Preliminary results of test drilling between Lake McMillan and Major Johnson Springs, Eddy County, New Mexico

By

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PUBLICATIONS: Reports on areas within the Permian Basin

Enclosed are the following reports: Summary of saline ground-water conditions in the Roswell Basin, Chaves and Eddy Counties, New Mexico, by J. W. Hood; An appraisal of potential ground-water salvage along the Pecos River between Acme and Artesia, Chaves and Eddy Counties, New Mexico, by R. W. Mower, J. W. Hood, R. L. Cushman, and others; Possibilities of retarding saline-water encroachment in the Roswell basin by retirement of water rights, by the Ground Water Branch; Evaluation of the Queen Lake depression as a storage basin for brine, Eddy County, N. Mex., by E. R. Cox and J. S. Havens; Preliminary appraisal of ground-water conditions in southeastern Eddy County and southwestern Lea County, New Mexico, by W. E. Hale and Alfred Clebsch, Jr.; Diagram showing relations of Permian rocks in part of Eddy County, New Mexico, by Elmer Baltz; Analysis of flow from Carlsbad Springs, Eddy County, New Mexico, by L. J. Bjorklund; Ground-water conditions in the vicinity of Carlsbad, N. Mex., by W. E. Hale; Preliminary results of test drilling between Lake McMillan and Major Johnson Springs, Eddy County, New Mexico, by E. R. Cox; Feasibility of injecting brine from Malaga Bend into the Delaware Mountain Group, Eddy County, N. Mex., by E. R. Cox and J. L. Kunkler; Magnesium Brine Wells of the DOW Corporation near Carlsbad, N. Mex., by C. V. Theis, and W. E. Hale; Some notes on the geology and ground-water resources of the Guadalupe Mountains in Eddy County, New Mexico, by R. S. Jones; Brine production and disposal in the oil fields of southern Lea County, N. Mex., by A. Nicholson, Jr.; Saline water in New Mexico, by J. W. Hood and L. R. Kister, Jr. These reports are for use in preparing the proposed report for the Permian Basin study. They should be returned to Albuquerque when they have served their purpose.

Sam W. West

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

PRELIMINARY RESULTS OF TEST DRILLING BETWEEN LAKE McMILLAN AND MAJOR JOHNSON SPRINGS, EDDY COUNTY, NEW MEXICO

By

Edward R. Cox

Prepared in cooperation with the
PECOS RIVER COMMISSION

August 1957

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PRELIMINARY RESULTS OF TEST DRILLING BETWEEN LAKE McMILLAN AND MAJOR JOHNSON SPRINGS, EDDY COUNTY, NEW MEXICO

By

Edward R. Cox
U. S. Geological Survey

INTRODUCTION

An investigation of the ground-water conditions between Lake McMillan and Carlsbad Springs in Eddy County, New Mexico is being conducted by the Geological Survey in cooperation with the Pecos River Commission. The main purpose of the study is to account for the water in the Pecos Valley in this area. (See location map, fig. 1.) Lack of control data on the water-bearing beds, particularly in the critical area between Lake McMillan and Major Johnson Springs, made it desirable to drill test holes in this area and establish observation wells. The Pecos River Commission provided the necessary funds to drill nine test holes. The preliminary results of this test-drilling program together with a summary of general conditions in the area are presented in this report in advance of a more comprehensive report on the area that is planned.

Lake McMillan has leaked since it was formed by the construction of McMillan Dam about 1900. Leakage occurs through the floor of the lake and, until recently through sink holes along the east side of the lake. The construction of a levee to cut off the sinks along the east side has reduced the leakage materially. Most past studies in this area have led to the conclusion that much if not all of the water leaking from the reservoir returns to the Pecos River at the Major Johnson Springs area about 3.5 miles southwest of McMillan Dam. This present investigation is being made, in part, to determine as nearly as possible whether all the water leaking from Lake McMillan returns to the Pecos River in the Major Johnson Springs area.

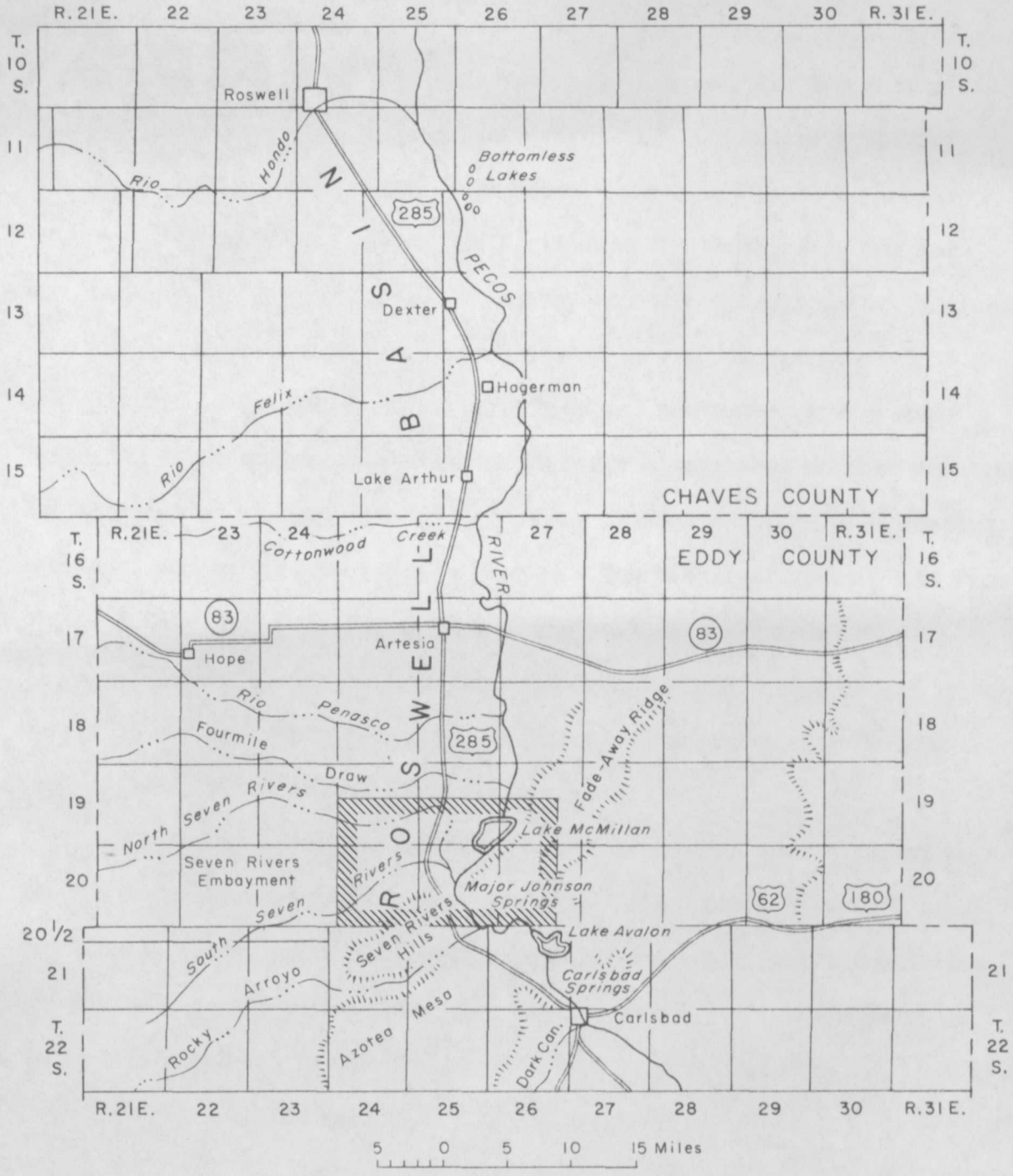
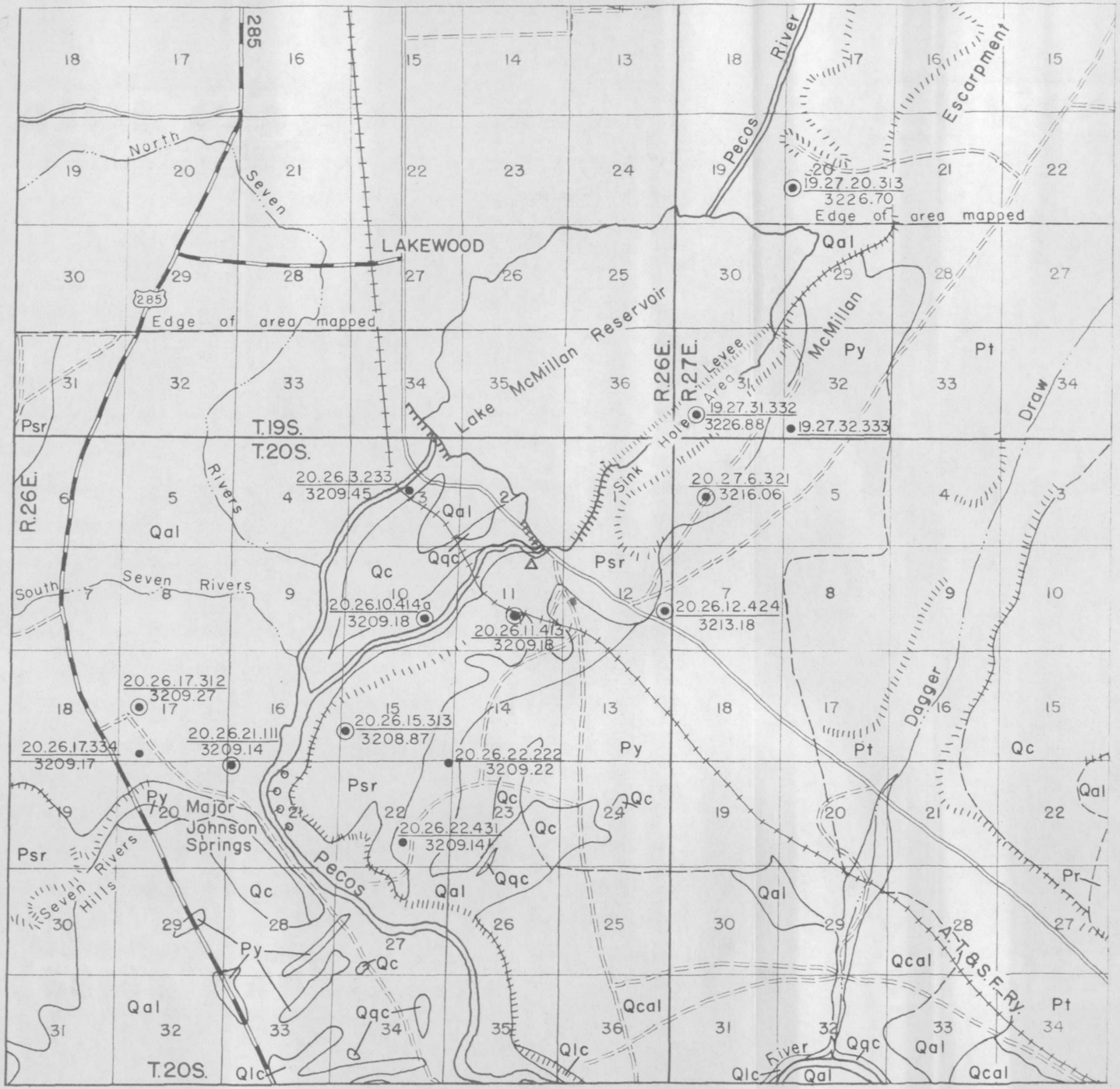


Figure 1.--Part of Pecos Valley in New Mexico showing area (hachured) covered by this report

GENERAL GEOLOGIC SETTING

The rocks pertinent to this investigation are, for the most part, Permian in age (see fig. 2) and are part of the lagoonal or back-reef equivalent of the Capitan and older reefs. These sediments generally strike northeast and southwest and dip toward the southeast. The formations consist of limestones, dolomites, sandstones, siltstones, shales, red beds, and evaporites, in places covered by conglomerates, caliche, and alluvial fill of Quaternary age. East and southeast of Fade-Away Ridge, a northeast-trending ridge about 6 miles southeast of Lake McMillan, the back-reef rocks are covered by younger rocks consisting of dolomites, red beds, and evaporites and by alluvium. The back-reef rocks grade from predominately carbonate rocks nearest the reef into red beds and evaporites at various distances from the reef front. This facies change generally is quite abrupt in each formation and is progressively farther from the reef front in the older sediments.

The oldest formation considered here is the San Andres formation. The San Andres is overlain by the Grayburg, Queen, Seven Rivers, Yates, and Tansill formations. The Seven Rivers, Yates, and Tansill formations are the back-reef equivalents of the Capitan limestone. The formations older than the Seven Rivers formation do not crop out in this area but are exposed farther to the west.



EXPLANATION

Qal — Alluvium

Qcal — Alluvium and caliche cover

Qc — Caliche

Qlc — Limestone conglomerate

Qqc — Quartzose conglomerate

Quaternary

Pr — Rustler formation

Pt — Tansill formation

Py — Yates formation

Psr — Seven Rivers formation

Permian

Contact
Dashed where approximately located

◉ 20.26.11.413 / 3209.18
Test well finished in Seven Rivers formation. Upper figure is well number. Lower number is altitude of water level May 7, 1957

● 20.26.22.222 / 3209.22
Other wells finished in Seven Rivers formation

△ Gaging station

Spring

1 0 1 2 3 Miles

Figure 2

GEOLOGIC, WELL-LOCATION, AND WATER-LEVEL MAP OF LAKE McMILLAN - MAJOR JOHNSON SPRINGS AREA, EDDY COUNTY, NEW MEXICO

The San Andres and Grayburg formations consist of about 1,400 feet of limestone, dolomitic limestone, and dolomite in this area. The solutional development in the upper part of the San Andres in the Roswell area and the upper part of the San Andres and Grayburg from about Artesia south to the Seven Rivers hills, which trend southwestward from about 2 miles west of Major Johnson Springs, constitutes the artesian system of the Roswell basin. (See location map, fig. 1.) It is probable that some of the base flow of Major Johnson Springs comes indirectly from this artesian system.

The Queen formation consists of about 400 feet of sandstone, limestone, and dolomite in this area. The basal 100 feet of the Queen is predominately sandstone, and the upper 50 feet of the section locally is called the Artesia red sand. The sandstones are generally less permeable than the limestones and dolomites, and it is thought that the sandstone at the top of the Queen formation acts as a barrier against downward solutional development by water from the overlying Seven Rivers formation.

The Seven Rivers formation in this area consists of about 300 feet of dolomite with a few sandy members, and anhydrite, gypsum, and red beds in the evaporite facies. The Seven Rivers crops out along a belt from the Azotea Mesa through the Seven Rivers Hills and Seven Rivers Embayment and along the south and east sides of Lake McMillan. The upper 30 to 50 feet of the carbonate section, called the Azotea tongue, persists as dolomite through the evaporite facies and caps the Seven Rivers Hills and the McMillan Escarpment. The Azotea tongue dips southeastward at about 5° east of Lake McMillan and the entire formation consists mostly of dolomite a few miles southeast of Lake McMillan.

Solution openings have developed in the gypsiferous Seven Rivers in a narrow band along the east shore of Lake McMillan and in a zone extending about a mile on either side of a line from the southern tip of Lake McMillan to Major Johnson Springs. These solutional openings may extend under Lake McMillan, but no data are available on this area. These solution openings have developed to various degrees and are connected to form an integrated conduit system from Lake McMillan to Major Johnson Springs. Although solution openings have developed a short distance into the dolomite, the dolomite facies in the Seven Rivers formation seems to form a barrier to movement of ground water to the east and southeast.

The Yates formation overlies the Seven Rivers formation and consists of about 400 feet of sandstone and dolomite, with gypsum, red beds, and some sandstone in the evaporite facies. The Yates formation crops out in a belt through the Guadalupe Mountains to the south of the area, along the lower reaches of Rocky Arroyo, an ephemeral eastward-flowing stream which joins the Pecos River about 2.5 miles south of the Major Johnson Springs, and east of Lake McMillan and Major Johnson Springs. The facies change in the Yates is closer to the reef front than the facies change in the Seven Rivers, so that the evaporites of the Yates overlie the carbonates of the Seven Rivers formation between Lake McMillan and Lake Avalon.

The Tansill formation, uppermost of the back-reef equivalents of the Capitan limestone, consists of about 200 feet of thinly bedded dolomites and evaporites with a prominent thin silt member near the top. The Tansill crops out in a narrow belt immediately north and northwest of the Capitan reef front. The Capitan reef front is exposed in the prominent escarpment extending southwest from Carlsbad to Guadalupe Peak in Texas.

East of Carlsbad and north of Fade-Away Ridge the Capitan and Tansill rocks are covered by gypsum, red beds, and dolomite of the Rustler formation. The Rustler is part of the Ochoa series of late Permian age. Only about the lower third of the Rustler formation is present in this locality.

Throughout the Pecos Valley in this area are small deposits of lime-cemented conglomerate of Quaternary age. The quartzose conglomerate consists of pebbles, primarily quartzite, with some limestone pebbles in a sandy matrix. The limestone conglomerate consists of pebbles and cobbles of limestone with some quartzite pebbles in a calcareous matrix. The conglomerates are generally above the zone of saturation, but in one of the larger deposits they contain perched water.

In parts of the area, the Permian rocks and the Quaternary conglomerate are covered by a relatively thin mantle of alluvium and some of the hills and ridges are capped by caliche. In places the alluvium and caliche cover have not been differentiated (fig. 2).

The alluvium along the Pecos River between Seven Rivers Hills and Carlsbad is quite thin. However, south of Carlsbad and north of Seven Rivers Hills relatively thick deposits of alluvium are present and are developed extensively for ground water for irrigation. The minimum or base flow of Major Johnson Springs seems to be derived almost directly from water discharged from the alluvium north of Seven Rivers Hills.

GROUND-WATER CONDITIONS

Periodic measurements of water level have been made in as many of the existing wells as possible east of the Pecos River between Lake McMillan and Lake Avalon since 1952. Hydrographs of these water-level measurements indicate the wells tap two independent aquifers, one in the cavernous Seven Rivers formation between Lake McMillan and Major Johnson Springs and one in the Yates formation to the south and east. Fluctuations of the water levels in the wells that tap the Seven Rivers formation are similar to fluctuations in the stage of Lake McMillan (fig. 3). Fluctuations of the water levels in the wells in the Yates formation show no relation to the stage of Lake McMillan, but resemble the fluctuations of the stage of Lake Avalon. In addition, water-table contours drawn from altitudes of the water level in the Yates aquifer indicate possible recharge to this aquifer from the Pecos River in the vicinity of the mouth of Rocky Arroyo in the southeast corner sec. 35, T. 20 S., R. 26 E. Miscellaneous streamflow measurements of the Pecos River between Major Johnson Springs and Lake Avalon also indicate a loss from the river in the vicinity of the mouth of Rocky Arroyo. Altitudes of the water levels in the two aquifers also indicate that the upper surface of the zone of saturation in the Yates is nearly 100 feet lower than that in the Seven Rivers formation.

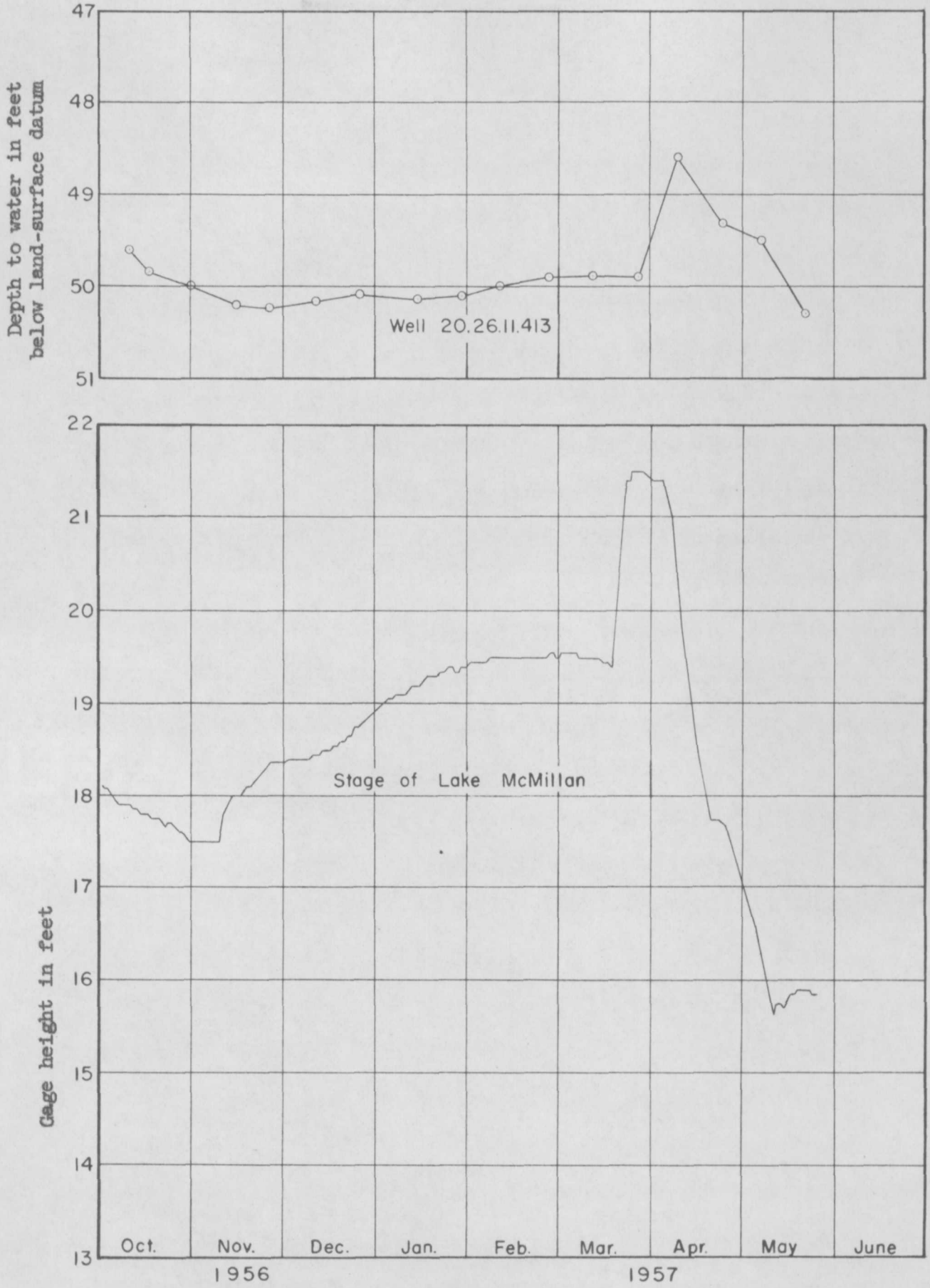


Figure 3.--Relation between fluctuations of water level in well 20.26.11.413 and the stage of Lake McMillan, Eddy County, N. Mex.

TEST DRILLING

Wells in the area between Lake McMillan and Lake Avalon at the time the investigation began were mostly stock wells and test holes drilled for the investigation of Dam site 3 in sec. 6, T. 21 S., R.26 E. An adequate number of stock wells tapping the Yates formation in the area were suitable for observation purposes. However, only 3 wells--1 stock well and 2 old test holes--were found that were finished in the cavernous Seven Rivers formation between Lake McMillan and Major Johnson Springs. Periodic water-level measurements referred to approximate altitudes of measuring points indicated a relatively flat gradient of the water table in this aquifer.

The need was apparent for test drilling in the area not only to establish additional observation wells in the Seven Rivers aquifer but also to determine if possible the areal extent of the solutional development in the Seven Rivers formation.

When the drilling rig owned by the State Engineer office became available in October 1956, a number of drilling sites were selected and a priority established in the event all the test holes could not be drilled. The first two holes were drilled at sites 20.26.11.413 and 20.26.15.313 to establish wells on a direct line between Lake McMillan and Major Johnson Springs. The third and fourth sites were selected at 19.27.31.332 and 20.27.6.321 in order to establish observation wells on the east side of Lake McMillan at different distances from the lake. The fifth site, 20.26.10.414a was selected near an existing shallow test well, 20.26.10.414, finished in the alluvium, to determine any differences in the altitudes of water in the alluvium and the Seven Rivers aquifer in that area. The sixth site was selected a short distance west of Major Johnson Springs at 20.26.21.111 to determine the extent of the cavernous conditions west of the springs and to establish an observation well near the springs. With the completion of these six holes, the initial funds allocated for the drilling program were exhausted.

In March 1957, the drilling rig again became available for test drilling in the Lake McMillan area. Five sites were selected and a priority established for the order of drilling. The first well was drilled at site 20.26.17.312 about a mile northwest of Major Johnson Springs in order to determine the extent of the cavernous conditions in the Seven Rivers formation northwest of the springs and to determine the slope of the water table toward the springs from the northwest. The second site at 19.27.20.313, just northeast of Lake McMillan near the bluff, was drilled to determine possible leakage from Lake McMillan through the gypsum bluffs northeast of the reservoir. The remaining sites were selected east and southeast of Lake McMillan 1 to 2 miles away from the lake shore in order to penetrate the carbonate facies of the Seven Rivers formation to determine the effectiveness of the facies-change barrier. Owing to the hard material encountered at the third site, 20.26.12.424, the funds for the drilling program were exhausted with the completion of this well. An additional observation well was established by casing a seismograph shot hole at 19.27.32.333. However, a perched-water zone was encountered in this well and it is not known at this time if efforts to seal off the perched water were successful. A summary of the pertinent construction and hydrologic data for the test holes is listed in table 1. The material encountered in drilling the test wells is shown in table 2.

Water levels in the nine test wells plus other wells in the area are measured at biweekly intervals. Spirit levels have been run to all the wells finished in the Seven Rivers aquifer. A staff gage has been installed at one of the larger springs in the Major Johnson Springs area. A pressure recorder has been installed on well 20.26.10.414a, and a float-operated recorder has been installed on an abandoned well at 20.26.17.334 about one mile west of Major Johnson Springs.

SUMMARY OF RESULTS OF TEST DRILLING

As had been anticipated, many solution cavities were encountered in the gypsum and red-bed section of the Seven Rivers formation at wells 20.26.10.414a, 20.26.11.413 and 20.26.15.313 along a general line between Lake McMillan and Major Johnson Springs and at well 20.26.21.111 immediately west of the spring area. These test wells were finished in the upper part of the Seven Rivers formation; thus the depth of solutional activity in the Seven Rivers at these sites was not determined.

Very little solutional development was observed in the sections drilled in the upper part of the Seven Rivers formation at well 19.27.20.313 a short distance northeast of Lake McMillan and wells 19.27.31.332 and 20.27.6.321 a short distance eastward from the sinkhole area on the east shore of Lake McMillan. This suggests greater solutional development along the strike of the Seven Rivers toward Major Johnson Springs rather than down the dip of the beds to the southeast. Also, little solutional development was observed in the section drilled in the upper part of the Seven Rivers at well 20.26.12.424 to the southeast of Lake McMillan. The lower part of the Seven Rivers may consist of gypsum at this site and may be more permeable. At the site of well 20.26.17.312, about 1.3 miles northwest of the spring area no appreciable solution cavities were encountered in drilling. On the basis of geologic evidence gained through test drilling, the Seven Rivers formation appears to have considerable solution passages in the area between Lake McMillan and Major Johnson Springs. To the east and southeast of Lake McMillan the Seven Rivers formation shows considerably less evidence of solution and is relatively tight as compared with the formation in the Lake McMillan to Major Johnson Springs locality.

Some water was encountered in all the test wells and all were cased for use as observation wells. These wells together with the previously existing wells in the area may be expected to provide the control needed for observing the ground-water conditions in the Seven Rivers formation in this locality.

The water-level measurements made May 7, 1957 and listed in table 1 for the test wells and as shown on figure 2 for a few additional wells indicate that the water table or piezometric surface of the water in the Seven Rivers formation is nearly flat in the area between Lake McMillan and Major Johnson Springs. The data suggest that water in the Seven Rivers formation in this locality moves southwestward from Lake McMillan toward the spring area. A slight trough in the water table or piezometric surface is indicated on May 7, the axis of which is parallel to and east of the Pecos River between Lake McMillan and Major Johnson Springs. The average altitude of the springs in the Major Johnson Spring area was approximately 3,208 feet on May 7.

The altitude of the water table or piezometric surface rises markedly to the north along the east side of Lake McMillan. This suggests that the Seven Rivers formation is much less permeable along the east side of the lake than in the area southwest from the lake. No information is available on the shape and position of the water table or piezometric surface of the water in the Seven Rivers formation under the lake. In May 1957, however, water levels in the alluvium immediately north and west of the lake and in the Seven Rivers formation east of the lake were below the floor of the reservoir which at its lowest point is at an altitude of about 3,255 feet. It seems probable that the trough in the water table or piezometric surface indicated in the aquifer in the Seven Rivers formation southwest of Lake McMillan extends northward under the east side of the lake. Much of the water leaking from the reservoir and water moving southward from the alluvium north of the lake appears to be moving along this trough toward Major Johnson Springs. There is no evidence to indicate that water moves through the Seven Rivers formation south or southeastward from Lake McMillan and does not reappear in the Major Johnson Springs area; however, unless the Seven Rivers formation is absolutely tight there is opportunity for some water to move to the south and southwest. This water would move into the Yates and Tansill formations farther southeast and reappear in the Pecos River in the Carlsbad Spring area.

Continuing observations of the fluctuations of water level in the wells finished in the Seven Rivers formation and comparison with leakage from Lake McMillan and other sources of recharge to the aquifer may provide further evidence on movement of water in the area and possibly provide a basis for the determination of the aquifer characteristics--the coefficients of transmissibility and storage. Such information will be of value in any possible future considerations of utilization of the underground storage contributory to Major Johnson Springs.

Table 1.--Records of test wells drilled in the vicinity of Lake McMillan and Major Johnson Springs, Eddy County, N. Mex., from October 1956 to April 1957.

All test wells in this series drilled in cooperation with Pecos River Commission using drilling rig owned by the State Engineer of New Mexico.

Diameter of test wells approximately 3 inches; cased with 2-inch plastic or 1½-inch galvanized pipe.

Location number	Date completed	Depth of well (ft)	Casing				Depth water encountered (ft)	Water level May 7, 1957	
			Depth (ft)	Depth of perforations below land-surface datum (ft)	Height above land-surface datum (ft)	Altitude of top (ft)		Depth below top of casing (ft)	Altitude (ft)
19.27.20.313	3/27/56	67	62	42 to 62	1.3	3,277.20	42	50.50	3,226.70
19.27.31.332	10/24/56	80	79	59 to 79	1.1	3,277.08	46	50.20	3,226.88
20.26.10.414a	11/ 2/56	65	65	45 to 65	1.0	3,233.44	24	24.26	3,209.18
20.26.11.413	10/10/56	105	68.5	48.5 to 68.5	1.5	3,260.18	50	51.00	3,209.18
20.26.12.424	4/11/57	121	121	81 to 121	1.2	3,310.70	84	97.18	3,213.52
20.26.15.313	10/17/56	95	89	69 to 89	.9	3,270.13	61	61.26	3,208.87
20.26.17.312	3/21/57	85	69	49 to 69	1.4	3,258.67	49	49.40	3,209.27
20.26.21.111	11/ 6/56	55	49	29 to 49	1.0	3,236.67	27	27.53	3,209.14
20.27. 6.321	10/31/56	118	105	85 to 105	1.0	3,306.99	95	90.93	3,216.06

Table 2.--Description of cuttings and cores from test wells drilled in the vicinity of Lake McMillan and Major Johnson Springs, Eddy County, N. Mex., October 1956 to April 1957.

(See table 1 for additional well and hydrologic data.)

Well 19.27.20.313
Date completed: March 27, 1957
Use of well: Test and observation well.
Altitude of land surface: 3,276 feet.
Total depth: 67 feet.

Description of material	Thickness (feet)	Depth From (feet)	Depth To (feet)
Silt	1½	0	1½
Gypsum and red clay, soft	7½	1½	9
Gypsum, white and red, hard, with solution pits	1	9	10
Gypsum, white, hard	1½	10	11½
Gypsum, red and white, soft, with solution pits	½	11½	12
Gypsum, white, hard	1½	12	13½
Dolomite, white, with solution pits	½	13½	14
Dolomite, white, broken, with stringers of gypsum	2	14	16
Gypsum, red to white, medium hard, with some red clay	3	16	19
Gypsum, white and red, massive, with clay stringers	2½	19	21½
Gypsum, white and red, crystalline	1½	21½	23
Gypsum, reddish-brown to white, medium soft, with clay	2	23	25
Gypsum, white, hard	4	25	29
Dolomite, white, hard	1	29	30
Gypsum, white, medium soft	4	30	34
Gypsum, medium soft, with clay stringers	7	34	41
Gypsum, white, medium soft	6	41	47
Clay, red, soft	6	47	53
Dolomite, hard	7	53	60
Gypsum, medium soft	7	60	67

Table 2.--Continued

(See table 1 for additional well and hydrologic data.)

Well 19.27.31.332
Date completed: October 24, 1956
Use of well: Test and observation well.
Altitude of land surface: 3,276 feet.
Total depth: 80 feet.

Description of material	Thickness (feet)	Depth From (feet)	Depth To (feet)
Gypsum and clay, white to red, soft	10	0	10
Gypsum, white with some pink and green, soft, granular, with a few fragments of dolomite and clay	10	10	20
Gypsum, white, soft, with tan dolomite and greenish-gray clay	19	20	39
Dolomite, medium soft, with many stringers of gypsum	6?	39	45?
Gypsum, white, soft, with stringers of gypsum			
Gypsum, white, soft, with stringers of dolomite	4?	45?	49?
Dolomite, white to brown, medium hard	2?	49?	51?
Gypsum, white, soft, with stringers of dolomite	29?	51?	80

Table 2.--Continued.

(See table 1 for additional well and hydrologic data.)

Well 20.26.10.414a
Date completed: November 2, 1956
Use of well: Test and observation well.
Altitude of land surface: 3,232 feet.
Total depth: 65 feet.

Description of material	Thickness (feet)	Depth From (feet)	Depth To (feet)
Clay, brown, silty.....	17	0	17
Clay and sand, brown.....	8	17	25
Sand, medium-grained, argillaceous.....	16	25	41
Dolomite, medium hard, with many solution pits.....	24	41	65

Table 2.--Continued.

(See table 1 for additional well and hydrologic data.)

Well 20.26.11.413
Date completed: October 10, 1956
Use of well: Test and observation well.
Altitude of land surface: 3,259 feet.
Total depth: 105 feet.

Description of material	Thickness (feet)	Depth From (feet)	Depth To (feet)
Silt, brown, with cobbles and boulders.....	3	0	3
Caliche, tan, hard, with boulders.....	4	3	7
Boulders, and soft material (probably clay; cuttings washed away).....	5	7	12
Dolomite, brown to gray, hard, with many solution openings and joints; some of which are filled with calcite and clay.....	22	12	34
Cavity.....	1	34	35
Dolomite, brown to gray, hard, with many solution openings.....	12	35	47
Clay, blue.....	2	47	49
Dolomite, brown to gray, hard, with many solution openings, with heavy petroleum in vugs.....	8	49	57
Cavity.....	½	57	57½
Dolomite, brown to gray, hard, with many solution openings, some containing heavy petroleum.....	7½	57½	65
Dolomite, brown to gray, hard, with many solution openings.....	21	65	86
Cuttings washed away; gypsum [illegible].....	1	86	87
Dolomite?, hard.....	1	87	88
Cuttings washed away; gypsum[illegible] soft...	6	88	94
Cuttings washed away; alternating hard and soft material; layers of dolomite and probably gypsum and/or clay.....	11	94	105

Table 2.--Continued.

(See table 1 for additional well and hydrologic data.)

Well 20.26.12.424
Date completed: April 11, 1957
Use of well: Test and observation well.
Altitude of land surface: 3,310 feet.
Total depth: 121 feet.

Description of material	Thickness (feet)	Depth From (feet)	Depth To (feet)
Silt	1	0	1
Gypsum; with greenish-tan clay, medium soft	9	1	10
Shale, dark-gray, medium hard	5	10	15
Shale, brown to dark-gray, sandy, medium hard	6½	15	21½
Shale, sandy, and limestone, gray, sandy, hard, in alternating layers	4	21½	25½
Dolomite, gray, hard, with shale stringers	1½	25½	27
Shale, greenish-gray, sandy, hard	1	27	28
Dolomite, white to gray, hard, with joints and some small solution pits	3	28	31
Dolomite, white to gray, hard, with some joints and petroleum stains	12	31	43
Dolomite, light-gray to grayish-brown, medium hard, with joints, a few solution pits and very few petroleum stains	4½	43	47½
Shale, gray to dark-gray, sandy, dolomitic, medium hard, with lenses of shale, dark-gray, with some joints	8	47½	55½
Dolomite, white to gray, very hard, with very thin stringers of silt	4½	55½	60
Breccia, subrounded dolomite gravel with tan clay	1	60	61
Shale, light-brown, sandy, dolomitic, hard	1	61	62
Dolomite, light-gray to brown, hard, with joints and some small solution pits	1	62	63
Dolomite, white to gray, hard	3	63	66
Dolomite, gray to dark-gray, very hard, broken, pyritic	1	66	67
Shale, multicolored (gray, yellow, green), slightly sandy, dolomitic, hard	2	67	69
Dolomite, gray, very hard, with some small solution pits and some petroleum stains	2	69	71

Table 2.--Continued

Well 20.26.12.424.--Continued.

Description of material	Thickness (feet)	Depth From (feet)	Depth To (feet)
Shale, gray to yellow, somewhat mottled, dolomitic, pyritic, hard	1	71	72
Dolomite, gray to brown, very hard, with a few solution pits and petroleum stains; some shale, pyritic, in lenses	2	72	74
Dolomite, gray to brown, pyritic, hard, with a few solution pits and petroleum stains	1½	74	75½
Shale, gray to dark-gray, dolomitic, quite pyritic, sandy, mottled, hard	3½	75½	79
Siltstone, brown to dark-gray, medium hard, not well cemented	1	79	80
Siltstone, brown to green, shaly, medium hard	1½	80	81½
Dolomite, gray to brown, hard, jointed, with some solution pits and petroleum stains	7½	81½	89
Dolomite, grayish-brown, and shale, gray pyritic, dolomitic, in alternating layers	1	89	90
Siltstone, gray, dolomitic, shaly, medium hard	3½	90	93½
Dolomite, gray, broken, with some solution pits and petroleum stains	4½	93½	98
Gypsum and shale, dark-gray, soft, in alternating layers	2	98	100
Gypsum, white, very soft	1	100	101
Gypsum, white to gray, medium hard, with few stringers of dolomite or clay	14	101	115
Dolomite and gypsum, white to gray, in alternating layers, with some petroleum stains in the dolomite	1	115	116
Dolomite, gray to white, medium hard, with gypsum stringers	2	116	118
Gypsum, white to gray, medium hard	3	118	121

Table 2.--Continued

(See table 1 for additional well and hydrologic data.)

Well 20.26.15.313
Date completed: October 17, 1956
Use of well: Test and observation well.
Altitude of land surface: 3,269 feet.
Total depth: 95 feet.

Description of material	Thickness (feet)	Depth From (feet)	Depth To (feet)
Sand, brown, fine	4	0	4
Sand, brown fine to coarse	2	4	6
Sand, brown, argillaceous, fine	1	6	7
Sand, light-brown, argillaceous, fine to medium	2	7	9
Dolomite, tan, hard, broken, jointed	41	9	50
Cuttings washed away, soft material (gypsum or clay)	5	50	55
Cuttings washed away, alternating layers of hard and soft material (probably dolomite with clay and/or gypsum)	9	55	64
Dolomite, hard	5	64	69
Cuttings washed away, alternating layers of hard and soft material (probably dolomite with clay and/or gypsum)	26	69	95

Table 2.--Continued.

(See table 1 for additional well and hydrologic data.)

Well 20.26.17.312
Date completed: March 21, 1957
Use of well: Test and observation well.
Altitude of land surface: 3,257 feet.
Total depth: 85 feet.

Description of material	Thickness (feet)	Depth From (feet)	Depth To (feet)
Silt, gray, with a small amount of very fine sand	20	0	20
Clay, yellow, sticky	5	20	25
Clay, yellow, slightly sandy	1	25	26
Limestone, hard	1	26	27
Clay, yellow, slightly sandy	2	27	29
Clay, pink	1	29	30
Limestone	1	30	31
Clay, pink	6	31	37
Dolomite, grayish-white	6	37	43
Clay, red	2	43	45
Dolomite, hard	8	45	53
Dolomite, gray, soft	2	53	55
Dolomite, gray to pink, soft, and clay	13	55	68
Dolomite, hard	2	68	70
Dolomite, grayish-white, soft	3	70	73
Dolomite, hard	5	73	78
Dolomite, white, very hard, with a few solution pits	7	78	85

Table 2.--Continued.

(See table 1 for additional well and hydrologic data.)

Well 20.26.21.111
Date completed: November 6, 1956
Use of well: Test and observation well.
Altitude of land surface: 3,236 feet.
Total depth: 55 feet.

Description of material	Thickness (feet)	Depth From (feet)	Depth To (feet)
Sand, brown, very fine-grained, argillaceous, with caliche pebbles	10	0	10
Caliche, multicolored, medium soft, with many solution pits	5	10	15
Travertine, gray to light-brown, medium soft, light weight, with many solution pits	10	15	25
Dolomite, gray to brown, medium soft, with solution pits	6	25	31
Cuttings washed away, soft material (gypsum or clay)	8	31	39
Dolomite	1	39	40
Cuttings washed away, soft material (gypsum or clay)	12?	40	52?
Dolomite	3?	52?	55

Table 2.--Continued.

(See table 1 for additional well and hydrologic data.)

Well 20.27.6.321
Date completed: October 31, 1956
Use of well: Test and observation well.
Altitude of land surface: 3,306 feet.
Total depth: 118 feet.

Description of material	Thickness (feet)	Depth From (feet)	Depth To (feet)
Silt, brown, loose, dry, with fragments of caliche	9	0	9
Dolomite, gray to brown, hard, jointed	31	9	40
Dolomite and gypsum in alternating layers	8	40	48
Shale, greenish-gray, hard	2	48	50
Dolomite, brown, sandy, medium soft	2	50	52
Dolomite, gray to tan, hard	4	52	56
Shale, dark-gray, sandy, soft, with dolomite stringers	3	56	59
Dolomite, brown, sandy, medium hard, with probable shale stringers (washed away)	7	59	66
Cuttings washed away, soft material, probably clay or shale	4	66	70
Cuttings washed away, dolomite?	14	70	84
Cuttings washed away, clay or gypsum?	21	84	105
Dolomite, medium hard, very hard at 118 feet	13	105	118