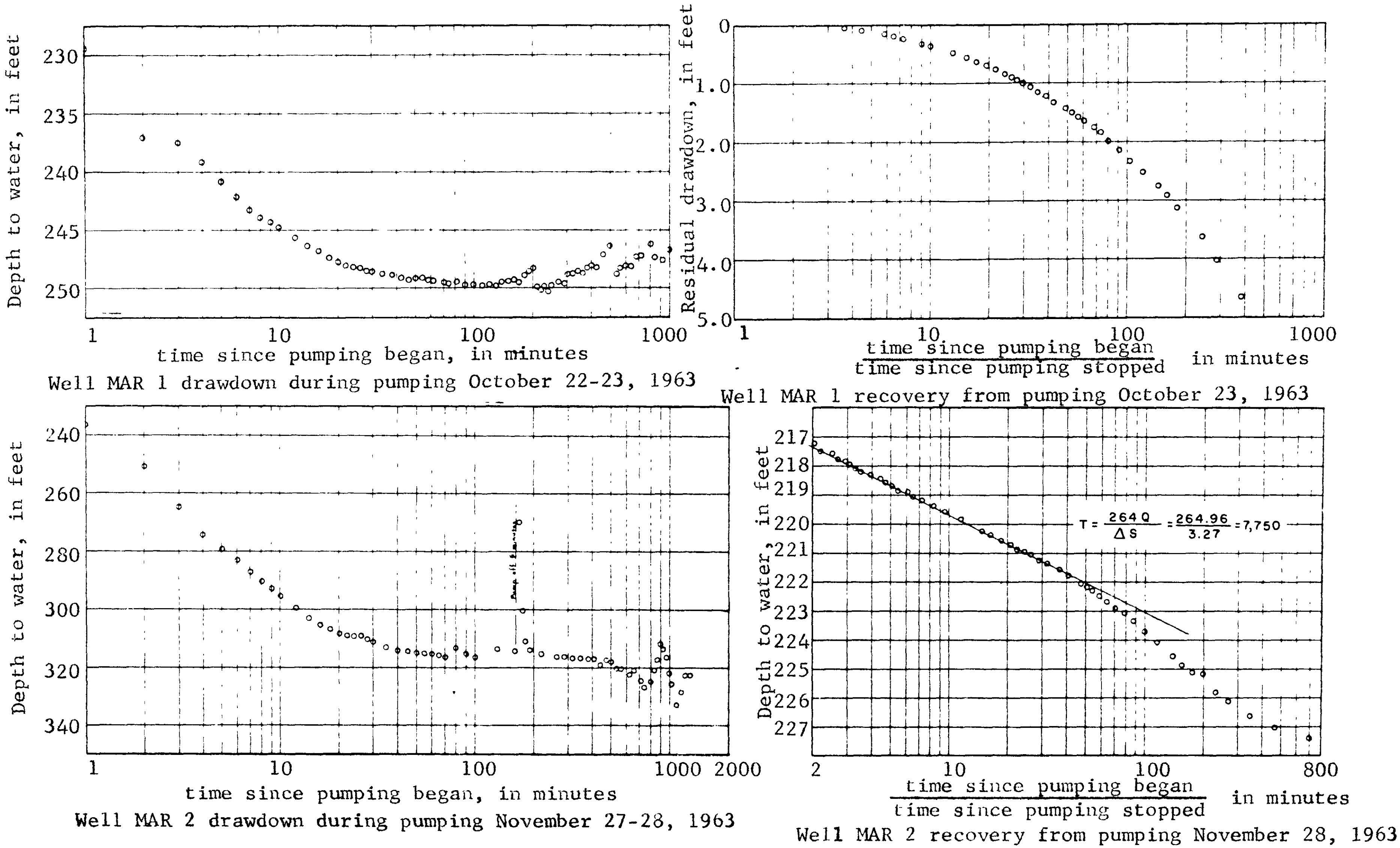

Figure 6.--Drawdown and recovery of water level in wells MAR 1 and MAR 2 for dates shown.