NM-105

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

By

OFR: 68-85 Gene C. Doty July 1964

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
Albuquerque, New Mexico

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Gene C. Doty

Prepared in cooperation with the U.S. Army, Corps of Engineers

Administrative report

July 1964

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Summary of test wells drilled for MAR site water supply,

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Introduction

The U.S. Geological Survey was requested by the U.S. Army, Corps of Engineers to designate test well locations for a water supply at ZMAR (now MAR) facility. On 6 July 1962 the Survey was further requested to provide personnel for inspection and interpretation of geological formations, technical advice on drilling, and a summary report of drilling operations. A well field to provide a minimum of 139,000 gallons per day of water or a maximum of 200,000 gallons per day was required. MAR facility is in the southeast quarter of sec. 21, T. 19 S., R. 6 E. northeast of the White Sands Missile Range Headquarters area, in the Tularosa Valley (See fig. 1).

Methods and procedures

Data from wells north of the Small Missiles Range were evaluated and the topography of the basin and the pattern of geologic outcrops in the San Andres Mountains was studied. Fan slopes nearest the facility were examined for size, drainage area, and type of material. The southwest corner of sec. 17 and the southeast corner of sec. 28, T. 19 S., R. 5 E., and the southwest corner of sec. 34, T. 20 S., R. 5 E. were selected as favorable sites for water well test holes. The location for the third test well was moved from sec. 34, T. 20 S., R. 5 E. to the northwest corner of sec. 21, T. 19 S., R. 5 E., after wells 1 and 2 were drilled, to further explore the areal extent of potable water tapped by wells 1 and 2.

The Cass Drilling Company of El Paso, Texas, drilled the MAR test wells by the hydraulic rotary method. The contractor bladed the ground smooth and dug mud pits at the three well sites: the wells then were drilled singly in numerical order (See tables 1 and 2). Temporary 10-inch casing was installed to a depth of about 120 feet in test wells 1 and 2 to prevent gravel from caving into the hole during deeper drilling operations; temporary 6-inch casing was installed in all three wells so that the upper water sample could be collected by bailing. Water samples from farther down the wells were collected by air jetting beneath a packer. Electric logs were made by Welex (See table 3). Test well 1 was plugged back from 1,000 to 650 feet with gravel and a neat cement cap by the contractor; well 2 was plugged back from 749 to 420 feet by Halliburton cementing service. Perforated casing was placed adjacent to the permeable zones indicated on the electric logs of wells 1 and 2. Well 1 was developed by bailing and surging with the test pump; wells 2 and 3 were plugged and abandoned before development was completed. Well 1 was pumped for 12 hours at about 165 gpm to determine well and aquifer characteristics. This well was retained for water-level observations. Work on the test wells was supervised by an inspector for the Corps of Engineers with the advice of the Geological Survey.

Geology and ground water

The Tularosa Valley is a northtrending topographic valley formed by uplift of rocks of Precambrian through Cretaceous ages on the east and west sides. Material eroded from the uplifted rocks has filled the basin to an unknown depth. These deposits range in age from Tertiary to Recent and consist of irregular beds and lenses of unconsolidated to semi-consolidated clay, silt, sand, and gravel. The alluvial deposits (bolson fill) along the base of the mountains flanking the valley yield potable water to wells, locally.

The source of ground water in the valley is precipitation on the drainage area. As runoff drains toward playas in the floor of the valley, a small portion of the water sinks into the permeable fan slopes and continues to drain toward the valley floor as ground water. Surface water is evaporated from the playas and some ground water is probably discharged by seeps and evapotranspiration.

Wells in the Tularosa Valley obtain water from permeable beds in the bolson deposits. The greatest yield is obtained from wells that penetrate clean gravel deposited in old stream channels. The streams that deposited the fan materials moved laterally across the fan repeatedly; therefore, the sequence of bolson deposits penetrated in wells a short distance apart is commonly diverse and the yield of the wells may range widely. The larger the fan the greater the reservoir capacity of the aquifer.

Water quality ranges widely in the Tularosa Valley. Most of the water is highly mineralized with chloride and sulfate salts. The minerals are from salt and gypsum in the Yeso Formation of Permian age. Water that drains across or through rocks of the Yeso Formation, or through bolson deposits derived from the Yeso, dissolves these minerals and carries them toward the valley floor. Potable ground water is found where the drainage area contains little or no Yeso outcrop or Yeso fan deposits and where the ground water of good quality has not mixed with the highly mineralized water underlying the valley floor.

Aquifer tests

MAR test well 1 was pumped for 12 hours at a rate of 165 gallons per minute and the drawdown was about 40 feet. The well was equipped with an electric submersible pump. The discharge was measured with a orifice plate and manometer. A throttling valve was installed in the discharge pipe to maintain a constant discharge. Water levels were measured with an electric tape during drawdown and recovery. Figure 2 is a hydrograph of these measurements. Water levels were plotted against time to determine the coefficient of transmissibility of the aquifer (figs. 3 and 4). The data indicate a coefficient of transmissibility of 11,600 gpd/ft (gallons per day per foot) based on drawdown and 18,100 gpd/ft based on recovery. The water pumped during the test contained very little sand; samples taken just before the pump was stopped contained no sand.

MAR test well 2 was partly developed by bailing and then the test pump was installed. About 60 to 80 gpm of water containing fine sand was pumped for a few minutes before the pump broke suction and sand locked. The pump assembly was lifted with the rig, shaken several times, and replaced. The pump was started again, and it sand locked in about 10 minutes. The fluid pumped from the well was estimated to contain 30 to 50 percent sand. Extensive development, and possibly different well construction, would have been required to make MAR test well 2 produce. The additional effort would have added but little to the data already obtained; therefore, the well was abandoned.

MAR test well 3 was bailed dry when the first water sample was collected. Yield of the well was estimated to be 1.6 gpm and further development was not justified.

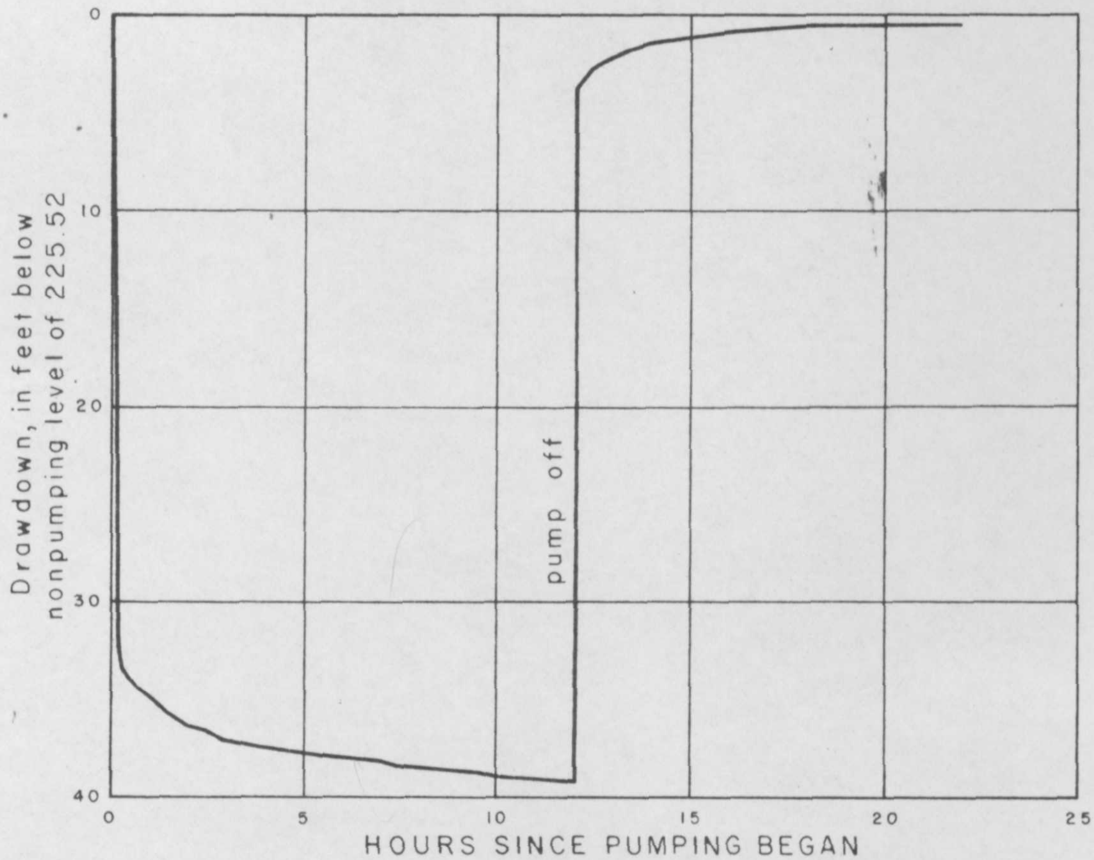

Figure 2.--Drawdown and recovery of water level in well 19.5.17.333 (MAR 1), May 3-4, 1963.

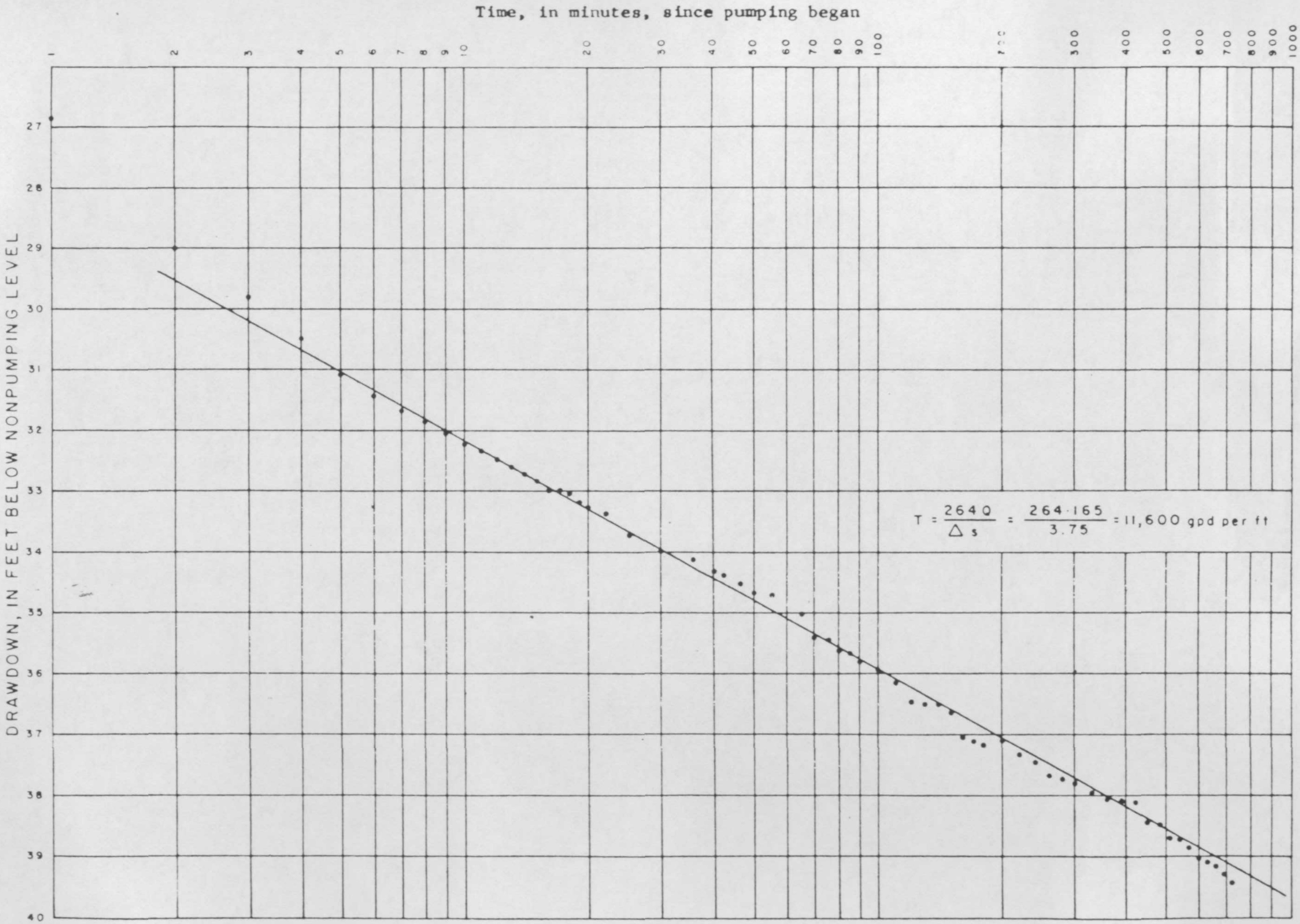

Figure 3.--Drawdown in well 19.5.17.333 (MAR 1) during pumping May 3, 1963.

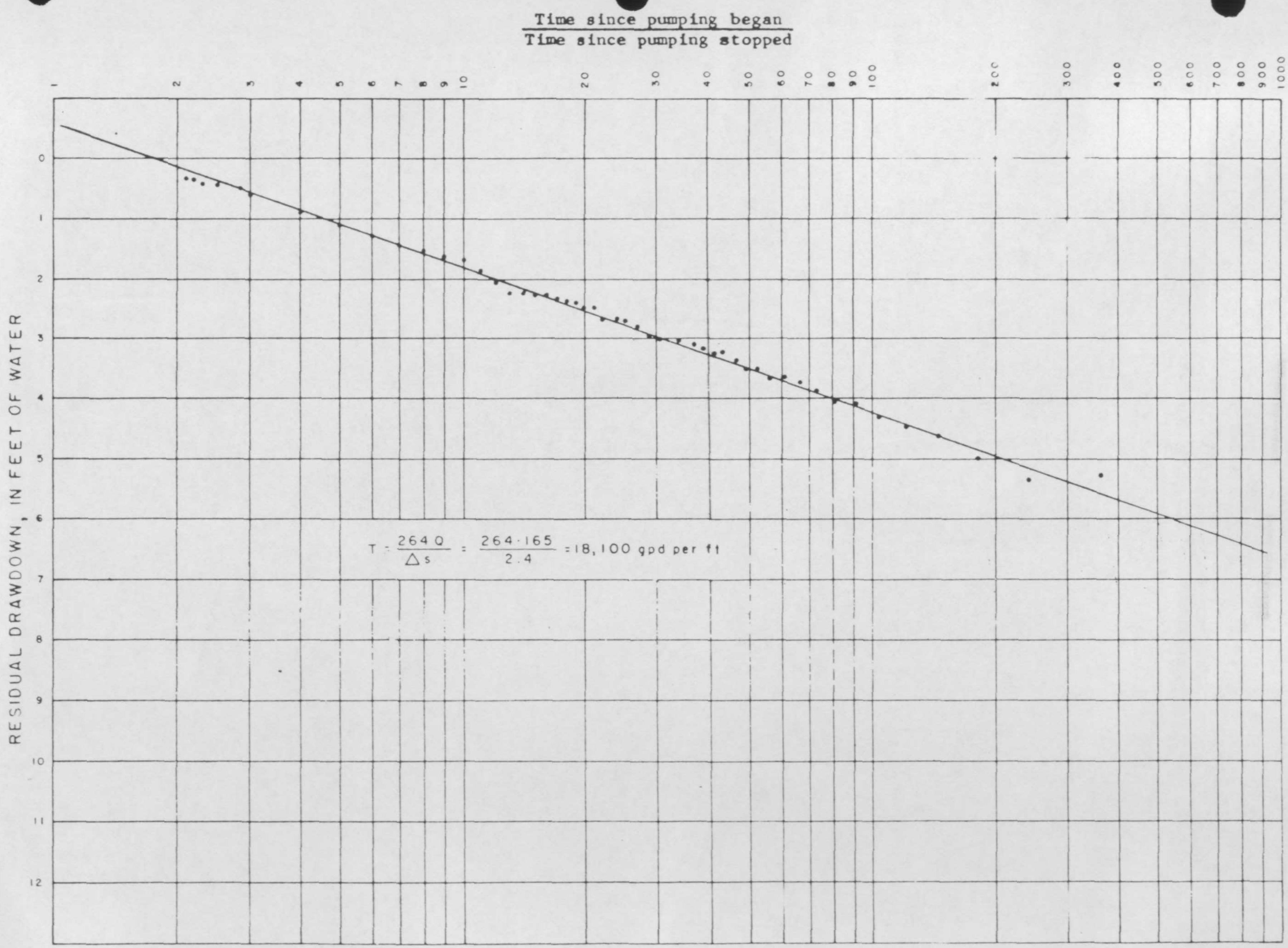

Figure 4.--Water level recovery in well 19.5.17.333 (MAR 1) May 3-4, 1963.

Chemical quality of water

Water from the MAR test wells ranged from potable to nonpotable. The topmost water samples are potable but very hard; the lowermost samples from the test wells are highly mineralized and nonpotable. Chemical analyses of water samples are listed in table 4. A sample of water from a well at MAR site is less mineralized than the lowermost samples from the test wells; the ground water beneath the valley floor probably becomes more highly mineralized with depth. Water collected during the aquifer test of MAR test well 1 is probably representative of the quality of water that will be obtained from production wells in this area.

The thickness of the saturated zone containing water of good quality decreases toward the valley floor (fig. 5). If the water quality interface in figure 5 is a plane, the dip of the interface is about 6 degrees westerly along a line striking N 30° W.

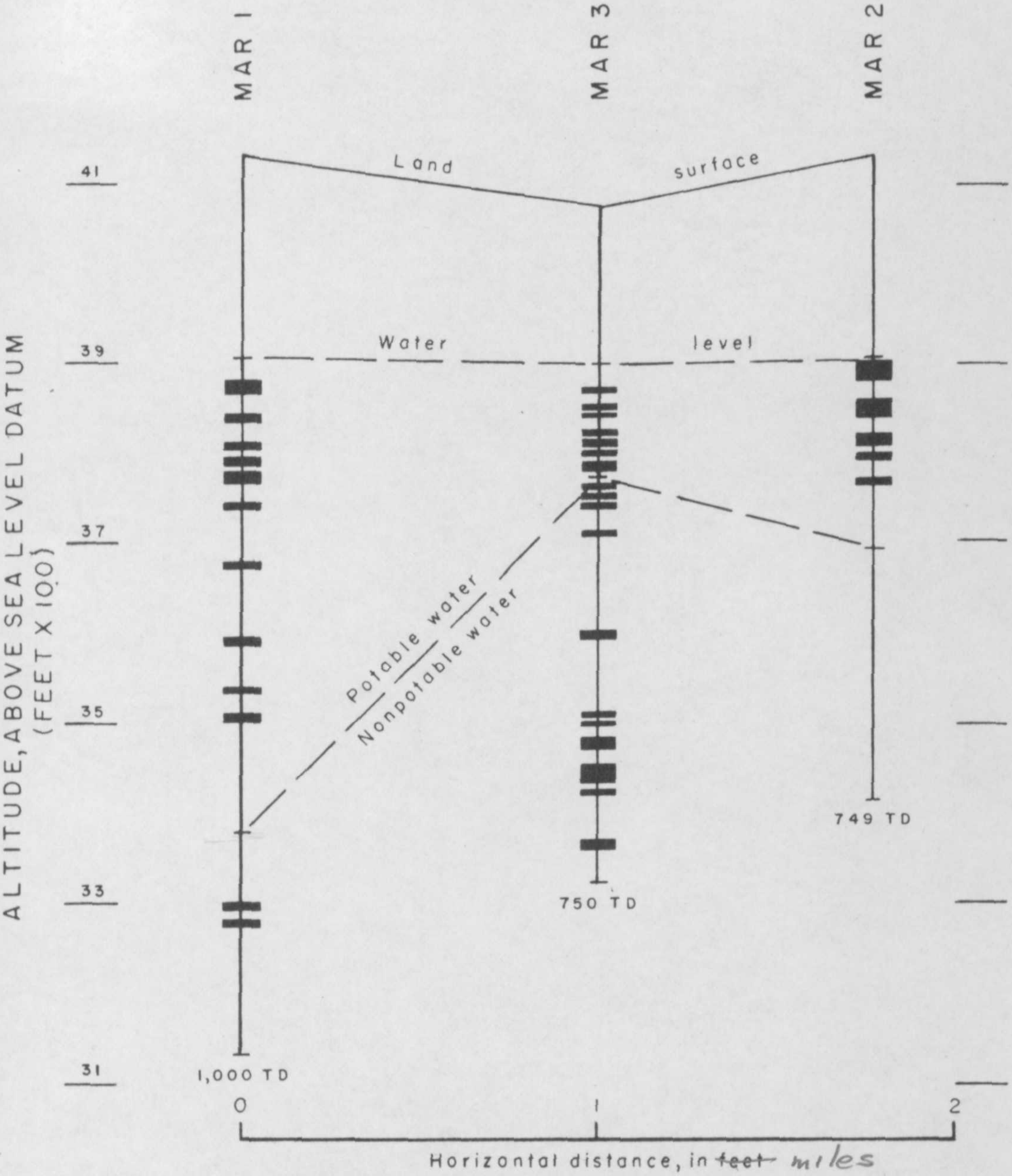

Figure 5.--Depth to water, interface between potable and nonpotable water, and principal zones of permeability below water level in MAR test wells 1, 2, and 3.

7a

Summary and recommendations

Potable ground water is available from the area near MAR test well 1. The water is obtained from thin permeable beds of sand and gravel interbedded with thick beds of clay. The bolson deposits in the lower part of MAR test well 1 were finer grained than those near the surface and, in general, the bolson deposits penetrated by MAR test wells 2 and 3 were finer grained than those in MAR test well 1. Also, the beds of larger particle sizes (gravel and sand) penetrated by MAR test wells 2 and 3 were mixed with more clay than those in well 1. Very few "clean" beds of sand and gravel were penetrated below the water table by wells 2 and 3. The coefficient of transmissibility on the order of 10,000 determined from the aquifer test in MAR test well 1 is probably higher than would be obtained from aquifer tests of wells 2 and 3. Water of very poor quality underlies the well field area and was tapped by all 3 wells. The concentration of dissolved solids in the water increases with depth--first sulfate and then chloride. The potable water wedges out to the east.

Production wells should be drilled no farther than a few hundred feet east of MAR test well 1 and should be drilled to a depth of 650 feet or less to avoid tapping saline water. The casing should be about 10 inches in diameter to accommodate a pump of sufficient capacity for the desired yield. Wells should be spaced at least 1,000 feet apart to prevent excessive interference between wells during pumping. Gravel envelope construction of production wells is advisable in view of the large quantities of sand penetrated in MAR test wells 2 and 3. Properly constructed production wells probably will yield more water than the MAR test well 1; however, the bolson deposits are heterogeneous and the character of the materials penetrated by wells a short distance apart differ widely. Pilot holes should be drilled and a determination made from a study of cuttings, electric logs, and chemical analyses of a bottom-hole water sample as to whether or not the well is completed as a production well. A thorough development program is mandatory to obtain maximum possible yield from the well. The completed well should be tested by pumping to determine aquifer characteristics and the regimen of pumping appropriate for the well. Detailed suggestions concerning the location, construction, and development of the production wells have been included in the contract specifications for these wells.

Table 1 .--Records of MAR test wells, White Sands Missile Range, N. Mex.

Well: 19.5.17.333 (MAR 1)

Location: SW$\frac{1}{4}$SW$\frac{1}{4}$SW$\frac{1}{4}$ sec. 17, T. 19 S., R. 5 E.

Altitude: Land surface altitude 4,135 feet above sea level datum, interpolated from USGS topographic maps.

Depth: Drilled to 1,000 feet below land surface, plugged back to 650 feet.

Date completed: 5-3-63 (test pumped).

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

Drilling method: Hydraulic rotary

Casing and well record: Drilled 3-4-63 to 4-3-63. 15-inch hole from 0 to 120 feet cased with temporary 10-inch casing. 8 5/8-inch hole to 1,000 feet total depth. Hole backfilled with gravel to 670 feet and neat cement from 670 to 650 feet. Well cased with 6 inch steel, welded joint, casing, perforated with torch cut 1/8 x 4 inch slots. Perforated intervals: 250-270, 285-300, 318-328, 336-368, 386-406, 452-462, 500-550, 588-598, 617-632 feet.

Well completion record: 10-inch casing pulled and steel cap welded on 6-inch casing. Well retained as observation well.

Geologic source and yield: Water obtained from sand and gravel bolson deposits. Well pumped at 165 gpm for 12 hrs with 39.4 ft drawdown.

Formation logs: (1) Sample description, (2) Contact caliper and induction electrical log

Water sample: See table 4.

Table 1.--Continued

Well: 19.5.28.443 (MAR 2)

Location: SW¼SE¼SE¼ sec. 28, T. 19 S., R. 5 E.

Altitude: Land surface altitude 4,135 feet above sea level datum, interpolated from USGS topographic maps

Depth: Drilled to 749 feet, plugged back to 420 feet.

Date completed: 6-5-63

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

Drilling method: Hydraulic rotary

Casing and well record: Drilled 5-11-63 to 5-24-63. 15 inch hole from 0 to 117 feet cased with temporary 10" casing. 8 3/4-inch hole to 749 feet total depth. Hole plugged back to 420 feet with cement. Well cased with 6-inch steel screw-joint casing perforated with 1/8 x 4-inch torch cut slots. Perforated intervals: 240-320, 340-400 feet.

Well completion record: 6-inch casing pulled, well plugged with heavy mud and abandoned.

Geologic source and yield: Water obtained from sand and gravel bolson deposits. About 20 gpm of water was jetted by air for a water sample but the turbine test pump sanded up and locked during surging to develop well; yield insufficient to justify further development

Formation logs: (1) Sample description, (2) Contact caliper and induction electrical log

Water sample: See table 4.

Table 1.--Continued

Well: 19.5.21.111 (MAR 3)

Location: NW$\frac{1}{4}$NW$\frac{1}{4}$NW$\frac{1}{4}$ sec. 21, T. 19 S., R. 5 E.

Altitude: Land surface altitude 4,080 feet above sea level datum, interpolated from USGS topographic maps.

Depth: 750 feet

Date completed: 7-4-63

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

Drilling method: Hydraulic rotary

Casing and well record: Drilled 6-24-63 to 7-3-63. 15-inch hole drilled to 81 feet; 8 3/4 hole to bottom. Temporary 6-inch casing with lower 86 feet slotted run when hole depth was 290 feet to collect water sample. No casing installed to total depth.

Well completion record: Plugged and abandoned

Geologic source and yield: Sand and gravel bolson deposits. Well estimated making 1.6 gpm when bailed for water sample. Yield did not justify further development.

Formation logs: (1) Sample description, (2) Contact caliper and induction electrical log

Water sample: See table 4.

Table 2.--Sample description logs of MAR test wells.

Well 19.5.17.333 (MAR 1)

Material	Depth interval (feet)
Gravel, granule to pebble and some coarse sand. Particles are subangular to rounded and consist of limestone, dolomite, chert, vein quartz and igneous rock. Some caliche cement	0 - 112
Clay, tan, gravel, and coarse sand	112 - 130
Clay, tan, some fine to very fine sand	130 - 145
Clay, tan	145 - 155
Clay, tan and large gravel	155 - 160
Gravel, little clay	160 - 165
Clay, tan, with imbedded pebbles	165 - 170
Clay, tan, and granule to pebble gravel	170 - 200
Gravel, pebble, and some clay	200 - 210
Clay, tan, and some gravel	210 - 215
Clay, tan	215 - 225
Clay, tan, and pebble gravel, some sand	225 - 255
Gravel, pebble, tan clay and some coarse sand	255 - 270
Clay, tan and pebbles	270 - 280
Clay, tan	280 - 285
Gravel and some clay	285 - 290
Gravel, pebble	290 - 300
Clay, tan, and some pebbles	300 - 305

Table 2 .--Sample description - Continued

MAR 1-Continued

Material	Depth interval (feet)
Clay, tan and pebble gravel	305 - 320
Gravel and clay	320 - 330
Clay and gravel	330 - 355
Gravel, and tan and white clay	355 - 365
Clay, tan, granules and some coarse sand	365 - 385
Gravel and clay	385 - 395
Clay, tan and some granule to pebble gravel	395 - 450
Gravel and white, green, and tan clay	450 - 460
Clay and some granules to pebble gravel	460 - 535
Gravel, granule to pebble, and clay	535 - 545
Clay, tan, and a few granules	545 - 590
Gravel and clay in beds 4 to 5 inches thick	590 - 600
Clay, tan, and a few granules	600 - 620
Gravel, granule to pebble, and clay	620 - 630
Clay, and a few granules	630 - 670
Clay, tan, with streaks of white sandy, silty clay	670 - 675
Clay, tan, and a few granules	675 - 720
Clay	720 - 750
Clay and gravel	750 - 785
Clay	785 - 805
Clay and some gravel	805 - 840
Clay	840 - 860
Clay and fine sand	860 - 915

Table 2.--Sample description - Continued

MAR 1 - Continued

Material	Depth interval (feet)
Clay	915 - 945
Clay and very fine sand, and few granules of limestone	945 - 950
Clay	950 - 960
Clay, hard	960 - 980
Clay	980 - 990
Clay and gravel	990 -1000

Table 2 .--Sample description - Continued

Well 19.5.28.443 (MAR 2)

Material	Depth interval (feet)
Gravel and clay	0- 10
Gravel, pebble, little sand and clay	10- 35
Sand, gravel and clay	35- 40
Gravel, sand, and some clay	40- 60
Gravel, to pebble or larger size	60-100
Gravel, pebble and some clay	100-105
Gravel, granule and some larger particles, and some clay and very fine sand	105-115
Gravel, to pebble or larger size, and clay in 1-2 foot thick beds	115-125
Gravel, to pebble or larger size	125-135
Gravel, granule, clay and some sand	135-145
Gravel, pebble or larger, sand and little clay	145-170
Clay, tan, fine sand and beds 2-3 feet thick of clay and gravel	170-200
Gravel, pebble or larger and some sand	200-210
Gravel and tan clay	210-225
Clay, tan, and gravel, some sand	225-230
Gravel, pebble or larger, and some tan clay	230-250
Clay, tan, and pebble gravel	250-275
Gravel, sand and clay	275-280
Clay, tan, and some granule gravel	280-310

Table 2.--Sample description - Continued

MAR 2 - Continued

Material	Depth interval (feet)
Gravel, pebble or larger and some tan clay ----------	310-320
Clay, tan, and granule gravel ------------------------	320-345
Clay, tan, sand, and gravel --------------------------	345-355
Clay, tan, and some granule gravel ------------------	355-360
Clay, tan --	360-400
Clay, tan, with some sand and gravel ----------------	400-435
Clay, tan --	435-510
Clay, tan and some granule gravel -------------------	510-565
Clay, tan with few granule gravel imbedded ----------	565-700
Clay, buff, and gray silt ---------------------------	700-730
Clay, and silt, some fine sand, some hard streaks ---	730-749

Table 2.--Sample description - Continued

Well 19.5.21.111 (MAR 3)

Material	Depth interval (feet)
Sand, and fine gravel	0- 10
Gravel, granule, sandy, partly cemented with caliche	10- 15
Gravel, to pebble size, and clay	15- 20
Gravel, granule, sandy, rounded, and little clay	20- 50
Clay, some gravel	50- 55
Gravel, probably tightly caliche cemented and little clay	55- 65
Sand, coarse, clayey	65- 70
Clay, sandy, light brown	70- 81
Gravel, granule to pebble or larger, little tan clay, some particles cemented with caliche; lost circulation at 87 feet and added cottonseed hulls	81-110
Clay, tan, and gravel as above	110-135
Clay, tan, little gravel and sand	135-150
Clay, tan, gravel and sand	150-165
Clay, tan, little gravel and sand	165-170
Clay, reddish tan, and granule to cobble gravel	170-175
Clay, reddish tan, little gravel, sand	175-215
Clay, cream, little gravel and sand	215-295
Clay, tan, slightly sandy	295-305
Clay, tan, slightly sandy, some large gravel with caliche cement	305-315
Clay, tan, sandy	315-325

Table 2.--Sample description - Continued

MAR 3 - Continued

Material	Depth interval (feet)
Clay, tan, slightly sandy and few pebbles	325-330
Clay, tan, slightly sandy	330-345
Clay, tan, some coarse sand	345-360
Clay, reddish tan, slightly sandy, few granule gravel fragments and trace of caliche	360-460
Clay, as above; little sandstone, fine, white, caliche cement	460-610
Clay, tan	610-625
Clay, tan; few thin layers of white, friable, calcareous, fine sand	625-640
Clay, tan, some red, some fine sand	640-750

Table 3.--Electric logs of MAR test wells

(logs are in pocket)

Well 19.5.17.333 (MAR 1) Contact caliper log

Well 19.5.17.333 (MAR 1) Induction-electric log

Well 19.5.28.443 (MAR 2) Contact caliper log

Well 19.5.28.443 (MAR 2) Induction-electric log

Well 19.5.21.111 (MAR 3) Contact caliper log

Well 19.5.21.111 (MAR 3) Induction-electric log

Table 4.--Analyses of water samples from MAR test wells and well at MAR site.

(Analyses by U.S. Geological Survey. Chemical constituents in parts per million.)

	Well 19.5.17.333 (MAR 1)				Well 19.5.28.443 (MAR 2)		Well 19.5.21.111 (MAR 3)		Well 19.6.21.434 MAR site
Sample interval (feet)	250-350	582-718	827-1,000	See perf. intervals	246-310	670-749	178-290	605-705	- 80-208 (?)
Well depth (feet)	380	718	1,000	650	400	749	290	750	208
Date of collection	3-20-63	3-28-63	4-6-63	5-9-63	5-21-63	5-24-63	6-27-63	7-3-63	4-23-62
Silica (SiO_2)				25	21				
Iron (Fe), dissolved 1/				0.02	0.02				
Calcium (Ca)				81	53				
Magnesium (Mg)				36	38				
Sodium (Na) Potassium (K)				42	94				
Bicarbonate (HCO_3)				254	212			182	
Carbonate (CO_3)				0	0			0	
Sulfate (SO_4)	234	93	2,460	162	225	2,640	258	1,890	5,740
Chloride (Cl)	42	48	27,200	42	55	20,500	45	18,100	558
Fluoride (F)				.5	.7				
Nitrate (NO_3)				6.9	8.6				
Dissolved solids									
Sum				520	599				
Residue on evaporation at 180°C					612				
Hardness as $CaCO_3$				352	290				
Non-carbonate				144	116				
Specific conductance (micromhos at 25°C)	950	726	68,700	809	917	56,200	930	49,300	10,000
pH				7.4	7.8				
Color				1	4				
SAR				1.0	2.4				

1/ In solution at time of analysis.

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Test wells SMR-4 and SMR-5, White Sands Missile Range, Dona Ana County, New Mexico

By

Gene C. Doty

Open-file report

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

February 1969

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c.-Dual-induction laterolog of test well SMR-5, White Sands Missile Range, Dona Ana County, N. Mex. --- (In pocket)

d.-Proximity log-microlog of test well SMR-5, White Sands Missile Range, Dona Ana County, N. Mex. --- (In pocket)

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Test wells SMR-4 and SMR-5, White Sands Missile Range, Dona Ana County, New Mexico

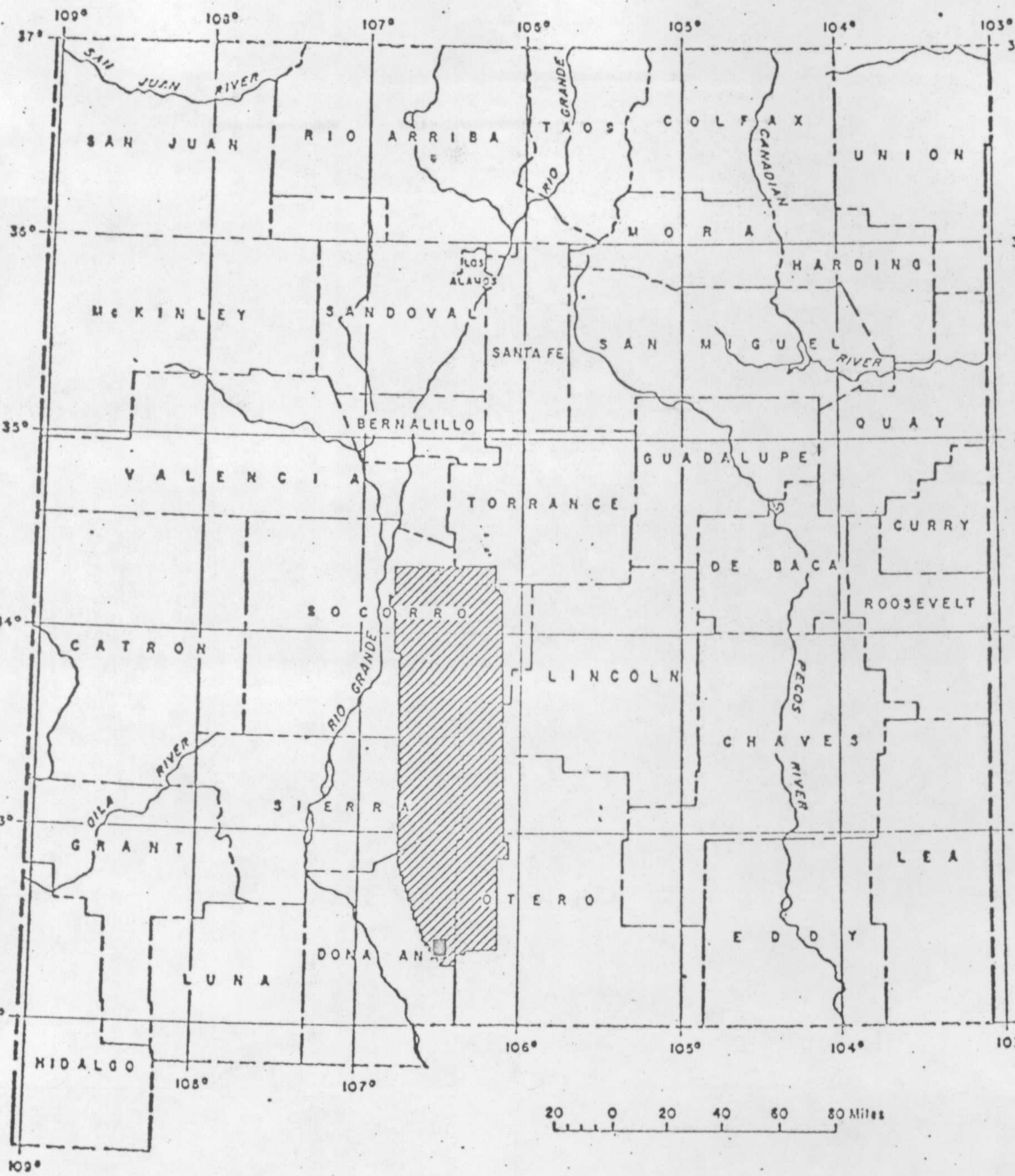
By

Gene C. Doty

Introduction

Test wells SMR-4 and SMR-5 were drilled during November and December, 1967, as a part of the continuing program of water-resources investigation set forth in the White Sands Missile Range Water Master Plan, to further define the extent of the potable-water reservoir tapped by test wells SMR-1, 2, and 3. The geography, geology, and hydrology of the Post Area and adjacent areas has been described by Herrick (1960), Davis and Busch (1968), and Hood (1968) and the reader is referred to these sources for detailed information. The location of the Missile Range and the project area within the Missile Range is shown on figure 1.

Test well SMR-4 was drilled north of the mountain reentrant at the Post Area on the alluvial fan that heads in the HTA (Hazardous Test Area). Test well SMR-5 was drilled on the floor of the basin east of the SMR (Small Missile Range) complex (fig. 2).



EXPLANATION

Project area

White Sands Missile Range

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

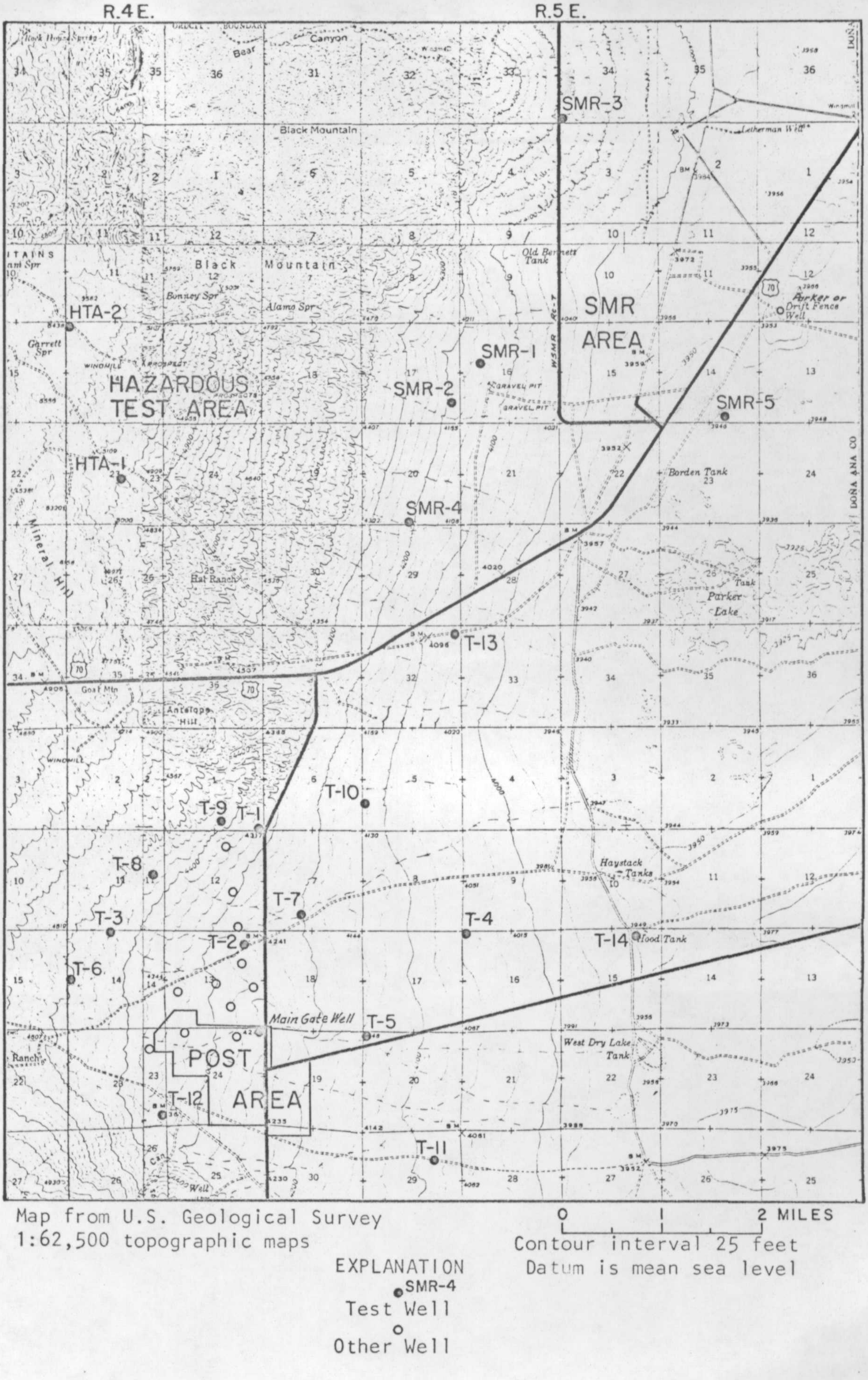


Figure 2.--Wells in and near SMR, HTA, and Post Areas, White Sands Missile Range, Dona Ana County, New Mexico.

Test well SMR-4 is located east of a slight, discontinuous scarp across the gradient of the fan. The scarp probably was formed by recent faulting. West of the scarp, test wells in the Hazardous Test Area penetrated only a thin section of unconsolidated material (Doty, 1968) and the scarp may mark the boundary between an older pediment to the west and the deep trough of the bolson to the east. Test well SMR-5 is located along an extended line of fan drainage on the floor of the bolson. This location was believed to be underlain by potable water because Parker well, (formerly known as Drift Fence well), in sec. 12, T. 21 S., R. 5 E. about 1.2 miles northeast of SMR-5, has yielded a small supply of potable water for many years.

The drilling procedure for test wells SMR-4 and SMR-5 required that the wells be drilled in succession by conventional hydraulic, rotary-drilling equipment. Samples of drill cuttings were to be collected after each five feet of penetration. Rate of penetration was to be recorded automatically by a drilling-rate recorder. Water samples were to be collected from selected intervals as drilling progressed, the uppermost sample by bailing in an open hole and the lower samples by means of expansion packers. In addition to water samples for mineralogical analysis, samples for tritium and radiocarbon analysis were to be collected from the uppermost and lowermost water-bearing zones in SMR-4, and a sample for tritium and radiocarbon analysis was to be collected from the uppermost water-bearing zone in SMR-5. When the well had been drilled to total depth, geophysical logs were to be made; casing then was to be installed with perforated sections adjacent to permeable zones as determined from the geophysical and cuttings-sample logs. The well then was to be developed by bailing and surging, a test pump installed, and further developed by pumping and surging. When the well had been thoroughly developed, an aquifer test consisting of pumping for eight hours and of measuring water-level recovery for an additional eight hours was to be made. A concrete well-head (platform) was then to be constructed and the well retained for water-level observation.

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 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 included F. E. Busch, H. E. Lobley, and the writer, supervised by J. B. Cooper, Hydrologist, and W. E. Hale, District Chief, Water Resources Division, Albuquerque, New Mexico

Results of drilling

Drilling of test well SMR-4 began November 9, 1967 and continued through December 4, 1967 at which time the well had been drilled to 1,010 feet, two water samples had been collected, geophysical logs made (figs. 3a and 3b, in pocket), casing installed, and the well developed by bailing and surging. Table 1 is a record of drilling and table 2 is a description of drill cuttings. Early development work was discouraging; the well was bailed dry three times by bailing at an average rate of about 17 gpm (gallons per minute) during a period of 115 minutes. A mud-cutting chemical was then added to the well and the water in the well agitated vigorously for about an hour with the bailer. The chemical was then left in the well overnight. The following morning a close-fitting surge block was passed several times through the perforated section of the casing. The well was then bailed and agitated with the bailer for several hours. The next day the well was bailed at a rate of about 25 gpm for 5 hours and 10 minutes. Drawdown when bailing stopped was less than two feet.

Figure 3a.--Dual-induction laterolog of test well SMR-4, White Sands Missile Range, Dona Ana County, N. Mex. (In pocket)

3b.--Proximity log-micrololog of test well SMR-4, White Sands Missile Range, Dona Ana County, N. Mex. (In pocket)

Drilling of test well SMR-5 began December 8, 1967 with a small drilling rig that had been set up during the bailing of SMR-4. A water sample was collected December 11, 1967, when the well had been drilled to a depth of 249 feet. Table 3 is a record of drilling and table 4 is a description of drill cuttings. Temporary casing of 10-inch inside diameter was installed and the water sample was collected by bailing the open hole. Drilling was resumed with the temporary casing in the hole; and on December 13, when the well had been drilled to a depth of 666 feet, a packer was set at a depth of 615 feet for collection of a second water sample. The water sample was not collected until December 18, 1967 because of inclement weather. Chemical quality of the water sample did not justify deeper drilling and arrangements for geophysical logging were made. The temporary casing could not be removed from the hole. Logging was completed December 21, 1967 (figs. 3c and 3d, in pocket) after which the well was backfilled with heavy mud and abandoned.

Figure 3c.--Dual-induction laterolog of test well SMR-5, White Sands Missile Range, Dona Ana County, N. Mex. (In pocket)

3d.--Proximity log-microlog of test well SMR-5, White Sands Missile Range, Dona Ana County, N. Mex. (In pocket)

The small rig was moved from test well SMR-5 to test well SMR-4 and a test pump was installed in test well SMR-4 on December 27, 1967. After the well was developed by surging and pumping, an aquifer test was made December 29, 1967. The well was pumped at an average rate of 150 gpm for 8 hours with a maximum drawdown of 5.28 feet. The coefficient of transmissibility was computed to be about 100,000 gallons per day per foot (figs. 4 and 5). The well was fitted with a removable cap and retained for water-level observation.

Test well SMR-4 penetrated about 100 feet of high-yield water-bearing material in the depth interval 460 to 560 feet. The remainder of the saturated material penetrated probably will yield but small quantities of water because of the relatively high clay content of the formation material. The presence of a thick water-bearing zone such as that penetrated by test well SMR-4 is unusual in bolson materials and the bed probably is not areally extensive. The quality of water is good within the zone of saturation penetrated (table 5).

Test well SMR-5 penetrated water of poor quality that is characteristic of water in the lower part of the basin (table 5). The first water sample collected was nonpotable due to its high sulfate content but was otherwise of relatively good quality. Because the temporary casing could not be removed from the well, the induction electric log (fig. 3c) cannot be used to determine if better quality water might have been obtained from a shallower depth than that at which the first water sample was collected. Probably, the near potable water zone in this area is about 100 feet thick.

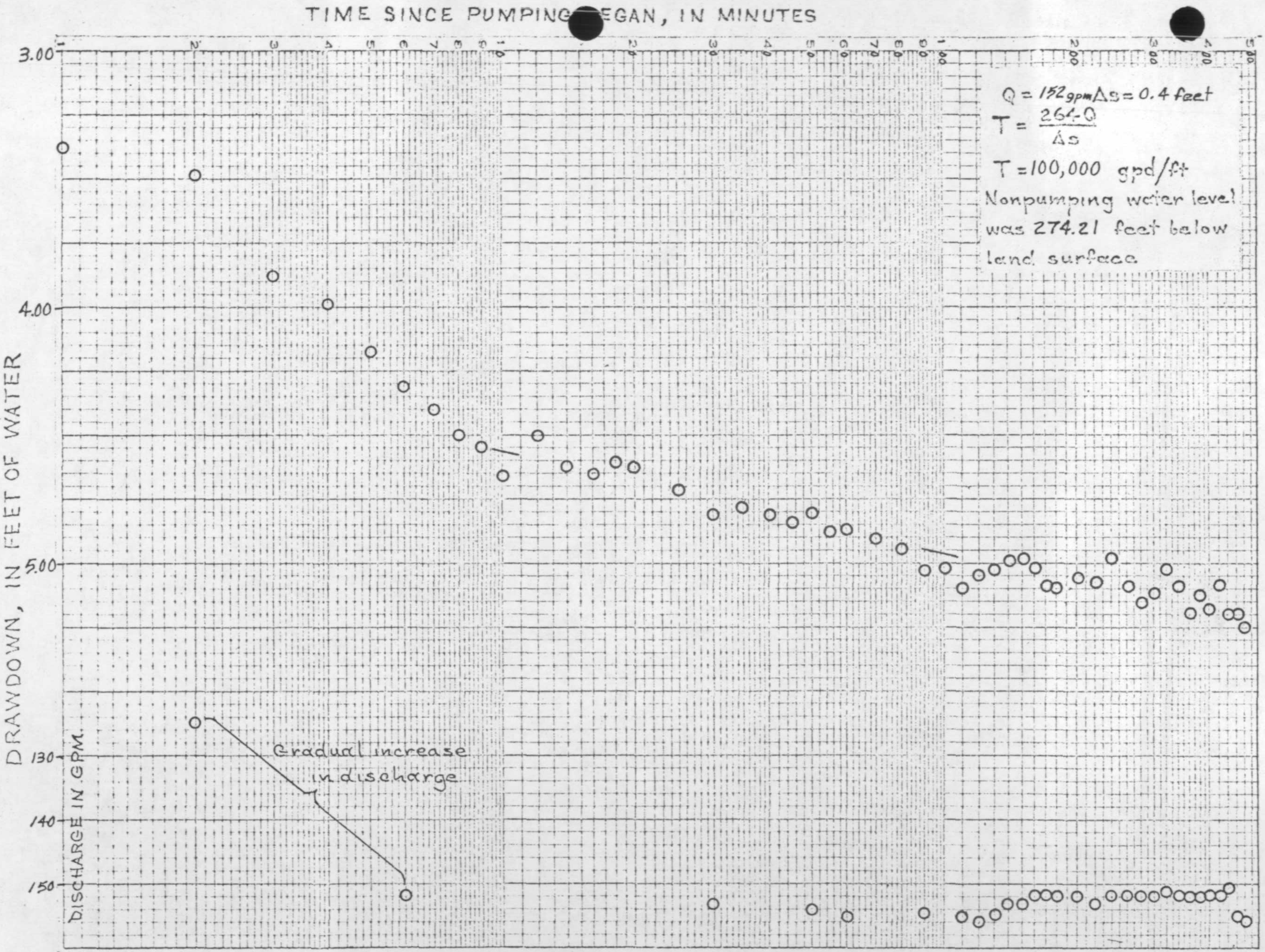


Figure 4.--Drawdown in test well SMR-4, December 29, 1967, White Sands Missile Range,

Dona Ana County, N. Mex.

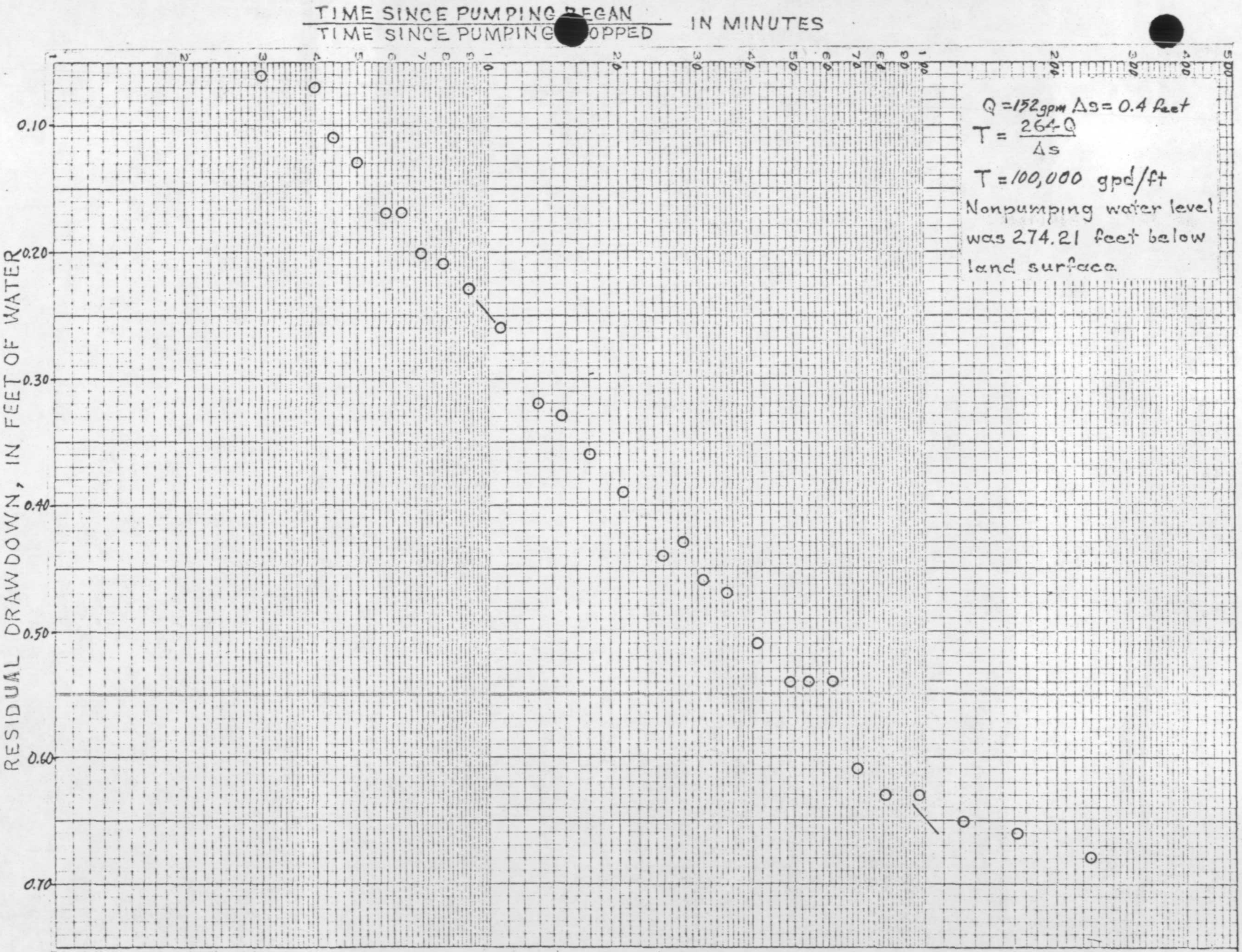


Figure 5.--Residual drawdown in test well SMR-4, December 29, 1967, White Sands Missile Range, Dona Ana County, N. Mex.

The results of chemical analyses of water samples from both wells are included in table 5. Three of these water samples were also analyzed for tritium and Carbon-14 to determine the approximate age of the water. The tritium analyses were made and ratios of Carbon-12 to Carbon-13 were determined by Isotopes Inc., 50 Van Buren Ave., Westwood, New Jersey. The Carbon-14 determinations were made by the Geological Survey laboratory in Denver, Colorado as were the adjusted age computations based on the Carbon-12/13 ratio. The results of these analyses are as follows:

Sample	Tritium			Carbon-14		
	Tritium units	Disintegrations per minute per liter	Minimum age (yrs.)	$C^{12}/13^{0}/00$	Age in years	
					Unadjusted	Adjusted
SMR-4 at 450 feet	1.8±.2	13±2	26	-23.4	5,500	5,410
SMR-4 at 1,016 feet	1.3±.2	9.3±1.5	32	-10.3	18,400	11,800
SMR-5 at 249 feet	2.6±.3	19±2	20	- 7.8	11,800	2,870

The results of the radiochemical analyses suggest that ground water in the area is older than the age-dating range of tritium. The difference in age determined from the Carbon-14 analyses between the samples from the upper part of each well suggests that the water from SMR-5 is younger than that from SMR-4. This is illogical because the ground-water gradient is from SMR-4 to SMR-5. The sample from SMR-4 may have been obtained from a greater depth, relative to saturated thickness, than the sample from SMR-5 and the two samples are not therefore directly comparable. The possibility also exists that the sample from SMR-5 was contaminated with younger water from the drilling process, or that the presence of carbonate detritus in the bolson fill near SMR-5 has affected the analysis. Local vertical movement of water near SMR-5 may occur, but the possibility is slight because of the preponderance of clay in the bolson fill.

Recommendations

Production wells with a yield of several hundred gallons per minute of potable water could be drilled near SMR-4. The depth at which saline water underlies this area is unknown. One or more test wells to determine the interface between fresh water and saline water and to monitor changes in water level and quality should be drilled prior to the drilling and pumping of production wells. The monitoring wells should be located east of the proposed well-field area at a distance of about one mile. The pilot hole of production wells also should be drilled into the saline water to provide additional knowledge about the altitude of the saline-water surface.

The saturated zone penetrated in test well SMR-5 is comprised mostly of clay and the yield of a well finished in it probably would be only a few gallons per minute. Thus, the area near SMR-5 is considered unsuitable for development of large supplies of either near potable or nonpotable water.

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.

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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.

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BASIC DATA

Table 1.--Records of test well SMR-4, White Sands Missile Range, Dona Ana County, N. Mex.

Location: SE¼SE¼SW¼ sec 20, T. 21 S., R. 5 E.

Altitude: 4,210 feet

Depth (drilled): 1,016 feet (cased): 580 feet

Date completed: Test pumped December 29, 1967

Drilling contractor: Boyd and Son Drilling Co., Las Cruces, N. Mex.

Drilling method: Hydraulic rotary

Casing and well record: Drilled 12¼-inch hole to 450 feet and 7 7/8-inch hole to total depth; hole reamed to 12¼ inches from 450 to 580 feet and steel, 8-inch casing installed with 1/8x2-inch mill-cut slots, 36 slots per foot, in the interval 470-570 feet.

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

Formation logs: 1.) Sample description 2.) dual induction laterolog 3.) proximity log-microlog.

Geologic source: Fan deposits and bolson fill of Quaternary and Tertiary age.

Yield: Well pumped at 152 gpm for 8 hours with 525 feet of drawdown.

Nonpumping water level: 274.21 feet below land surface.

Water quality: Potable, see table 5.

Table 2.--Sample description log of test well SMR-4, White Sand Missile Range, Dona Ana County, N. Mex.

Material	Depth interval (feet)	
Sand, very fine to very coarse, angular to rounded, poorly sorted, arkosic, some clay and granule gravel --	0	30
Sand, as 0 to 30, and granule to pebble gravel; some clay --	30	40
Gravel, granule to pebble, and sand; trace of clay ------	40	50
Sand, very coarse to very fine, and granule to pebble gravel; trace of clay ------------------------------	50	60
Gravel, granule to pebble, and sand; trace of clay -----	60	65
Sand, and gravel as 50 to 60 ---------------------------	65	70
Gravel and sand, as 60 to 65 ---------------------------	70	75
Sand, very coarse to very fine, and granule to pebble gravel; trace of clay ------------------------------	75	115
Gravel and sand with a trace of clay as 60 to 65 --------	115	120
Sand and gravel with a trace of clay as 75 to 115 -------	120	150
Sand and gravel as 75 to 115, with about 15 percent clay-	150	280
Sand, gravel, and clay ----------------------------------	280	310
Sand and clay with some granule to pebble gravel --------	310	340
Sand and granule to pebble gravel with some clay --------	340	360
Sand with some granule to pebble gravel and a trace of clay --	360	390
Sand --	390	405
Sand, some granule gravel and a trace of clay -----------	405	455

Table 2.--Sample description log of test well SMR-4, White Sands Missile Range, Dona Ana County, N. Mex. - Concluded

Material	Depth interval (feet)	
Sand, some granule to pebble gravel and a trace of clay	455	740
Sand, some granule to pebble gravel and clay	740	875
Sand, and granule to pebble gravel	875	905
Sand, some granule to pebble gravel and clay	905	950
Sand, trace of gravel and clay	950	970
Sand and granule to pebble gravel with some clay	970	1,000
No sample	1,000	1,016

Table 3.--Record of test well SMR-5, White Sands Missile Range, Dona Ana County, N. Mex.

Location: SE¼SW¼SE¼ sec. 14, T. 21 S., R. 5 E.

Altitude: 3,950 feet

Depth (drilled): 666 feet (cased): 249 feet

Date completed: Plugged and abondoned December 24, 1967.

Drilling contractor: Boyd and Son Drilling Co., Las Cruces, N. Mex.

Drilling method: Hydraulic rotary.

Casing and well record: Drilled with 18-inch bit to 249 feet and 10 3/4-inch outer-diameter, torch-slotted, steel casing installed. Drilled from 249 feet to total depth with 7 7/8-inch bit. Temporary 10 3/4-inch casing could not be removed.

Well completion record: Plugged and abandoned.

Formation logs: 1.) Sample description 2.) dual induction laterolog 3.) proximity log-microlog.

Geologic source: Bolson fill of Quaternary and Tertiary age.

Yield: Not test pumped; bailed at 20 gpm during collection of upper water sample.

Nonpumping water level: 108.6 feet below land surface.

Water quality: Nonpotable; see table 5.

Table 4.--Sample description log of test well SMR-5, White Sands Missile Range, Dona Ana County, N. Mex.

Material	Depth interval (feet)	
Clay, tan, white, and red, calcareous, silty and sandy; samples below 5 feet contain gypsum	0	290
Sand, very coarse to very fine, angular to rounded, poorly sorted, and tan clay	290	300
Clay, tan, silty, and sand	300	390
Sand, very fine to very coarse, angular to rounded, poorly sorted, silty, and clayey	390	445
Sand, as 390 to 445, silt, and clay; some gravel to pebble gravel 475 to 480	445	540
Clay and silt, tan, sandy	540	565
Sand and clay, silty	565	570
Clay, silty, and sand	570	615
Sand and silty clay	615	666

Table 5.--Results of chemical analyses of water samples from test wells SMR-4 and SMR-5, White Sands Missile Range, Dona Ana County, N. Mex.

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

Well number	SMR-4	SMR-4	SMR-4	SMR-4	SMR-5	SMR-5
Sample interval (feet)	273-450	670-703	965-1,016	470-570	109-249	615-666
Date of collection	11-14-67	11-16-67	11-20-67	12-29-67	12-11-67	12-18-67
Temperature °C	24	26	29	28	21	22
Silica (SiO_2)	39	--	36	43	60	15
Iron (Fe)	.91	--	.01	.03	.00	.02
Manganese (Mn)	--	--	--	--	--	--
Calcium (Ca)	54	37	64	77	195	575
Magnesium (Mg)	28	6.9	9.8	15	81	685
Sodium (Na) / Potassium (K)	149	98	126	48	207	2,500
Bicarbonate (HCO_3)	188	158	222	182	194	278
Carbonate (CO_3)	0	0	0	0	0	0
Sulfate (SO_4)	173	110	173	140	922	6,450
Chloride (Cl)	89	62	70	37	104	1,930
Fluoride (F)	3.1	--	1.3	2.5	1.8	3.3
Nitrate (NO_3)	6.8	4.6	12	8.4	.2	.4
Dissolved solids						
Calculated	591	--	601	460	1,670	12,300
Residue on evaporation at 180°C	610	--	597	474	1,800	13,400
Hardness as $CaCO_3$	146	121	200	255	820	4,250
Noncarbonate hardness as $CaCO_3$	0	0	18	106	661	4,020
Alkalinity as $CaCO_3$	--	--	--	--	--	--
Specific conductance (micromhos at 25°C)	917	684	920	700	2,200	13,900
pH	8.1	7.8	7.7	7.8	7.5	7.5
Color	7	--	4	3	3	3

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

By

Gene C. Doty

Table 3

Fig. 1