TEXAS
WATER
DEVELOPMENT
BOARD

Report 150

GROUND-WATER CONDITIONS IN ANDERSON, CHEROKEE, FREESTONE, AND HENDERSON COUNTIES, TEXAS

AUGUST 1972

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REPORT 150

GROUND-WATER CONDITIONS IN ANDERSON, CHEROKEE, FREESTONE, AND HENDERSON COUNTIES, TEXAS

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GROUND-WATER CONDITIONS IN ANDERSON, CHEROKEE, FREESTONE, AND HENDERSON COUNTIES, TEXAS

ABSTRACT

Anderson, Cherokee, Freestone, and Henderson Counties are in the rolling hills and forests of East Texas. The total population of the four counties in 1970 was slightly more than 97,000. The largest cities include Palestine, Jacksonville, and Athens.

The geologic units which constitute the principal aquifers are the Wilcox Group, Carrizo Sand, Queen City Sand, and Sparta Sand. The Wilcox and the Carrizo are much more important than the Queen City and the Sparta. Nearly all the municipal and industrial ground-water supplies are from either Wilcox or Carrizo wet ls.

Recharge is received by the aquifers from precipitation and streamflow on the outcrops. The aquifers are full to overflowing and most of the recharge is rejected as evapotranspiration and seepage in the stream valleys. For each aquifer the principa! controlling factor in the amount of water which can be obtained from wells is the ability of the aquifer to transmit water from its recharge area to points of withdrawal.

Fresh water exists in the Wilcox Group over a wide area, extending from its outcrop in the western part of the four-county area essentially to a line trending northeast-southwest passing through southern Anderson and central Cherokee Counties. The maximum depth of occurrence of fresh water in the Wilcox is in excess of 2,000 feet in south-central Anderson County. Yields of individual wells range from a few gallons per minute to nearly 1,200 gallons per minute, depending upon location and type of construction. Total estimated pumpage from Wilcox wells in 1969 was 5.5 million gallons per day. The estimated total supply available from Wilcox wells is 48 million gallons per day. This estimate is based on the assumption that there will be no interference as a result of increased pumping outside the four-county area. The estimated maximum yield of an individual well ranges up to 1,500 gallons per minute, and the estimated maximum yield of an individual well field ranges up to 12 million gallons per day, depending on location.

Fresh water exists in the Carrizo Sand throughout the area of its occurrence in the four-county area. The water has less mineralization northwest of the Mount Enterprise fault zone. Yields of individual wells range up to 700 gallons per minute. Estimated pumpage from the Carrizo was 5.5 million gallons per day in 1969. The estimated potential yield of the Carrizo to wells is 35 million gallons per day. The estimated maximum yield of an individual well ranges up to 1,500 gallons per minute, and the estimated maximum yield of an individual well field ranges up to ten million gallons per day. The largest well-field yield is available in southeastern Cherokee County, but development of large quantities in this locality would reduce the-yield of existing well fields in the Nacogdoches-Lufkin area to the east.

Fresh water occurs in the Queen City Sand over a large area in the central part of the four-county area. Because of its shallow and widespread extent, the Queen City contains the most readily available ground-water supplies over a large area, especially for rural domestic and livestock use. Only about one million gallons per day was pumped from the Queen City in 1969. The estimated potential yield from wells is eight million gallons per day. The estimated maximum yield of an individual well ranges up to 400 gallons per minute and the estimated yield of an individual well field ranges up to 1.5 million gallons per day.

The Sparta Sand has a small potential, mostly in southern Cherokee County. In 1969 the pumpage from the Sparta was about 0.2 million gallons per day. The estimated potential yield to wells is one million gallons per day. Depending upon location, the estimated maximum yield of an individual well ranges up to 500 gallons per minute, and the estimated maximum yield of an individual well field ranges up to one million gallons per day.

No evidence has been found of any serious, widespread contamination of ground water from oil field brines. Encroachment of brackish water toward centers

of pumping is not a present problem, and there is little likelihood of its becoming a problem in the foreseeable future.

When maximum supplies of water are desired or developments are in areas of borderline quantity or quality, test-drilling programs and the use of pilot production wells are recommended. A more thorough continuing observation program on pumpage and water levels is recommended for the Carrizo and Wilcox aquifers.

GROUND-WATER CONDITIONS IN ANDERSON, CHEROKEE, FREESTONE, AND HENDERSON COUNTIES, TEXAS

INTRODUCTION

Purpose

The purpose of this report is to describe the occurrence, availability, and quality of the ground-water resources of Anderson, Cherokee, Freestone, and Henderson Counties. The report is particularly concerned with sources of moderate to large supplies of water suitable for public supply, industrial, and irrigation uses. Data have also been included, however, which will benefit persons desiring smaller supplies for domestic and livestock use.

It is believed that the report will be helpful as a guide in developing and obtaining the maximum benefits from the available ground-water supplies. In addition, the report is designed to provide information for use by regulatory agencies in protecting the fresh ground water from contamination.

Scope

This investigation has included, insofar as practicable with available data, a complete evaluation of the ground-water resources of each of the aquifers in the four counties. The geology of the water-bearing formations has been studied, together with the quality of water in each formation. A quantitative evaluation has been made of the water available for development from each principal aquifer.

The first phase of the investigation was to compile and study all available reports and records on the ground-water resources of the area. In addition to obtaining reports by the U.S. Geological Survey, the Texas Water Development Board, and others, this work included compilation and analysis of voluminous unpublished records on water wells and oil tests, primarily frorn the files of the Texas Water Development Board, the U.S. Geological Survey, and this firm.

A new inventory was then made in the field to locate and obtain additional data where necessary on all wells which have been drilled for municipal, industrial, and irrigation purposes, and representative wells used for domestic and livestock supplies. Information on the various wells was obtained from well owners, drillers, and consultants. For each well a determination was made of the formation supplying its water, as indicated by available well records, the geologic map (Bureau of Economic Geology, various dates), and nearby well logs. Depth to water measurements were made in wells where this was practicable, and water samples were taken from numerous wells for chemical analyses. Pumping tests to determine the hydraulic characteristics of the water-bearing formations were made of nearly all wells for which satisfactory tests could be obtained and which had not previously been tested.

Many additional electric logs of water wells and test holes and oil tests were obtained to supplement the logs already in the files of Texas Water Development Board and this firm. Every available log was obtained except in areas where logs are closely spaced in oil fields.

Records of total pumpage were obtained from major ground-water users as well as from the Texas Water Development Board’s files. Records of past water levels in wells were obtained from the Texas Water Development Board and U.S. Geological Survey files and from well owners, drillers, and consultants.

All of the available information on the geology and hydrology of the ground-water resources has been analyzed, and the results have been tabulated and/or plotted on maps, cross sections, and graphs and are presented in this report.

The character, thickness, and depth of the water-bearing formations are described. Estimates have been made of the quantities of water which can be developed from each of the principal water-bearing formations, and the amounts of water which can be obtained from individual wells and well fields.

The construction and operating characteristics of existing wells are presented and available pumpage and water-level records are included. Rainfall, streamflow, natural recharge, and natural discharge are described and discussed in the context of their relationship to the available ground-water resources.

The chemical quality of water in each formation is discussed and presented by means of chemical analyses of water from wells. In addition, interpretations of electric logs have been made to present estimates of the quality of water in the Wilcox Group at depths and in areas where chemical analyses of water from wells are not available. A review has been made of possible contamination problems, and the results of this review are discussed.

Finally, recommendations have been made with respect to a continuing observation program on pumpage, water-level fluctuations, and future development, and on methods for further investigation, especially test drilling, to determine optimum locations and yields of new wells and well fields.

The detailed records on which this report are based have been placed on file with the Texas Water Development Board. These include especially the well schedules on the individual wells and the drillers' and electric logs. Tables 7, 8, 9, and 10 give the most important information on all the wells, but the well schedules for some of the wells give additional information which may be of help in particular problems. All of the drillers' and electric logs are identified in Tables 7, 8, 9, and 10 and their locations are shown on Figures 25, 26, 27, and 28, but because of space limitations the only electric logs which are actually presented in the report are those in the geologic sections in Figures 30, 31, 32, 33, 34, 35, 36, and 37, and the only drillers' logs presented in the report are the representative logs included in Tables 11, 12, 13, and 14.

Area of Investigation

This investigation and report includes all of Anderson, Cherokee, and Henderson Counties. It includes all of Freestone County except a small part of its northwestern corner. Only that part of Freestone County northwest of the Wilcox outcrop (see Figure 29) is not included. The location of Anderson, Cherokee, Henderson, and Freestone Counties is shown on Figure 1.

The four counties are in the rolling hills and forests of East Texas. Farms and ranches predominate in the western two-thirds of the area, while in the eastern one-third, piney woods are common. Altitudes range from about 190 feet along the Trinity River in southeast Freestone County to about 760 feet near Rusk in central Cherokee County. The principal streams are the Trinity River, which separates Anderson and Freestone Counties; the Neches River, which forms the western boundary of Cherokee County and the eastern boundary of Anderson County; and the Angelina River, which forms a portion of the eastern boundary of Cherokee County.

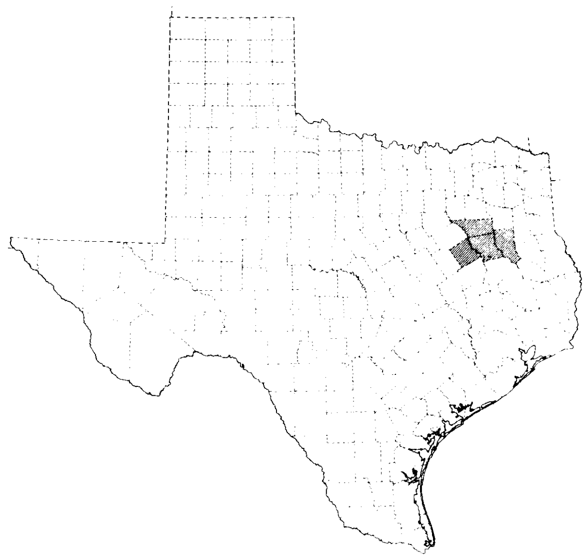


Figure 1.—Location of Anderson, Cherokee, Freestone, and Henderson Counties

Population

According to the U.S. Bureau of the Census, the 1970 county populations were as follows:

	1970 POPULATION
Anderson County	27,789
Cherokee County	32,008
Freestone County	11,116
Henderson County	26,466

The largest towns include Palestine in Anderson County, Jacksonville in Cherokee County, Teague in Freestone County, and Athens in Henderson County, with the following populations in 1970:

	1970 POPULATION
Palestine	14,525
Jacksonville	9,734
Teague	2,864
Athens	9,582

The largest other towns and their populations in 1970 are as follows:

	1970 POPULATION
Anderson County	
Elkhart	997
Frankston	1,056
Cherokee County	
Alto	1,045
Rusk	4,914
Freestone County	
Fairfield	2,074
Wortham	1,036
Henderson County	
Malakoff	2,045
Trinidad	1,079

Climate

The annual precipitation at Palestine, Dialville, Fairfield, and Athens is shown on Figure 2. Dailville is about midway between Jacksonville and Rusk in Cherokee County. The annual precipitation at the four stations has ranged from less than 20 inches, at Fairfield in 1963, to more than 60 inches, mostly at Dialville. The average annual precipitation at Fairfield is nearly 38 inches, and at Dialville it is nearly 46 inches. At Palestine and Athens it is about 40 inches.

Figure 2 also shows the average monthly precipitation and the average monthly temperature for the same stations. The average annual temperature is about 66 degrees Fahrenheit.

Previous Investigations

The earliest reports containing information on ground-water conditions in the four-county area were by Taylor (1907) and Deussen (1914). Records of a few of the earliest deep wells are included in those reports. In the mid-1930's thorough inventories of water wells and springs were made by Chenault (1937) in Freestone County, Cromack (1936) in Cherokee County, and Lyle (1936) in Henderson County. These inventories were conducted under the Works Progress Administration (WPA), and the results were published as mimeographed reports by the Texas Board of Water Engineers in 1936 and 1937. No such inventory was made in Anderson County.

In the 1940's and 1950's, studies were made of several local areas. Sundstrom (1940) and Bennett (1942) reported on conditions in the vicinity of Palestine. Ground-water conditions in the vicinity of Rusk were studied by Clark and Sundstrom (1940). McMillion (1956) made a study of conditions in the Elkhart area in southern Anderson County.

Reconnaissance investigations of the principal aquifers in the Trinity and Neches River basins, which include Anderson, Cherokee, Freestone, and Henderson Counties, were made by the Texas Water Commission, beginning in 1959. These investigations were reported on by Peckham and others (1963) and Baker and others (1963). Also, various consulting studies have been made in the area, particularly for the cities of Palestine and Jacksonville.

A bibliography is included at the end of the text of this report. Listed in the bibliography are the principal reports available on the geology and ground-water resources of Anderson, Cherokee, Henderson, and Freestone Counties, as well as the adjoining counties.

Well-Numbering System

The Texas Water Development Board's statewide well-numbering system is used in this report. As indicated on Figure 3, the system is based on longitude and latitude, with each well being assigned a seven-digit number. In addition, a two-letter county designation prefix is used.

Each 1-degree quadrangle in or overlapping into the State is given a two-digit number from 01 to 89. These are the first two digits of a well number. Each 1-degree quadrangle is further divided into sixty-four 7-1/2-minute quadrangles which are each assigned a two-digit number from 01 to 64. These two digits constitute the third and fourth digits of a well number. Each 7-1/2-minute quadrangle is subdivided into nine 2-1/2-minute quadrangles which are numbered 1 to 9. This is the fifth digit of a well number. Finally, each well within the 2-1/2-minute quadrangles is assigned a two-digit number beginning with 01. These two digits constitute the sixth and seventh digits of a well number.

Each seven-digit well number has a two-letter prefix to identify the county in which the well is located. The prefix for Anderson County is AA, for Cherokee County it is DJ, for Freestone County it is KA, and for Henderson County it is LT.

The four counties are in that part of Texas covered by 1-degree quadrangle numbers 33, 34, 35, 37, 38, and 39. The 7-1/2-minute quadrangles in these counties are as numbered on the location maps, Figures 25, 26, 27, and 28. On these location maps, the

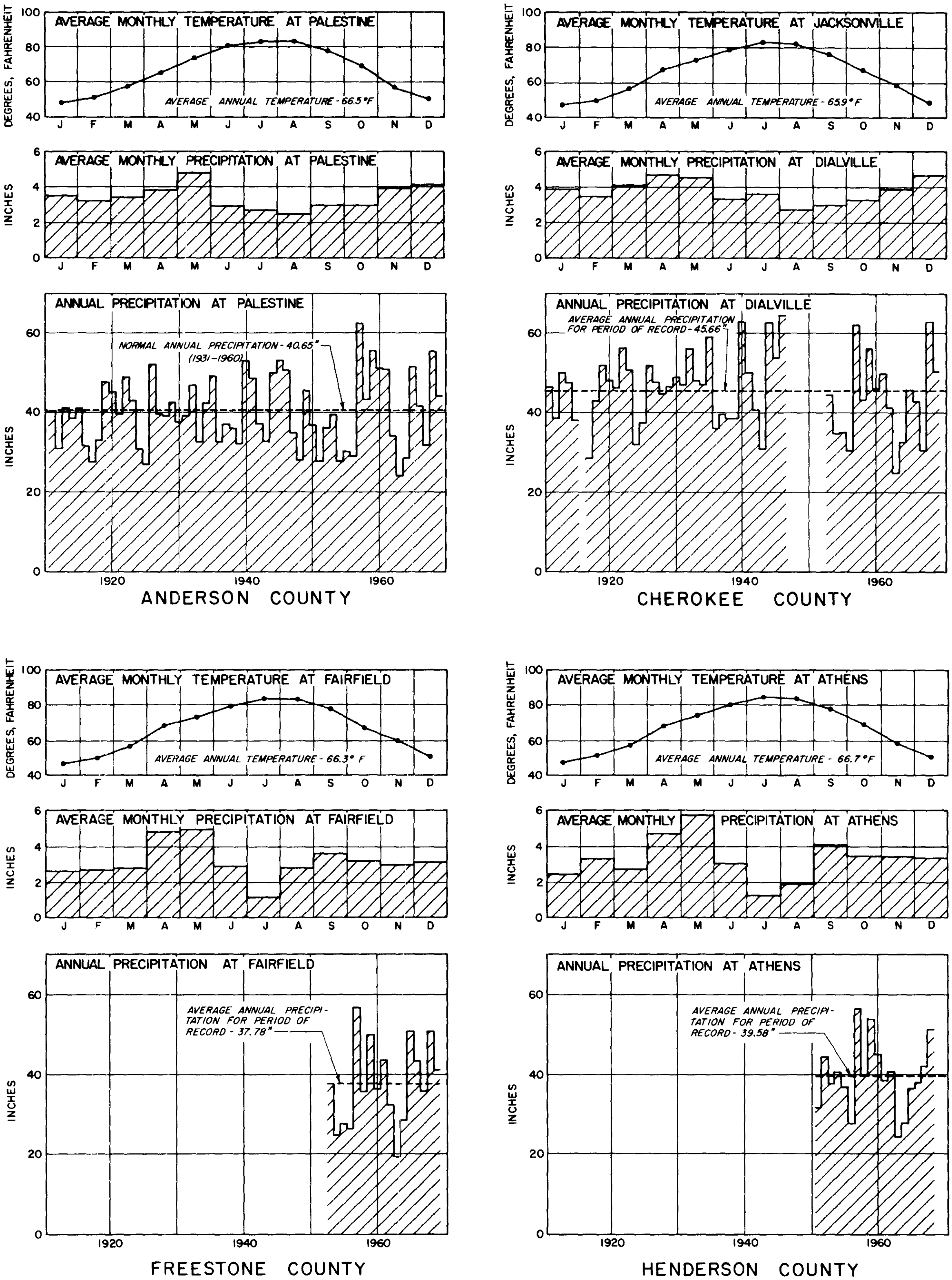


Figure 2
Temperature and Precipitation

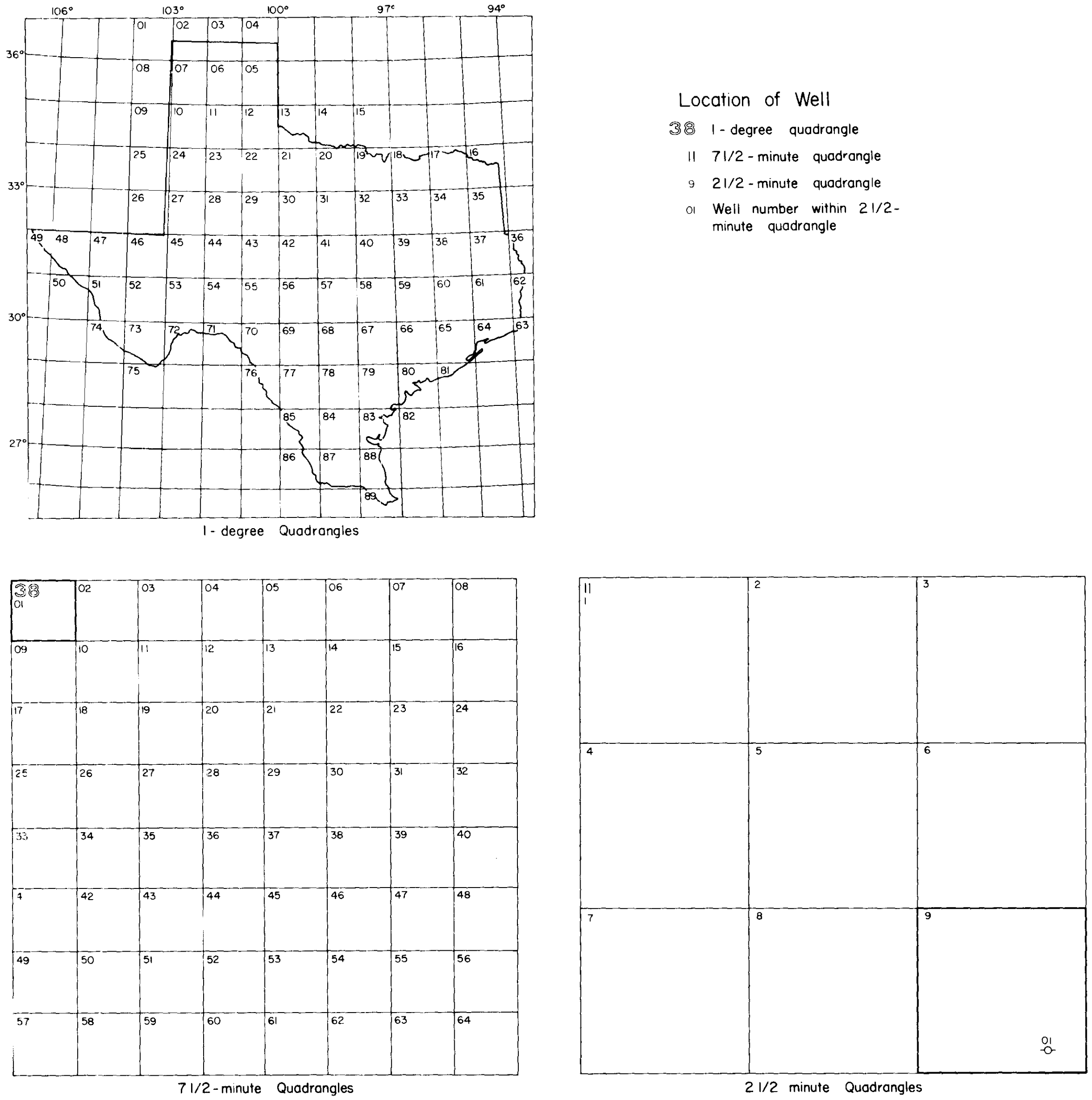


Figure 3.—Well-Numbering System

2-1/2-minute quadrangles are not gridded or numbered, for reason of space limitations. However, their notation occurs as the first digit of the three-digit number beside each well location.

In this report each complete well number is dashed as follows for convenience: AA-38-11-901. This is the designation for the city of Palestine's Water Well No. 1. The number indicates that it is Well 01 within 2-1/2-minute quadrangle 9, within 7-1/2-minute quadrangle 11, within 1-degree quadrangle 38, and within Anderson County.

The present well-numbering system is different from that used in earlier reports by Chenault (1937), Cromack (1936), and Lyle (1936). The numbers used for wells and springs in these earlier reports and the corresponding well numbers used for the same wells and springs listed in this report are given in Table 1.

Acknowledgements

Many persons, agencies, and companies contributed data for this investigation and made wells available for testing. Particular appreciation is expressed to the following: Texas Water Development Board; U.S. Geological Survey; Texas State Department of Health; the cities of Alto, Athens, Elkhart, Fairfield, Frankston, Jacksonville, Malakoff, Palestine, Rusk, Teague, and

Table 1.--Well Numbers Used by Chenault (1937), Cromack (1936), and Lyle (1936) and Corresponding Numbers Used in This Report

CHEROKEE COUNTY

Old Number	New Number	Old Number	New Number
3	DJ-34-61-304	44	DJ-34-63-406
5	34-53-904	48	34-63-903
7	34-62-105	49	34-63-604
8	34-54-703	50	34-63-603
9	34-62-104	64	34-64-504
10	34-61-303	67	34-64-503
11	34-61-302	68	34-64-604
13	34-61-603	69	34-64-605
17	34-62-402	70	34-64-505
19	34-62-502	80	35-49-701
20	34-62-201	81	34-64-305
25	34-62-304	83	35-57-101
26	34-62-604	84	34-64-304
27	34-62-603	85	34-64-303
30	34-63-103	96	38-08-204
31	34-63-104	100	38-08-606
38	34-63-206	101	38-08-303
40	34-63-105	103	38-08-205
43	34-63-405	110	34-64-804

Table 1.--Well Numbers Used by Chenault (1937), Cromack (1936), and Lyle (1936) and Corresponding Numbers Used in This Report--Continued

CHEROKEE COUNTY--Continued

Old Number	New Number	Old Number	New Number
114	DJ-34-64-706	198	DJ-38-05-604
119	34-64-707	200	38-05-906
124	38-08-106	206	38-05-605
126	38-07-304	208	38-06-406
128	38-07-303	209	38-06-407
131	34-63-902	215	38-06-803
135	34-63-803	234	38-07-406
142	38-07-104	238	38-07-407
156	34-62-901	239	38-07-702
169	38-06-304	244	38-07-803
175	38-06-105	245	38-07-508
176	38-06-405	247	38-07-504
178	38-06-104	249	38-07-505
181	34-61-904	250	38-07-506
183	34-62-805	251	38-07-507
185	34-62-703	252	38-07-804
187	34-61-903	259	38-08-701
189	38-05-303	260	38-07-903
190	38-05-603	263	38-08-403

Table 1.--Well Numbers Used by Chenault (1937), Cromack (1936), and Lyle (1936) and Corresponding Numbers Used in This Report--Continued

CHEROKEE COUNTY--Continued

Old Number	New Number	Old Number	New Number
265	DJ-38-08-404	322	DJ-38-16-905
266	38-08-502	323	38-16-501
267	38-08-803	325	38-16-604
269	38-08-804	326	38-16-502
271	38-08-503	327	38-16-503
272	38-08-504	329	38-16-203
274	38-08-505	330	38-16-204
277	38-08-607	332	38-16-205
278	38-08-608	333	38-08-805
281	38-08-901	338	38-16-102
301	38-08-902	339	38-16-103
304	38-16-304	341	38-16-504
308	38-16-305	342	38-16-404
309	37-09-103	346	38-16-703
311	38-16-603	351	38-24-303
314	37-09-402	354	38-24-201
317	37-09-703	357	38-24-203
318	37-09-701	368	38-23-305
320	38-16-906	369	38-23-304

Table 1.--Well Numbers Used by Chenault (1937), Cromack (1936), and Lyle (1936) and Corresponding Numbers Used in This Report--Continued

CHEROKEE COUNTY--Continued

Old Number	New Number	Old Number	New Number
370	DJ-38-23-303	458	DJ-38-07-704
374	38-15-902	459	38-15-103
377	38-16-704	460	38-14-305
389	38-08-702	465	38-14-904
391	38-07-904	466	38-14-905
392	38-07-905	467	38-14-906
394	38-15-303	469	38-14-907
396	38-15-301	470	38-14-505
407	38-23-203	471	38-14-602
409	38-23-104	473	38-14-203
410	38-23-204	474	38-14-306
427	38-15-104	475	38-14-204
429	38-15-504	478	38-06-902
430	38-15-404	481	38-06-804
437	38-23-105	492	38-13-302
438	38-23-405	493	38-14-104
439	38-23-107	494	38-14-105
440	38-22-301	495	38-14-406
450	38-14-604	496	38-14-201

Table 1.--Well Numbers Used by Chenault (1937), Cromack (1936), and Lyle (1936) and Corresponding Numbers Used in This Report--Continued

CHEROKEE COUNTY--Continued

Old Number	New Number	Old Number	New Number
497	DJ-38-14-506	632	DJ-37-17-402
498	38-14-404	638	38-24-903
501	38-13-901	640	37-17-704
502	38-14-703	642	37-17-403
503	38-14-403	648	37-17-703
506	38-14-504	651	38-24-901
510	38-14-802	657	38-24-801
604	38-23-404	658	38-24-802
607	38-23-403	663	38-23-902
608	38-23-604	668	38-23-705
609	38-23-505	669	38-23-704
611	38-24-404	679	38-32-103
615	38-24-402	681	38-24-706
620	38-24-505	684	38-32-102
626	38-24-502	689	38-32-205
627	38-24-503	690	38-24-805
628	38-24-601	691	38-32-204
630	38-24-504	693	38-32-206
631	38-24-602	694	38-32-302

Table 1.--Well Numbers Used by Chenault (1937), Cromack (1936), and Lyle (1936) and Corresponding Numbers Used in This Report--Continued

CHEROKEE COUNTY--Continued

Old Number	New Number	Old Number	New Number
695	DJ-37-25-201	721	DJ-37-25-804
697	38-32-505	722	37-25-802
700	38-32-401	723	37-25-902
703	38-32-501	726	37-25-701
707	37-25-402	728	37-33-201
709	38-32-502	730	37-25-703
711	38-32-802	731	38-32-904
714	38-32-905	734	38-40-302
715	38-32-906	735	38-40-301
716	38-32-907	736	37-33-104
720	37-25-803	738	37-33-102

Table 1.--Well Numbers Used by Chenault (1937), Cromack (1936), and Lyle (1936) and Corresponding Numbers Used in This Report--Continued

FREESTONE COUNTY

Old Number	New Number	Old Number	New Number
24	KA-39-14-803	68	KA-39-22-410
25	39-14-802	75	39-22-203
38	39-22-105	76	39-22-102
40	39-21-605	77	39-22-103
41	39-21-612	79	39-22-204
43	39-21-606	80	39-22-104
44	39-21-607	82	39-14-806
45	39-21-608	83	39-14-805
46	39-21-609	95	39-23-408
49	39-21-610	101	39-22-904
51	39-21-501	103	39-22-905
53	39-21-611	104	39-22-906
56	39-21-601	111	39-22-508
59	39-22-407	112	39-22-509
60	39-22-408	113	39-22-510
62	39-22-409	115	39-22-511
63	39-22-406	122	39-21-902
64	39-22-405	123	39-22-703
65	39-22-404	124	39-22-704

Table 1.--Well Numbers Used by Chenault (1937), Cromack (1936), and Lyle (1936) and Corresponding Numbers Used in This Report--Continued

FREESTONE COUNTY--Continued

Old Number	New Number	Old Number	New Number
213	KA-39-14-603	269	KA-39-16-704
215	39-15-402	270	39-16-705
216	39-15-403	271	39-16-703
223	39-15-505	274	39-15-904
237	39-15-404	276	39-15-905
239	39-15-405	280	39-15-805
240	39-14-901	282	39-15-806
245	39-15-704	284	39-15-803
246	39-15-406	285	39-15-807
249	39-15-705	300	39-23-504
250	39-15-804	302	39-23-505
256	39-15-903	304	39-23-506
257	39-15-605	305	39-23-507
260	39-15-602	312	39-23-302
261	39-15-603	314	39-23-306
262	39-15-604	316	39-23-307
266	39-16-405	322	39-23-305
267	39-16-701	400	39-07-601
268	39-16-702	402	39-08-101

Table 1.--Well Numbers Used by Chenault (1937), Cromack (1936), and Lyle (1936) and Corresponding Numbers Used in This Report--Continued

FREESTONE COUNTY--Continued

Old Number	New Number	Old Number	New Number
404	KA-39-08-102	528	KA-38-25-203
405	39-08-401	538	38-25-303
406	39-08-701	540	38-25-304
408	39-08-702	541	38-25-305
409	39-08-703	544	38-26-102
413	39-16-101	546	38-26-104
414	39-16-102	547	38-26-105
418	39-16-203	548	38-26-106
419	39-16-103	606	39-23-605
421	39-16-403	613	39-24-101
424	39-16-404	614	39-24-102
425	39-16-402	616	39-24-202
426	39-16-401	618	39-24-203
517	38-17-402	622	39-24-504
518	38-17-403	625	39-22-501
521	38-17-805	626	39-24-502
524	38-17-704	627	39-24-503
525	38-17-703	629	39-24-402
527	38-25-202	630	39-22-403

Table 1.--Well Numbers Used by Chenault (1937), Cromack (1936), and Lyle (1936) and Corresponding Numbers Used in This Report--Continued

FREESTONE COUNTY--Continued

Old Number	New Number	Old Number	New Number
631	KA-39-24-401	835	KA-39-30-608
635	39-23-604	836	39-30-607
644	39-24-702	837	39-30-601
648	39-31-303	839	39-31-410
649	39-31-304	841	39-31-102
650	39-31-302	842	39-31-103
667	39-32-206	853	39-31-202
668	39-32-207	858	39-31-203
670	39-32-104	860	39-31-204
675	39-32-208	872	39-30-905
681	38-25-102	873	39-30-603
682	38-25-103	874	39-30-602
692	39-32-502	875	39-30-604
693	39-32-503	877	39-31-405
810	39-23-705	879	39-31-407
814	39-23-706	881	39-31-406
820	39-23-704	882	39-31-408
821	39-23-703	887	39-31-602
824	39-30-302	901	39-39-101

Table 1.--Well Numbers Used by Chenault (1937), Cromack (1936), and Lyle (1936) and Corresponding Numbers Used in This Report--Continued

HENDERSON COUNTY

Old Number	New Number	Old Number	New Number
8	LT-33-46-102	71	LT-33-47-807
9	33-46-201	101	33-48-102
10	33-46-202	102	33-48-503
12	33-46-203	103	33-48-504
15	33-46-303	109	33-48-613
16	33-46-302	116	33-48-614
20	33-47-104	120	33-48-611
34	33-47-405	121	33-48-903
35	33-47-406	122	33-48-505
37	33-47-402	124	33-48-401
40	33-46-603	137	33-47-906
42	33-46-604	138	33-47-905
43	33-46-503	140	33-47-907
46	33-46-602	143	33-48-803
47	33-46-502	144	33-48-802
54	33-47-408	158	33-55-304
57	33-47-805	160	33-55-305
58	33-47-806	161	33-55-306
68	33-47-702	164	33-55-307

Table 1.--Well Numbers Used by Chenault (1937), Cromack (1936), and Lyle (1936) and Corresponding Numbers Used in This Report--Continued

HENDERSON COUNTY--Continued

Old Number	New Number	Old Number	New Number
165	LT-33-55-308	225	LT-34-41-804
167	33-56-506	226	34-41-602
170	33-56-407	227	34-41-603
173	33-55-602	229	34-42-106
174	33-55-603	230	34-42-502
177	33-55-604	231	34-42-407
180	33-55-605	232	34-42-707
203	34-42-406	233	34-42-708
204	34-42-105	234	34-42-709
205	34-41-302	237	34-41-904
208	34-41-203	239	34-41-905
210	34-41-407	242	34-41-805
211	34-41-107	243	34-41-806
212	34-41-108	245	34-41-708
214	33-48-303	246	34-41-709
218	34-41-408	261	34-41-707
219	33-48-610	265	34-49-104
220	33-48-612	267	34-41-807
224	34-41-409	279	34-50-505

Table 1.--Well Numbers Used by Chenault (1937), Cromack (1936), and Lyle (1936) and Corresponding Numbers Used in This Report--Continued

HENDERSON COUNTY--Continued

Old Number	New Number	Old Number	New Number
280	LT-34-50-506	426	LT-34-43-705
290	34-50-102	428	34-43-706
292	34-50-105	429	34-43-703
311	34-49-505	433	34-50-304
314	34-49-506	435	34-50-305
315	34-49-507	436	34-51-105
316	34-49-508	437	34-51-106
318	34-49-606	438	34-51-206
319	34-49-203	439	34-51-303
325	34-49-401	440	34-51-207
402	34-43-506	441	34-51-605
404	34-43-105	502	34-45-101
409	34-42-605	504	34-45-405
413	34-43-704	505	34-45-102
414	34-43-605	508	34-44-204
415	34-43-507	511	34-44-502
417	34-43-606	512	34-44-405
421	34-43-903	513	34-43-607
425	34-43-805	514	34-44-406

Table 1.--Well Numbers Used by Chenault (1937), Cromack (1936), and Lyle (1936) and Corresponding Numbers Used in This Report--Continued

HENDERSON COUNTY--Continued

Old Number	New Number	Old Number	New Number
515	LT-34-44-407	604	LT-34-52-506
516	34-44-703	606	34-52-505
517	34-44-503	608	34-52-403
518	34-44-501	609	34-52-704
520	34-44-504	612	34-61-106
523	34-44-604	614	34-61-405
527	34-45-703	615	34-61-107
537	34-45-704	619	34-52-804
538	34-44-906	622	34-60-406
543	34-44-704	624	34-60-407
544	34-44-705	628	34-60-408
545	34-51-304	702	34-51-606
546	34-52-105	704	34-51-904
552	34-52-306	706	34-51-505
554	34-52-307	707	34-50-604
556	34-44-905	710	34-50-605
560	34-52-305	715	34-50-804
563	34-52-205	717	34-50-903
567	34-52-404	719	34-51-703

Table 1.--Well Numbers Used by Chenault (1937), Cromack (1936), and Lyle (1936) and Corresponding Numbers Used in This Report--Continued

HENDERSON COUNTY--Continued

Old Number	New Number	Old Number	New Number
721	LT-34-51-804	803	LT-34-50-404
722	34-51-905	805	34-49-809
723	34-59-203	809	34-49-703
724	34-59-204	810	34-49-704
726	34-59-205	813	34-49-402
728	34-51-704	814	33-56-904
732	34-58-203	816	33-56-905
733	34-58-303	823	34-49-903
735	34-59-106	824	34-57-304
736	34-59-107	825	34-57-305
737	34-59-503	831	34-58-204
740	34-59-304	834	34-58-103
741	34-59-305	842	34-57-504
742	34-59-504	845	34-57-505
743	34-59-505	846	34-57-601
744	34-59-405	847	34-57-602
750	34-58-901	855	34-57-703
751	34-58-604	857	34-57-403
752	34-59-406	862	33-64-604

Table 1.--Well Numbers Used by Chenault (1937), Cromack (1936), and Lyle (1936) and Corresponding Numbers Used in This Report--Continued

HENDERSON COUNTY--Continued

Old Number	New Number	Old Number	New Number
864	LT-33-64-902	919	LT-33-56-803
865	34-57-704	920	33-56-804
867	34-57-705	921	33-56-802
902	33-56-606	922	33-56-705
905	33-56-604	923	33-56-706
908	33-56-507	924	33-56-707
913	33-56-408	926	33-56-708
914	33-56-409	927	33-56-906
917	33-56-704		

Wells; the many rural water supply corporations in the area; drilling contractors including C. C. Innerarity, Layne Texas Company, Neal Drilling Company, Rehkop Drilling Company, R. K. Sims, Texas Water Wells, Frank Ward, and White Drilling Company; consulting engineers including S. M. Cothren and Associates, James C. Duff, K. G. Johnson, and Rady and Associates.

Grateful appreciation is also expressed to Mr. Hubert Guyod, logging consultant, Houston, Texas, for his assistance in estimating the quality of water in the Wilcox Group from electric logs.

INVENTORY OF WATER WELLS

In the course of this investigation, an inventory was made of all existing water wells used for municipal, industrial, and irrigation purposes. In addition, an inventory was made of representative domestic and livestock wells. Information on important test holes and springs was also obtained, and where possible on previous large wells which have been abandoned and destroyed. Figures 25, 26, 27, and 28 show the locations of the wells and springs inventoried. Information on each is listed in Tables 7, 8, 9, and 10.

The records of wells, test holes, and springs inventoried by Chenault (1937) in Freestone County, Cromack (1936) in Cherokee County, and Lyle (1936) in Henderson County have been preserved in this report in those instances where locations could definitely be determined on county road maps prepared by the Tlexas Highway Department. These earlier records are considered especially important because, for most of the large number of wells, test holes, and springs previously inventoried, results of chemical analyses of water are available. An effort was made to determine their locations as part of this study, and the locations of many could be determined. Others could not be located, either because the wells have long since been abandoned and destroyed or because of inaccuracies in earlier maps. Where necessary, the records of the old wells have been brought up to date.

The well records obtained by the Texas Water Commission during reconnaissance investigations of the ground-water resources in the Neches and Trinity River basins (Baker and others, 1963, and Peckham and others, 1963) were also used and updated in the course of this investigation. Also, many well records were obtained from drillers' reports on file with the Texas Water Development Board, well drillers, consultants, and individual well owners.

ELECTRIC LOGS AND DRILLERS' LOGS

Six hundred and sixty-five electric logs of oil tests, water wells, and test holes were used in this study. The electric logs are especially useful because of the detailed information they reveal concerning the subsurface stratigraphy of the formations and the quality of water in the formations. The lithologic character, depth, thickness, and sand thickness of the formations, as presented in this report, are based largely on studies and correlations of electric logs. The logs are identified in Tables 7 through 10, and copies are on file with the Texas Water Development Board. The numbers of logs used in each county are as follows:

Anderson County	203 logs
Cherokee County	213 logs
Freestone County	106 logs
Henderson County	143 logs

The wells for which drillers' logs are available are indicated in Tables 7 through 10. All of the actual logs are on file with the Texas Water Development Board. Representative drillers' logs of water wells and test holes are given in Tables 11 through 14.

GEOLOGY AS RELATED TO THE OCCURRENCE OF GROUND WATER

General Stratigraphy and Structure

The geologic units containing fresh water in Anderson, Cherokee, Freestone, and Henderson Counties include, from oldest to youngest: rocks of Cretaceous age; Midway Group, Wilcox Group, Carrizo Sand, Reklaw Formation, Queen City Sand, Weches Formation, Sparta Sand, and Cook Mountain Formation, all of Eocene age; and terrace and floodplain deposits of Pleistocene and Recent age. These geologic units have a combined thickness in excess of 4,000 feet in parts of the area and include deposits of continental, deltaic, and marine origin. Each of the units yields some fresh water to wells in one or more of the four counties.

The ranges in thickness, composition, and water-bearing properties of the formations are summarized in Table 2. Table 3 gives the thickness of the Eocene units at several localities within the four counties. The geologic sections (Figures 30 through 37) show the general altitude, depth, thickness, extent, and electric log character of the units, as well as the general quality of the water contained in the sands of the Wilcox, Carrizo, Queen City, and Sparta units.

The geologic map (Figure 29) shows the surface extent of the formations in Anderson, Cherokee, Henderson, and Freestone Counties. This generalized map was prepared directly from more detailed maps published by the Bureau of Economic Geology,

Table 2.--Stratigraphic Units and Their Water-Bearing Properties

Stratigraphic Unit	Approximate Range in Thickness (feet)	Principal Composition	General Water-Bearing Properties
Alluvium	0-50	Sand, silt, and clay, with some gravel.	Yields small quantities of fresh to brackish water.
Cook Mountain Formation	0-125	Clay.	Yields very small quantities of fresh water in outcrop area.
Sparta Sand	0-255	Interbedded sand and clay.	Yields small quantities of fresh water.
Weches Formation	0-155	Clay.	Yields very small quantities of fresh water in outcrop area.
Queen City Sand	0-555	Interbedded sand and clay.	Yields small quantities of fresh water.
Reklaw Formation	0-315	Clay, silt, and sand.	Yields very small quantities of fresh water.
Carrizo Sand	0-220	Massive sand.	Yields small to moderate quantities of fresh water.
Wilcox Group	0-2,710	Interbedded sand, silt, and clay.	Yields small to large quantities of fresh and brackish water.

Table 2.--Stratigraphic Units and Their Water-Bearing Properties--Continued

Stratigraphic Unit	Approximate Range in Thickness (feet)	Principal Composition	General Water-Bearing Properties
Midway Group	1/	Clay.	Yields very small quantities of water in outcrop area.
Rocks of Cretaceous age on Butler, Palestine, and Keechi Domes and in extreme northwestern Henderson County	1/	Clay, limestone, and marl.	Yields very small quantities of water in outcrop area.

1/ Not determined.

Table 3. --Thicknesses of Stratigraphic Units

Stratigraphic Unit	Approximate Thickness of Unit (feet)								
	Anderson County			Cherokee County		Freestone County		Henderson County	
	at Palestine	at Frankston	at Elkhart	at Jacksonville	at Wells	at Fairfield	at Teague	at Athens	at Chandler
Cook Mountain Formation	1/	1/	50	1/	125	1/	1/	1/	1/
Sparta Sand	60	1/	200	50	250	1/	1/	1/	1/
Weches Formation	95	1/	60	70	115	1/	1/	1/	1/
Queen City Sand	450	370	365	360	95	1/	1/	1/	280
Reklaw Formation	175	180	240	210	310	1/	1/	1/	65
Carrizo Sand	100	100	90	90	100	1/	1/	110	100
Wilcox Group	1,550	1,140	1,900	1,500	2,710	700	690	800	980

1/ Not present

University of Texas. Figure 29 also shows the location of the principal faults and fault zones in the area and the locations of the Butler, Palestine, Keechi, and Boggy Creek domes.

The oldest geologic units having surface exposures within the four-county area are of Cretaceous age. These rocks crop out on the Butler, Palestine, and Keechi domes, and in a small area in the northwestern part of Henderson County. Formations of Eocene age occur at the surface over most of the four-county area, with the Wilcox and Queen City having by far the largest outcrop areas. The alluvial deposits of Pleistocene and Recent age are limited to the flood plains and closely associated terrace deposits along the Trinity, Neches, and Angelina Rivers and their principal tributaries. The most extensive alluvial and terrace deposits are those associated with the Trinity River.

The four counties lie across the southern portion of the East Texas embayment, or syncline. This large structural trough is a part of the even larger Gulf Coastal Plain. The East Texas syncline has a dominant influence on the geology and ground-water conditions of the Eocene formations throughout East and Northeast Texas. The axis of the East Texas syncline trends approximately north-south in the report area. It extends through Smith County, just east of the eastern boundary of Henderson County, and continues through Cherokee and Anderson Counties in the general vicinity of the Neches River.

The rocks dip toward the axis of the East Texas syncline from each side. The regional rate of dip of the formations in Henderson County is typically about 20 to 100 feet per mile to the east and east-southeast. Similar conditions exist in western Anderson County and in Freestone County. In northeastern Cherokee County, the dip of the formations is typically about 20 to 100 feet per mile to the west and west-southwest. In extreme southern Cherokee and Anderson Counties, the coastward dip of the Gulf Coastal Plain proper is dominant, and southerly dips of about 50 feet per mile persist in these localities.

There are many local structural features which significantly affect the depth, thickness, and dip of the formations, some of which are shown on Figure 29. Numerous salt domes occur in the study area, with the greatest concentration in the central part of the East Texas syncline. Also, two major zones of faulting cut across separate parts of the four-county area. Thus, locally, conditions are complex, and the exact dept:hs of the formations in many areas cannot always be estimated accurately.

The salt domes result from the upward movement of salt due to differential pressure on deep-seated parent deposits. These upwellings of salt have pushed up, sometimes pierced, and nearly always influenced significantly the position of the overlying beds. The domes which have had the most pronounced effect upon the present day surface geology include the Butler dome in eastern Freestone County and the Palestine and Keechi domes in west-central Anderson County. Atop each of these domes, rocks of Cretaceous age and of the Midway Group have been pushed upward to the extent that they now occur at the surface. Over the Boggy Creek dome, in northeastern Anderson County and the adjoining part of Cherokee County, rocks of the Wilcox Group occur at the surface. Within the four counties there are several other domes, but most have not had as significant an effect on the Wilcox and younger formations as those already mentioned. These other domes and their locations are as follows:

ANDERSON COUNTY

Concord Dome	11 miles north-northwest of Palestine
Bethel Dome	18 miles northwest of Palestine
Brushy Creek Dome	12 miles north-northeast of Palestine

FREESTONE COUNTY

Oakwood Dome (extending into Leon County)	16 miles southeast of Fairfield

HENDERSON COUNTY

La Rue Dome	10 miles east-southeast of Athens

A major zone of faulting, called the Mount Enterprise fault zone, extends from southwestern Anderson County northeastward into Cherokee County and across north-central Cherokee County and on into southern Rusk County. This zone is an irregular belt of faulting ranging in width from one to eight miles. The larger fault displacements range up to at least 600 feet, but more commonly are between about 50 and 200 feet. The faults are particularly significant with respect to ground-water conditions. They act as partial to complete barriers to the movement of ground water. Because of the faults, the quality of water in some areas is poorer than it might otherwise be. Also, the effects of the faults result in substantially larger long-term drawdowns of water levels in wells and well fields, with the largest effects being on those wells and well fields closest to the faults.

In the southwestern part of the Mount Enterprise fault zone, a large fault trough, or graben, occurs. It has been called the Elkhart graben. This structural feature, trending northeast-southwest, is about 16 miles in length and about 4 miles in width. It extends from about 6 miles southwest of the town of Elkhart to about 10 miles northeast of Elkhart (see Figure 29). The rocks in the central block of the graben are downfaulted, by amounts ranging from about 50 to 300 feet, relative to their positions on either side of the graben.

A fault zone known as the Luling-Mexia-Talco zone cuts across the northwestern tips of both Freestone and Henderson Counties (see Figure 29). This fault zone is an important part of the structural pattern of East Texas and is important for its associated oil fields. The surface extent of this zone of faulting lies almost wholly within the outcrop of the Midway Group and older formations, however, and the faulting does not affect the Eocene ground-water reservoirs.

Other areas of faulting exist within the four counties. In comparison with the Mount Enterprise fault zone and the Luling-Mexia-Talco fault zone, all are minor in extent. Most are in the vicinity of the Butler, Palestine, and Keechi domes.

Principal Water-Bearing Formations

The Wilcox Group, Carrizo Sand, Queen City Sand, and Sparta Sand are the most important water-bearing units in Anderson, Cherokee, Freestone, and Henderson Counties. The Wilcox and Carrizo are much more important than the Queen City and Sparta. Nearly all the municipal and industrial ground-water supplies are from either Wilcox or Carrizo wells. The largest capacity wells and the deepest wells in the four-county area are in the Wilcox Group. Large numbers of mostly small-capacity wells draw water from the Queen City because of its widespread surface and near-surface occurrence. Fewer wells tap the Sparta due to its more limited areal extent.

Wilcox Group

The Wilcox Group overlies the Midway Group and occurs at the surface mostly in a broad belt trending approximately north-south across Freestone and Henderson Counties. The Wilcox is a thick unit, and the width of its outcrop in Freestone and Henderson Counties ranges from 10 to 22 miles. In addition, the Wilcox is exposed at the surface in small areas on the Butler, Palestine, Keechi, and Boggy Creek domes, as well as in a few small areas in east-central Cherokee County. Elsewhere east of its outcrop in Henderson and Freestone Counties, the Wilcox occurs in the subsurface beneath younger strata.

The Wilcox consists mainly of interbedded sand, silt, and clay, with minor amounts of lignite. The sands are typically gray and most are relatively thin-bedded, fine-grained, and silty. Locally, however, some of the sands, particularly in the middle to lower part of the Wilcox, are fine- to coarse-grained and very thick-bedded. Individual beds within the Wilcox Group generally cannot be correlated from well to well due to lateral changes in character and thickness. In some areas, however, predominantly sandy zones within the Wilcox or predominently clayey zones do appear to correlate from well to well.

On the Waco Sheet (Bureau of Economic Geology, 1970)) the Wilcox outcrop in Freestone County is divided into three formations. They are called from youngest to oldest the Calvert Bluff Formation, the Simsboro Formation, and the Hooper Formation. Of the three formations, the Simsboro typically contains more massive, coarse-grained sands, and in an area to the southwest of Freestone County, the Simsboro is known to be a prolific aquifer. As a part of the present study, an effort was made to differentiate the Simsboro Formation within the four-county area based on electric log characteristics. More electric logs from wells in Freestone County show definable Simsboro sections than do electric logs from wells in any of the other counties. However, even in Freestone County, the percentage of logs showing an easily recognizable Simsboro section is only slightly more than 30 percent. The percentage of logs showing an easily distinguishable Simsboro section in Anderson and Henderson Counties is about 30 percent. On only about 11 percent of the logs in Cherokee County is it possible to differentiate a section probably correlative with the Simsboro as mapped in Freestone County. Accordingly, it is not believed practicable to differentiate the formations of the Wilcox Group in the subsurface for any of the purposes of this report.

Figures 38, 39, 40, and 41 show the depth to the top and altitude of the top of the Wilcox Group. The altitude of the top of the Wilcox ranges from about 500 feet above sea level in northern Henderson County to about 800 feet below sea level in the most southern part of Cherokee County. The thickness of the Wilcox Group increases from the outcrop area toward the southeast across the four-county area. The Wilcox has a thickness of about 800 to 1,100 feet in the subsurface in Henderson and Freestone Counties where its full thickness is present. The Wilcox increases in thickness to about 1,500 feet and then 2,000 feet across central Anderson and central Cherokee Counties. It increases in thickness to more than 2,200 feet in southeastern Anderson County and attains a maximum thickness in the study area of over 2,700 feet in southernmost Cherokee County. Local variations in the thickness of the Wilcox occur in the salt dome areas. The Wilcox thins over those salt domes which were the most active during Wilcox time. These include the Palestine, Keechi, and Boggy Creek domes.

The quality of the water in the Wilcox of the four-county area varies from fresh to brackish to salty both laterally and vertically. The geologic sections, Figures 30 through 37, illustrate the general distribution of the fresh, brackish, and salty water within the Wilcox Group. The thickest fresh water sections or zones within the Wilcox occur in eastern Henderson County, central and northern Anderson County, and northwestern Cherokee County. The Wilcox contains mostly only brackish water in the southern third of Anderson County and the southeastern half of Cherokee County. There is some salty water in the lower part of the Wilcox

Group in some areas in each of the four counties, but the thickest salty water zones are in extreme southeastern Cherokee County.

Figures 42, 43, 44 and 45 show the intervals of the Wilcox Group containing fresh, brackish, and salty water based on interpretations of electric logs. The net sand thicknesses occurring within the fresh and brackish water zones of the Wilcox Group are also shown. Net sand thickness refers to the total thickness of sands suitable for screening in wells. In the fresh water section of the Wilcox the net sand thickness ranges up to 520 feet, but mostly is between 250 and 400 feet. The maximum depth of occurrence of fresh water in the Wilcox is in excess of 2,000 feet.

From the data given on Figures 38 through 45, the elevation of the base of the fresh water zones within the Wilcox can be determined. This is done by subtracting the thickness of the Wilcox Group containing fresh water from the elevation of the top of the Wilcox. Similarly, by subtracting both the thickness of the Wilcox containing fresh water and the thickness of the underlying part of the Wilcox containing brackish water from the elevation of the top of the Wilcox, the elevation of the base of the brackish water in the Wilcox can be determined.

Carrizo Sand

The Carrizo Sand directly overlies the Wilcox Group and occurs at the surface in a narrow belt one-fourth to four miles wide immediately east of the Wilcox outcrop in Freestone, Anderson, and Henderson Counties. Other surface outcrops occur around or near the Butler, Palestine, Keechi, and Boggy Creek and La Rue domes, along several faults of the Mount Enterprise zone in eastern Anderson County and northeast-central Cherokee County, and also in the northeastern corner of Cherokee County.

The Carrizo is typically reddish-brown to llight gray and cross-bedded in surface outcrops. In the subsurface, the Carrizo is typically a white, massive, fine- to medium-grained quartz sand. It often contains a few thin clay lenses, but it is not usual for a significant part of the formation to be clay. In drillers' logs, the Carrizo is often described as "white sand," and frequently the notation "cuts good" is given, referring to a relatively fast drilling rate.

The Carrizo is rather uniform in composition and in its character on electric logs over much of the area. This uniformity and a markedly higher resistivity commonly distinguish it on electric logs from the overlying Reklaw and the underlying Wilcox sands. In some localities where little or no resistivity differences exist between the Carrizo and sands of either the Reklaw or Wilcox, and formation samples are not available, picking the upper or lower contacts of the Carrizo is arbitrary. This tends to be the case for the Reklaw-Carrizo contact in many localities in western Henderson County and for the Reklaw-Carrizo contact and Carrizo-Wilcox contact at several scattered locations throughout the report area. In this study the Carrizo determinations from electric logs generally have been made to include only the most massive and resistive of the sands of the possible Carrizo interval. Therefore, some sands of the Carrizo, if they are interbedded with clay, may have been included in the Reklaw or Wilcox. In all cases, the zone picked as Carrizo is believed to correlate with that hydrologic unit which, in much of the East Texas area, typically has a higher permeability than either overlying or underlying sands and is a prolific aquifer.

Figures 46, 47, 48, and 49 show the depth and altitude of the top of the Carrizo Sand. With few exceptions the Carrizo is at relatively shallow depths throughout the area of its occurrence in the report area. A fairly large area where the Carrizo is at moderate depths is in southern Cherokee County, southeast of Alto. Other smaller areas exist. They include the Coon Creek area in southwest Henderson County, the Elkhart graben area in southern Anderson County, and an area north of the Boggy Creek dome, including the common corners of Cherokee, Anderson, and Henderson Counties.

Figures 50, 51, 52, and 53 show the total thickness of the Carrizo as well as the net sand thickness within the formation. The total thickness of the Carrizo ranges from 10 to 220 feet within the report area. The net sand thickness within the Carrizo averages about 90 to 110 feet throughout southern Cherokee, southern Anderson, and in Freestone Counties. The Carrizo has a smaller average net sand thickness in and north of the Mount Enterprise fault zone in Cherokee County, in northeastern Anderson County, and in Henderson County. In these areas the average net sand thickness ranges from about 40 to 80 feet.

Figure 54 shows the localities where the Carrizo Sand has the best water-yielding characteristics and where its water-yielding capabilities are relatively poor. Figure 54 is based on electric log interpretations. It shows the localities where the Carrizo is massive in character and more than 100 feet in total thickness. It also shows those localities where the Carrizo either is less than 50 feet in total thickness or is very broken and clayey in character. It is apparent from Figure 54 that more of the thinner or clayey Carrizo sections exist in Henderson County, in northern Cherokee County, and in northeast Anderson County and that more of the thick and massive Carrizo sections occur in the southern half of the four-county area.

Queen City Sand

The Queen City Sand is an important water-bearing unit within the four-county area more because of its widespread, shallow extent than because of the size of the supplies available from it. The Queen City is at the surface in a large area extending over the central part of the report area (see Figure 29). Thus, sands of the Queen City contain the most readily available ground-water supplies over a large area, especially for rural domestic and livestock use.

The Queen City directly overlies the Reklaw Formation and consists mostly of alternating beds of very fine- to fine-grained quartz sand and clay. Because of its shallow occurrence, most of the electric logs available do not show the character of the entire section of Queen City present at the log locations. Most show only the lower portion of the Queen City section. Because of lateral changes in character and thickness, individual beds within the Queen City generally cannot be correlated on available electric logs, except in very closely spaced holes.

Figures 55, 56, and 57 show the outcrop of the Queen City Sand, the depth to the base of the formation, the total thickness of the formation, and the net sand thickness within the formation in Anderson, Cherokee, and Henderson Counties. No similar map is included for the Queen City in Freestone County because of its limited extent in that county. The surface extent of the Queen City in Freestone County is shown on Figure 29.

The Queen City occurs at the surface or underlies shallower formations in essentially the following areas: all of western Henderson County; all of Anderson County, except for an area along its western edge and atop a few of the salt domes; and most of Cherokee County, except mainly in areas in northeastern Cherokee County both north and south of the Mount Enterprise fault zone.

The thickness of the Queen City Sand changes markedly within the report area. The thickest sections of the Queen City occur along the axis of the East Texas syncline. The formation thins both east and west of the axis as well as to the south and east across southern Cherokee County. The Queen City is mostly between 200 and 450 feet thick in those parts of the area where it is thickest. Throughout its large outcrop area, its thickness is partly controlled by toppgraphy, and it attains a maximum known thickness of 555 feet in a structural depression north of the Boggy Creek dome in the northeastern corner of Anderson County. In southern Cherokee County, the thickness of the formation ranges from 65 to 100 feet.

The net sand thickness within the Queen City, on logs showing its entire thickness, averages between 50 and 60 percent of the total thickness. The net sand thickness ranges from as little as 45 feet in southeastern Cherokee County to more than 300 feet in localities where the Queen City is the thickest.

In Freestone County, the Queen City outcrops to the south of the Butler dome and in an area along the southeastern Freestone County line between Upper Keechi Creek and Buffalo Creek, adjacent to the Oakwood dome. In the viciinity of the Oakwood dome, the Queen City attains a maximum thickness of approximately 200 feet, with about half the formation being sand.

Sparta Sand

The Sparta Sand caps the very tops of a few scattered hills in western Henderson County. It caps some of the highest hills in the northern two-thirds of Anderson and Cherokee Counties. It occurs at the surface in a larger area in southern Anderson County in the vicinity of the Elkhart graben. As a source of water in these areas, however, it is not overly important because of its limited extent and/or high topographic position. In southern Cherokee County, the Sparta is of more than limited importance. South of Alto in Cherokee County, the Sparta outcrops in a belt about three to eight miles wide trending east-west and dipping to the south beneath the Cook Mountain Formation.

The Sparta consists mostly of very fine- to fine-grained quartz sand, clay, and silty clay containing some lignitic beds. Typically about half the total thickness of the formation is sand. Individual sand zones within the Sparta can only rarely be correlated from well to well. Figure 58 shows the depth and altitude of the top of the Sparta at the few localities for which data are available in southern Cherokee County. The total thickness and net sand thickness for the Sparta are also included on Figure 58.

Other Formations

Cretaceous Rocks

Rocks of Cretaceous age occur in the deep subsurface throughout the four-county area, except in a small area in northwestern Henderson County where they occupy a normal position in the Gulf Coastal Plain sequence, or where they have been pushed upwards and at present occur at the surface in small areas atop the Butler, Palestine, and Keechi salt domes. The Palestine Sheet (Bureau of Economic Geology, 1967) indicates that Buda, Woodbine, Eagleford, Austin, Taylor, and Navarro strata have been identified on the Palestine dome; Navarro and Taylor rocks on the Keechi dome; and Navarro rocks on the Butler dome. The Cretaceous strata shown on Figure 29 as outcropping in northwestern Henderson County have been termed the Kemp Clay. The Cretaceous rocks, where present, consist of clay, marl, and chalk with lesser amounts of limestone and sandstone.

No water wells are known that tap the Cretaceous rocks within the four counties except for three shallow dug wells in northwestern Henderson County which apparently tap the Kemp Clay. The presently available geologic map shows the Kemp to be at the surface in the area of the three wells, indicating that the wells draw from the Kemp. However, it is believed possible that a thin, unmapped veneer of alluvial deposits may exist in the area, and if so, could be furnishing water to the wells either exclusively or in combination with the Cretaceous strata. Accordingly, the producing formation for these wells is in question and is indicated as "K?" throughout this report.

Midway Group

The Midway Group overlies Cretaceous rocks and underlies the Wilcox Group. It crops out in northwestern Freestone and Henderson Counties and in small areas atop the Butler, Palestine, and Keechi domes. The Midway consists almost entirely of clay and silt and is largely impermeable. Probably only a few water wells draw any water from the Midway and all are shallow dug wells on the Midway outcrop in northwestern Freestone and Henderson Counties. For some wells in northwestern Henderson County adjacent to the Trinity River, the available geologic map shows the Midway to be at the surface in the area of the wells, indicating the wells draw from the Midway. It is believed possible, however, and even probable in some cases judging from drillers' logs, that a thin unmapped veneer of alluvial deposits may exist in the area. If so, the alluvial deposits may be furnishing the water to the wells either exclusively or in combination with the Midway. For all such wells, the producing formation is shown as "M?" in this report.

Reklaw Formation

The Reklaw Formation overlies the Carrizo Sand and has a maximum thickness of about 315 feet in southern Cherokee County. It thins to the north and west, ranging in thickness from 135 to 240 feet in northern Cherokee County to about 40 to 150 feet in Henderson County. It is about 110 to 190 feet in thickness in central Anderson County and slightly more than 100 feet in eastern Freestone County.

From outcrops in Leon County, Stenzel (1938) divided the Reklaw Formation into two members, with the Marquez Shale being the upper part and the Newby Sand being the lower part. Similar units appear to exist throughout the southern half of the four-county area. There the upper part of the Reklaw is principally clay, with the lower 20 to 70 feet of the formation generally being a silty, glauconitic, fine-grained, quartz sand. In Henderson County and to some extent in northern Anderson and Cherokee Counties, the Reklaw Formation is thinner and of a different character. The thick clays characteristic of the upper part of the Reklaw farther south are not present, and the formation consists principally of interbedded sand and clay. Where such conditions exist, it is not always possible to distinguish with certainty the upper part of Reklaw from the overlying Queen City, or the lower part of the Reklaw from the underlying Carrizo. It is quite often impossible to make the distinction based on drillers' logs. It can usually be done more readily from formation samples than from electric logs. It is considered important to distinguish between the basal Reklaw sands and sands of the underlying Carrizo inasmuch as the Reklaw is probably much less permeable, and also because in parts of the area the Reklaw is believed to contain more mineralized water than that contained in the underlying Carrizo.

Weches Formation

The Weches Formation overlies the Queen City Sand and consists principally of glauconitic clays and silts with some fine-grained sands. In some areas, especially in the central part of Cherokee County, the Weches Formation contains rock with a relatively high iron content. Because of its resistance to weathering, this rock forms high hills and scarps. The Weches outcrops in many, mostly small areas in Anderson and Cherokee Counties. In central Anderson and Cherokee Counties, it typically is capped by the overlying Sparta Sand.

The Weches is 115 to 155 feet thick in the subsurface in southern Cherokee County. Throughout most of the area of its occurrence in Anderson and central and northern Cherokee Counties, however, it is from 50 to 70 feet in thickness. Few wells are known which tap the Weches Formation, and all are probably of very small capacity.

Cook Mountain Formation

In southern Cherokee County and in the Elkhart graben in southern Anderson County, the Cook Mountain Formation occurs at the surface overlying the Sparta Sand. It consists mostly of clay and probably has a maximum thickness on the order of 50 to 100 feet in the heart of the Elkhart graben. In southern Cherokee County, its maximum thickness is estimated to be about 125 feet. Few wells draw from the Cook Mountain and all are probably of very small capacity.

Alluvium

Terrace and floodplain deposits occur along the Trinity, Neches, and Angelina Rivers and their principal tributaries. The most extensive deposits occur along and adjacent to the Trinity River. The alluvium consists of sand, silt, and clay, with some gravel. The alluvium and terrace deposits are believed to attain a maximum thickness of approximately 50 feet. A few shallow dug wells obtain water from the alluvium and all are of relatively small capacity.

RECHARGE, MOVEMENT, AND NATURAL DISCHARGE OF GROUND WATER

The water-bearing formations receive recharge in their outcrops from precipitation and streamflow. At present, a very large percentage of this recharge is rejected because the formations are full, and the water spills out of them into the stream valleys crossing the outcrops, where it is discharged principally by evapotranspiration but partly by seepage. A very large, unknown amount of recharge is rejected by these means from the four principal aquifers, the Wilcox, Carrizo, Queen City, and Sparta. If the amount of rejected recharge were 2 inches of the total yearly precipitation of 38 to 46 inches, the total rejected recharge would be nearly 300 million gallons per day for these four aquifers. Quite likely the amount is even more.

Some of the recharge moves down the dips of the formations. Under natural conditions, prior to pumping, a very small amount moves generally down the dip of a formation for many miles and along the way slowly seeps upward through confining beds, eventually to be discharged at the land surface through seeps and/or evapotranspiration. For the Wilcox, Carrizo, Queen City, and Sparta aquifers, the total amount moving in such a manner is estimated to be only a few million gallons per day.

Rates of water movement in the formations, where unaffected by pumping wells, range from infinitesimally slow to as much as several hundred feet per year locally. The rates of movement in most of the sand formations, however, are between 10 and 100 feet per year.

Pumping from a well changes the pattern of flow nearby so that water moves into the well from all directions. Figure 4 is a diagrammatic sketch showing recharge from precipitation and streams and the position of the piezometric surface, both prior to pumping and during pumping. A gentle slope of the piezometric surface down the dip of the formation is shown prior to pumping, with a cone of depression sloping toward the well both updip and downdip during pumping. The direction of movement is shown toward the well from both updip and downdip directions during pumping.

Any water which is pumped from wells must be balanced by a reduction in natural discharge, a reduction in the amount of recharge being rejected through seeps and/or by evapotranspiration, or withdrawal of water from storage, or a combination of these. Thus, to have a perennial supply which does not continue to withdraw water from storage and eventually dry up the formation, the pumpage must be balanced by an equal amount of recharge being diverted to the wells. The two major quantitative factors which limit the amount of ground water which can be obtained on a perennial basis, therefore, are the recharge available for interception by pumping and the rate at which water can flow from the recharge area to the wells.

These counties are in an area of high precipitation, and the aquifers are principally artesian and are comprised of sand. In situations of this type, it is very rare to have a shortage of recharge. Nearly always, the limiting factor is the transmissibility of the formation, which controls the amount of head loss, or drawdown of piezometric surface, caused by the water moving from the recharge area to the wells. Conversely, almost always there is a surplus of available recharge and the formations continue to reject recharge in their outcrop areas by returning it to the surface and atmosphere through seepage and evapotranspiration.

Within these four counties, the water table in the outcrop of every aquifer is above the base level of the major streams crossing the outcrop, and its position appears to be controlled by the elevations of the stream valleys. The water table is highest in the divide areas, sloping away from the divides toward the valleys, where most of the evapotranspiration and seepage takes place. The water table also slopes in the direction of the dip of the formation, so that some of the water entering the outcrop can move into and through the artesian portion of the aquifer to be discharged downdip by natural discharge or by wells.

The major streams in and adjacent to ihe four-county area are shown on Figure 5. Also given on this figure are summaries of available records of streamflow. All of the streams vary widely in flow between dry and wet periods. During very dry periods there is little or no flow in the streams. This means that at these times only a very small part or none of the recharge rejected from the water-bearing formations actually is rejected as seepage into streams. Instead, by far the greatest part of the rejected recharge at these times, as well as at other times, is evapotranspiration where the water tables are shallow in and near the stream valleys.

Also shown on Figure 5 is the average annual runoff for the drainage basin above each gaging station. In the four-county area, the annual runoff averages about 8 inches per year out of a total precipitation of some 38 to 46 inches. Thus, on the order of 30 to nearly 40 inches of the precipitation is (1) consumed by evapotranspiration soon after it falls on the ground, (2) enters the outcrops of the water-bearing formations and then is discharged back to the surface and/or atmosphere, or (3) moves down the dip of the formations.

It is next to impossible with any reasonable amount of investigation to measure the total available

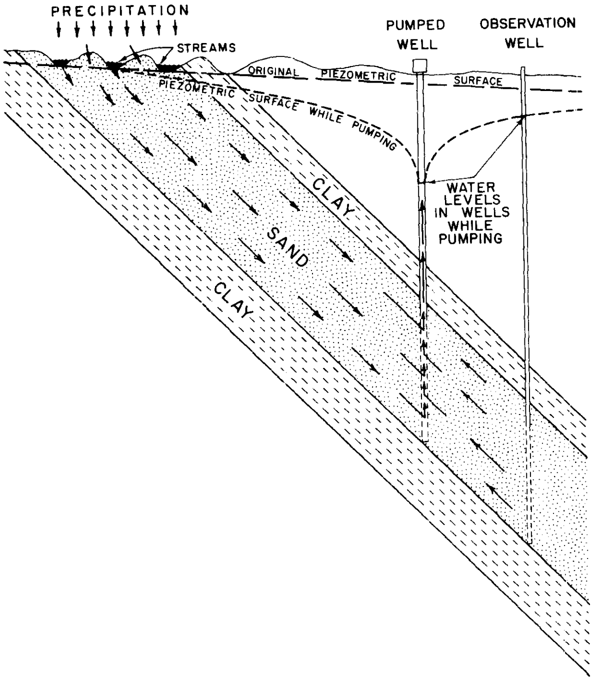


Figure 4.—Diagrammatic Sketch Showing Recharge and Drawdown in Typical Artesian Sand

recharge directly because of the stratification of the formations in their outcrops, the difficulty in obtaining average values for infiltration rates, and the difficulty of obtaining average values for evapotranspiration from the water table. About the only way reliable measurements of the total available recharge can be obtained in an area of this kind is to actually overpump the formation and then determine how much shortage occurs. When this is done, the water table is lowered below the reach of plants throughout the outcrop area, including the stream valleys, and measurements are made of the very slow continuing rate of decline of water level with continued pumping. In these counties, the water tables for the principal aquifers are now essentially as high as they have always been, and it appears certain they can never be lowered to the point of salvaging all rejected recharge, amounting to hundreds of millions of gallons per day, under any practicable arrangement of wells and well yields. In other words, the abilities of the aquifers to transmit water from recharge areas to wells is much more of a limiting factor than the availability of recharge to the formations.

WELL CONSTRUCTION AND DISTRIBUTION

The types of water well construction and the distribution of wells may be determined by a study of Tables 7, 8, 9, and 10 and Figures 25, 26, 27, and 28. Except for dug wells of shallow depth, nearly all of the wells are cased and have screen or slotted pipe opposite the zones from which they draw water. A very few wells are completed open hole. All of these are small in diameter and are low yielding.

The larger municipal and industrial wells have cemented casings and are gravel packed, as illustrated by the drawing of a well belonging to Industrial Generating Company on Figure 6. Smaller wells are usually not cemented or gravel packed and may be as little as two inches in diameter. Most of the largest wells have 14-inch, 16-inch, or 18-inch surface casing and 8-inch, 10-inch, or 12-inch screen and liner.

In recent years a distinctly different pattern of well use and source of supply has occurred in many of the smaller communities and much of the rural area within the four counties. Rural water-supply corporations stemming from a program of the U.S. Department of Agriculture's Farmers Home Administration have been formed. These water-supply corporations distribute water over wide areas. There are 35 water-supply corporations, obtaining their supplies from wells, within the four-county area. Fourteen are in Anderson County, nine in Cherokee County, five in Freestone County, and seven in Henderson County. The water-supply corporations were formed beginning in the middle of the 1960's. By 1967 or 1968, 80 percent of the existing water-supply corporations were in operation. Within the areas served, most of the private wells formerly supplying domestic and livestock requirements have been abandoned. Thus, there are many private domestic and livestock wells which have been abandoned for from three to five years.

There are over 1,300 water wells listed in Tables 7, 8, 9, and 10. About half of the water wells are drilled and half are dug wells. The drilled wells range in diameter from 2 to 20 inches and in depth from less than 50 feet to more than 2,300 feet. The dug wells are of large diameter and are mostly between 20 and 60 feet in depth.

There are 141 public supply wells, 53 industrial wells, and 33 irrigation wells listed in Tables 7, 8, 9, and 10. More than a thousand wells are listed which are currently or were formerly used for domestic and/or livestock purposes. Well yields range from very small up to nearly 1,200 gallons per minute.

More than 80 percent of the water wells in the area are from four water-bearing units, the Wilcox Group, Carrizo Sand, Queen City Sand, and Sparta Sand. There are 563 wells listed as drawing from the Wilcox Group. Of these, 91 are used for municipal purposes and 32 for industrial purposes. There are 12 irrigation wells in the Wilcox. The deepest Wilcox well is 2,355 feet in depth. Reported pumping rates for Wilcox wells range up to 1,176 gallons per minute. Most of the Wilcox wells are in Freestone County and in central Henderson

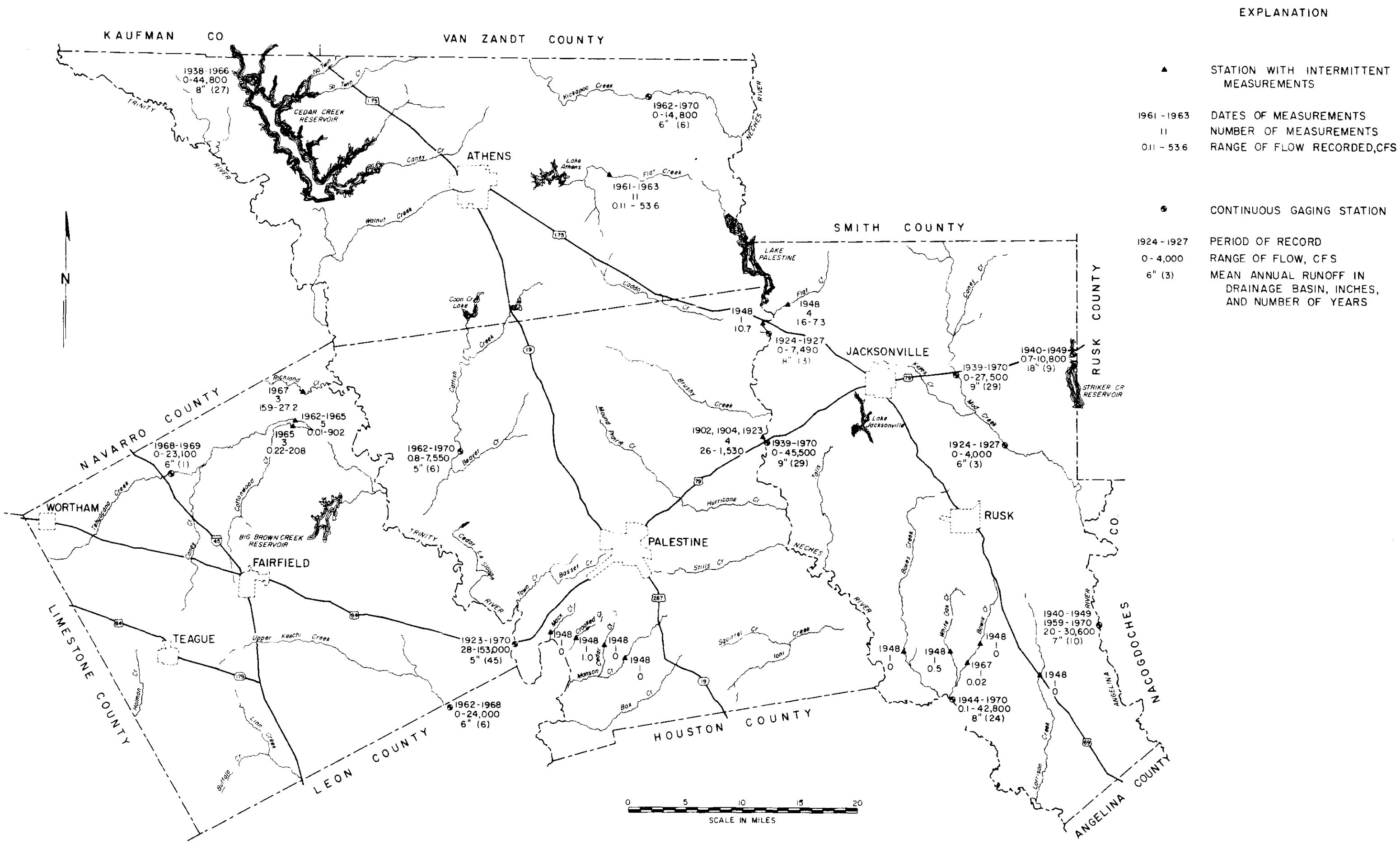


Figure 5
Surface-Water Flow Measurements

Base from Texas State Highway
Department county maps

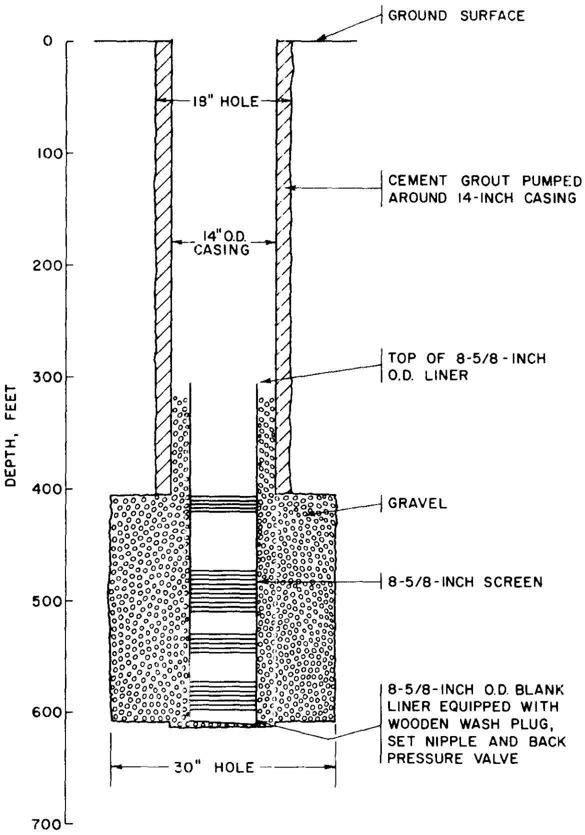


Figure 6.—Construction of Production Well

County. There are no Wilcox wells southeast of a line passing through Slocum in southeastern Anderson County and approximately through Rusk in Cherokee County.

One hundred fifty-five wells are listed for the Carrizo Sand. About half are drilled wells, ranging in diameter from 2 to 18 inches, and about half are large-diameter, shallow dug wells. Of the 155 wells, 30 are used for municipal or other public supplies, 9 are for industrial supplies, and 14 are for irrigation purposes. Reported pumping rates of Carrizo wells range up to 700 gallons per minute. Carrizo well depths range up to 1,060 feet, with most of the larger capacity wells having depths ranging from about 400 to 750 feet. Most of the large-capacity wells are located in Anderson and Cherokee Counties.

There are 322 wells listed as drawing from the Queen City Sand. They are located predominantly in Anderson, Cherokee, and eastern Henderson Counties. Most are shallow dug wells, but some are drilled wells ranging up to 640 feet deep. The greatest reported yield is 72 gallons per minute. There are 11 Queen City wells currently being used for public supply purposes, and one industrial well and one irrigation well.

Seventy-six wells are shown for the Sparta Sand. Most of these are in Cherokee or southern Anderson County. Shallow dug wells predominate. Drilled wells range in depth to 400 feet. There are one industrial well and one irrigation well currently in use. All the other wells listed for the Sparta are currently or were formerly used for domestic and for livestock purposes.

Tables 7, 8, 9, and 10 list 208 wells as drawing from rocks of Cretaceous age, Midway Group, Reklaw Formation, Weches Formation, Cook Mountain Formation, and alluvium. All of these formations are relatively weak aquifers.

Three wells are shown as drawing water from rocks of Cretaceous age, and 32 wells from the Midway Group. All are small-yielding wells. Nearly all are large-diameter, shallow dug wells located in the northwestern tip of Henderson County. For many of these wells, the producing formation is shown as "K?" or "M?" in this report. This is because of the possibility, and even the probability in some cases, that a thin veneer of alluvial deposits may exist in the area of the wells, and that the alluvial deposits may be furnishing water to the wells either exclusively or in combination with the Cretaceous rocks or Midway Group.

There are 82 wells listed as drawing from the Reklaw Formation. One is currently being used for industrial purposes, and the remainder are currently or were formerly used for domestic and livestock purposes. Only nine of the wells were drilled. These range up to 480 feet in depth. Seventy-three of the wells are large-diameter, shallow dug wells. There are no public supply or irrigation wells tapping the Reklaw.

The formation which occurs above the Queen City Sand, the Weches, is mostly clay. Shallow, large-diameter wells have been constructed in the Weches to obtain water for domestic and livestock use. Of the 29 wells listed for the Weches, only six are currently in use. The wells range in depth from 21 to 55 feet, and all are low-yielding wells.

The total number of Cook Mountain wells listed is ten, and all are located in extreme southeastern Cherokee County, except for one well located south of Elkhart in Anderson County. The wells in the Cook Mountain Formation are all large-diameter, dug wells used solely for domestic and livestock purposes. They range in depth from 15 to 50 feet, and all are low-yielding wells.

Of the 52 wells shown for the alluvium, nine are used for industrial purposes. All the rest are used for domestic and livestock purposes or are abandoned. Most of the wells in the alluvium are located in the northwestern part of Henderson County adjacent to the Trinity River, although a few are at scattered locations throughout the four-county area. Typically, the wells in the alluvium are shallow dug wells, mostly between 20 and 60 feet deep. There are 12 drilled wells ranging in diameter from two to eight inches. All the wells in the alluvium are relatively small-yielding wells.

CHEMICAL QUALITY OF GROUND WATER

The results of available chemical analyses of water from wells listed in Tables 7, 8,9, and 10 are given in Tables 15, 16, 17, and 18. Included are the results of 1,331 chemical analyses of ground water. Four hundred sixty-five of these analyses were made as a part of this investigation. The other chemical analyses were made in connection with earlier investigations, or were provided by well owners or others who had them made for special purposes. In addition to the analyses listed in Tables 15, 16, 17, and 18, the dissolved-solids contents of water from various wells are given for the different water-bearing formations in Figures 59, 60, 61, 62, and 63. Some of the values for dissolved solids in these illustrations have been estimated from partial analyses. In order to provide better coverage, dissolved-solids contents are included for some wells which were inventoried in previous investigations, but which could not be located in this investigation, and therefore are not included in the tables giving well records or chemical analyses. For these wells the approximate locations as determined from maps in earlier reports are given along with the dissolved solids as reported by, or estimated from, the analyses in those reports.

In addition to sampling and analyzing water from selected wells and compiling previous analyses, the quality of the ground water has been studied by means of electric logs made in water wells, oil wells, and test holes. The electric logs are listed in Tables 7 through 10 and their locations are shown on Figures 25 through 28. Nearly all the water contained in the Sparta, Queen City, and Carrizo Formations is fresh throughout the four-county area. The Wilcox contains large amounts of both fresh water and poor quality water. Where the electric logs are reasonably suitable for interpretation, the quality of water shown by them to occur in the Wilcox Group has been designated as “fresh,” “brackish,” or “salty.” The term “fresh” as used here denotes water of less than 1,000 parts per million dissolved solids. The term “brackish” means water with 1,000 to 3,000 parts per million dissolved solids, and the term “salty” denotes water having more than 3,000 parts per million dissolved solids. The Wilcox interpretations were made with the help of Mr. Hubert Guyod, Logging Consultant of Houston, Texas. Partly because of the basic limitations of electric logs, partly because the original logs were made under a variety of conditions and with various types of equipment, and partly because much of the data necessary for careful control of quality of water interpretations is lacking, the interpretations are considered to be approximations, generally having a possible range of error up to about 30 percent. The interpretations of the electric logs have been used to define the extent of the fresh, brackish, and salty water in the Wilcox. These interpretations are given on Figures 42,43, 44, and 45.

Some fresh water can be obtained from every formation outcropping within the four-county area. The freshest water normally is obtained from very shallow wells in and near the outcrops, but more highly mineralized water can also be found in these areas. The water normally becomes more highly mineralized with depth and distance downdip from the outcrop or source of recharge. At some distance downdip, each formation contains only salty water. The formations which contain fresh water the greatest distances downdip are those with the greatest transmissibilities and the greatest hydraulic continuity. Those which contain brackish and salty water in the most places are those which are generally the poorest producers of ground water and in which sands are the most disconnected, providing for the least flushing action from recharge.

Wilcox Group

In the outcrop area in Freestone and Henderson Counties and to some extent downdip from the outcrop area, the sands of the Wilcox Group contain mostly fresh water, generally having less than 500 parts per million dissolved solids, with many analyses showing less than 300 parts per million dissolved solids. Farther downdip to the south and southeast the water in the Wilcox typically becomes more mineralized. In Anderson and Cherokee Counties, the available analyses indicate water more in the range of 500 to more than 1,000 parts per million dissolved solids. Southeast of a generally northeast-southwest trending line approximately paralleling the Mount Enterprise fault zone and passing across Anderson County a few miles north of Elkhart and on across Cherokee County, electric logs indicate that sands of the Wilcox contain mostly brackish and salty water, with only relatively thin sands in the uppermost part of the Wilcox in some localities containing any fresh water. In the few places in southeastern Cherokee County where fresh water exists in sands in the uppermost Wilcox, these sands are probably connected with those of the Carrizo which also carry fresh water.

Some tonguing or inter-fingering of the fresh, brackish, and salty water in the Wilcox is noticeable. In some places brackish water overlies fresh water and in others there is an alternation of zones containing fresh and brackish water. The area where the most significant tonguing appears to occur is generally in a zone approximately parallel to the northeast-southwest trending line described above as passing across Anderson County a few miles north of Elkhart and on across Cherokee County. Some tonguing of fresh, brackish, and salty water is also evident in the vicinities of some of the domes, notably the Butler and Oakwood domes in southeastern Freestone County. The water quality pattern in the Wilcox both in the vicinities of the domes and along the Mount Enterprise fault zone is, in detail, much more complex than is shown by the available data included in the geologic sections or in Figures 42, 43,44, and 45.

In a few cases in the outcrop of the Wilcox, water from dug wells is very highly mineralized. Such is the case for a few wells in the outcrops of other formations as well. These are anomalous situations, however, and do not represent the quality of water generally present in the outcrops of either the Wilcox or the other formations. It is believed that the water quality from these wells is due to very local conditions, probably mostly to either lack of flushing of poor quality water principally from clay zones, or the concentration of minerals by evapotranspiration. Such occurrences have no significant bearing on the quality of the water in the Wilcox as a whole.

Normally the hardness of the water in the deep, fresh water Wilcox wells is quite low, generally being less than 20 to 30 parts per million. In shallower wells it may be high or low, ranging in some wells to over 300 parts per million.

Some of the wells in the Wilcox show high iron contents, the amounts ranging up to several parts per million. The analyses for many wells, however, show low iron contents. Generally the wells with the high iron contents are near the outcrop, although some of the wells and test holes downdip also show high iron contents.

The pattern of occurrence of iron in the water from Wilcox wells, as well as from other water-bearing formations in the area, is not clearly shown by the available data. It is believed this is because of the relative ease of obtaining false samples with respect to iron. Very small amounts of turbidity in water, such as from drilling mud where the samples were taken from test holes, are known to give false iron results. Also, most of the water samples collected during this study were obtained from small-diameter, drilled wells from which it was only possible to sample after the water passed through a pressure tank. The same is believed to be true for many of the previous analyses available on smaller capacity wells in the area. For such samples it is impossible to exclude the effects of corrosion from water standing in steel well casings or pressure tanks. In addition, samples of water from pressure tanks or other storage tanks or from dug wells may show iron contents too low because of prior precipitation of the iron. For these reasons many of the iron contents reported in Tables 15, 16, 17, and 18 are suspect and are not considered strictly applicable to the natural water.

Carrizo Sand

The Carrizo Sand contains fresh water throughout the area of its occurrence within the four-county area. It tends to be a continuous, massive sand, and the quality of the water from the Carrizo is very consistent over large areas, as well as from top to bottom in the formation. The Carrizo contains water of low dissolved-solids content throughout a large part of the four-county area. Analyses available for wells in Freestone County typically show dissolved-solids contents much less than 200 parts per million. The same is true for the data available in Henderson County and in most of Anderson County. In and south of the Mount Enterprise fault zone in Anderson and Cherokee Counties, the mineralization of the Carrizo water is somewhat higher, typically being between 300 and 700 parts per million dissolved solids. The southern limit of Carrizo water containing less than 1,000 parts per million dissolved solids lies south of Cherokee and Anderson Counties in Angelina and Houston Counties, outside the area covered by this report. Its closest proximity to Cherokee County is estimated to be three to four miles south of the most southern corner of Cherokee County.

The hardness of the Carrizo water is typically low everywhere except near and in its outcrop area, generally being less than 20 to 40 parts per million. In wells in and near its outcrop it may be high or low, ranging in some wells to over 200 parts per million.

A few Carrizo wells produce slightly turbid water. Also in some wells the Carrizo water has a sulfur odor due to minor amounts of hydrogen sulfide. These occurrences appear to be more frequent in the southeastern half of Cherokee County, but do occur in other parts of the four-county area.

Queen City Sand

The Queen City Sand contains water which is typically quite fresh in its outcrop, although a few shallow dug wells contain highly mineralized water. The dissolved-solids contents for Queen City wells normally are below 200 parts per million. Where the Queen City Sand occurs at depth, in southeastern Cherokee County and within the Elkhart graben in southern Anderson County, the dissolved-solids content of the water ranges from less than 200 parts per million to slightly over 500 parts per million. In the extreme southeastern edge of Cherokee County near Wells, the Queen City probably contains even poorer quality water, and interpretation of electric logs indicates that the water is brackish,

Hardness of the Queen City water has a considerable range, but most values are between 20 and 100 parts per million. Objectionable iron staining from the water is commonly reported.

Sparta Sand

Within its outcrop area, the Sparta Sand contains water which is very fresh. Many analyses for wells in outcrop areas have less than 100 parts per million dissolved-solids. In downdip wells in southeastern Cherokee County, dissolved-solids contents range up to 920 parts per million. Hardness of the water ranges to over 200 parts per million, but most analyses show less than 100 parts per million.

Other Formations

Figures 59, 60, 61, and 63 show the dissolved-solids contents for water from the rocks of Cretaceous age, Midway Group, Reklaw Formation, Weches Formation, Cook Mountain Formation, and alluvium. All of these formations are relatively weak aquifers.

The analyses available for wells listed for the Cretaceous and Midway have a considerable range in dissolved-solids content, extending from very fresh to highly mineralized. As stated earlier, it is possible that many of these wells may produce water in combination with or even exclusively from alluvial deposits.

Analyses are available for Reklaw wells ranging in depth from 10 feet to 480 feet. Most analyses are for wells in the outcrop area. Some wells in the outcrop area contain highly mineralized water, but most of the wells produce relatively fresh water. At downdip locations, the dissolved-solids content for the lower part of the Reklaw ranges up to 775 parts per million. The lower part of the Reklaw, although not a high-yielding aquifer, appears to be hydraulically connected with the Carrizo and therefore contains relatively fresh water to considerable depths. It appears that water in the lower Reklaw at downdip locations in the southern half of the four-county area is more mineralized than that in the Carrizo, and it appears that wherever the Reklaw contains fresh water, the underlying Carrizo also contains as fresh or fresher water.

The Weches and Cook Mountain Formations are essentially clay, and all the wells in these formations are dug wells in the respective outcrop areas. The water from all wells for which data are available is fresh, but the formations are very poor aquifers.

The dissolved-solids contents of water from wells tapping the alluvium range from very fresh to highly mineralized. Available analyses indicate a range from less than 100 to nearly 10,000 parts per million dissolved solids. Existing supplies from the alluvium are small, but in parts of northwestern Henderson County it is the only ground water available.

Surface Water

Records of chemical quality of surface water are available at a few places in Anderson, Henderson, Cherokee, and Freestone Counties. Most of the available analyses show very fresh water. Analyses of water from the Trinity River show somewhat more mineralized water than for most of the other streams in the area. This is mostly a reflection of upstream conditions and not of side inflow to the Trinity within the area.

A few of the small streams in the four-county area have shown abnormally high mineralizations which have been attributed to the past disposal of oil field brines (Leifeste and Hughes, 1967, and Hughes and Leifeste, 1967). These include the lower reaches of Tehuacana and Richland Creeks in Freestone County and the upper reaches of Striker Creek (Bowles Creek) along the Cherokee-Rusk county line.

TEMPERATURE OF GROUND WATER

Figure 7 shows the temperature of water produced by wells of various depths. The data are coded by producing formation. Temperatures shown on the graph are those measured during the present study, as well as the temperatures reported by previous investigators. For each well, the water temperature has been plotted against either the total well depth, or if known, the depth of the middle of the interval screened in the well.

The data shown on Figure 7 indicate that the average temperature gradient in the area is about I-1/2°F per hundred feet of depth. The water temperature from a depth of 200 feet averages about 70°F, from 900 feet about 80°F, and from 1,500 feet about 90° F.

OIL AND GAS FIELDS

Locations

Numerous oil and gas fields occur in the four-county area. Figure 8 shows the locations of the oil and gas fields. Many of the fields shown on Figure 8 have production from several zones, and separate field designations have been assigned to these zones by the Railroad Commission of Texas. Several of the fields shown on Figure 8 have had no production in recent years. With few exceptions, all the fields were discovered after 1940. Production depths range from about 500 feet for the shallowest pay (Carrizo) in the Slocum Field to over 11,000 feet for the deepest pay (Smackover).

Surface Casing

An act of the Texas Legislature in 1899 required that oil and gas wells be cased to prevent all water from above from penetrating the oil- and gas-bearing rocks. Later acts of 1919, 1931, 1932, and 1935 gave broad

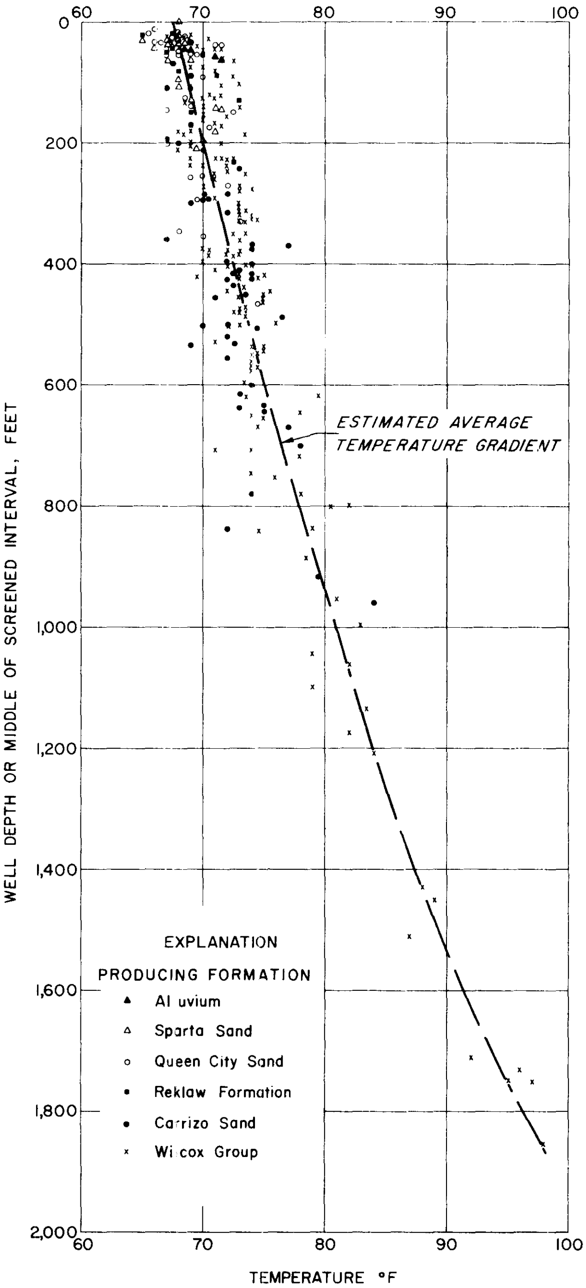


Figure 7.—Temperature of Ground Water

powers to the Railroad Commission of Texas to prevent oil and natural gas and water from escaping from the strata in which they are found into other strata.

The Railroad Commission first handled the determination of the amount of surface casing that should be set in a well. Subsequently, the Texas Board of Water Engineers and its successors, the Texas Water Commission and the Texas Water Development Board, have made recommendations concerning the protection of water considered to be of usable quality. The protection can be by means of surface casing or one of several of the cementing techniques available to the oil and gas industry. Water with dissolved-solids concentrations up to at least 3,000 parts per million is recommended for protection by the Water Development Board. Water with higher mineral concentrations is recommended for protection if it is being used.

Some of the earliest requirements for surface casing in the area probably were not adequate for protection of the ground-water supplies. The recommendations made in recent years, however, appear entirely adequate to protect ground water containing 3,000 parts per million dissolved solids or less. At least by the middle 1950's, the recommendations were generally for protection down to the base of the Wilcox throughout the area. Beginning in the early 1960's, an effort was begun to gather more information so that better recommendations could be given. Recommendations are now given to a depth and not a stratigraphic reference, and in some areas zones of protection are given, together with positions of cement plugs if the hole is abandoned.

For many of the fields in the four-county area, the Railroad Commission has included the depth of fresh water protection in field rules. These field rules were reviewed during the present study with respect to adequacy of the depth of fresh water protection included in the requirements. The depth included in all of the field rules appears to be entirely adequate to protect ground water containing 3,000 parts per million dissolved solids or less.

Plugging of Abandoned Test Holes and Wells

In recent years, the plugging of abandoned test holes and wells has been supervised by the Texas Railroad Commission. Insofar as known, all such holes are adequately plugged. Undoubtedly some of the older test holes and wells were not carefully plugged, but no indication of contamination of ground-water supplies from improper plugging was found during this study.

Disposal of Salt Water

Few records are available on the history of production and disposal of salt water produced from oil and gas wells in the area. Originally all water produced probably was disposed of on the surface either by placing it into surface drainage or into pits. In the 1950's, the disposal of produced salt water by injection wells began. Available records for 1956 show that in Anderson, Cherokee, Freestone, and Henderson Counties the amount of produced salt water disposed of by injection wells was 74, 29, 21, and 13 percent, respectively, of the total water produced. The remainder was disposed of on the surface, either into surface drainage or into pits. Subsequently, disposal by injection wells became increasingly common. By 1962 about 80 percent of the salt water produced was disposed of through injection wells. The percentage became even higher in later years.

The Railroad Commission of Texas issued a statewide order banning unlined surface pits effective January 1, 1969. As a result of this order, nearly all of the produced salt water is now being injected into disposal wells. Only a few widely scattered surface pits appeared to be in use during the field checks made as a part of this study in 1970.

Only minor amounts of surface damage from salt water were found in any of the oil and gas fields, and there are no indications that the ground water in the vicinity of any of the fields has been seriously contaminated over wide areas. None of the analyses of water from wells which have been compiled indicates contamination from oil field brines.

PUMPAGE AND WATER LEVELS IN WELLS

Pumpage

Ground-water pumpage in Anderson, Cherokee, Freestone, and Henderson Counties totaled an estimated 14,100 acre-feet in 1969. This is an average of 12.7 million gallons per day. The breakdown by use in each county was:

Pumpage of Ground Water in 1969

	ANDERSON COUNTY		CHEROKEE COUNTY	
USE	MILLION GALLONS PER DAY	ACRE-FEET PER YEAR	MILLION GALLONS PER DAY	ACRE-FEET PER YEAR
Public supply	0.8	900	2.9	3,300
Industrial	2.5	2,800	0.3	300
Irrigation	0.3	300	0.1	100
Rural domestic and livestock	0.9	1,000	1.2	1,300
Total	4.5	5,000	4.5	5,000

	FREESTONE COUNTY		HENDERSON COUNTY	
USE	MILLION GALLONS PER DAY	ACRE-FEET PER YEAR	MILLION GALLONS PER DAY	ACRE-FEET PER YEAR
Public supply	0.6	650	0.8	900
Industrial	1/	1/	0.8	900
Irrigation	1/	1/	1/	1/
Rural domestic and livestock	0.6	650	0.9	1,000
Total	1.2	1,300	2.5	2,800

1/ Amount very small.

The amounts of pumpage for public supply and industrial use are principally from the annual pumpage inventory conducted by the Texas Water Development Board, supplemented with data from some users. Pumpage for rural domestic and livestock purposes has been estimated from census data and conditions observed in the present study.

Of the 12.7 million gallons per day pumped in 1969, about 5.5 million gallons per day was from the Carrizo Sand, with about the same from the Wilcox Group. About one million gallons per day is pumped from the Queen City. Only very small amounts are produced from all the other formations yielding water in the four-county area.

Figure 9 shows the past pumpage of ground water in each of the four counties for public supply and industrial use. The increases over the years mostly reflect mounting public supply use. The recent decrease for Anderson County is due to the cessation of pumping by the city of Palestine in 1969 when a surface-water supply began to be used.

The areal distribution of the major pumpage for 1969 is shown on Figure 10. Included are all users

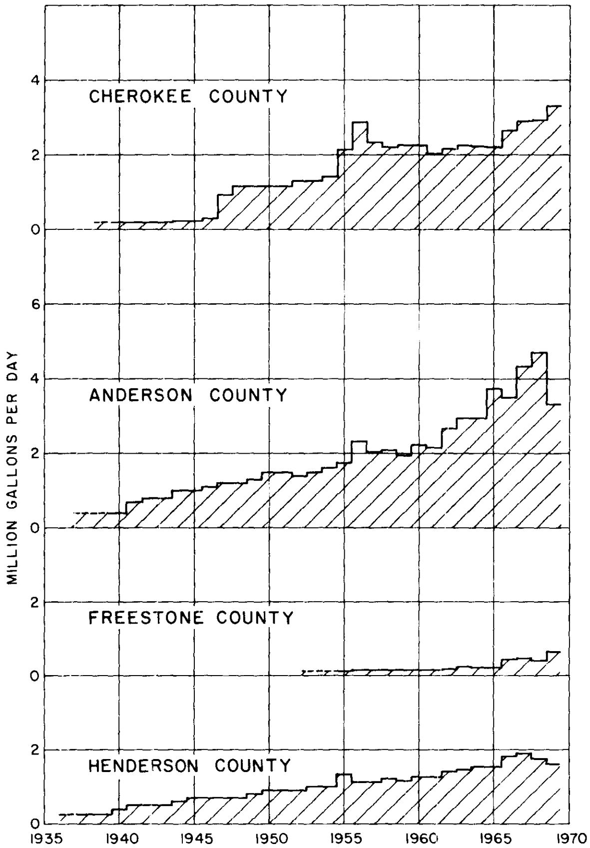


Figure 9.—Pumpage of Ground Water for Public Supply and Industrial Purposes

pumping an average daily amount of 50,000 gallons or more. As shown on Figure 10, most of the Wilcox pumpage in the area occurs in the northwestern half of the four-county area, whereas most of the Carrizo pumpage occurs in the southeastern half. The largest single user in 1969 was the city of Jacksonville which pumped 1.8 million gallons per day. At no other locality within the four-county area was much more than one million gallons per day being pumped in 1969. There were numerous users pumping between about 0.2 million gallons per day and one million gallons per day. These included the smaller cities and towns, a few industries, and numerous water supply corporations furnishing water to rural communities and areas.

In earlier years, the largest single user in the four-county area was the city of Palestine, which pumped as much as 2.2 million gallons per day from Wilcox wells in 1967 and nearly that much in 1968. Since 1969 the city of Palestine has obtained its supply from Lake Palestine. Similarly, the city of Athens now obtains most of its supply from Lake Athens, but formerly pumped as much as one million gallons per day from the Wilcox.

Water Levels in Wells

Altitudes of water levels in representative wells in 1970 and 1971 are shown on Figures 64, 65, 66, and 67. Representative water levels in wells are also listed in Tables 7, 8, 9, and 10.

Drawdowns in water levels as a result of pumping from Wilcox and Carrizo wells are noticeable within the four-county area in a few wells. No large or regional drawdowns are indicated in wells in any of the other formations. From the data available for wells tapping the Wilcox, noticeable water-level declines have occurred in one area in southeastern Henderson County. About a half million gallons per day was produced there in 1969 for oil field waterflooding purposes, and more recently the pumpage has been higher. Smaller, less noticeable drawdowns have occurred in Wilcox wells principally at Fairfield and in the Slocum area. Some water-level declines in Wilcox wells were formerly present at Athens and Palestine, but they now have largely disappeared due to the cessation of pumping by these cities.

From the water levels in Figures 64, 65, 66, and 67, the most noticeable drawdowns occurring in wells tapping the Carrizo Sand are at Jacksonville, in extreme southeastern Cherokee County at Wells, and to a lesser extent, in the Rusk area. The Carrizo water levels at Jacksonville are deep in relation to the relatively small pumpage. This is due to the barriers to movement created by the faults in the vicinity.

In extreme southeastern Cherokee County, in the vicinity of Wells, water levels in the Carrizo have been drawn down on the order of 150 to 170 feet. The area is on the northwestern side of a large, area-wide cone of depression in the piezometric surface for the Carrizo Sand. The decline in water levels has been the result of pumping from the Carrizo to the east in Angelina and Nacogdoches Counties, where in 1968 pumpage from the Carrizo was nearly 27 million gallons per day. The city of Wells is about 16 miles west of the Carrizo pumpage in Angelina and Nacogdoches Counties.

RESULTS OF PUMPING TESTS

Results of pumping tests to determine specific capacities of wells and the transmissibility and storage coefficients of the principal aquifers are given in Tables 4 and 5. Examples of such tests are shown on Figure 11. A pumping test is essentially a process of measuring the effect on the water level in one or more wells caused by a change in rate of pumping. The results of the pumping tests are used in determining how much water can be pumped under given conditions on a long-term basis.

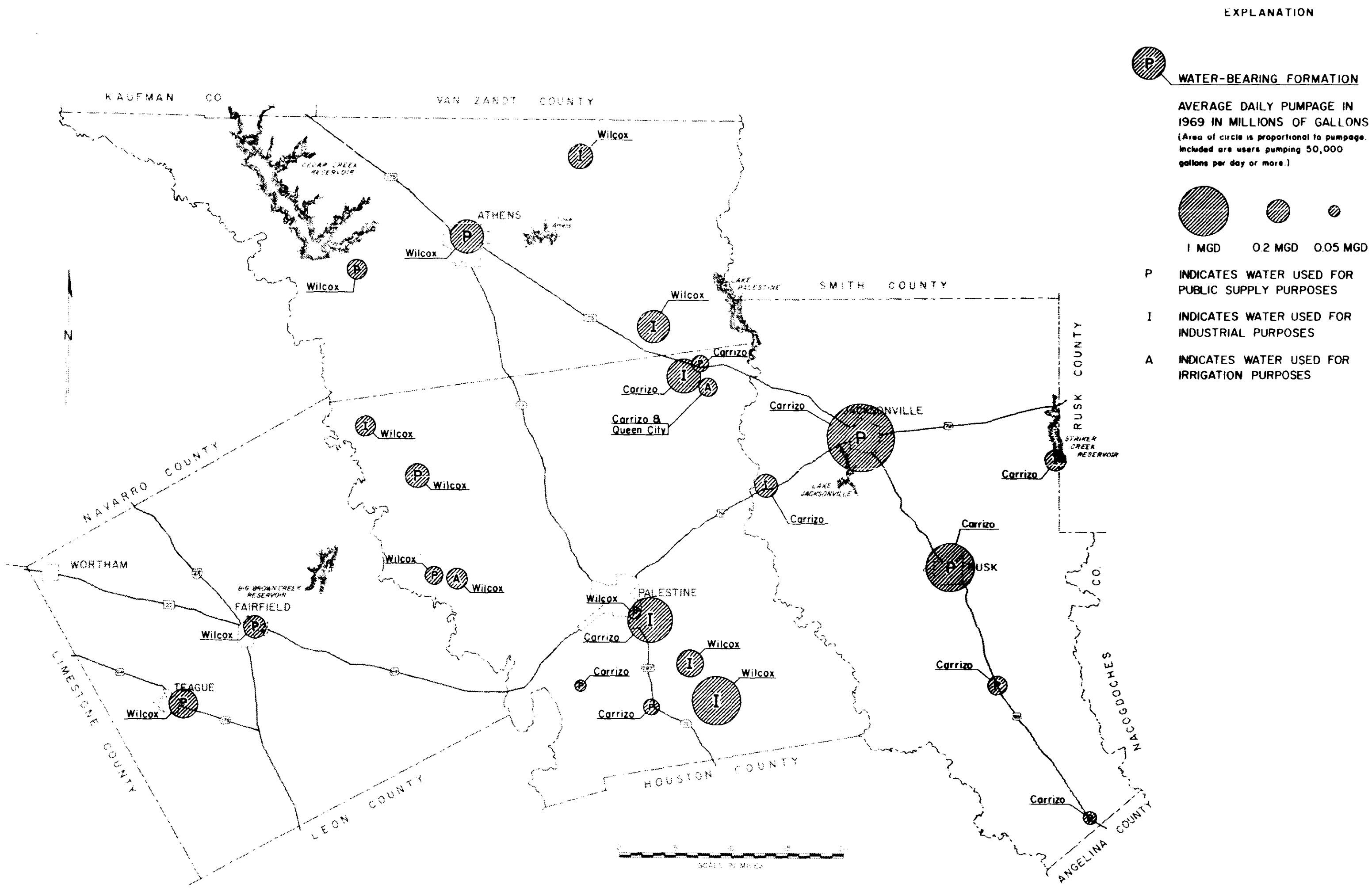


Figure 10

Areal Distribution of Major Pumpage of Ground Water in 1969

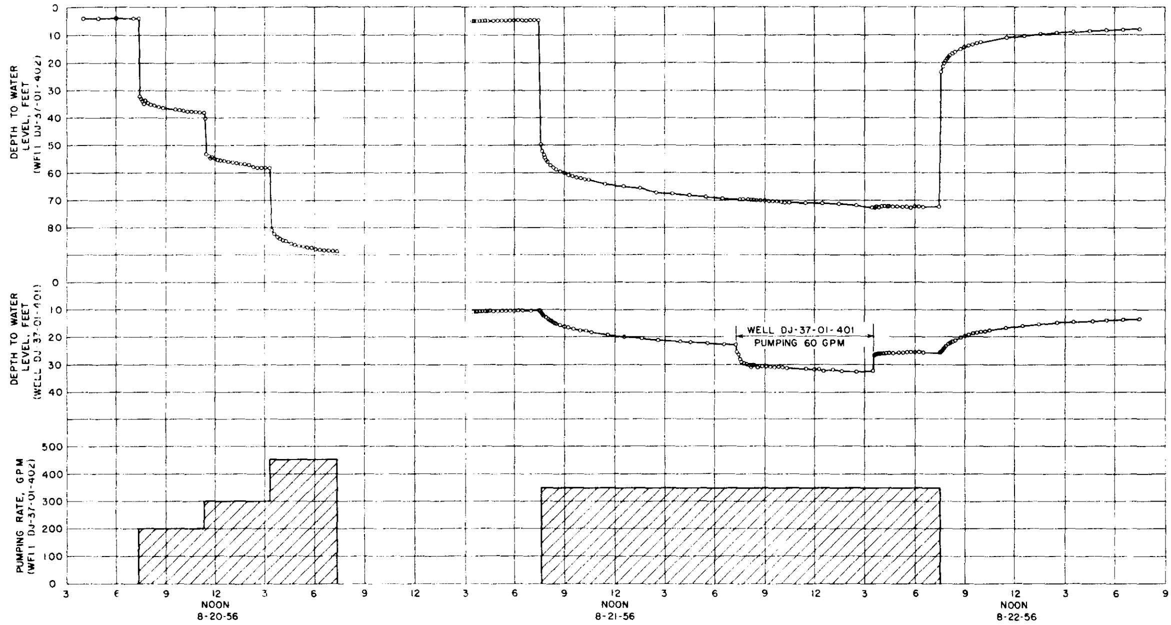


Figure 11.—Example of Pumping Test

Specific Capacities of Wells

The specific capacity of a well is a measure of the amount of water that the well will produce with a given amount of drawdown of water level within the well itself in a relatively short period of time. The units commonly used are gallons per minute per foot of drawdown. The specific capacity of a well is affected partly by the hydraulic characteristics of the formation from which it obtains water and partly by the type of construction and efficiency of construction of the well itself.

Table 4 gives the specific capacities measured for wells within the four-county area. The specific capacities for Wilcox wells range from 0.1 to 22.5 gallons per minute per foot of drawdown. For Carrizo wells they range from 0.8 to 21.1 gallons per minute per foot of drawdown. For Queen City wells they range from 0.7 to 2.1 gallons per minute per foot of drawdown. No specific capacity information is available for wells tapping other formations.

Averages computed from the data in Table 4 are as follows:

WATER-BEARING UNIT	NUMBER OF WELLS	AVERAGE SPECIFIC CAPACITY (GPM/FT)	AVERAGE SCREEN LENGTH (FEET)	AVERAGE SPECIFIC CAPACITY PER HUNDRED FEET OF SCREEN (GPM/FT)
Queen City Sand	7	1.4	45	3.1
Carrizo Sand	34	7.1	66	10.7
Wilcox Group	72	3.9	87	4.5

Coefficients of Transmissibility, Permeability, and Storage

Table 5 lists the coefficients of transmissibility, permeability, and storage determined from pumping tests of Queen City, Carrizo, and Wilcox wells in Anderson, Cherokee, Freestone, and Henderson Counties. The coefficient of transmissibility is a measure of the amount of water that will move through an aquifer under a unit hydraulic gradient. It is expressed in gallons per day per foot of width of the formation. From the coefficient of transmissibility and the thickness of sand at the pumped well the field coefficient of permeability may be determined. This is equal to the transmissibility divided by the thickness of sand and is expressed in gallons per day per square foot of cross-sectional area through which the water moves.

The coefficient of storage, which is obtained from a pumping test when one or more separate observation wells are used, is a measure of how much water is given up from storage when the piezometric surface is lowered. It is dimensionless and is equal to the number of cubic feet of water which is released in each column of the aquifer with a base of one square foot when the

Table 4.--Specific Capacities of Wells

Well Number	Well Owner	Pumping Rate (gpm)	Length of Screen in Well (feet)	Effective Time[1/] (hours)	Specific Capacity (gpm/ft)
	ANDERSON COUNTY				
	Queen City Sand				
AA-38-04-403	E. B. Birdwell	15	54		1.5
AA-38-11-905	Palestine Ice Co.	18	41		1.6
AA-38-12-403	K. G. Johnson	72	90	2	2.1
AA-38-27-305	Pilgram Water Supply Corp.	15	20	1-1/2	0.7
	Carrizo Sand				
AA-34-60-602	City of Frankston No. 1	202	40	24	6.1
AA-34-60-603	City of Frankston No. 2	300	45	1	3.5
AA-34-60-903	Hunt Oil Co.	302	56	3	6.4
AA-34-61-501	Upper Neches Municipal River Authority	135	30	3	1.6
AA-38-12-402	Norwood Water Supply Corp.	60	30		1.2
AA-38-13-106	Neches Water Supply Corp.	134	100	2	9.0
AA-38-19-802	Lakeview Methodist Assembly No. 2	99	40	2	7.3
AA-38-19-803	Lakeview Methodist Assembly No. 1	65	20		2.3
AA-38-20-103	Vernon Calhoun Packing Co. No. 1	278	50		9.0
AA-38-20-203	Vernon Calhoun Packing Co. No. 2	703	75	1	15.3
AA-38-20-801	City of Elkhart No. 2	477	88	1	11.3
AA-38-21-706	Slocum Water Supply Corp.	18	45	6	2.6

For footnotes see end of table.

Well Number	Well Owner	Pumping Rate (gpm)	Length of Screen in Well (feet)	Effective Time[1/] (hours)	Specific Capacity (gpm/ft)
	ANDERSON COUNTY--Continued				
	Wilcox Group				
AA-34-57-801	J. T. Whitman	20	100		0.5
AA-34-58-901	Newman	20	20		2.0
AA-38-01-101	Getty Oil Co.	115			1.5
AA-38-01-103	Cayuga Water Supply Corp.	35	52		0.2
AA-38-02-302	B.B.S. Water Supply Corp.	79	38	1-1/2	2.6
AA-38-02-402	Arnold Wisenbaker	15	21		1.0
AA-38-03-701	Montalba Water Supply Corp.	58	51	1-1/2	5.3
AA-38-05-401	W. T. Todd	180	51		5.3
AA-38-09-601	State of Texas-Dept. of Corrections	680	130	2	7.6
AA-38-11-603	Lone Pine Water Supply Corp.	52	55	1	3.0
AA-38-11-801	City of Palestine No. 2	975	243	24	13
AA-38-11-901	City of Palestine No. 1	923	248	24	8
AA-38-11-902	City of Palestine No. 4	1,176	325	24	16
AA-38-11-903	Missouri Pacific Railroad	715	311		6
AA-38-18-602	Getty Oil Co.	221	83		9.2
AA-38-18-901	Woodhouse Consolidated School	100	15		1.1
AA-38-19-201	Four Pines Water Supply Corp.	151	50	1	2.3
AA-38-19-301	City of Palestine No. 3	1,140	285	24	9
AA-38-19-402	Hunt Oil Co.	234	51		3.5
AA-38-20-104	Walston Springs Water Supply Corp.	180	87		3.0

For footnotes see end of table.

Table 4.--Specific Capacities of Wells--Continued

Well Number	Well Owner	Pumping Rate (gpm)	Length of Screen in Well (feet)	Effective Time[1] (hours)	Specific Capacity (gpm/ft)
	ANDERSON COUNTY--Continued				
	Wilcox Group--Continued				
AA-38-20-604	Kimball Production Co.	448	114	1/2	5.0
AA-38-21-703	Shell Oil Co. - B. F. Weaver No. 1	285	120	2	22.5
AA-38-21-704	Shell Oil Co. - J. B. Parker No. 1	137	60	1-1/2	7.3
AA-38-21-705	Shell Oil Co. - J. B. Parker No. 2	325	100	1	18.0
AA-38-29-105	Texaco, Inc.	455	110	1/2	16.8

For footnotes see end of table.

Table 4.--Specific Capacities of Wells--Continued

Well Number	Well Owner	Pumping Rate (gpm)	Length of Screen in Well (feet)	Effective Time[1] (hours)	Specific Capacity (gpm/ft)
	CHEROKEE COUNTY				
	Queen City Sand				
DJ-38-32-903	Forest Water Supply Corp.	50	60	2	1.8
	Carrizo Sand				
DJ-37-01-401	Texas Power & Light Co. No. 1	343	76	24	5.4
DJ-37-01-402	Texas Power & Light Co. No. 2	350	66	12	5.4
DJ-37-09-101	Reklaw Water Supply Corp. No. 2	43	52	2	4.5
DJ-37-33-202	City of Wells No. 2	102	70	2	12.0
DJ-38-05-903	Humble Oil & Refining Co. No. 1	263	95	1/2	6.4
DJ-38-05-904	Humble Oil & Refining Co. No. 2	277	80	1/2	15.4
DJ-38-06-402	Sheffield Steel Corp.	580	122	3	8.8
DJ-38-06-501	City of Jacksonville No. 2	680	100	1/2	21.1
DJ-38-06-603	City of Jacksonville No. 3	692	50	2	13.1
DJ-38-06-604	City of Jacksonville No. 1	621	105	12	10.3
DJ-38-08-104	New Summerfield Water Supply Corp.	108	50	24	3.1
DJ-38-14-503[2]	Maydelle Water Supply Corp.	39	67	2	1.8
DJ-38-15-102	Dialville-Oakland Water Supply Corp.	30	36	2	2.1

For footnotes see end of table.

Table 4.--Specific Capacities of Wells--Continued

Well Number	Well Owner	Pumping Rate (gpm)	Length of Screen in Well (feet)	Effective Time[1] (hours)	Specific Capacity (gpm/ft)
	CHEROKEE COUNTY--Continued				
	Carrizo Sand--Continued				
DJ-38-15-502	W. R. Nichols	473	101	24	7.1
DJ-38-15-601	City of Rusk No. 1	348	60	1/2	4.4
DJ-38-15-603	City of Rusk No. 3	457	90	19	10.9
DJ-38-15-604	State of Texas - Dept. of Mental Health and Mental Retardation	350	95	18	11.7
DJ-38-24-804	City of Alto No. 2	402	88	1	11.2
	Wilcox Group				
DJ-34-64-402	Blackjack Water Supply Corp.	63	42	2	6.1
DJ-34-64-502	New Concord Water Supply Corp.	62	84	1/2	2.0
DJ-37-09-102	Reklaw Water Supply Corp. No. 1	75	94	2	7.1
DJ-38-08-105	New Summerfield Water Supply Corp.	102	76	2	7.4

For footnotes see end of table.

Well Number	Well Owner	Pumping Rate (gpm)	Length of Screen in Well (feet)	Effective Tim&' (hours)	Specific Capacity (gpm/ft)
FREESTONE COUNTY					
Wilcox Group					
KA-38-17-301	R. L. Lipsey	752	600	1/12	3.9
KA-38-17-401	Butler Water Supply Corp.	93		1	1.9
KA-39-15-601	Industrial Generating Co.	335	115	2	3.7
KA-39-15-703	Pleasant Grove Water Supply Corp.	35	30		0.5
KA-39-15-902	H. B. Zachry Construction Co.	229	30	1-1/2	4.2
KA-39-16-502	Industrial Generating Co.	302	92	2-1/2	3.2
KA-39-16-503	Brown and Ftoot, Inc.	60	40	2	1.0
KA-39-22-901	City of Teag,ue	300	120	1	1.3
KA-39-23-101	Kirvin Water Supply Corp.	50	30		1.0
KA-39-23-301	City of Fairfield No. 2	205	100	1	2.7
KA-39-23-302	City of Fairfield No. 1	123	100	1	3.6
KA-39-23-303	City of Fairfield No. 3	316	136	1/2	5.2
KA-39-23-304	Ward Prairie Water Supply Corp.	40	40		0.5
KA-39-24-905	Humble Oil and Refining Co.	60	74		1.1
KA-39-24-906	W. D. Morse	20	80		1.0

For footnotes see end of table.

Well Number	Well Owner	Pumping Rate (gpm)	Length of Screen in Well (feet)	Effective Time[1] (hours)	Specific Capacity (gpm/ft)
	HENDERSON COUNTY				
	Queen City Sand				
LT-34-44-203	W.H. Nickie	50	30		1.1
LT-34-61-404	Foster Ready Mix	20	21		0.7
	Carrizo Sand				
LT-34-45-403[3]	Henderson County Municipal Water Authority	170	90	2	0.8
LT-34-58-401	Koon Kreek Klub	366	42		8.7
LT-34-61-104	Wes McGuffey, Jr.	50	42		1.2
LT-34-61-105	James Berry	60	40		0.8
	Wilcox Group				
LT-33-56-601	City of Malakoff No. 1	200	50	1/12	3.1
LT-33-56-604	City of Malakoff No. 3	165	62		2.9
LT-34-42-403	Bethel-Ash Water Supply Corp.	43	30	2	1.3
LT-34-43-501	Lone Star Producing Co. No. 4	225	93		1.7
LT-34-43-702	City of Murchison	154	58	2	1.5
LT-34-44-401	City of Brownsboro	125	81		2.1
LT-34-44-404	T & F Dairy	20	84		2.0
LT-34-49-503	The Arthur Hawn Co.	20	30		1.0
LT-34-49-603	W.B. Fields	14	20		0.7

For footnotes see end of table.

Well Number	Well Owner	Pumping Rate (gpm)	Length of Screen in Well (feet)	Effective Time[1/] (hours)	Specific Capacity (gpm/ft)
	HENDERSON COUNTY--Continued				
	Wilcox Group--Continued				
LT-34-49-604	A. C. Rasco	20	20		1.5
LT-34-49-605	Hampton Concrete Co.	15	21		0.1
LT-34-49-807	Crescent Heights Water Supply Corp.	130	60		1.6
LT-34-49-902	Dogwood Estates	60	62		4.3
LT-34-50-101	City of Athens No. 5	246	120		2.1
LT-34-50-102	City of Athens No. 3	410	178		5.3
LT-34-50-104	City of Athens No. 6	640	155	2	4.5
LT-34-50-201	Christian Youth Foundation No. 1	35	58		0.8
LT-34-50-303	Damon Douglas	24	40		0.3
LT-34-50-802	Virginia Hill Water Supply Corp.	150	40		3.0
LT-34-52-103	Moores Station Water Supply Corp.	87	55	2	3.5
LT-34-57-203	C. C. Miller	20	67		0.5
LT-34-58-402	Koon Kreek Klub	137	45	12	0.5
LT-34-58-502	G. E. Brown	27	20		1.0
LT-34-58-503	Hubert Mott	20	20		1.3
LT-34-58-504	John Murchison	200	120	2	1.4
LT-34-60-202	Hunt Oil Co. No. 1	450	180		3.3
LT-34-60-203	Hunt Oil Co. No. 3	401	125		1.1
LT-34-60-204	Hunt Oil Co. No. 4	503	132		4.2

1/ Where no effective time is given, the exact time is unknown and may range from a few minutes to one day.
2/ Well also screens part of Wilcox Group.
3/ Well also screens part of Reklaw Formation.

Table 5. --Results of Pumping Tests

Pumped Well	Pumping Rate (gpm)	Length of Test (hours)	Alignment of Data	Sand Thickness at Pumped Well (feet)	Coefficient of Transmissibility (gpd/ft)	Field Coefficient of Permeability[1] (gpd/ft²)
ANDERSON COUNTY						
Queen City Sand						
AA-38-12-403	72	2	Good	94	3,000	32
AA-38-27-305	15	3-1/2	Good	42	3,000	71
Carrizo Sand						
A-A-34-60-602	210	1-1/2	Good	90	14,200	158
AA-38-13-106	134	2	Good	110	20,800	189
AA-38-19-802	99	2	Good	85	15,000	176
AA-38-20-801	477	2	Good	80	14,000	175
AA-38-21-706	18	1	Good	60	12,800	214
Wilcox Group						
AA-38-02-302	79	2	Good	38[2]	5,400	142
AA-38-03-701	58	2	Good	110	16,400	149
AA-38-09-601	680	2	Good	149	9,600	65
AA-38-11-801	975	9	Good	295	24,000	81
AA-38-11-801	975	8	Good	295	16,000[3]	54
AA-38-11-901	922	8	Good	219	17,200	78
AA-38-11-902	1,176	48	Fair	325	22,000	68
AA-38-19-301	1,150	9	Fair	284	14,000	49
AA-38-21-703	285	2	Good	120	40,500	338
AA-38-21-704	137	1-1/2	Good	150[4]	47,000	313

For footnotes see end of table.

Table 5.--Results of Pumping Tests--Continued

Pumped Well	Pumping Rate (gpm)	Length of Test (hours)	Alignment of Data	Sand Thickness at Pumped Well (feet)	Coefficient of Transmissibility (gpd/ft)	Field Coefficient of Permeability[1] (gpd/ft²)
CHEROKEE COUNTY						
Queen City Sand						
DJ-38-32-903	50	2	Good	45	3,000	67
Carrizo Sand						
DJ-37-01-401	343	24	Good	75	10,900	145
DJ-37-01-402	350	24	Good	60	11,400	190
DJ-37-01-402	350	12	Good	75	12,300[5]	164
DJ-37-09-101	43	2	Good	52[2]	11,000	212
DJ-37-33-202	102	2	Good	70[2]	34,000	476
DJ-38-06-604	621	12	Good	90	12,700	141
DJ-38-06-603	692	2	Fair	80	18,500	231
DJ-38-15-102	30	2	Good	36[2]	4,200	117
DJ-38-15-502	473	24-1/2	Good	101[2]	15,600	154
Wilcox Group						
DJ-34-64-402	63	2	Good	90	13,100	145
DJ-37-09-102	75	2	Good	94[2]	12,800	136
DJ-38-08-105	102	2	Good	90	24,500	272

For footnotes see end of table.

Table 5.--Results of Pumping Tests--Continued

Pumped Well	Pumping Rate (gpm)	Length of Test (hours)	Alignment of Data	Sand Thickness at Pumped Well (feet)	Coefficient of Transmissibility (gpd/ft)	Field Coefficient of Permeability[1] (gpd/ft^2)
FREESTONE COUNTY						
Wilcox Group						
KA-38-17-401	93	2-1/2	Good		4,300	
KA-39-15-601	335	2	Good	115[2]	6,000	52
KA-39-15-802	75	2	Good	50[2]	1,400	28
KA-39-15-902	229	2	Good	30[2]	2,400	80
KA-39-16-502	358	2	Good	134	3,800	28
KA-39-22-901	310	1-1/2	Fair	120[2]	2,000	17
KA-39-23-301	205	8	Fair	117	4,200	36
KA-39-23-302	123	2	Good	132	5,800	44
KA-39-23-303	465	10	Fair	133	9,500	71
KA-39-23-404	90	2	Good	90[2]	1,900	21

For footnotes see end of table.

Table 5.--Results of Pumping Tests--Continued

Pumped Well	Pumping Rate (gpm)	Length of Test (hours)	Alignment of Data	Sand Thickness at Pumped Well (feet)	Coefficient of Transmissibility (gpd/ft)	Field Coefficient of Permeability 1/ (gpd/ft²)
HENDERSON COUNTY						
Carrizo Sand						
LT-34-45-403 6/	170	2	Fair	90 2/	2,000	22
Wilcox Group						
LT-33-56-604	122	2	Good	62 2/	2,600	42
LT-34-42-403	43	2	Good	70	4,200	60
LT-34-43-702	154	2	Good	46	2,000	43
LT-34-50-101	246	2	Fair	120 2/	2,400	20
LT-34-50-104	640	2	Good	100	6,700	67
LT-34-52-103	87	2	Good	80	12,500	156
LT-34-58-402	100	6	Fair	45	1,400	31
LT-34-58-504	200	2	Good	142	2,500	18
LT-34-60-202	450	6	Fair	170	9,200	54
LT-34-60-203	450	6	Fair	125	5,700	46

1/ Based on sand thickness, or length of screen if sand thickness not available.
2/ Screen length.
3/ Based on interference test using AA-38-11-901 as observation well. Coefficient of storage from test is 0.00037.
4/ Estimated data.
5/ Based on interference test using DJ-37-01-401 as observation well. Coefficient of storage from test is 0.00011.
6/ Well also screens part of Reklaw Formation.

piezometric surface is lowered one foot. In an unconfined aquifer (under water-table conditions), the coefficient of storage is essentially equal to the effective porosity of the water-bearing formation and may be as large as 0.3. In a confined aquifer (under artesian conditions), the coefficient of storage is very much smaller (usually less than 0.001). It is controlled by the compressibility of the aquifer, the compressibility of water, the compressibility of clay bodies interbedded with and adjacent to the aquifer, and leakage from adjacent beds.

If a pumping test is made on a well which completely penetrates the aquifer, the coefficient of transmissibility computed from the test represents the entire aquifer. If not, it usually represents only a portion of the aquifer, and the transmissibility for the entire aquifer must be estimated from the permeability of the sand as determined from the pumping test and thicknesses of sand determined from logs of other wells which completely penetrate the aquifer. None of the individual pumping tests made on wells tapping the Wilcox Group or Queen City Sand was on a well which completely penetrated the aquifer. Most of the Carrizo tests were on completely penetrating wells.

The areal distribution of the pumping tests and the average coefficients recorded in the various localities are shown on Figure 12. Of the 51 tests available, 3 are for Queen City wells, 15 are for Carrizo wells, and 33 are for Wilcox wells.

Recorded permeabilities for the Wilcox Group range from 17 to 338 gallons per day per square foot and average about 88 gallons per day per square foot. Those for the Carrizo Sand range from 22 to 476 gallons per day per square foot and average 184 gallons per day per square foot. Permeabilities for the sands in the Queen City Sand, as determined from the tests, range from 32 to 71 gallons per day per square foot and average about 57 gallons per day per square foot.

INTERFERENCE BETWEEN WELLS AND LONG-TERM DRAWDOWNS OF WATER LEVELS

Under natural conditions and prior to pumping from wells, an aquifer is in a state of approximate dynamic equilibrium. Over a climatic cycle the natural recharge is balanced by the natural discharge, and except for temporary fluctuations the piezometric surface of the aquifer, as represented by water levels in wells, remains stable.

When a well is pumped a cone of depression is created in the piezometric surface around the well to cause water to flow from the aquifer into the well. In the report area, the cone of depression continues to grow in all directions until it reaches the outcrop area and causes additional water to flow from the outcrop to the well essentially at the same rate at which it is pumped. At first the water from the outcrop is drawn from storage, and the water table in the outcrop slowly declines. This causes a small part of the water which formerly was evaporated, or transpired, or seeped to surface streams to move in the aquifer toward the well, eventually in an amount equal to the pumpage. At that time the piezometric surface again becomes stabilized, and no further decline of water levels in wells is caused by the pumping (see Figure 4).

The depth and rate of growth of the cone of depression in the piezometric surface is controlled by the coefficient of transmissibility, the coefficient of storage, and the geometric boundaries of the aquifer. If these factors are known, the Theis non-equilibrium formula may be used, with time and distance as variables, to compute the cone of depression at any time after pumping begins.

After equilibrium conditions are reached, the extent and shape of the cone of depression in the piezometric surface are controlled only by the coefficient of transmissibility and the geometry of the boundaries of the aquifer, as the coefficient of storage is no longer a factor. In other words, the coefficient of storage assists in controlling the time at which equilibrium conditions are reached, but does not control the final amount of drawdown and the final shape of the cone of depression.

In making calculations of drawdowns, the outcrop (source of recharge) is considered as a line source, and a fault which completely displaces a formation is considered as a line barrier. In the calculations the effects of both are handled mathematically by image wells, the locations of which are determined by the positions of the outcrop and/or barrier,

Cones of depression created by individual wells overlap, and under artesian conditions they are additive. This means that the effect of pumping two or more separate wells may be determined by computing the effect of each and adding them together.

Figure 13 is comprised of graphs made by means of the Theis non-equilibrium formula, showing the drawdown of water level (piezometric surface) at different times after pumping begins, assuming a pumping rate of 500 gallons per minute, a coefficient of transmissibility of 10,000 gallons per day per foot, a coefficient of storage of 0.00005, and a distance to line source (outcrop) of 15 miles. Graphs are presented of the drawdown after pumping one day, after pumping one month, and after equilibrium conditions are reached. The drawdowns shown are proportional to the pumping rate. If the pumping rate were 1,000 gallons per minute instead of 500 gallons per minute, the drawdown would be twice as much as shown by the graph. At equilibrium the drawdown is inversely proportional to the coefficient of transmissibility, and if the coefficient of transmissibility were 20,000 gallons

EXPLANATION

• WELL LOCATION

Carrizo PRINCIPAL FORMATION SCREENED IN WELLS TESTED (Wilcox, Carrizo, or Queen City)

580-620 DEPTH TO TOP AND BOTTOM OF SCREENS IN WELL, FEET

90 SAND THICKNESS OR LENGTH OF SCREEN IN WELL (F-indicates test represents full thickness of formation. P-indicates test represents part of full thickness of formation.)

14,200 COEFFICIENT OF TRANSMISSIBILITY, GPD/FT

158 FIELD COEFFICIENT OF PERMEABILITY, GPD/FT^2

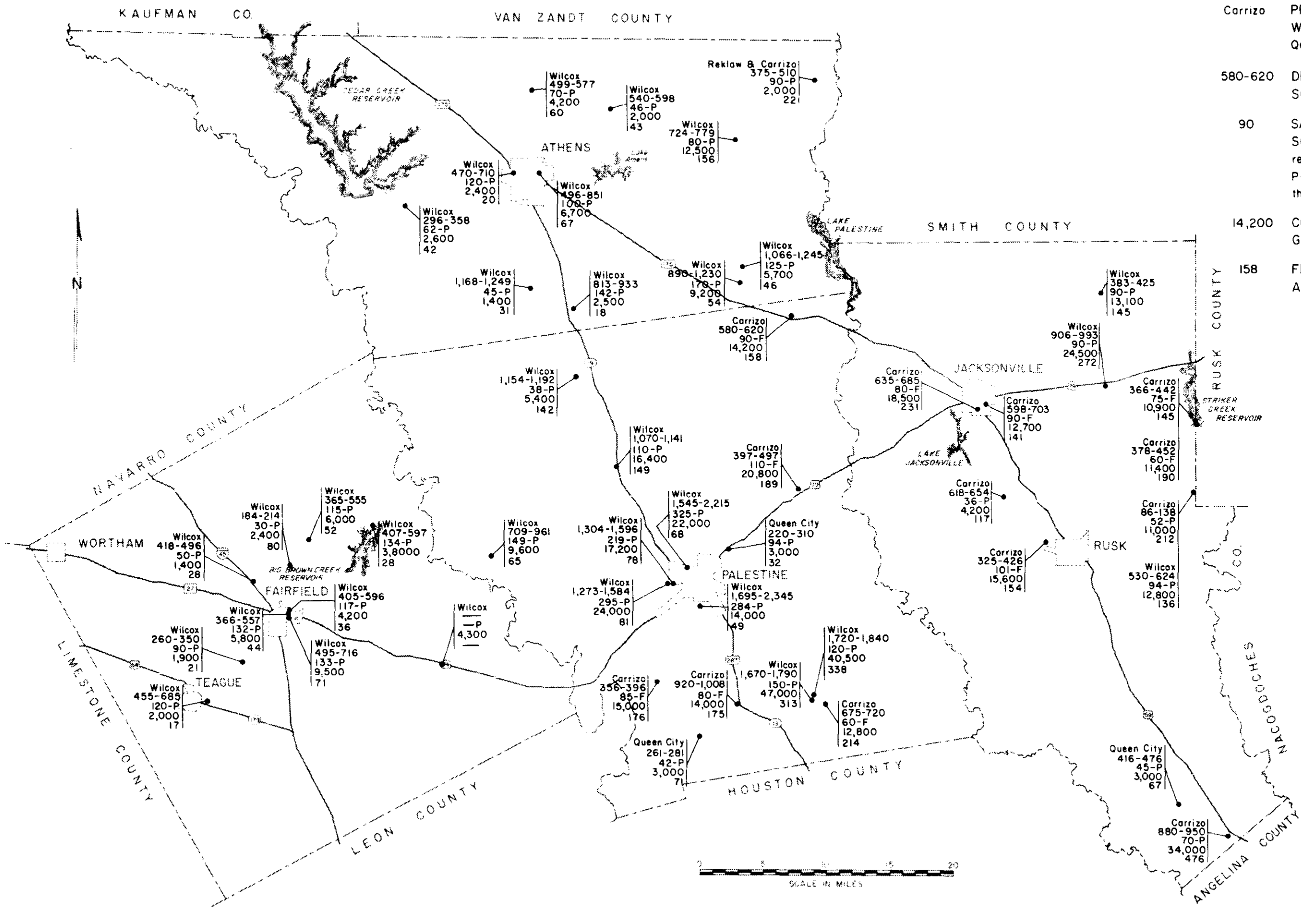


Figure 12
Results of Pumping Tests

Base from Texas State Highway Department county maps

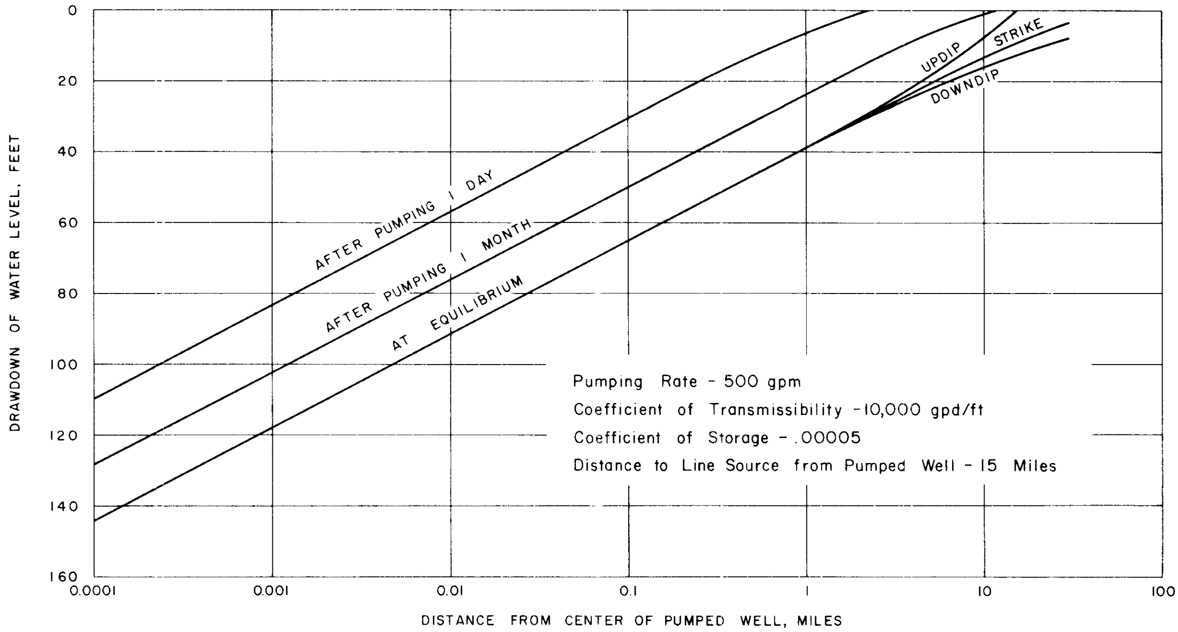


Figure 13.—Computed Drawdown of Water Levels Caused by Pumping

per day per foot instead of 10,000 gallons per day per foot, the drawdown would be one-half as much. This relationship also would apply for periods prior to equilibrium if both the coefficient of transmissibility and the coefficient of storage were changed by the same percentage from the coefficients used for the graphs.

The position of the line source determines the drawdown at equilibrium, along with the transmissibility coefficient and the pumping rate. If the line source were closer to the pumped well than 15 miles as shown, the drawdown at equilibrium would be less. If it were farther, the drawdown at equilibrium would be greater.

Drawdowns are shown on Figure 13 for distances from the center of the pumped well ranging from 0.0001 mile to 30 miles. The distance of 0.0001 mile is approximately one-half foot, representing the radius of a well about 12 inches in diameter. The drawdown shown at this distance is the theoretical drawdown in a 100 percent efficient well of that diameter.

For an aquifer which is rather uniform in thickness and character, the average coefficient of transmissibility determined from pumping tests can be applied directly in determining the cone of depression resulting from pumping a well. On the other hand, for an aquifer in which the sands are lenticular and represent only a small portion of the formation as a whole, the many boundaries to the sands created by their lenticular nature must be taken into consideration in using the average coefficient of transmissibility with the non-equilibrium formula to predict drawdowns of water levels. The coefficient of transmissibility as determined from a pumping test normally represents only a short period of time during which the cone of depression extends from the well tested for no more than a few thousand feet. If the cone of depression later grows through additional, more confining boundaries the effective coefficient of transmissibility then becomes smaller.

POSSIBLE BRACKISH WATER ENCROACHMENT

At present, pumpage from the water-bearing sands in the four-county area is relatively small and distances from wells to brackish water are generally great. There is no likelihood of brackish water moving into the existing fresh water wells except where the wells are already on the edge of the brackish water. Future encroachment of brackish water is unlikely unless there is development of heavy pumping close to areas where brackish water is located. Only under such conditions can brackish water be brought into wells in sufficient quantities to substantially change the mineralization of the water pumped from the wells.

The mineralization of the water from the wells cannot change greatly until the water between the wells and the brackish water is pumped out. Considering the fact that water moves radially to the center of pumpage from all directions, it normally takes many years for brackish water to move to well fields from any great distance. Accordingly, any change in mineralization is normally slow, and it occurs over a long period of time. If periodic observations of quality of water are made, there is ample opportunity to relocate wells or to develop a supplemental supply before the mineralization of the water becomes too great.

AVAILABILITY OF GROUND WATER

Although some fresh ground water is available from every formation outcropping within Anderson, Cherokee, Freestone, and Henderson Counties, only the Wilcox Group, Carrizo Sand, Queen City Sand, and Sparta Sand are capable of yielding large quantities. Of the four, the Wilcox Group and Carrizo Sand are by far the most important. The Queen City is next in importance. The Sparta's capability is small, mostly in a small area in southern Cherokee County. Of all the remaining formations the Reklaw Formation and alluvium are each slightly better than the Cretaceous rocks, Midway Group, Weches Formation, or the Cook Mountain Formation, but all are weak producers and should be considered only for very small to small water supplies.

The basal Reklaw sands are hydraulically connected to the Carrizo in many places and should not be considered as a source of ground water entirely separate from the Carrizo. Wells yielding 50 to 100 gallons per minute might be obtained in some places in the basal Reklaw, however, if there were reason to make such wells in this sand instead of in the Carrizo. Yields of existing wells in the alluvium range up to about 30 gallons per minute. This is believed to be about the limit for individual well yields obtainable from the alluvium. With the exception of the Reklaw and alluvium none of the "weak producing" formations should be expected to yield more than a few gallons per minute to a well at any place, and even this is too much to expect in many places.

From the standpoint of availability of the ground-water supply it should be pointed out that wherever the Cook Mountain Formation contains fresh water the Sparta, Queen City, or Carrizo also contain fresh water and provide a much better source. Similarly, wherever the Weches contains fresh water the Queen City, Carrizo, or Wilcox also contain fresh water. And, wherever the Reklaw contains fresh water the sands of the Carrizo or Wilcox also exist and provide a much better source of fresh ground water.

In the extreme northwestern parts of Freestone and Henderson Counties, northwest of the Wilcox outcrop, the Midway Group and the alluvium (where it exists) are the only units capable of producing fresh ground-water supplies. In these areas many users have had difficulties in developing even a domestic supply, and the availability of ground water is very limited.

Information on yields and the more favorable areas for development from the Wilcox, Carrizo, Queen City, and Sparta aquifers is presented in the following sections of the report. Only water containing less than 1,000 parts per million dissolved solids is considered.

Yields of Individual Wells

In estimating yields of wells, it is necessary to establish criteria with respect to well construction and drawdown of water level. For the following discussion on maximum individual well yields obtainable it is assumed that the screens in the wells will be at least eight inches in diameter and of sufficient diameter so that there will be very little head loss due to turbulent flow in the wells. It is further assumed that all the sands in the producing sections will be screened and that the wells will be constructed and developed in such a manner that they are essentially 100 percent efficient. In other words, it is assumed that there will be no extra drawdown in the wells due to restriction of water movement through the faces of the wells. Finally, it is assumed that the drawdown in a well due to its own pumping is approximately 100 feet in the first day of pumping, provided this does not draw the pumping level below the top of the producing section of the aquifer. In cases where less than 100 feet of available drawdown exists to the top of the producing section, some provision has been made for partial dewatering of the formation, and also the one-day drawdowns have been reduced to less than 100 feet as necessary.

Wilcox Group

The estimated maximum yields obtainable from individual wells producing fresh water from sands of the Wilcox Group are shown on Figure 14. In addition to the assumptions described above, it is assumed with respect to the Wilcox wells that no more than 400 feet of thickness of the Wilcox will be included in the developed portion of any Wilcox well. In other words, it is assumed that the distance between the top of the top screen and the bottom of the bottom screen will be no more than 400 feet. Within this limitation, it is assumed that the well will be screened in that portion of the Wilcox having the greatest amount of sand which produces fresh water, provided there is at least 100 feet of available drawdown to the top of the producing section.

The estimated maximum yields of individual wells range up to 1,500 gallons per minute. To obtain the largest yields will require gravel-walled wells with screens of at least 10 inches in diameter and preferably 12 or 14 inches.

Carrizo Sand

Figure 15 shows the estimated maximum yields of individual wells for the Carrizo Sand. They also range up to 1,500 gallons a minute. As for the Wilcox, to obtain

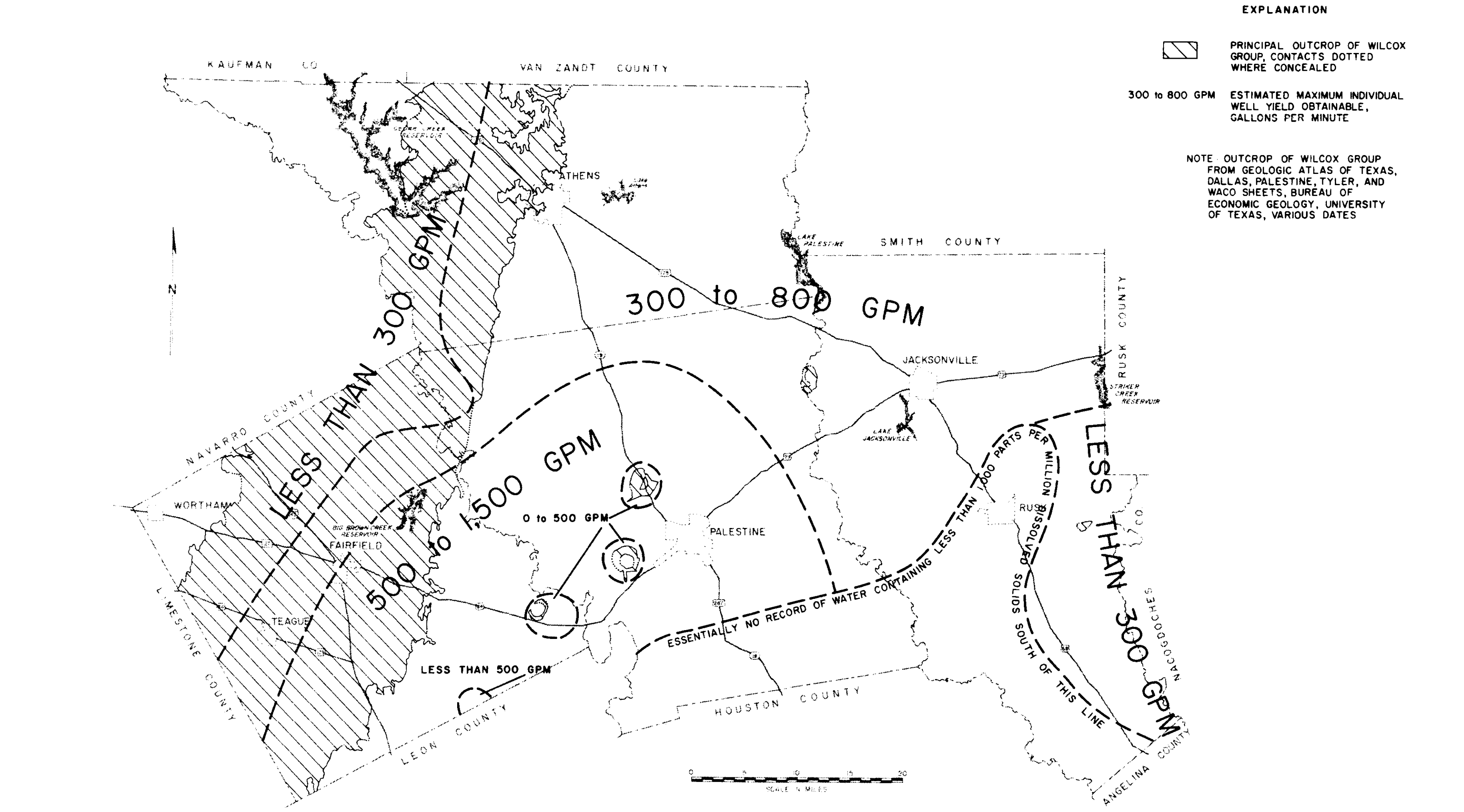


Figure 14

Estimated Maximum Individual Well Yields-Wilcox Group

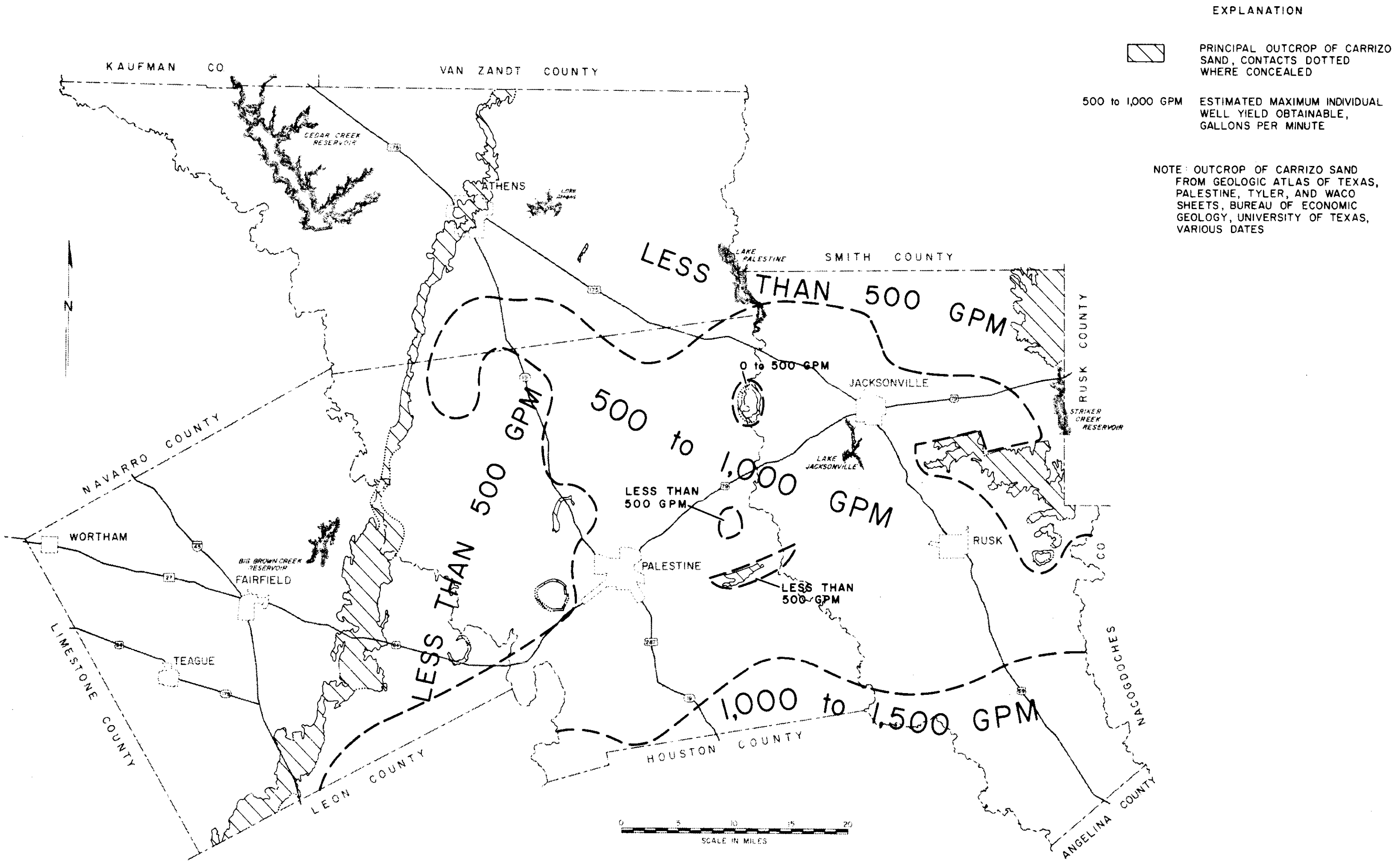


Figure 15

Estimated Maximum Individual Well Yields-Carrizo Sand

Base from Texas State Highway Department county maps

the largest yields will require gravel-walled wells with screens of at least 10 inches in diameter and preferably 12 or 14 inches, Generally, the estimated maximum yields increase from northwest to southeast. Generally, the largest yields are available in extreme southern Anderson County and in southeastern Cherokee County.

Queen City Sand

Estimated maximum yields of individual wells are shown for the Queen City Sand on Figure 16. They range up to 400 gallons per minute. In making the estimates an average permeability of 57 gallons per day per square foot is used. The highest yields are generally available in those areas where the Queen City is the thickest. This is mostly in an area paralleling the axis of the East Texas syncline in western Henderson County, northwestern Cherokee County, and central Anderson County. Elsewhere, the estimated maximum yields, of individual wells are less than 200 gallons a minute, with the exception of a small area in southwestern Henderson County where they range from 150 to 300 gallons a minute.

Sparta Sand

Figure 17 shows the estimated maximum yields of individual wells for the Sparta Sand. They range up to 500 gallons per minute in the only area considered, which is in extreme southeastern Cherokee County. Elsewhere in the four-county area, the saturated thickness of the Sparta is generally too small for moderately yielding wells, except within the part of the Elkhart graben where the Sparta is overlain by Cook Mountain. There, it is estimated that maximum well yields of about 150 gallons per minute are obtainable locally.

The estimates for the Sparta assume an approximate effective transmissibility range of 4,000 to 10,000 gallons per day per foot for the full thickness of the Sparta. This range in transmissibility is based upon tests made in adjacent counties. No wells suitable for testing are completed in the Sparta within the report area.

Individual Well-Field Yields

Additional criteria are necessary with respect to estimating maximum yields of individual well fields. First and most important, no allowance is made for interference effects between one well field and another. This means that the estimates of maximum yield are, for the most part, valid for only one well field in the aquifer at the present time Each well field will create drawdown of the piezometric surface throughout much of the aquifer, and this will have an effect on the drawdown available for use by each additional field which may be installed. Furthermore, each additional field that is installed will have an effect on the first field which was developed, thus reducing the drawdown available for it and its maximum potential yield. The effects of interference between well fields are considered in succeeding sections of this report, but for this section, the purpose of which is to estimate the maximum available yield of any one well field, it is not practicable to consider such interference effects.

Next, in estimating the yield of a well field it has been necessary to assume a maximum number of wells, spacing between wells, and the desired yields of the wells. For the estimates, therefore, it has been assumed that no well field will contain more than ten wells and that the wells in a field will generally be spaced in a line approximately one-half mile apart. Where practicable, the yields of individual wells have been selected so that about 100 feet of drawdown will be created in each well during the first day from its own pumping.

It has also been necessary to assume limits for allowable drawdown. Allowable drawdown, as used in this report, refers to the distance between the piezometri,c surface and either the top of the producing section in the wells or some other level considered to be a reasonable depth for pumping levels. The limits used for each aquifer are given in the following sections of the report.

Wilcox Group

Because the portion of the Wilcox Group containing fresh water sands is so thick, more than one well may be made at a single site, under the limitation imposed that no more than 400 feet of section will be taken into any one well. Therefore, in estimating the yield of the Wilcox Group, the Wilcox sands have been divided into separate sections. This has been done by splitting the Wilcox into an upper 400-foot thick section and then allocating the remainder of the Wilcox to one or two other sections depending on the total remaining fresh water thickness of the Wilcox. The allowable drawdown is assumed to be the distance between the original piezometric surface and the top of the Wilcox section developed by the wells. The maximum drawdown allowed in the estimates is 500 feet. Recharge areas for each of the Wilcox sections are considered to be in Freestone and Henderson Counties and to the east of Cherokee County in parts of Rusk and Nacogdoches Counties. The boundary effects created by the Mount Enterprise fault zone are also taken into consideration in making the estimates. On the basis of these conditions and assumptions, the estimated ranges in maximum individual well-field yield are shown in Figure 18.

The estimates range up to 12 million gallons per day. The largest Wilcox well-field yields can be obtained to the east of its outcrop in Freestone, Anderson, and Henderson Counties. In these areas, the thickness of the

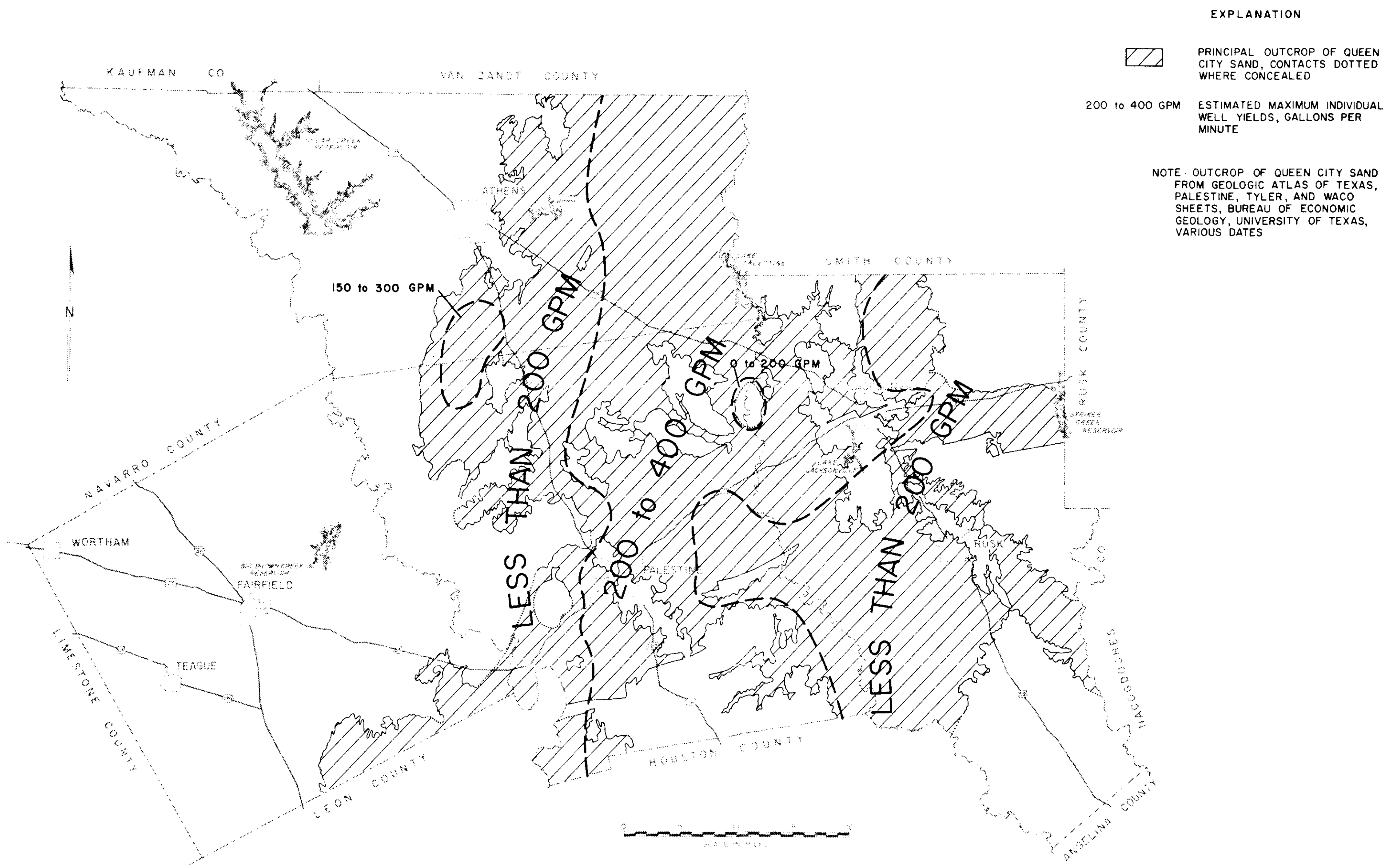


Figure 16

Estimated Maximum Individual Well Yields-Queen City Sand

Base from Texas State Highway Department county maps

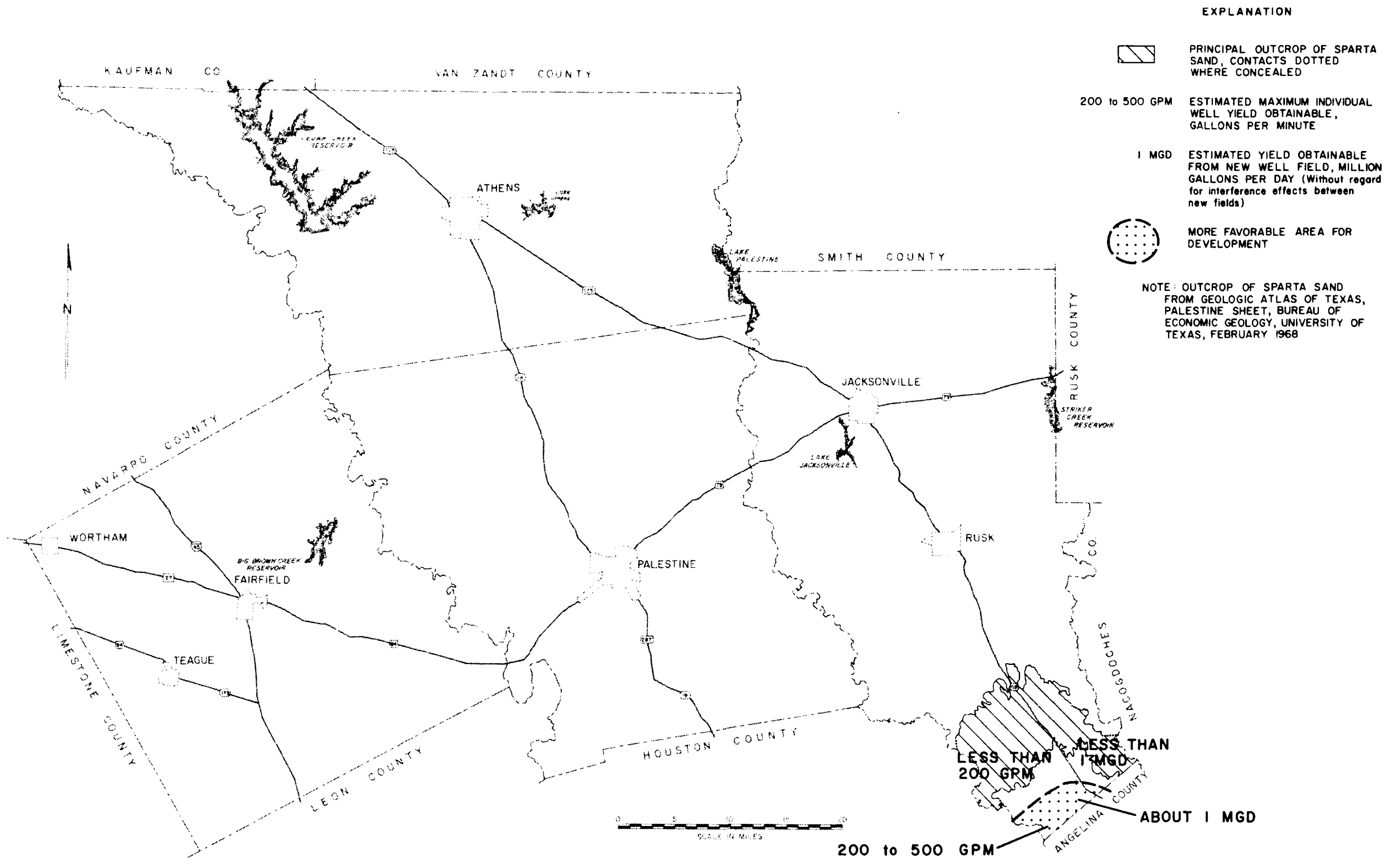


Figure 17

Estimated Maximum Individual Well Yields, Well-Field Yields, and Area More Favorable for Development-Sparta Sand

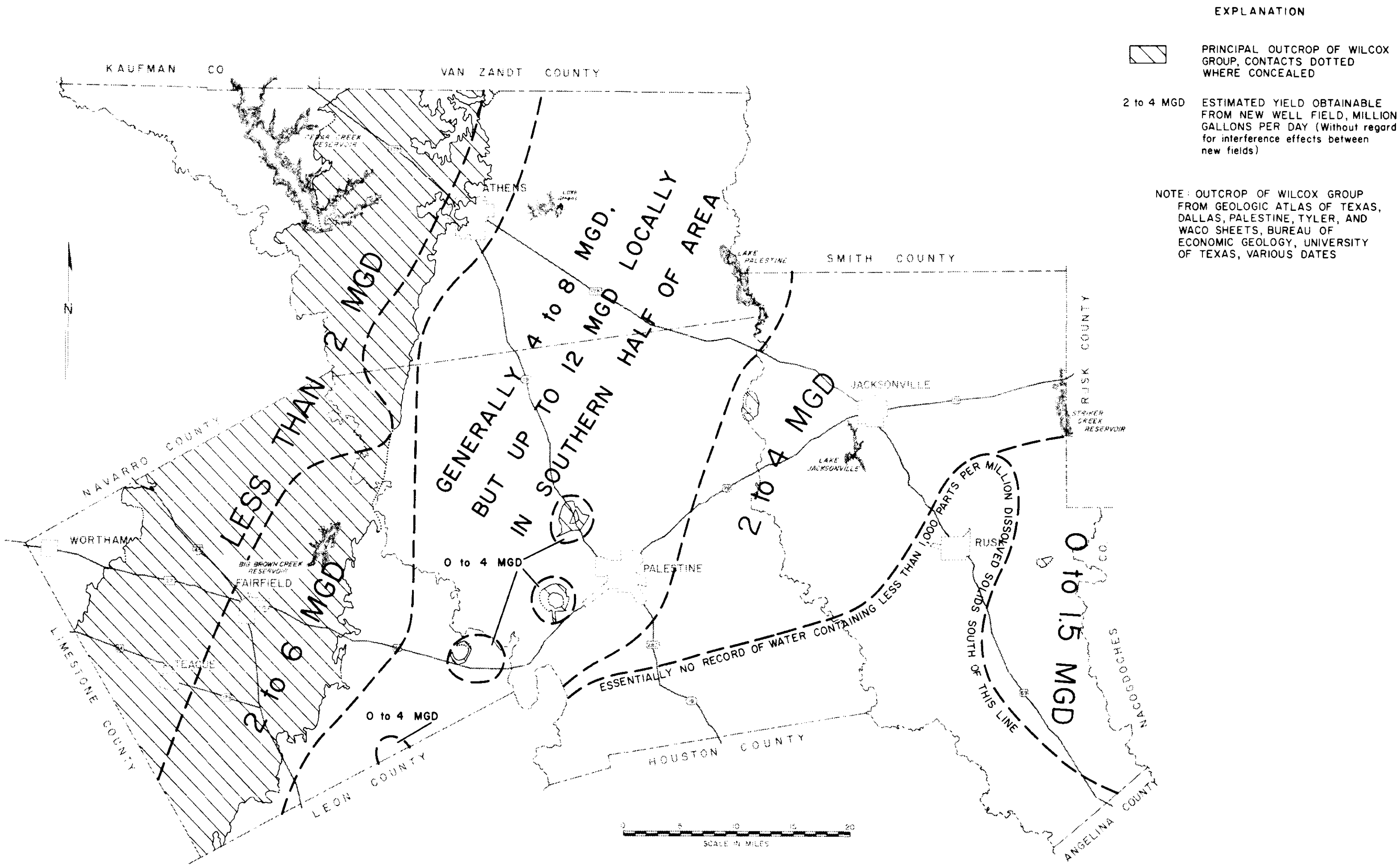


Figure 18
Estimated Individual Well-Field Yields-Wilcox Group

Base from Texas State Highway
Department county maps

Wilcox sands containing fresh water is the greatest, the boundary effects of the Mount Enterprise fault zone the least, and the distances to recharge areas the smallest.

Carrizo Sand

Figure 19 shows the estimated maximum individual well-field yield for a new field in the Carrizo Sand. The estimated yield ranges up to 10 million gallons per day. The estimates are based on an allowable drawdown amounting to the distance between the original piezometric surface and the top of the Carrizo Sand, up to a maximum of 500 feet. As with the other aquifers, the estimates are made without considering the effects of the new field on either the existing wells in the Carrizo or on any new well field, and vice versa. The estimates of yield take into consideration the range of transmissibilities considered to exist in the Carrizo over the area and the boundary effects of the Mount Enterprise fault zone. In applicable parts of the area, they also take into consideration the actual pumpage-drawdown experience for the Lufkin-Nacogdoches area in adjoining Angelina and Nacogdoches Counties.

The Carrizo occurs at reasonably shallow depths throughout much of the area of its occurrence within the four-county area. This generally limits the allowable drawdown to the top of the Carrizo Sand and hence limits the well-field yields obtainable to values less than they would if the Carrizo were deeper.

Queen City Sand

Figure 20 shows the estimated maximum individual well-field yield for a new well field in the Queen City Sand. The estimated yield ranges up to 1.5 million gallons per day.

The assumed deepest allowable pumping level is the top of the producing section of the Queen City or 500 feet below the present piezometric surface, whichever is shallower. As in the case of all of the other formations, these estimates are made without considering the effects of the new field on either existing wells or on any new field, and vice versa.

Sparta Sand

Figure 17 shows the estimated maximum individual well-field yield for the Sparta Sand. As explained earlier, only in southeastern Cherokee County does the Sparta generally have the potential for moderate production. There, the estimates range from less than 1 million gallons per day, principally in its outcrop area, to about 1 million gallons per day in a small area in extreme southern Cherokee County southwest of Wells. The estimates are based on an allowable drawdown amounting to the distance between the present piezometric surface and the top of the Sparta Sand. The maximum allowable drawdown present is estimated at about 140 feet. In the outcrop the estimates are less partly because the allowable drawdown is less and partly because the saturated thickness of the formation becomes less going northward in the outcrop.

Total Availability of Ground Water Within Anderson, Cherokee, Freestone, and Henderson Counties

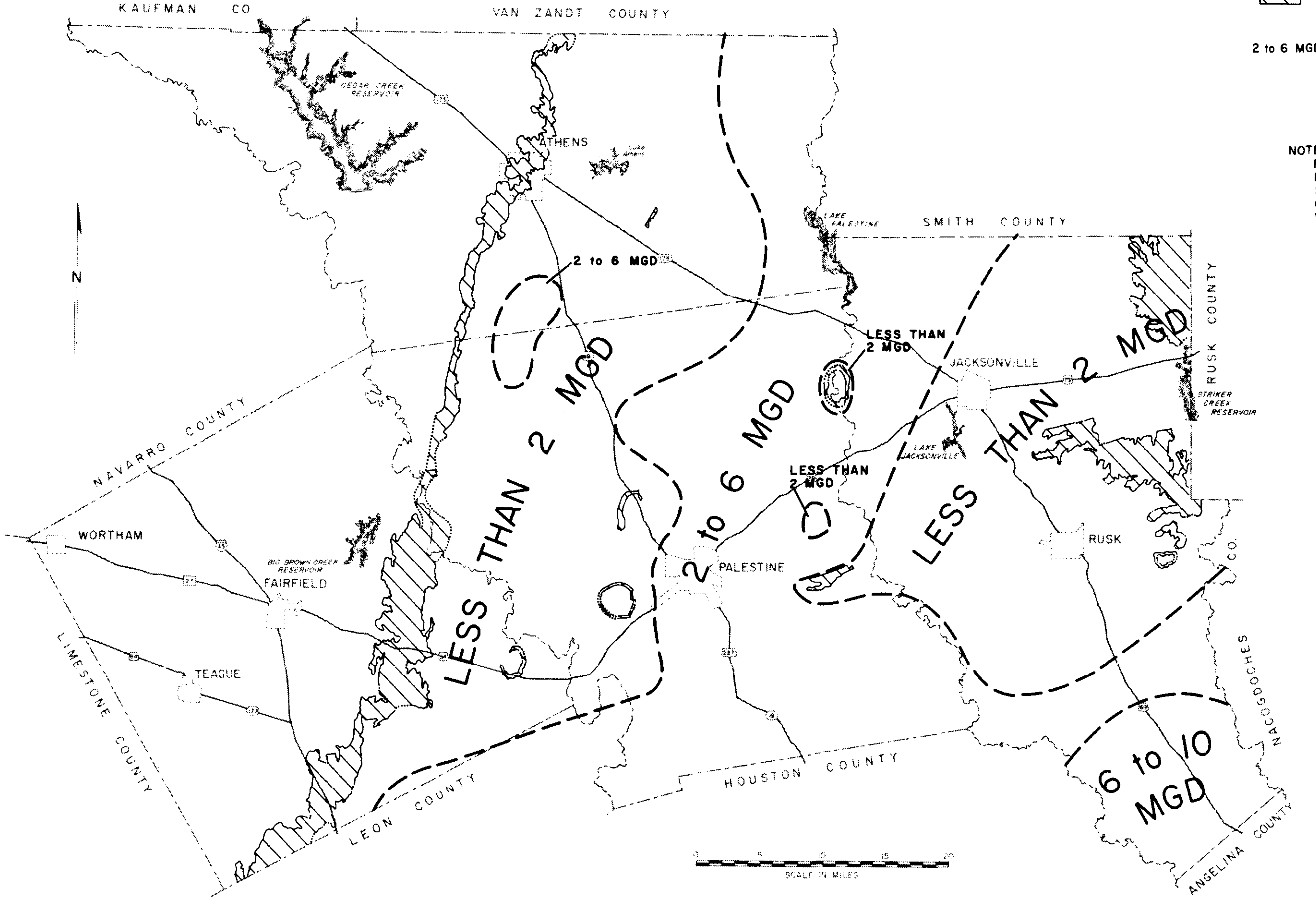
More important and more realistic than the preceding estimates of maximum yield of individual well fields are estimates of total availability of water from each of the principal aquifers within the four counties. A summary of these estimates is given in Table 6.

Estimates of the total availability of water are made to include pumping from existing well fields within the four-county area and from new well fields consisting of moderate- to large-yielding wells. The estimates are made on the basis of locating the new fields reasonable distances apart in the most favorable areas with respect to transmissibility of the aquifer and allowable drawdown of water level. They also assume that new fields will be located at distances from existing fields in the four-county area which will preclude unreasonable interference effects on these fields. They also assume that pumpage from the aquifers is not increased in adjacent counties, as no new interference is allowed for from these counties. In this respect, the estimates are perhaps somewhat too high, for some additional development will occur in adjacent counties.

A second method of estimating the available supplies is based on the full development of each aquifer throughout its extent, both inside and outside of the four-county area. The figures given for the available supplies by this method are estimates of the maximum amounts of water that will flow down the dips of the formations from their outcrops to wells in the four-county area. The estimates are based on the estimated effective transmissibilities of the formations, the dips of the beds, and the widths of the areas of occurrence of the aquifers in the four counties.

Wilcox Group

The 1969 pumpage from the Wilcox Group is estimated to have been 5.5 million gallons per day. The supply available from well fields with no increase in pumpage outside these counties is estimated at 48 million gallons per day. This water would be taken from well fields spaced about seven miles apart located in areas to obtain the maximum transmissibility and maximum allowable drawdown up to 500 feet. The estimate of the maximum amount of water that can flow from the outcrop to points of withdrawal in the



EXPLANATION

PRINCIPAL OUTCROP OF CARRIZO SAND, CONTACTS DOTTED WHERE CONCEALED

2 to 6 MGD — ESTIMATED YIELD OBTAINABLE FROM NEW WELL FIELD, MILLION GALLONS PER DAY (Without regard for interference effects on other fields)

NOTE: OUTCROP OF CARRIZO SAND FROM GEOLOGIC ATLAS OF TEXAS, PALESTINE, TYLER, AND WACO SHEETS, BUREAU OF ECONOMIC GEOLOGY, UNIVERSITY OF TEXAS, VARIOUS DATES

Figure 19

Estimated Individual Well-Field Yields-Carrizo Sand

Base from Texas State Highway Department county maps

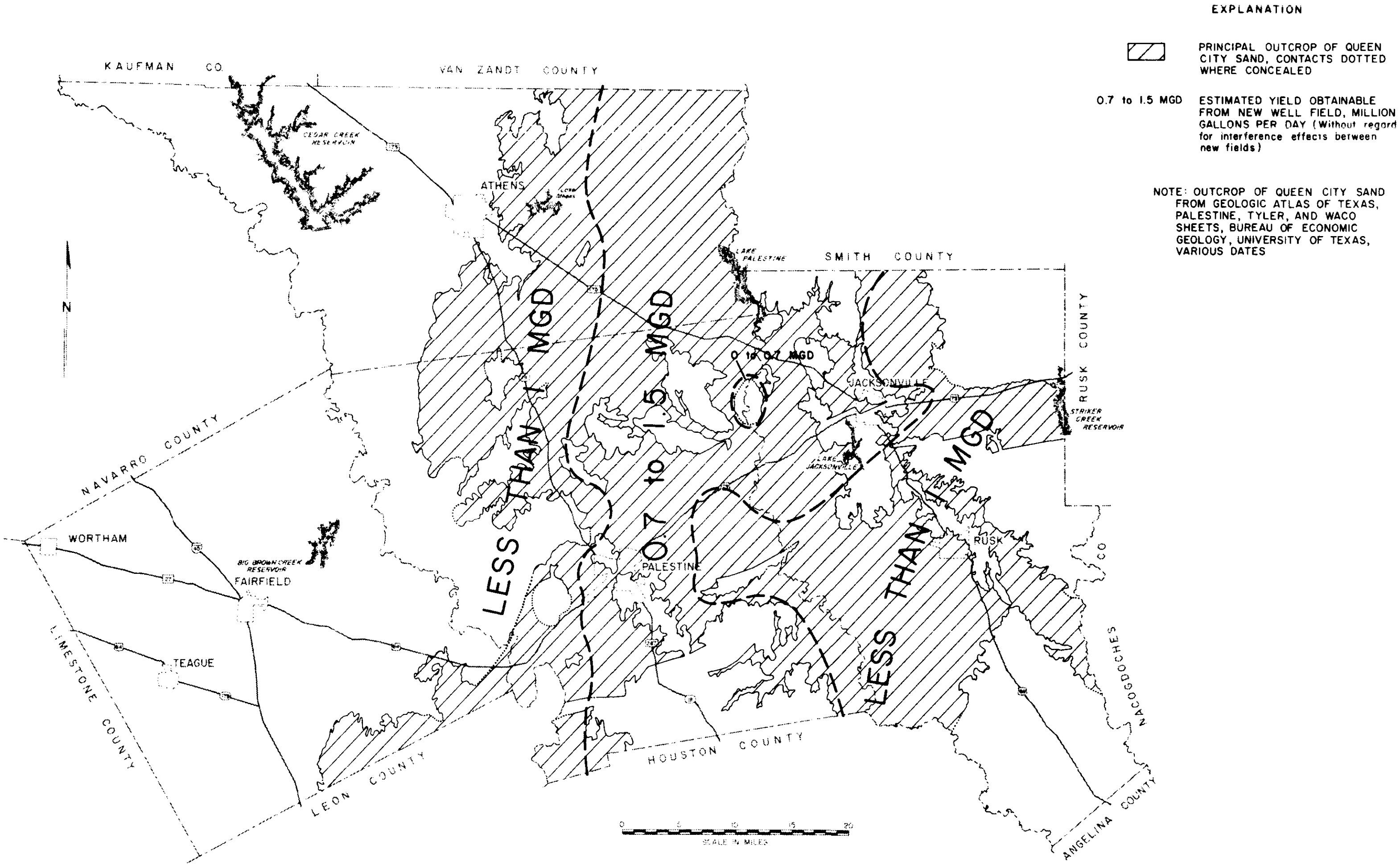


Figure 20

Estimated Individual Well-Field Yields-Queen City Sand

Base from Texas State Highway Department county maps

Table 6.--Estimated Total Amount of Ground Water Available in Anderson, Cherokee, Freestone, and Henderson Counties

Aquifer	1969 Pumpage (million gallons per day)	Supply Available under Practical Conditions, but with No Increase in Pumpage Outside These Counties 1/ (million gallons per day)	Supply Available from Maximum Possible Number of Wells, with Full Development Outside These Counties 2/ (million gallons per day)
Wilcox Group	5.5	48	30
Carrizo Sand	5.5	35	22
Queen City Sand	1.0	8	14
Sparta Sand	0.2	1	2

1/ The figures in this column are based on the sum of the estimated maximum yields from well fields of small to moderate size spaced uniformly in areas of greatest transmissibility and greatest allowable drawdown. The well fields in each aquifer interfere with one another, but the estimates assume that pumpage from the respective formations in adjacent counties will remain the same as at present, and there will be no interference from these outside counties.

2/ The figures in this column represent estimates of the maximum amounts of water that will flow down the dips of the respective formations from their outcrops into and in Anderson, Cherokee, Freestone, and Henderson Counties, if the aquifers are also fully developed in adjacent counties.

four-county area without unwatering the aquifer is 30 million gallons per day. This estimate is less than the estimate of the amount of water which can be developed by well fields. This is primarily because the locations of the hypothetical Wilcox well fields are such that they can draw a substantial part of their water from adjacent counties.

Carrizo Sand

The 1969 pumpage from the Carrizo Sand is estimated to have been 5.5 million gallons per day within the four-county area. The supply estimated to be available from well fields with no additional development outside the four-county area is 35 million gallons per day. Approximately two-fifths of this water would be available from well fields located in those parts of southern Anderson and southeastern Cherokee County where the allowable drawdown is greatest. Development of this water, however, would lower water levels in existing well fields to the east at Nacogdoches and Lufkin to such an extent that well yields there would be seriously affected.

The estimated amount of water which will flow down the dip of the Carrizo Sand from its outcrop without unwatering part of the formation is about 22 million gallons per day. This is less than the estimate of the amount of water which can be developed from well fields because the location of the hypothetical Carrizo well fields are such that they can draw a large part of their water from adjacent counties.

Queen City Sand

Present pumpage from the Queen City Sand is low, amounting to an estimated 1 million gallons per day. The supply estimated to be available from well fields, with no additional development outside the four-county area, is 8 million gallons per day. Most of this water would be available from well fields located in those parts of the area where the Queen City is the thickest. This is in western Henderson and in parts of Anderson and Cherokee Counties along the axis of the East Texas syncline.

The estimated supply available from the Queen City based on flow down the dip of the beds and assuming full development outside these counties is 14 million gallons per day. This is more than is estimated to be available from well fields, due to assuming the well fields to be of moderate size, similar to what a city or industry would expect.

Sparta Sand

Present pumpage from the Sparta Sand is estimated to be 0.2 million gallons per day, and the supply estimated to be available from well fields, with no additional development outside the four counties, is 1 million gallons per day. Most of this water would be available from one well field in extreme southern Cherokee County, where the allowable drawdown is greatest. The estimated supply of water available from the Sparta based on the flow down the dip of the beds and assuming full outside development is 2 million gallons per day.

Interrelationship Between Ground Water and Surface Water

Estimates of the total availability of water from existing well fields and/or new well fields for the Wilcox, Carrizo, Queen City, and Sparta aquifers total 92 million gallons per day. Should most or all of this water be developed there would eventually be a relatively small decrease in the base flow of the streams in the four-county area. However, the amount of decrease would be only a portion of the 92 million gallons per day.

Most of the base flow does not arrive at the streams by deep percolation but comes to them from relatively high- and intermediate-level seeps and springs. This is evidenced by the degree of fluctuation in the base flow, and by the fact that all the streams have essentially no flow in dry times. The seeps and springs which make up the bulk of the base flow of the streams owe their existence to the very stratified and lenticular character of the formations in the area. They represent rejected recharge from perched and semi-perched ground-water zones. Under conditions of full ground-water development, water levels in the perched and semi-perched zones would be little affected, and these zones would largely continue to furnish water to the streams. Most of the water to support the ground-water pumpage would come from salvaging water presently being discharged from the formations by evapotranspiration, and only a relatively small part would come from salvaging recharge to the formations currently being rejected by seepage to streams.

MORE FAVORABLE AREAS FOR GROUND-WATER DEVELOPMENT

Wilcox Group

The area considered to be more favorable for development of the Wilcox Group is shown on Figure 21. In selecting the area, consideration has been given to individual well yields, well-field yields, and quality of water. The area has been kept several miles away from known brackish water to minimize danger of brackish water encroachment.

EXPLANATION

PRINCIPAL OUTCROP OF WILCOX GROUP, CONTACTS DOTTED WHERE CONCEALED

MORE FAVORABLE AREA FOR DEVELOPMENT

NOTE: OUTCROP OF WILCOX GROUP FROM GEOLOGIC ATLAS OF TEXAS, DALLAS, PALESTINE, TYLER, AND WACO SHEETS, BUREAU OF ECONOMIC GEOLOGY, UNIVERSITY OF TEXAS, VARIOUS DATES

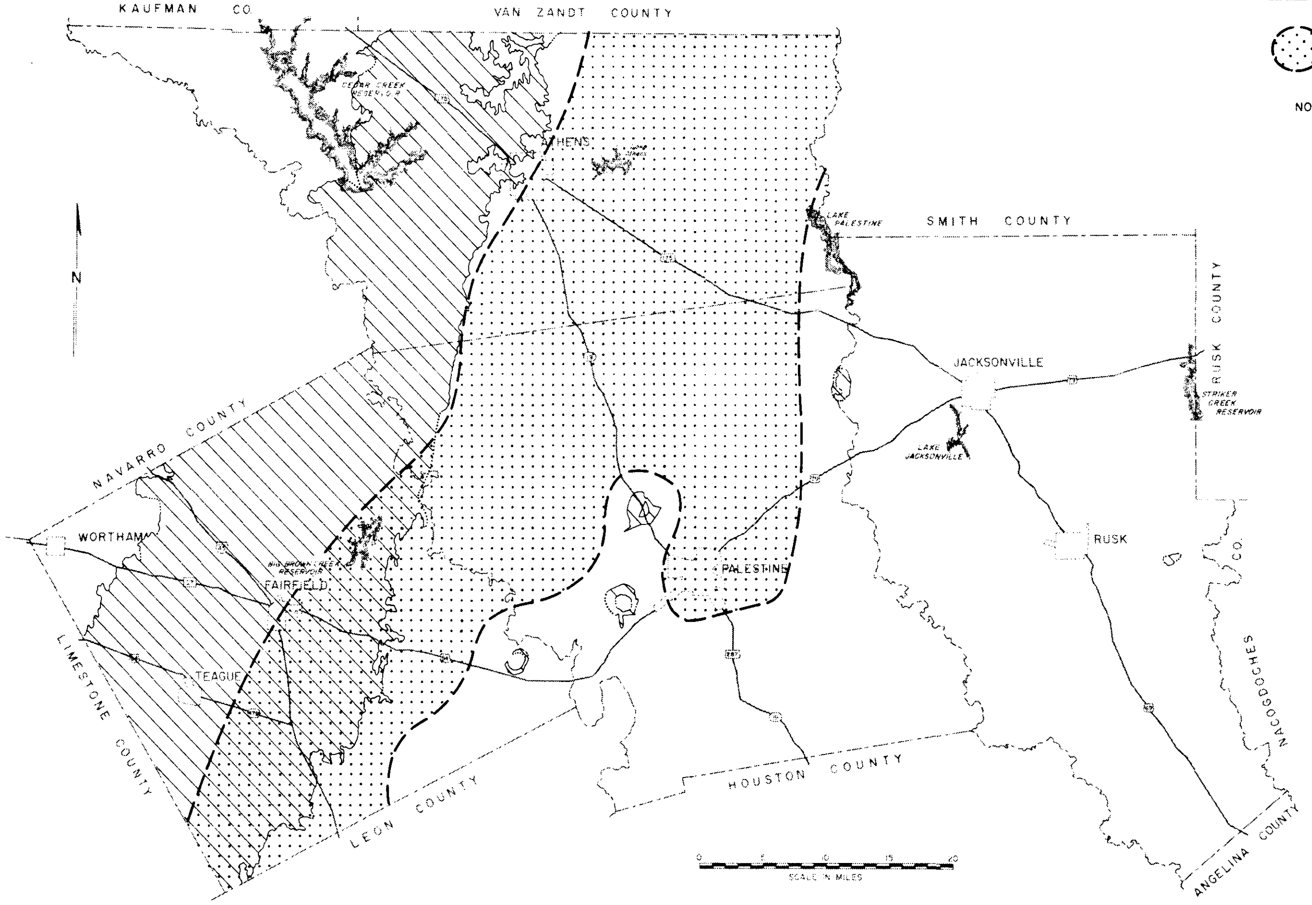


Figure 21
More Favorable Area for Development-Wilcox Group

Base from Texas State Highway Department county maps

Carrizo Sand

The areas considered to be more favorable for development of the Carrizo Sand are shown on Figure 22. The areas have been selected primarily from the standpoint of available well yield and well-field yield. The dissolved-solids content of Carrizo water in the more favorable area in southwestern Henderson County and in the more favorable area extending across northeastern Anderson County, as shown on Figure 22, is about 200 parts per rnillion or less. In the more favorable area indicated in southern Anderson and southeastern Cherokee County, the dissolved-solids content is significantly higher, ranging from about 350 to 700 parts per million. As mentioned earlier, the development of large quantities in southeastern Cherokee County would reduce the yields of existiing Carrizo well fields at and near Nacogdoches and Lufkin.

Queen City Sand

The area considered to be more favorable for development of the Queen City Sand is shown on Figure 23. Included is the area in which the thickness of the Queen City is the greatest and the largest well and well-field yields are expected.

Sparta Sand

Within the four-county area, the area considered to be more favorable for development of the Sparta Sand is very limited. As shown on Figure 17, the most favorable area is downdip from the Sparta outcrop in Cherokee County, where the allowable drawdown to the top of the Sparta is the greatest. Basically this only includes a very small area in the extreme southern tip of Cherokee County southwest of Wells.

TEST DRILLING

The estimates of well yields, well-field yields, and total availability of water and quality of water which are given in this report are believed to be the best which can be made based on the available data. There is always a possibility, however, that some differences from the estimates will be found in actual practice, for even the most uniform of the water-bearing units in the four-county area has sufficient variability to preclulde absolute prediction.

It is common practice in the construction of a large well in the area to first drill a pilot hole entirely through the water-bearing formation to be developed. From the information obtained from this hole, a decision is made whether to complete the well. If so, the well is then designed on the basis of that information. When the greatest possible yield is desired or when the desired yield or quality of water is near the estimated limits of the ability of the aquifer to produce, it is desirable to precede the construction of wells with one or more test holes. These test holes are small diameter holes which are drilled solely for the purpose of obtaining information, and then are abandoned. Several holes may be drilled in a particular locality to determine the variations in ground-water conditions which exist and to select the site or sites which appear best for construction of large wells.

Normally the test drilling program is conducted to obtain three types of information: (1) information on the positions and thicknesses of the water-bearing sands, (2) representative samples of each water-bearing sand, and (3) information on the quality of the water contained in the sands.

The positions and thicknesses of the sands are obtained from drillers' and electric logs, and samples of sand are normally obtained as cuttings collected during the drilling of the hole. Cores are not usually taken because of the expense required to obtain representative coverage. It is important, however, that the drill cuttings be taken in a very careful manner so that they are as representative of the water-bearing sands as possible. This requires that the drilling mud entering the drill stem be kept as free as possible of sand and that the hole be cleaned of all drill cuttings prior to drilling the interval from which the sample of sand is desired. Then during the drilling of the interval to be sampled a portion of the drilling fluid should be diverted through a large sampling box or other receptacle within which the sand the mud is carrying can be separated in order to obtain a representative sample of the sand. After the bottom of the interval to be sampled is reached, drilling should stop and circulation of the drilling fluid should be continued and the sampling process continued until all drill cuttings have been carried to the surface. It is normal practice to take drill cutting samples at intervals of approximately ten feet in all the water-bearing sands of interest. Sieve analyses are made of the samples of sand thus obtained in order to determine their range in grain size. This information is used, together with other data obtained, in estimating the yield of water which might be obtained from a well at the site and in selecting the size of screen, and type and grading of gravel if the well is to be gravel packed, to be used in construction of the well.

Quality of water information is obtained from a test hole in two ways, one by actually taking samples of the water and the other from the electric log made in the hole. An electric log which is made under controlled conditions with proper, standardized equipment normally can be evaluated to determine the general degree of mineralization of the water. It cannot, however, be evaluated closely enough to determine the precise degree of mineralization, nor is there any way to determine the concentration of various mineral constituents in the water. Therefore, when this

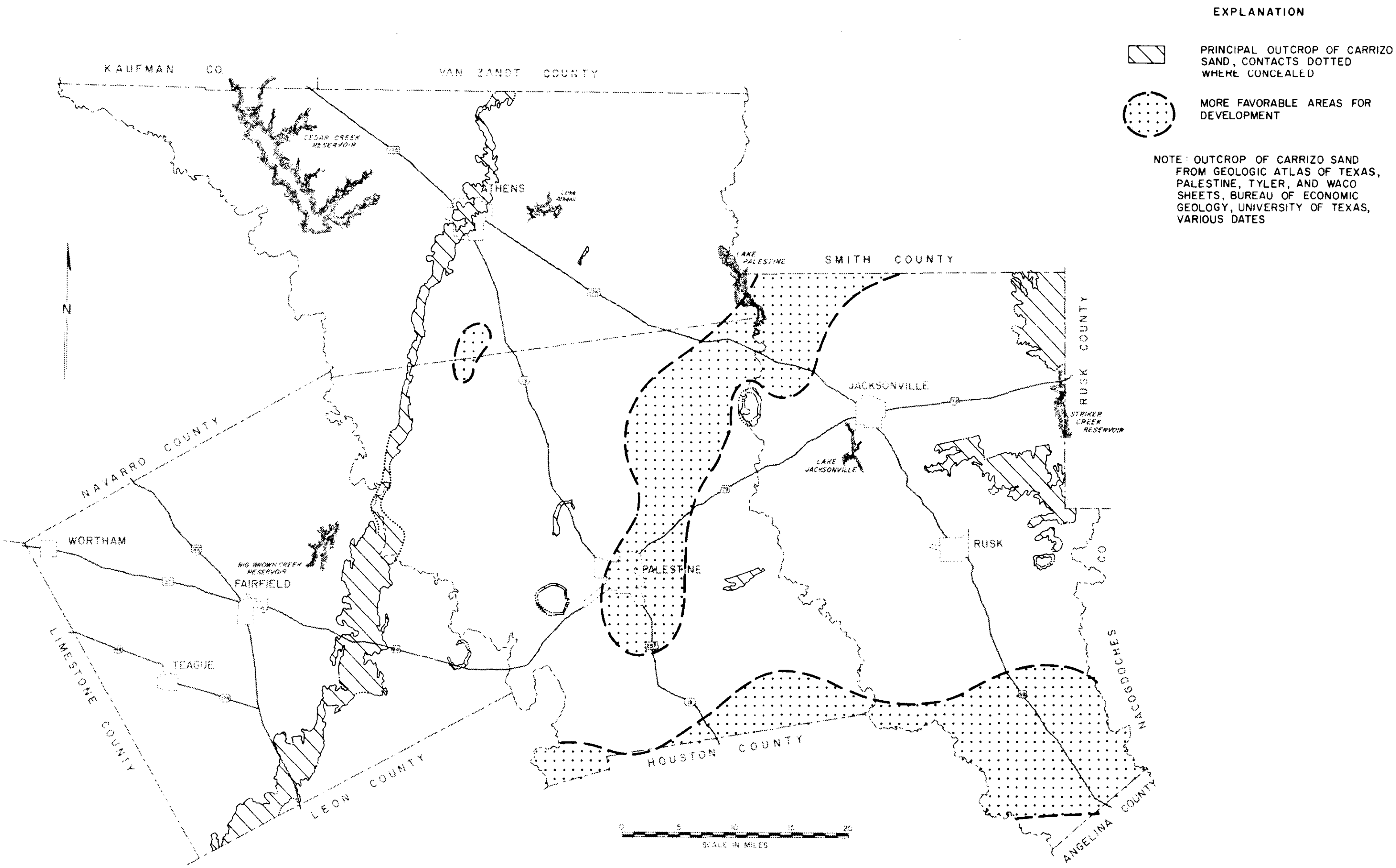


Figure 22

More Favorable Areas for Development-Carrizo Sand

Base from Texas State Highway Department county maps

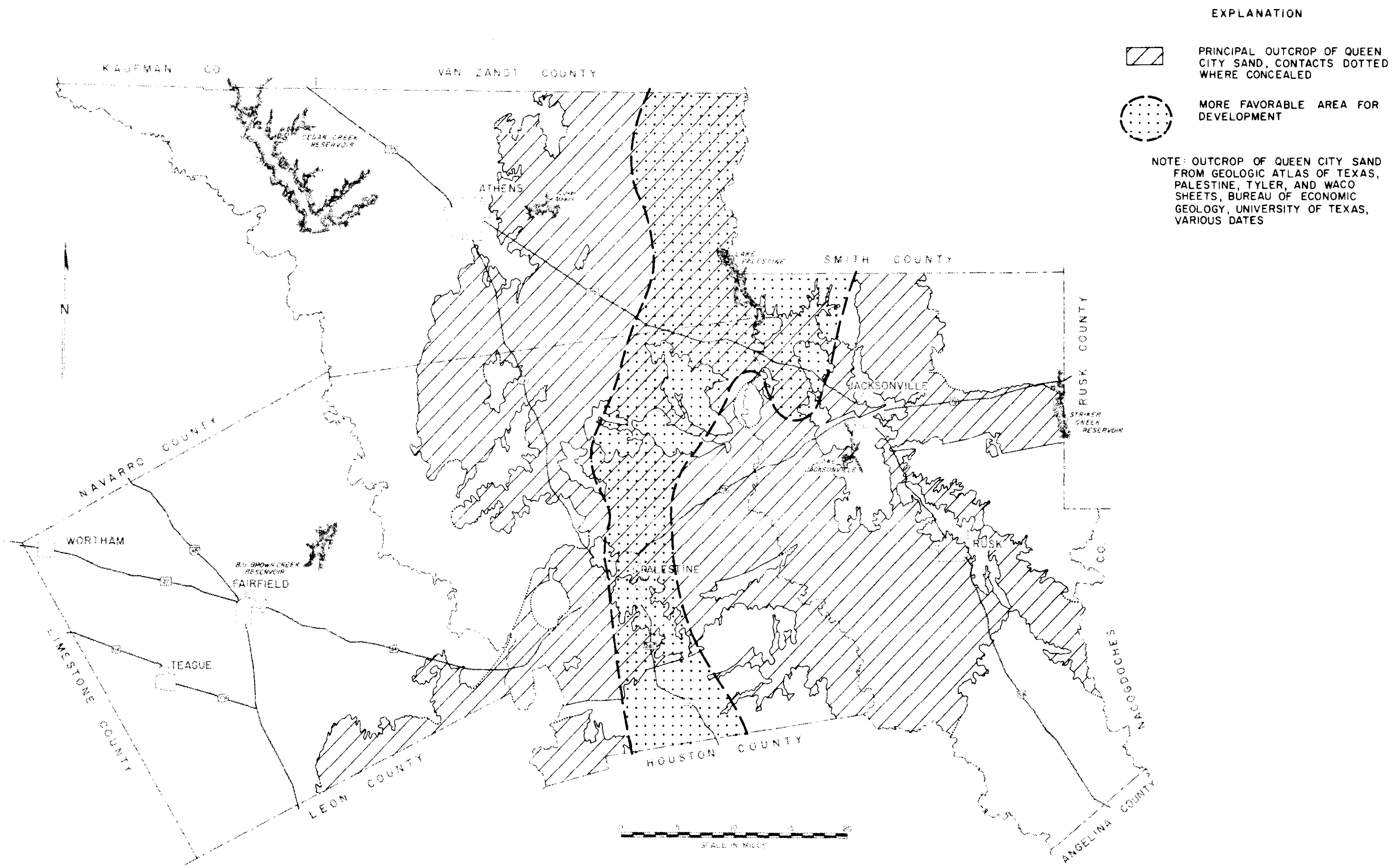


Figure 23

More Favorable Area for Development-Queen City Sand

Base from Texas State Highway
Department county maps

information is desired, it must be obtained by taking water samples.

A standard method for taking water samples from a test hole is shown in Figure 24. In this method, the original hole drilled is 6-3/4-inches in diameter. When the hole penetrates about 15 to 30 feet into a sand from which a water sample is desired, drilling is stopped. The position and shape of the hole at that time is indicated by the drawing at the left side of Figure 24. Next, the hole is reamed to a diameter of 9-7/8-inches down to a point just above the zone selected for water sampling. Then the original 6-3/4-inch hole is washed out to its original depth. The hole at that time is illustrated by the center drawing. Then a string of pipe with packer and screen is set in the hole, as shown at the right of Figure 24. The pipe is usually 4 inches in diameter, and the packer is a commercial rubber cone type, with typical dimensions of 6 by 9 by 14 inches. Often a canvas "shirt tail" is wrapped on the packer to assist in sealing. The packer is set on the shoulder between the 6-3/4-inch and the 9-7/8-inch portion of the hole. Below the packer a commercial 4-inch water well screen 10 to 20 feet long is attached to the 4-inch pipe. After the packer is seated, the temporary well thus constructed is pumped by airlift. The well is usually pumped for several hours until the water becomes clear. If pH, hydrogen sulfide, iron, and manganese are not problems, final samples for chemical analysis are taken at the end of this airlift pumping period. Otherwise, after the water becomes clear the airline is removed from the 4-inch pipe, and a small diameter turbine or hi-lift pump is installed and the temporary well is again pumped until the water becomes clear, after which the final samples are taken. In this case, the pH and hydrogen sulfide are determined in the field at the time the sample is taken. The water normally must be pumped until it is entirely clear, because even a very small amount of mud left in the water will affect the determination of iron and manganese in the water and show falsely high contents of these constituents.

At the end of the pumping, periodic measurements are made of the recovery of the water level in this temporary well, usually for about 2 hours. By study of the rate of water-level recovery, reasonably reliable estimates can usually be made of the static water level, and sometimes valuable information can be obtained concerning the transmissibility of the water-bearing sand which is screened.

The casing and screen are then pulled from the hole, and drilling of the 6-3/4-inch hole is resumed until a second water-bearing zone is encountered from which a water sample is desired, at which time the entire water-sampling process is repeated.

If a large well field is desired, the test-drilling program may be followed by the construction of a pilot production well. This is a well which is located and designed on the basis of the results of the test-drilling program and which is intended to serve as the first well in the proposed well field if successful. After the pilot production well is constructed, it is tested in a thorough manner to determine the operating characteristics of the well, the quality of the water, the coefficients of transmissibility and storage, and any local boundaries of the aquifer. From the tests, decisions are made as to whether the well yield and water quality are satisfactory for the proposed well field and what spacing will be desirable for other wells. Any necessary changes in design of the other wells also are made at this time. Should the pilot production well prove unfavorable, a decision can be made to abandon the project or change its scope before additional wells are constructed.

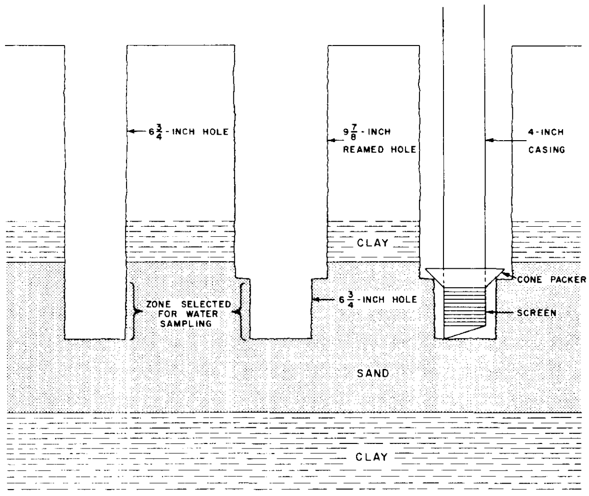


Figure 24.—Procedure for Water Sampling From Test Hole

Moderately yielding wells in the area may be constructed in a manner similar to that shown on Figure 6. Diameters may be enlarged or reduced to more or less than those shown, for greater or lesser yields.

OBSERVATION PROGRAM

At present, an annual survey of ground-water pumpage by major users in this area is conducted by the Texas Water Development Board. Additional observations on the ground-water conditions would be desirable, however, especially for the Carrizo and Wilcox aquifers. Periodic measurements of water levels should be made in a network of wells tapping these aquifers. In addition, occasional inventories should be made of all important new wells which are drilled, and any new electric logs which become available should be compiled. With these records as a base, the observation program may be expanded as needed to observe the effects of any new well fields and to cover other formations.

The results of such an observation program will make possible a continuing evaluation of the availability of ground water throughout the four counties and provide for modifying estimates and/or conclusions as new data show this to be desirable.

PRINCIPAL CONCLUSIONS AND RECOMMENDATIONS

The principal water-bearing formations in Anderson, Cherokee, Freestone, and Henderson Counties are the Wilcox Group, Carrizo Sand, Queen City Sand, and Sparta Sand, in that order. Other geologic formations in these counties are capable of producing only small quantities of fresh water.

Fresh water in the Wilcox Group mostly occurs in its outcrop and downdip to the southeast to a line trending generally northeast-southwest and passing just north of Slocum in Anderson County and Reklaw in Cherokee County. The line approximately parallels the Mount Enterprise fault zone. The estimated 1969 pumpage from the Wilcox Group was 5.5 million gallons per day. The estimated total supply available from wells is 48 million gallons per day, assuming no increase in pumping from outside areas. The estimated maximium yield of a single well ranges up to 1,500 gallons per minute, and the estimated maximum yield of an individual well field up to 12 million gallons per clay, depending upon location. The quality of water is better in the western pat-': of the area than in most of Cherokee County, where, although termed fresh, much of the water is considerably more mineralized than the water obtained from the overlying Carrizo Sand.

The Carrizo Sand contains fresh water throughout its area of occurrence in the four-county area. Pumpage during 1969 is estimated to have been 5.5 million gallons per day. The total supply available from the Carrizo from well fields is estimated at 35 million gallons per day with no increase in pumpage outside the four-county area. Estimated maximum individual well yields range up to 1,500 gallons per minute, and the estimated maximum individual well-field yield ranges up to 10 million gallons per day in one area but is generally less than 6 million gallons per day. The largest well-field yield can be obtained near the southern and southeastern edge of the area, particularly in southeastern Cherokee County, but development of such supplies will lower water levels to such an extent in adjoining areas to the east that the yields of existing well fields at and near Nacogdoches and Lufkin will be seriously affected.

Fresh water is found in the Queen City Sand throughout its outcrop area, which is extensive within the four-county area, and in two relatively small localities downdip, one in southern Anderson County and one in southern Cherokee County. The estimated pumpage from the Queen City Sand in 1969 was 1 million gallons per day. The estimated supply available from wells is 8 million gallons per day. Most of this supply is available in the central part of the area along the axis of the East Texas syncline where the Queen City is the thickest. Estimated maximum yields of individual wells in the Queen City range up to 400 gallons per minute, and the estimated maximum yield of an individual well field ranges up to 1.5 million gallons per day. The quality of water in the Queen City is quite fresh throughout its outcrop area. In extreme southeastern Cherokee County the Queen City water is brackish.

The Sparta Sand has a limited extent within the four-county area. The most important area of its occurrence is in southern Cherokee County where a small area has potential for development. Pumpage from the Sparta in 1969 is estimated to have been about 0.2 million gallons per day, and the estimated supply available is 1 million gallons per day. The estimated maximum individual well yield ranges up to 500 gallons per minute, and the estimated maximum individual well-field yield ranges up to 1 million gallons per day.

A test-drilling program would be desirable before a large development is undertaken in any of the formations in the area where test holes and/or large wells have not previously been drilled or where conditions may be borderline from the standpoint of obtaining the desired quantity or quality of water.

Continuing programs of observation, primarily on pumpage and water levels in wells, should be conducted for the Wilcox and Carrizo aquifers. None of the other formations have enough present development to warrant an observation program.

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Buffalo	1:24,000	Mexia	1:24,000
Bullard	1:62,500	Oakwood	1:24,000
Butler	1:24,000	Palestine	1:62,500
Chandler	1:24,000	Rosser SW	1:24,000
Creslenn Ranch	1:24,000	Roustabout Camp	1:24,000
Cushing	1:62,500	Rusk	1:62,500
Dew	1:24,000	Slocum	1:62,500
Donie	1:24,000	Stewards Mill	1:24,000
Douglass	1:62,500	Streetman	1:24,000
Elkhart	1:62,500	Styx	1:24,000
Fairfield	1:24,000	Teague North	1:24,000
Farrar	1:24,000	Teague South	1:24,000
Frankston	1:62,500	Tennessee Colony	1:62,500
Henderson	1:62,500	Tool	1:24,000
Jacksonville	1:62,500	Troup	1:62,500
Keechi	1:24,000	Turlington	1:24,000
Kennard NE	1:24,000	Wells	1:24,000
Kerens	1:24,000	Winkler	1:24,000
Kirvin	1:24,000	Wortham	1:24,000
Lanely	1:24,000	Young	1:24,000
Long Lake	1:24,000		

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	THICKNESS	DEPTH
Well AA-34-57-801		
Owner: J. T. Whitman Driller: Rekhop Drilling Co.		
Red clay	30	30
Fine sand	46	76
Clay	8	84
Sand	18	102
Shale and coal	68	170
Silty sand	10	180
Shale	20	200
Silty sand	30	230
Shale	60	290
Broken sand	10	300
Shale	35	335
Broken sand	15	350
Shale	5	355
Broken shale	8	363
Shale	22	385
Broken sand	5	390
Shale	10	400
Sand	10	410
Broken sand	30	440
Shale	20	460
Well AA-34-58-901		
Owner: Newman Driller: Rekhop Drilling Co.		
Clay	20	20
Blue clay	30	50
Sand	30	80
Clay	25	105
Rock	1	106
Sand	24	130
Rock	2	132
Shale	33	165
Sand	95	260
Coal	1	261
Shale	149	410
Broken sand	20	430
Rock	5	435
Broken sand	70	505
Water sand	55	560
Well AA-34-60-603		
Owner: City of Frankston No.2 Driller: Texas Water Wells		
Rotary to ground level	11	11
Red clay and gray shale	57	68

	THICKNESS	DEPTH
Well AA-34-60-603 (Continued)		
Sand	21	89
Gray shale	31	120
Lignite and shale	100	220
Sandy shale	36	256
Shale and sand	125	381
Sand and sandy shale	72	453
Shale	32	485
Rock	2	487
Sand	13	500
Shale	22	522
Rock	4	526
Sand, good	70	596
Shale with sand streaks	51	647
Well AA-34-61-703		
Owner: B. L. Saunders Driller: White Drilling Co.		
Red and yellow sandy clay	6	6
Red and white pack sand	39	45
Gray sandy shale with thin sand streaks	55	100
Gray sticky shale	54	154
Gray sand	206	360
Gray sandy shale	50	410
Gray sticky shale	10	420
Green sand	25	445
Gray and brown shale with rock layers	24	469
Green sand	11	480
Green and brown sandy shale	30	510
Gray sticky shale	20	530
Gray sandy shale with fine sand streaks	25	555
White shale	15	570
White sand (medium fine)	45	615
Well AA-38-01-806		
Owner: B.C.Y. Water Supply Corp. No.1 Driller: Andrews & Foster Drilling Co.		
Red clay	10	10
Sand	138	148
Shale	12	160
Sand and shale	20	180
Shale and sand	10	190
Sand	60	250
Shale	20	270
Sand	20	290
Shale	15	305

	THICKNESS	DEPTH
Well AA-38-01-806 (Continued)		
Shale	15	320
Shale	55	375
Sand	115	490
Shale and sand	18	508
Shale	7	515
Sand and rock	20	535
Shale	45	580
Sand	90	670
Shale	50	720
Soft sandy shale	20	740
Shale	28	768
Sandy shale	44	812
Shale	53	865
Sandy shale	30	895
Shale	19	914
Soft sandy shale	26	940
Shale and rock breaks	122	1,062
Well AA-38-02-402		
Owner: Arnold Wisenbaker Driller: Rekhop Drilling Co.		
Surface	7	7
Sand	28	35
Shale	15	50
Sand	18	68
Shale	62	130
Sand	90	220
Shale	90	310
Broken sand and shale	55	365
Shale	165	530
Broken sand and shale	15	545
Sand	25	570
Sand with shale streaks	55	625
Shale	5	630
Well AA-38-03-701		
Owner: Montalba Water Supply Corp. Driller: Layne Texas Co.		
Top soil	3	3
Hard red clay	25	28
Rock	2	30
Layers of rock and sand streaks	18	48
Clay and rock	12	60
Fine sand	8	68
Clay and sand layers	26	94
Shale and sand	244	338

	THICKNESS	DEPTH
Well AA-38-03-701 (Continued)		
Fine sand	18	356
Shale	8	364
Sand	87	451
Shale	15	466
Hard shale and lignite	129	595
Sandy shale	8	603
Rock	5	608
Shale and layers of rock	2	610
Gray shale, sandy shale and hard streaks	46	656
Sandy shale (cut good)	20	676
Shale	10	686
Lignite	14	700
Light gray sandy shale	41	741
Sandy shale and sand	42	783
Sand and lignite	60	843
Shale	23	866
Sandy shale and shale	177	1,043
Shale	5	1,048
Shale and sand streaks	9	1,057
Sand and shale layers (cut hard)	22	1,079
Sand, lignite and shale breaks	31	1,110
Sand, layers of lignite and shale	29	1,139
Sand and shale streaks	23	1,162
Sand and shale breaks	5	1,167
Shale	3	1,170
Shale, sand layers and lignite	23	1,193
Well AA-38-04-201		
Owner: W. H. Whitehurst Driller: White Drilling Co.		
Red pack sand	30	30
White clay with coarse sand streaks	45	75
Brown shale	5	80
Gray sticky shale	23	103
Brown and gray sandy shale	52	155
Brown sticky shale	64	219
Brown sand with sandy shale streaks	26	245
Gray sticky shale	20	265
Gray sand	45	310
Gray sticky shale	20	330
Gray sandy shale	10	340
Gray sticky shale	18	358
Gray sand with rock layers	51	409
Brown sandy shale	3	412
Gray sticky shale	33	445

Well AA-38-04-201 (Continued)

	THICKNESS	DEPTH
Brown and green sandy shale	35	480
Green sand	20	500
Brown sandy shale	10	510
Gray sticky shale with rock layers	10	520
Brown shale	5	525
Green sand	25	550
Gray sticky shale	15	565
Green and brown sandy shale with sand streaks	20	585
White sand	15	600
White shale	20	620
White sand	16	636
Gray shale	2	638
Good gray sand	17	655

Well AA-38-05-401

Owner: W. T. Todd
Driller: Layne Texas Co.

	THICKNESS	DEPTH
Surface sand	9	9
Clay	6	15
Sand, rock	16	31
Sandy clay	23	54
Hard rock	1	55
Iron ore	5	60
Hard sandy shale	12	72
Fine gray water sand	22	94
Hard shale	14	108
Fine white water sand	15	123
Hard shale	7	130
Sandy shale with streaks of sand and lignite	68	198
Fine gray sand, dry	20	218
Shale and lignite	3	221
Sandy shale and lignite	9	230
Gumbo	27	257
Fine gray sand	28	285
Gumbo	6	291
Hard rock	1	292
Sandy shale and boulders	102	394
Brown shale	37	431
Sandy shale	31	462
Sand, rock	2	464
Shell	23	487
Sand, rock	1	488
Shale	25	513
Rock	1	514
Shale	5	519

Well AA-38-05-401 (Continued)

	THICKNESS	DEPTH
Gumbo	25	544
Sandy shale and boulders	14	558
Hard sandy shale and boulders	15	573
Packed sand	5	578
Hard sandy shale and shale streaks	67	645
Hard white rock	50	695
Shale and lignite	15	710
Gumbo	9	719
Rock	1	720

Well AA-38-09-601

Owner: State of Texas Dept. of Corrections
Driller: Layne Texas Co.

	THICKNESS	DEPTH
Clay and sandy clay	90	90
Brown sand and lignite	315	405
Sandy shale and streaks of lignite	132	537
Sand, broken	25	562
Sandy shale and streaks of sand	30	592
Sand and sandy shale	108	700
Lignite	5	705
Sand	63	768
Shale, streaks of sand and lignite	110	878
Sand	90	968
Shale	17	985

Well AA-38-11-901

Owner: City of Palestine No.1
Driller: Layne Texas Co.

	THICKNESS	DEPTH
Surface sand	13	13
Clay	22	35
Lignite	2	37
Sand, shale and lignite	120	157
Shale	25	182
Sand	62	244
Shale	16	260
Sandy shale	45	305
Sand	6	311
Sand, shale and lignite	71	382
Shale	14	396
Shale, layers of rock	4	400
Shale	32	432
Sand	12	444
Sand, shale	23	467
Shale	23	490
Sand, shale	48	538
Sand	27	565

	THICKNESS	DEPTH
Well AA-38-11-901 (Continued)		
Shale	10	575
Sandy shale	25	600
Shale	19	619
Sandy shale	101	720
Rock	2	722
Shale	22	744
Fine gray sand	32	776
Lignite	8	784
Sand, shale	98	882
Sand	14	896
Sandy shale	216	1,112
Hard sandy shale	74	1,186
Shale	99	1,285
Rock (very hard)	9	1,294
Sand	90	1,384
Shale	16	1,400
Shale and sand	36	1,436
Sand	153	1,589
Shale	78	1,667
Fine shaly sand and lignite	50	1,717
Sand, shale	44	1,761
Hard shale	30	1,791
Sandy shale	94	1,885
Rock	1	1,886
Shale	27	1,913
Sand	25	1,938
Shale	80	2,018
Well AA-38-13-106		
Owner: Neches Water Supply Corp. Driller: C. C. Innerarity		
Reddish clay	12	12
Coffee ground formation	13	25
Small sand streaks	10	35
Blue clay	70	105
Sand, clay	30	135
Sand and blue clay	30	165
Blue clay	33	198
Blue clay	22	220
Sand and clay streaks	40	260
Blue clay	96	356
Sand	19	375
Hard clay	5	380
Sand and clay	40	420
Sand, very little clay	96	516
Hard clay	29	545

	THICKNESS	DEPTH
Well AA-38-13-106 (Continued)		
Tight sand	56	601
Hard clay	4	605
Well AA-38-18-901		
Owner: Woodhouse Consolidated School Driller: Layne Texas Co.		
Soil	1	1
Red clay	7	8
Sand	7	15
Clay	2	17
Sand	5	22
Rock	2	24
Clay	6	30
Rock	1	31
Gray sand	12	43
Rock	1	44
Coarse gray sand	12	56
Sand and thin clay layers	20	76
Gray sandy clay	22	98
White sand	31	129
Sand and clay layers	14	143
Gray sand	21	164
Red shale	1	165
Shale	36	201
Sandy shale	22	223
Shale	24	247
Rock (hard)	1	248
Shale	21	269
Rock (hard)	6	275
Shale and sandy shale	31	306
Shale and sandy shale	25	331
Shale and sand layers	9	340
Sand, gray (good)	19	359
Shale	2	361
Well AA-38-19-803		
Owner: Lakeview Methodist Assembly No.1 Driller: Layne Texas Co.		
Clay	56	56
Sand and shale	32	88
Shale	47	135
Sand and shale	29	164
Shale	94	270
Sand	10	280
Shale	4	284
Sand and breaks of shale	23	307

	THICKNESS	DEPTH
Well AA-38-19-803 (Continued)		
Shale	8	315
Fine white sand	95	410
Shale	173	583

Well AA-38-20-702

Owner: Miss Ivey Payne
Driller: White Drilling Co.

	THICKNESS	DEPTH
Red, yellow and white sandy clay	15	15
Yellow and brown clay	15	30
Green shale with sand streaks	30	60
Brown sand and sandy shale	50	110
Brown and green sandy shale	33	143
Brown sand	53	196
Gray and brown sandy shale	20	216
Gray sand with shale streaks	64	280
Gray shale	10	290
Fine gray sand with shale and lignite streaks	70	360
Brown shale	30	390
Brown and gray sandy shale	55	445
Brown sand	6	463
Brown and gray sandy shale	97	560
Brown shale and sandy shale	15	575
Brown and green sandy shale	30	605
Green sandy shale and green sand	30	635
Green and brown sand and sandy shale	40	675
White sand	82	757
Gray shale	42	799
Medium fine gray sand with thin streaks of sandy shale	61	860

Well AA-38-21-705

Owner: Shell Oil Co., J. B. Parker No.2
Driller: Layne Texas Co.

	THICKNESS	DEPTH
Surface soil	10	10
Shale and hard streaks	60	70
Streaks of shale and sand	85	155
Sand and streaks of shale	51	206
Shale	14	220
Sand and streaks of shale	80	300
Sandy shale, streaks of lignite and rock	193	493
Shale and sand streaks	12	505
Sand and streaks of shale	89	594
Shale and streaks of sand	61	655
Shale	95	750
Shale and streaks of lime	75	825
Shale and streaks of lignite	193	1,018

	THICKNESS	DEPTH
Well AA-38-21-705 (Continued)		
Rock	3	1,021
Shale and lignite	39	1,060
Sand	24	1,084
Shale	6	1,090
Sand and streaks of shale	45	1,135
Shale	16	1,151
Sand	10	1,161
Shale, streaks of lime and lignite	142	1,303
Shale and sandy shale	245	1,548
Fine sand	40	1,588
Lime	2	1,590
Sandy shale	50	1,640
Shale and streaks of sand	82	1,722
Coarse sand and streaks of lignite	50	1,772
Lignite and shale	5	1,777
Coarse sand and lignite	31	1,808
Shale and lignite	10	1,818
Fine sand and lignite	10	1,828
Shale and sandy shale	25	1,853

Well AA-38-27-705

Owner: Emmett Coleman
Driller: Carruth Drilling Co.

	THICKNESS	DEPTH
Sand and surface clay	30	30
Hard shale and shells	35	65
White sand (no water)	55	120
Shale	140	260
Tight sand	20	280
Water sand	50	330
Water sand	20	350

Well AA-38-28-202

Owner: City of Elkhart No.1
Driller: Layne Texas Co.

	THICKNESS	DEPTH
Surface clay	60	60
Blue shale	20	80
Blue soft shale	80	160
Gumbo	18	178
Hard gumbo	101	279
Hard shale	23	302
Sand, rock and boulders	28	330
Water sand	40	370
Hard shale	58	428
Water sand and sand rocks	40	468
Hard shale	4	472
Hard shale, mixed with sand	98	570
Water sand	70	640

Well DJ-34-54-801

Owner: J. E. Boyle
Driller: White Drilling Co.

	THICKNESS	DEPTH
Red, white, and yellow clay	17	17
Green shale with rock layers	43	60
Brown shale with brown sand streaks	110	170
Gray shale and sandy shale	30	200
Coarse gray sand	222	422
Brown sandy shale	27	449
Gray shale	6	455
Gray and brown sandy shale	153	608
Gray sticky shale	25	633
Gray and brown shale	45	678
Green sand with rock layers	12	690
Brown sandy shale with rock layers	10	700
Green sand	10	710
Brown sandy shale	15	725
Clear, white sand	8	733
Brown sandy shale and green sand	22	755
White shale and sandy shale	14	769
Gray shale and lignite streaks	11	780
Fine gray sand	11	791
Gray sandy shale	29	820
Fine gray sand	10	830
Hard brown shale	6	836
Hard brown shale	4	840
Gray sticky shale	5	845
Fine gray sand	22	867
Gray sticky shale	23	890
Gray and brown shale	32	922
Very fine gray sand	6	928
Gray sandy shale	8	936
Fine gray sand	9	945
Hard gray shale	11	956
Brown sandy shale	28	984
Gray sticky shale	32	1,016
Gray sandy shale	19	1,035
Fine gray sand	32	1,067
Gray sandy shale	15	1,082
Medium fine sand	10	1,092
Gray shale	19	1,111
Very fine gray sand	5	1,116
Hard shale	7	1,123

Well DJ-34-62-901

Owner: Eunice Sanborn
Driller: Layne Texas Co.

	THICKNESS	DEPTH
Sandy soil	6	6
Rock	2	8
Red rock and hard sand	7	15
Blue and yellow hard sand	5	20
Blue rock	11	31
Rotten green shale	6	37
Rock	1	38
Rotten green shale	7	45
Rock	2	47
Blue rock	21	68
Brown clay and hard layers of fine sand	74	142
Brown sand	83	225
White salt and pepper sand	73	298
Shale and sand	25	323
Sand	40	363
Shale	26	389
Hard shale	15	404
Brown shale	80	484
Rock	1	485
Boulders	2	487
Brown shale	63	550
Rock and boulders	8	558
Boulders and shale	10	568
Shale and boulders	48	616
Tough shale	5	621
Shale	22	643
Fine sand	28	671
Shale	17	688
Shale and shells	67	755
Tough shale	18	773
Shale and shells	22	795
Shale	40	835
White sand	11	846
Sand and lignite (coal)	22	868
Broken layers of sand - lignite and shale	57	925
Lignite coal	10	935
Tough shale	17	952
Shale and shells	24	976
Rock	3	979
Tough shale	23	1,002
Shale	23	1,025

	THICKNESS	DEPTH
Well DJ-34-63-301		
Owner: L. S. Wilson Driller: White Drilling Co.		
Red, yellow and white clay	20	20
Brown shale with some green shale	72	92
Gray and brown shale	23	115
Gray sticky shale	13	128
Brown and green shale	49	177
Green sand	10	187
Brown shale with thin sand streaks	23	210
Fine sand and sandy shale	22	232
Gray sticky shale	5	237
Gray and brown shale	4	241
White sand	43	284
Well DJ-34-63-605		
Owner: J. Paul Karcher Driller: Rehkop Drilling Co.		
Surface	12	12
Shale	43	55
Rock	1	56
Shale	89	145
Sand	10	155
Broken sand and shale	55	210
Sand	15	225
Shale	125	350
Silty sand	63	413
Sand	7	420
Shale	10	430
Sand	18	448
Well DJ-34-64-402		
Owner: Blackjack Water Supply Corp. Driller: Lanford Drilling Co.		
Clay	90	90
Brown fine sand	28	118
Brown shale	64	182
Medium grey shale	22	204
Shale	179	383
Medium grey shale	92	475
Shale	79	554

	THICKNESS	DEPTH
Well DJ-34-64-502		
Owner: New Concord Water Supply Corp. Driller: Key Water Well and Drilling Co.		
Surface soil	20	20
Surface sand	20	40
Sandy shale	15	55
Water sand	20	75
Shale	7	82
Sand	3	85
Sandy shale	25	110
Water sand	81	191
Sandy shale	40	231
Sand	9	240
Sandy shale	40	280
Sand with shale brake	52	332
Water sand	83	415
Shale	12	427
Well DJ-37-01-401		
Owner: Texas Power and Light Co. No. 1 Driller: Texas Water Wells		
Surface	15	15
Sand	45	60
Sandy clay	19	79
Clay	11	90
Hard sand and shale	79	169
Shale	46	215
Shale and hard streaks	82	297
Soft shale and hard streaks	13	310
Sandy shale	20	330
Sand	23	353
Sandy shale	4	357
Sand soft streaks	89	446
Shale	4	450
Sandy shale hard	17	467
Hard sand	7	474
Hard sandy shale	26	500
Well DJ-37-33-202		
Owner: City of Wells Driller: Layne Texas Co.		
Clay	16	16
Sand	4	20

	THICKNESS	DEPTH
Well DJ-37-33-202 (Continued)		
Clay	31	51
Clay and sand streaks	17	68
Rock	2	70
Shale and sand streaks	60	130
Hard shale	59	189
Sandy shale	20	209
Find sand	35	244
Shale and streaks of sand	129	373
Shale and sandy shale	120	493
Sand and shale streaks	48	541
Shale and sandy shale	131	672
Rock	4	676
Hard shale	21	697
Rock	1	698
Sandy shale	40	738
Shale and rock layers	9	747
Shale and sandy shale	55	802
Sand and shale streaks	36	838
Sand	24	862
Sandy shale and shale	19	881
White sand	59	940
Sand and shale streaks	9	949
Shale	11	960
Well DJ-38-05-903		
Owner: Humble Oil and Refining Co. No. 1 Driller: Texas Water Wells		
Surface sand and clay	6	6
Red clay	11	17
Sand and gravel, streaks of red clay	16	33
Gray shale	27	60
Fine gray sand	22	82
Gray shale	37	119
Rock, hard	2	121
Gray shale	33	154
Rock, hard	1	155
Gray shale, streaks of rock	30	185
Rock	1	186
Green sand	24	210
Shale	3	213
Brown sand	24	237
Shale	11	248
Sand streaks	52	300

	THICKNESS	DEPTH
Well DJ-38-05-903 (Continued)		
Sand, small streaks of lignite	45	345
Sandy shale	4	349
Sand	7	356
Rock, hard	2	358
Shale - streaks rock	18	376
Hard sand, lignite	42	418
Hard rock	2	420
Sandy rock shale	19	439
Shale streaks, rock and streaks of sand	34	473
Sand and streaks of rock	11	484
Shale	18	502
Rock	1	503
Shale	2	505
Well DJ-38-06-604		
Owner: City of Jacksonville No. 1 Driller: Layne Texas Co.		
Iron ore and green rock	7	7
Iron ore and green rock	10	17
Green rock	10	27
Green rock and clay	16	43
Fine white sand	9	52
Yellow and brown clay	61	113
Brown clay	27	140
Packed white sand	12	152
Brown clay	7	159
Blue sand and shale	45	204
Soft gray sand and shale layers	28	232
Sandy shale and shale	57	289
Gray green sand (good)	43	332
Sandy shale and lignite	40	372
Brown shale	9	381
Green sandy shale	20	401
Blue sandy shale	19	420
Blue and gray shale	11	431
Green and blue shale and boulders	16	447
Fine brown sand	9	456
Gray shale and boulders	14	470
Sandy shale and boulders	10	480
Blue shale and boulders	21	501
Brown and blue shale	22	523
Blue sandy shale and boulders	20	543

	THICKNESS	DEPTH
Well DJ-38-06-604 (Continued)		
Fine blue gray sand	10	553
Blue sandy shale and lignite	5	558
Fine white sand	25	583
Gray green sand and sandy shale	26	609
Coarse white sand	54	663
White sand (cuts good)	34	697
Hard blue shale	6	703
Brown sandy clay and lignite streaks	55	758
Hard brown shale	36	794
Brown shale and thin layers of lignite	39	833
Rock	1	834
Brown shale	15	849
Sandy shale	13	862
Brown shale	24	886
Gray shale and lignite	31	917
Gray sandy shale	11	928
Gray sand - good	50	978
Shale and hard lignite	5	983
Sand (cuts good)	3	986
Hard shale, lignite and sand breaks	19	1,005
Sand (cuts good)	6	1,011
Packed sand shale and lignite	5	1,016
Sand (cuts good)	15	1,031
Sandy shale and lignite	25	1,056
Fine gray sand (cuts good)	16	1,072
Sandy shale	8	1,080
Fine gray packed sand and lignite	21	1,101
Gray sand - drills good	57	1,158
Hard sand	4	1,162
Hard gray shale	23	1,185
Hard brown sand lignite and shale	15	1,200
Gray fine sand	15	1,215
Gray sticky shale	24	1,239
Shale and boulders	25	1,264
Gray shale and sand breaks	42	1,306
Sandy shale	7	1,313
Hard rock	3	1,316
Sandy shale	14	1,330
Hard sand rock	1	1,331
Sand	15	1,346
Hard sand rock	1	1,347
Sand - drills good	23	1,370
Hard rock	4	1,374
Shale and sand breaks	11	1,385
Sand and lignite	5	1,390
Sticky shale	5	1,395
Sand and lignite	5	1,400
Rock	1	1,401
Shale, sand breaks, lignite	63	1,464
Hard shale	8	1,472
Sandy shale	21	1,493
Sand and brown sand	72	1,565
Well DJ-38-07-902		
Owner: Gallatin Water Supply Corp. Driller: Key Water Well and Drilling Co.		
Surface and clay	30	30
Shale	218	248
Sand	20	268
Shale	39	307
Water sand	63	370
Shale	10	380
Well DJ-38-08-105		
Owner: New Summerfield Water Supply Corp. Driller: Layne Texas Co.		
Red clay and iron rock	16	16
White clay and sand layers	8	24
Brown clay	36	60
Gray sandy clay	40	100
Sandy shale and lignite	31	131
Sand	5	136
Sandy shale	55	191
Sand	10	201
Sand and shale	17	218
Sand (cut good)	10	228
Sandy shale	97	325
Rock	1	326
Sandy shale	79	405
Sand and shale	20	425
Sandy shale layers	23	448
Shale	6	454
Sand and shale layers	21	475
Shale and sand streaks	20	495
Sandy shale	7	502

	THICKNESS	DEPTH
Well DJ-38-08-105 (Continued)		
Sand (hard)	26	528
Sand and shale	6	534
Sand	12	546
Sand and shale	29	575
Shale and hard layers	13	588
Shale and sand layers	80	668
Sand (fine)	9	677
Shale and sand layers	25	702
Sand	3	705
Shale and sand layers	84	789
Rock	1	790
Sand	8	798
Lignite	3	801
Sandy shale and layers of sand	47	848
Sand and thin shale layers	27	875
Sand and shale layers	10	885
Sand and thin shale layers	35	920
Sand and thin shale layers	2	922
Sand	80	1,002
Shale and sand layers	8	1,010
Sandy shale and lignite	62	1,072
Shale and sand	18	1,090
Sand and shale	34	1,124

Well DJ-38-08-302

Owner: Stryker Lake Water Supply Corp.
Driller: Rehkop Drilling Co.

	THICKNESS	DEPTH
Sand	8	8
Iron ore rock	1	9
Green sand	51	60
Queen City sand	30	90
Shale	40	130
Sand	50	180
Shale	30	210
Sand	66	276
Shale	2	278
Carrizo sand	26	304
Shale	12	316

Well DJ-38-13-304

Owner: W. M. Seeton
Driller: White Drilling Co.

	THICKNESS	DEPTH
Surface sand	8	8
Red and yellow clay	9	17

	THICKNESS	DEPTH
Well DJ-38-13-304 (Continued)		
Green shale/rock layers	44	61
Green sand	24	85
Brown shale and sandy shale	35	120
Fine gray sand with shale streaks	75	195
Gray shale	10	205
Gray sand	5	210
Gray shale	5	215
Gray sand with shale streaks	112	327
Gray sandy shale with lignite streaks	17	344
Gray sand with sandy shale streaks	29	373
Brown and gray sandy shale	59	432
Gray sticky shale	9	441
Gray sandy shale	7	448
Brown and gray sticky shale	7	455
Brown sandy shale	20	475
Brown shale with rock layers	56	531
Green and brown shale with rock layers	50	581
Gray sand	5	586
Gray shale	14	600
Gray clear sand	20	620
White shale	7	627
Good white sand	21	648

Well DJ-38-14-503

Owner: Maydelle Water Supply Corp.
Driller: C. C. Innerarity

	THICKNESS	DEPTH
Red and white clay	13	13
Red surface sand	12	25
White clay	10	35
Hard blue clay	168	203
Sand	1	204
Hard blue clay	28	232
Sand	1	233
Blue clay (soft)	35	268
Sand	2	270
Soft clay	14	284
Clay	30	314
Sand	17	331
Clay	9	340
Sand	3	343
Clay	5	348
Sand	1	349

	THICKNESS	DEPTH
Well DJ-38-14-503 (Continued)		
Clay	2	351
Sand with 3" to 4" clay strips	15	366
Clay	24	390
Sand (400-404 good)	14	404
Hard clay	42	446
Sand	4	450
Hard clay	45	495
Soft clay	14	509
Clay with sand streaks	64	573
Soft shale	7	580
Sand with shale	7	587
Sand streaks with shale	100	687
Clay	10	697
Hard clay	3	700

Well DJ-38-15-102

Owner: Dialville - Oakland Water Supply Corp.
Driller: Layne Texas Co.

	THICKNESS	DEPTH
Surface	3	3
Rock	4	7
Rock and sandy clay	21	28
Sandy clay and streaks sand	56	84
Sand and sandy clay	85	169
Sand	25	194
Sand and sandy clay	16	210
Sand and sandy clay	45	255
Sand	51	306
Sandy clay	9	315
Rock	1	316
Sandy clay and sand	58	374
Shale	98	472
Sandy shale and hard streaks	41	513
Sand (broken)	17	530
Sand (broken)	20	550
Sand and gravel	43	593
Clay and streaks sand	19	612
Sand	40	652
Shale (broken)	20	672
Sand	20	692
Sandy clay	49	741
Clay	8	749

Well DJ-38-15-601

Owner: City of Rusk No. 1
Driller: Layne Texas Co.

	THICKNESS	DEPTH
Bed clay	15	15
Sandy clay and gravel layers	2	17
Fine yellow sand	20	37
Fine brownish sand	16	53
Brown clay	22	75
Sand	40	115
Hard sand	5	120
Hard brown and yellow shale	24	144
Hard fine grey sand	15	159
Hard fine grey shale, sandbreaks - hard	28	187
Hard fine shale	37	224
Rock	4	228
Shale	55	283
Rock	2	285
Hard brown shale	28	313
Hard brown shale	4	317
Fine grey broken sand	15	332
Fine grey sand - cut good	25	357
Fine hard grey sand, blue, red, white shale	25	382
Fine hard packed grey sand	22	404
Soft grey sand	31	435
Soft grey sand	25	460
Grey shale and sand	37	497
Grey shale and sand	122	619
Grey shale	37	656
Grey shale, sandy shale, layers of lignite	19	675
Grey sandy shale and sand	56	731
Fine grey sand and shale (cut fair)	41	772
Fine light grey sand (cut fair)	19	791
Good grey sand (cuts little hard)	33	824
Sand and hard lignite	6	830
Lignite	20	850
Fine grey sand (cut fair)	15	865
Lignite and hard sand	25	890
Hard grey shale with breaks of fine grey sand and lignite	45	935
Fine grey sand and lignite	25	960
Gray sand with lignite and shale breaks	24	984

Well DJ-38-15-601 (Continued)

	THICKNESS	DEPTH
Grey sand with lignite	25	1,009
Grey sand (cuts good)	25	1,034
Grey sand and lignite	25	1,059
Grey shale and lime	16	1,075
Grey sand and lime shale	26	1,101
Rock	4	1,105
Rock	1	1,106
Coarse sand, shale, lignite and shell	39	1,145
Coarse grey sand (good)	30	1,175
Rock	2	1,177
Rock	2	1,179
Hard blue shale and lignite	25	1,204
Shale and lignite	32	1,236
Rock	1	1,237
Shale	25	1,262
Rock	2	1,264
Fine light grey shale and sand	25	1,289
Soft grey sand	42	1,331
Light grey sand and shale streaks	143	1,474
Sand, shale and lignite layers	24	1,498
Sandy shale and lignite	7	1,505

Well DJ-38-23-306

Owner: Earnest Hudnall
Driller: Frye Drilling Co.

	THICKNESS	DEPTH
Top soil and sand	22	22
Shale, some rock	17	39
Shale, some rock	41	80
Shale, some rock	21	101
Shale	20	121
Soft shale	21	142
Soft shale	20	162
Soft shale, rock	21	183
Shale, rock	20	203
Shale, some rock	41	244
Shale, fine sand	21	265
Sand, shale, sand	20	285
Interbedded sand and shale	21	306
Good sand, some shale	20	326
Good sand	22	348

Well DJ-38-24-804

Owner: City of Alto No. 2
Driller: Texas Water Wells

	THICKNESS	DEPTH
Ground level	4	4
Clay	2	6
Rock	4	10
Clay	15	25
Shells, shale and sand streaks	51	76
Shale	36	112
Sand	108	220
Shale	240	460
Sand	12	472
Sandy shale	28	500
Sand	86	586
Shale	5	591
Sand	14	605
Shale	8	613

Well DJ-38-32-908

Owner: R. S. Hadaway
Driller: Innerarity and Leubner Drilling Co.

	THICKNESS	DEPTH
Red clay	15	15
Surface sand	35	50
Blue clay	7	57
Sand strips	3	60
Blue clay	49	109
Sand strips	28	137
Blue clay	18	155
Sand strips	25	180
Clay and sand strips	20	200
Clay	25	225
Sand	16	241

Well KA-38-17-301

Owner: R. L. Lipsey
Driller: Katy Drilling, Inc.

	THICKNESS	DEPTH
Surface - clay	15	15
Clay - sand breaks	15	30
Sand - rock	22	52
Clay	35	87
Sand and clay breaks	30	117
Sand - rock - lignite	41	158
Clay - lignite	61	219
Sand	7	226
Clay	31	257
Sand - rock	14	271
Clay - lignite	37	308
Clay	100	408
Sand	18	426
Shale - lignite	90	516
Sand	5	521
Shale - lignite	11	532
Sand - shale breaks	11	543
Shale	57	600
Sand	10	610
Shale	5	615
Sand	30	645
Shale	37	682
Sand	75	757
Shale	14	771
Sand	11	782
Shale	27	809

Well KA-38-17-803

Owner: Allen Beatty
Driller: Neal Drilling Co.

	THICKNESS	DEPTH
Clay	23	23
Sand	9	32
Blue shale, rock at 35 feet	13	45
Sand	20	65
Sandy shale	15	80
Blue shale	20	100
Gray sandy shale, rock at 120 and 134 feet	40	140
Sandy shale	10	150
Gray shale	7	157
Sandy shale	13	170
Sand	15	185
Gray shale	15	200
Blue shale	20	220
Gray shale, rock at 294 feet	96	316

Well KA-38-17-803 (Continued)

	THICKNESS	DEPTH
Sandy shale	39	355
Gray shale	17	372
Sand	6	378
Gray shale	12	390
Sand	5	395
Gray shale	10	405
Sand	25	430

Well KA-38-18-803

Owner: Easter Price
Driller: Frank Ward

	THICKNESS	DEPTH
Red Clay	4	4
Yellow sandy clay	16	20
Yellow coarse sand	20	40
Rock hard	1	41
Dark shale, traces rock	29	70
Rock hard	1	71
Sand	3	74
Hard shale	2	76
Sand gray light	19	95

Well KA-39-08-405

Owner: Ben Ward
Driller: Frank Ward

	THICKNESS	DEPTH
Top soil	1	1
Red clay	2	3
Yellow clay	15	18
Yellow coarse sand	3	21
Yellow clay	14	35
Coal	7	42
Shale, trace sand, coal	28	70
Dark shale	10	80
Gray sand	25	105
Gumbo dark	2	107

Well KA-39-14-501

Owner: Ruell Lopes
Driller: R. K. Sims

	THICKNESS	DEPTH
Red clay	10	10
Sandy clay	1	11
White clay	6	17
Blue shale	5	22
Rock	15	37
Red sand	3	40
Sandy shale	30	70
Blue shale	20	90

	THICKNESS	DEPTH
Well KA-39-14-501 (Continued)		
Shale, water, sand	10	100
Shale	22	122
Well KA-39-15-102		
Owner: Cvel Kimball Driller: Frank Ward		
Top soil	12	12
Red clay	8	20
Yellow clay	15	35
Dark shale	54	89
Hard rock	1	90
Sand shale dark	20	110
Dark shale	30	140
Dark shale, traces of sand	40	180
Dark gumbo	37	217
Rock hard	1	218
Gray sand	27	245
Dark gumbo	2	247
Well KA-39-15-601		
Owner: Industrial Generating Co. Driller: Layne Texas Co.		
Top soil	2	2
Clay	26	28
Lignite	3	31
Clay	50	81
Sand with hard streaks	50	131
Shale with streaks of sand	41	172
Rock	1	173
Shale	13	186
Sand	25	211
Shale	21	232
Sand with hard streaks	53	285
Shale with streaks of lignite and sand	20	305
Shale	30	335
Sand and shale	42	377
Sand (cut good)	72	449
Shale with streaks of sand	13	462
Shale	52	514
Sand with streaks of lignite	7	521
Sand (broken) (poor)	34	555
Shale	34	589

	THICKNESS	DEPTH
Well KA-39-15-703		
Owner: Pleasant Grove Water Supply Corp. Driller: Andrews and Foster Drilling Co.		
Sandy shale	10	10
White sand	60	70
Blue shale	8	78
Sand, lignite at 87 feet	10	88
Shale	22	110
Rock	1	111
Shale	2	113
Lignite	3	116
Shale	19	135
Sandy shale	10	145
Lignite	4	149
Sand	7	156
Shale	43	199
Sand	61	260
Sandy shale	42	302
Shale	16	318
Sandy shale	30	348
Shale	14	362
Sand and shale	8	370
Sand	30	400
Shale	30	430
Shale with a few sand breaks	30	460
Hard blue shale	42	502
Well KA-39-16-105		
Owner: Ralph Lamar Driller: John Cobb Drilling Co.		
Gray clay	95	95
Gray clay,sandy	55	150
Sandy gray clay	100	250
Gray clay	50	300
Sand	57	357
Well KA-39-16-502		
Owner: Industrial Generating Co. Driller: Texas Water Wells		
Ground level	3	3
Clay	17	20
Sand and shale streaks	120	140
Shale and sand streaks	190	330
Sand and shale	20	350
Shale	50	400
Sand	30	430
Sandy shale	40	470

Well KA-39-16-502 (Continued)

	THICKNESS	DEPTH
Sand	40	510
Shale	20	530
Sand	20	550
Shale	14	564
Sand and shale streaks	36	600
Shale	50	650
Sand	20	670
Shale	30	700
Sand	30	730
Shale	130	860

Well KA-39-21-603

Owner: B. L. Alewine
Driller: R. K. Sims

	THICKNESS	DEPTH
Yellow sand	8	8
Sandy clay	17	25
Shale	15	40
Red streaked sand	25	65
Blue sand	63	128
Rock	3	131
Blue sand	1	132
Blue shale	16	148

Well KA-39-22-512

Owner: Art Dickerson
Driller: Neal Drilling Co.

	THICKNESS	DEPTH
Sand and clay	20	20
Sand	18	38
Lignite	2	40
Blue shale	70	110
Sandy shale	15	125
Gray shale	95	220
Sandy shale	45	265
Gray shale	30	295
Sandy shale	13	308
Sand	28	336
Shale	22	358
Sand	26	384
Shale, gray	43	427
Sandy shale	18	445
Gray shale	33	478
Rock	2	480
Sandy shale	20	500
Black shale	80	580

Well KA-39-22-901

Owner: City of Teague
Driller: Layne Texas Co.

	THICKNESS	DEPTH
Top soil	2	2
Clay	5	7
Clay and sandy clay	18	25
Sand	47	72
Sandy clay	5	77
Clay	15	92
Clay, shale and lignite	41	133
Shale and sandy shale	20	153
Sandy shale	7	160
Sand and shale streaks	48	208
Shale	12	220
Lignite	6	226
Sand and lignite	19	245
Shale	11	256
Coarse sand	57	313
Shale	27	340
Sandy shale and shale	70	410
Shale	8	418
Sand and shale streaks	12	430
Shale and sandy shale	20	450
Shale and sand streaks	41	491
Shale and sandy shale	13	504
Hard rock	5	509
Sandy shale	11	520
Shale and sandy shale	75	595
Fine sand and streaks of shale	26	621
Shale	37	658
Rock	1	659
Sand and streaks of shale	30	689
Sandy shale and shale	48	737
Rock	1	738
Sandy shale	19	757
Shale and sand streaks	24	781
Sandy shale	11	792
Sandy shale and streaks of sand	31	823
Shale and sandy shale	77	900

Well KA-39-23-101

Owner: Kirvin Water Supply Corp.
Driller: Andrews and Foster Drilling Co.

	THICKNESS	DEPTH
Red and yellow clay	10	10
White sand	35	45
Dark shale, lignite at 54 feet	15	60
Gray sand	7	67

	THICKNESS	DEPTH
Well KA-39-23-101 (Continued)		
Shale	3	70
Sand, shale and lignite	25	95
Shale	40	135
Sandy shale	10	145
Sand and rock at 156 feet	15	160
Shale	10	170
Sand	42	212
Rock	1	213
Shale	12	225
Rock	1	226
Shale	16	242

Well KA-39-23-303

Owner: City of Fairfield No. 3
Driller: Layne Texas Co.

	THICKNESS	DEPTH
Soil	1	1
Red clay	5	6
Sandy clay	49	55
Clay	15	70
Gray shale and sand streaks	66	136
Gray shale and lignite	24	160
Sand and shale layers	13	173
Shale, lignite and sand	41	214
Gray shale and layers of sand	44	258
Shale and sandy shale	6	264
Sand and streaks of shale	16	280
Lignite, shale and sand	9	289
Shale, streaks of shale and lignite	18	307
Sand, shale and lignite streaks	6	313
Shale and sandy shale	34	347
Shale and lignite	26	373
Sand	5	378
Shale	4	382
Sand	4	386
Shale and sandy shale	15	401
Sand and sandy shale layers	14	415
Shale and lignite	17	432
Sand (cut good), streaks of shale	23	455
Shale, few sand streaks	29	484
Shale	5	489
Sand	5	494
Shale	2	496
Sand	7	503
Shale	2	505
Sand, few shale layers	30	535
Shale	3	538

	THICKNESS	DEPTH
Well KA-39-23-303 (Continued)		
Sand, thin shale layers	12	550
Shale and sand	8	558
Sand (cut good)	27	585
Shale	3	588
Sand (cut good)	17	605
Sand and shale layers	7	612
Sand and shale	3	615
Sand, thin shale layers	20	635
Shale, sand and lignite streaks	25	660
Shale and hard streaks	14	674
Sand and shale layers	22	696
Shale, streaks of shale and lignite	8	704
Sand, streaks of shale and lignite	13	717
Shale and streaks of lignite	7	724
Sand, lignite and shale streaks	8	732
Shale and hard streaks of lime	5	737
Shale	7	744

Well KA-39-23-304

Owner: Ward Prairie Water Supply Corp.
Driller: Andrews and Foster Drilling Co.

	THICKNESS	DEPTH
Red clay	25	25
Sand	10	35
Shale	50	85
Sand and lignite	15	100
Shale and lignite	65	165
Sand	10	175
Shale	25	200
Sandy shale	88	288
Sand	57	345
Shale, sand and lignite	60	405
Sand	38	443
Shale, sand and lignite	52	495
Shale	25	520
Sand and shale	83	603
Shale	7	610
Sand	10	620
Shale and sand streaks	35	655
Sand	37	692
Rock	1	693
Sand	22	715

Well KA-39-23-403

Owner: Freestone County Country Club
Driller: Neal Drilling Co.

	THICKNESS	DEPTH
Clay	6	6

	THICKNESS	DEPTH
Well KA-39-23-403 (Continued)		
Sand	34	40
Sandy shale	20	60
Sand	115	175
Hard sand	5	180
Hard sandy shale	20	200
Sand	20	220
Sandy shale	52	272
Sand	23	295
Sandy shale	11	306
Sand	19	325
Sandy shale	20	345
Sand	18	363
Lignite	9	372
Gray shale	12	384
Sandy shale, rock at 393 feet	9	393
Gray shale, rock at 403 feet	17	410
Sandy shale	10	420
Gray shale	74	494
Sandy shale	53	547
Sand	15	562
Gray shale	58	620
Sandy shale	20	640
Gray shale	15	655
Well KA-39-23-407		
Owner: J. W. Mitchell Driller: Neal Drilling Co.		
Clay	10	10
Sand	20	30
Sandy shale	10	40
Brown shale	7	47
Sand, rock at 53 feet	6	53
Blue shale, rock at 75 feet	22	75
Sandstone	5	80
Gray shale	10	90
Lignite	10	100
Sand	54	154
Gray shale	6	160
Sandy shale	5	165
Sand	25	190
Gray shale	6	196
Sand	4	200
Gray shale	10	210
Lignite	10	220
Gray shale, rock at 225 feet	25	245
Sand	9	254
Lignite	8	262
Well KA-39-23-407 (Continued)		
Gray shale	25	287
Sand	5	292
Gray shale	8	300
Sandy shale	40	340
Lignite	10	350
Sandy shale	5	355
Sand	5	360
Gray shale	46	406
Sand	38	444
Well KA-39-23-503		
Owner: Robert Dunlop, Jr. Driller: Neal Drilling Co.		
Sand	4	4
Clay	16	20
Sandy shale	20	40
Blue shale	40	80
Brown shale	20	100
Gray shale	40	140
Sand	50	190
Gray shale, rock at 202 feet	40	230
Sand	90	320
Sandy shale	30	350
Sand	20	370
Sandy shale	15	385
Sand, tested very little water	25	410
Gray shale	40	450
Rock	2	452
Gray shale, rock at 455 feet	18	470
Sandy shale, rock at 470 feet	4	474
Sand	8	482
Gray shale, rock at 523 feet	78	560
Sandy shale	20	580
Gray shale, rock at 600 feet	62	642
Sand	20	662
Gray shale, rock at 728 feet	66	728
Gray shale	52	780
Well KA-39-23-603		
Owner: J. C. Leadbetter Driller: Neal Drilling Co.		
Clay	10	10
Sand	10	20
Sand and clay	20	40
Blue shale	40	80
Gray shale	42	122
Lignite	4	126

	THICKNESS	DEPTH
Well KA-39-23-603 (Continued)		
Sand	4	130
Gray shale	15	145
Sand	5	150
Sandy shale	5	155
Brown shale	5	160
Gray shale	20	180
Sand, stiff shale	70	250
Gray shale	10	260
Sandy shale	30	290
Sand	90	380
Well KA-39-24-506		
Owner: Turlington Water Supply Corp. Driller: C. C. Innerarity		
Surface clay	20	20
Blue clay	155	175
Sand	3	178
Blue clay	2	180
Tight sand	5	185
Sand	30	215
Blue clay	7	222
Sand, good	26	248
Blue clay	5	253
Sand	15	268
Clay and sand streaks	37	305
Hard blue clay	30	335
Rock	1	336
Sand	39	375
Hard blue clay	10	385
Sand	13	398
Sand and clay	42	440
Sand	5	445
Sand	10	455
Sand and clay streaks	51	506
Sand	4	510
Clay	30	540
Good sand	115	655
Hard and soft clay	45	700
Well KA-39-24-906		
Owner: W. D. Morse Driller: Rehkop Drilling Co.		
Surface	30	30
Broken sand	90	120
Clay	100	220
Broken sand and clay	70	290
Clay	20	310

	THICKNESS	DEPTH
Well KA-39-24-906 (Continued)		
Sand	80	390
Shale	10	400
Sand	10	410
Sandy clay	150	560
Well KA-39-31-404		
Owner: John Eppes Driller: Neal Drilling Co.		
Clay	30	30
Brown shale	30	60
Sandy shale	20	80
Sand	22	102
Sandy shale	23	125
Sand	5	130
Gray shale	60	190
Brown shale	10	200
Gray shale	27	227
Rock	2	229
Brown shale	11	240
Sand	3	243
Brown shale	22	265
Sandy shale	5	270
Gray shale	15	285
Sandy shale	20	305
Sand	45	350
Well KA-39-31-603		
Owner: Grady McAdams Driller: Neal Drilling Co.		
Top sand	7	7
Clay	5	12
Sand, red	18	30
Shale, light gray	14	44
Sandy shale	20	64
Shale	10	74
Sand	9	83
Shale	9	92
Sand	5	97
Shale	23	120
Sand, iron	6	126
Shale	4	130
Sand	6	136
Shale	21	157
Sand	9	166
Shale	8	174
Sand with shale streaks	52	226
Sand, rock, stone	3	229

	THICKNESS	DEPTH
Well KA-39-31-603 (Continued)		
Shale	19	248
Sand and lignite	8	256
Shale	6	262
Sand, fine and hard	16	278
Shale	2	280
Well KA-39-32-102		
Owner: Faye Hagen Driller: Neal Drilling Co.		
Clay	20	20
Blue shale	20	40
Sandy shale, rock at 66 feet	40	80
Lignite	3	83
Sand	52	135
Gray shale	20	155
Sand, very little water	85	240
Gray shale	45	285
Sandy shale	22	307
Sand	33	340
Well KA-39-32-402		
Owner: M. W. Whitlock Driller: Neal Drilling Co.		
Sand	6	6
Clay	34	40
Sandy shale	40	80
Brown shale	6	86
Sand	9	95
Brown shale	5	100
Sand	3	103
Brown shale	17	120
Gray shale	20	140
Lignite	7	147
Sandy shale	16	163
Gray shale	14	177
Sand	10	187
Gray shale	13	200
Brown shale	17	217
Sand, tested and was iron water	26	243
Gray shale	17	260
Sandy shale	127	387
Sand, good water	38	425
Well KA-39-32-701		
Owner: R. G. McSwane Driller: Neal Drilling Co.		
Sand and clay	20	20
Sand	50	70

	THICKNESS	DEPTH
Well KA-39-32-701 (Continued)		
Blue shale	10	80
Sandy shale	20	100
Gray shale, lignite 127-130 feet	70	170
Sand	15	185
Gray shale	115	300
Sandy shale	35	335
Gray shale	15	350
Sand, set and tested iron	55	405
Sandy shale	35	440
Gray shale	78	518
Sandstone, hard	2	520
Sand, good	30	550
Well KA-39-39-301		
Owner: I. W. Whitaker Driller: Neal Drilling Co.		
Sand	60	60
Gray shale	40	100
Hard sandy shale	40	140
Gray shale	88	228
Sand, iron water	26	254
Gray shale	46	300
Sandy shale	25	325
Gray shale	115	440
Sandy shale	5	445
Gray shale	25	470
Sandy shale	15	485
Hard sand	5	490
Gray shale	10	500
Hard sand, good	35	535
Well KA-39-39-404		
Owner: J. B. Lawler Driller: Neal Drilling Co.		
Clay	20	20
Sandy shale	87	107
Sand	13	120
Sandy shale	22	142
Sand	14	156
Sandy shale	24	180
Blue shale, rock at 195 feet	50	230
Sandy shale	50	280
Blue shale	25	305
Sandy shale	55	360
Gray shale	65	425
Sand	22	447

	THICKNESS	DEPTH
Well LT-33-47-902		
Owner: Lewis Avant Driller: Hampton Drilling Co.		
Clay	12	12
Sand	14	26
Clay	25	51
Water, sand and clay	13	64
Well LT-33-55-302		
Owner: John Key Driller: Hampton Drilling Co.		
Black clay	7	7
Yellow clay	5	12
Water, sand and gravel	10	22
Blue shale	14	36
Well LT-33-56-601		
Owner: City of Malakoff No. 1 Driller: Texas Water Wells		
Surface clay and sand	20	20
Gray sandy shale	72	92
Gray sand, streaks of lime and lignite	23	115
Fine sand, streaks of lime	25	140
Soft sand	22	162
Hard sand and lime	36	198
Shale	3	201
Light gray shale	50	251
Light gray sandy shale	41	292
Sandy shale	22	314
Soft gray sand	14	328
Hard sand	4	332
Sand, hard streaks	38	370
Sand and lime	10	380
Shale and lime	7	387
Well LT-33-64-501		
Owner: J. W. Murchison Driller: Andrews & Foster Drilling Co.		
Sand	12	12
Shale	3	15
Gravel, sand	5	20
Lignite	3	23
Shale	52	75
Sand and shale	20	95
Shale	25	120
Sand	10	130
Shale	5	135
Rock	1	136

	THICKNESS	DEPTH
Well LT-33-64-501 (Continued)		
Shale	24	160
Sand	10	170
Shale	55	225
Sand	10	235
Rock	2	237
Sand	53	290
Rock	2	292
Sand	18	310
Shale	10	320
Well LT-34-41-501		
Owner: Roy Hendley Driller: Andrews & Foster Drilling Co.		
Red clay	22	22
Sand	48	70
Shale and lignite	10	80
Blue shale	80	160
Sandy shale	10	170
Sand	110	280
Sandy shale	55	305
Shale	55	360
Shale and sand breaks	70	430
Sand	50	480
Well LT-34-42-403		
Owner: Bethel-Ash Water Supply Corp. Driller: Rehkop Drilling Co.		
Surface	20	20
Clay	25	45
Sand	75	120
Shale	100	220
Broken sand and shale	90	310
Shale	36	346
Sand	24	370
Shale with sand streaks	80	450
Sand	72	522
Shale	30	552
Sand (Wilcox)	33	585
Shale with coal streaks	2	587
Well LT-34-42-801		
Owner: Delmer Smith Driller: Rehkop Drilling Co.		
Surface	5	5
Clay	5	10
Sand	28	38
Clay	47	85

Well LT-34-42-801 (Continued)

	THICKNESS	DEPTH
Sand	65	150
Shale	50	200
Broken sand and shale	30	230
Shale	30	260
Broken sand and shale	60	320
Shale	80	400
Broken sand	35	435
Shale	100	535
Sand	15	550
Shale	50	600
Sand	27	627
Shale	5	632
Sand	18	650
Shale	65	715
Broken sand (Tested-would only make 10 gpm from 500 foot setting)	55	770
Shale	55	825
Sand	25	850
Shale	25	875
Sand	55	930
Shale	13	943

Well LT-34-43-205

Owner: Floyd Cornett
Driller: Rehkop Drilling Co.

	THICKNESS	DEPTH
Sand	20	20
Shale	85	105
Sand	12	117
Shale	188	305
Sand	5	310
Shale	180	490
Sand	60	550
Sandy shale	30	580

Well LT-34-44-601

Owner: Three Community Water Supply Corp.
Driller: Rehkop Drilling Co.

	THICKNESS	DEPTH
Clay	40	40
Sand	20	60
Lignite	3	63
Blue shale with sand streaks	394	457
Sand	33	490
Shale	140	630
Carrizo sand	105	735
Shale	12	747

Well LT-34-45-403

Owner: Henderson County Municipal Water Authority
Driller: Layne Texas Co.

	THICKNESS	DEPTH
Sandy clay and caliche	30	30
Sandy clay and clay	61	91
Clay	22	113
Hard rock	2	115
Shale	13	128
Streaks of sand, shale and lignite	28	156
Shale and sandy shale	54	210
Sand	10	220
Shale and streaks of sand	44	264
Sand and streaks of shale	17	281
Shale	32	313
Fine gray sand	25	338
Sand and streaks of shale	10	348
Fine gray sand and lignite	13	361
Shale	6	367
Fine gray sand and lignite	61	428
Shale	16	444
Shale, streaks of sand and rock	15	459
Sand and shale streaks	11	470
Shale and streaks of sand	23	493
Sand	16	509
Shale	18	527
Shale, streaks of sand and lignite	41	568
Sand	5	573
Shale	6	579
Lignite	10	589
Sand and streaks of shale	13	602
Shale and lignite	50	652
Sand	7	659
Shale and lignite	41	700
Sand and lignite	20	720
Shale and lignite	112	832
Sandy shale, shale and lignite	110	942
Sandy shale and shale	45	987

Well LT-34-49-605

Owner: Hampton Concrete Co.
Driller: West & Rehkop Drilling Co.

	THICKNESS	DEPTH
Surface	20	20
Shale	115	135
Sand	75	210
Shale	240	450
Sand	22	472

	THICKNESS	DEPTH
Well LT-34-49-605 (Continued)		
Shale	38	510
Water, sand	40	550
Well LT-34-50-802		
Owner: Virginia Hill Water Supply Corp. Driller: Rehkop Drilling Co.		
Sand	20	20
Clay	50	70
Broken sand	30	100
Sand	70	170
Shale	50	220
Broken sand	45	265
Shale	12	277
Broken sand	123	400
Sand	50	450
Shale	70	520
Broken shale	10	530
Sand	75	605
Shale	2	607
Sand	8	615
Shale	145	760
Broken shale	40	800
Shale	40	840
Broken sand	20	860
Sand	43	903
Broken sand	9	912
Shale	8	920
Sand	17	937
Shale	18	955
Sand	10	965
Shale	30	995
Sand	35	1,030
Well LT-34-51-502		
Owner: Hugh Reynolds Driller: Rehkop Drilling Co.		
Surface	5	5
Clay	5	10
Sand	25	35
Clay	50	85
Sand	30	115
Clay	95	210
Sand	40	250
Shale	10	260
Broken sand and shale	175	435
Shale	55	490

	THICKNESS	DEPTH
Well LT-34-51-502 (Continued)		
Sand	25	515
Shale	5	520
Sand	5	525
Sandy shale	135	660
Sand	60	720
Well LT-34-52-103		
Owner: Moore Station Water Supply Corp. Driller: Rehkop Drilling Co.		
Surface	5	5
Sand	195	200
Broken sand and shale	100	300
Shale	40	340
Broken sand and shale	60	400
Shale	80	480
Sand	30	510
Shale	10	520
Sand	60	580
Shale	140	720
Sand	80	800
Shale	100	900
Well LT-34-53-704		
Owner: D. Foster Driller: White Drilling Co.		
Yellow and red sand and sandy clay	11	11
Red, white and yellow clay	19	30
Red and yellow sand with little gravel	10	40
White sand	20	60
Gray sand with shale and lignite streaks	25	85
Gray shale with sand streaks	30	115
Gray sand	20	135
Gray shale with lignite and shale streaks	19	154
Gray sand and lignite and shale streaks	61	215
Gray and brown shale with sandy shale and sand streaks	60	275
Gray sand	18	293
Gray shale	53	346
Green sand with green and brown shale streaks	14	360
Gray and brown shale with sand streaks	30	390
Green sand and fossils with shale streaks	15	405
Brown and green shale with sand streaks and lignite	30	435
Gray shale with sand streaks and lignite	25	460

	THICKNESS	DEPTH
Well LT-34-53-704 (Continued)		
Clear gray sand	15	475
Gray shale	5	480
Gray sand	13	493
Gray and brown shale	134	627
Gray sand	13	640
Gray sandy shale and shale	25	665
Gray shale with sandy shale streaks and lignite	55	720
Gray sandy shale with lignite streaks	95	815
Gray shale	10	825
Gray sandy shale with lignite and shale streaks	65	890
Gray sand	40	930
Very sandy shale	10	940

Well LT-34-57-302

Owner: Circle 10-Boy Scouts of America
Driller: West & Rehkop Drilling Co.

	THICKNESS	DEPTH
Sand	90	90
Rock and coal	2	92
Broken sand with shale	233	325
Sand	45	370
Shale	10	380
Sand	58	438
Shale	47	485
Sand	10	495
Shale with sand streaks	110	605
Shale	50	655
Sand	10	665
Broken shale and sand	320	985
Sand	40	1,025
Shale	10	1,035
Sand	15	1,050
Shale	55	1,105

Well LT-34-58-402

Owner: Koon Kreek Klub
Driller: Holly Mining Co.

	THICKNESS	DEPTH
Sand and clay	28	28
Shale	38	66
Sand and gravel	24	90
Shale	70	160
Sandy shale	45	205
Lignite and shale	20	225
Sandy shale	113	338
Shale and lignite	32	370
Rock	6	376

	THICKNESS	DEPTH
Well LT-34-58-402 (Continued)		
Shale and rock	25	401
Sand	15	416
Shale and lignite	80	496
Sand	24	520
Shale and sand streaks	34	554
Shale	150	704
Sand	62	766
Sand and shale streaks	31	797
Shale and sandy lignite	83	880
Sand	24	904
Shale	16	920
Sand	30	950
Sandy shale	100	1,050
Sand	40	1,090
Shale	34	1,124
Sand with shale streaks	76	1,200
Shale	32	1,232
Sand	21	1,253
Shale	91	1,344

Well LT-34-58-504

Owner: John W. Murchison
Driller: Rehkop Drilling Co.

	THICKNESS	DEPTH
Sand	70	70
Shale	27	97
Sand	13	110
Shale	15	125
Sand	48	173
Shale	10	183
Sand	73	256
Shale	29	285
Sand (flowed)	212	497
Shale	51	548
Coal	4	552
Sand	36	588
Shale	102	690
Sand	25	715
Shale	25	740
Sand	6	746
Shale	44	790
Sand	142	932
Shale	18	950

	THICKNESS	DEPTH
Well LT-34-59-302		
Owner: La Poyner School Driller: Andrews & Foster Drilling Co.		
Red clay and rock	20	20
Sand	80	100
Lignite	2	102
Sand	208	310
Shale	10	320
Rock	2	322
Shale	38	360
Sand	28	388
Shale	20	408
Sand	32	440
Shale	45	485
Sand	3	488
Shale	44	532
Sand	68	600
Sand and shale	22	622
Well LT-34-60-202		
Owner: Hunt Oil Co. Driller: Texas Water Wells		
Sandy clay	15	15
Sand	77	92

	THICKNESS	DEPTH
Well LT-34-60-202 (Continued)		
Sand and gravel	262	354
Sand and shale	254	608
Shale	257	865
Sand	125	990
Shale	60	1,050
Sand	80	1,130
Shale	45	1,175
Sand	55	1,230
Shale	20	1,250
Well LT-34-61-104		
Owner: Wes McGuffey, Jr. Driller: Rehkop Drilling Co.		
Surface	20	20
Gravel	10	30
Clay	70	100
Broken sand and clay	100	200
Sand	50	250
Shale	320	570
Carrizo water sand	110	680
Shale	5	685