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UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGY AND GROUND-WATER RESOURCES OF THE BIG SPRING AREA, TEXAS

Prepared in cooperation with the
TEXAS STATE BOARD OF WATER ENGINEERS
and the CITY OF BIG SPRING

GEOLOGICAL SURVEY WATER-SUPPLY PAPER 913

UNITED STATES DEPARTMENT OF THE INTERIOR
Harold L. Ickes, Secretary

GEOLOGICAL SURVEY
W. E. Wrather, Director

Water-Supply Paper 913

GEOLOGY AND GROUND-WATER RESOURCES OF THE BIG SPRING AREA, TEXAS

BY

PENN LIVINGSTON AND ROBERT R. BENNETT

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TEXAS STATE BOARD OF WATER ENGINEERS
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GEOLOGY AND GROUND-WATER RESOURCES OF THE BIG SPRING AREA, TEXAS

By Penn Livingston and Robert R. Bennett

ABSTRACT

This report gives the principal results of an investigation of ground water in the Big Spring area, Texas. Big Spring, the county seat of Howard County, has an estimated population of about 16,000. It is situated on the Texas & Pacific Ry. and United States Highway No. 80 in western Texas, about 280 miles west of Fort Worth and along the boundary between the Edwards Plateau and the High Plains. Immediately south of the city is the bold escarpment of the plateau; to the north, west, and southwest lie the High Plains; and to the east lie the Osage Plains. The Edwards Plateau is capped by resistant limestones of Fredericksburg (Lower Cretaceous) age, which have a maximum thickness of about 160 feet. These limestones are underlain by sandstones of Trinity (basal Lower Cretaceous) age, which range in thickness from 60 to 100 feet and which form the principal water-bearing bed of the area. The High Plains are underlain in most places by a varying thickness of silt, clay, sand, and gravel, chiefly of Tertiary age. The Osage Plains are underlain chiefly by Triassic redbeds, which in general form an uneven floor beneath the Cretaceous and younger formations in the High Plains and Edwards Plateau. Beneath the Triassic redbeds is a great thickness of Permian rocks, which in parts of the area contain thick beds of rock salt.

Over a large part of the plateau the Cretaceous rocks appear to be flat lying but actually dip so as to form a northwestward-trending syncline. However, in places the rocks have slumped to form depressions or sinks, which serve as collecting basins for the water from the Trinity sand. As both Triassic and Cretaceous rocks are involved in the deformations, it is believed that they may have been formed as a result of the solution and removal of the Permian salt by circulating ground water. Two of these sinks have been well known for several years. One of them, usually called the city park sink, is about 2 miles south of Big Spring, and the other, usually called the section 33 sink, is about 6 miles southeast of the city. These sinks are nearly circular. They have a diameter of about 1 mile, and the maximum displacement of the beds is 200 to 300 feet. They serve as collecting basins for ground water drained from the surrounding Trinity sand, and wells drilled in them yield as much as 300 gallons a minute, largely from the cracks and crevices in the Fredericksburg limestones. As the Trinity sand is mostly fine-grained, wells outside the sinks seldom yield more than 20 to 30 gallons a minute.

For many years the water supply of Big Spring and most of the water used there by the Texas & Pacific Ry. Co. has come from wells in the sinks, supplemented by a relatively small supply pumped from well fields between them. It is estimated that the perennial yield of the sinks and intervening well fields amounts to an average of about 450,000 gallons a day. For several years the pumpage has been much more than that, and in 1937 it amounted to an average of about 1,000,000 gallons a day. A large part of the water has therefore come from stor-

age, and as a result the water table in the sinks, where the draft has been greatest, has declined to lower levels each year. If the water supply needed by the city continues to increase at the normal rate, most of the remaining water will be exhausted from the sinks in a few years if no other supply is provided.

Although in some areas, such as secs. 44 and 45, the rocks are slightly deformed, no deep sinks that are comparable with the city park and section 33 sinks were found on the Edwards Plateau. A large amount of water is stored in the Trinity sand in areas on the plateau south of the present well fields, but as the sands are fine only small yields can be obtained from wells in them. Near Lees, about 12 miles southwest of Big Spring, is a structural depression or sink about 1 mile in diameter, which contains Cretaceous limestone that is probably fractured and which is overlain by Tertiary and Quaternary deposits. Wells of fairly large yield could probably be obtained in this area. North of this sink is an east-west channel in the Triassic containing a considerable thickness of Tertiary and Quaternary deposits that also would probably yield considerable amounts of water. However, as the Big Spring oil field occupies the first area mentioned and a part of the other, the ground water may eventually become contaminated by salt water from the oil wells, if it is not already contaminated.

In another area, about 1 mile southwest of Lees, is another basin in which the Tertiary and Quaternary deposits are nearly 300 feet thick. They contain large amounts of clay, and the water from them is highly mineralized. In the vicinity of the Hall well, about 7 miles west of the above-mentinoed area, is a basin in the Triassic surface in which the saturated part of the Tertiary and Quaternary is about 70 feet thick, but it is problematical whether it would provide large quantities of satisfactory water over a long period.

In the northwestern part of Howard County the water in the Tertiary and Quaternary generally is comparatively low in dissolved minerals, but little is known regarding the thickness of the sediments. The city of Lamesa, located farther northwest, near the center of Dawson County, obtains its water supply from five wells in Tertiary deposits. West of Big Spring, in Martin County, the city of Stanton obtains rather highly mineralized water from wells in an area where the saturated part of the Tertiary is unusually thick. Other such areas are found in a district of considerable size around Stanton. In a part of this district the mineral content of the ground water is fairly low, but in others it is relatively high.

Wells drilled into the Triassic redbeds would probably yield only small amounts of water, which in general would be highly mineralized. The conclusion is that conditions are not favorable for developing the additional supplies of ground water of good quality that are needed by the city of Big Spring. It is evident that the city should seek immediately a surface water supply to meet the major part of its requirements.

INTRODUCTION

LOCATION OF THE AREA

Big Spring is in western Texas, about 280 miles west of Fort Worth, on United States Highway No. 80 and the Texas & Pacific Ry. It is situated at the south edge of the High Plains and at the north edge of the Edwards Plateau. Figure 1 shows the area covered by this report and also other areas in Texas in which ground-water investigations were in progress during 1929–42.

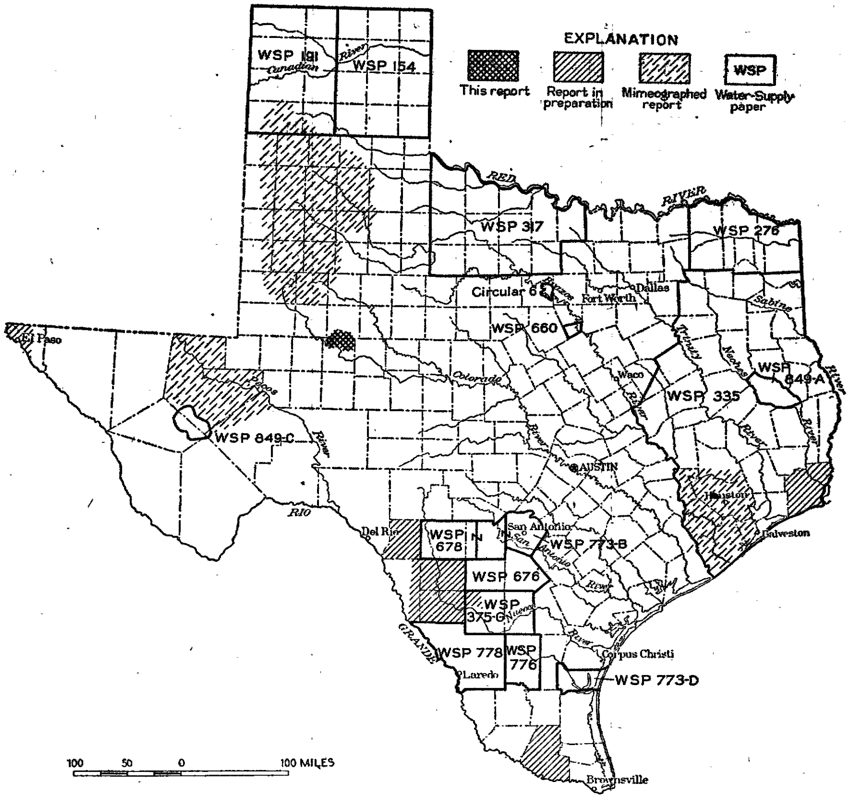


FIGURE 1.—Map of Texas showing areas in which investigations of ground-water resources were in progress, 1929–42.

PURPOSE AND SCOPE OF THE INVESTIGATION

In April 1937 arrangements were made for an investigation of the ground-water resources of the Big Spring area through a cooperative agreement between the Geological Survey, United States Department of the Interior, the Texas State Board of Water Engineers, and the city of Big Spring. The purpose of this investigation was to obtain basic geologic and hydrologic information as to the occurrence, quantity, and quality of the ground water in the Big Spring area and to determine the best methods to utilize the available water resources. Big Spring, which has grown to be a city of about 16,000 inhabitants,[1] for many years has been barely able to meet the demand for water; so it was evident that additional water supplies should be developed before the present supply was further greatly depleted.

The investigation was made under the direction of O. E. Meinzer, geologist in charge of the Division of Ground Water in the Geological

[1] Since the above was written there apparently has been a reduction in the population. The population of Big Spring in 1940, according to the United States Bureau of the Census, was 12,604.

Survey, and W. N. White, who is in charge of the ground-water investigations in Texas. The geologic part of the report was prepared by Mr. Bennett. A. N. Sayre, of the Geological Survey, spent a few days in the field with the writers and reviewed the geologic part of the report.

HISTORY OF THE BIG SPRING WATER SUPPLY [1a]

The spring from which the city of Big Spring derives its name flowed from the rocks just east of the present city park, about 2 miles south of the post office. In the early days of settlement this spring was the watering place for travelers, both Indians and white men, and supplied water for large herds of cattle that passed by on their way from ranges in west Texas to a market at Dallas or Forth Worth. When the Texas & Pacific Ry. was built, a pipe line was laid from the spring to the railroad to supply water for locomotives and other uses. The spring is reported to have had a flow at that time of about 100,000 gallons a day.[2] However, it did not yield enough water to meet the demands of the railroad and the growing town, and in an effort to increase the supply several wells were drilled by the railroad company a few hundred yards west of the spring. After heavy pumping from the wells the spring ceased to flow. Additional wells were put down close by to supply the city with water. The logs of these wells, together with the surface geology, show clearly that the spring and wells had their source in a common reservoir underlying a small area in which the rocks had slumped into a structural sink. The original water table in this slumped area was well up in the limestone; and fractures and solution channels in these rocks and interstices in the underlying sands afforded considerable underground storage. The spring flowed into a fairly deep draw just east of the sink and was the natural overflow from this underground reservoir. The railroad has pumped its wells almost continuously, while the city has pumped its wells intermittently depending on the demand for water.

After a pronounced decline of the water levels in its wells in the sink, the city drilled other wells about a mile to the southeast, near the center of sec. 18, where it obtained most of its supply for a long time. About 1925, as the yield of these wells began to decline, other wells were drilled still farther east, mostly in the southeastern part of sec. 17. About 1928 another subsided area similar to the city park sink was found by Hawley, Winton, and Alexander [3] near the north-

[1a] A brief description of the surface-water supply, which has been developed since the completion of this report, is given in an addendum on pages 111-112.

[2] Cummins, W. F., Report on the geography, topography, and geology of the Llano Estacado or Staked Plains, in Dumble, E. T., and others, Texas Geol. Survey 3d Ann. Rept., p. 177, 1891.

[3] Hawley, J. B., Winton, W. M., and Alexander, C. L., Big Spring water survey; unpublished report, May 1928.

eastern part of sec. 33, about 6 miles southeast of Big Spring. This area, which is known as the section 33 sink, has furnished most of the city water supply since about 1929. Wells in it have a higher capacity than those in the other city well fields. The water levels in this sink, as well as in the city park sink, have fallen substantially since the first wells were drilled. Although the city has put down many widely scattered test wells to the top of the Triassic shale, no place has been found except in the sinks where wells will yield more than 40 to 50 gallons a minute of acceptable water. In most places that have been tested the yield is considerably less.

With the growth of the city the requirements for water supply have increased greatly. In 1937 the average daily metered consumption was about 644,000 gallons from the public supply, but probably about 900,000 gallons was pumped from wells for the public supply and about 105,000 gallons was pumped by the railroad company. Water would, however, be used more liberally if rigid economy were not required.

PHYSICAL FEATURES

Parts of three physiographic sections lie within the area investigated, namely, the Edwards Plateau, the Llano Estacado or High Plains, and the Osage Plains. (See pl. 1.) The Edwards Plateau and the Llano Estacado belong to the Great Plains Province [4] and the Osage Plains to the Central Lowland Province.[5]

The Edwards Plateau in this region is capped by resistant Lower Cretacous limestone. It extends from Big Spring southward and covers the south-central part of Howard County and the southeastern three-fourths of Glasscock County, as well as a large part of the area south to San Antonio, Tex., a distance of nearly 300 miles. In the Big Spring area the plateau is well dissected by youthful drainage valleys and the topography is relatively rugged. (See pl. 2.) On the north and east sides abrupt escarpments separate the plateau from the Osage Plains (pl. 3, *B*), but on the west side the land surface slopes gently downward toward the Llano Estacado, owing partly to the overlapping of the Tertiary and Quaternary deposits.

West and north of the Edwards Plateau is the flat to gently rolling plain of the Llano Estacado, which is underlain with Tertiary and Quaternary deposits consisting of sand, gravel, silt, and clay. Drainage is only moderately developed on the Llano Estacado, and although Mustang Draw and Sulphur Springs Creek form deep valleys in some places, the land surface is in general quite flat.

[4] Fenneman, N. M., Physiographic boundaries within the United States: Assoc. Am. Geographers Annals, vol. 4, pp. 113–117, 1914.

[5] Fenneman, N. M., Physiographic provinces and sections in western Oklahoma and adjacent parts of Texas: U. S. Geol. Survey Bull. 730–D, p. 116, 1923.

East of the Llano Estacado are the Osage Plains, which, in this area, are underlain with Triassic shales and sandstones. This physiographic section includes about the eastern one-third of Howard County but none of Glasscock County. As the Triassic shales are very impervious, a high percentage of the rainfall runs off, forming numerous small drainage valleys.

Sulphur Springs Creek follows a southeasterly course across Dawson and Martin Counties and becomes Beals Creek below its confluence with Mustang Draw, about 7 miles west of Big Spring. Mustang Draw enters Glasscock County from the northwest and thence turns northward through Howard County to join Sulphur Springs Creek. Beals Creek continues eastward into the Colorado River in Mitchell County. There are no perennial streams within the area investigated except Beals Creek, which becomes a flowing stream about 3 miles east of Big Spring, where effluent from the sewage plant enters the creek. There are many intermittent ponds or lakes of brackish water along Beals Creek and its main tributaries, in the beds of which a white incrustation of alkali remains as the water evaporates. (See pl. 3, *A*.)

In general, the vegetation in the Big Spring area is sparse. On the Edwards Plateau a fairly abundant growth of scrub oak, cedar, and mesquite occurs in places, the scrub oak and cedar usually being found in areas underlain by limestone and the mesquite in areas underlain by sandstone. On the Llano Estacado and the Osage Plains the vegetation consists mainly of grasses and mesquite.

CLIMATE

The average annual rainfall in Texas decreases from east to west, generally at a fairly uniform rate. According to the United States Weather Bureau, the average annual rainfall was 18.70 inches at Big Spring during a period of 38 years, and 22.60 inches at Colorado, about 40 miles east of Big Spring, during a period of 29 years. During the 28 years for which rainfall records are available for both stations, Colorado had an average annual rainfall amounting to 3.1 inches more than that at Big Spring. The lowest annual precipitation at Big Spring, 4.80 inches, occurred in 1917; the highest, 35.81 inches, in 1919. About 80 percent of the rainfall occurs in the 7 months from April to October, during which time the monthly average is fairly uniformly distributed. The rain is often torrential and occurs largely as local showers. During the summer the prevailing winds are from the south and are hot and dry, and the rate of evaporation is very high.

Available records of rainfall at Big Spring, Garden City, Sterling City, and Colorado are given in table 1.

Table 1.—*Table of monthly precipitation*

[From records of U. S. Weather Bureau]

Big Spring, Howard County, Tex.

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1891	*0.75	T	0	0.12	2.70	0.50	1.35	1.20	3.50	1.10	0	1.00	12.22
1892	.20	0.10	1.98	0	2.14	1.10	2.70	.60	1.50	4.50	*.60	*.92	16.34
1900	.56	.25	.99	5.12	4.32	1.71	.99	1.65	2.77	2.04	1.18	.13	21.71
1901	.11	1.93	T	1.07	2.97	1.06	4.73	.11	3.03	.58	1.00	.24	16.83
1902	.61	.02	T	.56	4.55	1.41	12.89	1.24	2.46	.92	2.28	.34	27.28
1903	.81	.86	.24	.08	1.55	2.93	.36	.79	3.16	.22	0	T	11.00
1904	.25	T	0	1.12	3.40	4.06	.75	2.27	3.45	.50	.88	.43	17.11
1905	.45	1.39	2.89	3.34	5.71	3.52	3.40	2.50	3.38	1.79	1.74	.77	30.88
1906	.31	.81	.87	2.98	3.52	2.56	4.41	5.08	.84	1.11	2.96	.51	25.96
1907	.17	0	1.69	.22	1.97	.86	1.81	1.52	2.79	11.87	1.37	.27	24.54
1908	.43	.06	.28	5.47	4.09	.99	1.79	2.90	2.01	.25	1.40	0	19.67
1909	.02	T	.42	.01	2.17	1.62	.65	1.23	.70	.79	4.01	.64	12.26
1910	.23	.03	.28	1.00	.69	.71	1.24	.04	.42	2.32	.17	.12	7.25
1911	.58	4.20	.43	2.55	.32	.30	1.34	.37	1.79	.25	.18	2.53	14.84
1912	T	1.02	.17	.55	1.10	1.19	1.25	1.04	1.16	1.50	1.13	.99	11.10
1913	.29	.53	1.41	1.44	1.08	3.28	.97	.04	2.72	3.22	1.89	2.62	19.49
1914	.27	.04	.77	.58	4.29	4.00	1.44	3.99	.78	4.37	1.04	1.43	23.00
1915	.45	.15	.83	5.75	.44	1.65	3.34	4.39	3.44	.84	0	.93	22.21
1916	.21	T	1.08	3.02	.16	1.04	2.65	4.57	1.59	1.67	1.03	.11	17.13
1917	.38	0	.04	.98	.75	.88	.81	.03	.83	.01	.09	0	4.80
1918	.61	.71	.19	.10	1.16	3.54	.05	.26	1.91	2.04	.93	1.58	13.08
1919	.75	.05	3.33	1.59	1.57	6.83	1.01	3.42	8.77	7.44	.79	.26	35.81
1920	2.17	.16	.05	.10	5.44	1.80	1.28	6.76	.94	1.40	2.32	.14	22.56
1921	.29	.91	1.38	.13	2.12	3.53	1.12	1.00	1.36	.21	T	T	12.05
1922	.50	.02	1.41	12.77	2.63	2.63	.38	.04	0	1.11	1.35	0	22.84
1923	.29	3.10	2.16	4.58	1.24	2.50	1.68	.77	1.38	4.20	2.29	1.69	25.79
1924	.03	.50	.75	.91	3.35	.05	.90	2.04	.68	1.42	.05	.13	10.81
1925	.15	0	T	4.43	2.09	1.00	1.12	3.03	3.06	3.11	.14	0	18.13
1926	.98	.06	2.18	2.24	1.96	4.38	2.27	1.62	3.56	3.47	.32	2.19	25.23
1927	.53	1.69	.27	1.10	1.28	2.18	1.22	.41	4.01	.45	T	.42	13.56
1928	.35	.75	.02	.66	10.10	.95	1.87	2.68	.76	.81	.71	.06	19.72
1929	.32	.85	2.89	.13	3.18	1.08	2.81	1.72	5.44	3.28	.74	0	22.44
1930	.46	0	.11	2.33	1.95	1.65	.18	2.68	.24	2.62	2.32	1.43	15.97
1931	1.31	.97	1.20	2.53	.75	.59	2.48	.95	.04	7.06	2.06	2.39	22.33
1932	.98	3.27	.20	2.40	5.27	3.82	.90	4.41	4.47	.51	.07	2.92	29.22
1933	.19	.61	.11	.10	.46	.01	1.51	5.99	.70	.45	.87	.33	11.33
1934	.31	.08	1.82	1.85	.20	2.20	1.92	3.41	.58	.11	2.05	.08	14.61
1935	.11	1.25	1.33	1.20	3.98	3.28	.82	.57	5.19	1.40	.01	.37	19.51
1936	.12	T	1.39	.77	4.75	.19	1.23	.58	------	1.84	.50	.47	------
1937	------	.47	2.07	.27	2.91	1.35	.78	2.49	.14	.94	1.30	1.25	------
Average for 38 years	------	------	------	------	------	------	------	------	------	------	------	------	18.70

Garden City, Glasscock County, Tex.

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1912	------	------	------	------	------	------	------	------	------	1.05	1.36	0.84	------
1913	0.12	0.77	0.47	0.92	1.36	4.71	0.26	0.68	3.38	2.82	2.93	2.72	21.14
1914	.22	.17	.57	1.39	3.36	3.86	.77	12.09	1.01	3.75	.78	1.31	29.38
1915	.35	.71	.66	4.64	2.20	3.02	2.00	.60	4.05	.24	T	.65	19.12
1916	.05	T	.37	2.62	.67	.92	2.46	1.24	2.07	1.13	.60	.17	12.30
1917	.30	.01	.01	1.55	.52	.73	.31	1.12	1.10	0	.02	0	5.76
1918	.75	.38	.11	.17	2.40	1.99	.45	.55	3.02	2.34	2.87	1.16	16.19
1919	1.02	.05	4.05	2.90	.90	2.99	1.10	3.43	3.84	4.44	1.10	.19	26.01
1920	2.05	.21	.10	.02	.99	1.46	1.23	6.38	3.10	.60	2.96	.12	19.22
1921	.12	1.18	.92	.84	1.08	5.17	T	2.27	.33	.07	0	.10	12.08
1922	1.21	.02	1.18	7.36	4.70	4.20	*.19	.13	0	1.72	2.16	.01	22.88
1923	.64	3.85	1.75	3.08	.59	.40	1.19	.57	.82	3.33	1.39	*1.44	19.05
1924	*.02	*.62	.72	1.13	2.92	.07	.34	7.17	1.64	*1.12	*.02	*.16	15.93
1925	*.30	*0	*T	4.02	3.34	1.87	3.36	3.88	2.70	3.17	.10	T	22.74
1926	.58	0	6.12	2.71	1.74	.90	.83	1.47	1.30	4.55	.30	2.43	22.93
1927	.67	1.47	*.42	*.55	*.82	.26	3.40	.69	2.59	.22	0	1.12	12.21
1928	.36	.55	.81	.21	4.89	1.11	4.79	5.80	.87	1.35	.98	.18	21.90
1929	.44	.88	4.00	1.10	4.32	1.98	1.37	1.00	5.77	2.76	.91	T	24.53
1930	.19	*0	.10	3.00	1.45	1.30	T	2.50	.25	2.94	2.50	.70	14.93
1931	.35	1.70	1.30	2.65	3.71	1.15	3.42	------	T	3.05	2.45	1.50	------
1932	1.80	2.75	.28	2.41	4.86	7.18	.25	4.75	3.95	.33	T	2.52	31.08
1933	T	.10	T	T	.85	0	1.13	3.00	3.21	0	1.05	.20	9.54
1934	.30	T	1.55	3.55	.50	1.15	.18	6.65	1.00	0	2.00	0	16.88
1935	.23	1.80	0	.65	3.70	3.48	4.02	1.15	1.81	1.65	.87	.60	19.96
1936	.15	0	.40	.10	3.95	.75	1.90	1.80	11.15	1.60	.50	.80	23.10
1937	.30	0	1.20	.40	1.80	.80	1.55	4.00	2.10	.88	1.00	1.25	15.28
Average for 24 years	------	------	------	------	------	------	------	------	------	------	------	------	18.92

TABLE 1.—*Records of monthly precipitation*—Continued

Sterling City, Sterling County, Tex.

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1931	1.36	2.97	1.70	2.89	3.72	1.60	2.20	1.90	0	6.28	1.40	2.33	28.35
1932	1.30	3.55	.20	2.30	9.82	5.96	0	5.16	5.65	0	0	4.50	38.44
1933	0	.51	.51	0	0	0	2.70	.80	1.80	0	1.21	1.05	8.58
1934	.55	.33	2.05	3.21	0	.66	1.46	2.62	.35	0	1.18	0	12.41
1935	.22	2.00	.55	.64	6.57	2.48	4.03	1.00	3.20	1.95	1.35	.86	24.85
1936	.15	0	1.10	.47	4.35	.93	0	.25	14.70	2.35	.65	.90	25.85
1937	.33	.10	2.40	.70	4.45	2.00	1.75	2.40	.85	.85	.65	1.75	18.23
Average for 7 years	------	------	------	------	------	------	------	------	------	------	------	------	22.39

Colorado, Mitchell County, Tex.

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1888	------	------	0.24	4.80	0.17	2.31	0.23	4.30	0.34	2.65	2.84	1.46	------
1889	------	2.42	------	1.64	.19	------	------	------	2.68	1.66	1.79	.02	------
1890	0.14	------	.30	10.21	1.35	1.32	1.75	4.02	5.87	1.05	1.02	------	------
1891	.91	.05	.12	1.26	.12	1.10	.10	0.25	.30	------	0	.35	------
1892	.02	.05	.41	------	.65	.15	.30	.22	.28	.74	------	------	------
1893	------	.09	.14	0	------	0	------	------	.32	------	------	------	------
1898	------	------	------	------	------	------	.97	4.06	4.08	0	.46	2.34	------
1899	.56	T	T	1.58	3.20	4.04	1.58	0	1.58	1.84	.71	3.29	18.38
1900	.25	.26	*.99	12.31	*4.32	.42	1.50	1.61	3.25	1.72	*1.18	.18	27.99
1901	.14	1.63	.13	.91	3.04	.32	*4.73	*.11	*3.03	*.58	*1.00	*.24	15.86
1902	*.61	*.02	.41	.24	3.09	.95	14.52	.07	2.76	.76	1.77	.17	25.37
1903	1.14	1.00	.98	1.10	2.55	2.40	.16	3.29	2.60	.08	0	0	15.30
1904	1.68	.02	0	1.42	2.01	5.01	1.57	1.77	6.07	1.93	.45	.59	22.52
1905	.30	1.63	5.05	2.72	2.73	2.46	4.20	*2.50	3.71	1.69	1.74	.57	29.30
1906	.29	.73	1.43	3.10	6.01	2.12	3.15	7.82	2.95	2.77	2.33	.62	33.32
1907	.21	.00	2.04	.34	2.10	2.33	9.42	.15	.17	6.63	1.93	.44	25.76
1908	.45	.08	.33	5.73	5.61	.52	3.71	1.22	1.54	.62	1.71	0	21.52
1909	.03	.02	.37	.06	1.33	1.01	2.75	1.69	1.18	1.33	4.58	.86	15.21
1910	*.68	.20	.48	*.90	1.40	1.13	.16	.99	.90	3.53	.88	.18	11.43
1911	.41	4.84	.72	2.03	.67	.40	3.20	2.98	2.12	.32	.45	2.90	21 04
1912	0	1.20	.28	1.11	.89	1.67	1.08	2.92	.06	.90	0	1.90	12.01
1913	.77	*.56	.07	1.75	1.30	2.14	2.69	.19	4.00	2.60	2.75	4.57	25.39
1914	*.22	.15	.70	3.55	5.38	4.70	2.30	5.85	.20	5.76	.81	1.53	31.14
1915	.37	1.32	.21	5.89	2.24	2.53	2.66	2.86	6.58	1.62	0	.43	26.71
1916	.09	.08	.84	2.22	1.72	*1.03	.38	.38	.62	*2.08	*.94	.31	10.69
1917	------	------	------	------	------	------	------	.57	------	.07	T	0	------
1918	------	------	.11	.59	2.58	3.49	.74	.24	------	------	------	------	------
1919	1.56	.24	4.48	2.48	2.19	6.81	7.04	1.65	3.74	5.43	.93	.25	36.80
1920	2.11	.49	.16	T	7.24	5.66	.27	7.67	3.31	2.04	2.99	.27	32.31
1921	.26	.89	1,48	.42	.87	4.99	.48	1.09	2.27	T	T	.06	12.81
1922	.73	.17	1.27	12.28	4.98	2.65	.14	.21	T	.81	1.61	.22	25.07
1923	.75	3.35	1.79	3.78	3.64	3.13	.13	1.70	2.15	5.32	1.60	1.05	28.39
1924	.09	.10	.60	.64	5.11	.74	1.26	3.25	4.52	2.63	.03	.54	19.51
1925	.24	.02	T	3.47	3.66	.81	1.78	1.84	3.66	2.49	.21	0	18.18
1926	1.06	.08	2.69	3.36	2.77	4.19	2.79	2.89	8.96	3.31	.67	3.28	36.05
1927	.54	1.23	.48	.79	.24	1.85	2.66	2.00	3.06	1.40	T	.75	15.00
1928	.76	1.12	.57	.62	6.94	2.00	6.20	1.68	.77	1.38	.73	.17	21.94
1929	.54	.95	3.05	.60	3.98	.72	.58	*1.16	4.52	3.76	*.63	0	20.49
Average for 29 years	------	------	------	------	------	------	------	------	------	------	------	------	22.60

*Estimated.

PREVIOUS INVESTIGATIONS

The geology and hydrology of this area are briefly discussed in several reports. Cummins [6] has made several references to hydrologic and geologic features in the Big Spring area. Hoots [7] measured a few Triassic and Cretaceous exposures and briefly discussed the lithology and thickness of the formations in the vicinity of Big Spring.

Hawley, Winton, and Alexander [8] made an investigation of the Big Spring area in order to locate an additional water supply and

[6] Cummins, W. F., op. cit., pp. 127–223, 1891.

[7] Hoots, H. W., Geology of a part of western Texas and southeastern New Mexico: U. S. Geol. Survey Bull. 780–B, pp. 88, 105–106, 1925.

[8] Hawley, J. B., Winton, W. M., and Alexander, C. L., op. cit.

submitted their findings in a report to the city officials in 1928. A copy of this report has been frequently consulted by the writers.

Water-well inventories, sponsored by the Texas State Board of Water Engineers, were made in Howard and Glasscock Counties by the Works Progress Administration under the direction of Samuell [9] and Lang.[10]

Ward [11] made an investigation for the city and submitted a report in 1936 that dealt mainly with the feasibility of building dams across certain intermittent creeks in the area to impound storm water.

Some references to the geology near Big Spring have been given in earlier reports, but as these references are not pertinent to the present problem they are not cited here.

The late Mr. E. A. Kelley, whose private investigations of the geology of the Edwards Plateau in the vicinity of Big Spring have been especially helpful to the city and in subsequent investigations, deserves special mention even though his findings have not been published.

ACKNOWLEDGMENTS

The writers are grateful for the cooperation of Mr. E. V. Spence, city manager of Big Spring, and various city employees. Valuable information concerning oil tests and samples of cuttings were freely given by Mr. P. D. Moore, geologist with the Moore Bros. Oil Corporation, at Midland. Logs of oil wells were supplied by the Schermerhorn Oil Corporation, Big Spring, and by Mr. Noel Lawson, of the Tribal Oil Co., Big Spring, and others. Employees of the Texas & Pacific Ry. Co. furnished data regarding the amount of water pumped for railroad use. Mr. M. E. Roberts, geologist with the Pure Oil Co., gave valuable information regarding the general geology of west Texas.

MAPS

The map (fig. 1), showing areas in Texas in which investigations of ground-water resources have been in progress during 1929–42, has been taken from a report by White [12] and slightly revised. The general geology of several counties in the vicinity of Big Spring has been traced from the geologic map of Texas, which was prepared in 1937 by N. H. Darton, L. W. Stephenson, and Julia Gardner, of the

[9] Samuell, J. H., Records of wells, etc., in Howard County, Tex.: Texas State Board of Water Eng., Apr. 10, 1937 (mimeographed).

[10] Lang, J. W., Records of wells, etc., in Glasscock County, Tex.: Texas State Board of Water Eng., Nov. 22, 1937 (mimeographed).

[11] Ward, Joe, Report and recommendations to the city of Big Spring, Tex., on a supplemental water supply; unpublished report, 1936.

[12] White, W. N., Summary report on the survey of the underground waters of Texas: Texas State Board of Water Eng., mimeographed report, 1935

Geological Survey. (See pl. 1.) The base for maps shown by plates 6 and 13 was taken mainly from drawings by W. E. Carnrike, of Big Spring, and adjusted on the basis of information obtained from the State Highway Department and aerial maps. The locations of all city wells were taken from maps furnished by the city of Big Spring. Aerial mosaic maps, made by the Edgar Tobin Aerial Surveys, of San Antonio, were available for most of the area between Big Spring and the Howard-Glasscock County line.

The Trinity sand was mapped on an aerial mosaic map and transferred to a map of smaller scale by means of a pantograph. Inasmuch as the available aerial map covered only Howard County and the Trinity sand is not well exposed in Glasscock County, the outcrop of the sandstone is not so accurately shown for Glasscock County as for Howard County. The structural contours drawn on the top of the Trinity sand are based mainly on information obtained from well logs and from examination of the exposed Cretaceous strata. In some places the contours are generalized because of lack of detailed information.

GEOLOGIC UNITS

The rocks exposed in the Big Spring area are all of sedimentary origin. The oldest rocks exposed are nonmarine and consist largely of shales, clays, and sands. These rocks are included in the Dockum group, which are considered to be of Upper (?) Triassic age,[13] and lie unconformably upon rocks of Permian age (not exposed in this area).

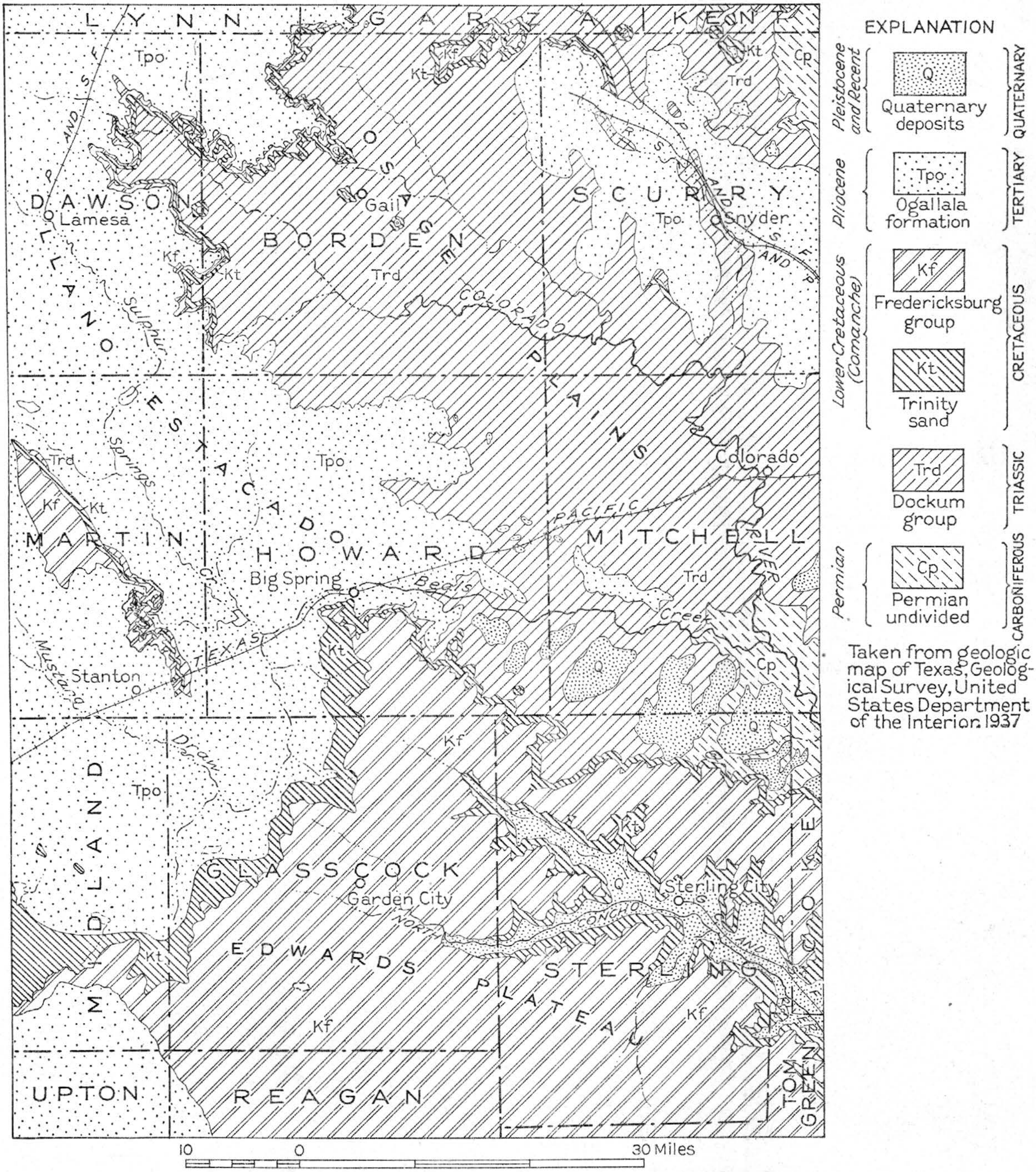
In the Edwards Plateau area the Triassic beds are unconformably overlain by the Trinity sand, consisting of conglomerate and sandstone of Lower Cretaceous age of marine or littoral origin, and deposited in an advancing sea. The Trinity sand is overlain by Lower Cretaceous limestones that are referred to the Fredericksburg group. In the High Plains area, where the Cretaceous beds have been largely removed by erosion, continental deposits of Tertiary and Quaternary age generally lie on the Triassic. In many places in the Osage Plains area near Big Spring the Triassic is overlain by Quaternary alluvial deposits. (See pl. 1.)

PERMIAN SERIES

The Permian strata, although not exposed in this area, are encountered in comparatively deep wells. Wells in the Big Spring oil field produce oil from several horizons in the Permian rocks.

The Permian rocks consist of three formations, which are, in ascending order, the Wichita, Clear Fork, and Double Mountain.[14]

[13] Hoots, H. W., op. cit., p. 86, 1925.
[14] Hoots, H. W., op. cit., p. 81, 1925.



GEOLOGIC MAP OF THE AREA SURROUNDING BIG SPRING, TEX.

A part of Hoots' descriptions [15] of the Permian strata follows:

The Wichita formation of the Permian in Runnels County may be said to consist largely of limestone in the lower 1,250 feet and shale with some limestone in the upper 450 feet; as identified in wells to the west, in northern Sterling and Glasscock Counties, a decrease in the amount of shale in the upper part is the only important change in the Wichita, though the base has not been penetrated; in southern Sterling County the lower part becomes very sandy; and to the northwest, in Mitchell, Howard, western Borden, Scurry, and western Fisher Counties, and as far northwest as Dickens County, sandstone, sandy limestone, and shale make up a considerable part of the Wichita rocks.

The Clear Fork formation as exposed in Runnels and Coke Counties and along the Texas & Pacific Ry. in northern Taylor and Nolan Counties is a series of shale and clay, mostly red, with some sandstone, dolomite, and limestone. The Double Mountain formation, in Coke and Mitchell Counties, consists of sandstone, sandy shale, and shale, mostly red, with numerous thick beds of gypsum. * * * When these upper Permian divisions are traced westward and northwestward from these wells in western Fisher and Nolan Counties and eastern Sterling County the most noticeable feature is the appearance of strata of rock salt which come in first in that part referred to the Double Mountain. Intercalated with the salt are beds of anhydrite, red shale, sandy shale, sandstone, and conglomerate. Rocks in the upper part, and, if the correlation is followed westward to a point near the center of the south end of the western Texas geosyncline, both salt and anhydrite are found to be common to the entire thickness herein referred to the Clear Fork. * * * Rock salt and anhydrite are characteristic of the Double Mountain in all parts of this western Texas region, but, so far as known, they are common to strata herein grouped as comprising the entire Clear Fork only in that part lying west of central Glasscock and Howard Counties.

TRIASSIC SYSTEM

DOCKUM GROUP

The Triassic rocks crop out at the base of the escarpment on the north and east sides of the Edwards Plateau and occupy a relatively large area, which is called the Osage Plains, east of the Llano Estacado. These sediments are mainly dark red to maroon shale that usually contains small flakes of mica and some gypsum. Lenticular beds of sandstone that are usually gray to red, cross-bedded, and very micaceous are present within the red shale at many localities. (See pl. 4, *A*.)

Only 100 to 200 feet of Triassic is exposed in the Big Spring area. Data from numerous drilled wells show that the Triassic varies in thickness, that it generally thickens toward the west, and that it has unconformities at the top and base. Adkins [16] reported the thickness of the Triassic in eastern Howard County as being from 500 to 600 feet. He [17] also quotes the approximate thickness of the Triassic beds in several wells as reported by Mr. J. E. Adams as follows: Eastern Howard County, 715 feet; central Howard County, 1,715 feet; north-central Howard County, 800 feet; and western Howard County, 865

[15] Hoots, H. W., op. cit., pp. 82-84, 1925.

[16] Adkins, W. S., The Mesozoic systems in Texas, in Sellards, E. H., and others, The geology of Texas: Texas Univ. Bull. 3232, p. 247, 1932.

[17] Idem, p. 248.

feet. Hoots,[18] stated that the Triassic beds along the east edge of the Llano Estacado in Borden, Scurry, Howard, and Mitchell Counties have a total thickness of 300 to 400 feet.

A fairly persistent zone of sand is encountered near the base of the Triassic by comparatively deep wells, but it does not crop out in the Big Spring area. Wells moderately near one another on the Edwards Plateau encounter the top of the Triassic at nearly the same altitude and thus show that the upper surface of these beds is rather even; however, a comparison of the altitudes of the Triassic surface in various parts of the Edwards Plateau area near Big Spring shows that there is a shallow northwestward-trending depression in the Triassic surface. In some localities on the Edwards Plateau a bed of yellow clay at the top of the Triassic suggests a zone of oxidation formed during a period of weathering. On the Llano Estacado, well logs show that the Triassic surface is uneven.

LOWER CRETACEOUS SERIES

TRINITY SAND

It has long been recognized that in early Cretaceous time the sea advanced across Texas from the southeast toward the north and northwest and deposited a basal sand and gravel upon a well-eroded surface of older rocks. Thus, the base of the Cretaceous in Texas is marked by a stratum of sand and conglomerate that has the appearance of belonging to a single stratigraphic unit but actually is of different age at different places along the line of advance. Hill [19] has discussed this matter in detail. He considered that the basal sands near Big Spring were the equivalent of the Paluxy sand, which is the top formation of the Trinity group near Waco and Fort Worth. According to Hoots,[20] "In the region herein described the Trinity is composed entirely of sand—commonly conglomeratic—and the Trinity group, as the deposits to the east are called, here becomes the Trinity sand." This usage is followed in this report as a matter of convenience because the correlation of the basal Cretaceous sand with beds in adjacent areas was beyond the scope of the present investigation.

The Trinity sand is well exposed on the north and east sides of the Edwards Plateau and also crops out at a few other places within the plateau. Although not well exposed along the west side of the plateau southwest of Big Spring, it apparently lies beneath later deposits. This sandstone lies unconformably on the even surface of the Triassic beds. It ranges in thickness from about 60 feet near Big Spring to about 100 feet a few miles southeast of Big Spring, as shown in figure 2. As this figure was drawn to show the broad relation of the thick-

[18] Hoots, H. W., op. cit., p. 87, 1925.

[19] Hill, R. T., Geography and geology of the Black and Grand Prairies, Tex.: U. S. Geol. Survey 21st Ann. Rept., pt. 7, pp. 132–140, 1901.

[20] Hoots, H. W., op. cit., p. 98.

ness of the Trinity sand in Howard County, the lines through points of equal thickness are generalized.

A coarse conglomerate that is composed mainly of red and black pebbles of chert and other varieties of quartz, tightly cemented with a slightly calcareous silty clay, usually occurs at the base of the sand-stone immediately overlying the Triassic sediments. This bed of conglomerate is about 5 to 10 feet thick throughout most of the area but pinches out in some places. The remainder of the formation is composed chiefly of moderately fine grained sandstone usually light gray to brown but, where exposed, may contain various shades of red. In general, it is somewhat friable, but as shown by plate 5, *A*, *B*, it is in places well cemented and forms vertical cliffs.

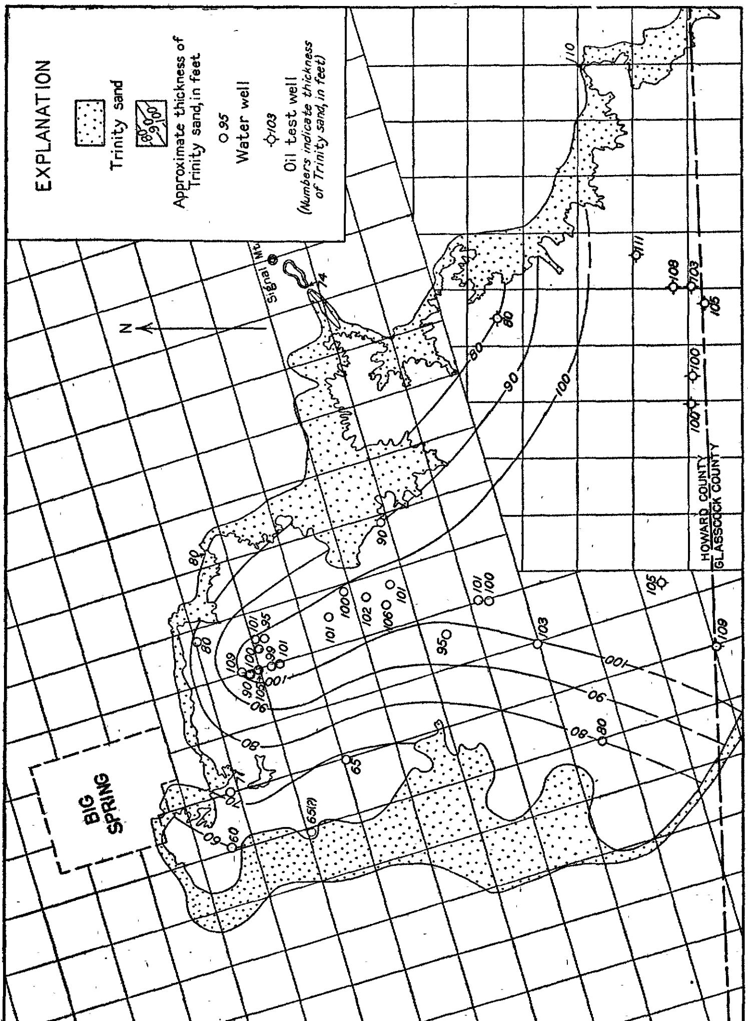


FIGURE 2.—Map of southern Howard County showing by contour lines the approximate thickness of the Trinity sand.

Layers of dark-red clay were encountered in some wells drilled through the Trinity sand. These layers are probably more or less lenticular and not persistent over large areas. They were seen at only a few localities within the sandstone on the outcrop, although light-colored clays were found in nearly every outcrop of Trinity sand examined. About 1½ miles north of the Stewart ranch house in sec. 38, block 32, a red silty clay crops out on the creek bank. This clay looks similar to Triassic rocks but actually is within the Trinity sand. No mica was seen in this clay, which lies just below Trinity sandstone beds. At other places this red clay is exposed with Trinity sandstone beds above and below it.

In some parts of the area the sandstone is quartzitic at the outcrop. It is believed that this quartzitic sandstone results from weathering processes at the surface and that the quartzitic beds probably grade into friable sandstone underneath the land surface. (See pl. 4, *B*.) None of the samples of well cuttings that were examined by the writers contained quartzitic sandstone. Cross bedding is common in some parts of the sandstone and is usually made more noticeable by quartz pebbles lying along the cross-bedding planes. Most of the sandstone has small amounts of pebbles of chert and other varieties of quartz, but a few beds consist only of fine sand.

Concretions are abundant in the sandstone in parts of the area. Brown spherical iron concretions that are usually about 1 to 2 inches in diameter are found near the top of the sandstone in most places. Large spherical to botryoidal concretions composed of sand and calcium carbonate, as much as 6 inches in diameter, are present at horizons in the sandstone in a few localities.

Hoots,[21] who reported an unconformity at the top of the Trinity sand at Signal Peak, about 10½ miles east of Big Spring, stated that the break in sedimentation was probably local and not accompanied by any great amount of erosion. An unconformity at the top of the Trinity sand was seen in a trench in the southeast corner NE¼ sec. 12, block 33, 2 miles south of Big Spring, near the north edge of the city park sink. In this locality, where a zone of pebbles lies on the irregular surface of the Trinity sand, the contact between the sand and the overlying fossiliferous marl is quite distinct (pl. 7, *A*), as it is also at the same horizons in the section on the north escarpment of the Edwards Plateau in the NE¼SE¼ sec. 7, block 32, 2 miles south of Big Spring. In some localities in the Edwards Plateau pebbles as much as 2 inches in diameter were found near the top of the Trinity sand.

Other than silicified wood, fossils were found in the Trinity sand at only one locality. These fossils were found in a clean friable sandstone about 5 feet below the base of the overlying Fredericksburg

[21] Hoots, H. W., op. cit., p. 100, 1925.

limestone. This locality is in the SW¼ sec. 18, block 32, about 3 miles south of Big Spring.

Three typical sections of the Trinity sand are given on the following pages.

Section exposed in NE¼NE¼ sec. 124, block 29, Glasscock County, 16 miles southeast of Big Spring

	Ft.	in.
Fredricksburg group:		
Limestone, brown, arenaceous	2	0
Trinity sand:		
Sandstone, light gray, medium coarse, friable; contains a few quartz pebbles	8	0
Sandstone, lavender to red, contains a few quartz pebbles and some iron oxide concretions, bed is more resistant	4	0
Sandstone, light gray, medium coarse, friable	11	
Sandstone, buff, massive, medium coarse, more resistant	3	6
Sandstone, light gray, very fine, some light red streaks	13	6
Sandstone, brown, massive, hard and well cemented, resistant	7	0
Covered except for an occasional exposure of soft, light gray friable sandstone	34	0
Sandstone, light gray, medium coarse, friable, massive, cross-bedded; contains coarse gravel lens	5	0
Clay, light gray, contains much silt and fine sand	2	0
Sandstone, light buff, hard, well cemented	3	0

Section exposed in SE¼SW¼ sec. 33, block 31, T. 1 S., Howard County, 10 miles southeast of Big Spring and ¾ mile southwest of Signal Peak. (See pl. 5, B.)

	Feet
Fredericksburg group:	
Limestone, brown, arenaceous, hard at top and soft and marly at base; contains quartz pebbles as much as 1 inch in diameter near base of bed	4
Trinity sand:	
Sandstone, hard, quartzitic, lenticular	1
Sandstone, light gray stained light red; contains iron oxide concretions and quartz pebbles about ¼ inch in diameter	5
Sandstone, gray, friable, less resistant; contains lenses of fine gravel	15
Sandstone, light gray, very friable, more resistant, coarser	10
Sandstone, light gray, very silty and argillaceous; contains a few quartz pebbles; at top are large pebbles as much as 3 inches in diameter, one having fusulinids in it	2
Sandstone, gray, silty as above; there is a light red zone in the center	6
Sandstone, light buff; contains streaks of light gray silty sandstone	7
Sandstone, light buff to light gray, friable, resistant; contains streaks of coarse gravel	10
Sandstone, light gray, silty	1
Clay, red; contains some silt and fine sand	5
(Covered)	7
Sandstone, buff, resistant; contains some streaks of gravel	5
Dockum group:	
Shale, dark red, micaceous	15

Section exposed on north escarpment of Edwards Plateau in NE¼SE¼ sec. 7, block 32, T. 1 S., Howard County, 2 miles south of Big Spring

	Ft.	in.
Trinity sand:		
Sandstone, buff; contains some streaks of gravel	2	8
Sandstone, gray, very fine; contains much silt	5	0
Sandstone, buff, coarser, more resistant	8	0
Sandstone, gray with 1 foot zone of maroon in center; contains large amount of silt	4	0
Sandstone, light gray, hard, resistant	5	0
(Covered)	16	0
Conglomerate made mainly of red and black quartz pebbles cemented together by silty clay	7	6
Dockum group:		
Clay, yellow to buff	2	0
Shale, dark red, micaceous	32	0

FREDERICKSBURG GROUP

The Fredericksburg group in east Texas is described by Hill under three formations, which are, in ascending order, the Walnut clay, the Comanche Peak limestone, and the Edwards limestone.[22] Although these formations may be present in the Big Spring area, it was not within the scope of the present investigation to attempt to differentiate them.

Hoots [23] reports two measured sections in Howard County. In one of these he assigns 8 feet of limestone to the Walnut and 107 feet to the Comanche Peak and Edwards limestones; in the other, 9½ feet of limestone to the Walnut and 113½ feet to the Comanche Peak and Edwards limestones.

The Fredericksburg limestones crop out south of Big Spring on the Edwards Plateau, and, as the plateau is well dissected by drainage, the limestones are exposed plentifully and well. Their total thickness in the Big Spring area is about 160 feet.

For the purpose of discussion the Cretaceous limestone in this report is divided into three somewhat ill-defined lithologic parts; however, it should not be inferred that these divisions represent separate formations.

The lower part consists of about 25 to 35 feet of nodular to massive-bedded, gray to brown limestone and some beds of marl. In some localities the nodular limestone probably grades laterally into marl, which is probably not persistent over a large area. The lower boundary of this unit is marked by a sandy marl that grades into sandstone below and into brown arenaceous limestone above. The limestones within the lower 15 to 20 feet are arenaceous in nearly all parts of the area. The upper boundary of this lower unit is marked by a hard gray bed of limestone almost entirely composed of fossil shells, which are mainly *Gryphaea*. This bed is very persistent throughout the area and is very easily recognized.

[22] Hoots, H. W., op. cit., p. 99.

[23] Hoots, H. W., op. cit., pp. 105–106.

Fossils are abundant within the lower unit and consist mostly of *Gryphaea*, *Exogyra*, echinoids, and gastropods. The following fossils collected from this lower unit were identified by John B. Reeside, Jr.:

Phymosoma texana (Roemer).
Holectypus planatus Roemer.
Gryphaea marcoui Hill and Vaughn.
Heteraster sp., probably H. texanus (Roemer).
Exogyra texana Roemer.
Neithea texana (Roemer).
Corbis sp.
Lunatia riograndis Roemer.
Turritella sp.
Cyprina sp.
Astarte sp.
Cyprimeria? sp.
Tylostoma sp.
Neithea sp.
Gastropod mold, undetermined.
Boring of unknown organism.

About 40 to 45 feet of argillaceous limestone and a few thin marl beds occur above the lower part. In most places the limestone is nodular or thin-bedded, fine-textured, and gray to dark gray, but where exposed it is light gray to light buff. The beds weather to steep slopes where exposed owing to the brittleness of the limestones and to the numerous bedding planes.

Fossils are relatively sparse, although a few large Foraminifera and some large fossils of other kinds are found. The following fossils collected from this middle unit were identified by John B. Reeside, Jr.:

Heteraster sp.
Exogyra texana Roemer.
Neithea texana (Roemer).
Pholadomya sancti-sabae Roemer.
Arctica sp.
Protocardia texana.
Cyprimeria sp.
Linearia? irradians Roemer.
Lunatia riograndis Roemer.
Tylostoma mutabilis Roemer.
Aporrhais sp.
Gryphaea sp.
Trigonia emoryi Conrad.
Lima n. sp.
Caprinula sp.
Isocardia sp., probably new.
Turritella n. sp.
Salenia sp.
Heteraster sp., probably H. texanus Roemer.
Pleuromya? sp.
Venerid pelecypod, internal mold.
Ostrea? sp.
Corbis sp., probably n. sp.
Anchura n. sp.
Pleuromya n. sp.
Aporrhais? sp.
Tylostoma sp.
Heteraster? sp.
Neithea sp.
Borings of unknown organism.
Undetermined molds of pelecypods and gastropods.
Undetermined objects, probably inorganic.

About 80 feet of massive bedded limestone occurs above the middle part. Some of the limestone beds are very chalky and coarse-textured and where weathered are very friable, so that they break into fragments when struck lightly with a hammer. The limestone in most places is light buff to buff but where exposed weathers to a light gray. Some marl layers lie between the massive beds of limestone, but they are usually very thin.

A 4- to 5-foot bed of light gray to light buff fossiliferous limestone that is hard, massive, and semicrystalline is present at the base of this unit. This bed is easily recognized and is apparently persistent over the area. The upper part of the unit is characterized by hard massive beds of limestone containing large chert nodules. These limestone beds are very resistant to erosion and consequently form a topographic bench.

Foraminifera are abundant in some of the beds, and some large fossils are found at a few horizons. The fossils listed below were collected from this upper unit and were identified by John B. Reeside, Jr.:

Caprinula? sp.
Eoradiolites cf. E. davidsoni (Hill).
Nerinea n. sp.
Neithea sp.
Protocardia sp.
Toucasia sp.
Eoradiolites? sp.

A few typical sections of the Fredericksburg limestones are given on the following pages.

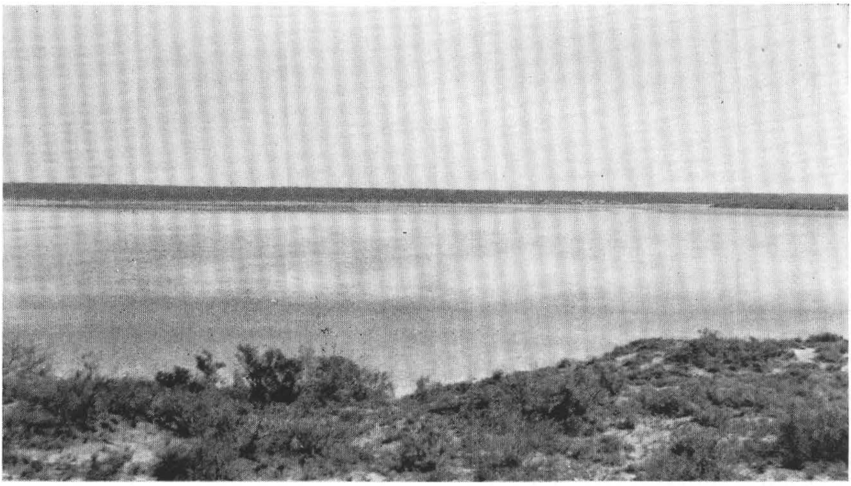
Section exposed in creek bed in NW¼SW¼ sec. 7, block 32, T. 1 S., Howard County, 2 miles south of Big Spring

	Ft.	in.
Fredericksburg group:		
Limestone, light buff to light gray, very argillaceous, irregularly bedded; contains gastropods at top	5	10
Limestone, gray, fine-textured, weathers buff; contains fragments of fossils	1	
Limestone, gray, massive, fine-textured, blocky	4	6
Shaly limestone, buff	1	4
Limestone, light gray, nodular; contains gastropods	5	3
Limestone, light gray, dense, fine-textured; contains gastropods	1	6
Marl, light bluff; contains pelecypods	1	
Limestone, gray, hard, massive	2	2
Limestone, gray, hard; contains an abundance of *Gryphaea*	3	0
Limestone, gray	2	3
Limestone, gray, nodular, soft; contains *Exogyra*	4	2
Limestone, gray, massive; contains echinoids and *Exogyra*	6	4
Limestone, light buff, massive	2	10
Limestone, brown, arenaceous, hard at top and softer at base; contains *Exogyra*	7	0
Trinity sand:		
Sandstone, gray to light red, argillaceous; contains some quartz pebbles	1	10

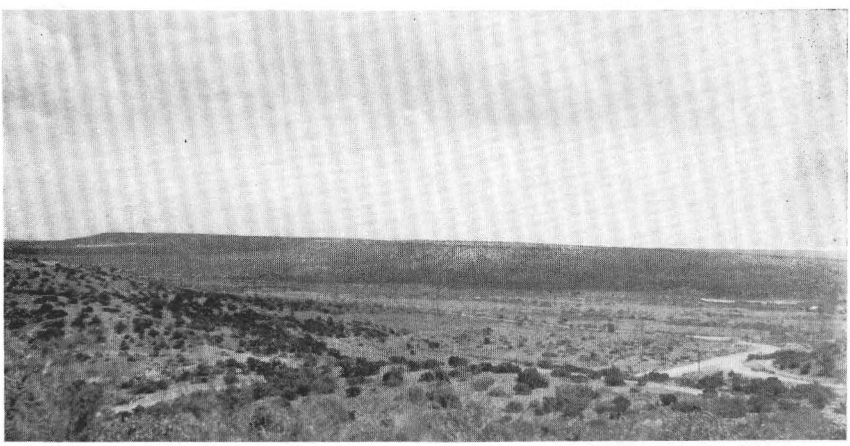
Section exposed on north escarpment of the Edwards Plateau in SW¼SW¼ sec. 10, block 32, T. 1 S., Howard County, 3½ miles east of the Big Spring

	Ft.	in.
Fredericksburg group:		
Limestone, buff, chert nodules	16	0
(Covered)	5	6
Limestone, buff, contains chert nodules	2	6
(Covered)	20	0
Limestone, light gray to light buff	4	0
Limestone, light buff, coarse-textured semi crystalline	6	6
Limestone, gray, fine-textured	7	6
Limestone, very argillaceous	2	6
Limestone, gray to buff, massive	5	4

AERIAL VIEW OF PART OF EDWARDS PLATEAU, SHOWING TYPE OF DRAINAGE IN THE VICINITY OF SECTION 33 SINK.



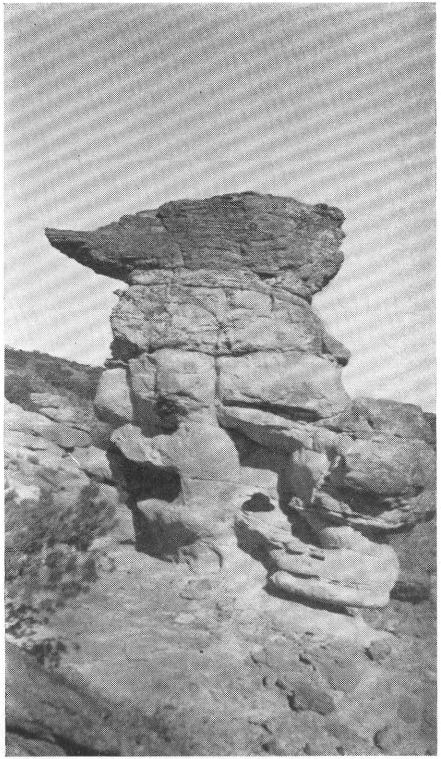
A. SALT-WATER LAKE IN BEALS CREEK DRAINAGE AREA.



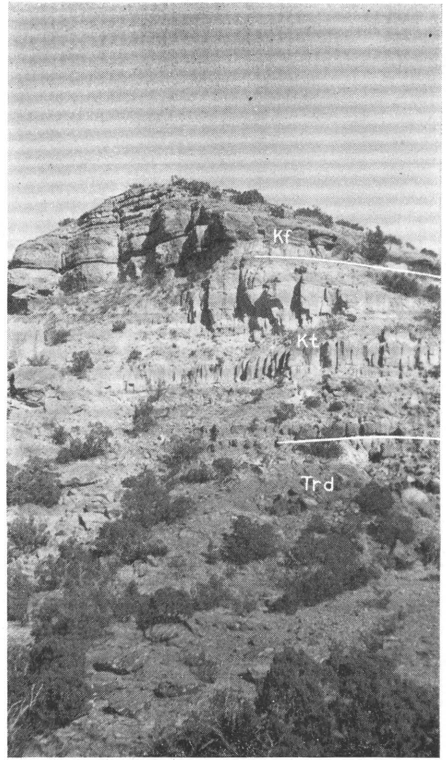
B. VIEW FROM SCENIC MOUNTAIN LOOKING EAST TOWARD THE NORTH ESCARPMENT OF EDWARDS PLATEAU NEAR BIG SPRING.

A. TRIASSIC SANDSTONE ABOUT THREE-FOURTHS OF A MILE SOUTHWEST OF SIGNAL PEAK, HOWARD COUNTY.

B. LARGE BLOCKS OF TRINITY QUARTZITIC SANDSTONE ON CREEK BANK ABOUT 1 MILE NORTH OF STEWART'S RANCH HOUSE.

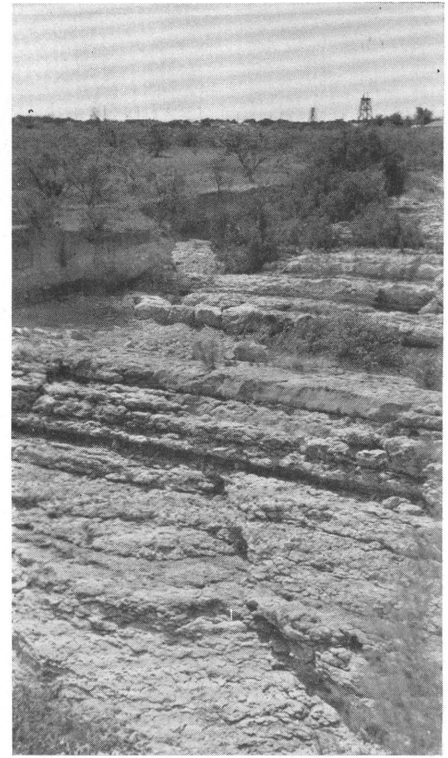


A. TRINITY SAND ABOUT 1 MILE NORTH OF DORA ROBERT'S RANCH HOUSE.



B. OUTCROP OF TRINITY SAND THREE-FOURTHS OF A MILE SOUTHWEST OF SIGNAL PEAK.

Kf, Fredericksburg limestone; Kt, Trinity sand; Trd, Dockum group.



C. LIMESTONE DIPPING WEST TOWARD CITY PARK SINK.

Section exposed on north escarpment of the Edwards Plateau in SW¼SW¼ sec. 10, block 32, T. 1. S., Howard County, 3½ miles east of the Big Spring—Continued

	Ft.	in.
Limestone, gray, fine textured, nodular to thin-bedded	21	0
Marl, light buff		6
Limestone, gray, nodular		7
Marl, light buff		6
(Covered)	4	6
Limestone, gray, lithographic		6
Limestone, gray, nodular; contains gastropods and large pelecypods	16	0
(Covered)	2	8
Limestone, upper part light red and lower part gray; contains an abundance of *Gryphaea*	7	0
Limestone, gray argillaceous, nodular; contains *Exogyra* in upper part	3	0
(Covered)	10	8
Limestone, light buff, arenaceous; contains *Exogyra*	2	0
(Covered)	4	0
Limestone, brown, arenaceous, hard, becomes more arenaceous and softer at base; contains *Exogyra* and echinoids	7	6
Trinity sand:		
Sandstone, buff, fine-grained	3	0

Section exposed on east side of Scenic Mountain in SE¼SE¼ sec. 1, block 33, T. 1 S., Howard County, 1½ miles south of Big Spring

	Ft.	in.
Fredericksburg group:		
Limestone, light buff, massive, hard	3	0
(Covered)	10	0
Limestone, light buff to gray, massive, hard	2	0
(Covered)	25	0
Limestone, gray, hard, dense; contains gastropods	4	6
Marl, light buff	1	6
Limestone, gray, lithographic, hard, weathers brown	1	0
(Covered)	2	0
Limestone, gray, almost entirely composed of *Gryphaea*		6
Marl, buff	2	6
Limestone, gray, hard, dense, lithographic	2	0
Shaly limestone, light buff	2	0
Limestone, gray, nodular	5	0
Marl, gray to light buff	2	0
Limestone, gray, hard; contains an abundance of *Gryphaea*	2	1
Limestone, gray, hard; contains some *Gryphaea*	2	0
Limestone, gray, hard; contains an abundance of *Gryphaea*	2	6
Limestone, gray nodular	3	0
Marl, light buff to gray	1	0
Limestone, gray, hard; contains an abundance of *Gryphaea*		6
(Covered)	5	0
Limestone, light gray, arenaceous; has pinkish cast on outcrop	5	0
(Covered)	13	6
Trinity sands:		
Sandstone, light gray; contains some streaks of reddish-brown and light-gray silty clay	8	0

Section exposed on north escarpment of Edwards Plateau in NE¼ SE¼ sec. 7, block 32, T. 1 S., Howard County, 2 miles south of Big Spring

	Ft.	in.
Fredericksburg group:		
Limestone, light buff to yellow, soft	5	0
Limestone, buff; contains many Foraminifera	3	0
Limestone, buff; contains many Foraminifera	8	0
Limestone, buff, hard, resistant, has grainy appearance upon weathering; contains many Foraminifera	2	0
Limestone, buff, hard, resistant, has grainy appearance upon weathering; contains many Foraminifera	1	8
Marl		3
Limestone, buff, massive, hard; contains large fossils and some Foraminifera	2	10
Limestone, buff, hard; contains Foraminifera	3	4
Limestone, buff, soft; contains many large fossils; contains a one-foot zone of *Gryphaea* at top	5	6
Marl		6
(Covered)	3	0
Limestone, light gray, hard, weathers to a buff, semi-crystalline; contains many Foraminifera	4	0
Limestone, light gray, nodular, argillaceous	15	0
Limestone, light gray, nodular, fine-textured, hard	11	0
Limestone, gray, nodular, hard, dense, fine-textured	16	0
Limestone, gray, hard; contains an abundance of *Gryphaea*	3	4
Limestone, gray, hard; contains an abundance of *Gryphaea*	1	0
(Covered)	8	0
Limestone, gray, hard, dense; contains gastropods and *Exogyra*	2	0
(Covered)	2	0
Limestone, dark gray, hard, dense, arenaceous	6	0
Limestone, brown, dense, hard at top becoming agrillaceous and soft at the base; is very arenaceous throughout	7	0

TERTIARY AND QUATERNARY DEPOSITS

Sediments that are considered probably to be chiefly Tertiary but in part Quaternary occupy an area north and west of the Edwards Plateau and lie unconformably on the Triassic redbeds. These deposits have been mapped on the Texas State map as the Ogallala formation, as shown in plate 1. In general, they are not well exposed, and well logs were about the only means of obtaining information as to their lithology and thickness.

The most important Tertiary and Quaternary deposits in regard to ground water are west of the Edwards Plateau in the vicinity of the west pool of the Big Spring oil field, which is shown on plate 6. These deposits consist mainly of clay, sand, and gravel. The gravel is made up largely of limestone pebbles, although quartz pebbles are always present and in some places are in a greater proportion than the limestone pebbles. Some of the limestone pebbles near the west pool of the Big Spring oil field are as much as 2 inches in diameter; but pebbles of this size probably occur at only a few localities. Water-worn fossil shells of Cretaceous age that were found in the sand and gravel probably indicate that much of this material was derived from Cretaceous rocks. Layers of clay occur in the deposits, but the sand and gravel in itself probably is nearly free from argillaceous material. Hard beds of caliche are present in many places and crop out in some parts of the area. The Tertiary and Quaternary deposits in the vicinity of the west pool of the Big Spring oil field are coarser than in most other areas. North and northwest of this field the sediments generally consist of fine sand and clay.

The thickness of the Tertiary and Quaternary sediments depends largely on the relief of the underlying Triassic surface, for thicker sediments are found where the Triassic surface is low. In the vicinity of the west pool of the Big Spring oil field, some wells have penetrated about 250 feet of these sediments. The area close to the north edge of this pool is underlain by an old channel in the Triassic that is filled with Tertiary and Quaternary deposits. (See pl. 8.) As there are no surface indications of this old channel, well logs were the only means of defining it. The channel probably is not very wide. However, its northern boundary could not be well established because of the scarcity of test wells in that particular region. Test well 149 was drilled in sec. 7, block 33, 11¼ miles south of Big Spring, to obtain information as to the extent of this channel. The Triassic shale was encountered at a depth of 82 feet, which indicated that the channel did not extend that far west or that the well was located on the south or north side of it, probably on the north.

Sediments of probable Quaternary age in the drainage valleys on the Edwards Plateau consist of large boulders and pebbles of limestone intermixed with clay and sand.

GEOLOGIC STRUCTURE

The part of the Edwards Plateau that extends from the south nearly to Big Spring (pl. 1) is the site of a relatively large, broad northwestward-trending syncline in the Cretaceous rocks. Although the Cretaceous strata are only gently deformed in most parts of this syncline, structural deformation has been more intense in several small areas, as the sinks from which the main water of the city is derived. In addition, there are numerous places in which solution of the Fredericksburg limestones near the land surface has resulted in a slight downwarping of beds in small areas.

The eastward-trending anticline over which the Big Spring oil field is located (pl. 6) probably is reflected only slightly in the Cretaceous rocks and does not affect the occurrence of ground water to any great extent.

The city park sink centers in the SE¼ sec. 12, block 33, about 2½ miles south of Big Spring. (See pl. 6.) The main part of this slumped area is about 3,000 feet in diamter, but there is a slight dip into the sink as much as three-fourths of a mile from the center. The beds in the structurally lowest part of the sink are about 280 feet below their normal position. Although the subsided area appears to be circular, well logs reveal a structurally low area extending westward, so that the area is actually elliptical. The entire section of Cretaceous strata in the area is preserved within the sink, although the upturned limestone and sandstone beds on the periphery have been beveled to some extent by erosion. (See pl. 5, *C*.) A fault of small throw probably is present around the southeast and the south edge of the sink. Other minor faults may occur around the periphery, but they are not evident at the land surface owing to the fact that in many places the beds are poorly exposed. Many radial and tangential fractures are well shown in some places within the sink. Tangential fractures in the Trinity sand at the east edge of the sink were filled with sand and calcium carbonate, which form a resistant material that now protrudes above the surrounding sandstone. As the city park subsidence coincides with a topographical depression, it is likely that drainage has been strongly affected by this sink.

Plate 9 is a geologic section along line A–A′ as designated on plate 6. This section extends across the city park sink and shows the amount of displacement and the relation of the sink to the surrounding strata.

Another subsided area centers in the NE¼ sec. 33, block 32, which is about 6 miles southeast of Big Spring. (See pl. 10.) This slumped area is commonly referred to as the section 33 sink because the structurally lowest part is in the NE¼ sec. 33, where the beds are about 210 feet below their normal position. The main subsided area of this sink, about 3,000 feet in diameter, is about the same size as the city park sink. Two long structurally low areas extend out from this central subsided area, one to the north and the other to the east. As in the city park sink, the entire Cretaceous section in the Big Spring area is preserved in the central part of the sink and the upturned beds at the periphery have been beveled by erosion. The slumped area that extends eastward from the main sink is indicated at the land surface by dips in the Trinity sand and by small step faulting or fracturing. The Trinity sand in this area has been fractured, but the fractures have been filled with sand and other material and are now exposed as small dikes. (See pl. 7, *B*.) Radial and tangential fractures are not well exposed in the central subsided area but are probably present, as in the city park sink. A topographic depression has been formed by this subsidence, and drainage has been affected to some extent. Quaternary clay and limestone and sandstone boulders lie on the Cretaceous limestone in some parts of the sink.

Plate 9 shows a geologic section along line B–B′ as designated on plate 6. This cross section shows the displacement of beds in the section 33 sink and the altitude of the surrounding strata.

Well logs indicate that the city well field that centers in the southeast corner sec. 17, block 32, about 3¾ miles southeast of Big Spring, is in a slight synclinal area. No structural irregularities were seen except for slight dips in the beds in some parts of the area. This area possibly may have been somewhat affected by the subsidence in sec. 33.

A subsided area in secs. 44 and 45, block 32, about 7½ miles south of Big Spring, is not nearly so pronounced as the city park sink or the section 33 sink. The strata on the north and east sides of this area dip gently toward the center of the area. The strata on the west and south sides are badly weathered and covered and no structure can be seen. Three test wells, however, two of which are wells 98 and 97 that were drilled by the city of Big Spring several years ago, probably are near the center of this subsidence, and they show that the beds have dropped about 20 to 30 feet as compared to 210 feet in the section 33 sink and 280 feet in the city park sink. Like other subsided areas in this region this area is marked by a large topographic depression. This may be due to more rapid erosion made possible by the fracturing of the limestone that occurred during the subsidence of the beds.

Some structural irregularities occur near Stewart's ranch house, which is about 13 miles southeast of Big Spring. (See pl. 6.) The altitude of the top of the Trinity sand near Stewart's ranch house is about 2,600 feet, whereas the altitude at the same horizon about 1 mile north is about 2,640 feet. No pronounced dips in the beds were noticed, however, as a dip of only about one-half degree would be necessary to account for a difference of 40 feet in that distance. Fracturing and possibly a few faults of small throw are present in the Trinity sand along the creek north of Stewart's ranch house. This general area is possibly a sink similar to the subsidence in secs. 44 and 45, block 32; if so, its center probably would be near the Stewart ranch house. A topographic depression has been developed here also, and the fact that structural subsidences in this area seem to form topographic depressions adds to the belief that a sink is present.

Small closed basins or depressions were found in the surface of the Edwards Plateau in many places in the Big Spring area. These basins are probably small solution sinks within the Fredericksburg limestones. Some of these sinks are shown on plate 6, but many others are not shown, especially those in Glasscock County.

Solution holes were found in the vicinity of sec. 1, block 32, about 8½ miles south of Big Spring. The solution hole shown in plate 11, *B*, is about 5 to 7 feet wide and about 10 feet deep, but its lateral extent at the base was not determined. The rocks surrounding this solution hole are very likely honeycombed with channels and crevices. The vegetation here is higher and more dense than elsewhere in the area, and the limestone at the surface is badly weathered.

Potholes formed by solution are present in the limestone in some parts of this area. (See pl. 11, *A*.) Udden [24] has written a detailed explanation of the formation of potholes of this type and suggests that their origin is due to the action of carbon dioxide produced by gelatinous and other algae, such as chara and diatoms that quickly revive after a rain.

One subsidence or sink found in Glasscock County was centered in the NE¼ sec. 21, block 34, about 12½ miles south of Big Spring. (See pl. 8.) This sink, which is covered with Tertiary and Quaternary sediments, could be studied only from information obtained from water test wells and from drillers' logs of oil tests, as there are no surface indications of the subsidence. Samples of rock cuttings from wells 174 and 178 contained sediments below the mantle of Tertiary and Quaternary deposits that appear to be very similar to Cretaceous strata. As the sequence of the Cretaceous beds here does not conform with the normal-lying Cretaceous strata, the top of the Triassic in these two wells is rather difficult to determine, but it certainly lies at least 300 feet below the land surface at an altitude of about 2,225 feet above sea level. The top of the normal-lying Triassic in areas nearby has an altitude of about 2,500 feet above sea level, which shows that the beds in this subsidence have dropped about 275 feet.

Test well 180 was drilled to determine whether this subsided area extended to the south. About 100 feet of Trinity sand covered with Tertiary and Quaternary sediments was encountered in this well and the Triassic was struck by the drill at a depth of 122 feet, which indicates that the top of the Triassic is at a much higher altitude than in wells 174 and 178. Test well 193 was drilled in the NE¼ sec. 30 to determine the depth to Triassic in that place and to see if any Cretaceous rocks were beneath the Tertiary and Quaternary deposits. The Triassic was encountered at a depth of 105 feet with Tertiary and Quaternary sediments lying on it. Well 189 in the northwest corner of sec. 33, block 33, penetrated Cretaceous strata that lie about 50 feet below normal. This was thought to indicate a northward dip and a structural feature possibly similar to the one in sec. 21. Test well 192 was drilled in the northwest corner of sec. 28, about 1 mile north of well 189, but no Cretaceous strata were found although the Triassic was encountered at a depth of 282 feet. (See pl. 8.) All the sediments above the Triassic were of Tertiary and Quaternary age and consisted almost entirely of clay. This area is very likely

[24] Udden, J. A., Etched pot holes: Texas Univ. Bull. 2509, Mar. 1, 1929.

an eroded basin in the Triassic shale that has become filled with later sediments.

The Cretaceous strata in Howard County were preserved probably because the beds within the synclinal area were not so actively eroded as the structurally higher rocks to the east, north, and west.

The lines on plate 6 showing the thickness of the Permian salt were taken from a more detailed map made by Mr. P. D. Moore, geologist of Moore Bros. Oil Corporation, Midland, Tex. This map was based on information obtained from well logs, and owing to the large number of oil tests in this region fairly accurate lines that indicate the thickness of the salt could be drawn. The area of no salt corresponds approximately to the area in which the Cretaceous rocks are preserved; and as these rocks were preserved because of their synclinal attitude some relation between the Permian salt and structure of the Cretaceous rocks is suggested. Further evidence of a relation is shown by the fact that the line indicating the edge of the salt curves abruptly around the city park sink in sec. 12, block 33, much as it does around the sink at the west edge of the west pool of the Big Spring oil field in sec. 21, block 34. In view of these facts, it seems logical to suspect that solution of salt in some manner has affected the structure of the Cretaceous strata at the surface.

Fractures, joints, and small faults were formed around and within the sinks when the strata subsided because the rocks were too inflexible to bend or warp.

The small depressions or basins at the surface of the Edwards Plateau probably were formed by meteoric water that dissolved some of the more soluble limestone beds. Water enters a crack or fracture and migrates downward until it encounters a marl bed or a more insoluble bed of limestone and then, moving laterally, forms an underground cave that is overlain with a limestone roof near the land surface. This roof of limestone collapses when it is not strong enough to support itself and thus forms a basin or depression that later becomes partly filled with soil and detrital material.

A large block of Cretaceous rocks, which dip steeply southward toward the Edwards Plateau and which are several feet below its normal position, occurs in sec. 14, block 32, about 4½ miles east of Big Spring. Within a small drainage valley that cuts completely through this block of Cretaceous rocks Triassic sediments crop out at the base of the Cretaceous block as well as on all sides of it. As the Triassic here apparently has no abnormal dip, and as the highly tilted beds of Cretaceous rocks lie on practically flat Triassic rocks, this large block of tilted Cretaceous rocks was possibly brought down by a landslide.

GEOLOGY AND ITS RELATION TO THE OCCURRENCE OF GROUND WATER

The Triassic redbeds or Dockum group, consisting largely of shale, is too impermeable to yield much water. However, some of the sandstone beds in the group yield small quantities of water to wells usually too highly mineralized for domestic use. Near the base of the group a zone of sand that nearly always contains highly mineralized water is reported by drillers to yield fresh water in some places. Well 1 probably was being drilled in the Triassic at the time the water sample shown in the table of water analyses was taken. This water is very hard and unfit for human use. As far as the writers could determine, only a few wells have been reported as containing fresh water from the Triassic and none from the deeper-lying formations. In the Triassic outcrop area most of the ranchers and farmers build surface reservoirs on the Triassic shale to impound surface water for stock use.

The Trinity sand, which consists almost entirely of quartz grains—usually subangular to well-rounded, and loosely cemented by a fine silt or clay—contains considerable amounts of water where the formation is below the water table. But as the interstices are dominantly small, the sand does not transmit water freely.

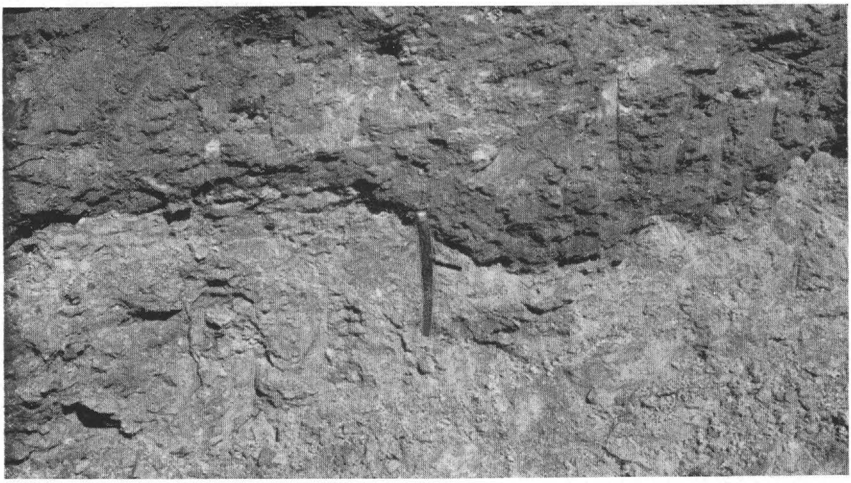
Field analyses of grain sizes of sand samples taken from wells 55 and 61 were made by means of a nest of small screens. Nine samples from well 61, representing the entire Cretaceous sandstone section, and four samples from well 55 were analyzed. The results are given in table 2. These figures show that the predominant grain size is less than 0.43 millimeter. The bed of basal conglomerate was not analyzed because the apparatus used was much too small for the large pebbles in this conglomerate. These pebbles are usually about one-fourth to one-half inch in diameter and are fairly well cemented by a calcareous silty clay.

TABLE 2.—*Field mechanical analyses of sizes of sand grains*

[Percent by volume]

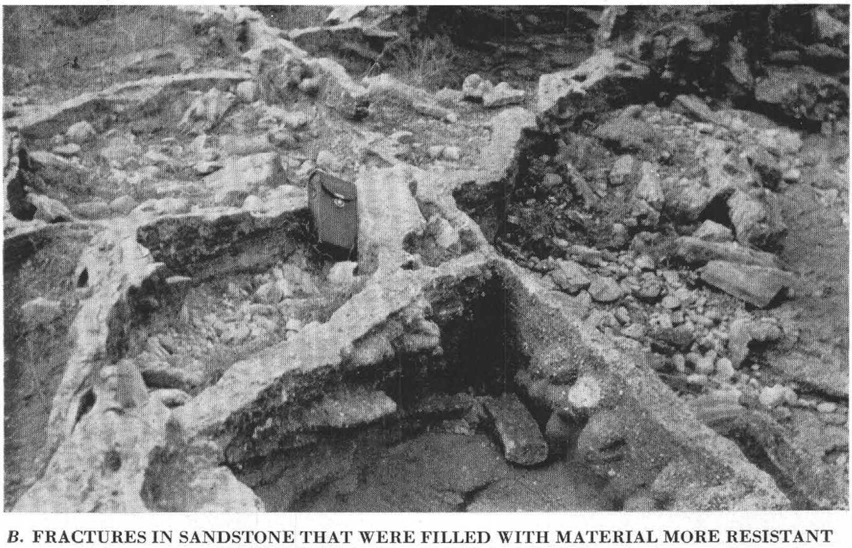
Depth (feet)	Size of sand grains			Depth (feet)	Size of sand grains		
	Larger than 0.43 mm.	0.43–0.23 mm.	Less than 0.23 mm.		Larger than 0.43 mm.	0.43–0.23 mm.	Less than 0.23 mm.
Well 55							
155–176	10	45	45	237–255	20	60	20
176–184	10	45	45	255–260	(1)	(1)	(1)
184–237	15	65	20				
Well 61							
162–175	5	65	30	205–215	10	40	50
175–180	5	55	40	215–225	20	50	30
180–185	5	55	40	225–240	(1)	(1)	(1)
185–192	5	60	35	240–250	35	25	40
192–195	(2)	(2)	(2)	250–259	5	15	80
195–205	5	70	25	259–263	(1)	(1)	(1)

[1] Coarse conglomerate. [2] Fine silty clay.



A. UNCONFORMABLE CONTACT BETWEEN FREDERICKSBURG GROUP AND TRINITY SAND IN NE¼ SEC. 12, BLOCK 33, 2 MILES SOUTH OF BIG SPRING.

Note limestone in upper part of picture. Photograph by A. N. Sayre.



B. FRACTURES IN SANDSTONE THAT WERE FILLED WITH MATERIAL MORE RESISTANT TO EROSION, NOW SHOWN AS RIDGES.

Fractures probably were formed in the Trinity sand in the sinks, but these very likely became filled with sand and other material soon after they were formed. Remnants of these fractures are exposed in a few localities and now exist as narrow ridges because the material that filled the fractures is more resistant to erosion than the surrounding sandstone. (See pl. 7, *B*.) Twelve samples of Trinity sand representing the entire section were collected on the outcrop and sent to the Geological Survey Hydrologic Laboratory for determination of porosity, permeability, mechanical analysis, and moisture equivalent. The results are given in table 3. The average permeability of 9 of the 12 samples for which permeability was determined was 34, and the average porosity of the 12 samples was 41.3 percent.

The limestones are in general too dense to yield water, but where cracks and fissures occur they serve as conduits through which water may be rather freely transmitted. In the sinks, however, numerous cracks and fissures were probably formed when the limestone slumped during the formation of the sink.

TABLE 3.—*Physical properties of samples of Trinity sand collected near Big Spring, Texas.*

[Tests by V. C. Fishel]

Laboratory No.	Field No.	Mechanical analysis (size in millimeters—percent by weight)						Apparent specific gravity	Porosity	Moisture equivalent by volume	Coefficient of permeability
		More than 1.0	1.0–0.50	0.50–0.25	0.25–0.125	0.125–0.062	Less than 0.062				
2295	1	79.8	4.6	6.4	4.4	2.3	2.1	1.81	32.1	6.6	--------
2296	2	.6	2.0	52.3	42.2	1.0	1.0	1.49	45.2	4.2	--------
2297	3	2.7	3.7	28.2	42.0	19.3	3.6	1.54	43.2	4.7	35
2298	4	--------	--------	5.7	46.0	31.9	15.9	1.63	40.2	6.1	9
2299	5	.6	.1	12.4	43.6	23.4	19.1	1.58	40.0	19.3	--------
2300	6	0	--------	8.4	72.9	14.7	3.7	1.50	44.4	5.0	29
2301	7	1.0	.3	30.9	58.8	5.5	2.8	1.51	44.0	6.3	25
2302	8	5.4	3.3	31.8	50.4	6.7	1.0	1.60	40.1	3.9	45
2303	9	--------	.2	29.2	68.6	1.3	.7	1.54	42.4	4.9	90
2304	10	--------	.6	12.8	55.4	13.4	17.2	1.66	37.8	11.1	30
2305	11	--------	--------	1.1	61.6	28.8	8.0	1.54	42.6	9.7	20
2306	12	--------	.1	7.1	62.5	25.0	4.6	1.50	43.8	7.8	22

On February 7, 1938, the writers were lowered by means of a cable into the shaft well, located in the city park, and they noticed from a distance that one large vertical fracture, lined with a crystalline deposit—probably calcium carbonate—was apparently the only irregularity in the limestone along the sides of the shaft. They saw no solution channels. Water was seeping into the well near the top of the nodular zone of limestone at a depth of about 120 to 125 feet below the land surface, and it increased in quantity from that level downward. A large part of the water pumped from this sink probably came from storage in the middle zone of limestone, as the numerous irregular bedding planes would allow many small fractures to form as a result of movement of the limestone.

Marl and clay layers and dense beds of limestone within the Fredericksburg group probably tend to retard most of the meteoric water from migrating down to the water table. The writers saw water running into the solution holes in the Edwards Plateau, but they did not determine whether any of it actually migrated to the water table. It seems quite possible that a large part of the water would seep down until it encountered a layer of clay or a dense bed of limestone and then, migrating laterally, would seep into the soil on the hillsides where the beds are exposed. No water was seen seeping from the limestone, but as drainage might be rapid during and for a short time after rains, it would be difficult to distinguish between surface and subsurface drainage. Samples of cuttings from well 125, drilled in the area containing solution holes, show that the color of rocks is much lighter than in other areas, which indicates that some leaching may have taken place. A small cavity or crevice was encountered in this well at a depth of 59 feet.

The Tertiary and Quaternary deposits in general are too fine and thin to yield much water, but coarse sediments, which were deposited on a very irregular Triassic surface, occur as thick beds in channels and basins at some localities. Wells drilled in these low areas usually yield a greater amount of water per minute than do wells in other areas.

Well 156, in sec. 8, block 34, about 14½ miles south of Big Spring, penetrated 120 feet of sand and gravel of Tertiary and Quaternary age before encountering the red shale of the Triassic. This well yielded about 500 gallons a minute, and inasmuch as surrounding wells not far distant encounter the Triassic at a much shallower depth and are less productive it is reasonable to expect that well 156 is in a buried channel or basin in the Triassic.

A pumping test was made on a well owned by Mr. A. K. Merrick 4 miles northwest of Big Spring. The well yielded about 20 to 25 gallons a minute of moderately soft water. This well probably is also in a buried channel or basin in the Triassic because surrounding wells are reported to be shallower and yield a smaller amount of water.

A few springs are found within the area investigated, although none yields a large amount of water. The spring from which the city of Big Spring was named is on the east edge of the city park sink, but has no flow of water at present. As shown by plate 12, *A*, the upturned beds of limestone and sandstone have been beveled by erosion at the spring site. The water apparently issued near the base of the limestone and not from the sandstone, as the cracks and fractures in the limestone form a more permeable material than the fine sandstone.

Moss Springs, which is about 9 miles east of Big Spring, is in the bed of an intermittent creek that has eroded through the Tertiary and Quaternary deposits into the Triassic shale at the Moss Springs.

site. (See pl. 12, *B*.) Part of the meteoric water falling within the drainage area of this creek and possibly some water that seeps from the Trinity sand migrates down to the impermeable Triassic shale and then moves laterally down the valley until it comes to the surface at Moss Springs, where the top of the Triassic is exposed. The flow of Moss Springs during 1937 was estimated as 50 to 100 gallons a minute, or about 75,000 to 150,000 gallons a day.

None of the other springs along the base of the eastward-facing escarpment of the Edwards Plateau yielded more than 2 gallons a minute. The water from most of these springs was seeping from the Trinity sand at the contact with the Triassic shale. A spring near the site of the old Barnett ranch house seeps from the Trinity sand at a level several feet above the top of the Triassic beds. Erosion has cut a small valley in the sandstone to form this spring.

All the springs seen along the escarpment of the Edwards Plateau occur as seeps and do not issue as a single stream.

SOURCE AND MOVEMENT OF GROUND WATER

A map of the water table in the area covered by this investigation is shown on plate 13. The altitude of the water table in most of the wells was obtained by measuring to the water level with a steel tape from a measuring point at or near the surface of the ground, the altitude of which was determined by instrumental leveling or with a surveyor's aneroid. (See table 8, p. 90.) Lines were then drawn on the map connecting points of equal altitude of the water levels. Ground water moves in the direction of the hydraulic gradient, and its movement in this area is roughly at right angles to the lines of water-level altitudes shown on the map.

WATER IN THE TRINITY SAND

The highest altitude of the water table is near the eastern part of the area enclosed on the map (pl. 13) by the 2,580-foot contour, about 7½ miles south of Big Spring and 2 miles southwest of the section 33 sink. Here the water is less affected by pumpage and by natural drainage than at any other place. The surface of the water table conforms surprisingly closely with the topography in other parts of the area, as for example in the valley traversed by United States Highway No. 87 in northeastern Glasscock County, where the water table is nearly parallel with the land surface. A ground-water divide conforms with the surface-water divide at the head of the valley near Panther Draw School.

The principal source of recharge to the Trinity sand is water from rainfall that seeps downward through the limestone. The rainfall penetration probably is not large, for it is hindered, if not altogether prevented in some of the area, by beds of marl or clay in the limestone or sandstone. In a number of places on the plateau, storm water that accumulates in surface depressions during and immediately after heavy rains disappears into the ground. This water may or may not reach the water table, depending on whether it is easier for the water to move laterally in the limestone to a point of discharge at a lower altitude or to seep down through places where the shale or clay beds are thin or have been fractured.

From the slope of the water table it is inferred that there is little or no recharge to the sandstone on its outcrop along the west escarpment, which is contrary to the belief that was held before the investigation was made. In fact, practically the entire belt of outcrop of the Trinity sand shown on plate 6 is essentially an area of ground-water discharge.

The Trinity sand and the overlying limestone within the subsided areas have dropped and have served as an ideal means of drawing the water from the surrounding sandstone into the sink, from which it can be drawn more rapidly. Considerable storage space for water has been provided in the fractured limestone, and the contact between the sandstone and this limestone affords opportunity for the sandstone to yield its water to the limestone. It is believed that the sandstone within the sunken areas does not contain many cracks and crevices that have not been filled with sand or other material and that the comparatively large yield of the wells in these areas is due to the ability of the limestone to store and transmit water. The water that has been pumped from the sinks has been derived partly from water that has seeped into the sinks locally and partly from replenishment by movement underground from surrounding saturated areas of the sandstone; but a large part of it has come from water that was stored in the sinks before pumping was first started, in cracks and crevices in the fractured limestone, and in interstices in the underlying sand. Surface water, such as waste water from the park swimming pool and liquid waste from several cess pools and pit privies, all within the area of the sink in the city park, may find their way into the water that is being used for the city supply. On February 7, 1938, the shaft in one of the city wells was inspected to a depth of about 180 feet by lowering the writers, one at a time, into the well. It was found that water was running into the shaft at a depth of 123 feet below the surface and that the inflow increased in volume below that level. It was estimated that about 5 gallons a minute were falling into the shaft as spray, but owing to the fact that the lowermost 20 to 30 feet of the shaft is curbed and backfilled with boulders, it was impossible to estimate the total inflow above the water surface. Further evidence of recharge from surface waters in the city park sink is indicated by the fact that the railroad wells in the sink sometimes yield muddy water after heavy rains. Shortly after rains surface water can be seen running into the ground near one of the culverts along the San

Angelo road about half a mile south of well 6. Heavy rains on June 18, 1938, raised the level of the Texas & Pacific Ry. lake high enough to submerge the rocks at the site of the original Big Spring, and a large volume of water ran from the lake into the city park sink. The water level in the sink rose 6.6 feet from May 3 to June 29, 1938, but considering the rate of pumping from the sink the water should normally have fallen from 2 to 3 feet during this period.

Artificial recharge to the sinks does not offer enough promise to be discussed in this report.

Undoubtedly, the amount of water stored in the Cretaceous sandstone south of Big Spring is sufficient to supply the city for many years. But the limiting factor is the amount of water that can be recovered by wells at a practicable cost, and this depends on the capacity of the sandstone to transmit water under a moderate hydraulic head from surrounding areas to the individual wells or well fields. The sandstone is fine and has a low coefficient of permeability. The natural hydraulic gradients are relatively low, and the gradients that can be developed by lowering the water levels in the wells by pumping are not great. Most of the water would probably have been removed by natural drainage long ago if the sandstone were coarse and its coëfficient of permeability high.

WATER IN THE TERTIARY AND QUATERNARY DEPOSITS

The district west of the outcrop area of the Cretaceous rocks in Howard County and the northern part of Glasscock County and the region west and north of Big Spring belong to the High Plains, which is covered in most places with a mantle of silt, clay, sand, and gravel that belong mostly to the Tertiary deposits. Wells in these deposits supply water to the farms and ranches for domestic use and stock and in some places for the irrigation of small gardens. They furnish the public water supplies of Stanton (population 1,384, 1930), 20 miles west of Big Spring in Martin County, and Lamesa (population 3,528, 1930), 44 miles northwest of the city in Dawson County, and provide water for drilling in the west pool of the Big Spring oil field. The farm and ranch wells yielding only a few gallons a minute are pumped with a windmill or small gasoline engine. According to reports, a city well at Stanton has a yield of 150 gallons a minute with a draw-down of about 16 feet, the three wells at Lamesa have a combined yield of 460 gallons a minute, and the wells in the oil field a yield of 20 to 30 gallons a minute each.

Mimeographed bulletins giving the results of the water-well inventories of the Works Progress Administration in Howard,[25] Glasscock,[26]

[25] Samuell, J. H., Records of wells, etc., in Howard County, Tex.: Texas State Board of Water Eng., Apr. 10, 1937, (mimeographed).

[26] Lang, J. W., Records of wells, etc., in Glasscock County, Tex.: Texas State Board of Water Eng., Nov. 22, 1937 (mimeographed).

and Martin [27] Counties, contain descriptions of several hundred wells in the Tertiary, together with water analyses and a map showing the location of the wells. A mimeographed paper on wells and springs in Dawson County [28] made in connection with the regular program of the Geological Survey in cooperation with the State Board of Water Engineers has also been released.

The water supplies in the Tertiary and Quaternary were studied in the course of the Big Spring investigation. Some work was done in Howard County north of the Texas & Pacific Ry., and special attention was given to the district southwest of Big Spring in the southern part of Howard County and the northern part of Glassock County. From information that is now available, it appears that generally in this part of the High Plains the Tertiary and Quaternary deposits are not very thick and that ordinarily only a small part of the formation is saturated. In a few places, however, the saturated zone is fairly thick either because the deposits themselves are thicker than the average or because the water table is higher. Two areas in the vicinity of the west pool of the Big Spring oil field near Lees, in which the deposits are exceptionally thick, were found from a study of the logs of oil tests. One of these areas, southwest of Lees, occupies a low place in the underlying redbeds that in part, at least, is a structural depression; the other, north and northwest of Lees, closely parallels the Howard-Glasscock County boundary and apparently occupies an old stream channel on the surface of the redbeds. These depressed areas are discussed in the section on geology (p. 21), and their approximate location is partly shown in plate 10 by contours drawn on the surface of the redbeds.

Three test wells were put down during the investigation in the vicinity of Lees. Well 192, which was put down about 1 mile southwest of Lees, penetrated a thickness of 280 feet of Tertiary and Quaternary deposits consisting mostly of clay and produced water of poor quality. Well 193, the second test well, which was drilled 2½ miles southwest of Lees, penetrated Tertiary and Quaternary deposits consisting partly of gravel and sand and reached the redbeds at a depth of 109 feet. Well 180, the third test well, located about 4 miles southwest of Lees, reached the redbeds at a depth of 122 feet after penetrating about 22 feet of Tertiary and Quaternary deposits and 100 feet of Trinity sand. These tests indicate that the depressed area is much smaller than had been thought from a study of the oil tests alone and that the eastern part of it would not be expected to

[27] Lang, J. W., Records of wells, etc. in Martin County, Tex.: Texas State Board of Water Eng., July 1936 (mimeographed).

[28] Cumley, J. C., Records of wells, etc. in Dawson County, Tex.: Texas State Board of Water Eng., Dec. 10, 1938 (mimeographed).

yield much water. However, the western part, shown on the map centering in sec. 21, block 34, has an area of at least 1 square mile.

It is estimated from well logs that in the middle of the area the Tertiary and Quaternary sediments have a thickness of about 150 feet and are underlain by about 270 feet of Cretaceous rocks. Moreover, the limestones in this part of the area are possibly fractured, as they are in the city park and section 33 sinks, and the limestones together with the underlying Trinity sand and overlying Tertiary and Quaternary deposits would yield a comparatively large amount of water. There are two water wells in this part of the area: Well 179 is used for stock and well 180 to supply water for drilling oil wells. Both yield water of good quality. However, as the center of the depressed area is occupied by a part of the west pool of the Big Spring oil field there is serious danger that the ground water eventually will be contaminated by salt water from oil-field operations.

The location of the depressed area north of Lees is only partly known. It seems to be in the form of a narrow trough several miles long and probably is not more than half a mile wide north of Lees, as it is bounded on the north by the closely adjacent Cretaceous outcrop. (See pl. 6.) Farther west it may be somewhat wider. One test well (149) was put down about 2½ miles west of Lees with a view to locating the depression and determining the thickness and character of the underlying materials. This well penetrated 82 feet of Tertiary and Quaternary deposits, of which 34 feet were saturated, before reaching the redbeds. (See well log, p. 85.) This well, like a dozen or more others in the vicinity, yielded water of good quality. Part of this area north of Lees, however, like a part of the one southwest of Lees, is occupied by the oil field, and the water in several wells in the vicinity of Lees already has been contaminated by salt water from the oil field operations and is no longer fit for use. Farther west there is less danger of contamination, and if the trough is very wide a water supply of considerable magnitude might be obtained from the sands and gravels in it. It has therefore been suggested elsewhere in this report that another test well be put down in this area.

An area was found about 8 miles west of Lees and 14½ miles southwest of Big Spring where the zone of the saturated part of the Tertiary and Quaternary is unusually thick and the permeability of the sands and gravels exceptionally high. The G. T. Hall well (156) is in this area. In a pumping test of several hours in October 1937 this well had an average yield of about 550 gallons a minute. The water, which was rather highly mineralized, varied materially in mineral content during the pumping, the chloride ranging from about 120 to about 180 parts per million and the hardness from about 400 to about 500 parts per million. The results of a complete analysis of a sample of water taken during the test (see table 9, p. 108) gives the fluoride as

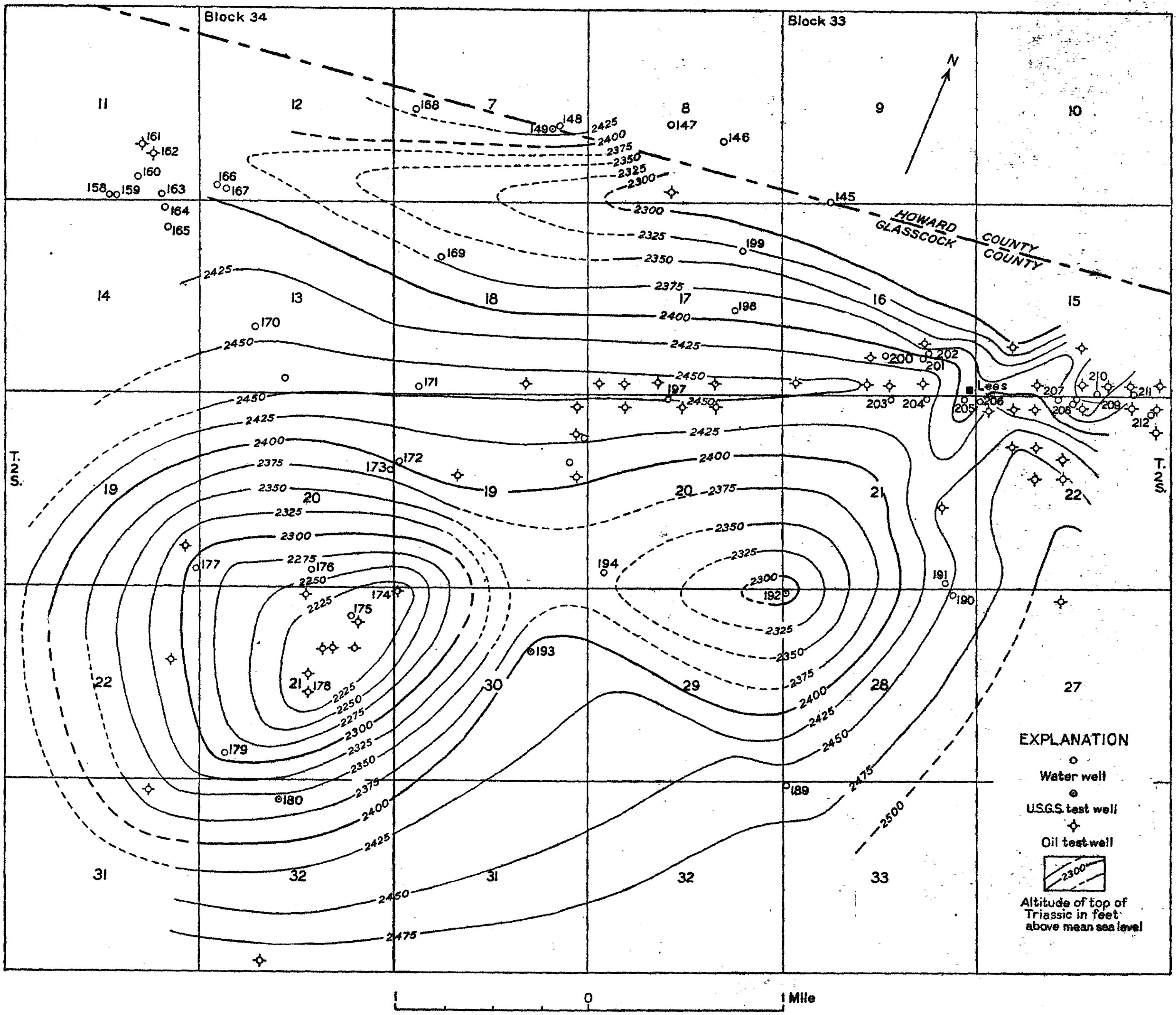
2.4 parts per million, which is above the generally accepted limits of safety.

A pumping test was made on one well owned by A. K. Merrick in the Tertiary and Quaternary deposits just east of the sand dunes about 2½ miles northwest of Big Spring post office. The well yielded 20 gallons a minute for a time, but the water in it was soon pumped down to the level of the redbeds. In most of the district in Howard County north of the Texas & Pacific Ry. the mineral content of the well water varies materially within short distances and in many of the wells is so highly mineralized that it would not ordinarily be considered acceptable as a public water supply. However, in the northwestern part of the county between Fairview and the Howard-Borden County boundary the mineral content of the water in most of the wells is relatively low. In that district the wells for which information is available are used for domestic purposes and stock, and drilling of the wells was stopped as soon as the small supply required was developed. The total thickness of the Tertiary and Quaternary therefore is largely a matter of speculation. A recent investigation has shown that this is also true in the southeast corner of Dawson County, which borders Howard County at the northwest corner. The city wells at Lamesa, located near the center of Dawson County, are reported to have penetrated 150 to 200 feet of sand, silt, clay, and caliche before reaching the redbeds, of which 60 to 80 feet were saturated. The city pumps five wells. Four are at the city hall, near the west boundary of the city, and the other is at the courthouse about 1 mile away, near the center of the city. According to city records, the average daily pumpage from January to June 1938, inclusive, was about 350,000 gallons a day, and the average from June to August 1936, inclusive, was about 400,000 gallons a day. No records are available for the pumpage during the summer of 1937.

In an area of about 5 square miles northwest, west, and southwest of Luther, 13 miles north of Big Spring, are five wells in which the average depth to the redbeds is 166 feet and the average thickness of the saturated part of the material is 30 feet. All are farm wells and none have been given adequate pumping tests. One of the wells is reported to have yielded 20 gallons a minute in a bailer test. All wells near Luther seem to yield good water.

As much as 40 to 50 feet of saturated material is reported in some of the domestic wells at Ackerly, in Dawson County, about half a mile west of the northwest corner of Howard County. One of the wells in this locality is reported to have yielded 30 to 35 gallons a minute in a bailer test. Ackerly is served by individual windmill wells.

In a few localities near Stanton, in Martin County, the saturated part of the sediments is thicker and more permeable than in most of this part of the High Plains. The well waters however are of variable



MAP SHOWING BY CONTOUR LINES THE TOP OF THE TRIASSIC SYSTEM IN PART OF NORTHERN GLASSCOCK COUNTY.

quality. Partial analyses of samples from about 70 wells in the Stanton district are given in the Works Progress Administration report. More complete analyses of water from four of the wells give fluoride content as well as other dissolved constituents. In three of the wells the fluoride is objectionably high. Moreover, when the results of all the analyses are plotted on the well map for Martin County it is found that nearly every one of the exceptional wells that yield water of moderate mineral content is closely surrounded by wells that yield rather highly mineralized water. The water from the city well at Stanton is somewhat high in sulphate, chloride, hardness, and total dissolved solids. It also contains fluoride in quantities that exceed the safe limit, but so do many of the other large public water supplies throughout the High Plains in Texas. Although the well water appears to be uniformly rather low in dissolved solids in an area of several square miles about 12 miles north of Stanton, in Martin County, in the two wells of the area for which fluoride determinations have been made the fluoride content is somewhat above the limit of safety.

PUMPAGE AND ITS EFFECT ON THE WATER TABLE

CITY PARK SINK

Water has been pumped from wells in the city park for many years by the city of Big Spring and the Texas & Pacific Ry. Co. The pumpage from the city-owned wells has been intermittent and irregular, depending on the demand for water. The railroad company's wells have been pumped 24 hours a day, and pumps have been stopped only for repairs. The combined discharge from the two city wells (12 and 16) was measured as 160 gallons a minute on July 31, 1937, and the combined discharge from the three wells of the Texas & Pacific Ry. Co. (17, 18, and 19) was measured as 110 gallons a minute on July 14, 1937. Table 4 includes the estimated amount pumped from the city wells each month from May 14, 1937, to January 30, 1938, and the amount pumped from the railroad wells each month from January 1933 to April 1938.

TABLE 4.—*Estimated pumpage in the Big Spring area, Texas*

[In thousands of gallons]

Date	Metered consumption [2]	City of Big Spring			Texas & Pacific Ry.[1]	
		Wells in city park	Well fields in secs. 17 and 18	Well field in sec. 33	Wells in city park	Lake
1932						
April	13,847					
May	10,817					
June	13,445					
July	14,768					
August	15,615					
September	11,312					
October	9,776					
November	9,649					
December	9,980					

See footnotes at end of table.

TABLE 4.—*Estimated pumpage in the Big Spring area, Texas*—Continued

Date	City of Big Spring				Texas & Pacific Ry.[1]	
	Metered consumption [2]	Wells in city park	Well fields in secs. 17 and 18	Well field in sec. 33	Wells in city park	Lake
1933						
January	9,247				4,500	
February	11,138				6,300	
March	8,052				5,000	
April	11,666				5,250	
May	13,209				6,150	
June	15,601				None	
July	15,415				None	
August	16,236				None	
September	10,470				5,600	
October	12,094				5,600	
November	10,009				5,770	
December	9,830				2,770	
1934						
January	9,827				5,148	None
February	10,804				4,570	None
March	10,403				5,046	None
April	11,989				4,818	
May	18,136				4,060	
June	22,221				4,290	None
July	19,553				3,700	None
August	21,667				4,440	None
September	19,067				4,270	None
October	17,770				3,998	None
November	16,230				3,946	1,300
December	12,152				4,780	3,700
1935						
January	12,312				1,500	3,710
February	11,895				525	3,300
March	11,239				500	3,600
April	15,679				5,148	None
May	15,583				4,550	400
June	15,202				840	3,800
July	18,727				315	3,250
August	23,428				350	3,250
September	15,461				770	3,000
October	14,474				510	400
November	12,444				490	3,400
December	11,884				400	3,620
1936						
January	13,802				930	3,250
February	12,500				1,560	2,500
March	14,805				4,350	None
April	20,774				4,260	None
May	20,796				3,390	940
June	20,452				1,560	3,900
July	27,207			[3] 15,155	3,000	285
August	29,936			30,051	3,180	2,000
September	25,512			22,417	3,990	1,052
October	15,212			15,235	1,380	3,750
November	14,229			14,445	1,380	3,860
December	13,477			14,480	1,440	4,980
1937						
January	13,677			17,945	2,250	4,680
February	13,231			17,625	2,363	4,440
March	12,826			19,085	2,808	4,680
April	17,286			23,620	2,232	4,800
May	21,529	[4] 1,700	[5] 1,484	23,948	2,840	4,380
June	23,439	4,700	5,682	27,947	2,940	4,920
July	27,445	6,900	9,283	25,481	3,300	5,064
August	33,552	6,100	10,270	25,501	3,900	4,500
September	22,972	6,400	7,262	23,024	3,600	4,100
October	18,683	6,900		16,632	3,900	4,400
November	16,547	6,800		11,263	4,200	4,250
December	13,881	5,200		9,911	4,200	4,100
1938						
January	14,550	3,400		11,799	3,750	4,800
February	15,387			10,840	3,390	3,700
March	16,219			11,317	3,780	3,850
					3,720	3,580

[1] Data furnished by Texas & Pacific Ry. Co.
[2] Does not include water used in city park, in irrigating golf course, flushing hydrants, and fire protection. Data furnished by city water department.
[3] July 16–31. [4] May 14–31. [5] May 20–31.

A water-stage recorder was maintained on well 14 in the city park from May 14, 1937, to February 8, 1938. The record shows that the water table in this well fluctuates widely with the rate of pumping from wells 12 and 16 located at a distance of about 280 and 290 feet, respectively. As the recorder float and counter-weight were caught at times in this well, which is not exactly vertical, the water-level record is not complete.

On the morning of June 1, 1937, the water level in well 14 stood about 159.5 feet below the measuring point; about 7½ months later, on the morning of January 18, 1938, it stood about 190.35 feet below the measuring point, or about 30 feet lower than it was on June 1, 1937. Prior to the first measurement, the city wells had not been pumped for approximately 5 days and the pumps on the wells of the Texas & Pacific Ry. Co. had been shut down for nearly 2 days. With regard to the second measurements, the motor on well 16, one of the two pumped by the city in this sink, was out of order from December 14, 1937, to January 21, 1938, so that the well was not pumped during that time. The pump in the other city well (12) was not used from January 12 to 18, 1938. No record is available as to the pumpage from the wells of the Texas & Pacific Ry. Co. just prior to January 18. However, the graph obtained by the recorder shows that starting and stopping the pumps in the railroad wells does not affect the water level in well 14 more than a few tenths of a foot.

The estimated combined pumpage from the railroad and city wells during the period between the measurements amounted to about 72,000,000 gallons, or an average of 300,000 gallons a day. Cummins[29] states that in 1891 the spring yielded 100,000 gallons of water a day. (See p. 4.) This may have represented approximately the average rate of underflow to the sink at that time and may be close to the present rate of underflow. If so, two-thirds of the water that was pumped from the sink during the months between the measurements came from storage within the sink. If no more water were pumped from the park sink the water would rise, over a period of years, to a level where the spring would begin to flow again.

WELL FIELD IN SEC. 18

The wells in this field have rather small yields. The field was practically abandoned several years ago on this account and because the pumping had caused a pronounced decline in the water table. Some of the lost head apparently had been recovered when this investigation was started. Three of the wells (33, 34, and 35) were cleaned out and put back in service during the summer of 1937. Pumping from well 33, however, was discontinued later in the year.

[29] Cummins, W. F., Report on the geography, topography, and geology of the Llano Estacado or Staked Plains, in Dumble, E. T., and others, Texas Geol. Survey 3d Ann. Rept., p. 177, 1891.

Although the yield from these wells amounted to about 14, 60, and 75 gallons a minute, respectively, in June 1937, the yield declined to about 25 gallons a minute from wells 34 and 35 in January 1938. Wells 34 and 35 were pumped almost continuously from June 1937 to June 1938, and the decline of the water table in well 31, about 900 feet northwest, amounted to about 4 feet during this period.

WELL FIELD IN SEC. 17

Drilling of wells was gradually extended from sec. 18 farther eastward as the yield from wells in use decreased until, in about 1925, drilling of wells was begun in the southeastern part of sec. 17. In all, over 30 wells have been drilled in the field, which covers part of secs. 16, 17, 20, and 21. (See pl. 13.) As these wells do not yield much water, many of them have been abandoned. Most of those that are now in use yield, on an average, about 15 to 20 gallons a minute, but a few yield 20 to 30 gallons a minute, and well 55, the best well in the group, yields 40 to 50 gallons a minute. Several of the wells are equipped with reciprocating pumps that are not frequently used because of the difficulty of keeping the machinery repaired and in operating condition. Table 4, showing estimated pumpage, indicates that between May 20 and September 30, 1937, the pumpage from this field together with that from the three wells in sec. 18 and three new wells that were drilled in sec. 21 during 1937 amounted to about 34,000,000 gallons, or about 250,000 gallons a day. Lowering of the water table in this field since pumping was first started has amounted to a maximum of about 10 feet. (See pl. 13.)

WELL FIELD IN THE SINK IN SEC. 33

The main source of the Big Spring water supply since about 1929 has been from the sink that centers near the northeast corner of sec. 33. Plate 10 shows the extent and shape of this slumped area by structure contours drawn on the base of the Trinity sand, and plate 9 shows a cross section of the sink in the geologic section.

The first test well drilled in the sink was begun under the direction of Hawley, Winton, and Alexander[30] during 1928. They state in their report to the city that water was encountered at a depth of 60 feet below the surface, or at an altitude of about 2,560 feet above mean sea level. As the base of the limestone in the center of the sink is at an altitude of about 2,430 feet, about 130 feet of the limestone in that part of it was then below the water table. Before wells were drilled in the sink and pumped, the water table in it probably sloped gently toward the east and was not depressed as it is now. The altitude of the water table in the sink in 1928 probably

[30] Hawley, J. B., Winton, W. M., and Alexander, C. L., Big Spring wate urvey; unpublished report, 1928.

represented a level that was largely controlled by a small amount of discharge into a creek east of the sink. The altitude of this creek bed is about 2,560 feet at a point about one-fourth of a mile east of well 71.

Water was pumped from the sink in wells 74, 75, 76, 80, 86, and 87 during 1937. Five of the six wells were pumped at the same time to supply enough water for the booster pump, and the number of hours of pumping each day varied with the demand. The rate of pumping ranged usually from 1,000 to 1,100 gallons a minute depending on the combination of wells in use. The effect of this pumpage on the water level in the unused wells 67 and 88 was registered by water-stage recorders. (See fig. 3, B, C.) The hours of pumping and the amount pumped during this period are given in table 5. These two wells are about 800 feet west and 1,200 feet northeast, respectively, from the nearest pumped well. A water-stage recorder was also maintained for a few weeks in wells 72 and 79, but the fluctuations of the water level varied so rapidly and so widely that the charts could not be used. The change in the water level in well 72 amounted to about 6 to 10 feet and the change in well 79 amounted to about 20 feet every time the pumps were started or stopped. These wells are very close to the pumped wells.

TABLE 5.—*Daily pumpage from the section 33 sink September 17 to October 1, 1937* [1]

Date	Well pumps		Estimated amount of water pumped per day	Remarks
	Started	Stopped		
Sept. 17	6:30 a. m.	8:30 p. m.	835,000	
18	6 a. m.	7:45 p. m.	919,000	
19	5:30 a. m.	2:30 p. m.	630,000	
20	6:30 a. m.	5:30 p. m.	739,000	
21	6 a. m.	6:45 p. m.	849,000	
22	8:15 a. m.	7 p. m.	851,000	
23	6 a. m.	4:45 p. m.	520,000	Pump not run 2½ hours during day.
24	6:30 a. m.	4:45 p. m.	678,000	
25	6:30 a. m.	5 p. m.	425,000	Pump not run 4 hours during day.
26	7 a. m.	4:15 p. m.	442,000	Pump not run 2½ hours during day.
27	7:30 a. m.	5 p. m.	489,000	Pump not run 2 hours during day.
28	7:15 a. m.	5:15 p. m.	654,000	
29	7 a. m.	7 p. m.	804,000	
30	6:45 a. m.	10:30 p. m.	667,000	Pump not run 5½ hours during day.
Oct. 1	5:45 a. m.	8:15 p. m.	966,000	

[1] Yield ranged from 1,000 to 1,100 gallons a minute.

The record of water levels and pumpage data were studied to select a period that would indicate the rate at which the water level in the sink is being lowered. As the sink had not been pumped for several days prior to February 9, 1937, and also prior to January 30, 1938, the water level at the center of pumpage on these days probably had recovered from most of the direct effect of pumping. The net loss of static water level near the center of the sink between these dates amounted to about 10 feet. The total amount of water pumped from

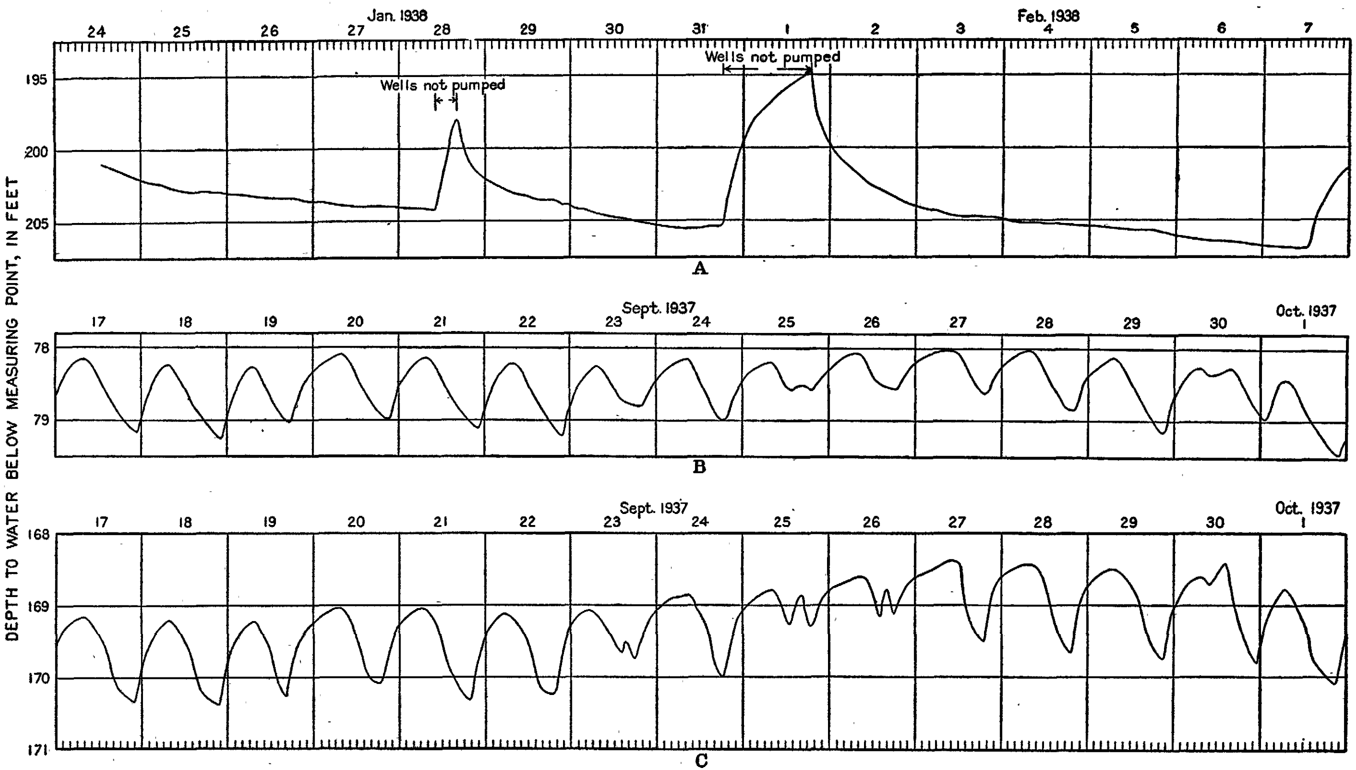


FIGURE 3.—Graphs made by recording gages showing the effect of pumping on the water table. A, Well 14, in city park; fluctuation due to operation of pumps in wells 12 and 16, which yield a total of 160 gallons a minute. B, C, Wells 67 and 88; fluctuation due to pumpage from section 33 sink.

the sink during the same period has been estimated as 710 acre-feet or an average of about 650,000 gallons a day. (See pl. 14.) The water level near the center of the sink has fallen about 65 feet from the original level during the 9 years since pumping was started, which is about 7 feet a year. Undoubtedly the average daily pumpage since 1929 was less than it was in 1937.

As the movement of water to wells in the sink in sec. 33 is very complicated, available data are insufficient to compute accurately the amount of underflow to the sink or the effective porosity of material unwatered. When pumping first began in 1929 the water level in the sink stood at an altitude of approximately 2,560 feet, and in January 1938 it stood about 65 feet below that altitude. During the time that the water level was being lowered some water was taken from storage within the limestone in the sunken area. A steeper hydraulic gradient was formed in the sandstone surrounding the sink; and considerable water was furnished from storage in the sandstone that lies more or less in normal position. There are not enough wells to define accurately the extreme limits of the sink; and little information is available as to the position of the sandstone around the periphery of the sink, but probably the displacement is comparatively abrupt along the south end and more gradual at the north and northeast sides.

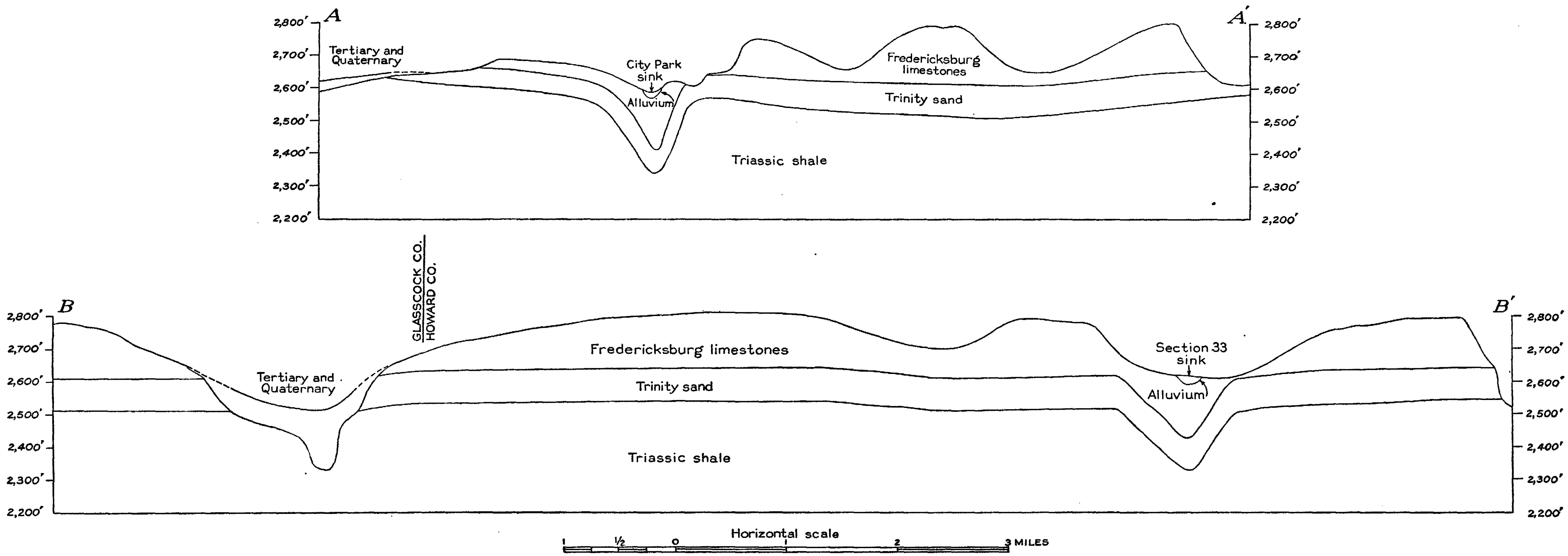
As the center of the water-table depression is south of the center of pumping, the amount of underflow probably is less from the south than from around the north side, where the slope of the sandstone is more gradual. A continuous bed of sandstone dipping into the sink from the north might contribute considerable water because of a greater saturated thickness of sand. The sink acts somewhat like a gravel-walled well under water-table conditions in that the fine sand yields water to the more permeable limestone, from which it is readily recovered; and, too, as the water table is lowered in a well the effective surface of the water-bearing sand in the well becomes less. The hydraulic gradient is increased toward the sink as the water table is lowered and increases the flow toward the sink; but, on the other hand, the saturated part of the sand in contact with the limestone decreases as the water level is lowered, and this effect probably partly offsets the increase that is due to a steeper gradient. It is believed, therefore, that in the future the water level will drop more rapidly with an equal rate of pumpage than it has dropped in the past.

The data regarding the altitude of the present water table in the outer part of the depressed area are not available in sufficient detail to warrant an estimate of the total unwatering that has taken place in both the limestone and the sandstone. Fairly reliable data are available, however, concerning the altitude of the water table within the limestone, as well as the shape and extent of the limestone, which covers an area of about one-fourth of a square mile within the sink.

The shape of the water-table depression in the sink as of January 30, 1938, is shown by plate 15. By superimposing plate 15 on the map of the surface of the Triassic in the sink shown in plate 10 and allowing 100 feet for the thickness of the sandstone, a fairly good idea was obtained regarding the amount of unwatering of limestone that took place from 1929 to 1938.

It is estimated that within that area the volume of limestone below the original water level amounted to about 10,800 acre-feet, that the volume unwatered since 1929 has amounted to about 8,300 acre-feet, that the volume unwatered from February 9, 1937, to January 30, 1938, amounted to 900 acre-feet, and that approximately 2,500 acre-feet are still saturated. The amount of water removed from storage and the amount remaining cannot be estimated because the ratio of the open spaces in the limestone to its volume is unknown. As the comparatively high yield of the wells in the sink depends largely on the amount of limestone lying below the water table, if nearly 1,000 acre-feet of limestone is unwatered each year and only 2,500 acre-feet of limestone lies below the water table, it will obviously not be many years before the yield from these wells will decrease rapidly. The limestone rests upon a cuplike base of sandstone, and as the water table declines a line representing the outer edge of the saturated limestone moves toward the center of the sink. The outer dashed line encircling the center of the sink (pl. 15) represents the edge of the saturated limestone on February 9, 1937, and the inner dashed line represents the edge on January 30, 1938. The drop of the water table amounted to about 10 feet during the period. The water level, near the center of pumpage on the latter date (see pl. 15), which stood at an altitude of about 2,495 feet, indicates that in that part of the sink the water table is still about 65 feet above the base of the limestone.

The rate of the inflow to the sink depends on the cross-sectional area of the material through which the water moves, on the hydraulic gradient, and on the permeability. Considering the section 33 sink, well 95 is probably just outside the sunken area, and it shows that about 40 feet of sand lies below the water level. Well 65 is in about the same position relative to the sink and has about 30 feet of sand below the water table. An imaginary line drawn just outside the limits of the sunken area, where approximately 40 feet of sandstone lies under water was found to be about 5 miles long. The water, therefore, moves into the sink through a cross section about 40 feet thick and 5 miles long, and the hydraulic gradient at right angles through this section has been estimated to be 30 feet to the mile. The average permeability of nine samples of the Trinity sand, as



GEOLOGIC SECTION IN HOWARD AND GLASSCOCK COUNTIES.

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determined in the Geological Survey Hydrologic Laboratory at Washington, was about 34. That is to say, 34 gallons a day will flow through a cross section 1 foot high and 1 mile long with a hydraulic gradient of 1 foot a mile. Under these conditions the flow into the sink would be 40 by 5 by 30 by 34, or about 200,000 gallons a day.

Wells in the sink have been drilled to the bottom of the Trinity sand. Water is yielded by the sandstone and the limestone, but most of the water probably comes through the limestone. The limestone at the wells becomes unwatered as the water level falls and more burden is thrown upon the sandstone to maintain the yield, which for some of the wells is from 200 to 300 gallons a minute. In some of the wells that yield water from the Trinity sand in the Big Spring area, especially in the sink in sec. 33, when the water level is pumped down and a steep hydraulic gradient toward the well is created, the sandstone does not stand up well and caving is not uncommon. It appears then that, as more demand is made on the sandstone in the water-bearing beds within the pumped part of the sink, considerable trouble will be experienced in keeping the wells free from sand. The wells cannot be expected to yield as freely as they yield now after the water table has fallen below the limestone, and if pumping is attempted at 200 to 300 gallons a minute they may collapse or yield a large amount of sand. Pumping from the sink should be reduced as soon as possible.

OTHER AREAS

Considerable water is pumped in the Big Spring oil field, in northern Glasscock County. The wells are scattered over a rather large area and the total average withdrawals probably are not more than about 100,000,000 gallons a year, or an average of about 300,000 gallons a day. The largest single water station is owned by the Continental Oil Co. and is just east of United States Highway No. 87, close to the Howard-Glasscock County line. It yields an aggregate of about 100 gallons a minute from several wells.

The volume of water pumped from ranch wells, which are widely scattered, is comparatively small.

WELL-DRILLING METHODS

Most of the water wells in the vicinity of Big Spring have been drilled with cable tools. The Cretaceous limestone and sandstone can be drilled more readily with such tools than with the rotary tools that are sometimes used to advantage for sinking wells in the sands, gravels, and clays of Tertiary and Quaternary age. Wells in these deposits, however, are usually shallow, many of them less than 100 feet deep, and are usually drilled with cable tools. In the early stages of well development little effort was made to drill the wells straight and almost all of the old wells in the well field in sec. 17 are so crooked that pumps operated in them wear rapidly and give considerable trouble.

According to local well drillers and pump operators, the Trinity sand ordinarily stands up fairly well and does not cave very much. Usually a short length of casing at the top to keep surface dirt out is all the casing that has been considered necessary. If dynamite is exploded in a well in the sandstone, complete removal of the material that caves in is difficult. Wells that have been shot seem to cave frequently when pumped, and in some of these wells caving has been so serious that the slotted pipe used for pump strainers has been clogged, the well filled with sand, and the yield from the well decreased to practically nothing.

Work was begun about November 1, 1937, on well 55 in the southeast corner of sec. 17 to determine if an increase in the yield could be obtained by converting an ordinary straight-wall well into a gravel-wall well. This well was 260 feet deep and penetrated about 100 feet of sandstone, the bottom of which was about 40 feet below the static water level. It was cased with 40 feet of 10-inch slotted pipe and, above this, with 12-inch blank pipe. According to reports, the yield of the well was about 125 gallons a minute for a few minutes when pumping started, but it soon declined to a much smaller amount. In October 1937 the yield was estimated to be about 40 gallons a minute, with a draw-down of about 40 feet.

The process of converting this well was as follows: The casing was loosened with a pair of jacks, one with a lifting capacity of 50 tons and the other of 75 tons, and was then pulled out with a cable-tool rig. (See pl. 16, *A*.) The well was then cleaned out and drilled to a depth of 277 feet, after which 10-pound shots of 60-percent dynamite were discharged successively at the 260-, 255-, 250-, 246-, 240-, 235-, and 230-foot levels and a 5-pound shot was discharged at the 225-foot level, the well being cleaned out with a 6-inch plunger-type sand bailer after each shot. About 30 cubic yards of material was loosened and removed by this method. The well was allowed to stand for about 2 weeks, during which no appreciable caving occurred, and it was then cased from top to bottom with 8-inch casing, the 40-foot section from the 220- to the 260-foot levels being slotted. The slots were cut with a torch lengthwise of the pipe. They were one-eighth of an inch wide, 12 inches long, 2¾ inches apart, and had 4-inch blank spaces between the ends of the slots. The slots were so arranged that the blank spaces did not come opposite each other in adjacent rows. After the casing was set the annular space between the casing and sides of the well was filled with hard well-rounded limestone gravel of uniform size. The gravel had been screened by hand until it passed a three-eighths inch mesh wire screen and was retained on a one-fourth inch mesh, mesh measured center to center. (See pl. 16, *B*, *C*.) The gravel was poured into the annular space through a 2-inch pipe extending from the surface to the bottom. At the top of the pipe was a funnel, 24 inches in diameter with a 1¾ inch straight side and a bottom sloping at an angle of 45° to an inside diameter of 2⅜ inches, fitted closely around the outside of the 2-inch pipe for a distance of 4½ inches. The weight of the funnel loaded with gravel rested on a 2-inch saddle clamped to the pipe just below the funnel. The gravel was admitted to the pipe through two slots 1½ inches wide by 5 inches long, cut on opposite sides of the pipe, the effective sizes of the openings being adjusted by moving the funnel up and down along the pipe. A stream of water amounting to about 15 gallons a minute that was fed into the 2-inch pipe above the slots helped to feed the gravel and acted as a lubricant for the gravel passing into the well. The lower end of the 2-inch pipe was provided with a piece of 1¾-inch strap iron that extended in a loop about 15 inches beyond the end of the pipe to which it was welded. The function of the strap iron was to take some of the weight off the 2-inch pipe as it was lowered, and thus to indicate the top of the gravel and how fast the well was filling. The strap iron was a little too short to prevent clogging the pipe with gravel; it should have been 10 to 15 inches longer. The pipe clogged with gravel a few times but was freed by a little shaking and pounding on the pipe. About 17½ cubic yards of gravel were placed on the first day and 15½ cubic yards on the second. This filled the space around the casing to a level about 75 feet above the bottom of the well. A few days later 7 cubic yards of gravel were added, making a total of 40 cubic yards, and this filled the space to a level within 10 feet of the surface. About 32 cubic yards of the gravel were placed below the static water level (at a depth of 220 feet), or an average of three-quarters of a cubic yard to each linear foot. The well filled rapidly above that depth, indicating that very little material had been loosened and removed. Fifty pounds of chloride of lime in dry form were added to the gravel to sterilize it as it passed through the funnel.

After the gravel-walling process was completed a pumping test was made with a deep-well impeller-type pump, which was set so that the lower end of the suction pipe was about 260 feet below the top of the well. The pump discharged about 150 gallons a minute for about 20 minutes and then began to draw air, after which the discharge dropped to about 100 gallons a minute and remained at that rate for about 8 hours. The test was continued for a total of 48 hours, at the end of which it was necessary to stop the pump for other reasons. The water levels in wells 53 and 56, 300 and 500 feet away, respectively, did not lower appreciably during the 48 hours of the test. Later the well was placed in service, and after several weeks of continuous pumping the yield had gradually decreased to an amount that was estimated at about 50 gallons a minute, or only about 10 gallons more than the yield before the well was converted. So far as the yield was concerned it was not worth while to gravel the well, but at any rate there is now no danger that the well will cave in or pump sand. The gravel serves to keep the well from caving against the well screen and clogging it and also to keep the sand far enough away from the screen so that the velocity of the water entering the well will be too low to carry the sand with it. Other things being equal, it should be possible to place gravel in other wells belonging to the city at a materially lower cost than was incurred for well 55 because of the experience gained in buying gravel and the improvement in technique as more experience is gained.

Much trouble has been reported with caving sand during drilling in the section 33 sink, and caving has occurred from time to time while the pumps were in operation. More and more trouble of this kind is to be expected. As the water level is lowered in the sink the limestone is unwatered, which makes it necessary to obtain a larger percentage of the supply from the sand. If a program is not worked out whereby pumpage from the sink can be greatly reduced during the next 2 years, plans should be made to convert the wells into the gravel-wall type similar to well 55, or at least to case them.

Earlier in this report it has been pointed out that a favorable location for additional development of ground water from the Trinity sand is near the northwest corner of sec. 45, about 2 miles southwest of the section 33 sink. It is suggested that this area be developed in one of two ways, depending on the relative costs and practicability of the two methods and the rate of withdrawal that will be necessary. One method is to drill a large number of wells, case them with proper casing and screens, and pack them with gravel. The other method is to sink a shaft to the top of the Triassic shale and drive horizontal tunnels from the shaft into the sandstone just above the Triassic redbeds.

CHEMICAL CHARACTER OF WATER

Eighty samples of water from wells in Howard and Glasscock Counties were collected for partial or complete chemical analyses, the results of which are given in table 9. (See p. 108.) The analyses were made by Margaret D. Foster in the Geological Survey Laboratory at Washington and by E. W. Lohr in the Geological Survey Laboratory at Austin, Tex. The field tests were made at Big Spring, Tex. The latter were not expected to be exact but were made to guide the selection of samples for partial or complete analyses. Field tests of samples from a few wells are included in the tables for the purpose of comparing the results.

TRIASSIC ROCKS AND DEEPER-LYING FORMATIONS

Many oil tests in this area have drilled into the Permian rocks, but apparently none have encountered any good water in the rocks of Permian age. The drillers report that in nearly all wells the water contains salt or sulfur. It is believed that little water below the top of the Triassic, within economical reach of the drill, can be used for domestic purposes. A few wells drilled in the lenticular sandstone beds near the top of the Triassic yield a small amount of fairly good water. Well 11, which was drilled to a depth of 229 feet, has water that contains about 282 parts per million of chloride and 320 of hardness. The ground beneath the discharge pipe from this well is stained brown, which suggests that the water contains a large amount of iron. The water collected from well 1, 9 miles southwest of Big Spring, when drilling was in progress in the Triassic at a depth of 670 feet, contained about 8,500 parts per million of chloride and 2,800 of sulfate. (See table 9, p. 108.)

CRETACEOUS ROCKS

The water in the Cretaceous limestone and sandstone from which Big Spring has drawn its water supply is usually of good quality and is delivered to the city without treatment and without chlorination. The Texas & Pacific Ry. Co., however, softens the water before accepting it for use in locomotives. The analyses in table 9 (p. 108) show that the Cretaceous rocks generally yield moderately mineralized calcium bicarbonate waters, which range in hardness from 200 to 300 parts per million. The chloride is generally less than 100 parts per million, but one sample (121) contained more than 1,000 parts.

TERTIARY AND QUATERNARY DEPOSITS

In general, ground water that is found in Tertiary and Quaternary deposits in Howard County is likely to be highly mineralized. According to analyses of water collected from wells drawing water from these deposits northeast, north, northwest, and west of Big Spring during a reconnaissance survey of Howard County by the Works Progress Administration,[31] the quality varies considerably within short distances. Some of the water is as good as the water in the Cretaceous. It is fairly soft and otherwise low in dissolved minerals and apparently is derived from rain water that collected in small depressions or in pockets of sand and gravel, whereas only a few hundred yards away water may be found that contains several thousand parts per million of salt and otherwise is so highly mineralized that stock will not drink it. The quality also varies considerably southwest of Big Spring except for a few miles along the west side of the outcrop of the Trinity sand, where the quality is fairly good.

[31] Samuell, J. H., Records of wells, etc., in Howard County, Tex.: Texas State Board of Water Eng., Apr. 10, 1937 (mimeographed).

A large area that is underlain by water of good quality except for its fluoride content in the vicinity of Lees, in Glasscock County, extends from the Cretaceous area as far west as the schoolhouse and from the Howard-Glasscock County line several miles into Glasscock County. With the exception of water from well 192, water in Tertiary and Quaternary deposits in this area as shown by the analyses in the table is moderately to highly mineralized and contains from about 375 to 600 parts per million of dissolved mineral matter.

SURFACE WATER

The intermittent flow of Beals Creek that passes through Big Spring is too highly mineralized for stock use. The banks around the lakes that form a chain upstream from Big Spring are covered with a white salt deposit, as the water evaporates during dry periods. Infrequent flood water freshens the water in these lakes to some extent but cannot be depended on to maintain a continuous flow.

CONTAMINATION OF GROUND WATER

Although the quality of the water in the west pool of the Big Spring oil field is generally good, some of the water wells show evidence of contamination and have been abandoned because water from them has become too highly mineralized to use. A few of the wells that have been abandoned or that are now yielding contaminated water are wells 117, 121, 197, 205, 206, 211, and 212. Other wells, however, that yield highly mineralized water, such as wells 141, 143, 155, 162, 166, and 170, are too far from the oil field to be contaminated from that source.

The general consensus of opinion of oil-well drillers and field superintendents is that the pressure of the salt water encountered while drilling the oil tests in the Big Spring field is not great enough to bring the salt water to within several hundred feet of the surface, and this opinion is confirmed by the small amount of definite information that is available. It is not likely, therefore, that the contamination is coming from oil tests that have not been properly cased or sealed. Carpenter and Hill [32] measured pressures in the 2,200-foot oil-producing zone in secs. 21 and 23 of the west pool. These pressures indicate that salt water might rise to an altitude of about 1,200 to 1,300 feet which is more than 1,000 feet below the land surface. The Moore brothers,[33] however, claim to have encountered salt water that rose to the surface while they were drilling a well near the west edge of the west pool in sec. 21, on the L. S. McDowell property. Salt water underlying that area with sufficient pressure to bring it to the surface would be expected to contaminate the shallow water if oil tests were

[32] Carpenter, C. B., and Hill, H. B., Petroleum engineering report, Big Spring field and other fields in West Texas and southeastern New Mexico: U. S. Bureau of Mines Rept. Inv. 3316, p. 77, 1936.

[33] Moore, P. D. and J. I., oral communication, 1938.

not properly sealed or cased. Water wells that have been abandoned or that yield highly mineralized water probably could be saved for many years of usefulness by casing the wells and cementing the space outside the casing from the water table to the land surface.

As a large percentage of salt water is pumped from the oil wells with the oil, it has been the practice in the oil field to impound the salt water in surface reservoirs; the theory being that if held long enough in reservoirs the salt water will evaporate. (See pl. 17, *A*, *B*.) Some of the salt water evaporates, but much of it probably seeps into the ground—especially from tanks that are built on the limestone outcrop—and migrates laterally rather rapidly through the limestone but perhaps less rapidly through the sands and gravels. The beds of clay included in the sands and gravels are probably lenticular and are not continuous over large areas, so that eventually contamination may become widespread.

As these salt-water reservoirs are a menace to the ground-water supply because of downward movement and frequent overflow during storms, it seems advisable to consider pumping this salt water through a common pipe line and discharging it into Mustang Draw downstream from the Edwards ranch house. It would flow only a comparatively short distance from there before it emptied into one of the salt-water lakes that characterize the intermittent streams in this part of the State.

Big Spring lies just outside the southeast edge of a large area covering most of the Panhandle of Texas where mottled enamel is widespread, according to a report by the United States Public Health Service [34] on the relation of fluoride to mottled enamel of children's teeth. Fluoride, which has been shown to cause mottled enamel, is present to the amount of only about one part per million in the Big Spring city water supply. Water from wells tested southwest of Big Spring in Tertiary and Quaternary deposits, however, has a fluoride content from 2.0 to 2.8 parts per million as shown in table 8 for wells 152, 156, 168, and 171 (see p. 109). No economically feasible method has yet been found to remove fluoride from large quantities of water such as a city supply. Until methods have been perfected for the removal of fluoride from large supplies, water containing over one part per million of fluoride should be avoided as much as possible when selecting a supply. Dean [35] has this to say concerning the relation of fluoride content to mottled enamel:

> In surveys made of cities having the requisites for quantitative evaluation and even where these requisites are closely approximate, there is a definite quantitative relation between the fluoride concentration and the clinical effect. Although a

[34] Dean, H. T., Dixon, R. M., and Cohen, Chester, Mottled enamel in Texas: U. S. Public Health Repts., vol. 50, No. 13, pp. 424–442, 1935.

[35] Dean, H. T., Chronic endemic dental fluorosis: Jour. Am. Medical Assoc., vol. 107, pp. 1269–1272, Oct. 17, 1936.

prognosis with respect to any one individual is obviously unwarranted, it is felt that a prognosis relative to the group response to waters of varying fluoride concentration may be tentatively made at this time. From the continuous use of water containing about one part per million, it is probable that the very mildest forms of mottled enamel may develop in about 10 percent of the group. In waters containing 1.7 or 1.8 parts per million, the incidence may be expected to rise to 40 or 50 percent, although the percentage distribution of severity would be largely of the "very mild" and "mild" types. At 2.5 parts per million an incidence of about 75 to 80 percent might be expected, with possible 20 to 25 percent of all cases falling into the "moderate" or a severer type. A scattering few may show the "moderately severe" type.

At 4 parts per million the incidence is, in general, in the neighborhood of 90 percent, and as a rule 35 percent or more of the children are generally classified as "moderate" or worse. In concentrations of 6 parts per million or higher an incidence of 100 percent is not unusual.

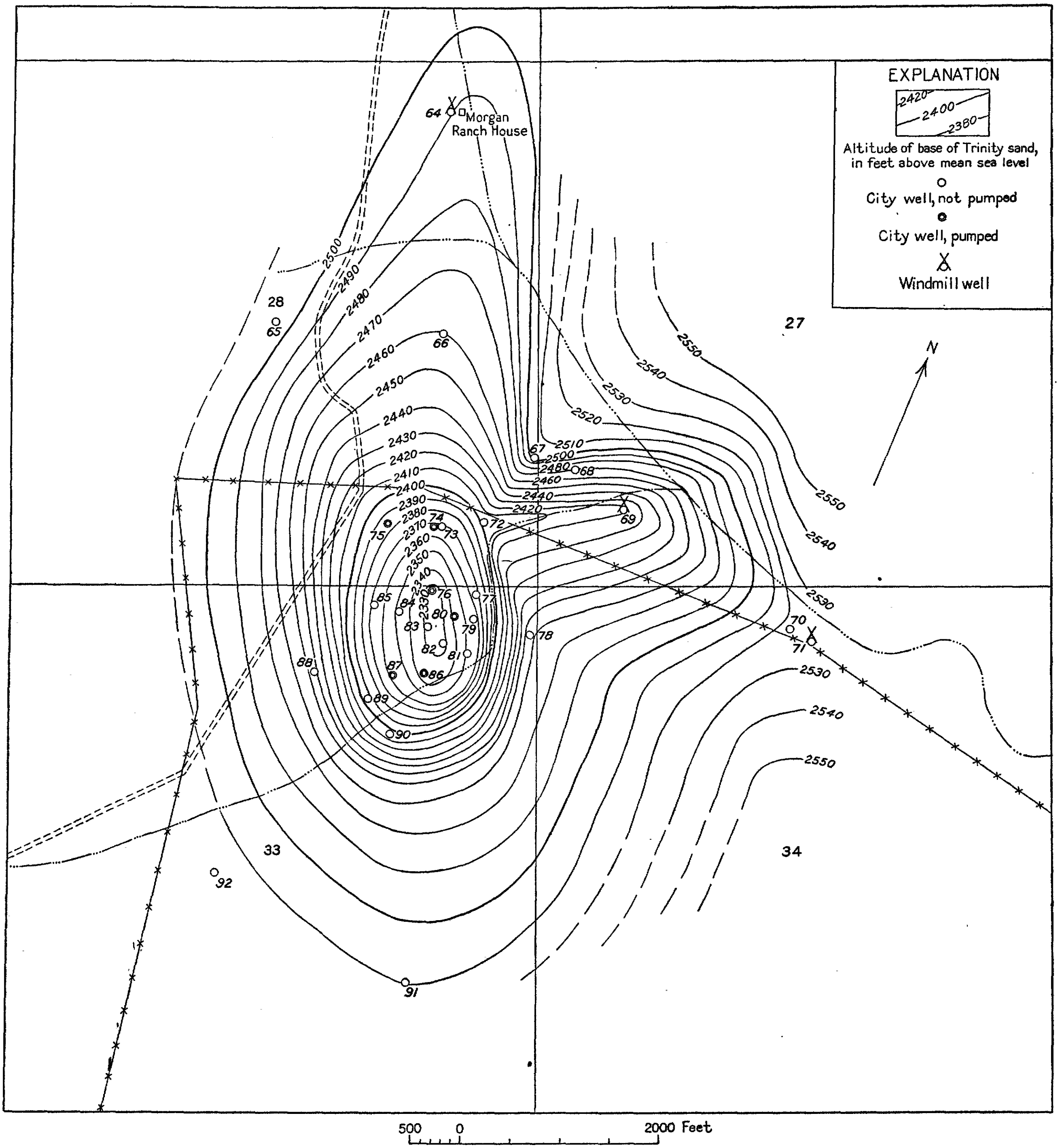
SURFACE WATER

The investigation on which this report is based did not include a study of the surface runoff or of the problems relating to the development of a surface-water supply. However, the following data obtained in connection with the investigation are here recorded.

The larger streamways in the immediate vicinity of Big Spring—Beals Creek and its two tributaries, Mustang Draw, and Sulphur Draw—are normally dry but carry large quantities of storm water on rare occasions. They contain numerous intermittent ponds of brackish water, which contaminate the storm water. Several streamways with small drainage areas head in the area of Cretaceous rocks. These carry water during and shortly after heavy rains that is doubtless of satisfactory mineral quality. Among these are the drainage basin above the former Big Spring and the drainage basin in which Moss Spring is situated. Some of the other small drainage basins that head in the Cretaceous area farther south are in danger of contamination from the overflow of salt-water reservoirs in the oil fields.

The Texas & Pacific Ry. Co. utilizes one of the small streamways by means of a reservoir directly below the former Big Spring. This streamway drains 7.65 square miles upstream from the dam as measured on an aerial mosaic map. The railroad company built another dam during 1909 about half a mile downstream from its present main dam to catch any storm water that was wasted from the upper reservoir. It has been reported that the first storm water of any consequence that passed the first dam occurred in 1919, when the lower reservoir partly filled and the dam was washed out. The lower dam has never been rebuilt. An appreciable amount of water ran over the spillway during the spring of 1932, and some water ran over in 1936.

The railroad company's pump house burned down on December 14, 1933, at a time when the lake was very low, and pumping from the lake was not resumed again until April 11, 1934. The water level was pumped down as far as possible by May 5, 1934, and the reservoir



MAP OF SECTION 33 SINK, HOWARD COUNTY, SHOWING STRUCTURE CONTOURS ON THE BASE OF THE TRINITY SAND.

463301—44 (Face p. 50)

did not fill enough to pump from it again until November 17, 1934. Water was pumped from the lake from November 17, 1934, until March 30, 1935. Except for a few hours of pumping on April 26 and May 24, pumping was not begun until May 28, 1935, but continued until February 23, 1936, when the reservoir was again dry. After the reservoir had filled again, pumping began on May 23, 1936, but the reservoir was pumped dry by August 26, 1936. The reservoir filled and water ran over the spillway for about 24 hours on September 26, 1936, and still had water in it when heavy rains during June 1938 filled the reservoir and sent a large amount of water over the spillway on June 18. Data furnished by the Texas & Pacific Ry. Co. show that from December 1, 1934, to December 1, 1937—a period of 3 years—112 million gallons were pumped from this lake, which amounts to about 104,000 gallons a day or 0.28 inches of run-off a year. (See table 4, p. 36.) This pumpage does not represent all the water that ran off the drainage area because an unestimated amount ran over the spillway for about 24 hours on September 26, 1936; and, in addition to this, a noticeable amount of water leaks past the dam at all times, increasing, of course, as the water in the reservoir rises. Evaporation from the lake surface is also very high. The rainfall record at Big Spring is not complete for this period, but the rainfall was apparently about 15 percent less than the average for which complete records are available. This fact does not indicate, however, that the run-off was necessarily that much below average because the run-off from any given basin depends on the intensity and distribution as well as the total amount of rainfall. No stream-flow data have been obtained for any of the other small drainage areas in the vicinity of Big Spring.

Ward [36] investigated several other draws in 1936 to determine the feasibility of damming some of the streamways and collecting the storm water for an auxiliary city water supply. In the report which he submitted to the city he concluded that the most feasible project investigated calls for an earthen dam to be built about a mile downstream from Moss Springs, 9½ miles due east of the post office in Big Spring.[37] (See pl. 18, *A*.) This dam would have a crest length of about 1,250 feet at a height of 67 feet above the creek bed.

This dam would be built on the Triassic rocks consisting of shale with more or less lenticular beds of fine sandstone, which, in general, are nearly impervious. The Triassic shale in the valley floor is covered with alluvium 20 to 30 feet thick. As Triassic sandstone crops out on the north bank at the dam site some leakage might develop through it;

[36] Ward, Joe, Report and recommendations to the city of Big Spring, Tex., on a supplemental water supply; unpublished report, 1936.

[37] In 1939, a dam was constructed about three-fourths of a mile farther downstream from the proposed dam site.

but the sandstone is very fine-grained and what little water seeps through would probably evaporate. Triassic red shale is found above this sandstone, and 25 to 35 feet of Quaternary? deposits lie on top of the red shale. These deposits consist mainly of conglomerate and silty clay. On the south bank, which is covered with loose material, exposures of bedrock were not seen. The Triassic shale and sandstone in the area contain some gypsum that can be seen in the form of a thin coating of white deposit in some places, notably in the bottom of a draw entering the main valley from the south, a few hundred yards upstream from the dam site. (See pl. 18, *B*.) Clay that is probably suitable for the puddled clay core of the dam occurs on the south side of the valley a few hundred yards upstream from the dam site, as shown near the left center of the view in plate 18, *A*. Sufficient water for puddling and for mixing concrete would be found below the bed of the creek when the excavation is made for the core wall.

Larger water supplies could be obtained from streams farther from Big Spring, namely, the Colorado River to the north and the Concho River to the southeast. No information is available to the writers in regard to the quantity or quality of the water of the Colorado River or in regard to available dam sites on that stream. Certain investigations of the North Concho River are being made by the United States Army Engineers.

SUMMARY AND CONCLUSIONS

The Triassic rocks and deeper formations in the Big Spring area are not satisfactory sources of ground water because the sandstones are in general fine-grained and do not yield much water to wells, and the water is usually highly mineralized. A few ranch wells draw small quantities of water from the Triassic rocks, but stock tanks impounding surface run-off are the only sources of water supply on much of the Triassic outcrop. Beds of salt occur in the Permian rocks about 1,200 feet below the land surface under the city of Big Spring and extend over most of the area in the general vicinity of Big Spring except underneath the area where the Cretaceous rocks crop out south of the city.

For many years the city of Big Spring has been drawing water that is fairly hard but otherwise of satisfactory quality from the Cretaceous sandstone and limestone rocks over a large area south of the city. The supply was first obtained from the Big Spring and later from four well fields. For the most part the sandstone is fine-grained, has a low permeability, and gives up water slowly to wells. Wells that have been drilled into this sandstone usually yield on an average about 20 gallons a minute. Although the sandstone contains in the aggregate a large amount of water, it is spread out over such a large area and such small amounts are available from each well and each locality that the cost of producing the water in large quantities is high.

Wells were drilled in the city park sink many years ago to supply more water to the city than could be obtained from the spring. As a result of pumping from the sink, the spring ceased to flow. The Texas & Pacific Ry. Co. has pumped three wells in the sink almost continuously at a total rate of about 100 gallons a minute, and the city has pumped intermittently two wells in the sink, depending on the demand for water. The water level in the sink fluctuates widely when the pumps are started or stopped. However, when the three railroad wells and one city well are pumped continuously at a total rate of about 180 gallons a minute, the water level declines about half a foot to 1 foot each week. In 1938 the water level in the sink was down nearly to the top of the Trinity sand so that there was little available storage remaining. Before any wells were drilled in the sink, Cummins[38] estimated the spring at the east edge of the city park sink to flow about 100,000 gallons a day, which probably approximates the amount of water percolating into the sink from the surrounding area and which may represent the perennial yield of the sink.

Wells in the well field in sec. 18 were abandoned several years ago on account of a declining water level and low yield from the wells. As the water level has risen during the past few years three wells yielding a total of about 100 gallons a minute were put back in service during May 1937. By June 1938 the yield from two of the wells had declined to a total of about 50 gallons a minute and the water level fell about 4 feet during this time.

Wells in the well field in sec. 17 yielded on an average about 220,000 gallons a day from May to September 1937, and probably have yielded about this amount each summer since 1925. As the water level has declined only about 10 feet near the center of pumping during this period, pumping at this rate can be continued for many years.

The well field in sec. 33 is in another slumped area similar to the one in the city park. Wells drilled in the sink in sec. 33 yield water much more rapidly than wells in any of the other areas. During 1937 they furnished on an average about 650,000 gallons a day. The water level near the center of the sink has fallen about 65 feet since pumping began about 9 years ago and fell about 10 feet between February 9, 1937, and January 30, 1938. The water level is still about 65 feet above the base of the limestone and about 165 feet above the base of the sandstone. It is believed that with the same rate of pumping, the water level will fall more rapidly in the future than it has fallen in the past and that within a few years the pumpage from this sink will have to be greatly reduced. The amount of water

[38] Cummins, W. F., Report on the geography, topography, and geology of the Llano Estacado or Staked Plains, in Dumble, E. T., and others, Texas Geol. Survey 3d Ann. Rept., p. 177, 1891.

percolating into this sink in 1937 is estimated as about 200,000 gallons a day.

Near the northwest corner of sec. 45, about 2 miles southwest of the section 33 sink, an area of nearly a square mile has the highest water table and is underlain by sandstone that is a little lower than normal, with the result that more sandstone lies below the water table there than elsewhere except in the sinks. Wells drilled in this area probably will yield more than the average of about 20 gallons a minute.

In the High Plains part of the area the farms, ranches, and towns are supplied with water from wells in Tertiary deposits, which are comparatively thin in most places but in a few localities are fairly thick. Results of test wells put down in Glasscock County show that the areas where the Tertiary deposits have considerable thickness are much smaller than was indicated by incomplete information obtained prior to the test drilling. The area in the vicinity of the west edge of the west pool of the Big Spring oil field, sec. 21, where the Triassic rocks are more than 300 feet below the surface, is small, and the water is in danger of contamination from both surface and subsurface oil-field operations. A depression about a mile southwest of Lees, where the Tertiary strata are over 200 feet thick, is not well-defined. The analysis of water from test well 192 in this depression shows that the water probably is too highly mineralized to be considered as a source for a city supply. The same condition probably is true at the lowest part of the depression in sec. 21.

Although well 156, which is in Glasscock County about 14½ miles southwest of Big Spring and is owned by G. T. Hall, yields a large quantity of water, the quality of the water is not entirely satisfactory for a city supply and it is not likely that the volume of the waterbearing beds at that location is sufficient to provide for a large continuous supply over a period of many years. It is believed, also, that the water from this well will become more highly mineralized with heavy pumping. A few localities in which the deposits are unusually thick or the water table is exceptionally high offer some prospect of supplying larger quantities. One such locality is about 14 miles southwest of Big Spring and about 3 miles southwest of Lees; there the silts, clays, sands, and gravels fill a structural depression covering about 1 square mile, in which Cretaceous rocks underlie Tertiary deposits. Conditions for obtaining water in this sink may not be greatly different from those in the city park and section 33 sinks. The water from wells around the rim of this depression is of acceptable quality, but nothing is known regarding the quality of the water in the lowest part of the depression. Moreover, as the center of the sink is occupied by a part of the Big Spring oil field, the water in the sink may become contaminated with salt water from oil-field operations. An area that apparently is shaped in part like a narrow trough is filled and covered with Tertiary and Quaternary deposits and extends eastward about one-half to three-quarters of a mile north of Lees. Water in wells in that area is also of acceptable quality, although the eastern part of the depression, like the one southwest of Lees, is occupied by a part of the oil field. This area, where the Tertiary deposits may be as much as 200 feet thick, is not outlined on the north side but might possibly contain a fairly large ground-water reservoir. A test hole drilled about three-quarters of a mile northwest of Lees would probably show whether further test drilling is warranted.

In general, in the area north of the Texas & Pacific Ry. in Howard County the quality of the water in the Tertiary and Quaternary deposits varies materially from place to place.

In the northwestern part of the county between Fairview and the Howard-Borden County line the water in most of the wells is comparatively good. However, little is known regarding the thickness of the water-bearing beds in that part of the county. A recent investigation has shown that the water in most of the wells in the southeastern part of Dawson County also is comparatively good. Lamesa, which had a population of 3,528 in 1930 and which is near the center of Dawson County, obtains an adequate public water supply from five wells. The pumpage from this battery of wells from January to June 1938, inclusive, was at the average rate of 350,000 gallons a day.

Stanton, in Martin County, with a population of 1,384 in 1930, obtains its water supply from Tertiary and Quaternary deposits, mostly from one well with a reported yield of 150 gallons a minute. In the vicinity of this well and in other localities within a few miles of Stanton, the saturated part of the sediments is unusually thick. In some of the wells the quality of the water is fairly good, but in most of them it is rather poor. Nearly all the wells that yield good water are closely surrounded by wells that provide water of rather poor quality. Conditions are generally unfavorable, therefore, for obtaining an additional supply of water for Big Spring from wells in the Tertiary and Quaternary deposits because of the poor quality of the water and its distance from the city. However, some potable supplies can probably be developed if necessary.

During 1937 the average daily metered consumption by the city of Big Spring amounted to about 640,000 gallons, but the average daily withdrawal from all the wells, including those pumped by the railroad company, probably was around 1,000,000 gallons. There is available for future needs a perennial yield of about 450,000 gallons a day from the four well fields in the Cretaceous rocks, as follows: City park sink, 100,000 gallons; well fields in secs. 17 and 18, 150,000 gallons; section 33 sink, 200,000 gallons. Additional water, perhaps enough to last for a year or two at the average rate of withdrawal in 1937—about 650,000 gallons a day—is available from storage in the section 33 sink. There is also a large amount of water in storage in the Trinity sand in areas that are not within the influence of the present pumping. Possibly an area of 10 square miles or more between the Big Spring oil field and the city wells is underlain by Trinity sand, in which an average thickness of 50 feet is saturated. If the effective porosity of the sand is 10 percent, about 32,000 acre-feet would be released from storage by the unwatering of the sand. This amount is equivalent to about 1,000,000 gallons a day for nearly 30 years. In addition, there would be some recharge from rainfall on the area. However, wells anywhere outside the sinks cannot be expected to have an average yield of more than about 20 gallons a minute, or about 30,000 gallons per day. As no additional sinks have been found in the district, the problem of recovering the water is a difficult one.

The results of the present investigation indicate that the conditions are not very favorable for developing the additional supplies of ground water of good quality that are needed by the city of Big Spring. The city evidently should seek immediately a surface water supply to meet the major part of its requirements.

If it is not practicable to develop an adequate supply from surface sources, additional supplies must be obtained from the undeveloped parts of the Cretaceous area and from the best localities that can be found in the Tertiary and Quaternary area after extensive test drilling. Additional supplies from either area will be expensive, and the Tertiary and Quaternary water will probably be of poorer quality than the present city supply.

WELL RECORDS

WATER LEVELS IN HOWARD COUNTY

Measurements of water level in Howard County were begun in well 81 (city well 65) on June 24, 1935. Several other city wells were added during the following year, and daily measurements of the water level in some of them have been continued to date. All measurements made thus far are included in table 6. For the most part, the wells that have been measured daily are close to heavily pumped areas and reflect directly the rate of pumping from the city well fields. The pumping from these well fields has been shifted frequently from field to field, and until recently no record has been kept of the amount or rate of pumping. It is, therefore, very difficult to interpret the meaning of the changes in water levels for each field separately. At the city park the water level fell about 10 feet during 1936 and about 30 feet more during 1937. In the well field in sec. 17 the water level fell several feet during 1936, but it recovered during 1937 to nearly the same level as during the winter of 1936–37. In the well field in sec. 33 the water level fell about 5 feet during 1936 and about 10 feet more during 1937. Considering all three fields together, there has been a substantial lowering of the water levels during these 2 years. The average metered consumption as shown by the records of the water department was only about 20,000 gallons a day more for 1937 than for 1936.

Water levels in wells outside the area of direct influence of the pumped fields did not fluctuate appreciably during 1937.

Water levels in table 6 are in feet below a measuring point; altitudes are in feet above mean sea level; and distances are in miles from the post office in Big Spring, Tex.

All depth-to-water measurements from January 1936 to January 1937 were made by employees of the Works Progress Administration unless otherwise indicated. After January 1937 all measurements were made by the writers or by city employees.

TABLE 6.—*Water levels in Howard County, Tex.*

WELL 6. A. L. Wasson. SE¼ sec. 11, block 33, 2¾ miles south of Big Spring, Tex. Measuring point, top of casing; altitude, 2,640.32 feet, 1.1 feet above land surface.

Date of measurement	Depth to water (feet)	Date of measurement	Depth to water (feet)	Date of measurement	Depth to water (feet)	Date of measurement	Depth to water (feet)
1937		1937		1937		1938	
May 4	149.81	June 26	149.88	Sept. 11	149.68	Jan. 27	149.34

WELL 10. Mr. L. Nall. SW½ sec. 12, block 33, 2½ miles south of Big Spring, Tex. Measuring point, top of pipe clamp; altitude, 2,616.26 feet; about 1.5 feet above land surface.

1936		1937		1937		1938	
Mar. 17	186.5	May 3	189.58	Aug. 19	190.78	Jan. 27	198.00
		July 16	189.90	Nov. 18	194.46		

WELL 12. City of Big Spring "shaft well" in city park. SE¼ sec. 12, block 33, 2½ miles south of Big Spring, Tex. Measuring point, top of concrete; altitude, 2,582.7 feet, about 1.0 foot above land surface.

1936		1936		1936		1936	
Jan. 17	155.1	May 29	157.1	June 22	164.2	July 20	168.5
May 5	160.8	June 4	158.9	24	164.1	22	169.4
8	160.7	11	165.2	July 3	165.1	Sept. 17	174.4
12	160.1	16	162.0	7	165.5		
26	158.6	18	163.9	8	165.5		
28	155.5	20	164.9	10	166.0		

WELL 13. City of Big Spring well 2. SE¼ sec. 12, block 33, 2½ miles south of Big Spring, Tex. Measuring point, top of 6-inch casing; altitude, 2,587.27 feet, 1.5 feet above land surface.

1936		1936		1936		1936	
Jan. 17	176.1	May 29	165.8	June 22	171.3	July 20	175.3
May 5	166.5	June 4	169.1	24	171.8	22	177.4
8	165.6	11	172.6	July 3	172.1	Sept. 17	184.8
12	166.7	16	169.2	7	172.8		
26	165.3	18	171.8	8	173.0	1937	
28	165.6	20	170.8	10	172.9	Jan. 24	170.2
						May 12	169.41

TABLE 6.—*Water levels in Howard County, Tex.*—Continued

WELL 15. City of Big Spring well 3. SE¼ sec. 12, block 33, 2½ miles south of Big Spring, Tex. Measuring point, top of 6-inch casing; altitude, 2,587.12 feet, 1.4 feet above land surface. Measurements discontinued. Water-stage recorder installed on well 20 feet west on May 14, 1937.

Date of measurement	Depth to water (feet)	Date of measurement	Depth to water (feet)	Date of measurement	Depth to water (feet)	Date of measurement	Depth to water (feet)
1936		1936		1936		1936	
Jan. 17	158.4	May 29	165.7	June 22	171.6	July 20	175.4
May 5	166.2	June 4	169.1	24	171.4	22	177.4
8	165.7	11	172.6	July 3	171.9	Sept. 17	184.8
12	166.7	16	169.5	7	172.8		
26	165.2	18	171.3	8	173.1	1937	
28	165.1	20	170.9	10	173.0	Jan. 24	170.2
						May 12	169.94

WELL 16. City of Big Spring well 4. SE¼ sec. 12, block 33, 2½ miles south of Big Spring, Tex. Measuring point, top of 12½-inch casing; altitude, 2,581.92 feet, 1.7 feet above land surface.

1936		1936		1936		1936	
Jan. 17	152.4	May 29	162.4	June 22	175.1	July 20	182.2
May 5	164.8	June 4	171.2	24	177.1	22	183.7
8	164.3	11	178.1	July 3	178.7	Sept. 17	199.5
12	164.4	16	174.0	7	179.3		
26	161.2	18	176.1	8	179.4		
28	162.1	20	167.9	10	178.6		

WELL 20. Texas & Pacific Ry. Co. SW¼ sec. 7, block 32, 2½ miles south of Big Spring, Tex. Measuring point, top of concrete block; altitude, 2,611.94 feet, 1.4 feet above land surface. Well is obstructed, and measurements have been discontinued.

1936		1936		1936		1936	
Jan. 21	179.3	May 12	194.5	July 3	194.6	July 22	203.3
May 5	194.4	June 22	195.2	10	155.2	Sept. 17	215.7
8	193.1	24	194.4	20	200.0		

WELL 21. Texas & Pacific Ry. Co. SW¼ sec. 7, block 32, 2½ miles south of Big Spring, Tex. Measuring point, top of concrete block; altitude, 2,611.99 feet, 1.6 feet above land surface.

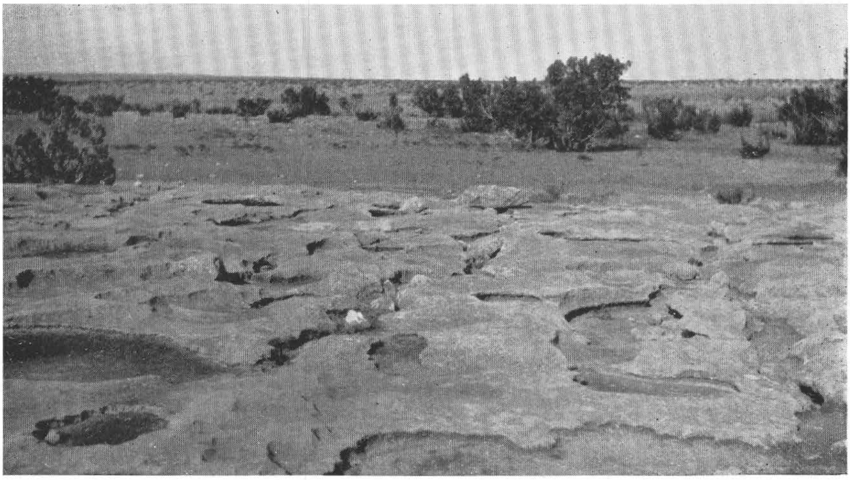
1936		1936	
Jan. 21	181.0	May 8	169.4
May 5	169.4	12	169.2
		June 22	169.1

WELL 22. Texas & Pacific Ry. Co. SW¼ sec. 7, block 32, 2½ miles south of Big Spring, Tex. Measuring point, top of concrete block; altitude, 2,612.83 feet, 0.75 foot above land surface. Well is obstructed at 193 feet below surface. Measurements have been discontinued.

1936		1936		1936		1937	
Jan. 21	180.1	May 12	193.6	July 3	193.5	June 1	181.91
May 5	193.1	June 22	194.2	37			
8	193.1	24	194.7	May 12	180.25		

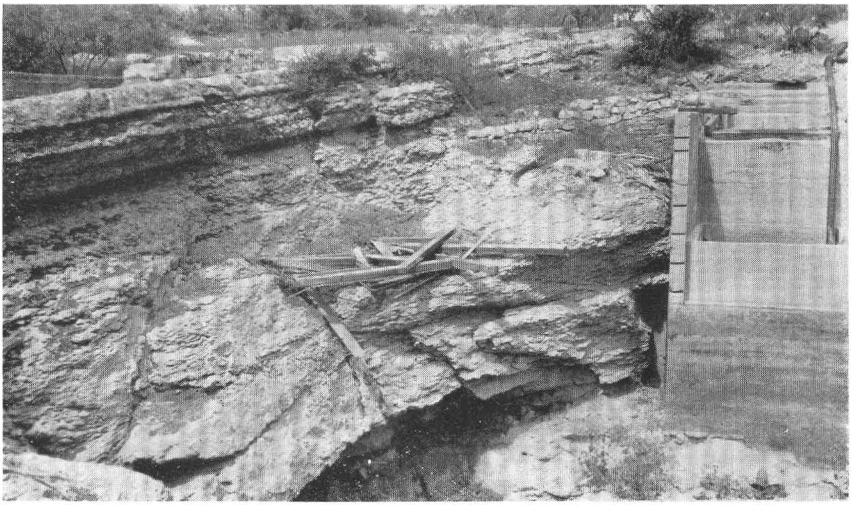
WELL 25. J. W. Clark. NW¼ sec. 18, block 32, 3 miles south of Big Spring, Tex. Measuring point, top of concrete; altitude, 2,660.44 feet, 0.7 foot above land surface.

1936		1937		1937			
June 25	89.1	May 5	90.95	Aug 18	91.01		



A. POTHOLES IN CRETACEOUS LIMESTONE, ABOUT 8½ MILES SOUTH OF BIG SPRING.

B. SOLUTION HOLE IN CRETACEOUS LIMESTONE, ABOUT 8½ MILES SOUTH OF BIG SPRING.



A. LOCATION OF ORIGINAL "BIG SPRING," NOW DRY.

B. MOSS SPRINGS, 9 MILES EAST OF BIG SPRING.

Flow from beneath overhanging rock ledge.

TABLE 6.—*Water levels in Howard County, Tex.*—Continued

WELL 28. City of Big Spring well 9. SE¼ sec. 18, block 32, 3¼ miles southeast of Big Spring, Tex. Measuring point, top of 6-inch casing in concrete block; altitude, 2,639.64 feet, 1.5 feet above land surface.

Date of measurement	Depth to water (feet)	Date of measurement	Depth to water (feet)	Date of measurement	Depth to water feet)(	Date of measurement	Depth to water (feet)
1936		1936		1936		1936	
Jan. 21	63.0	June 22	62.1	July 20	61.3	Sept. 8	61.4
22	64.4	24	62.1	22	62.0	12	61.7
May 7	59.1	July 3	62.2	Aug. 10	62.9	17	61.6
June 18	61.1	7	61.9	21	64.2		
20	61.1	9	61.8	Sept. 5	61.6		

WELL 29. City of Big Spring well 9a, SE¼ sec. 18, block 32, 3¼ miles southeast of Big Spring, Tex. Measuring point, top of 9-inch casing in concrete block; altitude, 2,639.87 feet, 1.2 feet above land surface.

1936		1936		1937			
Jan. 22	64.8	Aug. 21	63.7	Jan. 24	61.1		
May 7	63.1	Sept. 5	61.2				

WELL 30. City of Big Spring well 15. 3¼ miles southeast of Big Spring, Tex. Measuring point, top of 8-inch casing in concrete block; altitude, 2,653.91 feet, 1.3 feet above land surface.

1936		1936		1936		1936	
Jan. 24	79.0	June 22	81.3	July 20	79.8	Sept. 5	80.1
May 7	78.7	24	79.1	22	80.2	8	76.7
June 18	80.2	July 3	79.9	Aug. 10	81.4	12	79.0
20	79.6	7	79.5	21	82.3	17	79.8

WELL 31. City of Big Spring well 18. SE¼ sec. 18, block 32, 3¼ miles southeast of Big Spring, Tex. Measuring point, top of 8-inch casing, altitude, 2,666.47 feet, 0.8 foot above land surface.

1936		1936		1936		1937	
Jan. 22	93.5	July 7	94.8	Sept. 8	94.0	Aug. 18	95.76
May 7	95.7	8	94.1	12	93.6	Sept. 21	95.88
June 18	94.9	20	95.5	17	93.5	Nov. 17	96.05
20	95.0	22	95.6	1937		1938	
22	95.8	Aug. 10	97.4	May 5	93.74	Jan. 27	96.83
24	94.5	21	96.7	June 9	93.60		
July 3	94.1	Sept. 5	94.1	July 13	94.76		

WELL 32. City of Big Spring well 18a. SE¼ sec. 18, block 32, 3¼ miles southeast of Big Spring, Tex. Measuring point, top of 8-inch casing; altitude, 2,666.54 feet, 0.7 foot above land surface.

1936		1936		1936		1936	
Jan. 22	94.1	June 24	94.5	July 22	95.5	Sept. 12	96.2
May 7	94.1	July 3	91.3	Aug. 10	95.1	17	94.0
June 18	94.1	7	93.9	21	96.4		
20	94.9	8	93.8	Sept. 5	94.0	1937	
22	96.4	20	94.9	8	92.2	Aug. 18	95.75

WELL 33. City of Big Spring well 20. SE¼ sec. 18, block 32, 3¼ miles southeast of Big Spring, Tex. Measuring point, top of 8-inch casing; altitude, 2,716.20 feet, 0.8 foot above land surface.

1936		1936		1936		1937	
Jan. 23	142.2	July 20	142.7	Aug. 21	145.0	May 26	143.3
May 7	142.2	22	145.4	Sept. 5	143.0		

TABLE 6.—*Water levels in Howard County, Tex.*—Continued

WELL 34. City of Big Spring well 19. SE¼ sec. 18, block 32, 3¼ miles southeast of Big Spring, Tex. Measuring point, top of 6-inch casing; altitude, 2,680.1 feet, 0.3 foot above land surface.

Date of measurement	Depth to water (feet)	Date of measurement	Depth to water (feet)	Date of measurement	Depth to water (feet)	Date of measurement	Depth to water (feet)
1936		1936		1936		1937	
Jan. 23	92.5	July 3	109.2	Aug. 21	112.3	May 16	109.8
May 7	110.5	7	109.5	Sept. 5	109.7	26	108.2
June 18	110.1	8	109.4	8	109.8		
20	111.4	9	109.9	12	109.2		
22	110.5	20	110.2				
24	110.6	22	112.2				

WELL 35. City of Big Spring well 19a. SE¼ sec. 18, block 32, 3¼ miles southeast of Big Spring, Tex. Measuring point, top of 6⅝-inch casing; altitude, 2,680.9 feet, 1.8 feet above land surface.

1936		1936		1936		1936	
Jan. 22	110.1	June 24	110.8	July 22	112.3	Sept. 12	109.8
May 7	110.6	July 3	109.1	Aug. 10	112.8	1937	
June 18	110.7	7	109.9	21	112.5	May 19	109.20
20	111.2	8	109.6	Sept. 5	110.3	26	109.71
22	110.9	20	110.6	8	109.8	June 9	109.66

WELL 36. City of Big Spring well 21. NW¼ sec. 17, block 32, 3¼ miles southeast of Big Spring, Tex. Measuring point, top of 7-inch casing; altitude, 2,669.54 feet, 1.8 feet above land surface.

1936		1936		1937		1937	
Jan. 28	99.6	Aug. 21	102.9	June 9	99.36	Nov. 17	100.36
May 7	100.9	Sept. 5	100.0	July 13	99.35		
July 20	101.2			Aug. 18	99.96	1938	
22	102.3	1937		Sept. 21	100.28	Jan. 27	101.18
		Jan. 24	100.1				

WELL 37. City of Big Spring well 21a. NW¼ sec. 17, block 32, 3¼ miles southeast of Big Spring, Tex. Measuring point, top of 6⅝-inch casing; altitude, 2,669.62 feet 1.1 feet above land surface.

1936		1936		1936		1936	
Jan. 28	100.4	June 22	102.5	July 20	102.8	Sept. 8	101.3
May 7	102.0	July 3	101.7	Aug. 21	103.8	12	101.3
June 20	102.2	9	101.2	Sept. 5	101.7		

WELL 38. City of Big Spring well 23. NE¼ sec. 17, block 32, 3¼ miles southeast of Big Spring, Tex. Measuring point, top of casing; altitude, 2,693.68 feet about 1 foot above land surface.

1936		1937		1937		1936	
Feb. 10	127.0	June 9	127.3	July 15	127.6	Aug. 18	127.68

WELL 40. A. L. Wasson. NE¼ sec. 16, block 32, 3¼ miles southeast of Big Spring, Tex. Measuring point, top of casing at land surface; altitude, 2,765.88 feet.

1936		1937		1937		1938	
Aug. 14	212.0	June 9	211.59	Nov. 17	211.47	Jan. 27	211.92
		July 15	211.60				
1937		Aug. 18	211.60				
May 3	212.02	Sept. 21	211.72				

WELL 42. City of Big Spring well 33. SE¼ sec. 17, block 32, 3¾ miles southeast of Big Spring, Tex. Measuring point, top of 8-inch casing; altitude, 2,795.36 feet, 0.75 foot above land surface.

1936		1936		1936		1936	
Feb. 6	230.7	June 17	231.5	July 7	230.9	Sept. 5	232.1
May 5	230.2	18	230.8	9	230.9	12	223.7
8	230.9	19	231.3	20	238.7		
29	230.6	23	230.0	21	235.2		
June 16	231.9	24	231.7	Aug. 21	235.0		

TABLE 6.—*Water levels in Howard County, Tex.*—Continued

WELL 44. City of Big Spring well 32. SE¼ sec. 17, block 32, 3¾ miles southeast of Big Spring, Tex. Measuring point, top of 8-inch casing; altitude, 2,787.70 feet, 0.75 foot above land surface.

Date of measurement	Depth to water (feet)	Date of measurement	Depth to water (feet)	Date of measurement	Depth to water (feet)	Date of measurement	Depth to water (feet)
1936		1936		1936		1936	
Feb. 6	225.4	June 18	226.1	July 20	227.6	Sept. 8	227.0
May 5	225.1	19	226.8	21	230.4	12	229.4
8	226.5	23	226.0	29	231.9		
29	228.7	24	226.2	Aug. 10	228.3	1937	
June 16	227.1	July 7	226.8	21	230.0	May 12	225.73
17	226.3	9	225.1	Sept. 5	227.1		

WELL 45. City of Big Spring well 29. SE¼ sec. 17, block 32, 3¾ miles southeast of Big Spring, Tex. Measuring point, land surface; altitude, 2,777.3 feet.

1936		1936		1936		1936	
Feb. 7	217.7	May 5	217.3	May 8	220.9	June 18	219.5

WELL 46. City of Big Spring well 30. SE¼ sec. 17, block 32, 3¾ miles southeast of Big Spring, Tex. Measuring point, top of 8-inch casing; altitude, 2,776.53 feet, 0.25 foot above land surface.

1936		1936		1936		1936	
Feb. 7	217.5	June 19	220.2	July 10	219.8	Aug. 21	223.8
May 5	218.6	23	220.9	20	221.3	Sept. 5	221.6
8	218.5	24	219.1	21	223.4	12	224.6
June 16	226.8	July 7	220.4	29	227.2		
17	220.7	9	219.9	Aug. 10	225.4	1937	
						Jan. 24	220.4

WELL 47. City of Big Spring well 31. SE¼ sec. 17, block 32, 3¾ miles southeast of Big Spring, Tex. Measuring point, top of 8-inch casing; altitude, 2,781.37 feet, 0.5 foot above land surface.

1936		1936		1936		1936	
Feb. 6	221.3	June 16	222.7	June 24	221.5	July 20	225.2
May 5	221.7	17	222.3	July 7	222.7		
8	222.3	19	221.1	9	223.6		
29	224.9	23	223.0	10	223.8		

WELL 48. City of Big Spring well 34. SE¼ sec. 17, block 32, 3¾ miles southeast of Big Spring, Tex. Measuring point, top of 8-inch casing; altitude 2,764.72 feet, 0.7 foot above land surface.

1936		1936		1936		1936	
Feb. 5	206.1	May 29	210.0	June 19	210.3	July 20	212.0
May 6	208.7	June 16	210.3	24	209.8	29	217.5
8	209.3	18	210.1	July 10	211.7		

WELL 49. City of Big Spring well 34a. SE¼ sec. 17, block 32, 3¾ miles southeast of Big Spring, Tex. Measuring point, top of 8-inch casing; altitude, 2,764.54 feet, 2.5 feet above land surface.

1936							
Apr. 3	215.4						
May 6	209.8						
May 8	211.5						

WELL 51. City of Big Spring well 41. SW¼ sec. 16, block 32, 3¾ miles southeast of Big Spring, Tex. Measuring point, top of 8-inch casing; altitude, 2,771.24 feet, 0.1 foot above land surface.

1936		1936		1936		1937	
Feb. 5	214.8	July 17	219.6	Sept. 12	222.7	Jan. 24	217.9
May 6	201.0	21	222.8				
8	216.6	Sept. 5	217.5				

TABLE 6.—*Water levels in Howard County, Tex.*—Continued

WELL 52. City of Big Spring well 38. SE¼ sec. 17, block 32, 3¾ miles southeast of Big Spring, Tex. Measuring point, top of 8-inch casing; altitude, 2,771.23 feet, 0.6 foot above land surface.

Date of measurement	Depth to water (feet)	Date of measurement	Depth to water (feet)	Date of measurement	Depth to water (feet)	Date of measurement	Depth to water (feet)
1936		1936		1936		1937	
Feb. 2	215.2	June 24	218.6	Sept. 5	219.8	July 13	216.80
May 6	214.1	July 10	219.3	8	220.0	Aug. 23	217.30
8	216.0	20	219.8			Sept. 21	217.09
29	217.7	21	223.1	1937		Nov. 17	216.05
June 16	219.5	29	225.1	May 3	216.82		
18	210.1	Aug. 10	223.8	13	217.04	1938	
				June 1	216.95	Jan. 25	216.13

WELL 53. City of Big Spring well 37. SE¼ sec. 17, block 32, 3¾ miles southeast of Big Spring, Tex. Measuring point, land surface; altitude, 2,776.7 feet.

1936		1936		1937		1938	
May 6	213.4	July 10	223.0	May 3	222.48	Jan. 25	220.27
29	224.1	29	229.1	June 1	222.22	26	220.17
June 16	223.2	Aug. 10	228.6	July 13	222.02	27	220.27
18	224.2	21	227.4	Aug. 23	222.62		
24	222.5	Sept. 5	224.6	Sept. 21	222.53		
July 7	223.1	8	224.1	Nov. 17	220.80		
9	222.6	12	227.0				

WELL 54 City of Big Spring well 40. SE½ sec. 17, block 32, 3¾ miles southeast of Big Spring, Tex. Measuring point, top of 8-inch casing; altitude, 2,778.75 feet, 2.5 feet above land surface.

1936		1936		1936		1936	
May 5	222.4	June 18	229.6	July 20	229.8	Sept. 5	232.0
8	221.3	19	229.8	21	227.7	8	230.8
29	232.4	24	228.6	29	229.8	12	234.7
June 16	229.2	July 9	228.9	Aug. 10	231.1		
17	228.2	10	230.1	21	230.0	1937	
						Jan. 24	226.5

WELL 56. City of Big Spring well 45. SW¼ sec. 16, block 32, 3¾ miles southeast of Big Spring, Tex. Measuring point, top of casing at land surface; altitude, 2,777.55 feet.

1936		1936		1937		1938	
Apr. 4	206.0	July 21	226.1	July 13	221.18	Jan. 25	219.70
May 6	206.2	Sept. 5	223.3	Aug. 23	221.54	26	219.53
8	216.8			Sept. 21	221.42		
June 16	221.4	1937		Nov. 17	220.10		
July 17	222.1	May 3	221.35				
		June 1	221.10				

WELL 57. City of Big Spring well 40. NE¼ sec. 20, block 32,4 miles southeast of Big Spring, Tex. Measuring point, top of casing; altitude, 2,732.01 feet, 0.3 foot above land surface.

1937		1937		1937		1938	
May 3	171.89	July 15	171.60	Sept. 21	171.82	Jan. 25	172.30
June 11	171.90	Aug. 18	171.66	Nov. 17	171.71		

WELL 58. City of Big Spring well 40d. NE¼ sec. 20, block 32, 4 miles southeast of Big Spring, Tex. Measuring point, top of 8-inch casing; altitude, 2,734.65 feet, 1.1 feet above land surface.

1937		1937		1937		1938	
May 3	173.63	July 15	173.27	Sept. 21	173.50	Jan. 27	173.88
June 11	173.59	Aug. 18	173.34	Nov. 17	173.52		

TABLE 6.—*Water levels in Howard County, Tex.*—Continued

WELL 59. City of Big Spring well 40b. NW¼ sec. 21, block 32, 4¼ miles southeast of Big Spring, Tex. Measuring point, land surface; altitude, 2,791.4 feet.

Date of measurement	Depth to water (feet)	Date of measurement	Depth to water (feet)	Date of measurement	Depth to water (feet)	Date of measurement	Depth to water (feet)
1936		1937		1937		1937	
Dec. 10	214.0	Jan. 16	226.5	Jan. 24	214.0	June 11	230.0
				May 3	230.3	Aug. 18	230.0

WELL 61. City of Big Spring well 40g. NE¼ sec. 21, block 32, 4 miles southeast of Big Spring, Tex. Measuring point, top of concrete pump base; altitude, 2,780.72 feet, 1.5 feet above land surface.

1937		1937		1937			
Apr. 30	218.72	June 9	218.62	July 15	218.64		

WELL 63. A. L. Wasson. SE¼ sec. 21, block 32, 4¾ miles southeast of Big Spring, Tex. Measuring point, top of pipe clamp; altitude, 2,639.74 feet, 1.7 feet above land surface.

1936		1937		1937		1938	
Aug. 25	75.4	May 12	79.52	Aug. 18	79.47	Jan. 27	79.55
		June 2	79.60	Sept. 20	79.50		
		July 15	79.64				

WELL 64. Hardy Morgan. NE¼ sec. 28, block 32, 5 miles southeast of Big Spring, Tex. Measuring point, top of pipe clamp; altitude, 2,638.69, feet, about 2 feet above land surface.

1936		1937		1937		1937	
Aug. 25	89.4	June 10	93.47	Aug. 19	94.02	Nov. 17	94.56
		July 15	93.80	Sept. 16	94.11		
1937		Aug. 18	94.00	20	94.17	1938	
June 2	93.45					Jan. 31	95.05

WELL 65. Hardy Morgan. Center of sec. 28, block 32, 5¼ miles southeast of Big Spring, Tex. Measuring point, top of casing at land surface; altitude, 2,662.6 feet.

1937		1937		1937		1938	
Sept. 30	124.5	Oct. 8	124.56	Nov. 17	124.73	Jan. 30	125.09

WELL 67. City of Big Spring well 68. SE¼ sec. 28, block, 32, 6 miles southeast of Big Spring, Tex. Measuring point, top of 12½-inch casing; altitude, 2,609.02 feet, 1.5 feet above land surface.

1936		1936		1937		1938	
Feb. 17	71.2	July 17	74.5	Aug. 18	78.16	Jan. 30	77.92
May 7	73.4	21	75.0	Nov. 17	78.08		

WELL 68. City of Big Spring well 69. SW¼ sec. 27, block 32, 6 miles southeast of Big Spring, Tex. Measuring point, top of 12½-inch casing; altitude, 2,603.80 feet, 1.2 feet above land surface.

1936		1936		1937		1938	
Feb. 17	62.9	July 17	64.7	Aug. 18	67.12	Jan. 30	68.44
May 7	64.7	21	64.6	Sept. 20	67.50		

WELL 69. City of Big Spring well 70. SW¼ sec. 27, block 32, 6¼ miles southeast of Big Spring, Tex. Measuring point, top of 10-inch casing; altitude, 2,599.87 feet, 1.2 feet above land surface.

1936		1937		1937		1938	
Feb. 17	57.9	May 12	61.85	Aug. 19	62.53	Jan. 30	64.05
May 7	59.1	June 10	61.38	Sept. 20	62.84		
July 17	59.8	July 15	62.10	Nov. 17	63.25		
21	59.8						

TABLE 6.—*Water levels in Howard County, Tex.*—Continued

WELL 71. Hardy Morgan. NE¼ sec. 34, block 32, 6¼ miles southeast of Big Spring, Tex. Measuring point, top of casing; altitude, 2,576.23 feet, 2.7 feet above land surface.

Date of measurement	Depth to water (feet)	Date of measurement	Depth to water (feet)	Date of measurement	Depth to water (feet)	Date of measurement	Depth to water (feet)
1937		1937		1937		1937	
June 10	40.72	Aug. 18	40.88	Sept. 20	40.86	Nov. 17	40.80
Aug. 11	40.85						

WELL 72. City of Big Spring well 50. SE¼ sec. 28, block 32, 6 miles southeast of Big Spring, Tex. Measuring point, top of 12-inch casing; altitude, 2,617.84 feet, 1 foot above land surface.

1936		1936		1936		1937	
Feb. 10	109.2	June 19	114.0	July 10	107.3	Aug. 19	128.87
20	121.3	23	115.0	17	118.3		
May 7	117.1	25	115.8	21	120.3	1938	
June 17	114.4	July 8	105.8			Jan. 30	114.08

WELL 73. City of Big Spring well 51. SE¼ sec. 28, block 32, 6 miles southeast of Big Spring, Tex. Measuring point, top of casing; altitude, 2,626.49 feet, 0.7 foot above land surface. After Sept. 30, 1936, measurements were usually made betwen 6 and 8 o'clock a. m. before wells were pumped; readings by N. L. Riggan pump operator.

Date of measurement	Time	Depth to water (feet)	Date of measurement	Time	Depth to water (feet)	Date of measurement	Time	Depth to water (feet)
1936			1936			1936		
Feb. 10	9:00 a. m.	126.1	Aug. 6	5:30 a. m.	115.7	Aug. 30	6:00 a. m.	116.8
May 7	8:00 a. m.	131.3	6	9:15 p. m.	134.9	30	1:15 p. m.	133.6
June 17	11:20 a. m.	128.9	7	5:45 a. m.	116.2	31	6:00 a. m.	114.9
19	11:20 a. m.	129.1	7	8:45 p. m.	135.0	31	3:15 p. m.	133.2
23	11:15 a. m.	129.1	8	5:45 a. m.	116.0	Sept. 1	6:00 a. m.	114.3
25	11:50 a. m.	129.1	8	8:00 p. m.	134.6	1	7:30 p. m.	133.6
July 8	4:05 p. m.	111.9	9	6:00 a. m.	116.0	2	6:00 a. m.	115.7
10	11:45 a. m.	111.7	9	5:00 p. m.	133.3	2	7:00 p. m.	134.1
16	6:00 a. m.	113.3	10	5:45 a. m.	114.9	3	6:15 a. m.	116.0
16	8:00 p. m.	131.1	10	7:00 p. m.	128.8	3	5:00 p. m.	130.9
17	6:00 a. m.	113.1	11	5:45 a. m.	114.5	4	6:00 a. m.	115.2
17	8:00 p. m.	131.7	11	7:00 p. m.	133.1	4	6:30 p. m.	133.3
18	6:00 a. m.	112.8	12	6:00 a. m.	114.8	5	6:30 a. m.	115.0
18	8:00 p. m.	113.7	12	8:00 p. m.	132.0	5	6:15 p. m.	132.8
19	6:00 a. m.	113.7	13	6:00 a. m.	115.6	6	7:00 a. m.	114.9
19	8:00 p. m.	131.5	13	9:00 p. m.	134.8	6	7:00 p. m.	134.3
20	6:00 a. m.	113.7	14	6:00 a. m.	116.1	7	6:20 a. m.	115.4
20	8:00 p. m.	131.5	14	9:15 p. m.	135.4	8	6:30 a. m.	114.7
21	6:00 a. m.	114.5	15	5:45 a. m.	116.7	8	7:00 p. m.	133.8
21	7:30 p. m.	131.5	15	7:00 p. m.	134.7	9	6:30 a. m.	115.4
22	6:00 a. m.	114.2	16	6:00 a. m.	116.9	11	6:30 a. m.	111.6
23	6:00 a. m.	113.2	16	9:15 p. m.	135.2	11	7:15 p. m.	132.5
23	6:00 p. m.	126.6	17	6:00 a. m.	116.5	12	6:15 a. m.	114.0
24	6:00 a. m.	112.2	17	8:15 p. m.	135.3	12	7:00 p. m.	133.7
24	7:30 p. m.	131.2	18	6:00 a. m.	116.6	13	6:00 a. m.	115.0
25	6:00 a. m.	113.3	18	7:00 p. m.	135.0	14	6:30 a. m.	115.3
26	6:30 a. m.	112.5	19	5:45 a. m.	117.1	15	6:30 a. m.	115.6
26	6:15 p. m.	130.5	19	8:00 p. m.	135.7	15	6:15 p. m.	134.0
27	6:00 a. m.	112.7	20	5:45 a. m.	116.9	16	6:00 a. m.	115.8
27	8:00 p. m.	131.7	20	7:00 p. m.	135.8	20	7:00 a. m.	115.2
28	5:45 a. m.	113.7	21	5:45 a. m.	147.1	20	3:00 p. m.	127.9
28	9:30 p. m.	132.3	21	7:00 p. m.	113.5	21	6:15 a. m.	113.7
29	5:45 a. m.	115.0	22	5:45 a. m.	116.7	22	7:00 a. m.	112.1
29	7:40 p. m.	133.2	22	8:00 p. m.	135.0	23	7:00 a. m.	112.6
30	5:50 a. m.	115.3	23	6:00 a. m.	117.3	23	7:30 p. m.	127.3
30	6:00 p. m.	128.0	23	7:00 p. m.	135.6	25	6:30 a. m.	110.3
31	4:20 a. m.	114.3	24	6:15 a. m.	116.5	25	6:45 p. m.	128.4
31	6:15 p. m.	133.0	24	6:00 p. m.	128.2	26	8:00 a. m.	110.6
Aug. 1	5:15 a. m.	114.6	25	6:00 a. m.	116.2	26	5:30 p. m.	130.7
1	7:00 p. m.	133.1	25	8:30 p. m.	128.7	27	8:00 a. m.	110.2
2	6:00 a. m.	114.6	26	6:15 a. m.	116.1	27	6:45 p. m.	128.0
2	4:30 p. m.	132.5	26	8:00 p. m.	135.7	28	8:00 a. m.	109.0
3	5:45 a. m.	113.5	27	6:00 a. m.	116.8	28	6:30 p. m.	128.5
3	8:45 p. m.	132.8	27	8:15 p. m.	135.5	29	7:30 a. m.	109.0
4	5:45 a. m.	114.9	28	5:45 a. m.	116.7	29	6:45 p. m.	126.0
4	9:00 p. m.	134.2	28	10:00 p. m.	137.7	30	8:00 a. m.	108.5
5	5:45 a. m.	115.5	29	6:00 a. m.	117.4	30	5:30 p. m.	127.2
5	8:45 p. m.	134.5	29	6:45 p. m.	137.8			

TABLE 6.—*Water levels in Howard County, Tex.*—Continued

Date of measurement	Depth to water (feet)	Date of measurement	Depth to water (feet)	Date of measurement	Depth to water (feet)	Date of measurement	Depth to water (feet)
1936		1936		1937		1937	
Oct. 1	109.0	Dec. 21	109.2	Mar. 21	111.4	June 11	119.5
2	108.7	22	109.3	22	111.1	12	120.0
3	108.6	23	109.7	23	110.8	13	119.8
4	108.7	24	109.7	24	111.2	14	120.4
5	108.7	25	109.0	25	111.5	15	121.0
6	108.8	26	109.0	26	111.4	16	121.3
7	109.0	29	108.3	27	111.3	17	121.5
8	109.2	30	109.0	28	111.2	18	122.1
9	109.4	31	109.0	29	111.2	19	121.4
10	109.0			30	111.0	20	122.2
11	110.0	1937		31	111.2	21	121.5
12	109.0	Jan. 1	109.0	April 1	111 4	22	122.2
14	109.0	2	109.2	2	111.9	23	122.6
15	109.0	3	108.8	3	113.6	24	122.7
16	109.2	4	109.0	4	113.1	25	122.8
17	109.0	5	108.8	5	111.3	26	123.1
18	109.0	6	108.7	6	112.2	27	123.5
19	108.5	7	108.9	7	112.2	28	122.7
20	109.0	12	110.0	8	112.0	29	123.2
21	109.0	13	109.1	9	113.1	30	123.5
22	109.0	14	109.5	10	112.8	July 1	123.3
23	109.0	15	109.6	11	113.2	2	123.1
24	109.2	16	109.9	12	113.8	3	122.8
25	109.0	17	109.8	13	113.2	4	122.8
26	108.8	18	109.2	14	114.4	5	123.0
27	109.0	19	109.5	15	114.2	6	121.4
28	109.0	20	109.8	16	114.7	7	122.9
29	108.6	21	109.8	17	115.3	8	123.1
30	109.2	23	109.8	18	115.1	10	122.6
31	108.9	24	110.2	19	114.8	11	122.1
Nov. 1	109.2	25	109.6	20	114.8	12	120.8
2	109.0	26	110.3	21	115.2	13	120.5
3	109.6	27	110.5	22	115.5	14	121.8
4	109.0	28	110.2	23	116.2	15	122.9
5	108.8	29	110.2	24	116.2	16	122.8
6	109.7	30	110.2	25	115.6	17	123.5
7	109.7	31	110.2	26	115.8	18	123.3
8	109.8	Feb. 3	110.0	27	116.5	19	122.8
9	109.0	4	109.4	28	116.8	20	123.2
10	109.0	5	110.0	29	116.8	21	122.2
11	109.2	6	110.3	30	117.0	22	122.0
12	108.8	9	108.1	May 1	119.6	23	122.2
13	109.7	10	108.8	2	119.8	24	123.2
14	109.5	11	109.0	3	119.6	25	123.6
15	109.5	12	109.0	4	118.7	26	122.5
16	109.2	13	110.0	5	119.6	27	123.5
17	108.7	14	110.2	6	120.0	28	123.3
18	109.6	15	109.0	7	119.3	29	123.8
19	109.7	16	109.2	8	119.2	30	123.5
20	109.3	17	109.9	9	120.3	31	124.2
21	109.3	19	110.0	10	119.2	Aug. 1	123.8
22	109.2	20	109.8	11	118.8	2	123.4
23	109.2	21	109.9	12	118.6	3	124.6
24	109.0	22	110.7	13	117.6	4	124.5
25	109.2	23	111.1	14	118.2	5	124.0
26	109.5	24	111.4	15	118.8	6	124.8
27	109.0	25	111.8	16	118.8	7	124.1
28	109.0	26	112.0	17	120.1	8	124.8
29	109.0	27	112.5	18	119.8	9	124.3
30	108.9	28	112.4	19	120.7	10	124.6
Dec. 1	108.9	Mar. 1	112.2	20	120.7	11	125.6
2	108.8	2	112.5	21	120.2	12	125.6
3	108.8	3	111 8	22	121.0	13	125.7
4	108.8	4	111.5	23	121.0	14	125.4
5	108.9	5	111.2	24	120.3	16	124.7
6	108.8	6	110.0	26	117.4	17	125.2
7	108.7	7	111.3	27	116.6	18	125.2
8	109.5	8	110.8	28	117.5	19	125.3
9	109.5	9	110.6	30	119.8	20	124.5
10	110.2	10	110.7	31	118.1	22	121.0
11	109.3	11	111.3	June 1	117.8	23	121.2
12	109.7	12	111.3	2	119.0	24	122.0
13	110.0	13	111.5	3	119.0	25	122.2
14	109.4	14	111.0	4	119.5	26	123.3
15	109.7	15	111.0	5	120.8	27	122.8
16	109.4	16	110.8	6	120.8	28	123.1
17	109.2	17	110.6	7	119.3	29	123.3
18	109.7	18	110.9	8	118.7	30	124.1
19	109.9	19	111.0	9	119.2	31	124.8
20	109.2	20	111.2	10	119.3	Sept. 1	125.1

TABLE 6.—*Water levels in Howard County, Tex.*—Continued

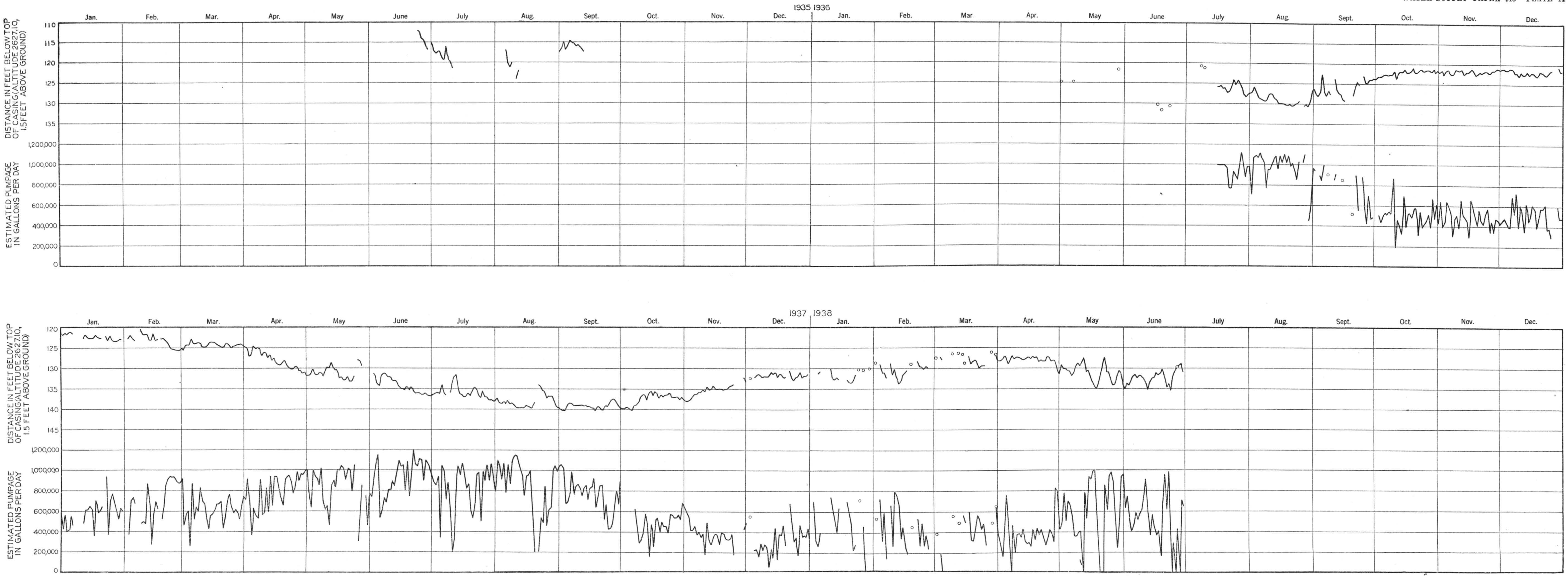
Date of measurement	Depth to water (feet)	Date of measurement	Depth to water (feet)	Date of measurement	Depth to water (feet)	Date of measurement	Depth to water (feet)
1937		1937		1938		1938	
Sept. 2	125.3	Nov. 5	123.0	Jan. 21	120.3	Apr. 22	115.7
3	125.7	6	122.7	22	120.2	23	116.1
4	125.8	7	123.0	23	119.4	24	116.1
5	125.1	8	122.7	25	118.3	25	115.5
6	124.5	9	122.6	27	118.3	26	115.3
7	124.8	10	121.8	Feb. 2	117.0	27	116.1
8	125.8	11	122.4	4	117.1	28	116.0
9	125.2	12	121.4	5	118.3	29	115.9
10	125.7	13	122.0	6	118.4	30	117.3
11	125.3	14	121.6	7	119.5	May 1	118.2
12	125.7	15	120.5	9	117.2	2	117.0
13	125.3	16	121.2	10	119.1	3	118.0
14	125.7	17	121.4	11	181.2	4	117.6
15	125.7	18	121.2	12	119.4	5	118.0
16	125.4	19	121.0	13	120.6	6	117.7
17	125.7	20	121.1	14	120.2	7	119.0
18	126.1	21	121.0	15	119.3	8	118.4
19	126.2	22	121.1	16	119.2	9	117.4
20	125.2	23	121.0	17	118.5	10	117.0
21	125.5	24	120.7	19	117.2	11	117.4
22	125.9	25	120.7	22	116.3	13	115.8
23	125.9	30	119.0	23	117.4	14	118.3
24	125.3	Dec. 1	119.2	24	117.4	15	118.1
25	125.2	3	119.0	25	118.2	16	119.2
26	124.4	5	118.7	26	117.5	17	120.1
27	124.2	6	118.9	27	117.8	18	120.8
28	123.8	7	118.7	Mar. 2	116.0	19	121.2
29	124.4	8	118.7	4	115.7	23	115.7
30	125.2	9	118.8	5	116.1	24	118.2
Oct. 1	125.4	10	118.9	10	114.8	25	118.2
2	126.0	11	119.1	13	114.7	26	119.6
3	125.6	12	119.1	15	115.2	27	120.6
4	125.2	13	118.2	16	116.6	28	120.2
5	125.3	14	118.7	18	115.6	29	119.5
6	125.9	15	118.2	19	117.0	30	118.3
7	126.3	16	119.0	20	116.6	31	118.6
8	125.1	17	118.6	21	116.3	June 1	120.7
9	125.1	18	118.5	22	116.7	2	121.2
10	124.6	19	119.3	23	117.7	3	120.0
11	123.8	20	118.2	24	117.6	4	120.7
12	123.3	22	118.1	25	117.7	5	120.0
13	123.2	23	119.2	26	117.7	6	119.5
14	123.9	24	120.0	29	115.2	7	118.7
15	122.7	25	119.2	31	115.2	8	119.6
16	122.1	26	119.3	Apr. 1	116.6	9	119.2
17	123.1	27	118.6	2	116.7	10	119.5
18	122.1	28	119.4	3	116.5	11	119.6
19	122.6	29	119.5	4	115.7	12	120.1
20	123.2	30	119.5	5	116.3	13	121.1
21	122.7	31	119.0	6	117.4	14	119.8
22	123.2			8	115.7	15	119.5
23	122.4	1938		9	116.5	16	119.0
24	122.9	Jan. 1	119.6	10	116.2	17	118.3
25	122.6	3	117.8	11	116.3	18	118.5
26	122.7	4	119.3	12	116.2	19	118.2
27	122.9	5	118.8	13	116.6	20	117.5
28	123.2	6	118.7	14	115.2	21	118.6
29	123.1	11	117.9	15	115.6	22	120.4
30	123.2	12	119.8	16	115.3	23	119.8
31	123.2	13	119.7	17	115.5	24	121.0
Nov. 1	124.0	14	119.5	18	115.2	25	118.6
2	124.0	15	120.1	19	115.5	27	117.0
3	124.1	19	120.1	20	115.4	29	115.7
4	123.7	20	120.6	21	116.0	30	116.4

WELL 78. City of Big Spring well 67. NE¼ sec. 33, block 32, 6 miles southeast of Big Spring, Tex. Measuring point, top of 8¼-inch casing; altitude, 2,650.78 feet, 2.2 feet above land surface.

1936		1936		1938			
Feb. 12	142.2	Feb. 20	146.0	Jan. 30	155.60		

WELL 79. City of Big Spring well 64. NE¼ sec. 33, block 32, 6 miles southeast of Big Spring, Tex. Measuring point, top of concrete pump base; altitude, 2,624.24 feet, 1.71 feet above land surface.

1936		1936		1936		1937	
Feb. 11	129.1	June 19	127.8	July 10	119.9	May 12	131.52
21	153.2	23	129.1	17	143.8		
May 6	133.1	25	137.8	21	138.5	1938	
June 17	128.6	July 8	118.4	Sept. 8	132.0	Jan. 30	126.76



STATIC WATER LEVEL IN WELL 82 AND PUMPAGE FROM SECTION 33 SINK, 1935–38.

TABLE 6.—*Water levels in Howard County, Tex.*—Continued

WELL 81. City of Big Spring well 65. NE¼ sec. 33, block 32, 6 miles southeast of Big Spring, Tex. Measuring point, top of 8-inch casing; altitude, 2,627.10 feet, 1.5 feet above land surface. After Sept. 30, 1936, measurements usually made between 6 and 8 o'clock a. m. before wells were pumped; readings by N. L. Riggan, pump operator.

Date of measurement	Time	Depth to water (feet)	Date of measurement	Time	Depth to water (feet)	Date of measurement	Time	Depth to water (feet)
1935			1936			1936		
June 24	5:30 a. m.	112.3	June 25	10:40 a. m.	138.7	Aug. 18	6:00 a. m.	130.2
24	1:50 p. m.	131.1	July 8	1:50 p. m.	120.7	18	9:30 p. m.	144.0
25	5:31 a. m.	112.3	10	9:35 a. m.	121.1	19	5:45 a. m.	130.5
25	5:44 p. m.	132.9	16	6:00 a. m.	125.8	19	8:00 p. m.	149.0
26	5:30 a. m.	114.2	16	8:00 p. m.	147.7	20	5:45 a. m.	130.2
26	5:21 p. m.	132.2	17	6:00 a. m.	125.8	20	9:00 p. m.	143.0
27	5:25 a. m.	114.5	17	8:00 p. m.	143.0	21	5:45 a. m.	130.5
27	8:27 p. m.	124.6	18	6:00 a. m.	125.5	21	7:30 p. m.	149.2
28	5:36 a. m.	115.8	18	8:00 p. m.	138.9	22	5:45 a. m.	130.4
28	9:06 p. m.	131.2	19	6:00 a. m.	126.4	22	8:00 p. m.	150.2
29	5:27 a. m.	117.2	19	8:00 p. m.	146.7	23	6:00 a. m.	130.3
July 1	5:25 a. m.	115.2	20	6:00 a. m.	126.0	23	7:00 p. m.	143.9
1	9:00 p. m.	131.7	20	8:00 p. m.	145.6	24	6:15 a. m.	129.9
2	5:32 a. m.	117.3	21	6:00 a. m.	127.2	24	6:00 p. m.	149.7
2	9:01 p. m.	131.7	21	7:30 p. m.	146.0	25	6:00 a. m.	129.4
3	5:19 a. m.	118.0	22	6:00 a. m.	127.0	25	8:30 p. m.	145.2
3	7:09 p. m.	128.7	22	5:00 p. m.	140.8	26	8:00 p. m.	150.8
4	5:08 a. m.	117.4	23	6:00 a. m.	125.5	27	6:00 a. m.	130.7
4	5:58 p. m.	133.6	23	5:00 p. m.	142.7	27	8:15 p. m.	150.4
5	5:25 a. m.	117.1	24	6:00 a. m.	124.1	28	6:00 a. m.	130.2
5	9:50 p. m.	130.4	24	7:00 p. m.	145.5	28	9:30 p. m.	145.1
6	5:10 a. m.	119.7	25	6:00 a. m.	125.5	29	6:00 a. m.	130.8
6	9:40 p. m.	132.1	25	6:15 p. m.	136.5	30	6:00 a. m.	129.5
7	5:13 a. m.	119.5	26	6:30 a. m.	124.2	30	1:00 p. m.	140.1
8	5:10 a. m.	115.7	26	6:15 p. m.	138.0	31	6:00 a. m.	126.8
8	10:36 p. m.	128.7	27	6:00 a. m.	125.0	31	3:15 p. m.	138.9
9	5:13 a. m.	119.4	27	8:00 p. m.	129.2	Sept. 1	6:00 a. m.	126.4
9	9:49 p. m.	128.7	28	6:00 a. m.	126.1	1	7:30 p. m.	140.0
10	5:23 a. m.	119.7	28	9:50 p. m.	147.8	2	6:00 a. m.	127.8
11	5:14 a. m.	121.6	29	6:00 a. m.	127.7	2	7:00 p. m.	140.5
11	9:35 p. m.	135.2	29	7:40 p. m.	148.3	3	6:15 a. m.	128.3
Aug. 6	5:45 a. m.	116.9	30	6:00 a. m.	128.3	4	6:00 a. m.	127.3
6	10:09 p. m.	135.1	30	6:00 p. m.	145.5	4	6:30 p. m.	139.5
7	5:35 a. m.	120.2	31	4:30 a. m.	127.6	5	6:30 a. m.	122.6
7	10:36 p. m.	135.1	31	6:15 p. m.	140.5	5	6:15 p. m.	139.0
8	5:29 a. m.	121.5	Aug. 1	5:15 a. m.	127.3	6	7:00 a. m.	127.2
9	5:31 a. m.	119.8	1	7:00 p. m.	141.1	6	7:00 p. m.	140.0
9	6:14 p. m.	136.3	2	6:00 a. m.	127.2	7	6:20 a. m.	128.1
10	6:46 a. m.	139.5	2	4:30 p. m.	140.4	8	6:30 a. m.	126.6
10	6:05 p. m.	140.0	3	5:45 a. m.	125.8	8	7:00 p. m.	139.7
11	5:35 a. m.	124.2	3	8:45 p. m.	140.2	9	6:30 a. m.	127.8
11	7:10 p. m.	141.7	4	5:45 a. m.	127.5	11	6:30 a. m.	123.7
12	5:43 a. m.	122.1	4	9:00 p. m.	148.7	11	7:15 p. m.	137.7
12	9:05 p. m.	143.6	5	5:45 a. m.	128.6	12	6:15 a. m.	126.5
Sept. 1	6:03 a. m.	117.5	5	8:45 p. m.	149.2	12	7:00 p. m.	139.4
2	6:25 a. m.	116.6	6	5:30 a. m.	128.8	13	6:00 a. m.	127.4
3	6:21 a. m.	114.8	6	9:15 p. m.	150.0	14	6:30 a. m.	127.7
4	6:01 a. m.	117.1	7	5:45 a. m.	129.3	15	6:30 a. m.	129.0
5	6:11 a. m.	115.8	7	8:45 p. m.	143.2	15	6:15 p. m.	148.8
6	6:14 a. m.	114.6	8	5:45 a. m.	129.4	16	6:00 a. m.	129.2
7	5:35 a. m.	115.1	8	8:00 p. m.	148.2	20	7:00 a. m.	128.0
8	6:20 a. m.	115.5	9	6:00 a. m.	129.1	20	3:00 p. m.	136.5
9	6:21 a. m.	116.2	9	5:00 p. m.	140.9	21	6:15 a. m.	126.0
10	5:58 a. m.	115.8	10	5:45 a. m.	127.7	22	7:00 a. m.	124.4
11	5:50 a. m.	116.2	10	7:00 p. m.	147.0	23	7:00 a. m.	125.5
11	4:05 p. m.	137.3	11	5:45 a. m.	127.5	23	7:30 p. m.	135.5
12	6:12 a. m.	116.9	11	7:00 p. m.	143.4	25	6:30 a. m.	123.0
12	4:53 p. m.	138.2	12	6:00 a. m.	127.7	25	6:45 p. m.	131.8
13	6:16 a. m.	117.6	12	8:00 p. m.	149.4	26	8:00 a. m.	124.8
			13	6:00 a. m.	128.8	26	5:30 p. m.	133.5
1936			13	9:00 p. m.	149.5	27	8:00 a. m.	124.7
Feb. 12	11:00 a. m.	130.8	14	6:00 a. m.	129.2	27	6:45 p. m.	132.0
May 1	------------	124.9	14	9:15 p. m.	150.0	28	8:00 a. m.	123.7
6	3:20 p. m.	137.1	15	5:45 a. m.	130.0	28	6:30 p. m.	139.2
7	10:40 a. m.	124.9	15	7:00 p. m.	149.7	29	7:30 a. m.	124.0
29	3:20 p. m.	137.1	16	6:00 a. m.	130.0	29	6:45 p. m.	138.3
June 17	8:25 a. m.	130.4	16	9:15 p. m.	146.7	30	8:00 a. m.	123.5
19	8:00 a. m.	131.7	17	6:00 a. m.	130.0	30	5:30 p. m.	139.0
23	9:50 a. m.	130.7	17	8:15 p. m.	148.9			

TABLE 6.—*Water levels in Howard County, Tex.*—Continued

Date of measurement	Depth to water (feet)
1936	
Oct. 1	123.7
2	123.3
3	123.2
4	123.2
5	122.7
6	122.6
7	122.8
8	122.6
9	122.7
10	121.9
11	123.7
12	122.1
13	121.8
14	122.0
15	121.5
16	122.1
17	122.0
18	121.9
19	120.9
20	122.2
21	122.1
22	121.6
23	121.3
24	121.8
25	121.6
26	121.5
27	121.7
28	122.0
29	121.3
30	122.2
31	121.5
Nov. 1	122.2
2	121.7
3	122.8
4	121.8
5	121.4
6	122.3
7	122.6
8	122.5
9	121.4
10	121.5
11	121.7
12	121.3
13	122.6
14	121.9
15	122.0
16	121.7
17	121.2
18	122.3
19	122.7
20	122.2
21	122.0
22	122.2
23	121.9
24	121.7
25	122.1
26	122.2
27	121.6
28	121.6
29	121.1
30	121.3
Dec. 1	121.4
2	121.2
3	121.4
4	121.5
5	121.3
6	121.3
7	121.3
8	122.3
9	122.1
10	123.0
11	122.0
12	122.6
13	122.4
14	121.8
15	122.5
16	122.0
17	122.1
18	122.7
19	122.9
Dec. 20	121.8
21	122.0
22	122.3
23	122.7
24	122.4
25	121.7
26	121.5
29	120.5
30	121.6
31	121.6
1937	
Jan. 1	121.3
2	121.9
3	121.5
4	121.7
5	121.3
6	121.1
7	121.6
12	122.7
13	121.8
14	122.4
15	122.8
16	122.7
17	122.6
18	121.8
19	122.5
20	122.7
21	122.7
23	122.2
24	123.3
25	122.3
26	123.3
27	123.5
28	123.5
29	123.3
30	122.9
31	123.2
Feb. 3	122.7
4	121.7
5	122.7
6	123.3
9	120.4
10	121.8
11	121.8
12	121.7
13	123.2
14	123.2
15	121.5
16	123.3
17	123.0
19	122.8
20	122.7
21	123.2
22	123.8
23	124.7
24	125.2
25	125.4
26	125.5
27	125.6
28	125.6
Mar. 1	125.2
2	125.7
3	124.3
4	124.3
5	124.3
6	122.8
7	124.0
8	124.0
9	123.8
10	123.8
11	124.8
12	124.8
13	124.8
14	124.2
15	123.7
16	123.7
17	123.8
18	124.3
19	124.5
1937	
Mar. 20	124.7
21	125.0
22	124.2
23	124.0
24	124.4
25	125.2
26	124.7
27	124.7
28	124.5
29	124.3
30	124.2
31	124.6
Apr. 1	124.9
2	125.2
3	127.3
4	126.9
5	124.7
6	125.3
7	125.1
8	125.3
9	127.1
10	126.3
11	126.3
12	127.5
13	126.8
14	128.2
15	127.6
16	128.8
17	129.2
18	129.3
19	128.6
20	128.2
21	129.2
22	129.9
23	130.2
24	130.2
25	129.7
26	129.7
27	130.7
28	130.8
29	131.4
30	131.2
May 1	131.9
2	131.8
3	131.4
4	130.3
5	131.6
6	131.7
7	131.2
8	131.2
9	132.1
10	130.7
11	129.9
12	130.0
13	128.7
14	129.7
15	130.7
16	130.5
17	132.5
18	132.3
19	133.0
20	132.9
21	132.3
22	133.3
23	133.3
24	132.0
26	128.1
27	128.2
28	129.5
June 3	131.3
4	132.5
5	134.1
6	134.5
7	131.7
8	131.3
9	131.5
10	132.3
11	132.3
12	133.1
13	133.1
1937	
June 14	133.2
15	134.3
16	135.0
17	135.1
18	135.4
19	134.5
20	135.5
21	134.6
22	135.4
23	136.2
24	136.1
25	136.1
26	136.5
27	136.6
28	136.1
29	136.7
30	136.7
July 1	136.6
2	136.5
3	136.2
4	136.0
5	136.4
6	134.1
7	136.4
8	136.7
10	136.2
11	134.7
12	132.3
13	131.7
14	134.7
15	136.5
16	136.7
17	137.3
18	137.1
19	136.3
20	136.8
21	135.5
22	134.7
23	135.2
24	136.7
25	137.4
26	135.7
27	137.2
28	137.2
29	138.0
30	137.7
31	138.2
Aug. 1	138.0
2	137.3
3	138.6
4	138.7
5	138.2
6	138.8
7	138.0
8	138.9
9	138.6
10	139.2
11	139.7
12	139.9
13	139.8
14	139.8
15	139.7
16	139.3
17	139.5
18	139.7
19	140.0
20	138.4
22	134.2
23	134.5
24	135.7
25	135.9
26	137.7
27	136.4
28	136.9
29	137.0
30	138.7
31	139.6
Sept. 1	139.7
2	140.2
3	140.3

TABLE 6.—*Water levels in Howard County, Tex.*—Continued

Date of measurement	Depth to water (feet)	Date of measurement	Depth to water (feet)	Date of measurement	Depth to water (feet)	Date of measurement	Depth to water (feet)
1937		1937		1938		1938	
Sept. 4	140.4	Nov. 7	136.5	Jan. 23	131.7	Apr. 24	128.4
5	139.2	8	136.0	25	130.4	25	127.5
6	138.6	9	136.2	27	130.5	26	127.5
7	138.7	10	135.3	Feb. 2	128.8	27	128.4
8	139.2	11	136.0	4	129.0	28	128.2
9	139.3	12	134.5	5	131.2	29	128.4
10	139.3	13	135.4	6	131.1	30	130.5
11	139.3	14	135.2	7	132.5	May 1	131.1
12	139.2	15	134.3	9	128.8	2	129.7
13	139.3	16	135.0	10	131.8	3	130.2
14	139.2	17	135.1	11	130.2	4	130.1
15	139.5	18	135.0	12	132.3	5	130.7
16	139.4	19	135.2	13	134.0	6	130.7
17	139.8	20	135.4	14	133.2	7	132.0
18	139.9	21	135.2	15	131.8	8	131.0
19	140.4	22	135.1	16	131.2	9	129.7
20	139.4	23	134.7	17	130.5	10	128.8
21	139.7	24	134.4	19	129.0	11	129.7
22	140.0	25	134.1	22	128.4	13	127.5
23	140.0	30	132.4	23	129.7	14	131.1
24	139.3	Dec. 1	133.7	24	129.7	15	130.6
25	139.5	3	132.5	25	130.5	16	132.3
26	138.4	5	132.4	26	129.7	17	133.6
27	137.7	6	132.0	27	130.0	18	134.5
28	137.6	7	131.7	Mar. 2	127.7	19	135.0
29	138.3	8	132.0	4	127.3	23	127.3
30	139.5	9	132.4	5	128.2	24	131.1
Oct. 1	139.8	10	132.2	10	126.6	25	131.1
2	140.0	11	132.2	13	126.5	26	132.8
3	139.8	12	132.2	15	126.8	27	134.3
4	139.6	13	131.0	16	128.9	28	134.0
5	139.7	14	131.6	18	127.2	29	132.2
6	140.2	15	131.2	19	129.2	30	130.5
7	140.2	16	132.3	20	128.5	31	131.1
8	139.1	17	131.4	21	128.2	June 1	134.0
9	139.2	18	131.8	22	128.6	2	135.1
10	138.4	19	132.5	23	130.0	3	133.6
11	137.2	20	132.2	24	129.5	4	134.1
12	136.6	22	130.6	25	129.5	5	132.8
13	136.7	23	132.4	26	129.5	6	131.9
14	137.9	24	133.1	29	126.2	7	131.5
15	136.4	25	132.4	31	126.9	8	132.5
16	135.7	26	132.2	Apr. 1	128.5	9	131.8
17	136.8	27	131.6	2	128.4	10	132.1
18	135.7	28	132.4	3	128.2	11	132.6
19	136.4	29	132.2	4	127.2	12	133.6
20	137.3	30	132.0	5	127.9	13	135.3
21	136.6	31	131.5	6	129.2	14	133.4
22	137.0			8	127.2	15	132.5
23	136.7	1938		9	127.9	16	132.3
24	136.7	Jan. 1	132.5	10	127.5	17	131.1
25	136.2	3	130.2	11	127.7	18	131.7
26	137.2	4	132.3	12	127.8	19	131.3
27	137.2	5	131.6	13	128.1	20	130.2
28	137.2	6	130.8	14	127.8	21	132.1
29	137.1	11	130.0	15	127.7	22	134.7
30	137.6	12	132.7	16	127.5	23	133.7
31	137.2	13	133.1	17	127.9	24	135.4
Nov. 1	138.2	14	132.4	18	127.4	25	132.3
2	138.3	15	132.9	19	127.7	27	129.7
3	138.2	19	132.9	20	127.5	29	128.8
4	137.6	20	133.7	21	128.6	30	131.1
5	137.2	21	133.6	22	128.2		
6	136.5	22	133.2	23	128.4		

WELL 82. City of Big Spring well 55. NE¼ sec. 33, block 32; 6 miles southeast of Big Spring, Tex. Measuring point, top of 12-inch casing; altitude, 2,628.97 feet, 1 foot above land surface.

1936		1936		1936		1938	
Feb. 12	143.5	June 23	149.4	July 17	190.1	Jan. 30	132.70
May 6	159.1	25	169.8	21	165.3		
June 17	143.6	July 8	128.2				
19	144.8	10	131.1				

TABLE 6.—*Water levels in Howard County, Tex.*—Continued

WELL 83. City of Big Spring well 56. NE¼ sec. 33, block 32, 6 miles southeast of Big Spring, Tex. Measuring point, top of 8-in. casing; altitude, 2,629.06 feet, 1 ft. above land surface. After Sept. 30, 1936, measurements were usually made between 6 and 8 a. m. before wells were pumped; readings by N. L. Riggan, pump operator.

Date of measurement	Time	Depth to water (feet)	Date of measurement	Time	Depth to water (feet)	Date of measurement	Time	Depth to water (feet)
1936			1936			1936		
Feb. 3	4:00 p. m.	135.2	Aug. 6	9:15 p. m.	168.3	Sept. 1	7:30 p. m.	157.5
20	----------	162.8	7	5:45 a. m.	156.7	2	6:00 a. m.	144.4
May 6	2:30 p. m.	159.1	7	8:45 p. m.	162.5	2	7:00 p. m.	159.3
7	10:15 a. m.	151.7	8	5:45 a. m.	155.3	3	6:15 a. m.	146.1
June 17	9:20 a. m.	145.5	8	8:00 p. m.	167.0	3	5:00 p. m.	158.8
19	10:50 a. m.	138.7	9	6:00 a. m.	153.9	4	6:00 a. m.	143.6
25	11:30 a. m.	152.4	9	5:00 p. m.	163.7	4	6:30 p. m.	155.0
July 8	3:15 p. m.	128.5	10	5:45 a. m.	146.5	5	6:30 a. m.	140.8
10	10:50 a. m.	131.0	10	7:00 p. m.	160.7	5	6:15 p. m.	154.2
16	6:00 a. m.	147.2	11	5:45 a. m.	146.1	6	7:00 a. m.	140.0
16	8:00 p. m.	162.7	11	7:00 p. m.	162.3	6	7:00 p. m.	156.3
17	6:00 a. m.	146.3	12	6:00 a. m.	147.4	7	6:20 a. m.	143.1
17	8:00 p. m.	162.0	12	8:00 p. m.	164.3	8	6:30 a. m.	138.0
18	6:00 a. m.	144.4	13	6:00 a. m.	151.6	8	7:00 p. m.	155.5
18	8:00 p. m.	161.4	13	9:00 p. m.	166.1	9	6:30 a. m.	142.0
19	6:00 a. m.	146.4	14	6:00 a. m.	154.2	11	6:30 a. m.	129.0
19	8:00 p. m.	163.1	14	9:15 p. m.	167.7	11	7:15 p. m.	150.7
20	6:00 a. m.	147.3	15	5:45 a. m.	156.7	12	6:15 a. m.	137.8
20	8:00 p. m.	163.5	15	7:00 p. m.	167.2	12	7:00 p. m.	155.7
21	6:00 a. m.	150.2	16	6:00 a. m.	156.5	13	6:00 a. m.	141.6
21	7:30 p. m.	164.2	16	9:15 p. m.	166.2	13	----------	------
22	6:00 a. m.	149.4	17	6:00 a. m.	154.8	14	6:30 a. m.	143.5
22	5:00 p. m.	162.4	17	8:51 p. m.	166.8	14	7:00 p. m.	162.4
23	6:00 a. m.	143.2	18	6:00 a. m.	155.0	15	6:30 a. m.	146.6
23	6:00 p. m.	153.8	18	9:30 p. m.	167.8	15	6:15 p. m.	163.7
24	6:00 a. m.	137.7	19	5:45 a. m.	156.9	16	6:00 a. m.	147.2
24	7:00 p. m.	158.3	19	8:00 p. m.	167.7	17	5:15 a. m.	150.8
25	6:00 a. m.	142.5	20	5:45 a. m.	155.3	17	7:00 p. m.	162.8
25	6:15 p. m.	158.7	20	9:00 p. m.	162.5	18	6:45 a. m.	147.5
26	6:30 a. m.	138.3	21	5:45 a. m.	156.0	18	6:30 p. m.	160.8
26	6:15 p. m.	155.7	21	7:30 p. m.	167.0	19	6:45 a. m.	145.6
27	6:00 a. m.	140.3	22	5:45 a. m.	154.0	19	6:00 p. m.	158.7
27	8:00 p. m.	160.0	22	8:00 p. m.	166.7	20	7:00 a. m.	141.8
28	6:00 a. m.	144.2	23	6:00 a. m.	154.3	20	3:00 p. m.	147.2
28	9:50 p. m.	163.0	23	7:00 p. m.	166.2	21	6:15 a. m.	134.4
29	6:00 a. m.	151.7	24	6:15 a. m.	151.3	22	7:00 a. m.	129.9
29	7:40 p. m.	165.1	24	6:00 p. m.	165.4	23	7:00 a. m.	134.0
30	6:00 a. m.	154.2	25	6:00 a. m.	150.1	23	7:30 p. m.	150.0
30	6:00 p. m.	164.7	25	8:30 p. m.	165.8	25	6:30 a. m.	127.1
31	4:30 a. m.	150.2	26	6:15 a. m.	153.0	25	6:45 p. m.	150.5
31	6:15 p. m.	164.2	26	8:00 p. m.	167.6	26	8:00 a. m.	133.7
Aug. 1	5:15 a. m.	148.1	27	6:00 a. m.	154.8	26	5:30 p. m.	152.7
1	7:00 p. m.	163.2	27	8:15 p. m.	163.7	27	8:00 a. m.	133.2
2	6:00 a. m.	147.7	28	6:00 a. m.	151.7	27	6:45 p. m.	144.0
2	4:30 p. m.	160.3	28	9:30 p. m.	167.8	28	8:00 a. m.	130.3
3	5:45 a. m.	142.0	29	6:00 a. m.	157.1	28	6:30 p. m.	140.2
3	8:45 p. m.	161.7	29	6:45 p. m.	165.5	29	7:30 a. m.	130.8
4	5:45 a. m.	148.1	30	6:00 a. m.	151.4	29	6:45 p. m.	136.2
4	9:00 p. m.	165.9	30	1:00 p. m.	158.8	30	8:00 a. m.	129.5
5	5:45 a. m.	154.3	31	6:00 a. m.	140.7	30	5:30 p. m.	137.2
5	8:45 p. m.	166.4	31	3:15 p. m.	155.1			
6	5:30 a. m.	155.2	Sept. 1	6:00 a. m.	139.2			

TABLE 6.—*Water levels in Howard County, Tex.*—Continued

Date of measurement	Depth to water (feet)	Date of measurement	Depth to water (feet)	Date of measurement	Depth to water (feet)	Date of measurement	Depth to water (feet)
1936		1936		1937		1937	
Oct. 1	129.8	Dec. 20	127.8	Mar. 21	134.0	June 11	147.7
2	128.9	21	128.0	22	131.6	12	151.0
3	128.7	22	129.2	23	131.5	13	150.7
4	128.6	23	129.7	24	132.8	14	151.1
5	127.2	24	129.9	25	134.6	15	154.2
6	126.8	25	127.1	26	133.0	16	157.5
7	127.3	29	125.1	27	132.8	17	157.6
8	127.2	30	128.0	28	132.7	18	158.5
9	127.4	31	127.8	29	132.2	19	152.9
10	125.5			30	131.2	20	158.0
11	130.7	1937		31	132.9	21	152.9
12	126.2	Jan. 1	127.2	Apr. 1	134.0	22	156.1
13	125.6	2	128.5	2	134.8	23	159.8
14	126.1	3	126.8	3	141.6	24	159.7
15	124.9	4	128.2	4	139.4	25	158.8
16	126.5	5	126.9	5	132.1	26	159.8
17	126.6	6	126.4	6	134.3	27	160.0
18	126.5	7	127.8	7	134.3	28	157.3
19	124.0	12	131.7	8	133.7	29	159.1
20	127.4	13	128.9	9	140.1	30	158.9
21	127.0	14	130.2	10	137.7	July 1	158.4
22	125.3	15	131.1	11	137.8	2	156.6
23	125.2	16	130.9	12	141.5	3	155.3
24	127.0	17	130.6	13	139.3	4	154.1
25	126.5	18	127.7	14	144.2	5	156.0
26	126.0	19	130.2	15	140.8	6	145.3
27	126.7	20	130.4	16	145.2	7	155.1
28	127.6	21	130.5	17	146.5	8	156.8
29	126.0	23	129.3	18	146.2	9	154.6
30	128.8	24	133.0	19	142.8	10	153.7
31	126.8	25	129.1	20	142.2	11	147.3
Nov. 1	128.5	26	129.7	21	144.7	12	139.5
2	127.2	27	132.9	22	147.7	13	139.3
3	129.6	28	132.2	23	149.3	14	149.5
4	127.1	29	131.8	24	148.3	15	156.3
5	126.8	30	130.5	25	145.5	16	156.4
6	128.7	31	131.0	26	146.2	17	159.4
7	129.8	Feb. 3	129.3	27	150.1	18	157.9
8	128.9	4	126.6	28	149.4	19	154.7
9	125.8	5	130.5	29	151.2	20	155.1
10	126.4	6	132.1	30	150.1	21	149.7
11	126.8	9	123.1	May 1	152.9	22	145.6
12	126.3	10	126.7	2	154.2	23	149.0
13	129.7	11	127.6	3	150.1	24	155.0
14	128.3	12	127.6	4	145.7	25	157.2
15	128.0	13	132.6	5	151.7	26	148.8
16	127.4	14	131.8	6	151.8	27	155.7
17	125.5	15	126.8	7	149.0	28	155.6
18	129.4	16	128.9	8	148.8	29	158.7
19	129.7	17	131.1	9	152.0	30	157.2
20	129.2	19	130.6	10	147.0	31	159.7
21	128.0	20	129.7	11	142.8	Aug. 1	157.5
22	128.6	21	130.9	12	143.5	2	154.2
23	128.0	22	133.6	13	138.5	3	159.9
24	127.4	23	135.8	14	141.4	4	159.7
25	128.1	24	131.2	15	147.4	5	157.7
26	129.2	25	138.0	16	145.4	6	160.6
27	127.0	26	137.7	17	152.9	7	155.7
28	127.2	27	137.7	18	152.0	8	160.0
29	125.5	28	137.4	19	156.2	9	157.6
30	126.7	Mar. 1	136.4	20	155.4	10	159.9
Dec. 1	126.7	2	137.6	21	153.5	11	162.3
2	126.4	3	132.9	22	155.5	12	162.6
3	126.8	4	132.1	23	155.8	13	162.5
4	126.8	5	132.3	24	149.9	14	160.7
5	126.9	6	128.1	26	134.6	15	159.0
6	126.5	7	133.0	27	134.7	16	157.2
7	126.7	8	131.5	28	139.7	17	158.2
8	130.0	9	131.3	30	152.8	18	159.0
9	129.1	10	131.8	31	141.7	19	159.7
10	131.3	11	132.7	June 1	142.8	20	152.7
11	128.2	12	134.3	2	148.0	22	138.6
12	130.2	13	134.0	3	146.0	23	139.6
13	129.6	14	132.2	4	150.2	24	144.4
14	127.4	15	130.4	5	156.2	25	145.7
15	129.5	16	130.7	6	157.5	26	152.5
16	128.7	17	131.5	7	146.5	27	147.2
17	128.2	18	132.1	8	144.0	28	149.0
18	130.0	19	133.1	9	145.5	29	149.2
19	130.5	20	133.4	10	147.4	30	156.3

TABLE 6.—*Water levels in Howard County, Tex.*—Continued

Date of measurement	Depth to water (feet)	Date of measurement	Depth to water (feet)	Date of measurement	Depth to water (feet)	Date of measurement	Depth to water (feet)
1937		1937		1938		1938	
Aug. 31	159.3	Nov. 5	144.3	Jan. 22	139.2	Apr. 23	133.4
Sept. 1	159.4	6	142.5	23	136.1	24	133.1
2	160.6	7	143.7	25	131.7	25	130.6
3	161.0	8	141.0	27	133.1	26	130.7
4	160.5	9	141.3	Feb. 2	----------	27	133.2
5	154.7	10	138.5	4	130.2	28	132.4
6	152.7	11	141.1	5	137.3	29	133.2
7	153.3	12	137.2	6	136.0	30	140.1
8	159.7	13	139.5	7	141.5	May 1	144.7
9	156.2	14	138.6	9	130.1	2	135.2
10	157.4	15	136.7	10	139.0	3	138.6
11	157.7	16	138.2	11	134.6	4	137.5
12	157.7	17	138.8	12	141.1	5	139.5
13	155.2	18	139.0	13	147.0	6	139.5
14	156.4	19	139.6	14	142.8	7	143.7
15	157.6	20	139.7	15	138.1	8	139.1
16	155.0	21	139.7	16	136.5	9	135.5
17	156.7	22	139.4	17	134.3	10	132.9
18	159.6	23	138.5	19	130.1	11	135.6
19	160.2	24	138.8	22	128.7	13	129.2
20	154.7	25	138.4	23	133.9	14	141.1
21	155.2	30	132.4	24	133.2	15	138.4
22	157.0	Dec. 1	136.7	25	135.5	16	145.2
23	158.1	3	134.4	26	133.1	17	148.5
24	152.7	5	133.7	27	134.4	18	152.9
25	153.1	6	133.4	Mar. 2	127.7	19	154.0
26	148.1	7	133.6	4	128.0	23	127.6
27	146.0	8	132.8	5	129.4	24	139.4
28	145.6	9	134.7	10	126.7	25	139.7
29	149.0	10	134.2	13	126.5	26	145.2
30	154.0	11	134.7	15	127.5	27	151.2
Oct. 1	155.5	12	134.6	16	133.8	28	148.8
2	159.1	13	131.8	18	128.8	29	141.6
3	155.4	14	133.3	19	134.8	30	135.8
4	153.4	15	132.2	20	132.7	31	137.2
5	152.9	16	136.2	21	131.8	June 1	148.5
6	156.7	17	133.1	22	132.7	2	152.4
7	158.4	18	135.2	23	137.1	3	146.3
8	151.0	19	136.7	24	135.4	4	146.8
9	150.8	20	135.7	25	135.9	5	141.7
12	141.6	22	131.8	26	135.5	6	139.3
13	141.2	23	138.3	29	126.7	7	137.3
14	146.4	24	139.7	31	127.6	8	141.7
15	141.5	25	136.6	Apr. 1	132.9	9	139.1
16	139.4	26	136.7	2	132.4	10	139.5
17	142.9	27	133.2	3	132.3	11	141.0
18	139.4	28	137.5	4	129.3	12	144.1
19	141.5	29	136.5	5	132.0	13	151.7
20	145.9	30	136.6	6	135.5	14	143.8
21	142.5	31	135.7	8	129.3	15	140.0
22	144.2	1938		9	131.4	16	139.3
23	143.2	Jan. 1	137.8	10	130.8	17	135.9
24	143.9	3	131.6	11	128.2	18	137.3
25	141.9	4	137.9	12	131.6	19	136.3
26	145.3	5	136.6	13	132.6	20	133.2
27	145.5	6	134.4	14	131.4	21	138.8
28	146.2	11	131.2	15	131.6	22	148.8
29	145.2	12	139.7	16	131.3	23	144.7
30	146.8	13	141.2	17	131.6	24	150.9
31	145.2	14	138.0	18	130.2	25	138.7
Nov. 1	149.7	15	140.1	19	131.8	27	130.7
2	148.8	19	140.5	20	130.9	29	129.8
3	148.7	20	142.6	21	133.7	30	135.9
4	145.5	21	142.4	22	2.431		

TABLE 6.—*Water levels in Howard County, Tex.*—Continued

WELL 88. City of Big Spring well 62. NE¼ sec. 33, block 32, 6 miles southeast of Big Spring, Tex. Measuring point, top of 12½-inch casing; altitude, 2,657.03 feet, 1.17 feet above land surface.

Date of measurement	Depth to water (feet)	Date of measurement	Depth to water (feet)	Date of measurement	Depth to water (feet)	Date of measurement	Depth to water (feet)
1936		1936		1936		1936	
Feb. 19	144.1	May 29	152.6	June 25	154.5	July 21	159.5
20	143.3	June 17	155.2	July 8	153.9	Sept. 8	162.0
21	168.5	19	154.9	10	153.0	1938	
May 6	152.9	23	154.7	17	157.6	Jan. 30	164.3

WELL 89. City of Big Spring well 60. NE¼ sec. 33, block 32, 6 miles southeast of Big Spring, Tex. Measuring point, top of 12-inch casing; altitude, 2,643.76 feet, 1 foot above land surface.

1936		1936		1936		1936	
Feb. 12	133.1	June 17	154.7	July 8	139.8	Sept. 8	159.7
20	150.6	19	153.1	10	141.5		
May 6	155.2	23	155.1	17	157.7	1938	
29	140.0	25	154.5	21	159.3	Jan. 30	150.29

WELL 90. City of Big Spring well 61. NE¼ sec. 33, block 32, 6 miles southeast of Big Spring, Tex. Measuring point, top of 12½-inch casing; altitude, 2,645.57 feet, 1 foot above land surface.

Date of measurement	Time	Depth to water (feet)	Date of measurement	Time	Depth to water (feet)	Date of measurement	Time	Depth to water (feet)
1936			1936			1936		
Feb. 13	------------	131.4	July 28	6:00 a.m.	141.7	Aug. 12	6:00 a.m.	143.7
May 6	1:10 p.m.	150.1	28	9:50 p.m.	155.2	13	6:00 a.m.	143.9
7	11:20 a.m.	137.1	29	6:00 a.m.	142.2	14	6:00 a.m.	144.0
29	1:45 p.m.	139.6	29	7:40 p.m.	155.4	15	5:45 a.m.	144.5
June 17	10:25 a.m.	150.2	30	6:00 a.m.	142.3	15	7:00 p.m.	156.8
19	9:45 a.m.	149.1	30	6:00 p.m.	150.7	16	6:00 a.m.	145.0
23	8:30 a.m.	147.6	Aug. 1	5:30 a.m.	142.7	16	9:15 p.m.	157.0
25	8:15 a.m.	149.7	1	7:00 p.m.	155.2	17	6:00 a.m.	145.0
July 8	11:45 a.m.	138.7	2	6:00 a.m.	142.5	17	8:15 p.m.	157.2
10	8:00 a.m.	140.1	2	4:30 p.m.	155.0	18	6:00 a.m.	145.2
16	6:00 a.m.	140.8	3	5:45 a.m.	142.2	18	7:00 p.m.	156.7
16	8:00 p.m.	153.8	3	8:45 p.m.	154.7	19	5:45 a.m.	145.1
17	6:00 a.m.	140.9	4	5:45 a.m.	142.8	19	8:00 p.m.	157.1
17	8:00 p.m.	153.2	4	9:00 p.m.	155.7	20	5:45 a.m.	145.1
18	6:00 a.m.	140.9	5	5:45 a.m.	143.4	20	7:00 p.m.	157.1
19	6:00 p.m.	141.3	5	8:45 p.m.	156.3	21	5:45 a.m.	145.4
20	6:00 a.m.	141.1	6	5:30 a.m.	143.4	21	7:00 p.m.	157.4
21	6:00 a.m.	141.7	6	9:15 p.m.	156.7	22	5:45 a.m.	145.4
21	8:00 p.m.	154.3	7	5:45 a.m.	143.7	22	7:30 p.m.	157.3
23	6:00 a.m.	141.2	7	8:45 p.m.	156.0	23	6:00 a.m.	145.6
23	6:00 p.m.	152.2	8	5:45 a.m.	144.0	24	6:15 a.m.	145.2
24	6:00 a.m.	141.0	8	8:00 p.m.	156.2	24	6:00 p.m.	157.6
24	7:30 p.m.	151.5	9	6:00 a.m.	144.0	25	6:00 a.m.	145.2
25	6:00 a.m.	141.5	9	5:00 p.m.	155.2	Sept. 8	9:15 a.m.	155.2
26	6:30 a.m.	141.0	10	5:45 a.m.	143.7			
26	7:00 p.m.	153.0	10	7:00 p.m.	155.3	1938		
27	6:00 a.m.	141.4	11	5:45 a.m.	143.7	Jan. 30	------------	152.2
27	8:00 p.m.	154.0	11	7:00 p.m.	155.2			

TABLE 6.—*Water levels in Howard County, Tex.*—Continued

WELL 92. City of Big Spring well 71. NE¼ sec. 33, block 32, 6 miles southeast of Big Spring, Tex. Measuring point, top of 10-inch casing at land surface; altitude, 2,664.05 feet.

Date of measurement	Depth to water (feet)	Date of measurement	Depth to water (feet)	Date of measurement	Depth to water (feet)	Date of measurement	Depth to water (feet)
1937		1937		1938			
Sept. 30	110.1	Nov. 17	109.0	Jan. 31	109.4		

WELL 93. Hardy Morgan. NE¼ sec. 32, block 32, 5¾ miles southeast of Big Spring, Tex. Measuring point, top of pipe clamp; altitude, 2,790.46 feet, 0.8 feet above land surface.

Date of measurement	Depth to water (feet)	Date of measurement	Depth to water (feet)	Date of measurement	Depth to water (feet)	Date of measurement	Depth to water (feet)
1937		1937		1937		1938	
May 12	214.75	Aug. 19	214.85	Nov. 17	214.70	Jan. 31	215.15
June 11	215.00	Sept. 20	214.80				

WELL 95. Fisher Bros. SW¼ sec. 41, block 32, 7 miles southeast of Big Spring, Tex. Measuring point, top of pipe clamp at land surface; altitude, 2,685.19 feet.

Date of measurement	Depth to water (feet)	Date of measurement	Depth to water (feet)	Date of measurement	Depth to water (feet)	Date of measurement	Depth to water (feet)
1936		1937		1937			
Aug. 27	102.17	May 4	102.22	June 15	102.23		

WELL 99. Hardy Morgan. NW¼ sec. 45, block 32, 7¾ miles southeast of Big Spring, Tex. Measuring point, top of casing; altitude, 2,724.00 feet, 0.2 foot above land surface.

Date of measurement	Depth to water (feet)	Date of measurement	Depth to water (feet)	Date of measurement	Depth to water (feet)	Date of measurement	Depth to water (feet)
1936		1937		1937		1937	
Aug. 27	147.4	June 17	146.3	Sept. 21	146.00	Nov. 17	146.05
		Aug. 18	146.00				

WELL 120. Texas & Pacific Ry. Co. NE¼ sec. 3, block 32, 10 miles southeast of Big Spring, Tex. Measuring point, top of pipe clamp; altitude, 2,750.1 feet, 0.7 foot above land surface.

Date of measurement	Depth to water (feet)	Date of measurement	Depth to water (feet)	Date of measurement	Depth to water (feet)	Date of measurement	Depth to water (feet)
1936		1937		1937		1938	
Mar. 23	180.1	May 21	177.85	Aug. 30	178.10	Feb. 3	178.07
		June 22	178.19	Nov. 18	177.97		

WELL 123. Albert Fisher. SW¼ sec. 1, block 32, 9 miles south of Big Spring, Tex. Measuring point, top of casing; altitude, 2,790.0 feet, 2.1 feet above land surface.

Date of measurement	Depth to water (feet)	Date of measurement	Depth to water (feet)	Date of measurement	Depth to water (feet)	Date of measurement	Depth to water (feet)
1936		1937		1937			
Mar. 23	216.5	June 22	213.63	Aug. 30	213.54		

WELL 124. Fisher Bros. SE¼ sec. 43, block 32, 8½ miles southeast of Big Spring, Tex. Measuring point, top of casing; altitude, 2,780.4 feet, 1.3 feet above land surface.

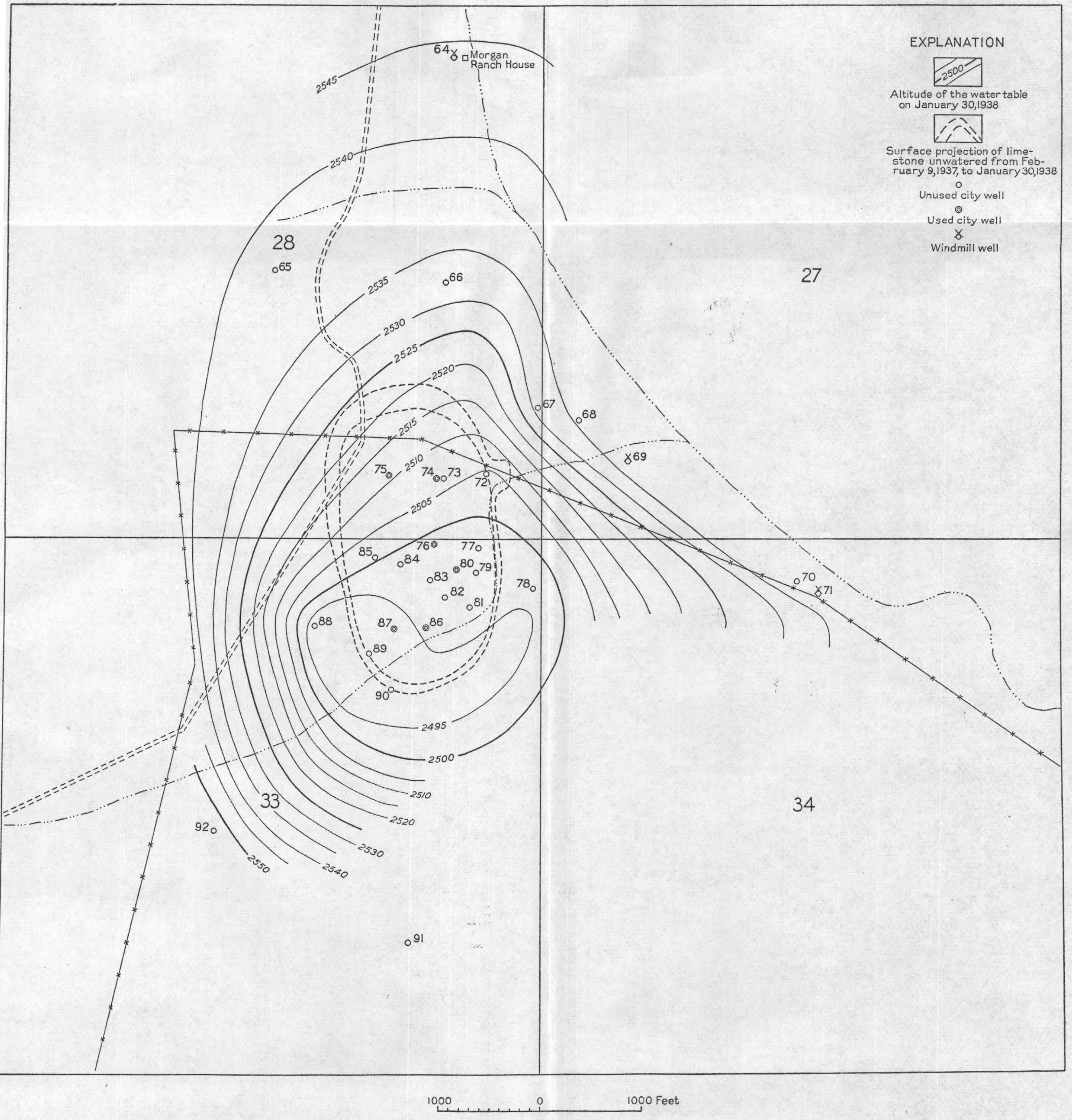
Date of measurement	Depth to water (feet)	Date of measurement	Depth to water (feet)	Date of measurement	Depth to water (feet)	Date of measurement	Depth to water (feet)
1937		1937		1938			
Sept. 14	202.35	Nov. 18	202.18	Feb. 3	202.35		

WELL 130. Fisher Bros. SW¼ sec. 36, block 33, 6 miles south of Big Spring, Tex. Measuring point, top of concrete at land surface; altitude, 2,624.95 feet.

Date of measurement	Depth to water (feet)	Date of measurement	Depth to water (feet)	Date of measurement	Depth to water (feet)	Date of measurement	Depth to water (feet)
1936		1937		1937			
Mar. 17	46.60	May 4	47.30	June 26	47.07		

WELL LOGS

Most of the logs used in this report were reported by drillers; however, the logs of wells 7, 40, 55, 57, 58, 60, 61, 62, 76, 86, 94, 100, 124, 125, 149, 174, 178, 180, 192, and 193 were compiled from the examination of well samples by the writers. The log of well 49 was made from examination of well samples by J. H. Samuell.



ALTITUDE OF WATER TABLE IN SECTION 33 SINK ON JANUARY 30, 1938.

463301—44 (Face p. 74)

TABLE 7.—*Logs of wells in the Big Spring area, Texas*

Well 2, 9¾ miles southwest of Big Spring

	Thickness (feet)	Depth (feet)
Cellar	10	10
Triassic and Permian redbeds:		
Pink sandy rock	45	55
Red rock	45	100
Redbeds	145	245
Red rock	185	430
Brown shale	40	470
Red rock	50	520
Sand	20	540
Red rock	95	635
Sandy red rock	10	645
Gray water sand	17	662
Sand	153	815
Triassic and Permian redbeds—Con.		
Sandy red rock	5	820
Hard sand	5	825
Redbeds	15	840
Red mud	10	850
Redbeds	70	920
Sandy red rock	175	1,095
Shell and sand	20	1,115
Red rock and shells	60	1,175
Anhydrite	15	1,190
Salt	90	1,280
Salt and anhydrite layers	70	1,350

Well 7, 2½ miles south of Big Spring

	Thickness (feet)	Depth (feet)
Fredericksburg group:		
Limestone reported (no sample)	35	35
Gray limestone and some dark-brown arenaceous limestone	5	40
Buff arenaceous limestone	3	43
Trinity sand:		
Fine brown sand and some coarse quartz pebbles	2	45
Fine colorless sand	7	52
Red clay	2	54
White sand reported (no sample)	26	80
Very coarse sand and gravel composed mostly of red and black quartz	2	82
Finer sand and gravel	3	85
Sand and gravel like above sample	2	87
Trinity sand—Con.		
Fine sand and gravel	2	89
Fine sand and gravel packed very hard (drills extremely hard)	1	90
Fine sand and some gray to light-red arenaceous clay	5	95
Very coarse sand and gravel	5	100
Sand and gravel stained red with clay	3	103
Dockum group:		
Red arenaceous micaceous shale with some yellow streaks	4	107
Do	4	111
Tough, sticky red shale with a few quartz pebbles	2	113

Well 16, 2½ miles south of Big Spring

	Thickness (feet)	Depth (feet)
Quaternary:		
Soil	3	3
Yellow clay and gravel	14	17
Fredericksburg group:		
Shell rock	14	30
White lime rock	70	100
Yellow lime rock	27	127
White lime; water in crevice	15	142
Blue shale	53	195
Pink sand rock	14	209
Trinity sand:		
Yellow sand	6	215
Trinity sand—Con.		
Yellow sand and gravel	5	220
Yellow sand rock	5	225
Light-yellow sand	6	231
Yellow sand	5	236
Pink sand	8	244
Red clay and sand	7	251
Yellow sand	21	272
Pink sand and gravel	8	280
Dockum group:		
Redbed	3	283

Well 40, 3¼ miles southeast of Big Spring

	Thickness (feet)	Depth (feet)
Fredericksburg group:		
Hard light-buff limestone and some chert	22	22
Light-gray to buff limestone	10	32
Light-gray limestone; microfossils abundant	18	50
Buff limestone	15	65
Light-gray to buff limestone	10	75
Dark-gray argillaceous limestone	20	95
Light to dark-gray argillaceous limestone	5	100
Light-gray to buff limestone	5	105
Buff limestone and some arenaceous limestone	25	130
Limestone reported (no sample)	18	148
Trinity sand:		
Sand reported (no sample)	19	167
Pink clay reported (no sample)	5	172
Light-colored clay and sand reported (no sample)	21	193
Yellow clay reported (no sample)	4	197
Light-pink clay reported (no sample)	13	210
Dark-pink clay and sand reported (no sample)	18	228
Dockum group:		
Red shale reported (no sample)	15	243

TABLE 7.—*Logs of wells in the Big Spring area, Texas*—Continued

Well 49, 3¾ miles southeast of Big Spring

	Thickness (feet)	Depth (feet)
Fredericksburg group:		
Top soil	1	1
White soil	5	6
Hard rock	5	11
Gray lime	4	15
Bluish-yellow limestone	4	19
Gray limestone	6	25
Bluish-gray limestone	6	31
Yellow clay	4	35
Gray clay	5	40
Clay	5	45
White limestone	20	65
Yellow limestone	5	70
White limestone	5	75
Fredericksburg group—Con.		
Gray limestone	14	89
Blue hard limestone	35	124
Yellow limestone	8	132
Yellow limestone and clay	13	145
Clay	3	148
Trinity sand:		
Sand	17	165
Yellow sand and clay	5	170
Pink clay	5	175
Yellow sand and clay	10	185
Sand	30	215
Pink sand	20	235
Dockum group:		
Redbed	22½	257½

Well 55, 3¾ miles southeast of Big Spring

	Thickness (feet)	Depth (feet)
Fredericksburg group:		
Soil reported (no sample)	2	2
Buff limestone	9	11
Hard light-buff limestone and numerous pieces of chert	15	26
Hard light-buff limestone	11	37
Light-gray limestone	18	55
Hard light-gray limestone	15	70
Light-gray to buff limestone	40	110
Gray fossiliferous limestone	37	147
Buff arenaceous limestone	8	155
Trinity sand:		
Light-buff sand and some quartz pebbles	21	176
Buff sand and some light-gray to lavender silty clay	8	184
Light-gray sand and some gravel	53	237
Sand and a small amount of fine gravel	18	255
Gravel and some sand	5	260
Dockum group:		
Red shale reported (no sample)	5	265
Red shale	12	277

Well 57, 4 miles southeast of Big Spring

	Thickness (feet)	Depth (feet)
Fredericksburg group:		
Soil reported (no sample)	2	2
White lime reported (no sample)	11	13
Yellow limestone reported (no sample)	4	17
Light-gray to buff limestone	6	23
Do	33	56
Dark-gray argillaceous limestone	25	81
Dark-gray fossiliferous limestone	7	88
Do	15	103
Fredericksburg group—Con.		
Buff arenaceous limestone	8	111
Yellow clay reported (no sample)	5	116
Trinity sand:		
Buff sand	54	170
Light-buff sand and a few quartz pebbles	5	175
Buff sand and a few quartz pebbles	20	195
Pink silty clay	2	197
Gravel and some sand	18	215
Dockum group:		
Red clay reported (no sample)	16	231

Well 58, 4 miles southeast of Big Spring

	Thickness (feet)	Depth (feet)
Ferdericksburg group:		
Soil reported (no sample)	5	5
Hard buff limestone and a small amount of chert	8	13
Light-gray to light-buff limestone	8	21
Light-gray to light-buff fossiliferous limestone	35	56
Dark-gray argillaceous limestone	21	77
Dark-gray fossiliferous limestone	11	88
Light to dark-gray fossiliferous arenaceous argillaceous limestone	12	100
Fredericksburg group—Con.		
Gray to buff arenaceous fossiliferous limestone	12	112
Trinity sand:		
Light-brown argillaceous sand and a few quartz pebbles	16	128
Pink silty clay	7	135
Gray sand reported (no sample)	33	168
Running sand reported (no sample)	4	172
Fine buff argillaceous sand	26	198
Gravel and a small amount of sand	15	213
Dockum group:		
Red clay reported (no sample)	8	221

TABLE 7.—*Logs of wells in the Big Spring area, Texas*—Continued

Well 60, 4 miles southeast of Big Spring

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Fredericksburg group:			Trinity sand:		
Soil reported (no sample)	3	3	Gray sand and some quartz pebbles	25	145
Hard light-buff limestone	31	34	Pink silty clay	6	151
Light-gray to light-buff limestone	16	50	Light-buff sand and a few quartz pebbles	54	205
Soft light-gray limestone	15	65	Gravel and some sand	15	220
Dark-gray argillaceous limestone	37	102	Dockum group:		
Gray to light-buff arenaceous limestone and fossil fragments	18	120	Redbed reported (no sample)	5	225

Well 61, 4 miles southeast of Big Spring

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Fredericksburg group:			Trinity sand—Continued.		
Soil reported (no sample)	2	2	Buff sand and a small amount of quartz pebbles	5	185
Hard light-buff limestone and a small amount of chert	31	33	Light-gray sand, fine gravel, and some gray to pink silty clay	7	192
Soft buff limestone	14	47	Slightly calcareous red silty clay	3	195
Soft light-buff limestone and some brown shale	8	55	Buff sand and some quartz pebbles	10	205
Hard very light-gray limestone and some brown shale	5	60	Slightly calcareous brown argillaceous sand	10	215
Very light-gray coarse-textured limestone	8	68	Light-gray sand and some gravel consisting mainly of red and black quartz	10	225
Very light-gray limestone	6	74	Coarse gravel and some sand	15	240
Very light-gray fine-textured fossiliferous limestone	51	125	Gravel and sand cemented by slightly calcareous light-red clay	10	250
Gray to dark-gray very fossiliferous limestone	15	140	Fine light-gray calcareous sand	9	259
Gray arenaceous limestone	22	162	Gravel and sand	4	263
Trinity sand:			Dockum group:		
Buff sand and some very argillaceous limestone	13	175	Red shale reported (no sample)	12	275
Very fine light-gray sand and some quartz pebbles	5	180			

Well 62, 4 miles southeast of Big Spring

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Fredericksburg group:			Trinity sand—Continued.		
Hard light-buff limestone and some chert	20	20	Pink silty clay	3	204
Light-buff to buff limestone	30	50	Light-buff sand and a small amount of gravel	22	226
Light-gray to light-buff limestone	47	97	Gravel and some sand	7	233
Dark-gray argillaceous limestone	50	147	Sand and gravel stained brown with clay	17	250
Gray to buff arenaceous fossiliferous limestone	13	160	Gravel and some sand	5	255
Trinity sand:			Dockum group:		
Light-gray sand	41	201	Red clay reported (no sample)	10	265

Well 65, 5½ miles southeast of Big Spring

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Fredericksburg group:			Trinity sand—Continued.		
Soil	2	2	White sand	8	71
Gray lime	1	3	Hard sand rock	11	82
Yellow broken lime	7	10	Yellow sand	19	101
Yellow clay	8	18	Yellow sand rock	9	110
Yellow broken lime	12	30	Sand and gravel	23	133
Yellow clay	3	33	Yellow sand rock	8	141
Yellow lime	5	38	Compact sand	3	144
Yellow clay	8	46	Gravel	8	152
Yellow lime	5	51	Dockum group:		
Hard white sandy lime	3	54	Mixed clay	3	155
Trinity sand:			Redbed	17	172
Yellow sand rock	9	63			

TABLE 7.—*Logs of wells in the Big Spring area, Texas*—Continued

Well 67, 6 miles southeast of Big Spring

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Fredericksburg group:			Trinity sand—Continued.		
Soil	6	6	White sand	4	62
Yellow lime	10	16	Compact sand	28	90
Trinity sand:			Gravel	15	105
Yellow sand	9	25	Dockum group:		
Gray sand rock	11	36	White clay	5	110
Light-yellow sand and rock	6	42	Redbed	5	115
White sand rock	16	58			

Well 68, 6 miles southeast of Big Spring

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Quaternary:			Trinity sand—Continued.		
Soil	6	6	Sand rock	6	122
Boulders	4	10	Red compact sand	3	125
Gravel and clay	42	52	Gravel	7	132
Sand and rock	4	56	Dockum group:		
Gravel	12	68	Redbed	35	167
Trinity sand:			Compact sand	15	182
White sand	24	92	Redbed	5	187
Red compact sand	24	116			

Well 69, 6¼ miles southeast of Big Spring

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Quaternary:			Trinity sand—Continued.		
Soil	4	4	Gravel	13	144
Gravel	8	12	Packsand and red clay	31	175
Boulders and walnut clay	38	50	Yellow sand rock	5	180
Gravel and boulders	6	56	Compact sand	1	181
Clay, gravel, and boulders	67	123	Dockum group:		
Trinity sand:			Redbed	4	185
Sand	8	131			

Well 70, 6¼ miles southeast of Big Spring

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Quaternary and Trinity sand:			Dockum group:		
Soil	12	12	Redbed	34	90
Gravel and yellow clay	42	54			
Gravel	2	56			

Well 72, 6 miles southeast of Big Spring

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Quaternary:			Fredericksburg group—Con.		
Soil	2	2	Yellow lime	2	80
Boulders	3	5	Blue lime	26	106
Fredericksburg group:			Yellow lime	4	110
Gray lime	6	11	Do	6	116
Yellow lime	11	22	Trinity sand:		
Gray lime	24	46	Sand	49	165
Yellow lime	7	53	Redbeds	21	186
Yellow clay	2	55	Pack sand	19	205
Yellow lime	13	68	Sand and gravel	10	215
Gray lime	4	72	Dockum group:		
Blue lime	4	76	Redbeds	5	220
Blue shale	2	78			

Well 73, 6 miles southeast of Big Spring

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Quaternary:			Fredericksburg group—Con.		
Soil	2	2	Blue lime	38	158
Boulders	4	6	Yellow sand and lime	7	165
Fredericksburg group:			Trinity sand:		
Gray lime	15	21	Sand	40	205
Yellow lime	24	45	Compact sand	25	230
Blue lime	11	56	Yellow sand	20	250
Gray lime	20	76	Gravel	10	260
Yellow lime	19	95	Dockum group:		
Gray lime	25	120	Redbed	5	265

TABLE 7.—*Logs of wells in the Big Spring area, Texas*—Coniinued

Well 75, 6 miles southeast of Big Spring

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Quaternary:			Fredericksburg group—Con.		
Soil	3	3	Blue limestone	4	112
Boulders	4	7	Blue shale	4	116
Fredericksburg group:			Blue limestone	23	139
Yellow limestone	3	10	Yellow sand and limestone	16	155
Gray limestone	12	22	Trinity sand:		
Yellow limestone	9	31	Yellow sand and rock	8	163
Gray limestone	11	42	Gravel and sand	12	175
Yellow limestone	18	60	Packsand	15	190
Gray sandy limestone	6	66	Gravel and sand	4	194
Yellow limestone	10	76	Compact sand	46	240
Gray limestone	15	91	Gravel and sand	14	254
Blue limestone	3	94	Dockum group:		
Yellow limestone	8	102	Yellow clay	5	259
Gray limestone	6	108	Redbed	3	226

Well 76, 6 miles southeast of Big Spring

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Quaternary:			Fredericksburg group—Con.		
Soil reported (no sample)	6	6	Dark-gray argillaceous limestone	10	193
Yellow clay and limestone pebbles (probably all reworked material)	32	38	Buff arenaceous limestone and a few fossil fragments	4	197
Dark-gray calcareous clay	12	50	Trinity sand:		
Fredericksburg group:			Medium-fine sand	9	206
Hard buff limestone and a small amount of chert	8	58	Light-gray sand and a small amount of clay	28	234
Soft light-gray to light-buff limestone	54	112	Sand and gravel	19	253
Hard light-buff limestone and a small amount of chert	47	159	Sand, gravel, and a small amount of gray to lavender silty clay	11	264
Light-gray to light-buff calcareous shale or marl	7	166	Sand, gravel, and silty clay	26	290
Gray fossiliferous limestone	17	183	Gravel and sand	10	300
			Dockum group:		
			Red clay reported (no sample)	16	316

Well 78, 6 miles southeast of Big Spring

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Quaternary:			Trinity sand:		
Soil and boulders	3	3	Hard sand rock	4	85
Fredericksburg group:			Yellow sand rock	3	88
Yellow broken limestone	48	51	Yellow sand	16	104
Yellow clay	7	58	Sand rock	7	111
Gray limestone	1	59	Compact sand	6	117
Yellow clay	4	63	Yellow sand rock	5	122
Yellow limestone	2	65	Yellow sand	6	128
Yellow clay	410	75	Sand	25	153
Yellow limestone	4	79	Compact sand	6	159
Yellow clay	2	81	Sand and gravel	14	173
			Dockum group:		
			Red beds	25	198

Well 79, 6 miles southeast of Big Spring

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Quaternary:			Fredericksburg group—Con.		
Soil and boulders	10	10	Yellow limestone	4	156
Fredericksburg group:			Trinity sand:		
Yellow limestone	7	17	Sand rock	6	162
Gray sandy limstone	8	25	Gravel	10	172
Gray limestone	10	35	Sand	22	194
Hard yellow limestone	7	42	Red rock sand	8	202
Blue limestone	12	54	Red pack sand	8	210
Gray limestone	14	68	Yellow sand	28	238
Soft yellow limestone	10	78	Red and blue pack sand	10	248
Gray limestone	2	80	Yellow sand	8	256
Cavity containing water	1	81	Gravel	7	263
Gray limestone	17	98	Dockum group:		
Yellow limestone	12	110	Yellow clay	2	265
Blue limestone	42	152	Red clay	2	267

TABLE 7.—*Logs of wells in the Big Spring area, Texas*—Continued

Well 82, 6 miles southeast of Big Spring

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet
Quaternary:			Fredericksburg group—Con.		
Soil	15	15	Yellow clay	4	164
Yellow and blue clay	40	55	Yellow limestone	4	168
Fredericksburg group:			Blue limestone	16	184
Gray limestone	13	68	Sandy lime rock	4	188
Yellow limestone	12	80	Trinity sand:		
Blue limestone	12	92	Yellow rock gravel	7	195
Gray limestone	9	101	White sand	25	220
Blue limestone	19	120	Red rock sand	5	225
Gray limestone	8	128	Yellow sand rock	15	240
Gravel	1	129	Yellow sand and gravel	15	255
Gray limestone	7	136	Red sand rock	8	265
Blue shale	4	140	Yellow sand	34	297
Broken yellow limestone	7	147	Gravel	2	299
Blue limestone	5	152	Dockum group:		
Yellow clay	3	55	Red bed	4	303
Yellow limestone	5	160			

Well 86, 6 miles southeast of Big Spring

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Quaternary (?):			Trinity sand:		
(No sample)	38	38	Fine buff sand	21	218
Fredericksburg group:			Light-gray sand and a few quartz pebbles	17	235
Hard light-buff limestone, chert, and some marl	50	88	Light-gray sand, a few quartz pebbles, and some light-gray to lavender silty clay	57	292
Soft gray argillaceous limestone	8	96	Gravel and a small amount of sand	8	300
Gray to buff limestone	19	115			
Gray argillaceous limestone	20	135			
Gray fossiliferous arenaceous limestone	62	197			

Well 87, 6 miles southeast of Big Spring

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Quaternary:			Fredericksburg group—Con.		
Soil and rock	15	15	Blue limestone	16	194
Yellow and blue clay	35	50	Gray limestone	11	205
Fredericksburg group:			Trinity sand:		
Hard rock	2	52	Yellow sand rock	4	209
White limestone	22	74	Running sand	5	214
Yellow limestone	8	82	Gray sand rock	24	238
Yellow clay	2	84	Hard sand	12	250
Blue limestone	13	97	Running sand	5	255
Gray limestone	43	140	Gravel and sand	5	260
Yellow lime and sand; water in crevice	10	150	Running sand	7	267
Light-yellow limestone	12	162	Hard sand rock	5	272
Yellow clay	3	165	Sand and gravel	9	281
Yellow limestone	13	178	Dockum group:		
			Red bed	1	282

Well 88, 6 miles southeast of Big Spring

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Quaternary:			Trinity sand—Continued.		
Soil	2	2	Compact sand rock	4	120
Boulders	2	4	Yellow sand rock	18	138
Fredericksburg group:			Gravel	3	141
Gray limestone	14	18	Compact sand	11	152
Yellow limestone	48	66	Sand	23	175
Blue limestone	4	74	Red compact sand	17	192
Yellow limestone	24	98	Gravel and sand	10	202
Gray limestone	3	101	Dockum group:		
Trinity sand:			Yellow clay	4	206
Hard sand rock	5	106	Redbed	3	209
Yellow sand rock	10	116			

TABLE 7.—*Logs of wells in the Big Spring area, Texas*—Continued

Well 89, 6 miles southeast of Big Spring

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Quaternary:			Fredericksburg group—Con.		
Soil	9	9	Gray limestone	7	156
Fredericksburg group:			Trinity sand:		
Gray limestone	13	22	Yellow sand rock	14	170
Yellow limestone	5	27	Sand and gravel	60	230
Gray limestone	32	59	Compact sand	6	236
Yellow limestone	23	82	Sand	7	243
Gray limestone	8	90	Gravel	9	252
Yellow limestone	20	110	Dockum group:		
Walnut clay	6	116	Yellow clay	6	258
Yellow limestone	3	119	Redbed	17	275
Blue limestone	30	149			

Well 90, 6 miles southeast of Big Spring

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Fredericksburg group:			Trinity sand:		
White limestone and boulders	6	6	Yellow sand rock	13	159
Yellow limestone	45	51	Gravel	17	176
Gray limestone	6	57	Compact sand	13	189
Yellow limestone	18	75	Sand	26	215
Walnut clay	6	81	Compact sand	11	226
Yellow limestone	9	90	Gravel	15	241
Gray limestone	14	104	Dockum group:		
Blue limestone	28	132	Redbed	3	244
Yellow limestone and sand	14	146			

Well 91, 6½ miles southeast of Big Spring

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Fredericksburg group:			Trinity sand—Continued.		
Soil	4	4	Yellow sand rock	25	125
Shell rock	12	16	Sand	20	145
Yellow limestone	42	58	Walnut clay	10	155
Trinity sand:			Yellow clay	6	161
Yellow sand	7	65	Dockum group:		
Walnut clay	15	80	Mixed clay	14	175
Yellow sand rock	15	95	Redbed	15	190
Pink sand rock	5	100			

Well 92, 6¼ miles southeast of Big Spring

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Fredericksburg group:			Trinity sand—Continued.		
Soil	5	5	Sand	3	75
Shell rock	13	18	Sand and clay	45	120
Yellow limestone	20	38	Sand and gravel	15	135
Yellow sandy limestone	6	44	Yellow sand	3	138
Trinity sand:			Gravel bed	12	150
Yellow sand	8	52	Dockum group:		
Gray sand	16	68	Redbed	2	152
Red clay	4	72			

Well 94, 6¾ miles southeast of Big Spring

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Fredericksburg group:			Trinity sand—Continued.		
Soil	3	3	Sand and fine gravel	13	163
Limestone reported (no sample)	32	35	Light-gray to pink silty clay	4	167
Gray to light-buff limestone	9	44	Medium-fine gray sand	13	180
Hard gray limestone	15	59	Light-gray to pink silty clay	9	189
Soft dark-gray argillaceous limestone	25	84	Sand and gravel stained light-red with clay	15	204
Buff arenaceous limestone	30	114	Gravel and some sand	5	209
Trinity sand:			Dockum group:		
Medium-fine sand stained brown with clay	36	150	Red micaceous shale	21	230

TABLE 7.—*Logs of wells in the Big Spring area, Texas*—Continued

Well 97, 7¾ miles southeast of Big Spring

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Fredericksburg group:			Trinity sand—Continued.		
Soil	8	8	Yellow clay	6	138
Shell rock	2	10	Sand	12	150
White limestone	10	20	Yellow clay	10	160
Yellow limestone	10	30	Red clay	2	162
White limestone	10	40	Gray sand	20	182
Gray "granite"	21	61	Yellow sand	12	194
Blue limestone	41	102	Red clay	4	198
Yellow sandy limestone	7	109	Gravel	12	210
Trinity sand:			Dockum group:		
Yellow sand rock	21	130	Yellow rock	3	213
Red clay	2	132	Redbed	14	227

Well 98, 7¾ miles southeast of Big Spring

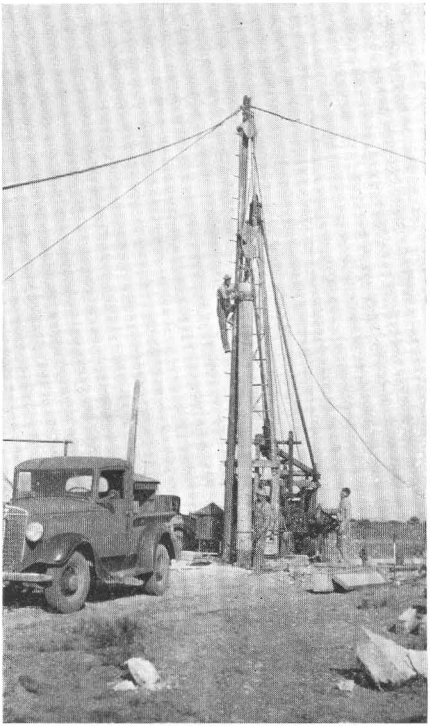
	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Fredericksburg group:			Trinity sand—Continued.		
Soil and clay	6	6	Red rock	8	125
Shell rock	5	11	Gray sand	5	130
Flint rock	4	15	Yellow sand	7	137
Yellow limestone	11	26	Gray sand rock	13	150
White limestone	8	34	Yellow sand	5	155
Blue limestone	60	94	Gray sand rock	5	160
Yellow limestone	8	102	Yellow sand and gravel	40	200
Yellow sandy limestone	4	106	Hard sand	7	207
Trinity sand:			Dockum group:		
Yellow sand rock	5	111	Redbed	23	230
Pink sand rock	6	117			

Well 99, 7¾ miles southeast of Big Spring

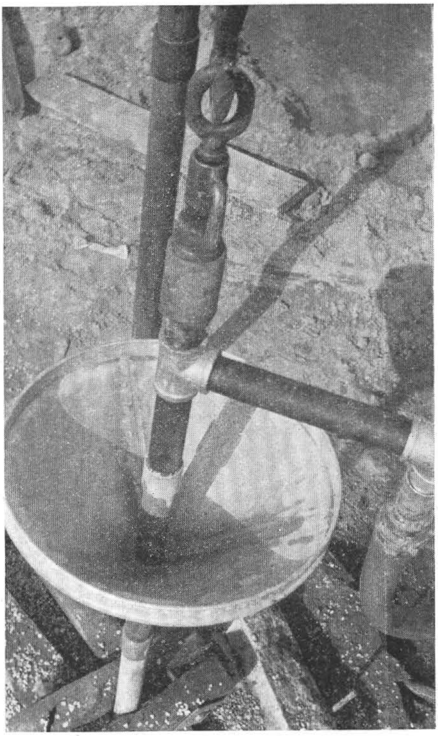
	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Fredericksburg group:			Trinity sand—Continued.		
Gray rock	16	16	Red clay	2	165
Yellow limestone	2	18	Yellow sand and clay	5	170
White limestone	4	22	Red clay	5	175
Yellow limestone	10	32	Yellow sand	10	185
White limestone	15	47	Sand	6	191
Gray "granite"	27	74	Yellow sand rock	4	195
Blue limestone	42	116	Pink clay	8	203
Trinity sand:			Sand and gravel	22	225
Blue clay	4	120	Dockum group:		
Yellow clay	43	163	Redbed	12	237

Well 100, 8 miles southeast of Big Spring

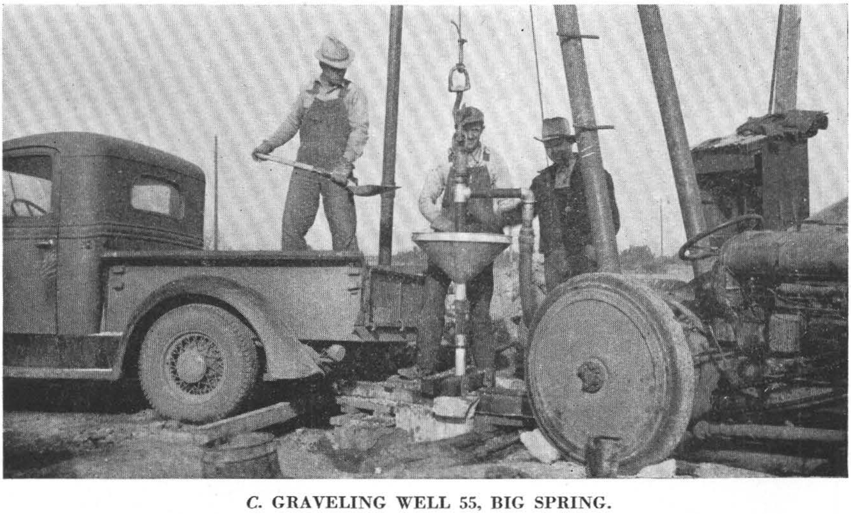
	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Fredericksburg group:			Fredericksburg group—Con.		
Soil	1	1	Gray medium fine-textured limestone	5	80
Dark-buff to dark-red hard fine-textured limestone	10	11	Gray medium fine-textured fossiliferous limestone	5	85
Buff to dark-red fine-textured limestone and some coarse-textured limestone	6	17	Dark blue-gray very fossiliferous limestone	5	90
Buff to light-red medium fine-textured limestone	5	22	Gray to dark blue-gray fossiliferous limestone	5	95
Light-red to buff fine to coarse-textured limestone	5	27	Soft gray to dark-gray fine-textured limestone	5	100
			Do	5	105
Light-gray fine-textured fossiliferous limestone	5	32	Dark blue-gray fine-textured argillaceous limestone	5	110
Dark-gray fossiliferous limestone and some shale	5	37	Blue-gray argillaceous limestone	5	115
Gray fossiliferous fine to medium coarse-textured limestone	4	41	Hard dark-gray fossiliferous limestone	5	120
Gray medium coarse-textured limestone	5	46	Moderately soft dark-gray fossiliferous limestone	5	125
Soft gray medium fine-textured limestone	4	50	Gray to dark-gray soft argillaceous limestone	5	130
Gray medium coarse-textured limestone	5	55	Gray to dark-gray soft argillaceous fossiliferous limestone	5	135
			Gray to dark-gray limestone	5	140
Light-buff to light-pink medium fine-textured limestone	5	60	Gray to dark-gray soft argillaceous arenaceous fossiliferous limestone	4	144
Soft gray medium fine-textured limestone	5	65	Shale reported (no sample)	1	145
Do	5	70			
Gray medium fine-textured fossiliferous limestone	5	75	Light-buff hard arenaceous semicrystalline limestone	4	149



A. PULLING CASING FROM WELL 55, BIG SPRING.



B. GRAVELING EQUIPMENT EMPTY.



C. GRAVELING WELL 55, BIG SPRING.

TABLE 7.—*Logs of wells in the Big Spring area, Texas*—Continued

Well 100, 8 miles southeast of Big Spring—Continued

	Thickness (feet)	Depth (feet)
Fredericksburg group—Con.		
Brown arenaceous limestone containing black dendritic spots	6	155
Sandy marl	2	157
Trinity sand:		
Sand and a few pebbles of quartz	3	160
Fine sand and a few pebbles of quartz	5	165
Fine light-buff sand and a few small pebbles of quartz	10	175
Fine light-buff sand and a few pebbles of quartz	5	180
Do	7	187
Trinity sand—Continued.		
Coarse sand and some gravel	6	193
Sand, gravel, and some fine gray to light pink silty sand	5	198
Sand and some lavender to gray arenaceous clay	5	203
Fine sand	7	210
Coarser sand and some gravel	4	214
Sand and gravel like preceding sample	7	221
Gravel	4	225
Sand and some gravel mixed with a small amount of clay	5	230

Well 101, 7 miles southeast of Big Spring

	Thickness (feet)	Depth (feet)
Trinity sand:		
Soil	4	4
Soft sand rock	26	30
Loose sand	3	33
Gravel and sand rock	10	43
Red rock	3	46
Pink sand rock	9	55
Red rock	7	62
Trinity sand—Continued.		
Gravel and sand rock	10	72
Red rock	4	76
Sand and gravel	14	90
Dockum group:		
Gray rock	3	93
Redbed	32	125

Well 113, 11 miles southeast of Big Spring

	Thickness (feet)	Depth (feet)
Fredericksburg group:		
Soil	12	12
Yellow lime	23	35
Gray lime	70	105
Blue lime	20	125
Brown lime	35	160
Trinity sand:		
Soft sand	20	180
Red rock	5	185
Brown sand	10	195
Red sand	35	230
White sand	10	240
Triassic and Permian redbeds:		
Red rock	175	415
Gray shale	20	435
Red rock	380	815
Red sand (hole full of water at 825 feet)	15	830
Red rock	30	860
Red lime	10	870
Gray lime	160	1,030
Red rock	5	1,035
Gray shale	15	1,050
Red shale	35	1,085
Redbed	185	1,270
Blue shale	25	1,295
Redbed	435	1,730
Red sandy shale	67	1,797
Gray lime	14	1,817
Red shale	9	1,820
Shale and lime shells	4	1,824
Light lime	21	1,845
Red sand (hole full of water)	25	1,870
Red rock	55	1,925
Gray sand	5	1,930
Gray lime	12	1,942
Red sandy shale	5	1,947
Red rock	128	2,075
Red sandy shale	65	2,140
Gravel	17	2,157
Red sandy shale	8	2,165
Triassic and Permian redbeds—Con.		
Red sand (water from 2,165 to 2,310 feet)	145	2,310
Red rock	15	2,325
Lime	10	2,335
Red rock	15	2,350
Lime	25	2,375
Red shale	45	2,420
Anhydrite	50	2,470
Gray lime	60	2,530
Lime shells	25	2,555
White lime	20	2,575
Gray lime	40	2,615
Sandy lime	15	2,630
Gray lime	295	2,925
Blue lime	30	2,955
Water sand (small amount of water)	15	2,970
Blue lime	10	2,980
Dry sand	20	3,000
Blue lime	15	3,015
Gray lime	50	3,065
Brown lime	125	3,190
Gray lime	165	3,355
Blue lime	65	3,420
Gray lime	40	3,460
Brown lime	40	3,500
Gray lime	45	3,545
Water sand	10	3,555
Gray sandy lime	30	3,585
Blue sandy lime	7	3,592
Gray sandy lime	2	3,594
Blue sandy lime	11	3,605
Gray sandy lime	17	3,622
Brown sand	5	3,627
Water at 3,623:		
Gray sandy lime	17	3,644
Sand (water)	16	3,650
Blue sandy lime	21	3,671
Gray sandy lime	17	3,688
Lime	42	3,730

TABLE 7.—*Logs of wells in the Big Spring area, Texas*—Continued

Well 119, 12 miles southeast of Big Spring

	Thickness (feet)	Depth (feet)
Fredericksburg and Trinity groups:		
Surface	193	193
Triassic and Permian redbeds:		
Redbed and red rock	25	218
Hard sand	40	258
Redbed	592	850
Hard sand	15	865
Redbed	15	880
Hard sand	100	980
Broken lime	200	1,180
Lime	47	1,227
Broken lime	48	1,275
Lime	44	1,319
Anhydrite and shale	15	1,334
Sulphur sand	5	1,339
Anhydrite	41	1,380
Lime	357	1,737
Lime and shale	28	1,765
Lime	385	2,150
Do	20	2,170
Do	125	2,295
Gray lime	35	2,330
Do	6	2,336
Brown lime	34	2,370
Gray lime	30	2,400
Sandy lime	9	2,409
Triassic and Permian redbeds—Continued.		
Gray lime	3	2,412
Blue shale	2	2,414
Gray lime	13	2,427
Lime	39	2,466
Hard lime	29	2,495
Do	19	2,514
Lime	4	2,518
Hard lime	47	2,665
Gray lime	25	2,690
Hard gray lime	43	2,733
Gray lime	18	2,751
Do	19	2,750
Do	31	2,801
Lime	43	2,844
Sandy lime	2	2,846
Water sand	20	2,866
Sandy lime	15	2,881
Lime shells	3	2,884
Sandy lime	10	2,894
Blue shale	6	2,900
Gray lime	15	2,915
Broken lime and blue shale	10	2,925
Lime	4	2,929
Gray lime	5	2,934
Oil sand	2	2,936

Well 124, 8¼ miles southeast of Big Spring

	Thickness (feet)	Depth (feet)
Fredericksburg group:		
Soft light-gray to light-buff limestone	25	25
Soft buff limestone	25	50
Hard light-gray to light-buff limestone	29	79
Gray argillaceous limestone and some fossil fragments	46	125
Buff arenaceous limestone and some fossil fragments	10	135
Trinity sand:		
Light-gray sand and a small amount of light-gray to lavender silty clay	26	161
Trinity sand—Continued.		
Light-gray to pink silty clay and some sand	4	165
Buff sand and a few small pebbles of quartz	26	191
Pink silty clay	6	197
Gray sand and a few small pebbles of quartz	19	216
Gravel and red clay	4	220
Red silty clay	10	230
Gravel and a small amount of sand	8	238
Dockum group:		
Red arenaceous shale	5	243

Well 125, 9 miles south of Big Spring

	Thickness (feet)	Depth (feet)
Fredericksburg group:		
Surface soil and reworked limestone	2	2
Light-gray to light-buff semicrystalline very coarse limestone containing an abundance of microfossils	5	7
Light-gray to slightly yellow medium fine-textured limestone	7	14
Light-gray to buff medium fine-textured limestone	7	21
Light-gray fine-textured argillaceous limestone	6	27
Soft buff argillaceous limestone and a small amount of light-gray limestone	7	34
Hard light-gray argillaceous limestone	6	40
Hard gray dense limestone (about a 1-ft. cavity struck at 59 ft.)	19	59
Hard gray dense limestone and a few pieces of fossil shell	8	67
Do	7	74
Hard gray dense limestone	5	79
Soft gray arenaceous limestone	3	82
Brown arenaceous limestone	5	87
Light-gray arenaceous limestone and some buff marl	5	92
Fredericksburg group—Con.		
Brown arenaceous limestone containing black dendritic spots; also a few fossil shell fragments and some brown marl	6	98
Trinity sand:		
Colorless quartz sand cemented together with brown calcareous clay	6	104
Sand and gravel consisting mostly of red opaque quartz and black chert	6	110
Do	10	120
Fine brown sand and a few quartz pebbles	5	125
Gray to lavender sandy clay	5	130
Fine colorlesss and and a small amount of red clay	5	135
Do	5	140
Fine colorless sand stained red	5	145
Coarser sand and a few pebbles of quartz mixed with red clay	5	150
Fine colorless sand stained light red	5	155
Do	7	162
Coarser colorless sand and a few pebbles of red and black quartz	5	167
Medium to fine colorless sand	6	173
Coarser colorless sand	7	180
Dockum group:		
Red micaceous shale containing a few pebbles of quartz	8	188

NOTE.—All the sand samples are slightly calcareous.

TABLE 7.—*Logs of wells in the Big Spring area, Texas*—Continued

Well 131, 6 miles south of Big Spring

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Tertiary and Quaternary:			Triassic and Permian redbeds—Continued.		
Clay and gypsum	38	38	Red sand	8	1,538
Trinity sand:			Red sand	10	1,548
Yellow sand	12	50	Redbed	4	1,552
White sand	5	55	Brown sand	12	1,564
White sand (30 barrels of water per day)	5	60	Redbed	356	1,920
Brown sand	6	66	Anhydrite	85	2,005
White sand (150 barrels of water per day)	4	70	Anhydrite (160 barrels of salt water per day)	15	2,020
Triassic and Permian redbeds:			Gray water sand (hole full of salt water)	14	2,034
Redbed	859	929	Red sand and shale	11	2,045
Red sand (212 barrels of salt water per day)	13	942	Red sand	7	2,052
Redbed	373	1,315	Red and blue shale	3	2,055
Brown shale	40	1,355	Red shale	10	2,065
Redbed	101	1,456	Redbed	40	2,105
Sand (18 barrels of salt water per day)	4	1,460	Anhydrite	10	2,115
Sandy redbed	30	1,490	Redbed and anhydrite	15	2,130
Redbed	40	1,530	Anhydrite	10	2,140

Well 149, 11¼ miles south of Big Spring

Tertiary and Quaternary:			Tertiary and Quaternary—Con.		
Soil and arenaceous clay	10	10	Limestone and quartz gravel	5	54
Arenaceous clay	10	20	Do	4	58
Arenaceous clay and some limestone gravel	5	25	Do	4	62
Gravel made mostly of limestone pebbles	4½	29½	Quartz sand and some limestone pebbles	8	70
Limestone gravel and some clay	10½	40	Do	7	77
Do	4	44	Quartz sand and some limestone pebbles all stained red with clay	5	82
Gravel composed of limestone pebbles and a few quartz pebbles	5	49	Dockum group:		
			Red micaceous shale	10	92

Well 156, 14½ miles southwest of Big Spring

Tertiary and Quaternary:			Tertiary and Quaternary—Con.		
Soil	7	7	Gravel	20	95
Caliche	17	24	Yellow clay	1	96
Hard lime rock	7	31	Sand and gravel	24	120
Sand rock	19	50	Dockum group:		
Gravel	23	73	Red clay	3	123
Pink clay	2	75			

Well 174, 13¾ miles south of Big Spring

Tertiary and Quaternary:			Tertiary and Quaternary—Con.		
(No sample)	30	30	Limestone pebbles and a few large quartz pebbles; also contains reworked fossil shells	6	126
Limestone gravel containing reworked fossil shells	5	35	Do	7	133
Do	5	40	Light-buff to yellow marl	5	138
Limestone gravel	5	45	Do	6	144
Do	5	50	Do	6	150
Do	5	55	Fredericksburg and Trinity groups:		
Do	5	60	Dark-gray argillaceous limestone containing fossils	3	153
Caliche or arenaceous limestone and quartz pebbles	5	65	Dark-gray limestone	4	157
Limestone and quartz gravel	5	70	Do	3	160
Do	5	75	Do	3	165
Do	5	80	Do	2	167
Do	5	85	Limestone	5	172
Limestone pebbles and a few large quartz pebbles	7	92	Red sandy shale	3	175
Do	8	100	Limestone and reworked fossil shells	5	180
Limestone pebbles	6	106	Limestone	5	185
Limestone pebbles and reworked fossil shells	8	114	Do	5	190
Limestone pebbles and a few large quartz pebbles	6	120	Do	5	195

TABLE 7.—*Logs of wells in the Big Spring area, Texas*—Continued

Well 174, 13¾ miles south of Big Spring—Continued

	Thickness (feet)	Depth (feet)
Fredericksburg and Trinity groups—Continued.		
Limestone—Continued	5	200
Do	5	205
Do	5	210
Do	6	216
Do	9	225
Do	5	230
Do	5	235
Do	8	243
Do	7	250
Do	5	255
Buff limestone and some gray shale	5	260
Do	5	265
Do	5	270
Do	5	275
Buff limestone and some red arenaceous limestone	5	280
Do	5	285
Limestone and some gray shale	5	290
Gray limestone, some arenaceous limestone, and a few fragments of fossils	6	296
Light-gray to dark-gray limestone	4	300
Do	5	305
Do	5	310
Do	7	317
Fredericksburg and Trinity groups—Continued		
Limestone and one small piece of gypsum	8	255
Very arenaceous limestone	10	333
Sand and some marl	12	347
Sand and gravel	3	350
Sand, shale, and limestone	5	355
Sand, limestone, and light-red shale	5	360
Sand, shale, and arenaceous limestone	5	365
Sand, arenaceous limestone, and fragments of fossils	3	368
Sand and clay	7	375
Do	10	385
Sand, gravel, and some limestone	5	390
Sand and limestone	30	420
Dockum group:		
Sand stained light-red with clay	10	430
Do	10	440
Do	10	450
Sand and light-red shale	10	460
Red shale, sand, and gypsum	10	470
Do	10	480
Red micaceous shale and some gypsum	40	520

Well 178, 14½ miles south of Big Spring

	Thickness (feet)	Depth (feet)
Quaternary, Tertiary, Cretaceous, and Triassic systems:		
Sand and caliche	10	10
Do	10	20
Caliche and some sand	10	30
Caliche, limestone, and sand	10	40
Limestone and sand	10	50
Sand and silt	10	60
Do	8	68
Coarser sand	12	80
Limestone and sand	10	90
Buff to light-gray limestone	10	100
Do	10	110
Do	10	120
Buff limestone and a small amount of sand	10	130
Buff limestone	10	140
(No sample)	10	150
Buff limestone and a small amount of sand	10	160
Do	10	170
Do	10	180
Light-gray to light-buff limestone	10	190
Do	10	200
Do	10	210
Do	10	220
Light-gray to light-buff limestone	10	230
White clay or shale	10	240
Gray limestone	10	250
Dark-gray limestone	10	260
Gray limestone and some sand	10	270
Quarternary, Tertiary, Cretaceous, and Triassic systems—Con.		
Gray fine-textured limestone	10	280
Do	10	290
Dark-gray to light-red very arenaceous limestone	10	300
Light-red arenaceous limestone	10	310
Light-gray to buff arenaceous limestone stained red	8	318
Sand and red shale	12	330
Sand, limestone, and one piece of gypsum	10	340
Sand, red shale, and some gypsum	10	350
Gravel, sand, and red shale	10	360
Sand, limestone, and red shale	10	370
Arenaceous limestone and light-red arenaceous shale	10	380
Do	10	390
Do	10	400
Do	10	410
Quartz gravel	10	420
Quartz gravel, red shale, and some gypsum	10	430
Sand and red shale	10	440
Sand, red shale, and arenaceous limestone	10	450
Red shale and some sand	10	460
Red shale, sand, and some gypsum	10	470
Red shale, a small amount of sand, and some gypsum	10	480

TABLE 7.—*Logs of wells in the Big Spring area, Texas*—Continued

Well 180, 15 miles south of Big Spring

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Tertiary and Quaternary:			Trinity sand—Continued.		
Dark-brown sandy soil	11	11	Fine gravel and sand	2	87
Hard light-brown caliche	6	17	Fine gravel and sand mixed with clay	5	92
Do	5½	22½	Subangular to subrounded colorless quartz sand and a small amount of fine colored quartz pebbles	6	98
Trinity sand:			Colored quartz pebbles, some subangular to subrounded colorless quartz sand, and a small amount of clay	6	104
Subangular to subrounded colorless quartz sand and a few red and black quartz pebbles	5½	28	Coarse pink quartz gravel and a small amount of colorless quartz sand	8	112
Do	6	34	Do	8	120
Finer subangular to well-rounded colorless quartz sand	6	40	Coarse pink quartz gravel and a small amount of colorless quartz sand stained red	4	124
Subangular to well-rounded colorless quartz sand	5	45	Dockum group:		
Do	7	52	Dark-red micaceous shale containing quartz pebbles	4	128
Subangular to well-rounded colorless quartz sand and a few colorless quartz pebbles	10½	62½			
Subangular to well-rounded colorless quartz sand and some large colored quartz pebbles	7½	70			
Do	5	75			
Fine, red, black, and brown brown quartz gravel and some sand	10	85			

NOTE.—The Triassic shale was struck at 122 feet according to the action of the drill.

Well 189, 14 miles south of Big Spring

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Fredericksburg group:			Trinity sand—Continued.		
Surface soil	1	1	Brown caliche sand	30	70
Gray limestone	19	20	White packsand	10	80
Trinity sand:			Gray gravel and sand	37	117
Gray packsand	10	30	Dockum group:		
Brown gravel bed	10	40	Red clay	8	125

Well 192, 13 miles south of Big Spring

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Tertiary and Quaternary:			Tertiary and Quaternary—Con.		
Black soil	4	4	Buff arenaceous clay and some limestone pebbles	18	233
Buff to light-pink arenaceous clay	10	14	Do	9	242
Do	4	18	Limestone gravel	4	246
Do	3	21	Very light-gray arenaceous clay	6	252
Pink clay reported (no sample)	11	32	Buff arenaceous clay and a few limestone pebbles	10	262
Buff to light-pink arenaceous clay	5	37	Do	8	270
Pink clay reported (no sample)	99	136	Gravel consisting of limestone pebbles and a few quartz pebbles	12	282
Buff to light-pink arenaceous clay	19	155	Dockum group:		
Do	15	170	Red micaceous shale	3	285
Yellow clay reported (no sample)	45	215			

TABLE 7.—*Logs of wells in the Big Spring area, Texas*—Continued

Well 193, 13¾ miles south of Big Spring

	Thickness (feet)	Depth (feet)
Tertiary and Quaternary:		
Soil	3	3
Light-brown caliche and clay	4	7
Caliche and reworked limestone	6	13
Caliche, reworked limestone, and clay	5	18
Brown silty clay	4	22
Do	4	26
Do	4	30
Do	2	32
Do	3	35
Do	2½	37½
Do	2½	40
Brown silty clay and a small amount of limestone pebbles	2	42
Do	3	45
Do	2	47
Do	5	52
Very light-gray caliche	3	55
Coarse limestone gravel	3	58
Tertiary and Quaternary—Con.		
Coarse limestone gravel and a few quartz pebbles	2	60
Do	2	62
Coarse limestone gravel, a few quartz pebbles, and fragments of reworked fossil shells	7	69
Do	6	75
Do	5	80
Do	5	85
Do	10	95
Coarse limestone gravel, a few quartz pebbles, fragments of reworked fossil shells, and some dark-red shale	5	100
Do	5	105
Do	4	109
Dockum group:		
Red shale and some limestone pebbles	5	114
Red micaceous shale	12	126

WELL RECORDS IN HOWARD AND GLASSCOCK COUNTIES

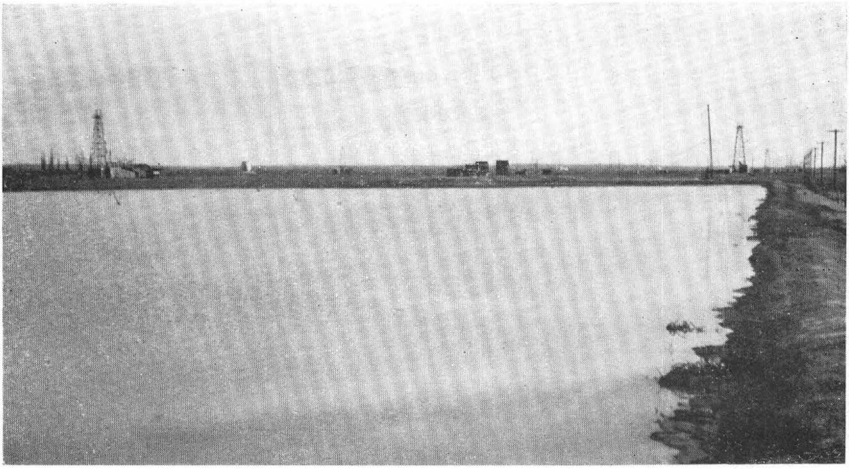
As the information in table 8 has been obtained from many sources some of it may be inaccurate. The writers have found very little recorded information concerning the wells. Locations for many of the wells were determined from aerial maps; locations for others were determined by automobile mileage and land lines. A few of the wells close to land lines that could not be clearly identified in the field may be shown in the wrong quarter section. Depths were either measured or taken from the best available information. Few of the wells have more than a short piece of casing at the surface, and the approximate diameter of casing or hole is given in the table. Unless otherwise noted the altitude was determined by the writers by means of an engineer's level or alidade. Depth-to-water measurements were usually made with a steel tape. Measurements made before April 1937 were furnished by employees of the Works Progress Administration, city of Big Spring employees, or others.

TABLE 8.—*Records of wells in Howard and Glasscock Counties, Tex.*

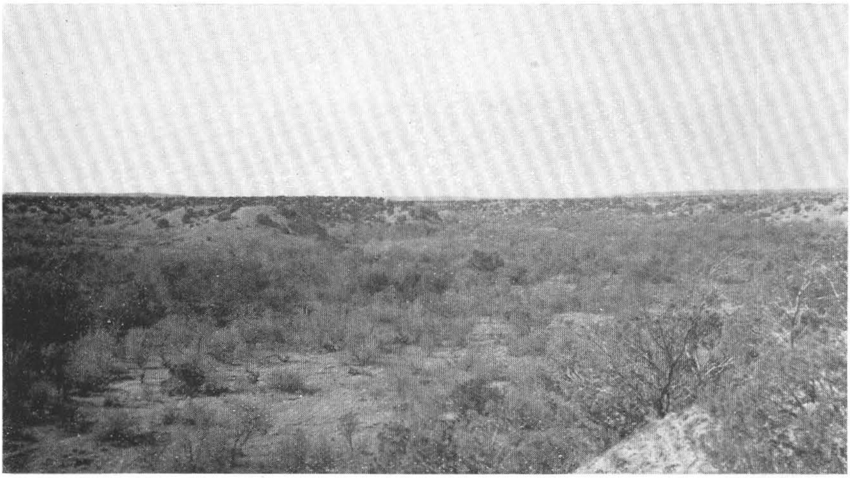
[All wells drilled, except as noted under "Remarks"]

No.	Location			Owner or name	Depth (feet)	Diameter (inches)	Principal water-bearing bed	
	Distance, in miles, and direction from post office in Big Spring	Section	Block				Character of material	Geologic age
1	9, southwest	NW¼ sec. 23	34	Mabel Quinn	670		Sandstone	Triassic.
2	9¾, southwest	SW¼ sec. 26	34	do	3,885	15½		
3	5, southwest	NE¼ sec. 21	33	Mrs. G. Connally	80	6		Tertiary and Quaternary.
4	4½, south	NE ¼ sec. 22	33	—— Wilcox	71	36		Do.
5	3¾, south	NE¼ sec. 23	33	F. Hardin	105	36	Sandstone	Cretaceous.
6	2¾, south	SE¼ sec. 11	33	A. L. Wasson	178	5	do	Do.
7	2½, south	SW¼ sec. 12	33	—— Norris	113			
8	2¾, south	do	33	J. B. Pickle	147	6	Sandstone	Cretaceous.
9	do	do	33	do	160		do	Do.
10	2½, south	do	33	Mrs. Nall	208	6	do	Do.
11	do	do	33	Mr. Nall	229	8	do	Triassic.
12	do	SE¼ sec. 12	33	City of Big Spring well 1		72	Limestone Sandstone	Cretaceous.
13	do	do	33	City of Big Spring well 2		6	Limestone Sandstone	Do.
14	do	do	33	City of Big Spring		12	Limestone Sandstone	Do.
15	do	do	33	City of Big Spring well 3		6	Limestone Sandstone	Do.
16	do	do	33	City of Big Spring well 4	283	12	Limestone Sandstone	Do.
17	do	SW¼ sec. 7	32	Texas & Pacific Ry		6	Limestone Sandstone	Do.
18	do	do	32	do		6	Limestone Sandstone	Do.
19	do	do	32	do		6	Limestone Sandstone	Do.
20	do	do	32	do		8	Limestone Sandstone	Do.
21	do	do	32	do		6	Limestone Sandstone	Do.
22	do	do	32	do		10	Limestone Sandstone	Do.
23	3¾, south	NE¼ sec. 24	33	Frank Pool	120	6	Sandstone	Do.
24	4, south	NW¼ sec. 19	32			12	do	Do.
25	3, south	NW¼ sec. 18	32	J. W. Clark		6	Sandstone (?)	Triassic (?).
26	do	do	32				Sandstone	Cretaceous.
27	3¼, southeast	SE¼ sec. 18	32	City of Big Spring well 7	131	8	do	Do.
28	do	do	32	City of Big Spring well 9	121	6	do	Do.
29	do	do	32	City of Big Spring well 9a		9	do	Do.
30	do	do	32	City of Big Spring well 15	126	8	do	Do.

A. SALT-WATER RESERVOIR ON SOUTH SIDE OF ROAD, 3 MILES EAST OF LEES.



B. SALT-WATER RESERVOIR ON NORTH SIDE OF ROAD, 1 MILE WEST OF LEES.



A. VIEW UPSTREAM FROM NORTH BANK AT PROPOSED DAM SITE ON MOSS SPRINGS CREEK.

B. WHITE MINERAL DEPOSIT ON SURFACE OF OUTCROP OF TRIASSIC SANDSTONE UPSTREAM FROM DAM SITE.

No.	Measuring point: Description	Measuring point: Height above land surface (feet)	Measuring point: Altitude above mean sea level (feet)	Depth-to-water (feet)	Date of measurement	Pumping equipment [1]	Use of water [2]	Quality of water	Remarks
1						N	N	[3]	Oil test; drilling at 670 feet.
2			[4] 2,530				N		Oil test drilled in 1928. See table of well logs.
3	Top of pipe clamp	1.0	2,558.46	73.4 71.37	Feb. 2, 1936 Sept. 28, 1937	R, W	D, S		
4	Top of wooden cover	.8	2,566.81	68.0 66.43	Mar. 4, 1936 Sept. 27, 1937	R, W	D, S	[3]	Dug.
5	Land surface		2,662.4	100 100	Mar. 17, 1936 Nov. 13, 1937	B	D, S		Dug. Seep water at base of sandstone.
6	Top of casing	1.1	2,640.32	[5]		R, W	D, S		
7	Land surface		2,658			N	N		Drilled 1937 through Cretaceous sandstone. No water. See table of well logs.
8	Top of pipe clamp	2.2	2,629.96	141.6 141.0	Mar. 17, 1936 May 4, 1937	N	N		
9	Land surface		2,627.9	137.2	Aug. 28, 1937	R, W	D, S		Drilled in 1937.
10	Top of pipe clamp	1.6	2,616.26	[5]		R, W	D, S		
11	Land surface		2,625			R, W	D, S	[3]	Do.
12	Top of concrete	1.0	2,582.7	[5]		I, E	M	[3]	Dug and drilled. Measured 80 gallons a minute July 31, 1937.
13	Top of casing	1.5	2,587.27	[5]		N	N		
14	Top of 8 x 8	1.5	2,587.33	[5]		N	N		Maintained water-stage recorder from May 14, 1937, to Feb. 8, 1938.
15	Top of casing	1.4	2,587.12	[5]		N	N		
16	do	1.7	2,581.92	[5]		I, E	M		Measured 80 gallons a minute July 31, 1937. See table of well logs.
17	Top of 12 x 12	1.7	2,580.42			R, E	Ry.		Measured 37 gallons a minute July 14, 1937.
18	do	1.7	2,579.35	148.64	June 1, 1937	R, E	Ry.		Do.
19	do	1.1	2,584.80			R, E	Ry.		Do.
20	Top of concrete	1.4	2,611.94	[5]		N	N		
21	do	1.6	2,611.99	[5]		N	N		
22	do	.8	2,612.83	[5]		N	N		
23	Top of pipe clamp	1.0	2,684.04	108.16	June 28, 1937	R, W	D, S		
24	Top of casing	1.2	2,663.84	89.08	June 23, 1937	N	N		Used well about 20 yards southeast.
25	Top of concrete	.7	2,660.44	[5]		R, W	D, S		May draw some water from Triassic.
26	Top of casing	1.3	2,643.39	70.86 70.93	Sept. 9, 1937 Nov. 17, 1937	N	N		
27	do	1.2	2,656.75			N	N		Well 6 in W. S. P. 817. Water level does not correspond with level in other wells.
28	do	1.5	2,639.64	[5]		N	N		
29	do	1.2	2,639.87	[5]		N	N		
30	do	1.3	2,653.91	[5]		N	N		

See footnotes at end of table.

TABLE 8.—*Records of wells in Howard and Glasscock Counties, Tex.*—Continued

No.	Location			Owner or name	Depth (feet)	Diameter (inches)	Principal water-bearing bed	
	Distance, in miles, and direction from post office in Big Spring	Section	Block				Character of material	Geologic age
31	3¼, southeast	SE¼ sec. 18	32	City of Big Spring well 18	153		Sandstone	Cretaceous.
32	do	do	32	City of Big Spring well 18a	147	8	do	Do.
33	do	do	32	City of Big Spring well 20		8	do	Do.
34	do	do	32	City of Big Spring well 19		6	do	Do.
35	do	do	32	City of Big Spring well 19a		6⅝	do	Do.
36	do	NW¼ sec. 17	32	City of Big Spring well 21		7	do	Do.
37	do	do	32	City of Big Spring well 21a		6⅝	do	Do.
38	do	do	32	City of Big Spring well 23	180		do	Do.
39	3, south	NE¼ sec. 17	32	City of Big Spring			do	Do.
40	3¼, southeast	NE¼ sec. 16	32	A. L. Wasson	243	8	do	Do.
41	do	NE¼ sec. 17	32	City of Big Spring			do	Do.
42	3¾, southeast	SW¼ sec. 17	32	City of Big Spring well 33	265	8	do	Do.
43	4, southeast	NW¼ sec. 20	32		270		do	Do.
44	3¾, southeast	SE¼ sec. 17	32	City of Big Spring well 32	260		do	Do.
45	do	do	32	City of Big Spring well 29	248	8	do	Do.
46	do	do	32	City of Big Spring well 30	250	8	do	Do.
47	do	do	32	City of Big Spring well 31	260	8	do	Do.
48	do	do	32	City of Big Spring well 34	250	8	do	Do.
49	do	do	32	City of Big Spring well 34a	257	8	do	Do.
50	do	do	32	City of Big Spring well 49	260	8	do	Do.
51	do	SW¼ sec. 16	32	City of Big Spring well 41	260	8	do	Do.
52	do	SE¼ sec. 17	32	City of Big Spring well 38	260	8	do	Do.
53	do	do	32	City of Big Spring well 37	260	8	do	Do.
54	do	do	32	City of Big Spring well 40	260	8	do	Do.
55	do	do	32	City of Big Spring well 40a	277	8	do	Do.
56	do	SW¼ sec. 16	32	City of Big Spring well 45	260	8	do	Do.
57	4, southeast	NE¼ sec. 20	32	City of Big Spring well 40c	231		do	Do.
58	do	do	32	City of Big Spring well 40d	221	8	do	Do.
59	4¼, southeast	do	32	City of Big Spring well 40b			do	Do.
60	4, southeast	NW¼ sec. 21	32	City of Big Spring well 40e	225		do	Do.

No.	Measuring point: Description	Measuring point: Height above land surface (feet)	Measuring point: Altitude above mean sea level (feet)	Depth-to-water (feet)	Date of measurement	Pumping equipment	Use of water	Quality of water	Remarks
31	Top of casing	.8	2,666.47	(5)		N	N		Measured 40 gallons a minute Aug. 4, 1937, draw-down 20 feet in 1⅓ hours.
32	do	.7	2,666.54	(5)		N	N		Measured 50 gallons a minute Aug. 4, 1937, draw-down 50 feet in 1⅓ hours.
33	do	.8	2,716.20	(5)		R, E	M		Estimated yield 15 gallons a minute June 15, 1937. Well 32 and 33 shot with dynamite at bottom.
34	do	.3	2,680.1	(5)		I, E	M		60 gallons a minute May 19, 1937, draw-down 17.5 feet in 1⅔ hours. Estimated 25 gallons a minute Jan. 26, 1938.
35	do	1.8	2,680.9	(5)		I, E	M		Measured 75 gallons a minute May 16, 1937. Shot with dynamite. Estimated 25 gallons a minute Jan. 26, 1938. Temperature 68° F.
36	do	1.8	2,669.54	(5)		N	N		
37	do	1.1	2,669.62	(5)		N	N		
38	do	2	2,693.68	(5)		N	N		
39	Top of concrete	0	2,748.58	153.2 152.75	June 11, 1937 Aug. 18, 1937	N	N		Water level does not correspond with level in other wells.
40	Top of casing	0	2,765.88	(5)		N	N		City test well. Reported yield 50 gallons a minute. See table of well logs.
41	do	0	2,757.33	167.45 167.04	June 11, 1937 Nov. 17, 1937	N	N		Water level does not correspond with level in other wells.
42	do	.8	2,795.36	(5)		R, E	M		
43	Land surface		2,807.7	243.05	Sept. 9, 1937	N	N		
44	Top of casing	.8	2,787.70	(5)		N	N		
45	Land surface		2,777.3	(5)		N	N		
46	Top of casing	.2	2,776.53	(5)		N	N		
47	do	.5	2,781.37	(5)		N	N		
48	do	.7	2,764.72	(5)		R, E	M		Measured 11 gallons a minute Sept. 23, 1937.
49	do	2.5	2,764.54	(5)		R, E	M		Measured 12 gallons a minute Sept. 23, 1937. See table of well logs.
50	Top of pump base	1.2	2,768.74			R, E	M	(3)	Measured 18 gallons a minute Sept. 23, 1937.
51	Top of casing	.1	2,771.24	(5)		R, E	N		
52	do	.6	2,771.23	(5)		N	N		
53	Land surface		2,776.7	(5)		N	N		
54	Top of casing	2.5	2,778.75	(5)		N	N		
55	Land surface		2,777.1	222.5	May 3, 1937	I, E	M		Maintained water state recorder Oct. 8, 1937, to Oct. 30, 1937. Cased, back-filled with 40 yards of gravel. Estimated yield 50 gallons a minute with 40 feet draw-down. See well logs.
56	Top of casing	0	2,777.55	(5)		N	N		
57	do	.3	2,732.01	(5)		N	N		Reported yield 19 gallons a minute. See table of well logs.
58	do	1.1	2,743.65	(5)		N	N		See table of well logs.
59	Land surface		2,791.4	(5)		N	N		
60	Top of concrete	1.5	2,736.3	175.32	Apr. 30, 1937	I, E	M		Measured 24 gallons a minute Aug. 17, 1937. See table of well logs.

See footnotes at end of table.

TABLE 8.—*Records of wells in Howard and Glasscock Counties, Tex.*—Continued

No.	Location			Owner or name	Depth (feet)	Diameter (inches)	Principal water-bearing bed	
	Distance, in miles, and direction from post office in Big Spring	Section	Block				Character of material	Geologic age
61	4, southeast	NW¼ sec. 21	32	City of Big Spring well 40g	275		Sandstone	Cretaceous.
62	do	do	32	City of Big Spring well 40f	205		do	Do.
63	4¾, southeast	SE¼ sec. 21	32	A. L. Wasson		6	do	Do.
64	5, southeast	NE¼ sec. 28	32	Hardy Morgan		8	do	Do.
65	5½, southeast	Center sec. 28	32	do	172		do	Do.
66	do	SE¼ sec. 28	32	do	172		do	Do.
67	6, southeast	do	32	City of Big Spring well 68	115	12½	do	Do.
68	do	SW¼ sec. 27	32	City of Big Spring well 69	187	12½	do	Do.
69	6¼, southeast	do	32	City of Big Spring well 70	185	10	do	Do.
70	do	NE¼ sec. 34	32	Hardy Morgan	90		do	Do.
71	do	do	32	do		6	do	Do.
72	6, southeast	SE¼ sec. 28	32	City of Big Spring well 50	220	12	Limestone Sandstone	Do.
73	do	do	32	City of Big Spring well 51	265		Limestone Sandstone	Do.
74	do	do	32	City of Big Spring well 52			Limestone Sandstone	Do.
75	do	do	32	City of Big Spring well 53	262		Limestone Sandstone	Do.
76	do	NE¼ sec. 33	32	City of Big Spring well 53a	316		Limestone Sandstone	Do.
77	do	do	32	City of Big Spring well 63			Limestone Sandstone	Do.
78	do	do	32	City of Big Spring well 67	198	8	Limestone Sandstone	Do.
79	do	do	32	City of Big Spring well 64	267		Limestone Sandstone	Do.
80	do	do	32	City of Big Spring well 54			Limestone Sandstone	Do.
81	do	do	32	City of Big Spring well 65		8	Limestone Sandstone	Do.
82	do	do	32	City of Big Spring well 55	303	12	Limestone Sandstone	Do.
83	do	do	32	City of Big Spring well 56		8	Limestone Sandstone	Do.
84	do	do	32	City of Big Spring well 57			Limestone Sandstone	Do.
85	do	do	32	City of Big Spring well 58			Limestone Sandstone	Do.
86	do	do	32	City of Big Spring well 59a	300		Limestone Sandstone	Do.

No.	Measuring point: Description	Measuring point: Height above land surface (feet)	Measuring point: Altitude above mean sea level (feet)	Depth-to-water (feet)	Date of measurement	Pumping equipment	Use of water	Quality of water	Remarks
61	Top of concrete	1.5	2,780.72	(5)		I, E	M		Drilled in 1937. Measured 3 gallons a minute Aug. 17, 1937. See table of well logs.
62	Top of pump base	.7	2,772.72	{182.73 {183.27	Apr. 30, 1937 July 15, 1937	R, E	M		Drilled in 1937. Measured 33 gallons a minute Aug. 17, 1937. See table of well logs.
63	Top of pipe clamp	1.7	2,639.74	(5)		R, W	S		Water level does not correspond with level in other wells.
64	do	2	2,638.69	(5)		R, E	D, S		Drilled in 1936. Cased to bottom of well.
65	Land surface		2,662.6	(5)		N	N		City test well. See table of well logs.
66	do		2,633.5	99.5	Sept. 17, 1937	N	N		
67	Top of casing	1.5	2,609.02	(5)		N	N		City test well. Maintained water-stage recorder Sept. 15, 1937, to Oct. 8, 1937. See well logs.
68	do	1.2	2,603.80	(5)		N	N		City test well. See table of well logs.
69	do	1.2	2,599.87	(5)		R, W	S		Do.
70	Land surface		2,578			N	N		Abandoned. See table of well logs.
71	Top of casing	2.7	2,576.23	(5)		R, W	N		Abandoned.
72	do	1	2,617.84	(5)		N	N		Maintained water-stage recorder Aug. 30, 1937, to Sept. 15, 1937. See table of well logs.
73	do	.7	2,626.49	(5)		N	N		See table of well logs.
74	Top of concrete	0	2,626.90			I, E	M		Measured 150 gallons a minute Jan. 26, 1938.
75	do	.2	2,636.81			I, E	M		Measured 135 gallons a minute Jan. 26, 1938. See table of well logs.
76	do	1.3	2,626.40			I, E	M		Drilled in 1935. Measured 310 gallons a minute Jan. 26, 1938. See table of well logs.
77	do	1.6	2,622.78	125.58	Jan. 30, 1938	N	N		
78	Top of casing	2.2	2,650.78	(5)		N	N		See table of well logs.
79	Top of concrete	1.7	2,624.24	(5)		N	N		Maintained water-stage recorder May 14, 1937, to July 2, 1937. See table of well logs.
80	do	1	2,624.68			I, E	M		Measured 220 gallons a minute Jan. 26, 1938.
81	Top of casing	1.5	2,627.10	(5)		N	N		
82	do	1	2,628.97	(5)		N	N		See table of well logs.
83	do	1	2,629.06	(5)		N	N		
84	Top of concrete	1.6	2,632.49	133.51	Jan. 30, 1938	N	N		
85	Top of steel pump base	1.7	2,641.45	140.02	Jan. 30, 1938	N	N		
86	Top of concrete	0	2,632.73			I, E	M	(3)	Measured 250 gallons a minute Jan. 26, 1938. See table of well logs.

See footnotes at end of table.

TABLE 8.—*Records of wells in Howard and Glasscock Counties, Tex.*—Continued

No.	Location			Owner or name	Depth (feet)	Diameter (inches)	Principal water-bearing bed	
	Distance, in miles, and direction from post office in Big Spring	Section	Block				Character of material	Geologic age
87	6, southeast	NE¼ sec. 33	32	City of Big Spring well 59c	282		Limestone Sandstone	Cretaceous.
88	do	do	32	City of Big Spring well 62	209	12½	Limestone Sandstone	Do.
89	do	do	32	City of Big Spring well 60	275	12	Limestone Sandstone	Do.
90	do	do	32	City of Big Spring well 61	244	12½	Limestone Sandstone	Do.
91	6½, southeast	SE¼ sec. 33	32	City of Big Spring well 72	190		Sandstone	Do.
92	6¼, southeast	SW¼ sec. 33	32	City of Big Spring well 71	152	10	do	Do.
93	5¾, southeast	NE¼ sec. 32	32	Hardy Morgan	240		do	Do.
94	6¾, southeast	NE¼ sec. 41	32	Fisher Bros	230	8	do	Do.
95	7, southeast	SW¼ sec. 41	32	do		8	do	Do.
96	8, southeast	SE¼ sec. 44	32	Hardy Morgan		8	do	Do.
97	7¾, southeast	NE¼ sec. 44	32	do	227	6	do	Do.
98	do	NW¼ sec. 45	32	do	230		do	Do.
99	do	do	32	do	237	6	do	Do.
100	8, southeast	NW¼ sec. 46	32	do	230	8	do	Do.
101	7, southeast	SE¼ sec. 34	32	do	125		do	Do.
102	6¾, southeast	NW¼ sec. 35	32	do		5	do	Do.
103	7¾, southeast	SW¼ sec. 36	32	do		5	do	Do.
104	8¾, southeast	SE¼ sec. 31	31	Dora Roberts		6	do	Do.
105	9½, southeast	SE¼ sec. 42	31	do	15		do	Do.
106	9¾, southeast	NE¼ sec. 43	31	do		6	do	Do.
107	9, southeast	SE¼ sec. 46	32	Hardy Morgan		5	do	Do.
108	do	SW¼ sec. 47	32	Clayton Stewart	85	5½	do	Do.
109	9¼, southeast	NW¼ sec. 102	29	do	116	6	do	Do.
110	9½, southeast	SW¼ sec. 106	29	do	87	6	do	Do.
111	10½, southeast	SW¼ sec. 107	29	do	282	8½	do	Do.
112	10¾, southeast	NW¼ sec. 100	29	Dora Roberts	257	8	do	Do.
113	11, southeast	SE¼ sec. 100	29	do	3,730			
114	11¼, southeast	SW¼ sec. 109	29	do		8	Sandstone	Cretaceous.
115	12, southeast	SE¼ sec. 109	29	do		6	do	Do.
116	15, southeast	SW¼ sec. 140	29	Pure Oil Co		8	do	Do.
117	11¾, southeast	NE¼ sec. 129	29	Dora Roberts	207	6	do	Do.
118	do	SE¼ sec. 130	29	W. E. Harriot	280	6	do	Do.

No.	Measuring point			Depth-to-water (feet)	Date of measurement	Pumping equipment	Use of water	Quality of water	Remarks
	Description	Height above land surface (feet)	Altitude above mean sea level (feet)						
87	Top of concrete	0.2	2,637.53			I, E	M		Measured 250 gallons a minute Jan. 26, 1938. See table of well logs.
88	Top of casing	1.2	2,657.03	(5)		N	N		Maintained water-stage recorder Aug. 16, 1937, to Feb. 8, 1938. See table of well logs.
89	do	1	2,643.76	(5)		N	N		See table of well logs.
90	do	1	2,645.57	(5)		N	N		Do.
91	Land surface		2,675.3			N	N		See table of well logs.
92	Top of casing	0	2,664.05	(5)		N	N		Water seeping into well at 60 feet below surface. See table of well logs.
93	Top of pipe clamp	.8	2,790.46	(5)		R, W	S		
94	Top of casing	1.1	2,731.77	147.77	June 26, 1937	N	N		City test well. See table of well logs.
95	Top of pipe clamp	0	2,685.19	(5)		R, W	S		
96	do	.7	2,759.65	182.6 182.37	June 11, 1937 Aug. 18, 1937	R, W	S	(3)	Water seeping into well at 135 feet below surface.
97	Land surface		2,718	138.75	Sept. 22, 1937	N	N		City test well. Water seeping into well at 114 feet below surface. See well logs.
98	do		2,707.8	123.5 124.4	Sept. 16, 1937 Nov. 17, 1937	N	N		City test well. See table of well logs.
99	Top of casing	.2	2,724	(5)		N	N		Do.
100	do	.5	2,769.54	194.94	Oct. 28, 1937	R, W	S		Drilled in 1937. See table of well logs.
101						N	N		City test well. See table of well logs.
102	Top of pipe clamp	1.9	2,546.18	40.38 41.98	June 10, 1937 Sept. 20, 1937	R, W	S		Water level does not correspond with level in other wells.
103	do	1.4	2,587.34	33.39 34.62	June 10, 1937 Sept. 1, 1937	R, W	S		
104	Top of casing	1.5		41.86	June 10, 1937	R, W	S		Yield 3 gallons a minute June 10, 1937, draw-down 0.3 foot.
105	Top of wooden cover	0		13.59	June 10, 1937	R, W	S		Dug.
106	Top of pipe clamp	2.0		13.90	June 10, 1937	R, W	S		
107	do	1.8	2,679.56	104.75 104.67	June 11, 1937 Aug. 18, 1937	R, W	S		Estimated yield 5 gallons a minute Aug. 18, 1937, draw-down 2.1 feet.
108	Top of casing	.6	2,639.74			R, W	S		Water level does not correspond with level in other wells. Probably surface seepage.
109	Top of pipe clamp	1.0	2,671.63	96.90	June 24, 1937	R, W	D, S		
110	do	.7	2,743.8	57.95	June 14, 1937	R, W	S		Water level does not correspond with level in other wells.
111	do	1.3	2,798.7	233.8 235.28	Mar. 24, 1936 June 14, 1937	R, W	S		
112	do	.6	2,754	200.00	June 15, 1937	R, W	S		
113	Land surface		2,755.5			N	N		Oil test. See table of well logs.
114	Top of pipe clamp	.6	2,716	163.6	June 15, 1937	R, W	S		
115	do	.7	2,678.6	72.76	June 15, 1937	R, W	S		Water level does not correspond with level in other wells.
116	Top of casing	1.3	[2] 2,699	157.0	Dec. 8, 1937	R	O		
117	Top of pipe clamp	.9	2,733			R, W	S		
118	do	1.4	2,785.2	213.75	June 15, 1937	R, W	D, S		In Forsan, Tex.

See footnotes at end of table.

TABLE 8.—*Records of wells in Howard and Glasscock Counties, Tex.*—Continued

No.	Location			Owner or name	Depth (feet)	Diameter (inches)	Principal water-bearing bed	
	Distance, in miles, and direction from post office in Big Spring	Section	Block				Character of material	Geologic age
119	12, southeast	NW¼ sec. 158	29	—— Settles	2,936			
120	9¾, southeast	NE¼ sec. 3	32	Texas & Pacific Ry.	235	6	Sandstone	Cretaceous.
121	10½, southeast	NE¼ sec. 5	32	G. W. Overton	159		do	Do.
122	11¼, south	NE¼ sec. 8	32	do	162	8	do	Do.
123	9, south	SW¼ sec. 1	32	Albert Fisher	240	5	do	Do.
124	8¼, southeast	SE¼ sec. 43	32	Fisher Bros.	243		do	Do.
125	9, south	SE¼ sec. 2	33	R. C. Coffee	188	5	do	Do.
126	8½, south	NW¼ sec. 1	33	Albert Fisher	157	6	do	Do.
127	7½, south	NE¼ sec. 48	33	J. P. Callahan	112	6	do	Do.
128	6, south	SW¼ sec. 31	32	Fisher Bros.	108	6	do	Do.
129	do	SW¼ sec. 36	33	do	60	5	do	Do.
130	do	do	33	do	60	6½	do	Do.
131	do	NW¼ sec. 36	33	do	3,933			
132	6¾, south	NE¼ sec. 38	33	McKinnon estate	40		Sandstone	Cretaceous.
133	6½, south	SW¼ sec. 35	33	do	89	6	do	Do.
134	7, south	NW¼ sec. 38	33	Mrs. F. L. Bell		8½	do	Do.
135	8½, south	SE¼ sec. 46	33	R. J. Stripling	81		do	Cretaceous (?).
136	7, south	SE¼ sec. 33	33	McKinnon estate	41	6		Tertiary and Quaternary (?).
137	7¼, south	NE¼ sec. 40	33	Albert Fisher	66	6		Do.
138	7½, south	do	33	do	73	5		Do.
139	7¾, south	SE¼ sec. 40	33	do	70			Do.
140	do	do	33	do	76	6		Do.
141	8½, south	SE¼ sec. 45	33	Hill estate	43	6⅝	Sand	Tertiary and Quaternary.
142	9, south	NE¼ sec. 4	33	Mrs. Eva Smith	55	48		Tertiary and Quaternary (?).
143	9¼, south	NW¼ sec. 4	33	do	44	6		Do.
144	9¾, south	SE¼ sec. 4	33	S. A. Petty	82	6		Triassic (?).
145	11, south	SW¼ sec. 9	33	M. M. Edwards	112	5⅝		Tertiary and Quaternary (?).
146	do	SE¼ sec. 8	33	D. B. Cox	88	6	Sand and gravel	Tertiary and Quaternary.
147	do	SW¼ sec. 8	33	do			do	Do.
148	11¼, south	SE¼ sec. 7	33	do	90		do	Do.

No.	Measuring point: Description	Measuring point: Height above land surface (feet)	Measuring point: Altitude above mean sea level (feet)	Depth-to-water (feet)	Date of measurement	Pumping equipment	Use of water	Quality of water	Remarks
119			[1] 2,694			N	N		Oil test. See table of well logs.
120	Top of pipe clamp	0.7	2,750.1	(5)		R, W	S		
121	Top of concrete	.1	2,696.69	125.05	Dec. 13, 1937	R, W	D, S	(3)	
122	do	.5	2,683.36	118.3	Feb. 24, 1937	R, W	O		
123	Top of casing	2.1	2,790.0	(5)		R, W	S		
124	do	1.3	2,780.4	(5)		N	N		City test well. Reported yield 15 gallons a minute. See table of well logs.
125	Land surface		2,750.3	171.0	Feb. 24, 1938	R, W	S	(3)	Drilled in 1937. See table of well logs.
126	Top of casing	.8	2,728.45	147.63	Sept. 27, 1937	N	N		Supplied water for oil test.
127	Top of platform	.3	2,690.64	109.3 108.6	Mar. 17, 1936 Sept. 28, 1937	R, W	D, S		
128	Top of pipe clamp	.8	2,648.66	67.00	June 15, 1937	R, W	S		
129	Top of casing	3	2,622.24	44.5 44.53	May 2, 1937 June 26, 1937	R, W	S		
130	Top of concrete	0	2,624.95	(5)		R, W	D, S		
131			[4] 2,623			N	N		Oil test drilled in 1928. See table of well logs.
132	Top of pipe clamp	1.0	2,597.19	31.20	Sept. 28, 1937	R, W	D, S	(3)	
133	do	1.4	2,599.94	60.6 61.13	Mar. 5, 1936 Sept. 28, 1937	R, W	D, S	(3)	
134	do	3.7	2,586.49	54.66	do	R, W	S	(3)	
135	Top of casing	0	2,637.5	78.35	Sept. 16, 1937	R, W	D, S	(3)	Old well 15 feet north.
136	Top of pipe clamp	.7		37.2	Sept. 28, 1937	R, W	D, S	(3)	
137	Land surface		2,553.8	38.5	do	R, W	D, S	(3)	
138	Top of pipe clamp	1.2	2,561.71	49.6	Mar. 16, 1936	R, W	D, S		
139	do	1.2	2,567.26	57.7 55.2	Mar. 16, 1936 Sept. 28, 1937	R, W	D, S	(3)	
140	do	1.0	2,567.16	56.0	Mar. 16, 1936	R, W	D, S	(3)	
141	do	1.2	2,580.53	35.0 35.6	do Sept. 28, 1937	R, W	S	(3)	Drilled in 1935.
142	do	2.0	2,613.98	51.5 53.8	Mar. 17, 1936 Sept. 9, 1937	R, W	D, S	(3)	Dug.
143	do	1.8	2,587.23	24.5	Sept. 28, 1937	R, W	S	(3)	
144	do	.3	2,641.29	79.6 79.44	Mar. 19, 1936 Sept. 16, 1937	R, W	S	(3)	
145	do	1.7	2,577.49	91.11	Dec. 13, 1937	R, W	D, S	(3)	
146	do	1.0	2,563.08	81.5 79.5	Mar. 19, 1936 Oct. 5, 1937	R, W	D, S	(3)	Another well 100 feet south.
147	do	1.0	2,553.37			R, W	D, S	(3)	
148	do	1.0	2,533.17	55.00	Feb. 7, 1938	R, W	D, S	(3)	

See footnotes at end of table.

TABLE 8.—*Records of wells in Howard and Glasscock Counties, Tex.*—Continued

No.	Location			Owner or name	Depth (feet)	Diameter (inches)	Principal water-bearing bed	
	Distance, in miles, and direction from post office in Big Spring	Section	Block				Character of material	Geologic age
149	11¼, south	SE¼ sec. 7	33	D. B. Cox	92	5	Sand and gravel	Tertiary and Quaternary.
150	9½, south	NE¼ sec. 43	33	R. C. Reed	40			Do.
151	9¾, south	SW¼ sec. 43	33	A. B. Shortes	43	36		Do.
152	10¼, southwest	SW¼ sec. 37	34	T. W. Ashley	86			Do.
153	10½, southwest	NE¼ sec. 47	34	do	107	8		Do.
154	11¼, south	SE¼ sec. 47	34	I. B. Cauble	80	8		Do.
155	11¾, south	SE¼ sec. 2	34	L. S. McDowell		6		Do.
156	14½, southwest	NE¼ sec. 8	34	G. T. Hall	123		Sand and gravel	Do.
157	13¼, south	SE¼ sec. 10	34	W. P. Edwards		6	do	Do.
158	12¾, south	SE¼ sec. 11	34	do	55	6	do	Do.
159	do	do	34	do	60	6	do	Do.
160	do	do	34	do	55	3	do	Do.
161	12½, south	do	34	do	118	8	do	Do.
162	do	do	34	do	110	15	do	Do.
163	do	do	34	do	18		do	Do.
164	12¾, south	NE¼ sec. 14	34	do	20	6	do	Do.
165	do	do	34	do	20		do	Do.
166	12½, south	SW¼ sec. 12	34	do	9		do	Do.
167	do	do	34	do	18	8	do	Do.
168	11½, south	NW¼ sec. 7	33	L. S. McDowell	60	6	do	Do.
169	12¼, south	NW¼ sec. 18	33	W. P. Edwards	60	6		Do.
170	13, south	SW¼ sec. 13	34	do	55	6		Do.
171	12¾, south	SW¼ sec. 18	33	Schoolhouse				Do.
172	13¼, south	NW¼ sec. 19	33	L. S. McDowell	85			Do.
173	do	NE¼ sec. 20	34	W. P. Edwards				Do.
174	13¾, south	NW¼ sec. 30	33	L. S. McDowell				
175	14, south	NE¼ sec. 21	34	do	90	6	Sand and gravel	Tertiary and Quaternary.
176	do	SE¼ sec. 20	34	Mrs. Overton	86	6		Do.
177	do	SE¼ sec. 19	34	W. P. Edwards	139	6		Do.
178	14½, south	SE¼ sec. 21	34	L. S. McDowell	2,546			
179	15, south	SW¼ sec. 21	34	do	72	6		Cretaceous(?).
180	do	NW¼ sec. 32	34	do	128	5	Sandstone	Cretaceous.

No.	Measuring point: Description	Measuring point: Height above land surface (feet)	Measuring point: Altitude above mean sea level (feet)	Depth-to-water (feet)	Date of measurement	Pumping equipment	Use of water	Quality of water	Remarks
149	Land surface			48.0	Feb. 15, 1938	N	N	(3)	U. S. Geol. Survey test well, 1938. Approximate altitude, 2,526 feet. See well logs.
150	Top of pipe clamp	1.0	2,541.02	34.5 35.96	Mar. 4, 1936 Oct. 4, 1937	R, W	D, S	(3)	Dug.
151	Top of curbing	.9	2,527.01	37.60	Oct. 4, 1937	N	N		Dug. Water reported too highly mineralized to drink.
152	Top of brick curbing	.5	2,523.53	81.41	Oct. 4, 1937	R, W	D, S	(3)	Dug.
153	Land surface		2,533.5			R, W	D, S	(3)	
154	Top of pipe clamp	.7	2,507.98	56.4 56.11	Mar. 6, 1936 Oct. 4, 1937	R, W	S	(3)	
155						R, W	S	(3)	
156	Top of casing	2.9	2,529.4	48.00	Nov. 6, 1937	N	N	(3)	Drilled 1937. Measured 545 gallons a minute 10-5-37. Draw-down, 35 feet in 2 hours. See table of well logs.
157	Top of pipe clamp		2,533.7	58.40	Nov. 6, 1937	R, W	S	(3)	
158	do	.5	2,504.43			R, W	D, S	(3)	
159	do	.9	2,501.12	32.9	Oct. 28, 1937	R, G	D, S		
160	do	1	2,504.89			R, W	D, S	(3)	
161	Top of casing	1.9	2,507.36	38.70	Oct. 28, 1937	N	N		Oil test backfilled to a depth of 118 feet.
162	do	1.2	2,506.77	37.05	Feb. 23, 1937	R, W	N	(3)	Oil test backfilled to a depth of 110 feet.
163	Top of pipe clamp	1.0	2,480.44			R, W	S	(3)	
164	do	1.2	2,473.72	5.3	Feb. 23, 1937	R, W	S	(3)	
165	do	.6	2,479.51			R, W	S	(3)	
166	do	.6	2,468.92			R, W	S	(3)	Dug.
167	Top of casing	1.9	2,473.25	8.40	Oct. 28, 1937	N	N		
168	Top of pipe clamp	2.2	2,516.28	53.4 53.44	Feb. 23, 1937 Oct. 4, 1937	R, W	S	(3)	
169	do	.6	2,526.12	50.25 50.60	Feb. 23, 1937 Oct. 6, 1937	R, W	D, S	(3)	
170	do	1.4	2,518.02	51.5	Feb. 23, 1937	R, W	S	(3)	
171	Land Surface		2,547.4			R, W	D	(3)	
172	Top of pipe clamp	.4	2,552.89	80.5	Oct. 6, 1937	R, W	D, S	(3)	
173	Platform	1.1	2,557.61			R, W	D, S	(3)	
174			[4] 2,539			N	N		Oil test. See table of well logs.
175	Land surface		2,537.9	65.9	Oct. 31, 1937	N	N	(3)	
176	Top of pipe clamp	.3	2,545.02	72.65	Feb. 23, 1937	R, W	D, S		
177	do	.7	2,525.89	54.7	Feb. 23, 1937	R, W	S	(3)	
178			[4] 2,528			N	N		Oil test drilled in 1935. See table of well logs.
179	Top of concrete	1.0	2,503.26	30.7	Feb. 9, 1937	R, W	S	(3)	
180	Land surface			17	Feb. 13, 1938	N	N	(3)	U. S. Geol. Survey test well, 1938. Approximate altitude, 2,490 feet. See well logs.

See footnotes at end of table.

TABLE 8.—*Records of wells in Howard and Glasscock Counties, Tex.*—Continued

No.	Location			Owner or name	Depth (feet)	Diameter (inches)	Principal water-bearing bed	
	Distance, in miles, and direction from post office in Big Spring	Section	Block				Character of material	Geologic age
181	16¾, south	SW¼ sec. 34	34	L. S. McDowell	44	40		Tertiary and Quaternary.
182	do	do	34	do	46	6		Do.
183	18½, south	NE¼ sec. 40	34	J. T. Bell	45	6		Do.
184	19, south	NW¼ sec. 40	34	do	54	48		Do.
185	do	NE¼ sec. 39	34	L. S. McDowell	22	40		Do.
186	17, south	NW¼ sec. 5	33	J. G. Carter	71	6		
187	16¾, south	NW¼ sec. 4	33	L. McWilliams	87	6	Sandstone	Cretaceous.
188	15¾, south	SW¼ sec. 40	33	G. Shaffer			do	Do.
189	14, south	NW¼ sec. 33	33	L. S. McDowell	125		do	Do.
190	12¾, south	NE¼ sec. 28	33	E. B. Gillean	122	6		Tertiary and Quaternary.
191	do	SE¼ sec. 21	33	—— Gillean	121			Do.
192	13, south	NW¼ sec. 28	33	—— Douglas	282	6	Sand and gravel	Do.
193	13¾, south	NE¼ sec. 30	33	L. S. McDowell	126	8	do	Do.
194	13¼, south	SW¼ sec. 20	33	—— Gillean	118	6	do	Do.
195	12¾, south	NE¼ sec. 19	33	Sam Turner	81	6		Do.
196	12½, south	do	33	do	107	6		Do.
197	12¼, south	NW¼ sec. 20	33	E. A. Lee	71	6		Do.
198	11¾, south	SE¼ sec. 17	33	W. P. Edwards		6		Do.
199	11¼, south	NE¼ sec. 17	33	do	86	8		Do.
200	11¾, south	SE¼ sec. 16	33	do				Do.
201	11½, south	do	33	Tribal Oil Co	136	6	Sand and gravel	Do.
202	do	do	33	W. & E. Production Co		8	do	Do.
203	11¾, south	NE¼ sec. 21	33			6	do	Do.
204	do	do	33				do	Do.
205	do	do	33	Noble Oil Co		8	do	Do.
206	do	NW¼ sec. 22	33	W. P. Lantron		6	do	Do.
207	11½, south	do	33			8	do	Do.
208	do	do	33				do	Do.
209	do	do	33				do	Do.
210	do	SE¼ sec. 15	33	Shell Oil Co	185	7	do	Do.

No.	Measuring point: Description	Measuring point: Height above land surface (feet)	Measuring point: Altitude above mean sea level (feet)	Depth-to-water (feet)	Date of measurement	Pumping equipment	Use of water	Quality of water	Remarks
181	Top of curbing	0.5	[6] 2,515	40.68	Feb. 9, 1937	R, W	S	--------	Dug.
182	Top of casing	.8	[6] 2,516	40.5	Feb. 9, 1937	R, W	S	--------	
183	Top of concrete	1.0	[6] 2,535	41.5	Feb. 5, 1937	R, W	D, S	--------	
184	do	.5	[6] 2,543	50.95	Feb. 5, 1937	R, W	D, S	--------	Dug.
185	Top of curbing	2.0	[6] 2,506	14.62	Feb. 9, 1937	R, W	S	--------	Do.
186	Top of concrete	.5	[6] 2,581	44.60	Mar. 2, 1937	R, W	D, S	--------	
187	Top of curbing	.8	[6] 2,614	66.63	Mar. 2, 1937	R, W	D, S	--------	
188	Top of pipe clamp	--------	[6] 2,622	82.0	Nov. 15, 1937	R, W	S	(3)	
189	--------	--------	[4] 2,584			N	N	--------	Abandoned. See table of well logs.
190	Top of pipe clamp	.7	2,589.78	113.6 115.30	Feb. 25, 1937 Nov. 2, 1937	R, W	D, S	(3)	
191	--------	--------	--------	--------	--------	R, W	D, S	(3)	
192	--------	--------	--------	--------	--------	N	N	(3)	U. S. Geol. Survey test well, 1938. Approximate altitude, 2,559 feet. Water level reported 85 feet below surface. See well logs.
193	Land surface	--------	--------	58.2	Feb. 8, 1938	N	N	(3)	U. S. Geol. Survey test well, 1938. Approximate altitude, 2,531 feet. See well logs.
194	--------	--------	--------	--------	--------	R, W	S	(3)	
195	Top of pipe clamp	.5	2,547.31	74.1 74.42	Feb. 24, 1937 Oct. 6, 1937	R, W	O	(3)	
196	do	1.1	2,549.15	75.6 75.4	Feb. 24, 1937 Oct. 6, 1937	R, W	O	(3)	
197	do	.4	2,541.97	57.3 56.42	Feb. 24, 1937 Oct. 24, 1937	R, W	N	--------	Water reported too highly mineralized to drink.
198	do	1.2	2,550.58	64.75	Oct. 5, 1937	R, W	D, S	(3)	
199	do	.4	2,557.95	73.05 72.98	Feb. 23, 1937 Oct. 5, 1937	R, W	D, S	(3)	
200	Top of block	1.0	2,577.06	--------	--------	R, W	D, S	(3)	
201	Top of casing	.3	2,578.34	84.67	Oct. 24, 1937	R	O	(3)	
202	Top of pipe clamp	1.0	2,580.91	87.4	Oct. 24, 1937	R	O	--------	
203	Top of casing	.5	2,569.03	73.65	Oct. 24, 1937	N	N	--------	
204	Top of pipe clamp	1.2	2,573.81	--------	--------	R	O	--------	
205	Top of 8 x 8	.8	2,579.90			R	O	--------	
206	Top of pipe clamp	1.0	2,588.08	90.35	Sept. 16, 1937	R, W	D, S	(3)	
207	Top of casing	.1	2,597.22	97.7	Oct. 23, 1937	R, G	O	--------	
208	Top of pipe clamp	1.0	2,599.64	98.0	Oct. 22, 1937	R, W	O	(3)	
209	do	2.0	2,600.56	--------	--------	R, W	O	(3)	
210	--------	--------	--------	--------	--------	R, E	O	(3)	

See footnotes at end of table.

TABLE 8.—*Records of wells in Howard and Glasscock Counties, Tex.*—Continued

No.	Location			Owner or name	Depth (feet)	Diameter (inches)	Principal water-bearing bed	
	Distance, in miles, and direction from post office in Big Spring	Section	Block				Character of material	Geologic age
211	11½, south	SE¼ sec. 15	33	Lion Oil Co	159	6	Sand and gravel	Tertiary and Quaternary.
212	do	NE¼ sec. 22	33	do	196		do	Do.
213	do	NW¼ sec. 23	33				do	Do.
214	do	NE¼ sec. 24	33				Sandstone	Cretaceous.
215	11¾, south	NW¼ sec. 24	33	Mrs. H. Phillips	150	6	do	Do.
216	12½, south	NE¼ sec. 26	33	do	168	6		Tertiary.
217	14½, south	NE¼ sec. 38	33	Claude Cole	159	6	Sandstone	Cretaceous.
218	18, south	NW¼ sec. 59	30	John Reeder	252	6	do	Do.
219	14¼, south	NW¼ sec. 11	32	R. D. Wright	156	6	do	Do.
220	13¼, south	NE¼ sec. 36	33	J. J. Phillips	162	6	do	Do.
221	12½, southeast	NE¼ sec. 9	32	—— Bedell	166		do	Do.
222	13, southeast	SW¼ sec. 161	29	Panther Draw School	139	12	do	Do.
223	13½, southeast	NE¼ sec. 188	29			6	do	Do.
224	13¼, southeast	SE¼ sec. 162	29				do	Do.
225	13¾, southeast	NE¼ sec. 187	29	Humble Oil Co	140	5	do	Do.
226	14½, southeast	SE¼ sec. 186	29	P. A. Ratliff	95	8	do	Do.
227	14¼, southeast	NE¼ sec. 186	29	L. E. Graves			do	Do.
228	do	NW¼ sec. 185	29	A. M. Burns	124	8	do	Do.
229	15½, southeast	SW¼ sec. 184	29	J. B. Hollis	137	6	do	Do.
230	do	NW¼ sec. 193	29	I. W. Morgan	128	6	do	Do.
231	16, southeast	NE¼ sec. 193	29	G. B. O'Barr	131	8	do	Do.
232	16¼, southeast	SE¼ sec. 193	29	O'Barr Bros	92	6	do	Do.
233	17, southeast	NW¼ sec. 211	29	R. K. Burns	89		do	Do.
234	17½, southeast	SE¼ sec. 181	29	P. Keil	99	8	do	Do.
235	do	do	29	Fairview School	106	6	do	Do.

No.	Measuring point: Description	Measuring point: Height above land surface (feet)	Measuring point: Altitude above mean sea level (feet)	Depth-to-water (feet)	Date of measurement	Pumping equipment	Use of water	Quality of water	Remarks
211	Top of casing	1.3	2,606.97	103.25 102.97	Mar. 1, 1937 Oct. 23, 1937	R, G	O	(3)	
212	do	1.3	2,605.33	101.00	Oct. 23, 1937	R, W	O	(3)	
213	do	.7	2,610.96	104.6	Oct. 23, 1937	R	O	----	
214	Top of pipe clamp	1.0	2,672.15	----	----	R, W	D, S	(3)	
215	do	.3	2,662.50	127.0 127.7	Feb. 24, 1937 Oct. 22, 1937	R, W	D, S	(3)	
216	do	1.4	2,606.4	92.7 93.9	Mar. 1, 1937 Oct. 23, 1937	R, W	D, S	(3)	
217	Top of concrete	.5	[6] 2,676	146.8	Jan. 24, 1938	R, W	D, S	----	
218	do	----	[6] 2,781	218.7	Jan. 24, 1938	R, W	D, S	----	
219	Top of pipe clamp	.6	2,639.99	114.8	Feb. 25, 1937	R, W	S	----	
220	do	.7	2,629.43	107.9	Mar. 1, 1937	R, W	D, S	----	
221	do	.8	2,651.79	130.9	Nov. 2, 1937	R, W	D, S	(3)	
222	do	1.2	2,628.73	106.4	Feb. 24, 1937	R, W	D	----	
223	do	3.6	2,620.20	100.1	Nov. 2, 1937	R, W	S	(3)	
224	do	.5	2,622.67	102.15	Dec. 13, 1937	R, W	D, S	----	
225	Land surface	----	2,609.6	89.2	Mar. 23, 1937	R, E	D, S	----	
226	Top of concrete	1.3	2,594.28	83.81 84.2	Mar. 11, 1937 Nov. 13, 1937	R, W	S	----	
227	Top of pipe clamp	1.0	2,611.21	99.80	Nov. 13, 1937	R, W	D, S	----	
228	do	1.2	2,609.58	98.0 98.99	Mar. 11, 1937 Nov. 3, 1937	R, W	S	(3)	
229	Top of concrete	----	----	92.45 93.32	Mar. 9, 1937 Nov. 3, 1937	R, W	D, S	(3)	
230	Top of pipe clamp	1.2	2,600.78	95.3 95.5	Mar. 9, 1937 Nov. 13, 1937	R, W	D, S	----	
231	do	1.2	2,614.12	107.4	Mar. 9, 1937	R, W	S	----	
232	do	1.2	2,574.10	73.2 74.41	Mar. 9, 1937 Feb. 3, 1938	R, W	D, S	----	
233	do	1.5	2,576.89	82.0 82.09	Feb. 23, 1937 Feb. 3, 1938	R, W	D, S	----	
234	do	1.4	2,590.28	86.0 85.97	Mar. 10, 1937 Nov. 13, 1937	R, W	D, S	----	
235	do	.5	2,595.91	92.2	Nov. 3, 1937	R, W	D, S	(3)	

See footnotes at end of table.

TABLE 8.—*Records of wells in Howard and Glasscock Counties, Tex.*—Continued

No.	Location			Owner or name	Depth (feet)	Diameter (inches)	Principal water-bearing bed	
	Distance, in miles, and direction from post office in Big Spring	Section	Block				Character of material	Geologic age
236	18, southeast	SW¼ sec. 180	29	J. E. Clifton	115	6	Sandstone	Cretaceous.
237	18¾, southeast	NE¼ sec. 209	29	P. A. Ratliff	113		do	Do.
238	19, southeast	SW¼ sec. 208	29	S. G. Childress	190	10	do	Do.
239	do	do	29	do	130	6	do	Do.
240	18¼, southeast	SW¼ sec. 210	29	C. Edmunson	80	6	do	Do.
241	18½, southeast	SE¼ sec. 210	29	C. Edmunson	139	8	do	Do.
242	19, southeast	NW¼ sec. 41	30	W. L. Foster	130		do	Do.
243	20¼, southeast	SW¼ sec. 42	30	do	98	7	do	Do.
244	21, southeast	NW¼ sec 30	30	do	110	6	do	Do.
245	do	SE¼ sec. 28	30	O'Barr Bros	83	6	do	Do.
246	21¼, southeast	do	30	Bill Reed			do	Do.

No.	Measuring point: Description	Measuring point: Height above land surface (feet)	Measuring point: Altitude above mean sea level (feet)	Depth-to-water (feet)	Date of measurement	Pumping equipment	Use of water	Quality of water	Remarks
236	Top of concrete	0.5	2,610.95	108.1 107.76	Mar. 8, 1937 Nov. 13, 1937	R, W	D, S		
237	Top of pipe clamp	.9	2,602.77	105.5 105.37	Mar. 18, 1937 Nov. 13, 1937	R, W	D, S		
238	Top of casing	1.0	2,638.56	126.55 127.62	Mar. 18, 1937 Nov. 13, 1937	N	N		
239	Top of pipe clamp	.7	2,606.08	96.8	Mar. 18, 1937	R, W	D, S		
240	do	.6	2,549.2	69.37 71.13	Mar. 18, 1937 Jan. 28, 1938	R, W	D, S	(3)	
241	Top of casing	.7	2,542.76			N	N		Drilled to supply water for highway construction.
242	Top of pipe clamp	1.0	6 2,617	104.6	Mar. 22, 1937	R, W	D, S		
243	Top of casing	3.0	6 2,576	76.1	do	R, W	D, S		
244	Top of concrete	.5	6 2,533	91.5	do	R, W	D, S	(3)	
245	Top of pipe clamp	.5	2,563.1	58.2 59.06	Mar. 9, 1937 Feb. 3, 1938	R, W	S		
246	do	.3	2,570.67	66.50	Jan. 28, 1938	R, W	S		

1 Pumps: B, Bucket; I, impeller, both turbine and centrifugal types; N, none; R, reciprocating. Power: E, Electric motor; G, gasoline or oil engine; W, windmill.
2 D, Domestic; N, not used; M, municipal; O, oil field; Ry, railway; S, stock.
3 See tables of water analyses.
4 Altitude above mean sea level as reported on well log, authority unknown.
5 See table of depth-to-water measurements.
6 Altitude above mean sea level determined by altimeter.

WATER ANALYSES

Analyses of water from the wells in the area are given in the tables following:

TABLE 9.—*Analyses of ground waters in Howard and Glasscock Counties, Tex.*

[Parts per million. Well numbers correspond to numbers in table 8]

Well No.	Owner	Depth (feet)	Date of collection	Total dissolved solids	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (KCO_3)	Sulphate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Total hardness as $CaCO_3$	Analyst [2]
	Triassic rocks [1]																
1	Mabel Quinn	670	July 3, 1937								260	2,800	8,500	0.1	0		EWL
11	Mr. Hall	229	Oct. 4, 1937										282			320	PL
144	S. A. Petty	82	Sept. 16, 1937										220			340	PL
	Cretaceous rocks [3]																
12	City of Big Spring		Dec. 10, 1937	411	17	0.04	81	9.3	51	0.7	248	58	56	0.2	6.0	241	MDF
50	do	260	Dec. 13, 1937	290	19	.05	78	5.4	18	.4	246	24	18	0	2.7	217	MDF
86	do	300	Dec. 10, 1937	316	17	.05	74	7.9	27	.8	242	30	28	1.0	3.3	217	MDF
96	Hardy Morgan		Jan. 8, 1938								252	30	40	.6	4.9		EWL
121	G. W. Overton	159	Oct. 23, 1937	(4)									1,020			1,100	PL
125	R. C. Coffee	188	Oct. 6, 1937										60			230	PL
132	McKinnon estate	40	Sept. 28, 1937										54			310	PL
133	do	89	do										24			230	PL
134	Mrs. F. L. Bell		do										55			240	PL
135	R. J. Stripling	81	Sept. 16, 1937										160			330	PL
179	L. S. McDowell	72	Jan. 8, 1938								360	60	103	1.0	7.7		EWL
180	do	128	Feb. 13, 1938				96	16	20		281	100	10	1.3	3.2	306	EWL
188	G. Shaffer		Jan. 8, 1938								272	22	23	.7	7.6		EWL
214			do								224	48	68	1.0	12		EWL
215	Mrs. H. Phillips	150	Oct. 22, 1937										70			280	PL
221	—— Bedell	166	Nov. 2, 1937										22			200	PL
223			do										12			275	PL
228	A. M. Burns	124	Nov. 3, 1937										72			285	PL
229	J. B. Hollis	137	do										52			255	PL
235	Fairview School	106	do										38			250	PL
240	C. Edmunson	80	Dec. 13, 1937	361	22	.04	72	14	35	1.2	252	38	43	.6	6.5	237	MDF
244	W. L. Foster	110	Jan. 8, 1938								302	35	31	.5	7.6		EWL

Tertiary and Quaternary deposits [5]

4	—— Wilcox	71	Sept. 27, 1937										90			360	PL
136	McKinnon estate	41	Sept. 28, 1937										90			290	PL
137	Albert Fisher	66	do										22			240	PL
139	do	70	do										310			570	PL
140	do	76	do										240			400	PL
141	Hill estate	43	do										650			1,150	PL
142	Mrs. Eva Smith	55	Sept. 9, 1937										300			450	PL
143	do	44	Sept. 28, 1937										660			1,420	PL
145	M. M. Edwards	112	Jan. 8, 1938								258	65	75	1.6	12		EWL
146	D. B. Cox	88	Oct. 5, 1937										90			270	PL
147	do		do										94			280	PL
148	do	90	do										160			360	PL
149	do	92	Feb. 13, 1938				70	23	86		300	68	90	1.4	10	269	EWL
150	R. C. Reed	40	Oct. 4, 1937										152			400	PL
152	T. W. Ashley	86	Jan. 8, 1938								308	38	57	2.8	9.6		EWL
153	do	107	Oct. 4, 1937										52			220	PL
154	I. B. Cauble	80	Jan. 8, 1938								278	22	38	1.1	2.8		EWL
155	L. S. McDowell		Oct. 4, 1937										1,250			1,480	PL
156	G. T. Hall	123	Oct. 5, 1937	894	66	0.45	103	46	112	13	280	188	158	2.4	58	446	MDF
156	do	123	do	(6)									118–178			400–520	PL
157	W. P. Edwards		Oct. 28, 1937										100			340	PL
158	do	55	Oct. 6, 1937										270			540	PL
160	do	55	Oct. 28, 1937										124			410	PL
162	do	110	do										1,400			1,340	PL
163	do	18	do										130			420	PL
164	do	20	do										140			370	PL
165	do	20	do										380			750	PL
166	do	9	do										700			1,000	PL
168	L. S. McDowell	60	Jan. 8, 1938								334	38	80	2.0	7.5		EWL
169	W. P. Edwards	60	Oct. 6, 1937										280			540	PL
170	do	55	Oct. 28, 1937										950			1,340	PL
171	Schoolhouse		Jan. 8, 1938								260	48	59	2.0	4.0		EWL
172	L. S. McDowell	85	Oct. 6, 1937										140			340	PL
173	W. P. Edwards		Jan. 8, 1938								238	50	77	1.8	11		EWL
175	L. S. McDowell	90	July 9, 1937								286	25	51	1.2	3.8		EWL
177	W. P. Edwards	139	Nov. 2, 1937										150			335	PL
190	E. B. Gillean	122	do										130			325	PL
191	—— Gillean	121	Jan. 8, 1938								250	50	72	1.2	10		EWL
192	—— Douglas	282	Apr. 2, 1938	3,900	24	.30	123	85		1,034	232	1,852	543	1.0	26.6	657	S
193	L. S. McDowell	126	Feb. 4, 1938				78	27		63	370	48	59	1.2	2.6	306	EWL
194	—— Gillean	118	Nov. 2, 1937										55			325	PL
194	do	118	Dec. 13, 1937	581	31	5	89	23				80	60	.9	31	317	S
194	do	118	do	534	20	3.05	90	24	69	2.2	357	85	58	.9	8.2	323	MDF
195	Sam Turner	81	Jan. 8, 1938								296	70	83	1.7	17		EWL
196	do	107	do								258	62	78	1.4	3.8		EWL
198	W. P. Edwards		do								284	55	80	1.8	9.3		EWL
199	do	86	do								280	50	66	1.9	10		EWL
200	do		Oct. 5, 1937										74			280	PL

See footnotes at end of table.

TABLE 9.—*Analyses of ground waters in Howard and Glasscock Counties, Tex.*—Continued

Tertiary and Quaternary deposits—Continued

Well No.	Owner	Depth (feet)	Date of collection	Total dissolved solids	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (KCO_3)	Sulphate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Total hardness as $CaCO_3$	Analyst
201	Tribal Oil Co.	136	Dec. 13, 1937	373	23	0.11	62	17			231	49	50	1.0	9.0	222	MDF
206	W. P. Lantron		Sept. 16, 1937	(4)									50			310	PL
206	do		Jan. 8, 1938								314	180	515	1.8	14		EWL
208			Oct. 22, 1937										140			360	PL
209			do										94			360	PL
210	Shell Oil Co.	185	Jan. 8, 1938								214	32	93	1.2	8.1		EWL
211	Lion Oil Co.	159	Oct. 23, 1937	(4)									700			750	PL
212	do	196	Oct. 22, 1937	(4)									800			1,340	PL
216	Mrs. H. Phillips	168	Jan. 8, 1938								246	50	64	1.2	10		EWL

1 Geologic age of water-bearing formation not certain for well 144.
2 Analysts: MDF, Margaret D. Foster; PL, Penn Livingston (field determinations); EWL, E. W. Lohr; S, State Hygienic Laboratory.
3 Geologic age of water-bearing formation not certain for wells 135 and 179.
4 Probably contaminated with salt water.
5 Geologic age of water-bearing formation not certain for wells 136, 137, 139, 140, 141, 142, 143, 145, 191, and 193.
6 Thirteen samples taken during pumping test; minimum and maximum results are shown for chloride and hardness.

ADDENDUM

May 11, 1942

The foregoing report was transmitted to the city of Big Spring during August 1938, and since then the city has developed a surface-water supply. The following information has been furnished largely by Mr. B. J. McDaniel, city manager of Big Spring, May 9, 1942.

The surface-water system, which was built at a cost of $500,000, consists of a dam on Moss Spring Creek and a dam on Powell Creek from which 63,600 feet of 14-inch cast-iron pipe has been laid to the city limits. The city also has built a filter plant at the southeastern city limits, an elevated water tank of 421,000 gallons capacity, and a surface reservoir and has laid 9,500 feet of 12-inch cast-iron pipe within the city limits as part of this new system.

The dam on Moss Creek is 50 feet high and 1,500 feet long. The drainage area is 28 square miles, and the reservoir capacity is about 2,600 acre-feet. The dam on Powell Creek is 35 feet high and 1,600 feet long, and the reservoir capacity is about 1,470 acre-feet. Part of the drainage from Devils Creek is diverted to the Powell Creek Reservoir, increasing the drainage area above the dam to 35 square miles. Both dams are of rolled damp-earth construction.

The distribution of the rainfall over the drainage areas has not been uniform. Practically all the surface water pumped to the city since the new surface-water system has been in use has come from the Powell Creek Reservoir. This reservoir has been full and some water has passed through the service spillway on two occasions. The Moss Creek Reservoir, on the other hand, has never been full and thus far very little water has been pumped from it.

Analysis of the impounded water taken on September 4, 1940, in parts per million, is as follows: Total dissolved solids, 180; calcium, 30; magnesium, 4.6; sodium and potassium, 33; bicarbonate, 134; sulfate, 28; chloride, 16; fluoride, 0.9; nitrate, 1; and total hardness, 93.

Section 33 sink continued to be the main source of the Big Spring water supply until June 26, 1940. At the time pumping was discontinued, the demand upon this sink was about 685,000 gallons a day, and the water level was the lowest on record, being about 173 feet below the surface in well 81. The wells have been kept as an emergency supply, and water levels have been observed frequently. The water level in the sink has risen gradually after large-scale pumping was discontinued, except from March 7 to April 3, 1941, when the wells were pumped. The total amount of water pumped from the sink between June 26, 1940, and May 9, 1942, was 18,780,000 gallons. The water level in well 81 was about 115 feet below the surface on May 9, 1942.

The amount of water pumped from section 17 has not been great since the surface-water supply has been available. Since January 1, 1938, the total pumpage has been about 220,355,000 gallons. The rise of the water level during the past 2 years has been about 2 feet.

The city has continued to draw some water from the city park sink, the total water pumped between January 1, 1938, and May 4, 1942, being about 138,240,000 gallons. On May 8, 1942, the water level was about 26 feet higher than it was on June 26, 1940.

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Analyses of water 108–110, 111

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