(200)
C i
no. 6
p. 2

UNITED STATES
DEPARTMENT OF THE INTERIOR
HAROLD L. ICKES, Secretary
GEOLOGICAL SURVEY
W. C. MENDENHALL, Director

U. S. GEOLOGICAL SURVEY
JAN 12 1934
LIBRARY

---0---

CIRCULAR 6

---0---

MINERAL-WATER SUPPLY
of the
MINERAL WELLS AREA, TEXAS

By

SAMUEL F. TURNER

Prepared in cooperation with the
Texas State Board of Water Engineers and
Texas State Department of Health

WASHINGTON

1934

UNITED STATES
DEPARTMENT OF THE INTERIOR
HAROLD L. ICKES, Secretary
GEOLOGICAL SURVEY
W. C. MENDENHALL, Director

---0---

CIRCULAR 6

---0---

MINERAL-WATER SUPPLY
of the
MINERAL WELLS AREA, TEXAS

By

SAMUEL F. TURNER

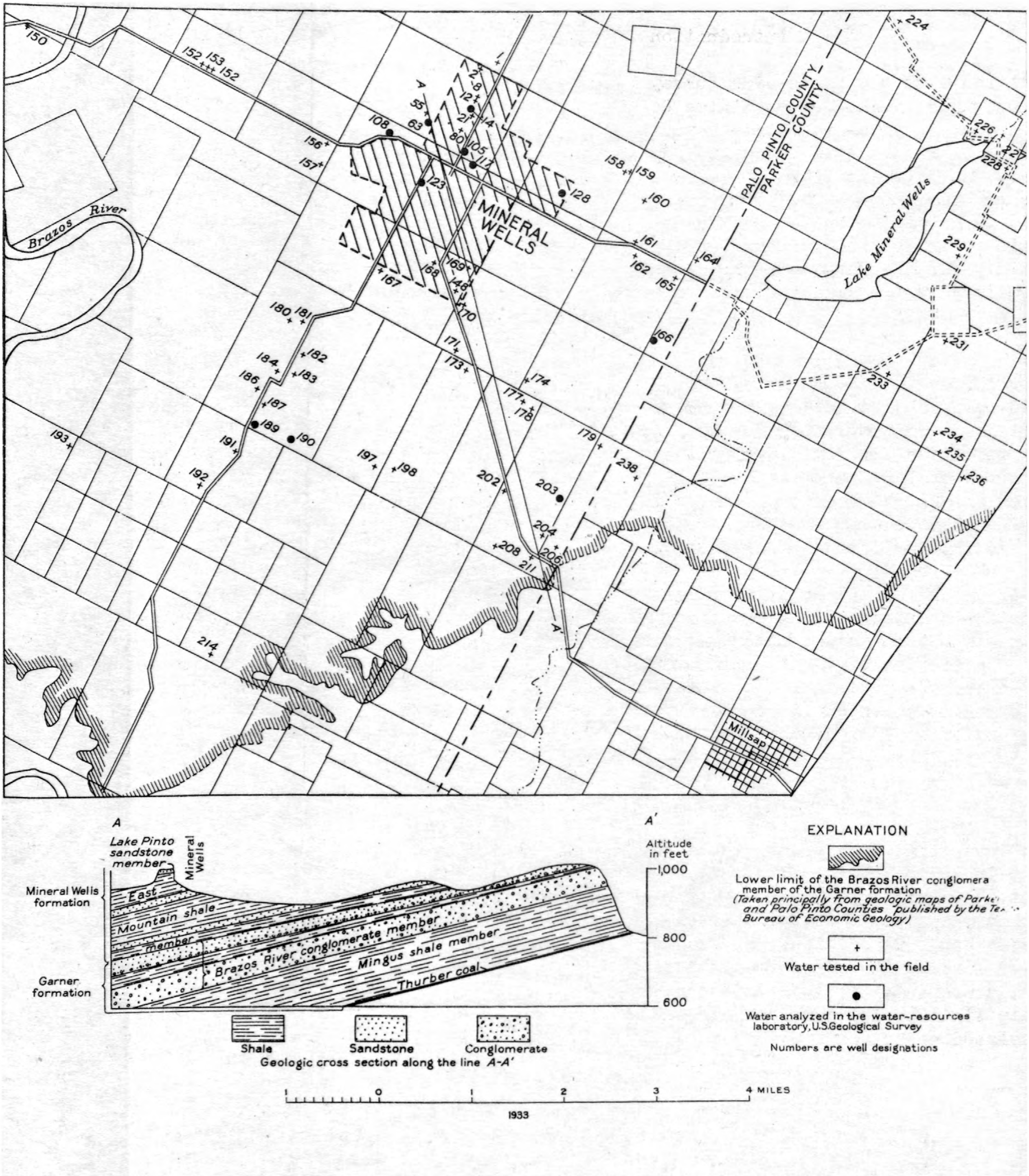
Prepared in cooperation with the
Texas State Board of Water Engineers and
Texas State Department of Health

WASHINGTON

1934

CONTENTS

ILLUSTRATION



MINERAL WELLS
Brazos River
Lake Mineral Wells
PALO PINTO COUNTY
PARKER COUNTY
Millsap
A
A'
Lake Pinto sandstone member
Mineral Wells
Mineral Wells formation
East
Mountain shale
member
Brazos River conglomerate member
Mingus shale member
Thurber coal
Garner formation
Altitude in feet
1,000
800
600
Shale
Sandstone
Conglomerate
Geologic cross section along the line A-A'
EXPLANATION
Lower limit of the Brazos River conglomera member of the Garner formation
(Taken principally from geologic maps of Parke and Palo Pinto Counties published by the Te Bureau of Economic Geology)
Water tested in the field
Water analyzed in the water-resources laboratory, U.S.Geological Survey
Numbers are well designations
1 0 1 2 3 4 MILES
1933

Mineral-water supply of the Mineral Wells area, Texas.

By Samuel F. Turner

Introduction

In connection with the State-wide survey of the ground-water resources of Texas now in progress by the Unites States Geological Survey and the State Board of Water Engineers, in which the State Department of Health is cooperating, a brief investigation was made in March and September 1931 in the vicinity of Mineral Wells. The investigation was made at the request of the city authorities and was under the direction of O. E. Meinzer, geologist in charge of the division of ground water of the United States Geological Survey, and W. N. White, hydraulic engineer in charge of ground-water investigations in Texas. It was undertaken mainly for the purpose of obtaining information regarding the relation of the geology to the occurrence of the mineral water for which the city is noted.

At the time of the investigation there were about 150 commercial mineral-water wells in the area, all in the city of Mineral Wells. These wells average about 200 feet in depth and penetrate about 30 feet of water-bearing sandstone in the upper part of the member known as the Brazos River conglomerate. In the course of the investigation data were collected in regard to about 240 wells throughout a considerably larger area. These well data are summarized in a table, copies of which are on file and open to public reference in the offices of the United States Geological Survey at Washington, D. C., the State Board of Water Engineers at Austin, Tex., and the city engineer at Mineral Wells, Tex.

Samples of water from 67 wells were tested in the field for hardness and for their chloride and sulphate content, and samples from 12 wells were analyzed in the water-resources laboratory of the United States Geological Survey in Washington, D.C. The results of the field tests and laboratory analyses are given in tables included in this circular. The location of the wells from which the samples were obtained is shown on the accompanying map, where each well is given a number corresponding with the number by which it is designated in all three of the tables.

Location and topography

The area investigated comprises about 150 square miles in the vicinity of Mineral Wells, in north-central Texas, about 60 miles west of Fort Worth. The most prominent, topographic features of this area are two southeastward-facing escarpments that cross it in a northeasterly direction. The higher escarpment crosses the southern part of the area, and its approximate location is indicated by the hachured line on the map. The other escarpment passes through the city of Mineral Wells, a prominent part of this escarpment being East Mountain, which is within the city limits. The remainder of the area consists of rolling country with a few isolated mesas.

Previous investigations

The geology of this area has been described in a general way by Plummer and Moore. 1/

The Bureau of Economic Geology of Texas has published a geologic map of Palo Pinto County, prepared by F. B. Plummer and revised by R. W. Cumley in 1929-30, and a geologic map of Parker County, prepared by J. M. Armstrong and Gale Scott in 1930.

Geologic formations and their water-bearing properties

The rock formations exposed in the area are of Pennsylvanian age. The rocks dip generally to the northwest at the rate of about 75 feet to the mile, but locally the direction and amount of dip are variable, owing to the presence of folds and to thickening and thinning of the formations. Nearly all the formations tend to thicken down the dip, but irregular deposition and erosion in the intervals between periods of deposition have caused them to be very thin in some parts of the area, and in places certain beds disappear entirely. Each formation member has an outcrop from which it extends toward the north and northwest, below the younger formations, to progressively greater depths beneath the surface. Available supplies of ground water in the area, both those that are highly mineralized and those that are not, occur in beds of moderately permeable sandstone and conglomerate which are interbedded with relatively impermeable shale and clay.

A generalized section of the geologic formations that crop out in this area is given in the following table. The structure of the rocks and the order in which they occur along the line A-A' on plate 1, through Mineral Wells, is shown in the cross section accompanying the map.

1/ Plummer, F. B., Preliminary paper on the stratigraphy of the Pennsylvanian formations of north-central Texas: Am. Assoc. Petroleum Geologists Bull., vol. 3, pp. 132-150, 1919. Plummer, F. B., and Moore, R. C., Stratigraphy of the Pennsylvanian formations of north-central Texas: Texas Univ. Bull. 2132, 1922.

Geologic formations in Mineral Wells area

System	Series	Group	Formation	Member	Thickness (feet)
Carboniferous	Pennsylvanian	Strawn	Mineral Wells	Lake Pinto sandstone	15-25
				East Mountain shale	200-300
			Garner	Brazos River conglomerate	25-100
				Mingus shale	200-300
				Thurber coal	

The Mingus shale member of the Garner formation crops out in the escarpment that crosses the southern part of the area and in the valleys immediately to the south and east of the escarpment. It is composed of shale with thin lenses of limestone. Only one used well in the area is known to draw its supply from this shale, and the supply is very weak. Many dry holes are reported in it. The Thurber coal, named from the coal mines in this vein at Thurber, is usually covered by debris from the Mingus shale at its outcrop in this area. A little water is sometimes found in this coal, but it is usually of poor quality.

The Brazos River conglomerate member in the Mineral Wells area is composed of three parts. The lower part is a massive conglomerate, usually cross-bedded, containing chert pebbles in a matrix of more or less tightly cemented sand. The southerly limit of the outcrop of this bed is shown by the hachured line on the map. Several of the layers in the conglomerate are somewhat permeable, but the greater part of the water circulation in it must be through the bedding planes and joints. Wells finished in this conglomerate usually find a good supply of moderately mineralized water, and water from some of the wells is bottled and sold for drinking in Mineral Wells.

The middle part of the Brazos River conglomerate is usually a blue clay or shale, which reaches a maximum thickness of 40 feet but in parts of the area is very thin. Where the clay is thick it serves as a relatively impermeable blanket separating the heavily mineralized water of the upper part of the member from the moderately mineralized water of the lower part.

The upper part of the Brazos River conglomerate is a tightly cemented sandstone, 10 to 40 feet thick, with a thin layer of conglomerate at the base. Good outcrops of this sandstone were examined at the north end of Lake Mineral Wells, in a small creek on the Mineral Wells-Garner road about 3 miles west of Garner, and near well 208, south of the Mineral Wells-Millsap road. The water from the sandstone is usually heavily mineralized, and most of the wells that yield commercial mineral water in the area obtain their water supplies from it. The sandstone itself is relatively impermeable, and the water in it circulates mainly through joints and bedding planes. In places down the dip west and northwest of Mineral Wells even these channels seem to be closed. Wells in the sandstone usually yield a small quantity of water, but many holes that penetrate it, especially in areas down the dip, are dry. The water in the lower part of the Brazos River conglomerate is under considerable artesian pressure, but in areas where considerable mineral water is pumped the water in the upper part is under little or no pressure, and when a well penetrates both horizons the comparatively fresh water from below is likely to rise in the well and dilute the mineral water.

The East Mountain shale crops out in the escarpment that passes through Mineral Wells, having its type locality at East Mountain, and underlies a large part of the rolling country southeast of the city. This shale contains two layers of lenticular sandstones that are in many places good water-bearers. A thin lenticular limestone, very fossiliferous, is present near the middle of it in some places. Many wells derive a water supply sufficient for domestic use from the sandstones. This water is usually moderately mineralized.

The Lake Pinto sandstone crops out along the top of the East Mountain escarpment in Mineral Wells. This sandstone yields small supplies of moderately mineralized water to several shallow wells in the northern part of the area.

Character and origin of the mineral water

The commercial mineral water at Mineral Wells is especially high in sodium sulphate and contains smaller amounts of other mineral constituents. (See analyses of water from wells 14, 63, 105, 108, 117, and 128.) The geologic processes that resulted in the high concentration of sodium sulphate and its high proportion in comparison with the other mineral constituents are not fully understood. It is believed that concentration of the soluble mineral matter of the area may have occurred in lakes or lagoons as a result of evaporation at the time the sediments that form the rocks were deposited. The mineral water as found today may be in part the original water that filled the interstices of the sediments when they were deposited, or it may be water that has percolated slowly through the sandstone or down through the overlying clayey beds and has redissolved the soluble mineral matter that may have been deposited as a result of the evaporation. In the percolating water, dissolved calcium may also have been replaced by sodium derived from the clayey materials through the process known as base exchange. The clayey beds overlying the mineral-water sandstone may have been deposited in the bottom of the lakes. As they became covered with greater and greater thicknesses of overlying deposits they were compressed, and part of the mineralized water in their interstices may have been forced into the underlying sandstone.

Mutual interference between mineral-water wells

At the time of the investigation most of the mineral-water wells were equipped with plunger pumps and were operated in groups of 2 to 13 wells, with power for each group supplied by one electric motor. The usual spacing between wells in a group was 15 to 25 feet, and in a part of the city there were as many as 13 wells on one city lot. The wells were pumped constantly unless motor or pump trouble developed. The strongest wells were yielding 1,500 gallons a day or more, and the moderately strong wells from 400 to 800 gallons a day, but some wells did not yield more than 10 gallons a day. It was found that nearly all the pumps "sucked air," although the intake was at the bottom of the well. This indicated that the capacity of the pumps was in excess of the capacity of the wells to yield water and that much of the power used in the operation of the pumps was being wasted.

Most of the owners of the mineral-water wells were of the opinion that the wells do not interfere with one another, even where they are very closely spaced. This opinion, however, was not borne out by the pumping tests that were made and is not in accordance with hydrologic principles. Ground water moves in the direction of the slope of the water table if the water is unconfined and in the direction of the pressure gradient if, like water in pipes, it is confined and under pressure. When a well is pumped the water level in it is drawn down, and a hydraulic gradient toward the well from all directions is created. If another well is put down within the area of influence of the pumped well it diverts to itself when pumped a part of the water that was previously moving toward the first well, and a composite cone of depression in the water table or pressure surface is produced that is deeper and of wider extent than that produced by either well alone. As a result the pumping lift in the first well is increased. If a large number of wells are drilled close together their areas of influence overlap, and a general lowering of the water levels takes place.

During the investigation two pumping tests were made to obtain information as to the depression of the water levels produced by pumping and the consequent mutual interference of the wells, two groups of wells kindly offered by the Baker Hotel Co. being used. For the first test three wells that had been undergoing repairs and had not been pumped for several days were selected. Well 117 was pumped and ovservations were made on well 114 (26 feet north of well 117) and well 115 (37 feet northeast of well 117). The pump on well 117 was started at 10 a.m. March 4 and was run continuously until 3 p.m. March 6, the other wells remaining idle during this period. The water level in well 114 dropped 0.30 foot in the first 6 hours of the test, 0.60 foot in the next 23 hours, and 0.40 foot in the last 24 hours, the total decline below the initial level during the period amounting to 1.30 feet. During the same period the total decline in well 115 amounted to 1.12 feet. This lowering of the water levels in the unpumped wells shows that these wells were within the area of influence of well 117.

For the second pumping test four new wells in a northwest-southeast line which previously had not been pumped were chosen. They consisted of well 55, at the southeast end of the line, and wells 54, 53 and 52, at intervals of 20 feet along the line in the order named. The pump on well 55 was started at 2 p.m. September 12 and was operated continuously until 9 a.m. September 15, the other wells in the line remaining idle during this period. During the test the water level dropped 5.51 feet in well 54, 5.13 feet in well 53, and about 4.90 feet in well 52, showing that all three wells were in the area of influence of the pumped well.

The experiments showed that as a result of pumping an area of influence extended at least 40 feet in the first test and at least 60 feet in the second. At the conclusion of both tests the water levels in the measured wells were still declining, indicating that the cones of depression of the pumped wells were still being extended and deepened.

Prospects for developing additional mineral water

At the time of the investigation all commercial wells producing mineral water were within the city of Mineral Wells,and it was locally believed that this was the only area in which the mineral water could be found. This relatively small area was being very heavily pumped, and there was need for a larger supply. The area in the vicinity of the city has not been completely prospected for the occurance of mineral water of similar characteristics, either in the same stratum or in different strata. It is believed that systematic prospecting with test wells over a fairly large area under the direction of an experienced geologist would be justified.

Information was obtained in regard to several wells on the outcrop of the Brazos River conglomerate, in none of which was any water of consequence found within 300 feet below the base of this conglomerate. Moreover salt-water sands are reported in the gas tests south of Mineral Wells at 500 to 800 feet below the surface, which would be about 300 to 600 feet below the base of the Brazos River conglomerate. Therefore, the prospects for developing a supply of water with the desired mineral characteristics by drilling below the Brazos River conglomerate do not appear to be very good. Well 152, 3 miles west of Mineral Wells, which apparently derives its supply from a sandstone lens in the East Mountain shale, yields water that is high in sulphate, as is shown by the field test, indicating that there is a prospect of developing mineral water of the desired type from beds at higher horizons than those now utilized.

On account of the northwestward dip of the rocks, the mineral-water stratum occurs at increasing depths to the northwest of the main producing area. The prospects of obtaining successful mineral-water wells by drilling to the mineral-water horizon in this area to the northwest have not been fully tested, but the results thus far obtained are somewhat unpromising. There is some indication that the undesirable choride and bicarbonate contents of the mineral water increase in the deeper wells to the northwest, although such increase has not been definitely proved. At the time of this investigation several dry holes had been drilled northwest of the producing area, and it is understood that others have been drilled since that time. On the other hand, dry holes have also been drilled in the city at sites surrounded on all sides by producing mineral-water wells. Thus both the undesirable mineralization and the dry holes may be due to local rather than general conditions in the area to the northwest.

The best prospects for developing additional supplies of mineral water are probably along the strike of the formation--that is, to the northeast and southwest of Mineral Wells, where the sandstone that yields the mineral water should be encountered at about the same levels as in the producing wells in the city. Mineral waters with high sulphate content were found in well 228, 7 miles northeast of the city; well 162, 2 miles east; well 178, 2 miles southeast; well 183, 2 miles south; and well 154, 3 miles west.

Partial analyses of ground waters in the Mineral Wells area

[Numbers in the first column refer to wells listed in well-record table and shown on the map. Samples collected March 9, 1931. M. D. Foster, analyst. Parts per million]

No.	Total dissolved solids a/	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium and potassium (Na+K) a/	Bicarbonate (HCO_3)	Sulphate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Total hardness as $CaCO_3$
14	4,850	-	62	39	1,541	622	2,522	370	9.1	315
63	1,728	-	63	33	520	564	581	252	1.2	293
105	4,200	-	200	158	974	606	2,308	260	1.2	1,148
108	2,828	-	b/ 32	-	985	518	1,480	200	2.9	108
117	4,834	2.5	255	225	1,003	682	2,895	120	.0	1,560
123	735	1.8	37	49	169	422	190	84	.0	293
128	3,754	3.2	222	180	768	564	2,033	272	1.2	1,293
149	707	-	b/ 24	-	-	410	105	135	1.7	-
166	620	.97	73	18	145	422	b/ 60	116	.0	256
189	590	.84	126	25	66	438	b/ 52	105	.0	418
190	602	.91	126	26	68	416	b/ 56	121	.0	422
203	4,618	.23	710	167	508	296	507	1,180	1,400.	2,460

a/ Calculated. b/By turbidity.

14. R. S. Luke, drilled well, 200 feet deep; mineral water. M.
63. Baker Hotel Co., drilled well, 214 feet deep; mineral water. M.
105. Crazy Well Water Co., drilled well, 202 feet deep; mineral water. M.
108. Oscar Bish, drilled well, 154 feet deep; mineral water. M.
117. Baker Hotel Co., drilled well, 187 feet deep; mineral water. M.
123. S. H. McMeen, drilled well, 322 feet deep; domestic supply. D.
128. Crazy Well Water Co., drilled well, 194 feet deep; mineral water. M.
149. Deep Well Water Co.'s well 459, drilled well 383 feet deep; public supply. D.
166. W. S. Ford, drilled well, 200 feet deep; domestic supply. D.
189. Mattie Foster, drilled well, 77 feet deep; domestic supply. D(?).
190. Mrs. Burris, drilled well, 48 feet deep; domestic supply. D(?).
203. R. E. Williams, dug well, 40 feet deep; domestic supply. M.

D. Water from "deep well strata" or lower part of Brazos River conglomerate; M, water from "mineral strata" or upper part of Brazos River conglomerate.

[By S. F. Turner, -- Parts per million]

No.	Owner or name	Depth (feet)	Probable producing horizon a/	Date sampled (1931)	Hardness as $CaCO_3$ b/	Chloride	Sulphate c/	Use of water d/
1	Oak Park Water Co.	406	D	Mar. 9	60	80	250	Public.
2	Dalton no. 1	268	M	Sept.15	-	650	2,500	Mineral.
8	Locke no. 5	199	M	do	45	650	3,000	Do.
12	Locke no. 1	203	M	do	180	600	3,500	Do.
21	Baker Hotel Co.	205	M	Mar. 4	-	320	1,400	Do.
55	Baker Hotel Co. no.15	237	M	Sept.15	500	270	2,900	Do.
80	Crazy Well Water Co.	330	D	Mar. 4	150	140	200	Public.
148	H. H. Milling	67+	EM	do	-	250	300	Mineral.
150	I. C. Taylor	101	EM	Sept.11	420	110	100	Domestic.
152	H. L. Hoaldridge	120	EM	do	900	400	1,800	Do.
153	C. H. Lunsford	17	LP	do	550	180	300	Do.
154	R. J. Harlan	256	M	do	55	330	1,500	Do.
156	W. J. Walker	250	D	do	55	100	100	Do.
157	E. A. Martin	118	EM	do	45	135	500	Do.
159	M. G. Lodal	230	-	do	120	120	300	Do.
160	Camp Wolters	40	EM	Mar. 4	170	30	300	-
161	A. L. Howard	103	M	do	290	110	500	Domestic.
162	E. B. Stripling	117	M	do	120	170	1,250	Do.
164	A. L. Howard	46	-	do	180	200	150	Do.
165	______ Hemphill	57	-	do	240	70	50	Do.
167	Nellie Lyles	105	EM	Sept. 9	650	150	250	Do.
168	Mrs. I. C. Wood	150±	EM	Sept. 8	400	90	90	Do.
169	L. J. Nelson	100	EM	do	350	100	90	Do.
170	L. P. Jumez	55	EM	do	500	350	100	Do.
171	-	23	EM	do	500	230	150	-
173	Henry Halff	84	EM	do	650	350	120	Domestic.
174	W. A. Sartin	40	EM	do	650	230	225	Do.
177	C. H. McMasters	180	D	do	360	250	150	Do.
178	do	170±	M	do	1,200	1,300	1,100	Do.
179	-	20±	M	Mar. 6	-	400	300	-
180	B. M. Hodges	282	-	Sept.9	900	235	300	Domestic.
181	do	100	EM	do	525	200	150	-

a/ Geologic horizon of principal water-bearing bed. LP, Lake Pinto sandstone member of Mineral Wells formation; EM, sandstones in East Mountain shale member of Mineral Wells formation; M, upper part of Brazos River conglomerate member of Garner formation; D, lower part of Brazos River conglomerate member.

b/ Hardness as calcium carbonate by the soap method.

c/ Test made by turbidity method and may be as much as 25 percent in error.

d/ Public, public supply; Mineral, sold as mineral water or evaporated to crystals; Domestic, used for domestic purposes and stock.

Field tests of ground waters in Mineral Wells area--Continued.

No.	Owner or name	Depth (feet)	Probable producing horizon	Date sampled (1931)	Hardness as $CaCO_3$	Chlor-ide	Sul-phate	Use of water
182	Jess Elder	65	M	Mar. 6	350	240	400	Domestic.
183	J. D. Ransport	80	M	Sept. 9	1,500	290	900	Do.
184	-	52	EM	do	775	200	200	Do.
186	A. E. Jacques	65	EM	do	525	160	150	Do.
187	Asia Wallace	135	D	do	500	160	200	Do.
191	W. M. Glover	60	M	do	450	180	250	Do.
192	Mrs. W. M. Glover	160	D	do	450	110	125	Do.
193	Glen Johnson	150±	D	do	400	106	200	Do.
197	_____ Clifton	167	M	do	750	300	700	Do.
198	B. D. Britton	60	EM	do	900	440	250	Do.
202	I. M. Davis	24	-	Sept. 8	480	300	160	Do.
204	R. M. Vaughan	145	-	do	750	120	300	Do.
206	Mrs. L. E. Mims	48	-	do	2,150	2,400	300	Do.
208	_____ Kline	15	-	do	1,650	1,400	750	Do.
211	Metz Bros.	70	D	Mar. 6	300	120	100	Do.
214	A. J. Hubbard	140	D	Mar. 7	230	40	100	Do.
224	G. W. Grimes	57	-	Sept.10	480	190	60	Do.
226	J. D. Brock	60	EM	do	360	40	60	Do.
227	Blue Springs (not a well	0	M	do	750	510	450	-
228	Ed Jordan	39	M	do	1,650	330	2,000	Domestic.
229	A. D. Howard	30	D	do	400	100	30	Do.
231	Dave Martin	40	D	do	400	160	90	Do.
233	-	163	-	do	120	800	30	-
234	Mrs. John Martin	96	-	do	30	255	75	Domestic.
235	Church	60	-	do	60	200	60	Public.
236	C. A. B. Gilbert	115	-	do	180	185	90	Domestic.
238	Omar Smith	21	-	Mar. 6	380	375	350	Do.