TEXAS WATER DEVELOPMENT BOARD

REPORT 58

OCCURRENCE AND QUALITY OF GROUND WATER IN MONTAGUE COUNTY, TEXAS

By

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Prepared by the Texas Water Development Board
in cooperation with the
Texas Water Pollution Control Board

August 1967

Published and distributed
by the
Texas Water Development Board
Post Office Box 12386
Austin, Texas 78711

FOREWORD

On September 1, 1965 the Texas Water Commission (formerly, before February 1962, the State Board of Water Engineers) experienced a far-reaching realignment of functions and personnel, directed toward the increased emphasis needed for planning and developing Texas' water resources and for administering water rights.

Realigned and concentrated in the Texas Water Development Board were the investigative, planning, development, research, financing, and supporting functions, including the reports review and publication functions. The name Texas Water Commission was changed to Texas Water Rights Commission, and responsibility for functions relating to water-rights administration was vested therein.

For the reader's convenience, references in this report have been altered, where necessary, to reflect the current (post September 1, 1965) assignment of responsibility for the function mentioned. In other words credit for a function performed by the Texas Water Commission before the September 1, 1965 realignment generally will be given in this report either to the Water Development Board or to the Water Rights Commission, depending on which agency now has responsibility for that function.

Ground-water studies that are currently being conducted by the staff of the Texas Water Development Board in a block of counties in north-central Texas were undertaken by the Texas Water Commission beginning January 1962 to meet a growing need for more detailed and accurate ground-water information in this area.

In recognizing the significance of ground water in this area, the Water Development Board is aware of the vital need for obtaining information on the depth of occurrence of usable quality water as the basis for providing adequate and equitable protection for these water supplies.

As initially planned, the investigations will be conducted in the following counties: Archer, Brown, Callahan, Clay, Coleman, Eastland, Jack, Jones, Montague, Palo Pinto, Shackelford, Stephens, Taylor, Throckmorton, and Young Counties. In these counties, several towns with municipal water supplies are served by ground water or have water wells as a standby supply. In addition to meeting municipal needs for water, ground water is often the sole source supplying domestic, farm, and ranch needs.

The area under study is underlain by Pennsylvanian and Permian rocks which either crop out at the surface or underlie Cretaceous and alluvial sediments at shallow depths. Ground water occurs erratically in shallow discontinuous zones of low permeability in Pennsylvanian and Permian rocks, in sands and fractured limestones in the relatively thin Cretaceous sediments, and in Pleistocene to Recent alluvial sediments that are found at the surface in parts of most of the counties included in this study. Initially the objective of these investigations was to provide additional data for use in making recommendations to the Railroad Commission and oil industry as to the depth to which usable quality water should be protected. It was recognized early in the course of the investigations, however, that the scope of the program should be enlarged to provide information for the use of landowners and others interested in water-resource development to facilitate development of the ground-water supplies available.

The present program of study has been under consideration for several years, although personnel had not been available to initiate such a long-range study. However, the scope, objectives, and methods of study to be employed had been part of the planning of the Texas Water Commission, and when funds became available to begin these investigations they were included in the ground-water program of the Commission.

In January 1962, funds allocated to the then Texas Water Commission by the Texas Water Pollution Control Board, for the purpose of investigation and prevention of ground-water pollution made possible the beginning of the present program. These funds were allocated to the Water Commission by the Pollution Control Board under the provision of the Act creating the Pollution Control Board which directs the Texas Water Commission to, "...investigate and ascertain those situations in which the underground waters of the State are being polluted or are threatened with pollution, and it shall report all findings to the Board together with its recommendations in regard thereto."[1]

It was determined that these studies could be most feasibly conducted on a county-by-county basis, and the initial investigations were begun in Stephens, Young, and Brown Counties. Reports from the results of the investigations in Stephens and Young Counties were published as Texas Water Commission Bulletins 6412 and 6415, respectively, whereas, on September 1, 1965 the ground-water programs became the responsibility of the Texas Water Development Board. Reports on each of the 13 other counties are being prepared and published by the Texas Water Development Board as the field studies are completed.

Texas Water Development Board

John J. Vandertulip

John J. Vandertulip
Chief Engineer

[1] 57th Texas Legislature, 1961, Article 7621d, Vernon's Civil Statutes.

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ABSTRACT

Montague County is within the outcrop area of upper Pennsylvanian, lower Permian, and lower Cretaceous formations in north-central Texas. The formations of upper Pennsylvanian and lower Permian age in most areas dip to the north and northwest. In almost the entire southeastern one-half of the county these are overlain by rocks of Cretaceous age, which dip gently to the southeast. Cretaceous rocks are predominately sandstone and have a great amount of ground-water storage capacity. Pleistocene to Recent alluvial sediments occur along the steams in Montague County.

Ground water of usable quality occurs in most areas of the county, and the water wells range in depth from about 20 feet to 1,000 feet. It is estimated that there are about 3,000 water wells in Montague County.

Comparison of chemical analyses of ground water in Montague County shows that the mineral constituents of the water vary in concentration, but generally can be used to establish the base quality of natural ground water in different areas of the county. A notably large chloride content of some analyses does not coincide with normal variation of ground-water quality. Water wells having this high chloride content are treated in this report as apparently contaminated wells. In many cases historical records to prove alteration of chemical quality are lacking.

The disposal of oil-field brine is probably an important source of chemical alteration of the native-quality water. Reported brine production for 1961 in Montague County was 26,495,015 barrels. Approximately 97 percent of the brine was reported disposed of into injection wells, about 2 percent was reported disposed of into open surface pits, and less than 1 percent was disposed of by other methods; however, open surface pits and other methods for brine disposal were used by many operators prior to the installation of injection wells.

OCCURRENCE AND QUALITY OF GROUND WATER IN MONTAQUE COUNTY, TEXAS

INTRODUCTION

Purpose and Scope

The purpose of the study in Montague County was two-fold: to obtain, through field study, information regarding the occurrence and chemical quality of ground water for use by landowners and others; and to provide sufficient information for the Texas Water Development Board and other agencies responsible for protection of water quality in the county so that water-quality-protection programs can be both adequate for protection of the water available and equitable when applied to industries operating in the county.

The objectives of the Montague County study were to obtain supplementary basic data to better delineate underground formations containing usable water, the depth of this water, and its chemical quality; to supplement available data on brines produced with oil and gas and the location and method of their disposal; to review surface-casing recommendations of this agency in the light of field observation to determine where revisions are needed; to evaluate the results of chemical analyses of water from wells and springs in the county in order to establish a base condition of water quality where possible and to pinpoint areas of contamination where it has occurred; and to prepare a report for the use of landowners, the Texas Water Development Board, and other State and Federal agencies.

The study was made under the general direction of John J. Vandertulip, Chief Engineer, Richard C. Peckham, director, Ground Water Division, and Bernard B. Baker, assistant director in charge of Availability Programs; and under the direct supervision of Loyd E. Walker, coordinator, West Texas Field Investigations Program.

Method of Investigation

A selective inventory of 395 wells and springs was conducted in 1964-65 to determine the manner in which water wells are constructed and, where possible, to determine the depth and aquifer in which the wells are completed (Table 3). No attempt was made to inventory all the water wells, since there are about 3,000 water wells in Montague County. Land-surface elevations were established at wells and springs with the aid of topographic maps and Paulin altimeter to provide a basis for comparing measurements of water levels in wells.

In order to determine the water-quality characteristics of ground water in Montague County, 358 water samples were collected from wells for chemical analysis (Table 4). Most of the laboratory analyses of water samples were made by the Texas State Department of Health under interagency and cooperative agreements with the Board. Some analyses were made by the U.S. Geological Survey.

Approximately 500 electric logs were studied as an aid in interpreting subsurface geologic conditions pertinent to the occurrence of ground water in the county. Oil-field brine disposal practices were observed, and chemical analyses of available oil-field brines were studied to determine their chemical characteristics. Maps and illustrations showing water quality and areas of brine production and disposal were prepared.

Previous Investigations

Several reports containing general information on the geology of north-central Texas are available; however, no detailed ground-water investigation of Montague County has been made prior to this study.

Gordon (1913) discussed the geology and ground water in Montague County in general terms and recorded chemical analyses of water samples from a few wells. Broadhurst and Follett (1944) inventoried 30 wells in and near Nocona, in north-central Montague County, and reported partial chemical analyses for 18 wells.

Several water wells were inventoried and water samples collected by E. Wallace Cooper with the Texas Water Development Board during brief contamination investigations conducted in 1966. These data are included in Tables 3 and 4.

Reconnaissance investigations have been made of ground-water resources of the Red River basin (Baker and others, 1963) and Trinity River basin (Peckham and others, 1963), but coverage within Montague County was generalized as would be expected in studies of this type. Other reports relating to the geology of the county are listed at the end of this report in the Selected References.

Well-Numbering System

Wells and springs in this report were numbered according to a statewide numbering system used by the Texas Water Development Board. Each well and spring is assigned a number to facilitate keeping records and locating the well within the State. This system is based on division of the State into quadrangles formed by degrees of latitude and longitude, and repeated division of these quadrangles into smaller ones as illustrated in Figure 1.

The largest quadrangle, a 1-degree quadrangle, is divided into sixty-four $7\frac{1}{2}$-minute quadrangles, each of which is further divided into nine $2\frac{1}{2}$-minute quadrangles. Each 1-degree quadrangle in the State has been assigned a number for identification. The $7\frac{1}{2}$-minute quadrangles are numbered consecutively from left to right beginning in the upper left hand corner of the 1-degree quadrangle, and the $2\frac{1}{2}$-minute quadrangles within the $7\frac{1}{2}$-minute quadrangle are similarly numbered. The first two digits of a well number identify the 1-degree quadrangle, the third and fourth digits identify $7\frac{1}{2}$-minute quadrangle, the fifth digit identifies the $2\frac{1}{2}$-minute quadrangle, and the last two digits designate the order in which the well was inventoried within the $2\frac{1}{2}$-minute quadrangle.

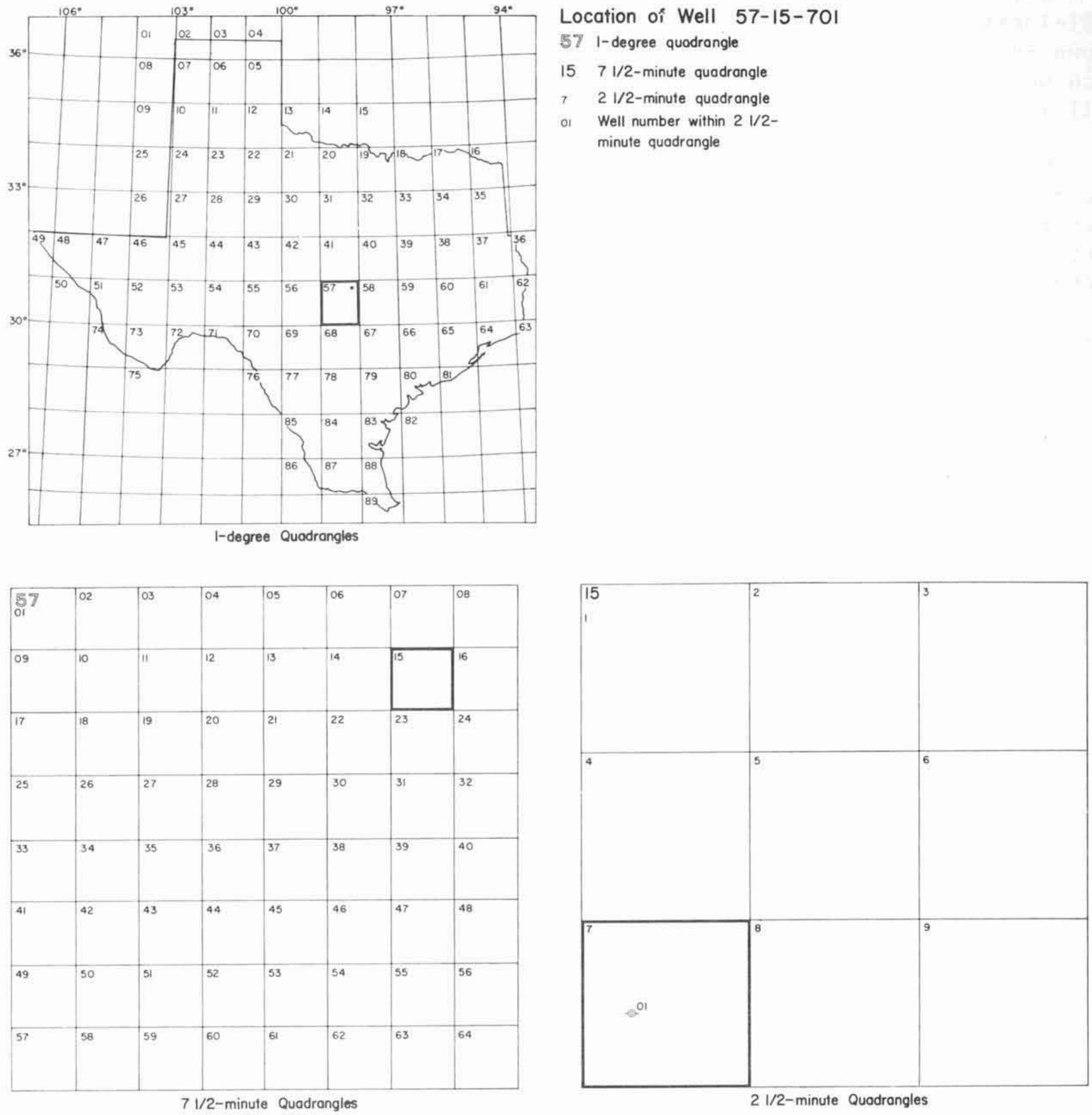

Figure 1

Well - Numbering System

Texas Water Development Board in cooperation with the Texas Water Pollution Control Board

All of Montague County falls within the 1-degree quadrangle 19. On the well-location map of this report (Figure 8), the $7\frac{1}{2}$-minute quadrangles are shown and numbered in their northwest corners. The 3-digit number shown with each well symbol contains the number of the $2\frac{1}{2}$-minute quadrangle in which the well is located and the number of the well within that quadrangle.

Some of the wells for which data are given in this report (Tables 3 and 4) are the same wells for which data are given in an earlier report on ground-water resources in the vicinity of Nocona, by Broadhurst and Follet (1944). The corresponding numbers assigned to these wells in this and the earlier report are listed in Table 1.

Table 1.--Well numbers used in this report and corresponding numbers previously used in Montague County by Broadhurst and Follett (1944)

New number	Old number	New number	Old number	New number	Old number
19-11-702	1	19-11-707	6	19-10-701	22
703	2	709	7	405	23
704	3	710	8	404	24
705	4	701	9	704	25
708	5	706	10		

Acknowledgements

Appreciation is expressed to the many farmers, ranchers, water-well drillers, and oil company personnel who generously contributed information and cooperated in the collection of field data. Thanks are extended to the individuals with the Departments of Geology of The University of Texas, Baylor University, and other institutions who have made and currently are making investigations in the area. Appreciation also is expressed to personnel in the Texas State Department of Health, the Railroad Commission of Texas, the U.S. Geological Survey, and other State and Federal agencies who furnished information.

GEOGRAPHIC SETTING

Location

Montague County comprises an area of 937 square miles, and lies generally between 97°29' and 97°59' west longitude and between 33°25' and 33°55' north latitude in the northern part of Texas (Figure 2). The town of Montague, the county seat, is in the central part of the county, and is about 50 miles east of Wichita Falls, and about 70 miles northwest of Fort Worth.

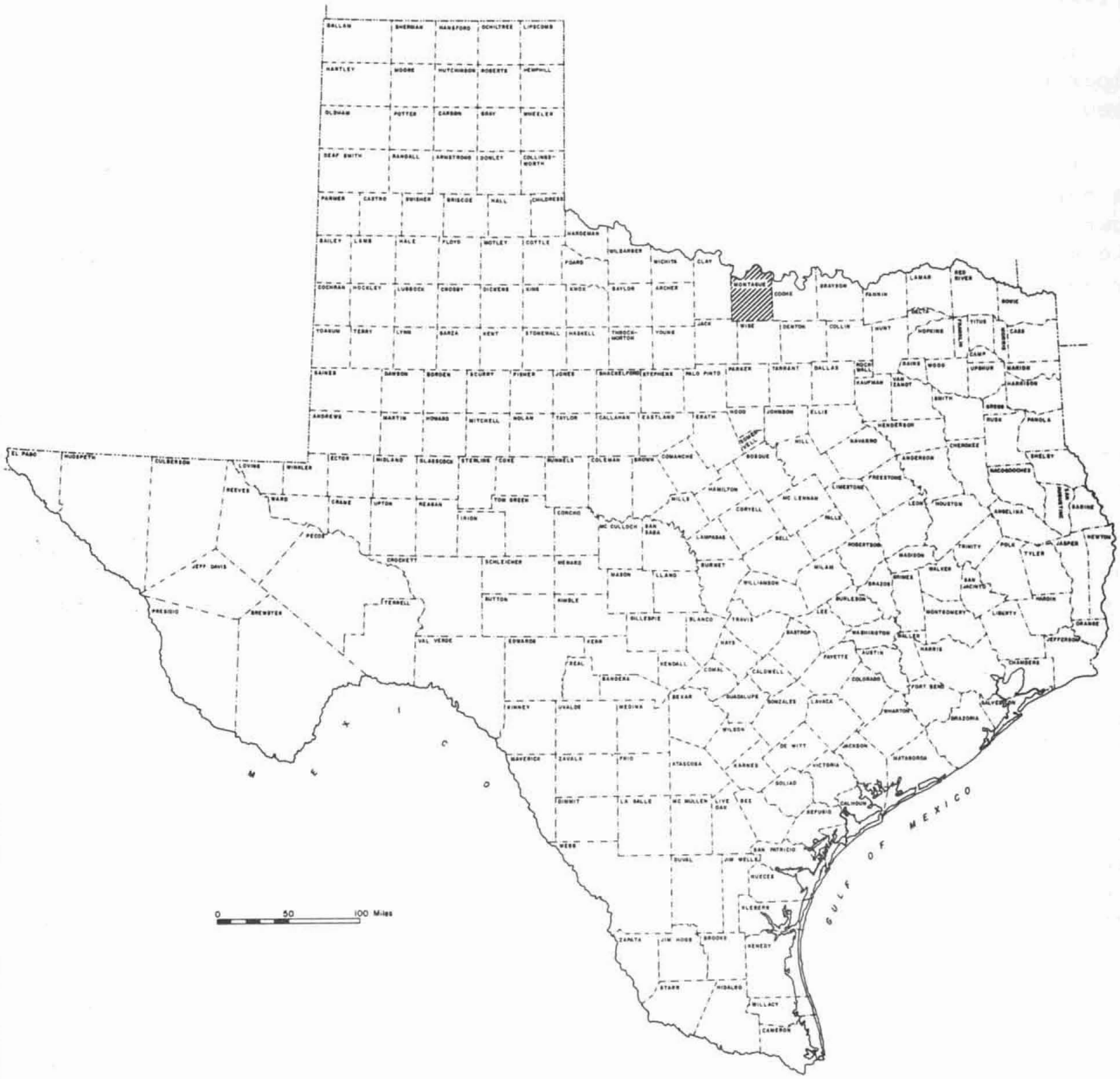

Figure 2

Map of Texas Showing Location of Montague County

Texas Water Development Board in cooperation with the Texas Water Pollution Control Board

Climate

The average annual rainfall depth is about 31 inches, based on U.S. Weather Bureau records for the 30-year period 1931-60. The greatest officially recorded annual rainfall depth in the county during 1931-60 was 51.50 inches at Montague in 1957, and the least amount was 17.72 inches at Bowie in 1956.

The mean temperature for the month of January is 42°F, while the mean temperature for July is 84°F. The mean annual temperature is 63°F. These are based on isothermal charts for the 50-year period 1910-59.

The average annual gross lake surface evaporation is about 70 inches and the net lake surface evaporation is about 40 inches, based on the period 1940-57 (Lowry, 1960, p. D-10). The average monthly distribution of the gross and net lake surface evaporation and the average monthly distribution of the rainfall are shown on Figure 3.

Topography and Drainage

The land surface in Montague County can be described as generally rolling with many hills, and ranges in elevation from about 750 to a little over 1,300 feet above mean sea level.

Montague County lies within two major drainage basins, the Red and Trinity Rivers. (See Figure 8.) The topographic divide between these two watersheds, at elevations of 1,000 to 1,300 feet above mean sea level, obliquely bisects the county into about equal parts.

The Red River marks the northern boundary of the county, and the major tributaries of the Red River in Montague County are Beaver, Belknap, Salt, Pecan, Panther, and Farmers Creeks (Figure 8).

Farmers Creek Reservoir, also known as Lake Nocona, is in the Red River basin in Montague County, 8 miles northeast of Nocona on Farmers Creek. The reservoir has a capacity of 25,400 acre-feet, and has been used as a municipal water supply for the city of Nocona since September 1961. The lake is owned and operated by the North Montague County Water Supply District for municipal, industrial, and mining purposes.

Bowie Lake is in the Red River basin, about 1½ miles southwest of Stoneburg on the West Fork of Middle Belknap Creek, a tributary of Belknap Creek. This reservoir has a capacity of 1,265 acre-feet and was used as a municipal water supply for the city of Bowie until the completion and diversion of water from Lake Amon G. Carter. Bowie Lake was constructed during 1936 and 1937 and is owned and operated by the city of Bowie. This lake has been a standby source of water supply since June 1956.

The southern half of the county is in the Trinity River basin. The major tributaries of the Trinity River in Montague County are Big Sandy, Brushy, Denton, and Clear Creeks which flow south and southeast (Figure 8.)

Lake Amon G. Carter is in southwestern Montague County, 6 miles southwest of Bowie on Big Sandy Creek, a tributary of the West Fork Trinity River. This reservoir has a capacity of 20,050 acre-feet and is the municipal water supply

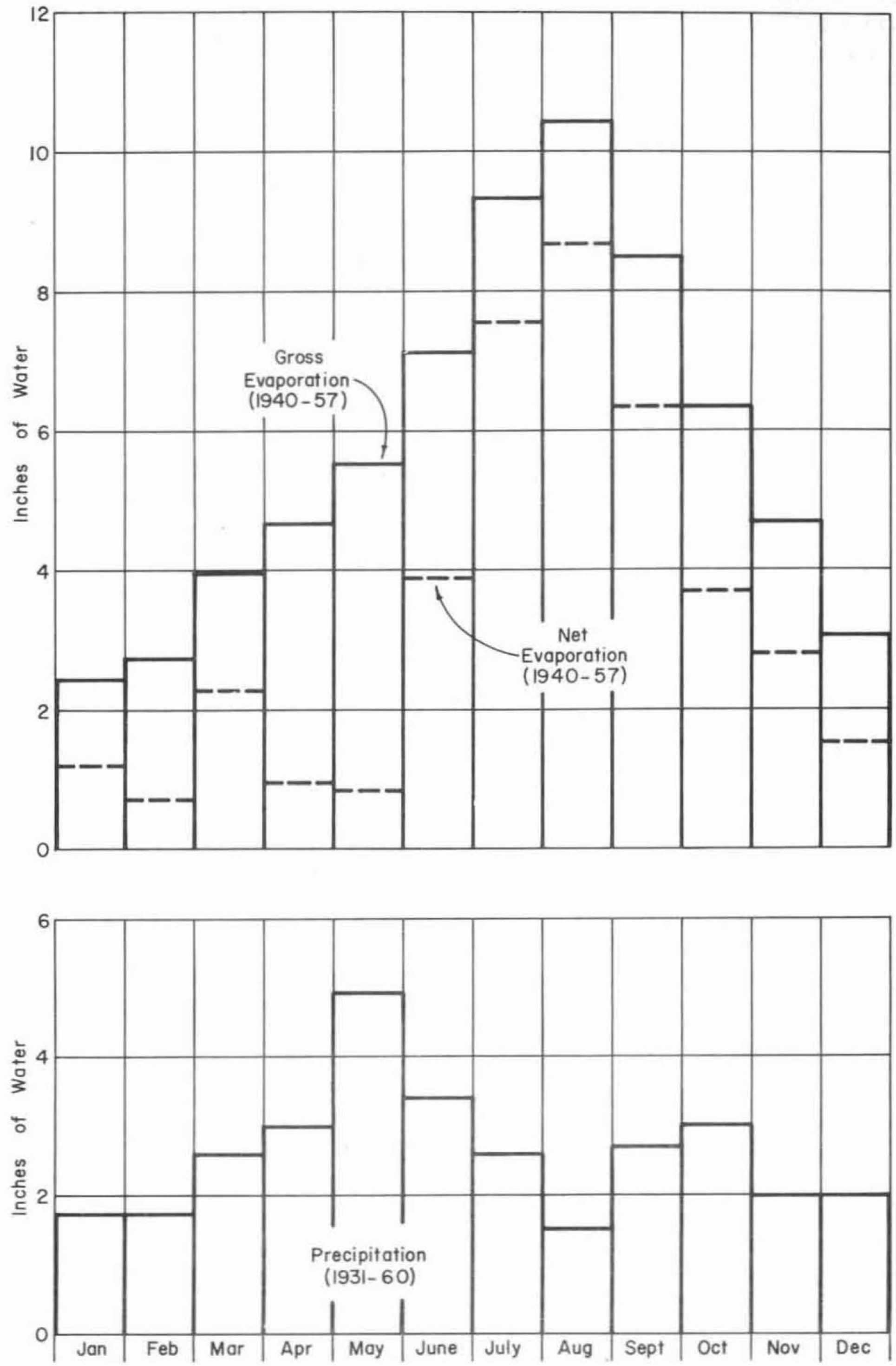

Figure 3

Average Monthly Precipitation and Lake Surface Evaporation, Montague County

(From records of U. S. Weather Bureau, and Lowry, 1960)

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for the city of Bowie. Diversion and use of water began in June 1956, and the lake was full with water flowing over the service spillway in May and June 1957. The lake is owned and operated by the city of Bowie (Dowell, 1964, p. 161-162).

Population and Economy

Montague County was created from Cooke County in 1857 and organized in 1858. Named for Daniel Montague, an early Indian fighter and pioneer surveyor, Montague County had a population of 849 according to the census of 1860. The population grew slowly during the next 10 years and was only 890 in 1870.

In the next 10-year period, the large ranches and rangeland were divided into farms, where cotton was the major crop, and by 1880 the population had grown to 11,257.

The population increased in the 1880's with the building of railroads across the county. The towns of Bowie, Saint Jo, and Nocona were incorporated during this period. Other towns in the county continued to grow also such as Red River Station, Burlington (Spanish Fort), Forestburg, Hardy, Montague, Belcherville, Sunset, Bonita, and Illinois Bend. The population had reached 18,863 in 1890.

The county continued to grow, having a population of about 24,800 in 1900, and by 1910 the population had reached 25,123. Because of improper cotton farming methods many people had to abandon their farms when long staple cotton was introduced, and the population declined to about 22,200 by 1920.

According to the Federal census, the population was 14,893 in 1960. The population of cities and towns within the county was 7,693, which is more than half the county population. The remaining 7,200 people live in rural areas and small communities.

Much of the once-farmed land has been returned to pasture, and the raising of beef cattle has increased. Montague County has been a leading Texas county in the number of registered Angus beef cattle for many years. Dairy cattle, poultry, sheep, and goats are also raised.

Agriculture has played an important part in the growth and economy of the county, producing crops such as cotton, wheat, small grains, corn, grain sorghums, peanuts, alfalfa, clover, and other legumes. Truck crops of various fruits and vegetables are also raised. Montague County has long been a leading Texas county in the growing of grapes. Texas A&M University has operated a horticultural experiment substation near the town of Montague since 1937, and has been experimenting with grapes, peaches, and other fruits.

Oil continues to provide a very important source of income in Montague County. Drilling began in 1901 and oil production began in 1916. The first commercial oil well from which oil was run into a pipeline was completed in 1924.

Over 2,000 producing oil wells have been drilled in the county which have produced more than 176,643,000 barrels of oil. The depth to producing horizons ranges from 800 to over 7,300 feet. Oil production in the county was approximately 6,642,000 barrels in 1963. Other natural resources include natural gas, sand and gravel, brick and pottery clay, coal, and asphalt.

(The information on the preceding page was obtained from "100 Years in Montague County," 1958, with permission of Ipta Printers, Saint Jo, Texas, and from the "Texas Almanac," compiled by A. H. Belo Corporation, 1966.)

OCCURRENCE AND QUALITY OF GROUND WATER

Usable-quality ground water in Montague County occurs principally in rocks of Pennsylvanian and Permian age in the northwestern one-half of the county, in rocks of Cretaceous age in the southeastern one-half of the county, and in alluvial sediments of Pleistocene to Recent age that occur along stream valleys (see geologic map, Figure 4). The rocks of Pennsylvanian and Permian age in most areas dip to the north and northwest, whereas the overlying Cretaceous rocks dip gently to the southeast.

In following sections of this report, conditions of ground-water occurrence in the following major geologic units are discussed: the Canyon and Cisco Groups of the upper Pennsylvanian System, the Wichita Group of the lower Permian System, the Trinity, Fredericksburg, and Washita Groups of the Cretaceous System, and alluvial sediments of the Quaternary System (Table 2). The outcrop areas of these rock units are shown on Figure 4, and subsurface correlations are illustrated in Figures 5 and 6.

Figure 11 is a contour map showing the approximate altitude of the base of usable quality water in Montague County, determined from a study of electric logs of oil and gas tests supplemented with data on water well depths and chemical analyses of water samples. Contour lines are drawn at 100-foot intervals with sea level as a datum.

The complexity of the Pennsylvanian and Permian rock sequence makes the zones in which ground water occurs difficult to trace in many areas. These complexities result from the irregular and discontinuous patterns of deposition in the area and are discussed in more detail in the Appendix.

The map showing base chemical quality of ground water by use of diagrams of chemical analyses (Figure 9) reveals a wide variation in the quality of ground water in Montague County. This variation is more evident in the northwestern one-half of the county, where rocks of Pennsylvanian and Permian age yield water to wells, than in the southeastern one-half of the county where water wells are completed in rocks of Cretaceous age.

The quality of water particular to each of the geologic units is discussed in detail in the following sections, and in the Appendix is a discussion of water-quality criteria, which is intended to be helpful in interpreting the data on analyses of water from wells in different parts of the county as discussed in this text and tabulated in Table 4. Although the water-quality contained in the Appendix provide useful guidelines, this investigation has shown use being made of ground water with mineral concentrations exceeding these criteria.

As can be seen from Table 4, the principal mineral constituents in the ground water are silica, calcium, magnesium, sodium, bicarbonate, sulfate, chloride, fluoride, and nitrate.

Table 2.--Geologic units and their lithologic descriptions, Montague County

System	Group	Formation	Lithologic character	Approximate maximum thickness (ft)
Quaternary			Surficial flood-plain and terrace alluvium of Pleistocene to Recent age along the streams; consists of sand, gravel, silt, and clay.	?
—— Unconformity ——				
Cretaceous	Washita	Duck Creek	Massive, bioclastic limestone and calcareous shale, blue-gray to gray in color.	?
	Fredericksburg	Kiamichi Clay	Dark yellow to olive-green to black shaly clay with lenticular siliceous limestone beds.	35
		Goodland Limestone	Massive, hard, white, semi-crystalline limestone.	30
		Walnut Clay?	Yellowish clay marl containing nodular limestone lentils.	15
	Trinity		Poorly consolidated, massive, cross-bedded, fine- to coarse-grained sand and gravel, with clay lentils.	600
—— Unconformity ——				
Permian	Wichita		Red shale and sandstone.	725+?
— ? — ? —				
Pennsylvanian	Cisco		Conglomerate, sandstone, shale, and thin limestone beds.	275+?
	Canyon	Home Creek Limestone Colony Creek Shale Ranger Limestone Placid Shale Winchell Limestone Wolf Mountain Shale Posideon Palo Pinto Limestone	Limestone, shale, and lenticular sandstone. Not exposed in Montague County.	2,000

Pennsylvanian System

Canyon Group

The rocks of the Canyon Group (upper Pennsylvanian) are not exposed at the surface, but occur in the subsurface through all of Montague County. The Canyon Group has been divided into eight formations in the Brazos River basin. These are, in ascending order: Palo Pinto Limestone, Posideon Formation, Wolf Mountain Shale, Winchell Limestone, Placid Shale, Ranger Limestone, Colony Creek Shale, and Home Creek Limestone (Table 2).

The limestone units in this sequence generally serve as persistent marker beds in north-central Texas, and some of them can be correlated in electric logs of oil and gas tests in Montague County as indicated on Figures 5 and 6. In some areas, the limestone marker beds are difficult to trace because of facies changes, thickness variations, or removal of the limestone beds by stream channeling. The thickness of the Canyon deposits in eastern Montague County is reported to be about 2,000 feet (Turner, 1957, p. 73).

No water wells are known to be completed in the Canyon Group in Montague County.

Cisco Group

Rocks of the Cisco Group (upper Pennsylvanian) in Montague County overlie the Canyon Group, and crop out in the southwestern part of the county (Figure 4).

The Cisco Group in this study is not differentiated. The Cisco Group in the Trinity River valley is not clearly understood, and precise correlation with the type sections in the Brazos River valley is lacking. According to Brown (1962, p. 17), "Thorough mapping of the Cisco Group of northeast Jack and southwest Montague Counties will be necessary before valid correlations and stratigraphic opinions can be proposed."

The rocks of the Cisco Group in Montague County are composed primarily of conglomerate, sandstone, shale, and thin limestone beds. The depositional pattern, according to Brown (1962, p. 14), is one of non-uniform rock bodies which display abrupt changes in thickness and lithology, but with an overall increase in the percentage of coarser clastic rocks when compared to rocks of the Cisco Group in Stephens and Young Counties. Deposition was probably in a near-shore environment, which is substantiated by the presence of coal beds, some of which were once mined commercially in Montague County.

The quality of ground water in the Cisco Group is not generally uniform throughout the area of development. Tabulated below, in parts per million, are the concentrations of several mineral constituents in three wells in or near the outcrop area of the Cisco Group, in southwest Montague County. These wells produce from conglomerate and sandstone of the Cisco Group at depths of 300 to 490 feet.

Well	Depth (feet)	Cal-cium	Magne-sium	Sodium	Bicar-bonate	Chloride	Nitrate	Dissolved solids
19-25-501	410	4	2	462	471	403	<0.4	1,150
19-33-201	300	30	13	92	281	33	3.0	374
19-34-304	490	4	2	207	432	51	<.4	521

Numerous water wells in the outcrop area of the Wichita Group are believed deep enough to penetrate water-bearing strata of the Cisco Group. Of 36 such wells, about half were sampled for chemical analysis. The water quality is not generally uniform. Most of the water from these wells is apparently produced from the water-bearing zones of the Wichita Group. The depths of these wells range from 154 feet (well 19-26-401) to 1,000 feet (well 19-19-402); about 74 percent of the wells are deeper than 500 feet.

As interpreted from electric logs of oil tests, sands containing water of usable quality occur at depths of more than 1,000 feet in some areas (Figure 11); however, a water sample from deep zones is available for only one of these areas (well 19-19-402, Table 4).

Permian System

Wichita Group

The Wichita Group (lower Permian) in Montague County conformably overlies the Cisco Group and crops out in the northwestern one-half of the county. This group covers about 40 percent of the land surface of the county, and ground water in this group is highly developed.

Formations of the Wichita Group in north-central Texas are the Pueblo, Moran, and Putnam Formations. In this report these formations, composed primarily of red shale and sandstone, are not differentiated but are treated as a unit. The thickness of the Wichita Group in Montague County is not known.

Ground water in the Wichita Group in Montague County occurs in springs at the surface and in wells to depths of 725 feet. About 51 percent of the wells are deeper than 200 feet. More than 250 wells produce water from these rocks.

The quality of water in the Wichita Group is not general uniform throughout the area of development. The analyses indicate that the chemical quality apparently has little or no relation to the depth of occurrence of the water; each analysis is generally representative of the depth and location of the well. Some general similarities, however, are graphically illustrated in the map showing base chemical quality (Figure 9). Most of the water samples contain high amounts of sodium and bicarbonate.

In the following discussion of water quality, the ranges in chemical constituents of water samples do not include the samples from apparently contaminated wells.

The content of dissolved solids in water samples from 218 wells completed in the Wichita Group ranges from 139 to 3,119 ppm (parts per million). About 68 percent of the wells produce water with more than 500 ppm dissolved solids, which is the maximum recommended by the U.S. Public Health Service (1962, p. 7-8) for drinking water suitable for public supply.

The nitrate concentration ranges from less than 0.4 to 170 ppm. More than 80 percent of the samples collected contain less than 1.0 ppm nitrate; however, six samples contain more than 45 ppm, which is the maximum limit recommeded by the U.S. Public Health Service (1962).

Fluoride content ranges from 0.1 to 6.0 ppm. About 46 percent of the samples contain less than 0.8 ppm of fluoride, and about 26 percent contain more than 1.7 ppm. Both nitrate and fluoride concentration limits for drinking water are discussed further in the Appendix.

Other major chemical constituents in the 218 water samples collected for chemical analysis are chloride, sulfate, bicarbonate, sodium, magnesium, calcium, and silica.

The range in chloride is from 5 to 1,320 ppm, and the range of sulfate is from 4 to 810 ppm. The maximum concentration recommended by the U.S. Public Health Service (1962) for water suitable for public supply is 250 ppm each for chloride and sulfate. Only about 15 percent of the samples contain more than 250 ppm chloride, and about 8 percent of the samples exceed 250 ppm sulfate.

The range of bicarbonate is from 61 to 977 ppm; however, only about 42 percent of the samples collected contain in excess of 500 ppm. Sodium concentration ranges from 11 to 1,160 ppm. Most of the samples collected are low in sodium, and about 36 percent contain more than 260 ppm. Magnesium content is also low, ranging from 1 to 144 ppm; all but one sample contain less than 75 ppm. The range of calcium is from 1 to 308 ppm; about 92 percent of the samples contain less than 100 ppm. Silica ranges from 4 to 28 ppm, but only about 30 percent of the samples contain more than 11 ppm.

Cretaceous System

Trinity Group

The Trinity Group (lower Cretaceous) in Montague County unconformably overlies the Wichita Group (lower Permian) and Cisco Group (upper Pennsylvanian), and crops out in the southeastern one-half of the county. The outcrop area covers about 30 percent of the land surface of the county, and the ground water is well developed.

Formations of the Trinity Group in central Texas are the Travis Peak, Glen Rose Limestone, and Paluxy Sand, in ascending order, but these formations are not differentiated in Montague County because in this area clastic sediments (sandstone and shale) predominate.

Rocks of the Trinity Group in Montague County consist of basal conglomerate and gravel overlain by poorly consolidated, massive, cross-bedded, fine- to coarse-grained, white to light-gray sand. These rocks erode rapidly to form small ravines and canyons with very narrow deep gorges. Lenticular beds of red, purple, and gray clay occur within the sand, but do not generally restrict the movement of ground water except perhaps locally. The thickness of the Trinity

Group is reported by Bullard and Cuyler (1930, p. 71) to range from less than 1 foot to about 600 feet, based on well records in Montague County.

Ground water occurs in rocks of the Trinity Group in springs at the surface and in wells to depths of at least 459 feet. Only 30 wells which produce water from the Trinity rocks were investigated so the overall range in well depths is not known.

An abundant supply of ground water of good to excellent chemical quality is available from rocks of the Trintiy Group. Twenty-six water samples were collected for chemical analysis, and some general similarities are graphically illustrated on the map showing chemical quality (Figure 9).

In the following discussion of water quality, the ranges of chemical constituents in water samples do not include the samples from apparently contaminated wells. The content of dissolved solids in 25 water samples collected for chemical analysis ranges from 358 to 930 ppm. Sixty percent of these samples contain more than 500 ppm dissolved solids. This is the maximum concentration recommended by the U.S. Public Health Service (1962) for drinking water suitable for public supply.

The concentration of nitrate ranges from less than 0.4 to 90.0 ppm; however, 28 percent of the samples contain more than 12 ppm, and only one water sample (well 19-27-902) contains more than 45 ppm, the maximum limit recommended by the U.S. Public Health Service (1962). Fluoride ranges from 0.1 to 1.2 ppm, and only 20 percent of the samples contain more than 0.3 ppm. Only one water sample (well 19-34-302) contains more than 0.8 ppm fluoride. Both nitrate and fluoride concentration limits for drinking water are discussed further in the Appendix.

Other major chemical constituents contained in the 25 water samples collected for chemical analysis are chloride, sulfate, bicarbonate, sodium, magnesium, calcium, and silica.

The range of chloride concentration is from 6 to 246 ppm, and of sulfate, 8 to 343 ppm. The maximum concentration recommended by the U.S. Public Health Service (1962) for water suitable for public supply is 250 ppm each for chloride and sulfate. None of the samples contains more than 250 ppm chloride, and only one sample (well 19-27-902) contains more than 250 ppm sulfate.

The bicarbonate content is rather high, ranging from 54 to 460 ppm. Only 8 percent of the samples contain less than 300 ppm, and 56 percent of the samples contain more than 400 ppm. Most samples are low in sodium content and the range is from 13 to 199 ppm.

Magnesium ranges from 1 to 49 ppm. Calcium ranges from 10 to 226 ppm; however, only 12 percent of the samples contain more than 150 ppm. Silica ranges from 9 to 32 ppm.

Ten wells on the outcrop of the Trinity Group apparently extend through the Trinity and penetrate water-bearing strata of the underlying Wichita or Cisco Groups. The depths of these wells range from 120 feet (well 19-26-501) to 747 feet (well 19-20-603). Chemical analyses of nine water samples reveal the water quality is not generally uniform. The content of dissolved solids, for example, ranges from 286 to 1,110 ppm. Water samples from three of the wells contain less than 500 ppm, which is the maximum concentration for dissolved solids recommended by the U.S. Public Health Service (1962). The quality variation in these wells is due in part to commingling of water from the Trinity Group and water from the underlying strata.

Fredericksburg Group

The Fredericksburg Group conformably overlies the Trinity Group in Montague County, and crops out in the southeastern part of the county (Figure 4). The outcrop area covers about 10 percent of the land surface in Montague County.

Formations of the Fredericksburg Group in Montague County are, in ascending order, the Walnut Clay?, Goodland Limestone, and Kiamichi Clay.

The Walnut Clay? consists of from 3 to 15 feet of yellowish clay marl and thin nodular limestone lentils. In northeastern Montague County this horizon is usually separated from the Goodland Limestone by 15 to 20 feet of fine sand similar to that of the underlying Trinity Group (Bullard and Cuyler, 1930, p. 71-72).

The Goodland Limestone consists of 20 to 30 feet of hard, pure, white, semi-crystalline limestone. The bedding is massive, consisting generally of about four beds ranging from 4 to 6 feet in thickness. The lower portion is chalky, but the upper portion is hard, white, fractures into thin plates. Weathered fragments of the limestone develop a spongy appearance because of more easily dissolved spots of calcite in the limestone (Bullard and Cuyler, 1930, p. 72-73).

The Kiamichi Clay overlies the Goodland Limestone in the extreme south-eastern part of Montague County (Figure 4), and consists of about 35 feet of dark yellow, olive green, and black shaly clay, with thin lenticular limestone beds in the lower portion, and at the top are two or three ledges of an indurated yellowish shell breccia that typically mark the Kiamichi Clay (Bullard and Cuyler, 1930, p. 74).

No water wells are known to be completed in the Fredericksburg Group in Montague County.

Washita Group

The Washita Group in Montague County is represented by the Duck Creek Formation, which crops out in the extreme southeast corner of the county (Figure 4).

Only the basal portion of the Duck Creek Formation is found in Montague County (Bullard and Cuyler, 1930, p. 74-75).

No water wells are known to be completed in the Duck Creek Formation in Montague County.

Quaternary System

Alluvium

Surficial deposits of terrace gravel, sand, silt, and clay occur along all the major streams in Montague County, although only the extensive deposits bordering the Red River are mapped (Figure 4). These alluvial deposits are Pleistocene to Recent in age, and were derived from rocks of the Pennsylvanian, Permian, and Cretaceous Systems. Most of these deposits are a result of stream deposition, although some are of windblown origin. Their thickness in Montague County is not known.

Water wells completed in the alluvial deposits range in depth from 19 to 72 feet.

The quality of water in the alluvium in Montague County is not generally uniform throughout the area of development. Four of the 11 water samples collected for chemical analysis are apparently contaminated ground water, and are not included in the following discussion of water quality. These four samples, from wells 19-03-702, 19-09-301, 19-09-305, and 19-18-705, are discussed in a following section of this report.

The content of dissolved solids in the remaining seven water samples ranges from 284 to 2,174 ppm. Five of these samples contain more than 500 ppm dissolved solids, which is the maximum concentration recommended by the U.S. Public Health Service (1962) for drinking water suitable for public supply.

The nitrate concentration ranges from less than 0.4 to 650 ppm; two samples (wells 19-10-511 and 19-11-406) contain more than 45 ppm, the maximum amount recommended by the U.S. Public Health Service (1962). Fluoride content ranges from 0.2 to 1.1 ppm. Only one water sample (well 19-10-511) contains more than 0.8 ppm fluoride. Concentration limits for nitrate and fluoride in drinking water are discussed in the Appendix.

Other chemical constituents in the water samples are chloride, sulfate, bicarbonate, sodium, magnesium, calcium, and silica.

The range of chloride concentration in the seven samples is from 46 to 540 ppm, and of sulfate, 13 to 259 ppm. The maximum concentration recommended by the U.S. Public Health Service (1962) for water suitable for public supply is 250 ppm each for chloride and sulfate. Three water samples (wells 19-03-505, 19-09-303, and 19-18-710) contain less than 250 ppm chloride, while only one sample (well 19-11-736) contains more than 250 ppm sulfate.

The bicarbonate content ranges from 222 to 405 ppm, and only three samples contain less than 300 ppm. Sodium content is low, ranging from 23 to 242 ppm. Three water samples (wells 19-03-505, 19-09-303, and 19-18-710) contain less than 55 ppm.

Magnesium content ranges from 11 to 166 ppm, and is generally low, as only one sample (well 19-10-511) contains more than 65 ppm. Calcium ranges from 40 to 225 ppm. Three of the samples (wells 19-03-402, 19-03-505, and 19-18-710) contain less than 70 ppm calcium. Silica content ranges from 9 to 19 ppm.

Thirty-three water wells located on the alluvial deposits apparently penetrate water-bearing strata of the underlying Wichita Group. The depths of these wells range from 20 feet (well 19-10-805) to 219 feet (well 19-03-301). Eleven of these wells are over 100 feet in depth.

The quality of water from wells that produce from both the alluvium and underlying strata of the Wichita Group is not generally uniform. Water from three of these wells, 19-03-701, 19-11-731, and 19-11-745, is apparently contaminated and will be discussed in other sections of this report. The dissolved-solids content of the other 28 samples collected ranges from 247 to 1,679 ppm. Only 25 percent of these samples contain less than 500 ppm, which is the maximum concentration for dissolved solids suggested by the U.S. Public Health Service (1962).

Summary of Well Yields and Construction in Montague County

Well yields in the Cisco Group (upper Pennsylvanian), Wichita Group (lower Permian), and Trinity Group (lower Cretaceous) vary within wide limits. Well yields from the alluvium are generally less than the yields of wells producing from older strata.

The maximum yield of wells equipped with windmills is about 3 to 4 gpm (gallons per minute). Windmills are generally used to furnish water to livestock, and a few furnish water for domestic use. Because of the non-uniform pumping rate, elevated tanks are used to provide water storage and pressure.

Most of the water wells that utilize windmills are completed with 5- to 7-inch diameter steel or galvanized iron casing, either set at total depth and perforated, or set above the water-producing zone. A 2-inch diameter tubing of galvanized iron is generally employed to carry the water to the surface, with wooden sucker rods operating the working barrel. The casing is generally bonded to the bore hole with concrete near the surface, and a concrete curb stabilizes the foundation.

The other drilled wells generally are equipped with electric, natural gas, or gasoline-powered pumps. Most of the pumps are either cylinder or jet type, and some of the deeper wells utilize submersible-type pumps. Wells used for municipal supply at Montague and Sunset produce water from rocks of the Wichita and Cisco Groups by use of submersible-type pumps. The wells at Sunset are cased with 8-5/8 inch diameter surface pipe and 7-inch diameter casing set at total depth and perforated. The yield of these wells is about 35 gpm. The wells at Montague are similarly completed and yield from 20 to 50 gpm.

The towns of Nocona and Bowie previously used water wells equipped with turbine pumps for a municipal supply before the new surface reservoirs were completed. The yield varied from well to well, due to variations in the porosity, permeability, and thickness of the water-bearing strata and size of bore hole. These wells, some of which were formerly abandoned oil and gas tests, were plugged back and completed in rocks of the Wichita and Cisco Groups.

The public supply wells at Forestburg and Saint Jo produce water from the Trinity Group. The wells are completed with 7- to 10-inch diameter steel casing, which is set at total depth and perforated, or set above the water-producing zone. The yield ranges from 35 to 60 gpm. Both submersible and turbine-type pumps are used.

Water from 20 water wells is used for industrial purposes. Well 19-19-402, which furnishes water for a water-flood project, is 1,000 feet deep, the deepest water well in the county. The well is completed with 10-3/4 inch diameter steel casing cemented to surface and perforated from 900 to 735 feet. The yield is 117 gpm, which is the largest known yield of water wells in the county.

Drilled wells used for domestic and livestock purposes are completed with 5- to 7-inch diameter steel or galvanized iron casing, set a total depth and perforated or slotted, or set above the water-producing zone. Some of the water wells are abandoned oil tests that have been plugged back and completed with 7- to 10-inch diameter steel casing. Most drilled wells used for domestic and livestock purposes are equipped with electric-powered pumps.

Most of the dug wells are lined with field stone to prevent caving, and the upper portion of the lining is cemented. The wells are usually equipped with a bucket or bailer; however, some are equipped with electric-powered jet pumps.

QUALITY-OF-WATER PROTECTION PROGRAMS

Surface Casing

The function of the Surface Casing Program in the Ground Water Division of the Texas Water Development Board is to recommend to members of the oil and gas industry and the Railroad Commission of Texas the depth to which ground water should be protected in drilling tests for oil and gas. The authority for participation by the Texas Water Development Board in the surface casing program is derived from rules promulgated by the Railroad Commission under authority given that agency by the statutes dealing with regulation of drilling and production activities of the oil industry.

Statewide Rule 13 (formerly Rule 12a) of the Railroad Commission requires that operators obtain a letter from the Texas Water Development Board recommending the depth to which fresh-water strata should be protected when drilling a new lease or area if the lease or area is not covered by field rules or lease recommendations. Rule 8 (formerly Rule 20) of the Railroad Commission requires that all fresh-water strata be protected in drilling or production activities.

In carrying out its duties under Rule 13, the Texas Water Development Board created the Surface Casing Program in the Ground Water Division. The staff of the Surface Casing Program is responsible for maintaining technical-data files upon which to base fresh-water-protection recommendations in all areas of the State, and for preparing these recommendations on application by operators contemplating drilling test wells. The recommended depth to which ground water should be protected in a given area is based on all pertinent information available to the Surface Casing Program staff at the time the recommendation is given. Recommended depths in any one area may therefore be revised when additional subsurface information becomes available. Known depths of water wells being used or depths of wells known to contain water of usable quality, such as domestic, municipal, industrial, livestock, or irrigation wells, are of great value. Electric or gamma-ray neutron logs run on oil and gas tests are used in many areas of the State to determine the depth at which the base of usable quality ground water occurs. Surface elevation is considered when a recommendation is given in an area that has moderate to high surface relief, as is common in the north-central Texas counties. This consideration of elevations is imperative when the area is dissected by streams, because of the danger that poor-quality water will cause contamination of surface and ground water by moving along the dip of the beds to emerge at lower elevations. All of this information is interpreted in the light of the best knowledge of the geology and ground-water hydrology available on the area involved.

Because of the erratic occurrence of ground water in Montague County, which was described in the preceding sections of this report, known depths of water wells are given special weight in preparing surface-casing recommendations in the county. Usefulness of electric logs in this geologic environment is limited in some areas because of the lack of continuous zones in the shallow subsurface that can be correlated, and the difficulty in interpreting water quality from such logs where the aquifer materials range so widely from sand to gravel to limestone over relatively short distances. In Montague County, the Surface Casing Program gives particularly close attention to surface elevations in addition to information on water wells because of the dissection of the surface rocks by tributaries of the Trinity and Red Rivers.

In Montague County, a county-wide depth recommendation is not feasible because the depth of protection that would be required in areas of deep water wells would be an excessive requirement in many other parts of the county. The preceding section of this report describes the occurrence of ground water of usable quality in a number of formations at depths ranging from the surface to over 1,000 feet. Thus, the results of this study confirm that surface-casing recommendations in this county should be made on a well-to-well or lease-to-lease basis in order to provide adequately for water protection without imposing unnecessary burdens of excessive protection in those areas where deep protection is not needed.

During the 8-year period from January 1958 to December 1965, the Surface Casing staff prepared 790 recommendations for protection of usable-quality ground water for oil and gas tests in Montague County. During 1966, the Surface Casing staff prepared 113 recommendations. The depths of these recommendations range from 175 to 1,400 feet.

Subsurface Disposal

The 57th legislature enacted Senate Bill 72 (Article 7621b, Vernon's Revised Civil Statutes) which defined a permit system for subsurface disposal of municipal and industrial wastes in Texas. This act in effect designated the Texas Water Development Board as the permit-issuing agency for all injection wells to dispose of "...industrial and municipal waste, other than salt water or other waste arising out of or incidental to the drilling for or the producing of oil or gas...," and the Texas Railroad Commission as the permit-issuing agency for all injection wells "...for the purpose of disposing of salt water or other waste arising out of or incidental to the drilling for or the producing of oil or gas...." However, Section 2-c of this statute also directed that any person applying to the Railroad Commission for a permit to inject salt water resulting from the drilling for or producing of oil or gas shall submit with the application a letter from the Board stating that the "drilling of such injection well and the injection of such salt water or other such waste into such subsurface stratum will not endanger the fresh water strata in that area and the formation or strata to be used for such salt water or other such waste disposal are not fresh water sands."

Opinions by the Attorney General of Texas pertinent to the implementation of Article 7621b are: (1) that "injection well," when correctly interpreted, includes only those wells which are drilled or used for the purpose of disposal and does not include an injection well where the purpose of the well is to increase production from an oil- or gas-bearing stratum, and (2) that a determination by the Texas Water Development Board is not binding on the Railroad Commission but merely advisory.

The staff of the Subsurface Disposal Program of the Texas Water Development Board reviews applications to dispose of salt water into subsurface zones and advises the operators and the Railroad Commission of the acceptability of such applications. Waterflood, pilot recovery, and other secondary recovery operations where salt water is injected into subsurface zones which are productive of oil or gas are granted permits by the Railroad Commission without consultation with the Texas Water Development Board. Also, the inspection of construction and completion of all injection systems is a regulatory function of the Railroad Commission.

From the effective date of Senate Bill 72, August 28, 1961, to December 31, 1966, the staff of the Subsurface Disposal Program has reviewed 51 applications to the Railroad Commission for salt water disposal wells in Montague County. Each of these applications was reviewed on an individual basis with consideration given to geologic and hydrologic data of the area, the method of completion of the proposed injection well, the volume of salt water to be disposed, and injection pressure to be used.

In addition to the salt water disposal wells, since January 1960, the Railroad Commission has granted permits to 118 projects involving the use of injection wells in pilot recovery, waterflood, and other secondary recovery operations in Montague County. The number of injection wells used in these projects ranges from one well in pilot recovery programs to as many as six or more injection wells in the waterflood projects. Generally, these projects are granted permits which contain provisions for expansion of the water-injection facilities by the use of additional injection wells as the operations progress.

OIL-FIELD BRINE PRODUCTION AND DISPOSAL

Quantity and Distribution of Produced Brine

The 1961 inventory of salt-water production throughout the State, compiled by the Railroad Commission of Texas and the then Texas Water Commission from data reported by oil companies and operators, shows that a total of 26,495,015 barrels of oil-field brine was produced in Montague County in 1961. This total includes 536,439 barrels produced in the Trinity River drainage basin and 25,958,576 barrels produced in the Red River drainage basin.

In the Trinity River drainage basin in Montague County, 373,780 barrels or 69.7 percent was reported disposed of into injection wells, 158,097 barrels or 29.5 percent was reported placed into open surface pits, and 4,562 barrels or

0.9 percent was reported disposed of by other methods such as hauling and spraying on roads and leases.

In the Red River drainage basin in Montague County, 25,435,974 barrels or 98 percent was reported disposed of into injection wells, 432,949 barrels or 1.7 percent was reported placed into open surface pits, and 18,150 barrels or 0.1 percent was reported disposed of by other methods such as hauling and spraying on roads and leases. An additional 71,503 barrels or 0.3 percent of the reported brine production was disposed of by unknown or unreported methods.

The tabulation of brine production and disposal in 1961 by field and by arbitrarily defined major producing areas is recorded in Table 5. Figure 10, which shows the location and amounts of reported brine disposal, was drawn by outlining the areas of greatest concentration of producing oil wells. No attempt was made to define individual oil fields on this map, but areas of extensive production were outlined to show the relative concentration of production.

Chemical Quality of Produced Brine

Twenty chemical analyses of brines produced with oil in Montague County are presented in Table 6. The ions normally present in samples from water wells (Table 4) are present in the brines, but sodium, calcium, magnesium, and chloride are in greater abundance. Sodium concentration appears to increase with depth; however, there generally is no relationship between mineral concentration and depth.

Sodium concentration ranges from 41,955 to 63,600 ppm; calcium, 14,080 to 22,010 ppm; magnesium, 790 to 3,251 ppm; and chloride, 104,495 to 134,500 ppm.

Bicarbonate and sulfate are present in lesser amount. Bicarbonate concentration ranges from 2 to 134 ppm. Sulfate ranges from 7 to 227 ppm.

ALTERATION OF NATIVE CHEMICAL QUALITY OF WATER

Although a study of contamination of surface water in Montague County is not within the scope of this project, it is important to note that ground and surface water are interrelated. If the chemical quality of surface water is significantly altered, some of the ground water in that area may be affected through vertical percolation; and of course stream quality can be affected by alteration of ground water that contributes to the base flow of the stream.

A few of the water wells in Montague County that show apparent alteration of native quality as the result of contamination by oil-field brines or other sources are shown on Figure 10. Figure 7 shows the chemical quality of the ground water in some of these wells, by means of radial-pattern diagrams. These diagrams compare the water quality in the apparently contaminated well with the presumably native (natural) water quality in a nearby well of about the same depth, and the chemical quality of a typical oil-field brine. The scale used to illustrate the quality of ground water is generally 40 times larger than the scale used to illustrate the brine. Other wells in the county show apparent quality alteration, but are not included in Figure 7 because historical records

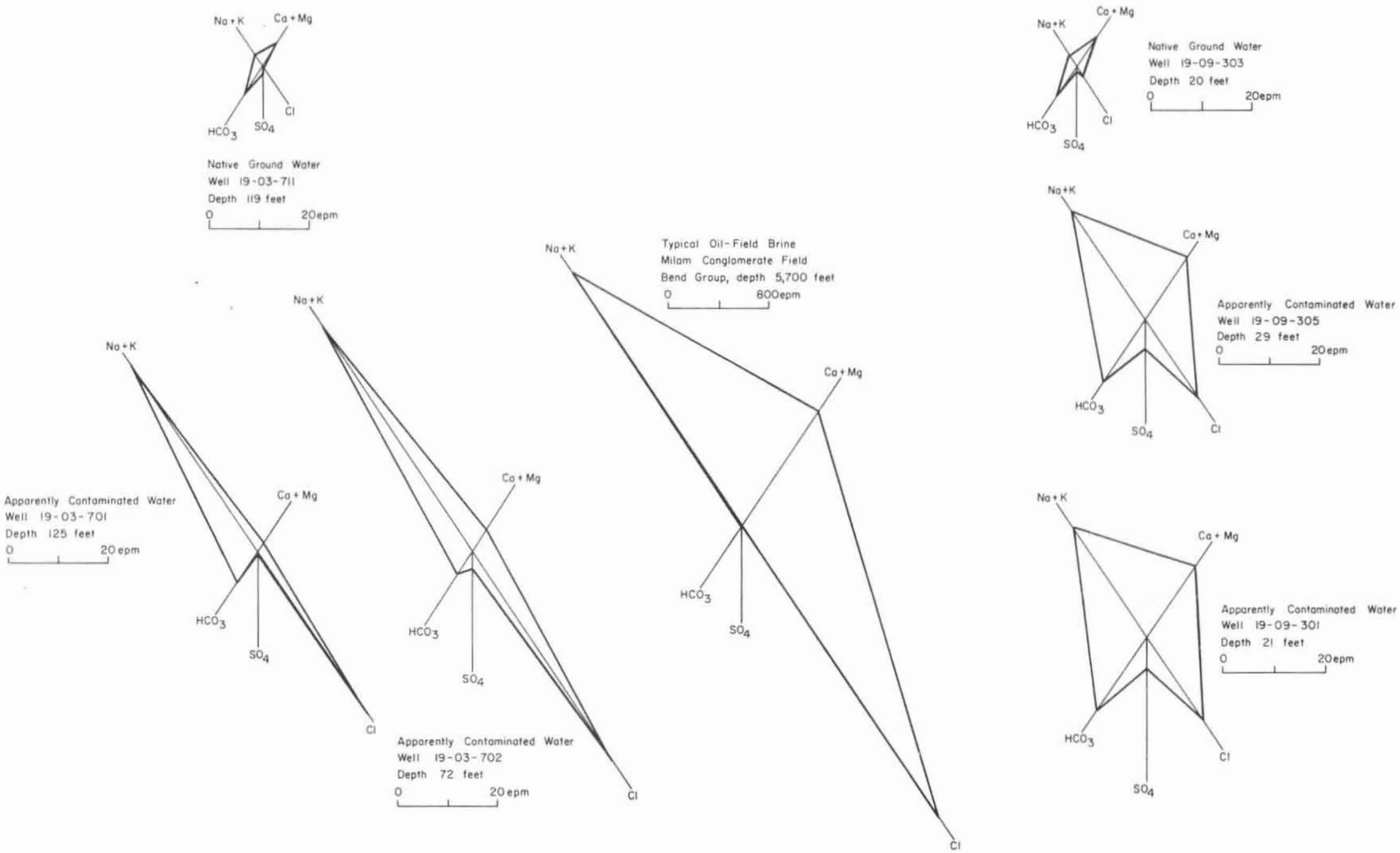

Figure 7

Diagrams of Chemical Analyses of Ground Water and a Typical Oil-Field Brine

Texas Water Development Board in cooperation with the Texas Water Pollution Control Board

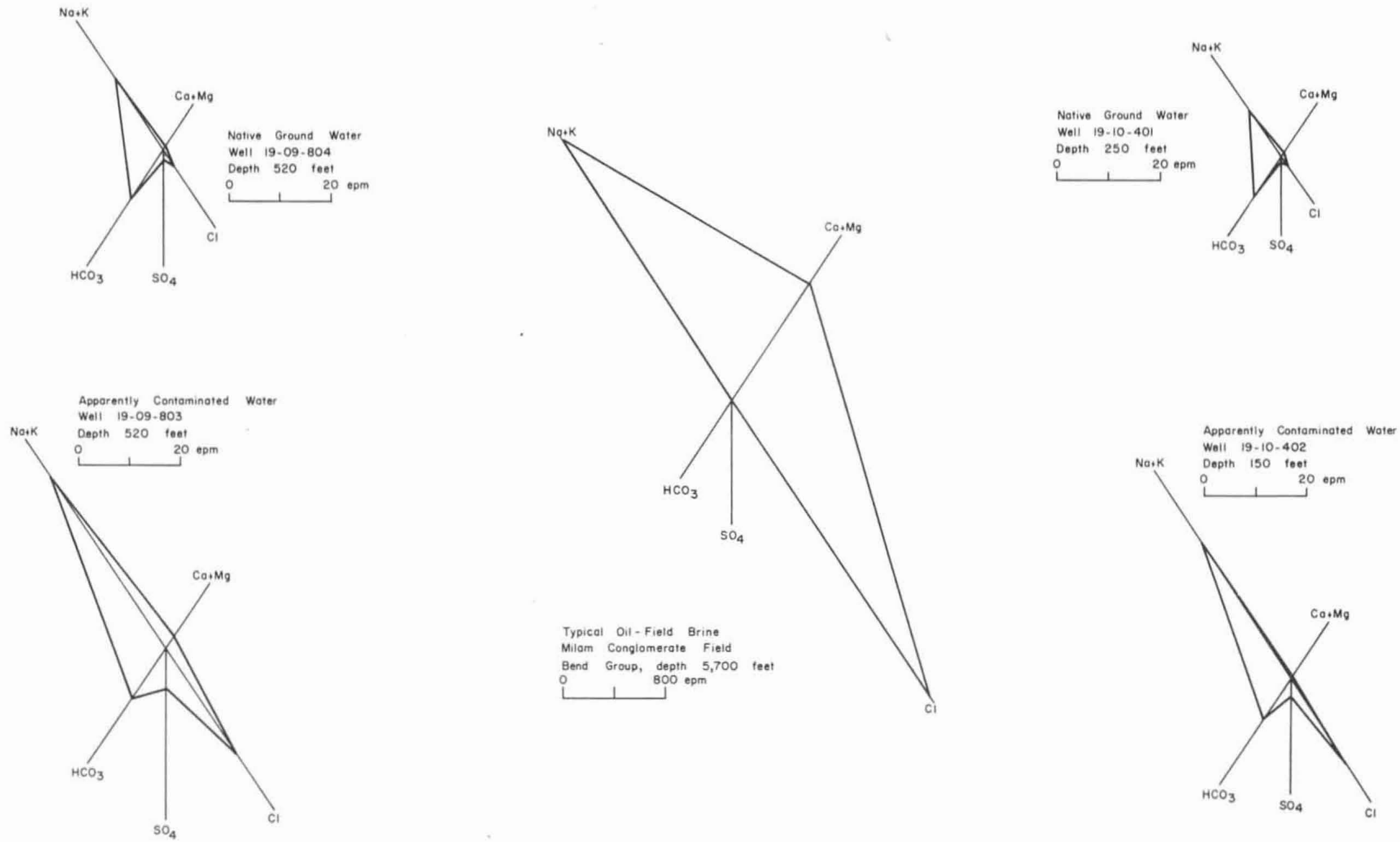

Figure 7--Continued

Diagrams of Chemical Analyses of Ground Water and a Typical Oil - Field Brine

Texas Water Development Board in cooperation with the Texas Water Pollution Control Board

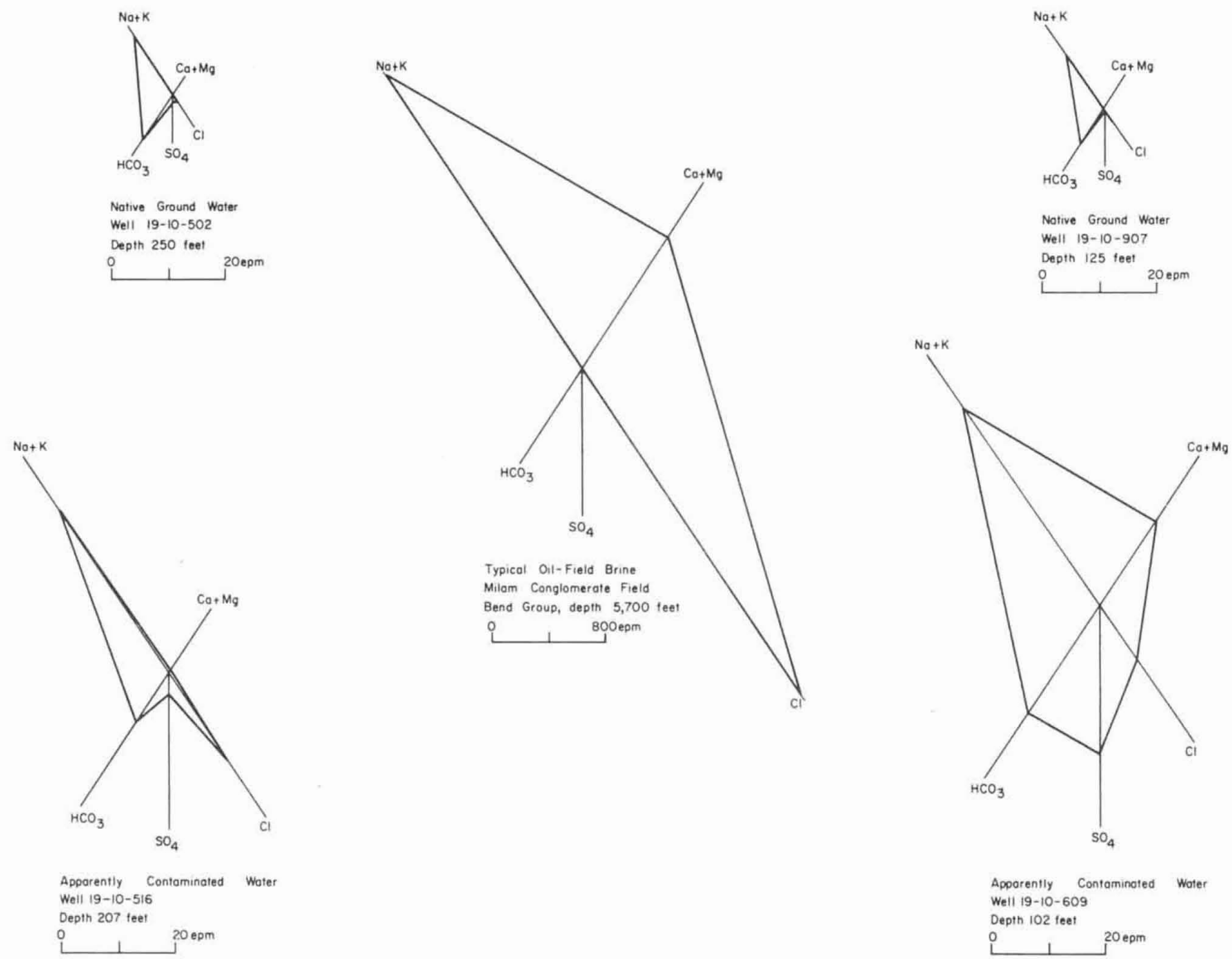

Figure 7--Continued

Diagrams of Chemical Analyses of Ground Water and a Typical Oil-Field Brine

Texas Water Development Board in cooperation with the Texas Water Pollution Control Board

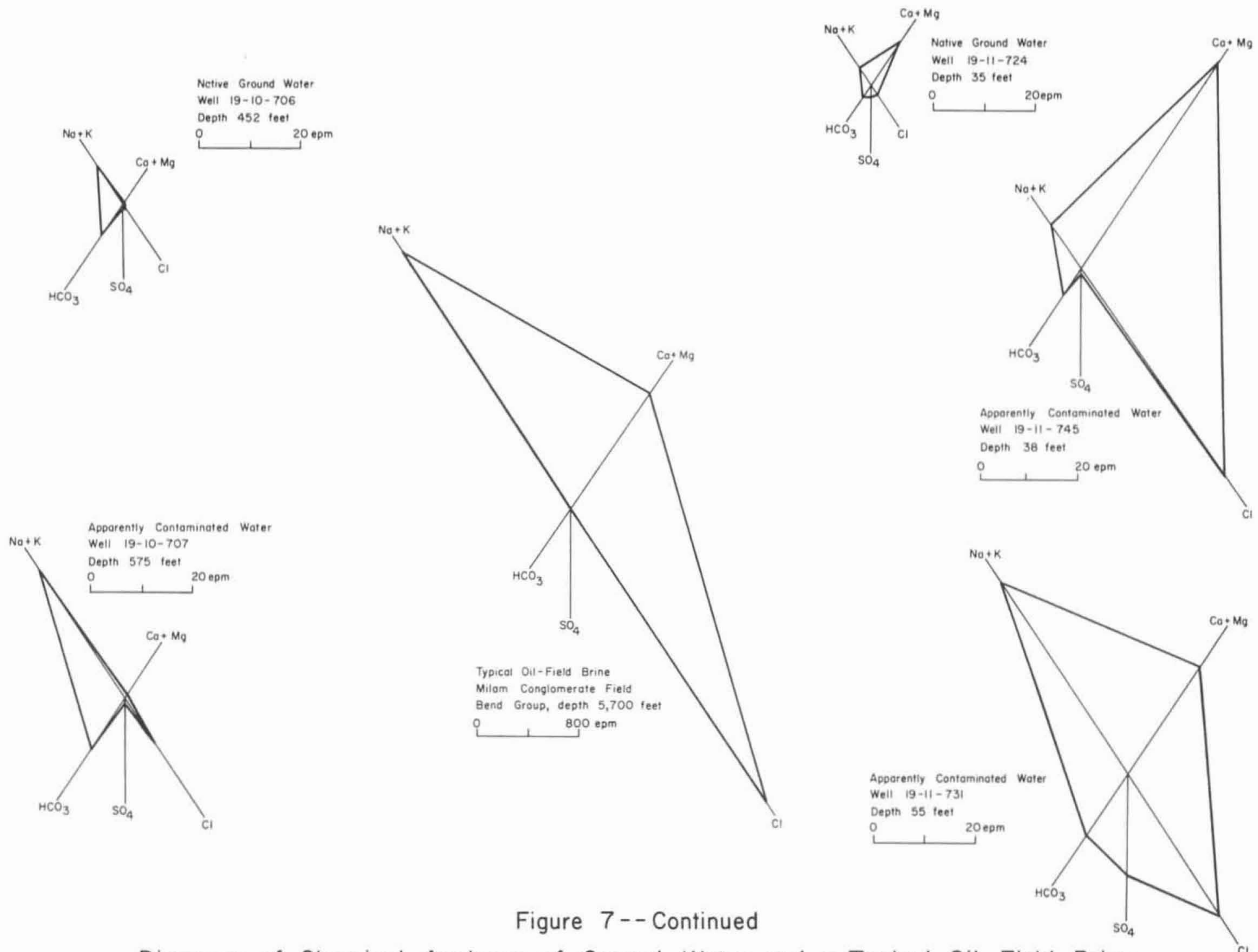

Figure 7 -- Continued

Diagrams of Chemical Analyses of Ground Water and a Typical Oil-Field Brine

Texas Water Development Board in cooperation with the Texas Water Pollution Control Board

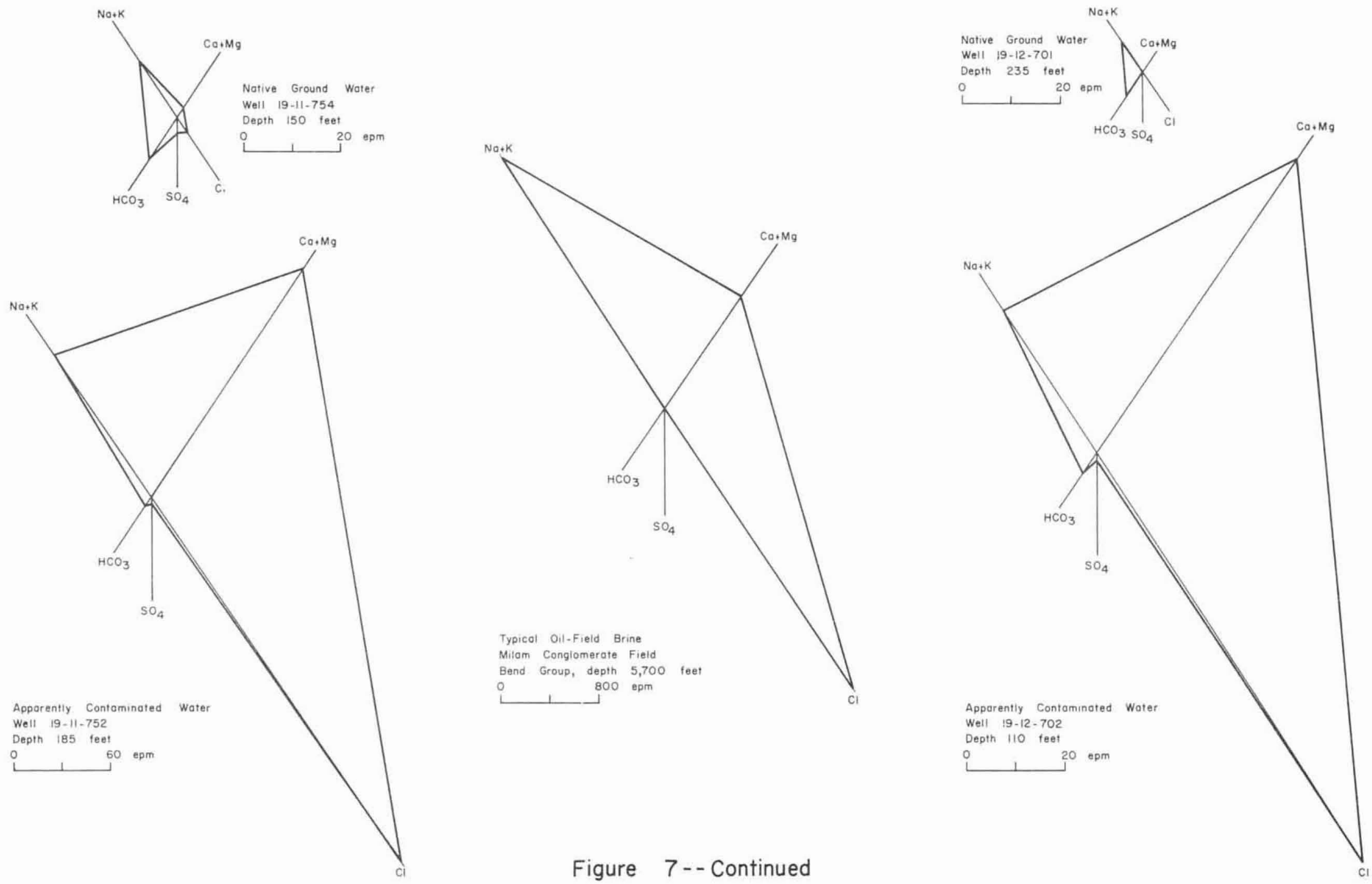

Figure 7 -- Continued

Diagrams of Chemical Analyses of Ground Water and a Typical Oil-Field Brine

Texas Water Development Board in cooperation with the Texas Water Pollution Control Board

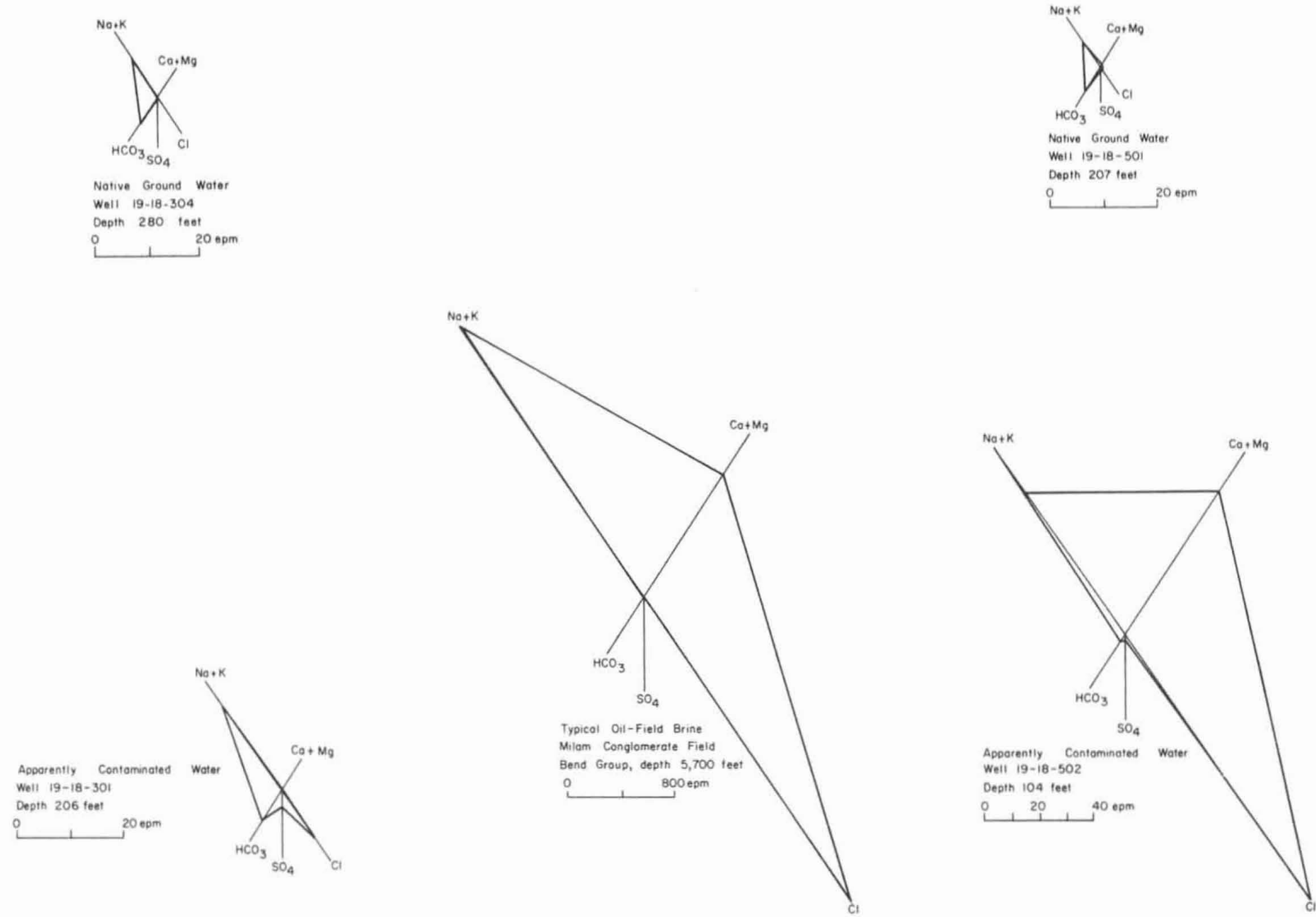

Figure 7--Continued

Diagrams of Chemical Analyses of Ground Water and a Typical Oil-Field Brine

Texas Water Development Board in cooperation with the Texas Water Pollution Control Board

of chemical quality are not available for comparison and because the native quality of ground water in the immediate vicinity could not be established.

The diagrams in Figure 7 show mineral concentrations in equivalents per million (epm), a system which expresses chemical analyses of water by the relationships among the ions in solution, rather than expressing the relationships between the weight of dissolved matter and the weight of solution in parts per million (ppm). In an analysis expressed in epm, unit concentrations of all ions are chemically equivalent; therefore, when all major constituents have been determined, the total equivalents of cations should very nearly equal the total equivalents of anions (Hem, 1959, p. 30-33).

Possible sources of the apparent contamination were noted near many of the water wells shown on Figure 10. The apparent contamination in wells 19-03-701 and 19-03-702 is probably due to previous surface disposal of oil-field brine in the North Nocona field. For wells 19-11-731, 19-11-745, and 19-11-752, a probable source of contamination is brine disposed on leases adjacent to and west of Nocona. Some of the oil wells in this area have been plugged, but a few are still productive and yield small amounts of oil and large amounts of salt water.

The high chloride content in water from well 19-12-702 probably reflects contamination with salt water from nearby oil wells in the Bonita field. A possible source of contamination in well 19-18-502 is a salt water disposal pit about 375 feet north, and for well 19-18-705, a former salt water disposal pit about 845 feet southeast.

In other cases of apparent alteration of the ground-water quality, a probable source of the contamination could not be readily determined. Shallow salt-water injection operations, improperly completed injection wells, and unplugged or improperly plugged abandoned oil and gas wells may be contributing to the ground-water mineralization.

Figure 10 shows several areas where an absence of vegetation is apparently due to seepage of oil-field brines into the soil. Most of these areas are on outcrops of rocks of Permian age. The surface underlain by rocks of Cretaceous age in Montague County generally does not exhibit large vegetative-kill areas, as the Cretaceous sands are very permeable and allows more rapid downward percolation of salt water than the surface underlain by rocks of Pennsylvanian and Permian age which contain greater amounts of shale.

Because of the efforts of the Red River Authority, surface contamination is not as widespread as in the past. A large number of surface pits formerly used for disposal of brine have been filled, and most of the brine produced with petroleum is now being injected into the subsurface.

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Table 3.--Records of wells and springs, Montague County

Water-bearing unit : A, Alluvium; T, Trinity Group; W, Wichita Group; C, Cisco Group.
Water level : Reported water levels given in feet; measured water levels given in feet and tenths.
Method of lift and type of power: B, bucket or bailer; C, cylinder; Cf, centrifugal; E, electric; G, natural gas, butane, or gasoline; H, hand; J, jet; N, none; S, submersible; T, turbine; W, windmill. Number indicates horsepower.
Use of water : D, domestic; S, livestock; Ind, industrial; P, public supply; Irr, irrigation; N, none.

Well	Owner	Driller	Date completed	Depth of well (ft)	Casing: Diameter (in.)	Casing: Depth (ft)	Water-bearing unit	Altitude of land surface (ft)	Water level: Below land-surface datum (ft)	Water level: Date of measurement	Method of lift	Use of water	Remarks
19-02-901	D. A. Boutwell	Jack McBride	1947	185	7 6	64 185	A?,W	818	25	--	C,H	N	Water sands reported at 22-35, 132-147, and 155-185 ft.
* 902	do	-- McNew	1930	163	7 6	84 163	A?,W	820	28	--	J,E, 1/2	D,S	Water sands reported at 22-30 and 138-150 ft; fresh-water sand reported by driller of nearby oil test at 342-392 ft.
* 903	Mrs. D. G. Gardner, Sr.	-- McGrew	1934	204	8 6	20 204	W	807	20	--	C,E, 3/4	D,S	
* 904	Mrs. George C. Gray	do	--	140	6	140	W	808	20	--	C,W	D,S	
* 905	Jack Crownover	-- NcNew	1938	190	8 6	40 190	A?,W	816	28	--	J,E, 3/4	D,S	Water sands reported at 28-45 and 63-190 ft.
* 906	do	Jake Blackwell	1959	190	7 6	48 190	A?,W	813	39.5	Sept. 25, 1963	C,W	S	Do.
* 907	Vester Molsbee	do	1955	125	6	125	A?,W	814	38.9	do	J,E	D,S	
* 908	Jack Crownover	do	1958	190	7 6	48 190	A?,W	800	--	--	C,W	S	Water sands reported at 28-45 and 63-190 ft.
* 03-201	W. B. McGaughy	Doyle Thomas	1963	150	7 5	30 130	A?,W	801	65	--	S,E, 1	D,S	Water sand reported at 120-150 ft.
* 301	S. D. Howard	Boyd Burnett	1955	219	8	219	A?,W	800	30	--	S,E	D,S	Water sands reported at about 28, 80, 125, and 219 ft.
401	Charlie Dodd	Jake Blackwell	1958	72	6	72	A	869	20	--	C,W	S	Water sand reported at 50-72 ft.
* 402	T. L. Hancock	--	--	67	7-1/2	67	A	809	32.3	Apr. 13, 1964	J,E, 1/3	D,S	Reported weak well.
* 501	Mrs. Dorothy C. Reed	Bridwell Oil Co.	--	175	7	--	A?,W	812	73.1	Aug. 20, 1963	C,E, 3/4	D,S	
* 502	S. D. Howard	Boyd Burnett	1955	125	7	125	W	850	37.5	Feb. 20, 1964	C,W	S	
* 503	John Crownover	--	--	100	7 6	40 100	A?,W	791	9	--	C,W	S	

See footnote at end of table.

Table 3.--Records of wells and springs, Montague County--Continued

Well	Owner	Driller	Date completed	Depth of well (ft)	Casing		Water-bearing unit	Altitude of land surface (ft)	Water level		Method of lift	Use of water	Remarks
					Diameter (in.)	Depth (ft)			Below land-surface datum (ft)	Date of measurement			
*19-03-504	John Crownover	Jack McBride	1928	99	7 5	40 99	A?,W	844	40	--	C,W	D,S	Water sands reported at 40-45 and 80-100 ft.
* 505	do	Whaley & Marshall Oil Co.	1948	48	10-1/2	40	A	841	38	--	J,E, 1/2	D,S	Water sand reported at 40-45 ft. Former oil test plugged back for water well.
* 701	Vester Molsbee	Continental Oil Co.	1919	125	8	125	A?,W	818	47.3	Sept. 25, 1963	C,W	S	
* 702	J. J. Beckham	Jack Beckham	1959	72	7	72	A	794	35	--	C,E, 3/4	D,S	Water sand reported at 35-72 ft.
* 703	S. F. Loy Estate	--	1916	60	6	60	A,W	831	23.7	Oct. 7, 1963	C,W	D,S	
* 704	Charlie Dodd	--	--	72	6	72	A,W	848	23.6	do	C,W	S	
705	Petroleum Investment Co.	--	--	75	5-1/2	75	W	879	30	--	C,E, 25	D,S, Ind	Pump jack operated by rodline.
706	do	--	--	75	5-1/2	75	W	875	30	--	C,E, 25	D,S, Ind	Do.
* 707	The Pure Oil Co.	--	--	100	5-1/2	97	W	887	50	--	C	D,S, Ind	Pump jack operated by rodline. Water sands reported at 20-37 and 63-92 ft, casing perforations at 65-97 ft.
708	P. H. Hughes	Edward Thomas	1961	85	6-1/2 6	20 85	W	884	53.3	Oct. 11, 1963	J,E, 1/2	D	Water sand reported at 76-80 ft. Water level measured in abandoned well 30 yards south.
709	W. Meekins	Jake Blackwell	1951	84	7 6	35 84	W	899	70	--	J,E, 1	D	Water sand reported at 79-84 ft.
* 710	Petroleum Investment Co.	--	--	100	5-1/2	100	W	900	45	--	C,E, 25	D,S, Ind	Pump jack operated by rodline.
* 711	Mrs. Pearl N. Jones	--	1938	119	6	119	W	857	30	--	C,W	D,S	
* 712	Mrs. H. F. Wilton	--	1900	173	7 6	70 173	W	872	72.0	Oct. 10, 1963	C,W	D,S	
* 713	Lesley Combs	Tommy Paine	--	280	6	280	W	828	20	--	J,E, 1/2	D,S	
* 714	Mrs. V. B. Howard	Jake Blackwell	1960	112	6	112	W	896	75.9	Oct. 14, 1963	J,E, 1	D	
* 715	R. F. Boutwell	-- Blackwell	1954	145	7 6	5 145	W	927	90	--	C,E, 1/2	D,S	Water sand reported at 135-145 ft.
716	T. B. Gist	do	1949	113	6	113	W	899	70	--	C,W	S	Water sand reported at 110-150 ft.

See footnote at end of table.

Table 3.--Records of wells and springs, Montague County--Continued

Well	Owner	Driller	Date completed	Depth of well (ft)	Casing: Diameter (in.)	Casing: Depth (ft)	Water-bearing unit	Altitude of land surface (ft)	Water level: Below land-surface datum (ft)	Water level: Date of measurement	Method of lift	Use of water	Remarks
*19-03-717	T. B. Gist	-- Gibson	1948	150	6	150	W	902	60	--	C,W	D,S	Water sand reported at 110-150 ft.
* 718	Ben Cunningham	--	--	200	5	200	W	902	--	--	C,W	D,S	
* 719	J. A. Lampkin	-- McNew	1941	129	7 6	15 129	W	885	55	--	C,E, 1	D,S	Water sand reported at 116-129 ft.
* 720	Prairie Valley High School	--	1929	225	6-5/8	225	W	878	--	--	C,E, 1	D,P	
* 721	Continental Oil Co.	Continental Oil Co.	1925	134	7	134	W	893	70	--	C,E, 3	Ind	Water sand reported at 110-134 ft.
* 801	W. Meekins	Jake Blackwell	1955	137	6	137	W	885	79.4	Oct. 14, 1963	C,W	S	Water sand reported at 70-137 ft.
* 802	The Pure Oil Co.	--	--	111	7	70	W	868	--	--	C	Ind,S	Water sand reported at 21-70 ft; salty water in sand at about 40-50 ft cemented off. Pump jack operated by rodline.
* 803	R. A. Cunningham	Jake Blackwell	1961	111	6	111	W	907	--	--	C,W	D,S	Water sands reported at 60-64 and 100-111 ft.
* 804	Fred Cunningham	-- McGrew	1920	126	6	126	W	923	80	--	C,W	D	Water sand reported at 75-100 ft.
805	do	John Lesh	1937	126	6	126	W	925	80	--	C,E	S	Do.
* 806	Fred Salmon	Jake Blackwell	1956	120	7	120	W	914	40	--	C,W	S	
* 807	Bridwell Oil Co.	Bridwell Oil Co.	1953	108	5-1/2	108	W	902	--	--	C,W	D	
* 808	Walsh and Watts Oil Co.	--	--	150	7	150	W	860	50	--	C,E, 50	D,S, Ind	
* 809	E. D. Grant	Doyle Thomas	1955	360	7 4	256 360	W	900	154.1	Feb. 11, 1964	C,W	S	Water sands reported at 110 and 350-360 ft.
901	Pete Uselton	Edward Thomas	1960	298	7	230	W	863	60	--	J,E, 1	D	Water sands reported at 82-104, 148-155, 210-225, 230-245, and 273-285 ft.
* 04-401	John J. Moore	Doyle Thomas	1960	205	6	205	W	785	12	--	J,E, 1	D	Water sand reported at 180-200 ft.
* 402	S. E. Howard	do	1962	205	7	205	W	824	15	--	J,E, 1/2	D,S	
* 403	W. T. Fox	do	1964	212	7 5	30 212	W	786	16	--	C,W	D,S	Water sands reported at 185-190 and 200-212 ft.
* 701	Jimmy Howard	Harvey Thomas	--	268	6	268	W	826	53.9	Feb. 6, 1964	C,E, 3/4	D,S	
* 702	J. G. Howard Estate	McCarty and Coleman Oil Co.	1944	--	9	388	W,C?	768	(+)	do	Flows	S	Base of usable quality water estimated from electrical survey 890 ft below surface.

See footnote at end of table.

Table 3.--Records of wells and springs, Montague County--Continued

Well	Owner	Driller	Date completed	Depth of well (ft)	Casing: Diameter (in.)	Casing: Depth (ft)	Water-bearing unit	Altitude of land surface (ft)	Water level: Below land-surface datum (ft)	Water level: Date of measurement	Method of lift	Use of water	Remarks
*19-04-703	Phil Howard	Jake Blackwell	1951	150	7	150	W	820	27	--	C,E, 1/2	D,S	Water sand reported at 140-150 ft.
* 801	R. C. Haralson	Doyle Thomas	1947	212	6	200	A?,W	854	134.8	Nov. 5, 1963	C,E, 1/2	D,S	
* 05-701	H. D. Hoover	--	--	160	6	160	W	820	--	--	C,W	D,S	
* 702	Ray Dowd	-- Ramsey	1910	225	6 4	225 130	W	761	45	--	C,E, 3/4	D,S	Well has caved to 130 ft. Water sands reported at about 80 and 120 ft.
* 09-101	Mrs. J. M. Turner	Jake Blackwell	1945	65	6	65	A,W?	889	14.4	Sept. 3, 1963	J,E, 1	D	Water level measured in abandoned well 20 ft north.
* 102	Mrs. Cora Williamson	--	--	50	--	--	A,W?	891	--	--	J,E, 1/2	D	
* 103	L. M. Staley Estate	Jack McBride	1940	527	5-1/2	527	W	908	100	--	1-1/2	D,S	Water sands reported at 400-420 and 500-518 ft.
* 201	G. T. Hughes	--	1900	40	72	40	A,W?	928	20	--	J,E, 1/2	D,S	Dug well.
* 202	Mrs. Jewel Castleberry	--	1921	72	6	72	A?,W	915	50	--	C,W	D,S	
* 203	C. O. Seeds	--	--	75	6	75	A?,W	902	45	--	J,E, 1	D,S	
* 204	Magnolia Pipeline Co.	--	1953	700	6-5/8	700	W,C?	876	--	--	Cf,E, 7-1/2	D,Ind	
* 205	H. C. Hughes	-- Wharton	1911	175	6	175	W	858	60	--	J,E, 1	D,S	Water sand reported at 150-175 ft.
* 206	do	do	1915	30	6	30	A,W?	927	17.0	Sept. 5, 1963	C,W	D,S	
* 207	Magnolia Pipeline Co.	--	1922	622	10 5-1/2	115 554	W,C?	807	(+)	Sept. 4, 1963	Flows	S	
* 208	W. C. Hughes Estate	Jack McBride	1931	354	--	--	W	861	103.8	June 8, 1964	C,E, 1	D,S	
* 301	Buck Boren	Buck Boren	1963	21	--	--	A	792	10	--	Cf,G, 5	S	
302	do	Sam Boren	1940	19	--	--	A	791	15	--	C,W	S	
* 303	Roy C. Fitts, Jr.	Roy C. Fitts, Jr.	1948	20	--	--	A	791	12	--	C,W	S	
304	O. F. Walker	Buck Boren	1953	21	--	--	A	790	10	--	C,W	S	

See footnote at end of table.

Table 3.--Records of wells and springs, Montague County--Continued

Well	Owner	Driller	Date com-pleted	Depth of well (ft)	Casing: Diam-eter (in.)	Casing: Depth (ft)	Water-bearing unit	Altitude of land surface (ft)	Water level: Below land-surface datum (ft)	Water level: Date of measurement	Method of lift	Use of water	Remarks
*19-09-305	O. F. Walker	Buck Boren	1955	29	--	--	A	793	10	--	C,W	S	Water sand reported at 15 ft.
* 501	Gold-Burg Independent School District	--	--	200	6	200	W	901	137.0	Mar. 6, 1964	J,E, 1	P	Supplies water to school of about 55 students.
* 502	C. W. Chandler	Jack McBride	1952	200	5-7/8	200	W	903	126.8	Aug. 8, 1963	S,E, 1	D,S	Casing perforations reported at 170-200 ft.
* 503	do	--	1926	90	5-3/8	80	W	884	80	--	C,W	S	
504	do	--	1906	60	--	--	W	891	--	--	C,W	S	Reportedly can be pumped dry by windmill.
505	do	--	--	Spring	--	--	W	879	(+)	--	Flows	S	Reported strong supply.
* 506	D. J. Leeper	Doyle Thomas	1963	105	7	88	W	901	45	--	C,E, 3/4	D	Water sands reported at 22-28, 47-55, and 91-105 ft.
* 507	J. G. Etheridge	--	--	83	6	83	W	906	14.6	Aug. 28, 1963	J,E, 1/2	D,S	
* 508	Walten E. Wilton	Harvey Thomas	1963	220	7 5-1/2	75 220	W	915	85	--	C,E, 3/4	D,S	Water sand reported at 180-220 ft.
* 509	J. H. Moody Estate	Jake Blackwell	1954	196	6	196	W	878	80	--	J,E, 1	D,S	
* 510	J. E. Rushing	Jack McBride	1951	325	5	325	W	828	6.4	Sept. 5, 1963	C,E, 3/4	D,S	Saline water sands reported at 14 and 60 ft are cased off. Water from shallow well nearby became saline about 1953.
* 511	J. R. Blevins	Earl Gambling	1957	325	8 6	8 325	W	921	95	--	C,W	D,S	
* 512	J. M. Capps	Jack McBride	1946	305	6-5/8	305	W	902	100	--	C,W	D,S	Water sand reported at 275-300 ft.
* 513	L. H. Campbell	do	1939	200	7	200	W	896	107.7	Nov. 14, 1963	C,E, 3/4	D	Water sand reported at 178-192 ft.
* 514	J. A. Staley	do	1934	188	7	188	W	900	--	--	C,E, 1-1/2	D	Water sand reported at 135-188 ft.
* 601	William G. Hawkins	do	1945	200	7	886	W	886	86.6	Aug. 23, 1963	C,W	S	
602	L. E. and H. D. Milam	--	--	Spring	--	--	W	840	(+)	--	Flows	N	
* 603	William G. Hawkins	Jack McBride	1939	200	7 6	30 200	W	914	75	--	C,W	D,S	
* 604	L. E. and H. D. Milam	do	1952	390	7	390	W	914	75	--	C,E	D,S	

See footnote at end of table.

Table 3.--Records of wells and springs, Montague County--Continued

Well	Owner	Driller	Date com-plet-ed	Depth of well (ft)	Casing: Diam-eter (in.)	Casing: Depth (ft)	Water-bear-ing unit	Altitude of land surface (ft)	Water level: Below land-surface datum (ft)	Water level: Date of measurement	Method of lift	Use of water	Remarks
*19-09-605	J. R. Blevins	Earl Gambling	1955	100	6	100	W	905	80	--	J,E, 3/4	D	Water sand reported at 90-100 ft.
* 606	H. B. Moss	Jack McBride	1934	352	5-1/2	352	W	871	26	--	C,E, 1/2	D,S	
* 607	L. H. Campbell	do	1947	386	6	386	W	883	80	--	C,W	D,S	Water sand reported at 354-370 ft.
* 608	W. A. Parr	Jake Blackwell	1949	160	6	160	W	891	25.4	Sept. 13, 1963	B,H	D,S	
* 801	J. A. Staley	Jack McBride	1938	725	7	725	W	931	--	--	C,W	S	
* 802	F. T. Leeper	do	1940	206	6	206	W	906	103.2	Dec. 6, 1963	C,E, 3/4	D,S	
* 803	Wilmer Seay	--	1917	520	6	520	W	862	60	--	C,E, 1/4	D	
* 804	do	Jack McBride	1936	520	6	520	W	877	50	--	C,W	S	Casing perforations reported at 480-500 ft.
* 901	Harold and Warren Seay	--	1956	100	4	100	W	895	20	--	C,W	D,S	
* 902	L. A. Mitchell	-- Richardson	1963	158	6	158	W	888	85.7	Apr. 22, 1964	C,W	S	
* 10-201	N. M. Miller	-- McGrew	1920	150	6	150	W	854	50	--	C,E, 3/4	D,S	Water sand reported at 140-150 ft.
* 202	Mrs. D. G. Gardner, Sr.	Jack McBride	1944	385	7	385	W	887	60	--	C,W	S	
* 203	Jack Kidwell	John Settles	1920	112	6	112	W	888	20	--	C,W	D,S	
* 301	Billy Miles	Doyle Thomas	1945	303	6	303	W	886	40	--	C,W	D,S	
* 302	Scott Phillips	Arthur Pennmooney	1955	297	6	297	W	883	--	--	C,W	D,S	Water sand reported at 294-297 ft.
* 401	Hardy Seay	Doyle Thomas	1956	250	7 5	150 250	W	851	20	--	C,W	S	Water sand reported at 230-250 ft.
* 402	do	do	1960	150	6	150	W	849	30	--	C,W	S	Water sand reported at 135-150 ft.
* 403	do	--	1938	50	5	20	W	860	(+)	Aug. 29, 1963	Flows	S	Water sand reported at 20-50 ft.
* 404	do	Jack McBride	1939	263	6	263	W	821	(+)	do	C,W	S	Water sand reported at 240-263 ft. Well 24 in 1944 Nocona report.
* 405	do	do	1941	240	6	240	W	804	(+)	do	Flows	S	Water sand reported at 222-242 ft. Well 23 in 1944 Nocona report.
501	Mrs. Kate Reed	Boyd Burnett	1951	85	6	85	W	908	40	--	N	N	Water sand reported at 65-85 ft.

See footnote at end of table.

Well	Owner	Driller	Date completed	Depth of well (ft)	Casing: Diameter (in.)	Casing: Depth (ft)	Water-bearing unit	Altitude of land surface (ft)	Water level: Below land-surface datum (ft)	Water level: Date of measurement	Method of lift	Use of water	Remarks
*19-10-502	Mrs. Bessie Grant	Jack McBride	1946	250	--	--	W	901	80.7	Aug. 23, 1963	J,E	D,S	
* 503	E. B. Henson	Jake Blackwell	1959	77	--	--	W	903	31.0	Aug. 26, 1963	B,H	D	Water sands reported at 37 and 62-75 ft.
* 504	Willard Grigsby	Doyle Thomas	1963	550	10-3/4 7	500 550	W?,C	868	37	--	C,W	S	Former oil test converted to water well. Casing perforations reported at 530-545 ft.
* 505	do	do	1963	700	10-3/4	722	W?,C	846	3.9	Aug. 27, 1963	C,G, 4	S	Former oil test converted to water well. Casing perforations reported at 580-630 ft.
506	do	--	--	Spring	--	--	A	830	(+)	--	Flows	N	Reportedly flows during wet weather.
507	do	--	--	Spring	--	--	A	830	(+)	--	Flows	N	Do.
* 508	Sudie Stowe Estate	--	1928	100	6	100	W	889	11.1	Aug. 28, 1963	B,H	D,S	
* 509	Wichita River Oil Co.	Jack McBride	1946	150	7	150	W	885	--	--	C,E, 1/2	D	
* 510	W. H. Farmer	--	1961	254	5-1/2	254	W	905	37.7	Aug. 30, 1963	C,E, 3/4	D,S	Water sands reported at 197-198 and 222-254 ft. Water level measured in abandoned well 10 ft west.
* 511	M. C. Swearingen	--	--	32	36	32	A	901	18.3	Sept. 9, 1963	C,W	S	Dug well.
* 512	do	--	1923	79	6	79	A?,W	876	21.0	do	J,E, 1/2	D	
* 513	Mrs. A. W. Coleman	Doyle Thomas	1955	410	5	410	W	894	70	--	C,E, 3/4	D,S	Water sand reported at 390-410 ft.
514	do	--	--	Spring	--	--	A,W?	860	(+)	--	Flows	S	Reportedly flows during wet weather.
515	do	--	--	Spring	--	--	A,W?	860	(+)	--	Flows	S	Do.
* 516	Chris Uselton	Harvey Thomas	1940	207	6	207	W	924	--	--	C,E, 1/2	D,S	
517	Crenshaw Estate	Jack McBride	1940	205	6	205	W	941	--	--	C,E, 1/2	N	
* 601	Mrs. R. L. Winter	Doyle Thomas	--	230	6	230	W	884	60	--	C,E, 3/4	D,S	
* 602	Jack Crain	--	1951	397	4	397	W	904	73	--	C,E, 3	D,S	Water sand reported at 385-395 ft.
* 603	James R. Roper	Harvey Thomas	1961	230	6	230	W	911	74.5	Sept. 20, 1963	B,H	D,S	Water sand reported at 225-230 ft.
* 604	Clayton C. Menasco	--	1910	56	6	56	W	909	30	--	C,E, 1/2	D,S	

See footnote at end of table.

Table 3.--Records of wells and springs, Montague County--Continued

Well	Owner	Driller	Date completed	Depth of well (ft)	Casing: Diameter (in.)	Casing: Depth (ft)	Water-bearing unit	Altitude of land surface (ft)	Water level: Below land-surface datum (ft)	Water level: Date of measurement	Method of lift	Use of water	Remarks
*19-10-605	R. W. Jones	Harvey Thomas	1952	315	5	315	W	895	35	--	C,E, 1/3	D,S	Water sand reported at 287-315 ft.
* 606	Vester Molsbee	-- McNew	1940	130	6	130	W	920	55	--	C,E, 3/4	D,S	Water sand reported at 92-100 ft.
* 607	Bob Weaver	Boyd Burnett	1940	180	6	180	W	926	99.0	Sept. 25, 1963	J,E, 1	D	
* 608	David Sappington	Doyle Thomas	1958	254	7	254	W	930	--	--	C,W	D	Water sand reported at 230-254 ft.
* 609	A. B. Cardwell	Wash McGrew	1935	102	6	102	W	858	19.5	Sept. 25, 1963	B,H	N	Water sand reported at 99-102 ft.
* 610	do	Boyd Burnett	1949	291	7	268	W	853	11	--	C,W	D,S	Water sand reported at 264-289 ft.
* 611	W. L. Hightower	Wash McGrew	1938	157	7 6	30 157	W	926	60	--	C,E, 1/2	D,S	Water sand reported at 140-157 ft.
* 612	L. R. Sawyer	--	1939	127	6	127	W	913	120	--	C,W	S	
* 613	do	Jack McBride	1953	265	7	265	W	910	90	--	C,E, 1	D,S	Water sands reported at 127-132, 230-235, and 248-263 ft.
* 614	Lee Ashcraft	Jake Blackwell	1957	160	6	160	W	945	40	--	C,E, 1	D,S	Water sand reported at 150-160 ft.
* 615	Jack Davis	do	1952	133	6	133	W	905	38.8	Sept. 26, 1963	B,H	D,S	
* 616	G. T. Pults	do	1958	100	6	100	W	887	27	--	C,E, 1/2	D,S	
* 617	Jack Crow	do	1960	185	6	185	W	887	52.3	Sept. 30, 1963	Cf,E, 1	D,S	Water sand reported at 168-182 ft.
* 618	W. V. Waters	Doyle Thomas	1962	305	7-1/2	305	W	909	85	--	C,E, 1/4	D	Water sand reported at 288-300 ft.
* 701	Hardy Seay	--	--	50	6	50	A?,W	900	30	--	C,W	D,S	Well 22 in 1944 Nocona report.
* 702	do	--	1943	70	5	10	A?,W	899	30	--	C,E, 1/2	D,S	Water sand reported at 10-70 ft.
* 703	do	Doyle Thomas	1960	50	8	50	A?,W	923	18.1	Aug. 29, 1963	C,W	S	Water sand reported at 40-50 ft.
* 704	do	Jack McBride	1940	390	6-7/8	390	W	827	(+)	do	Flows	S	Water sand reported at 312-390 ft. Well 25 in 1944 Nocona report.
705	H. B. Moss	--	--	140	6	140	W	840	--	--	C,W	S	
* 706	Weldon W. Porter	Jack McBride	1949	452	7	452	W	841	(+)	Mar. 24, 1964	Flows	S	Water sand reported at 340-450 ft.

See footnote at end of table.

Well	Owner	Driller	Date completed	Depth of well (ft)	Casing: Diameter (in.)	Casing: Depth (ft)	Water-bearing unit	Altitude of land surface (ft)	Water level: Below land-surface datum (ft)	Water level: Date of measurement	Method of lift	Use of water	Remarks
*19-10-707	H. B. Moss	Doyle Thomas	1963	575	9-5/8	575	W,C?	852	(+)	Apr. 22, 1964	Flows	S	Water sands reported at 346-364 and 516-576 ft. Former oil test converted to water well.
* 801	Johnny Carminati	do	1958	205	7	205	W	924	105.2	Aug. 22, 1963	C,E, 3/4	D	Water sand reported at 192-205 ft.
* 802	L. C. Coker	do	1955	285	--	--	W	915	4	--	J,E, 1/4	D,S	Water sand reported at 278-285 ft.
* 803	C. R. Bailey	--	1948	55	--	--	A?,W	924	--	--	C,W	S	
* 804	do	Jake Blackwell	1958	285	--	--	W	919	100	--	Cf,E, 1-1/2	S	Water sand reported at 245-285 ft.
805	Chris Uselton	--	--	20	--	--	A,W?	928	--	--	J,E, 1/2	D,S	Dug Well.
* 806	I. H. Copeland	Doyle Thomas	1952	300	7	300	W	950	60	--	C,W	S	
901	Nathan E. Allred	do	1941	385	--	--	W	903	73.9	May 14, 1964	Cf,E, 2	D,S	
* 902	G. M. Hendricks	Jake Blackwell	1952	110	6	110	W	897	45	--	J,E, 1/2	D,S	Water sand reported at 100-110 ft.
* 903	Travis S. Lemon	Jack McBride	1956	180	6	180	W	902	69.1	Aug. 22, 1963	C,E, 3/4	D,S	
* 904	Howard Paine	Boyd Burnett	1950	150	6	105	W	893	40	--	J,E, 3/4	D,S	
* 905	Roy Duncan	--	--	64	6	64	W	896	31.6	Aug. 22, 1963	B,H	D	
* 906	do	--	--	100	6	68	W	896	--	--	C,W	D	
* 907	J. T. Thompson	--	--	125	6	125	W	901	73.4	Aug. 26, 1963	J,E, 1	D	
* 11-101	Mrs. J. G. Mays	-- McGrew	1920	190	5	190	W	846	30	--	C,W	D	
* 102	Mrs. H. F. Wilton	--	1910	190	7 6	70 190	W	853	2	--	C,W	S	
* 103	John Harper	Doyle Thomas	1957	230	6-5/8	230	W	865	50	--	J,E, 1	D,S	Water sand reported at 210-230 ft.
* 104	Floyd Begley	Wash McGrew	1913	147	6	135	W	857	125.8	Oct. 17, 1963	C,E, 1/2	D,S	
* 105	Lesley Combs	Doyle Thomas	1945	250	6-5/8	--	W	887	--	--	C,E, 1/3	D,S	Water sand reported at 230-250 ft.

See footnote at end of table.

Table 3.--Records of wells and springs, Montague County--Continued

Well	Owner	Driller	Date completed	Depth of well (ft)	Casing: Diameter (in.)	Casing: Depth (ft)	Water-bearing unit	Altitude of land surface (ft)	Water level: Below land-surface datum (ft)	Water level: Date of measurement	Method of lift	Use of water	Remarks
*19-11-201	S. J. Young	Doyle Thomas	1946	200	6	200	W	909	80	--	C,E, 3/4	D,S	Water sand reported at 185-195 ft.
301	H. D. Brandon	Harvey and Edward Thomas	1963	224	7 5-1/2	134 224	W	880	58.2	Feb. 11, 1964	S,E, 1/2	D	Water sands reported at 117-118, 125-130, and 198-223 ft. Well deepened to 224 ft.
* 302	B. R. Bowling	Boyd Burnett	1964	140	5-1/2	140	W	857	28	--	J,E 3/4	D	Water sand reported at 122-130 ft.
* 401	Joe B. Brown	--	1938	160	5	160	W	978	--	--	C,W	D,S	
* 402	Glenn O. Wilson	--	--	60	48	60	A,W?	967	17.3	Aug. 2, 1963	J,E, 1/3	S	Dug well.
* 403	Miss Lula Bouldin	Edward Thomas	1962	267	5-1/2	267	W	968	85	--	S,E, 1	D,S	Water sand reported at 250-267 ft.
* 404	Mrs. John N. Bellah	Lee Ashcraft	1954	90	--	--	W	960	--	--	J,E, 1/4	S	
* 405	John Weaver	Jake Blackwell	1958	109	5-1/2	109	W	959	17	--	J,E, 1	D	
* 406	E. L. McNabb	E. L. McNabb	1930	20	60	20	A	963	11.5	Aug. 5, 1963	C,W	S	Dug well.
* 407	L. R. Sawyer	Jack McBride	1954	272	7	272	W	981	60	--	C,W	S	Water sands reported at 205-220 and 246-272 ft.
* 408	Cecil Keck	Doyle Thomas	1958	325	7	325	W	907	80	--	S,E, 1	D,S	Water sand reported at 258-322 ft.
* 409	O. M. Molsbee, Jr.	Jake Blackwell	1956	90	6	90	W	900	3	--	J,E, 1/2	D,S	
410	do	do	1951	90	6	90	W	895	9.3	Oct. 2, 1963	J,E 1/2	D,S	Water level measured in well 6 ft west.
411	Charlie Molsbee	-- Blackburn	1944	63	6	63	W	924	30	--	J,E 1/4	D,S	
* 412	O. T. Molsbee	Jake Blackwell	--	190	6	--	W	907	60	--	J,E, 1	D	
* 413	Waymon Tipton	do	1952	100	5-1/2	100	W	924	35.8	Oct. 22, 1963	J,E, 1/2	D,S	
* 414	Mrs. Pearl Molsbee	Jack McBride	1940	270	7	--	W	896	50	--	J,E, 1	D,S	
* 415	R. D. Teasley	Dennis Paine	1949	196	6-5/8	196	W	910	15	--	C,W	D,S	

See footnotes at end of table.

Table 3.--Records of wells and springs, Montague County--Continued

Well	Owner	Driller	Date completed	Depth of well (ft)	Casing: Diameter (in.)	Casing: Depth (ft)	Water-bearing unit	Altitude of land surface (ft)	Water level: Below land-surface datum (ft)	Water level: Date of measurement	Method of lift	Use of water	Remarks
*19-11-416	T. P. Skinner	Doyle Thomas	1954	229	6	229	W	922	--	--	C,E, 1/2	D,S	
*417	Mrs. Billie Molsbee	do	1955	252	6	252	W	924	--	--	C,E, 3/4	D,S	
*501	Fred Salmon	Jack McBride	1949	280	7 5	40 280	W	930	--	--	C,E, 1	D,S	Water sand reported at 200-280 ft.
601	G. H. Fooshee	--	1870	24	--	24	A	853	--	--	C,W	S	Dug well.
*602	do	Doyle and Harvey Thomas	1940	262	5	262	W	927	45	--	C,E, 1	D	
*603	C. M. Russell	-- NcNew	1928	190	7	180	W	896	51.5	Feb. 10, 1964	C,W	D,S	
604	do	Doyle Thomas	1959	162	10 7	50 100	W	857	(+)	Feb. 7, 1964	Flows	S	Water sand reported at 100-162 ft.
*701	City of Nocona	--	1944	727	8-5/8	680	W,C?	990	206.3	Nov. 8, 1944	N	N	Water sand reported at 662-754 ft. Well 9 in 1944 Nocona report. Original depth reported 780 ft.
*702	do	--	--	388	--	--	W	998	--	--	N	N	Water sand reported at 375-388 ft. Well 1 in 1944 Nocona report.
703	do	--	1926	712	8 5-1/4	-- --	W,C?	997	268.5	Nov. 17, 1944	N	N	Water sand reported at 682-704 ft. Well 2 in 1944 Nocona report.
*704	do	--	1926	600	--	--	W,C?	990	--	--	N	N	Well 3 in 1944 Nocona report.
*705	do	--	1926	600	--	--	W,C?	990	--	--	N	N	Well 4 in 1944 Nocona report.
706	do	Layne-Texas Co.	1927	893	--	--	W,C?	963	--	--	N	N	Well 10 in 1944 Nocona report.
*707	do	--	1942	600	--	--	W,C?	963	306.5	Nov. 19, 1944	N	N	Well 6 in 1944 Nocona report.
*708	do	--	1938	525	8 6-5/8	-- --	W,C?	963	320.7	Nov. 16, 1944	N	N	Well 5 in 1944 Nocona report.
*709	do	--	1938	371	--	--	W,C?	925	182.0	Nov. 10, 1944	N	N	Well 7 in 1944 Nocona report. Original depth reported 426 ft.
*710	do	--	1939	422	--	--	W,C?	925	140.9	do	N	N	Well 8 in 1944 Nocona report. Original depth reported 508 ft.
711	do	Kingery Bros.	1950	770	--	--	W,C?	958	--	--	N	N	Completed as water well from abandoned oil test; water well now abandoned.
712	do	--	1951	--	--	--	W,C?	967	--	--	N	N	Do.
713	do	Thomas & McBride	1949	598	--	--	W,C?	946	--	--	N	N	

See footnote at end of table.

Table 3.--Records of wells and springs, Montague County--Continued

Well	Owner	Driller	Date completed	Depth of well (ft)	Casing Diameter (in.)	Casing Depth (ft)	Water-bearing unit	Altitude of land surface (ft)	Water level Below land-surface datum (ft)	Water level Date of measurement	Method of lift	Use of water	Remarks
*19-11-714	Wallace K. Myers	Field and Thomas	1958	386	8-5/8 7	42 386	W	973	210	--	S,E, 1-1/2	D	Water sands reported at 235-250 and 350-385 ft. Reported yield approximately 13 gpm.
* 715	J. M. Land	--	1957	67	6-1/2	50	W	971	7	--	J,E, 1/2	D	Reported yield approximately 4 gpm.
* 716	do	--	1957	167	4-1/2	150	W	971	7	--	J,E, 1-1/2	D	Reported yield approximately 2 gpm.
* 717	do	--	1963	175	6-1/2	150	W	971	7	--	J,E, 1-1/2	D	Water sand reported at 96-128 ft.
* 718	W. H. Patterson	Jake Blackwell	1959	150	6	150	W	969	30	--	C,E, 1/3	D	
* 719	N. C. Field	Field and Thomas	1954	275	7	275	W	999	80	--	S,E, 3/4	D	Water sand reported at 240-275 ft.
* 720	Mrs. M. M. Gilbert	--	--	128	--	--	W	994	--	--	C,W	D	
* 721	O. M. Allison	N. C. Field	1957	138	6-5/8	138	W	970	--	--	J,E 1/2	D	
722	Joe B. Brown	Roy Berry	1935	19	48	19	A	976	9.9	Aug. 1, 1963	C,E, 1/4	N	Dug well.
* 723	J. B. Samples	--	1941	220	5	220	W	967	94.9	do	C,W	D	
* 724	Otto Menasco	--	1870	35	--	--	A,W?	987	23	--	J,E, 1/3	D	Dug well. Reported yield approximately 2 or 3 gpm.
* 725	Ruth and Kate Davis	Boyd Burnett	1940	243	7 5-1/4	60 242	W	980	--	--	C,E, 3/4	D	
* 726	Mrs. G. M. Utt	Jack McBride	1941	230	--	--	W	998	106.3	July 31, 1963	C,W	D	
* 727	Mrs. P. F. Lesh	P. F. Lesh	1943	265	7	265	W	991	--	--	C,E, 3	D	
* 728	Nathan E. Allred	Edward Thomas	1961	250	7 5-1/2	224 250	W	950	137.7	July 31, 1963	C,E, 1	D	Water sand reported at 235-261 ft.
729	A. N. Arveson	-- Thomas	1946	163	8	163	W	967	25	--	C,E, 1	N	
* 730	Aubrey Charles	Edward Thomas	1961	185	10 5	63 185	W	996	120	--	S,E	D	
* 731	G. H. Fooshee	-- Underwood	1907	55	6	55	A,W?	977	20.6	Aug. 5, 1963	B,H	D	
732	T. L. Priddy	Jake Blackwell	1956	155	6	155	W	956	76.6	do	J,E, 1	D	Water sand reported at 150-155 ft.

See footnote at end of table.

Table 3.--Records of wells and springs, Montague County--Continued

Well	Owner	Driller	Date completed	Depth of well (ft)	Casing: Diameter (in.)	Casing: Depth (ft)	Water-bearing unit	Altitude of land surface (ft)	Water level: Below land-surface datum (ft)	Water level: Date of measurement	Method of lift	Use of water	Remarks
*19-11-733	Virginia Lee Johnson	Boyd Burnett	1954	313	4	280	W	1,010	--	--	C,E, 1	D	Water sand reported at 280-313 ft.
* 734	J. W. Marshall	Reese Gibson	1951	420	7 7	150 420	W	1,004	106.8	Aug. 6, 1963	S,E, 3-1/2	D	Water sands reported at 250-300 and 400-420 ft.
* 735	Boyd Burnett	Boyd Burnett	1950	180	4	140	W	908	89.3	do	C,E, 3/4	D	Water sands reported at 140-180 ft. Water used in leather tanning.
* 736	E. T. Honeycutt	--	--	21	24	21	A	962	6.1	Aug. 7, 1963	J,E, 1/2	S	Dug well.
* 737	T. B. Cunningham	--	--	35	--	--	A,W?	991	20.1	Aug. 8, 1963	J,E, 1	D	Do.
* 738	P. M. Martin	Jack McBride	1948	150	7	150	W	971	15	--	C,E, 1	D	Water sand reported at 135-147 ft.
* 739	Eligie Skinner	-- Blackburn	1952	72	6	72	W	943	--	--	C,W	S	Water sand reported at 60-72 ft.
* 740	Lee Cardwell	--	--	50	5	60	W	944	25	--	C,W	D	
* 741	Jack Mercer	Thomas and McBride	1951	516	6 4-1/2	247 484	W,C?	943	--	--	S,E, 5	D	Water sand reported at 484-516 ft.
* 742	Virgle Vineyard	Edward Thomas	1959	280	7	280	W	900	140	--	C,E, 3/4	D,S	
* 743	Mrs. Joe Benton	B. A. Harry	1947	325	--	--	W	966	60	--	C,W	S	
* 744	Claude Underwood	Jake Blackwell	1949	113	8 6	43 113	W	955	72.8	Aug. 9, 1963	C,W	D,S	
* 745	Newt Clary	Newt Clary	1940	38	12	3	A,W?	969	12.2	do	B,H	D,S	Reportedly dug with hand auger.
* 746	John E. Zachary	Edward Thomas	1963	115	6	115	W	962	--	--	C,E	D,S	Water sand reported at 100-115 ft. Reported yield 4 gpm.
* 747	C. A. Richardson	--	1951	285	6	---	W	981	88.6	Aug. 21, 1963	J,E, 1	D	
748	Boyd Burnett	Wash McGrew	1948	80	6	---	W	922	23	--	N	N	
* 749	J. H. Howell	-- Blackburn	1948	85	6	85	W	916	26.8	Aug. 21, 1963	B,H	D,S	
* 750	Mrs. Eula K. McGuire	-- Blackwell	1947	56	66	56	W	911	21.6	do	J,E, 1/3	D	
* 751	Boyd Burnett	Boyd Burnett	1938	34	6	34	A,W?	908	10.8	do	N	N	
* 752	J. E. A. Burnett	do	1947	185	8 6	9 185	W	931	38.2	do	N	N	Water reportedly became saline about 1952. Abandoned 1958.

See footnote at end of table.

Table 3.--Records of wells and springs, Montague County--Continued

Well	Owner	Driller	Date completed	Depth of well (ft)	Casing: Diameter (in.)	Casing: Depth (ft)	Water-bearing unit	Altitude of land surface (ft)	Water level: Below land-surface datum (ft)	Water level: Date of measurement	Method of lift	Use of water	Remarks
19-11-753	J. E. A. Burnett	-- Rogers	--	800	8	--	W,C?	918	--	--	N	N	Abandoned domestic well. Reported once used as water supply well for oil-well drilling operations.
* 754	do	Wash McGrew	1913	150	6	150	W	926	40	--	C,W	D,S	
* 755	Mrs. Pearl Young	do	1938	175	6	--	W	914	--	--	C,W	D,S	
* 756	Gettes McCool	--	1905	176	6	--	W	926	--	--	C,W	S	
757	L. G. Neely	-- Blackburn	1958	143	6	143	W	889	61.8	Aug. 22, 1963	N	N	Water reportedly became saline in 1959. Abandoned.
* 801	Mrs. Joe Benton	E. E. Richardson	--	347	4-1/2	347	W	968	60	--	C,W	S	
* 901	Roy Pollock	Jake Blackwell	1950	332	6-1/2 5-1/2	200 332	W	915	39.8	Feb. 13, 1964	Cf,E, 3/4	D,S	Water sand reported at 318-332 ft. Fresh water reported at 450 and 600 ft in nearby oil test.
* 12-101	O. H. Lane	Doyle Thomas	1958	287	7	150	W	927	90	--	C,W	D,S	
* 102	Pete Uselton	Edward Thomas	1960	238	7 5-1/2	186 238	W	927	50	--	C,E, 3/4	D,S	Water sands reported at 75-97 and 190-235 ft. Fresh water sands reported in oil test at 130-240, 320-410, and 580-635 ft, approximately 1 mile northwest.
103	do	do	1960	305	--	--	W	927	50	--	N	N	Water sands reported at 70-101, 211-265, and 282-302 ft. Abandoned.
* 104	Mrs. Adis Miller	--	--	204	6	204	W	864	79.5	Feb. 10, 1964	C,W	D,S	
* 201	H. H. Durham	Jake Blackwell	1946	195	7 6	15 195	W	955	100	--	J,E, 1	D,S	
* 401	L. D. Godwin	Fields and Thomas	1960	285	7-1/4	285	W	920	24	--	J,E, 1	D,S	
* 402	C. R. Reed	Doyle Thomas	1962	225	7 5-1/2	180 225	W	1,002	126.5	Dec. 5, 1963	S,E, 3/4	D,S	Water sand reported at 200-225 ft.
403	A. H. Godwin	do	1957	235	8-5/8 7	65 225	W	966	105.9	Feb. 7, 1964	S,E	D,S	Water sands reported at 48-58 and 185-225 ft.
* 601	Midland Oil Co.	--	1957	112	5	112	K	884	76.7	May 7, 1964	J,E, 1	D,S	
* 602	H. J. Terry	Harvey Thomas	1962	145	7 5	30 145	K	944	105.8	Oct. 30, 1963	J,E, 3/4	D	Water sands reported at 20-30 and 140-145 ft.
* 603	Mrs. Minnie Cannon	Edward and Doyle Thomas	1962	160	7 5	33 150	K	948	--	--	C,E, 3	D,S	

See footnote at end of table.

Table 3.--Records of wells and springs, Montague County--Continued

Well	Owner	Driller	Date completed	Depth of well (ft)	Casing: Diameter (in.)	Casing: Depth (ft)	Water-bearing unit	Altitude of land surface (ft)	Water level: Below land-surface datum (ft)	Water level: Date of measurement	Method of lift	Use of water	Remarks
*19-12-604	Continental Oil Co.	Continental Oil Co.	1930	300	7	300	K,W?	889	--	--	C,E, 2	D,S, Ind	Reported yield approximately 8 gpm.
* 701	L. L. Newland	--	--	235	12	235	W	976	91.7	Dec. 5, 1963	S,E, 3/4	D,S	
* 702	A. J. Godwin	Edward Thomas	1963	110	7 5-1/2	54 110	W	939	25.1	June 6, 1964	J,E, 1/3	D,S	Water sand reported at 90-100 ft.
* 703	W. M. Goldsmith	-- Blackburn	1958	230	6	230	W	923	40	--	J,E, 1	D,S	Water sand reported at 225-230 ft.
* 13-101	A. R. Agee	Jake Blackwell	1958	187	6	187	W	868	160	--	C,E, 1/2	D,S	
* 102	O. A. King	do	1948	120	7 6	50 120	K	886	102	--	C,W	D,S	Water sand reported at 108-120 ft. Reported weak supply.
* 401	Seitz & Comegys Oil Co.	Seitz & Comegys Oil Co.	1938	205	7	205	K	888	100	--	C,E, 1	D,S, Ind	Water sand reported at 145-205 ft.
* 17-201	Mrs. Joe Benton	E. E. Richardson	1947	317	5	317	W	930	156.1	Nov. 21, 1963	C,W	S	Water sand reported at 276-317 ft.
* 202	do	B. A. Harry	1948	310	6-5/8	295	W	923	108.8	do	C,W	S	
* 203	do	--	--	310	--	--	W	860	--	--	C,E, 1-1/2	D,S	
* 301	B. C. Lovette	Doyle Thomas	1957	235	7	235	W	877	49.4	Mar. 21, 1964	C,W	S	Water sand reported at 180-220 ft.
* 501	Mrs. Joe Benton	--	--	225	6-5/8	225	W	863	--	--	C,W	S	
* 502	do	--	--	500	5	250	W,C?	880	44.4	Nov. 21, 1963	C,W	S	
* 601	Gold-Burg Independent School District	--	--	114	--	114	W	955	--	--	C,E, 3/4	D,P	Reportedly furnishes water to school of about 50 students.
* 602	Wilburn Cross	Doyle Thomas	1952	225	6	225	W	960	60	--	J,E, 3/4	D,S	Water sand reported at 215-225 ft.
* 603	B. C. Lovette	Edward Thomas	1963	215	7	215	W	950	50	--	C,E, 1/2	S	Water sands reported at 68-85 and 180-210 ft.
* 701	Wilburn Cross	-- Hunter	1954	341	6	341	W	935	15	--	C,W	S	Water sand reported at 300-341 ft.
* 901	City of Bowie	Doyle Thomas	--	360	8-5/8 7	-- --	W	905	(+)	Mar. 21, 1964	Flows	N	Water sand reported at 320-360 ft. Former public supply well.
902	do	do	1953	--	--	--	W	915	--	--	J,E	D,S	

See footnote at end of table.

Table 3.--Records of wells ans springs, Montague County--Continued

Well	Owner	Driller	Date completed	Depth of well (ft)	Casing: Diameter (in.)	Casing: Depth (ft)	Water-bearing unit	Altitude of land surface (ft)	Water level: Below land-surface datum (ft)	Water level: Date of measurement	Method of lift	Use of water	Remarks
19-17-903	City of Bowie	Doyle Thomas	1953	187	7	187	W	905	--	--	N	N	Water sands reported at 12-22, 90-123, and 134-182 ft.
904	do	do	1953	260	7	260	W	935	--	--	N	N	Water sands reported at 110-140, 184-198, and 214-258 ft.
18-101	B. C. Lovette	do	1962	180	7	--	W	885	50	--	C,E, 1/4	D,S	
* 102	do	do	--	400	8	400	W	855	(+)	Mar. 24, 1964	Flows	S	Former oil test converted to water well. Water sand reported at 350-400 ft.
103	N. B. Hamilton	Jack McBride	--	370±	7	370	W	870	15	--	C,W	N	Water sand reported at 315-370 ft.
* 104	Weldon Porter	do	--	350±	7	--	W	852	(+)	Mar. 21, 1964	Flows	S	
* 201	A. N. Arveson	-- Thomas	1950	160	8	160	W	909	140	--	C,E, 3/4	D,S	
* 202	do	Thomas and McBride	1945	270	--	--	W	910	140	--	C,W	S	
* 203	do	-- Thomas	1952	300	8	300	W	920	--	--	N	N	
* 204	do	do	1951	165	8	165	W	930	--	--	C,W	S	
* 205	Joe Pippin	Jack McBride	1948	275	7	275	W	940	70	--	C,E, 1	D,S	Water sand reported at 235-275 ft. Fresh water sand reported at 580-610 ft in oil test about 1/2 mile southwest.
206	Hannah Kirby	do	1946	270	7	270	W	970	70	--	C,W	S	Water sand reported at 235-270 ft.
207	Johnny Carminati	Doyle Thomas	1963	390	7	390	W	945	75	--	C,W	S	Water sand reported at 350-390 ft.
* 301	E. T. Honeycutt	Harvey Thomas	1934	206	6	206	W	924	84.8	Aug. 7, 1963	C,W	S	Water sand reported at 200-206 ft.
* 302	Frank Martin	--	1920	280	6	280	W	945	100	--	C,W	D,S	
* 303	Johnny Carminati	Doyle Thomas	1945	145	7 5	35 145	W	950	40	--	C,W	D,S	Water sands reported at 45-50 and 138-145 ft.
* 304	J. G. Dyer	--	1948	280	--	--	W	902	--	--	J,E, 1	D	
305	S. D. Howard	Frank Wood Oil Co.	1951	219	7	219	W	940	41.8	Mar. 5, 1964	N	N	
* 306	do	Boyd Burnett	1949	222	6	222	W	910	5.3	do	C,W	S	Well reportedly flowed until about 1953.
* 401	Herman G. Heard	Sam Harrison Drlg. Co.	1952	--	--	--	W	915	(+)	Oct. 8, 1963	Flows	S	

See footnote at end of table.

Table 3.--Records of wells and springs, Montague County--Continued

Well	Owner	Driller	Date completed	Depth of well (ft)	Casing: Diameter (in.)	Casing: Depth (ft)	Water-bearing unit	Altitude of land surface (ft)	Water level: Below land-surface datum (ft)	Water level: Date of measurement	Method of lift	Use of water	Remarks
*19-18-402	Mrs. Odessa Yowell	Marshall Pipe & Supply	1949	--	10	612	W,C?	885	(+)	Nov. 13, 1963	Flows	S	Abandoned oil test. Base of fresh water estimated from electrical survey at 860 ft below surface.
* 403	E. S. Johnson	Omohundro Oil Co.	1945	368	--	--	W	914	15	--	C,W	S	
* 404	Gordon Heard	Edward Thomas	1961	205	7	205	W	965	60	--	C,W	S	Water sand reported at 165-205 ft.
* 405	James Henry	Richardson-Henry Drlg. Co.	1961	220	6	220	W	962	40.1	Mar. 31, 1964	J,E, 3/4	D,S	Water reported at 214-220 ft.
* 406	Weldon Porter	--	--	385	7	385	W	867	(+)	Mar. 24, 1964	Flows	S	
* 501	Gordon Heard	Edward Thomas	1963	207	7	207	W	960	60	--	C,W	S	Water sand reported at 170-207 ft.
* 502	James Henry	Richardson-Henry Drlg. Co.	1963	104	6	104	W	955	20.2	Mar. 13, 1964	J,E, 3/4	N	Water sand reported at 70-100 ft. Reportedly abandoned shortly after drilling because of contaminations.
* 503	A. V. Corpening	Jack McBride	1943	240	7	240	W	950	28.4	Mar. 20, 1964	C,E, 1/2	D,S	
701	Gordon Heard	Edward Thomas	1962	190	7	190	W	1,006	83.2	Mar. 10, 1964	C,W	S	Water sand reported at 160-190 ft.
* 702	do	Jack McBride	1943	350±	7	350	W	950	--	--	J,E, 3	D,S	
* 703	do	Edward Thomas	1964	110	7	110	W	960	34.9	Mar. 10, 1964	C,G, 10	S, Ind	Water sand reported at 80-110 ft. Reported yield approximately 50 gpm.
* 704	Herman G. Heard	Mendota Oil Co.	1955	--	7	650	W,C?	1,025	168	--	N	N	Abandoned oil test. Owner attempted to convert to water well, but found water to be not of usable quality.
* 705	Jack Slaydent	--	1938	34	5-1/2	34	A	999	10.3	May 9, 1966	C,W	N	Formerly used for watering livestock. Apparently contaminated about 1965.
* 706	John H. Angove	--	--	90	--	--	W	1,013	--	--	C,W	S	
* 707	Gordon Heard	--	1947	480	7	480	W	1,055	92.0	Jan. 11, 1966	--	N	
* 708	Ben Parker Estate	--	--	100±	--	--	W	1,032	--	--	C,W	S	
* 709	Lillie Bates, et al.	--	--	135	--	--	W	1,050	--	--	C,W	D,S	
* 710	O. H. McNatt, Jr.	--	--	24	5	--	A	922	19.0	Jan. 13, 1966	--	N	Previously used for domestic and livestock supply.
* 801	Herman G. Heard	--	1940	163	7	--	W	1,090	101.1	Mar. 17, 1964	C,W	S	
* 19-101	City of Nocona	Jack McBride	1949	505	8-5/8 7	320 197	W,C?	955	--	--	T,E, 20	N	Previously used for public supply. Reported yield 50 gpm.

See footnote at end of table.

Table 3.--Records of wells and springs, Montague County--Continued

Well	Owner	Driller	Date com-plet-ed	Depth of well (ft)	Casing: Diam-eter (in.)	Casing: Depth (ft)	Water-bear-ing unit	Altitude of land surface (ft)	Water level: Below land-surface datum (ft)	Water level: Date of measurement	Method of lift	Use of water	Remarks
19-19-102	City of Nocona	--	1953	507	8-5/8 7	341 507	W,C?	950	--	--	T,E, 25	N	Previously used for public supply. Reported yield 40 gpm.
103	do	Jack McBride	1954	480	--	--	W,C?	965	105.8	July 18, 1963	T,E, 10	N	Previously used for public supply. Reported yield 30 gpm.
104	do	do	1954	310	--	--	W	975	--	--	T,E, 10	N	Do.
105	do	do	1955	503	10-3/4 8-5/8	-- --	W,C?	955	--	--	T,E, 20	N	Previously used for public supply. Reported yield 60 gpm.
* 106	T. P. Skinner	Doyle Thomas	1963	300	9-1/2	300	W	920	--	--	C,W	S	Completed as water well from abandoned oil test.
* 107	G. H. Fooshee	Fields and Thomas	1955	232	6-5/8	232	W	981	--	--	C,E, 1/2	D,S	Water sand reported at 196-229 ft.
* 108	do	--	--	265	--	--	W	950	--	--	C,E, 1	D,S	
* 109	J. P. Clingingsmith Estate	Jake Blackwell	--	250	7	250	W	985	--	--	C,W	D	
* 110	Leroy Priddy	Edward Thomas	1961	243	5-3/4	243	W	970	100.7	Nov. 22, 1963	C,W	D,S	
111	Mrs. Joe Benton	E. E. Richardson	1948	341	4-1/2	341	W	969	60	--	C,W	N	Water sand reported at 310-341 ft.
201	City of Nocona	--	1953	400±	--	--	W	970	--	--	T,E, 25	N	Previously used for public supply.
* 202	S. E. Bell Estate	--	1945	219	6	219	K?,W	1,050	71.1	Nov. 27, 1963	J,E, 1	D,S	
* 203	J. S. Etter	Harvey Thomas	1952	224	5	224	K?,W	1,010	85.9	do	S,E, 3/4	D,S	Water sand reported at 200-224 ft.
* 301	do	Standard of Texas	1952	224	7	224	K?,W	960	65	--	J,E, 2	S	Do.
* 401	C. E. Richardson	Edward Thomas	1960	300	8-5/8 7	130 300	W	1,055	150	--	S,E, 5	P	Water sands reported at 250-272 and 275-300 ft. Reported yield 50 gpm.
* 402	Nortex Oil and Gas Corp.	Nortex Oil and Gas Corp.	1956	1,000	10-3/4	1,000	W?,C	1,010	30	--	Cf,E, 25	Ind	Casing perforations reported at 735-900 ft. Reported yield 117 gpm. Used for waterflood.
* 701	G. E. Richardson	--	--	260	8-5/8 7	125 260	W	1,070	150	--	S,E, 3	P	Water sand reported at 235-260 ft. Reported yield 40 gpm.
* 702	do	Doyle Thomas	1954	260	8-5/8 6	135 260	W	1,071	110	--	S,E, 2	P	Water sand reported at 240-260 ft. Reported yield 20 gpm.

See footnote at end of table.

Table 3.--Records of wells and springs, Montague County--Continued

Well	Owner	Driller	Date completed	Depth of well (ft)	Casing: Diameter (in.)	Casing: Depth (ft)	Water-bearing unit	Altitude of land surface (ft)	Water level: Below land-surface datum (ft)	Water level: Date of measurement	Method of lift	Use of water	Remarks
*19-19-801	Henry Corado	Doyle Thomas	1954	197	7	197	K,W?	1,095	34.9	Mar. 31, 1964	S,E	Irr	Water sands reported at about 60, 120, and 175 ft. Reported yield 55 gpm.
* 802	Mrs. Lois Bell	--	1955	225	5	225	K,W?	1,095	71.6	Apr. 30, 1964	C,W	D,S	
* 20-601	City of Saint Jo	B. A. Harry	1938	430	7	430	K	1,155	160	--	S,E, 5	P	Reported yield 40 gpm.
* 602	do	Kingery Brothers	1945	700	7	700	K,W?	1,155	225	--	T,E, 20	P	Water sand reported at 670-695 ft. Reported yield 60 gpm.
* 603	do	Gatlin Drlg. Co.	1953	747	10-3/4	696	K,W?	1,150	--	--	T,E, 50	P	Casing perforations reported at 572-582, 640-649, and 653-673 ft.
* 25-201	L. C. Foster	Clyde Henson	1940	242	5-1/2	242	W	997	45	--	J,E, 1	D,S	Water sands reported at 115, 165, and 190-240 ft.
* 501	Leonard Martin	Leonard Martin	1960	410	4-1/2	390	C	1,020	300	--	C,E, 1	D,S	Water sand reported at 390-410 ft.
26-101	City of Bowie	Doyle Thomas	1953	500	7	600	W?,C	1,110	123	--	Cf,E, 10	N	Previously used for public supply. Last used 1956. Reported yield 12 gpm.
102	do	do	1953	590	7	427	W?,C	1,100	80	--	N	N	Water sands reported at 110-120, 268-284, and 385-422 ft. Reported yield 20 gpm.
* 103	Jack Slayden	Jewett Hunter	1943	81	5-1/2	80	W	1,033	--	--	J,E, 1/2	D,S	
* 104	N. J. Spikes	--	--	--	--	--	--	1,080	--	--	J,E	D,S	
* 105	Herman Fox	--	1962	80	--	--	W	1,045	--	--	C,W	S	
* 106	Bessie Henry	-- McBride	1956	97	4	97	W	1,065	--	--	J,E	D,S	
* 201	Union Texas Petroleum	--	1953	500	8-5/8	500	W,C?	1,130	--	--	C,G, 15	Ind	Water sands reported at 240-268, 338-352, and 385-425 ft.
* 202	do	Wichita Pipe & Supply	1965	742	8	742	W,C?	1,070	--	--	C,E	Ind	Casing perforations reported at 266-276, 318-328, 360-370, 386-396, 426-434, 440-450, 466-476, and 490-500 ft (510-520 ft plugged off). Reported yield 18 gpm.
* 203	do	do	1965	670	8	670	W,C?	1,070	--	--	C,E	Ind	Casing perforations reported at 238-252, 360-378, 388-404, 440-464, and 476-486 ft. Reported yield 5 gpm.
* 204	Jake Bridgewater	Richardson Water Well Servie	1965	83	5	83	K	1,138	59	--	J,E	D	Reportedly gravel packed.
* 205	Radio Station KBAN	do	1959	47	--	--	K	1,130	27	--	J,E	D	Corrosion problem reported; hole developed in pressure tank 5 years after installation.

See footnote at end of table.

Table 3.--Records of wells and springs, Montague County--Continued

Well	Owner	Driller	Date completed	Depth of well (ft)	Casing: Diameter (in.)	Casing: Depth (ft)	Water-bearing unit	Altitude of land surface (ft)	Water level: Below land-surface datum (ft)	Water level: Date of measurement	Method of lift	Use of water	Remarks
*19-26-206	The Westerner Bowling Alley	Edward Thomas	--	--	--	--	--	1,125	--	--	J,E	D	Supplies bowling alley.
* 207	Mrs. Ray Harlow	Richardson Water Well Service	--	120	--	--	K,W?	1,122	--	--	--	D	
* 301	Union Texas Petroleum	Jack McBride	1953	413	8-5/8	413	K,C?	1,130	--	--	T,G, 25	Ind	Water sands reported at 228-231, 260-270, and 380-390 ft.
* 302	do	Edward Thomas	1955	253	8	225	W	1,130	--	--	C,G	Ind	Water sand reported at 226-248 ft. Reportedly contaminated with hydrocarbons in 1966. Reported yield 6 gpm.
* 303	do	Jack McBride	1956	375	8 6	285 375	W	1,130	--	--	C,G, 15	Ind	Water reported at 340-375 ft.
* 304	do	do	--	384	8	384	W,C?	1,130	--	--	C,G, 15	Ind	Water sands reported at 247-270, 312-323, and 368-380 ft. Reported yield 15 gpm.
* 305	Clifton Brooks	--	--	35	--	--	K	1,091	30	--	J,E	D,S	Dug well, rock walled.
* 306	E. R. Moore	Richardson Water Well Service	1963	90	--	--	K	1,111	90	--	J,E	D,S	Water sands reported at 20 and 40 ft. Reported yield 8 gpm.
* 401	Service Pipeline Co.	--	1951	154	6	154	W,C?	1,035	68	--	J,E, 1-1/2	Ind	Reported yield 5-6 gpm.
501	E. H. Cunningham	Richardson-Henry Drlg. Co.	1963	128	7 5-1/2	94 126	K,C?	1,100	50	--	C,W	S	Water sands reported at 76-88 and 108-128 ft.
502	do	--	--	Spring	--	--	K	1,015	(+)	--	Flows	S	
* 601	B. E. Freeman	--	--	60	--	--	K	1,123	40	--	J,E, 1/2	D,S	Dug well, rock walled.
* 602	J. T. Floyd	Richardson Water Well Service	1957	65	4	65	K	1,117	39	--	J,E, 1/3	D	
* 603	Mrs. John L. Prater	Thomas	1962	112	--	--	K	1,119	--	--	J,E, 3/4	D	
* 27-101	Fred Salmon	Jake Blackwell	1955	110	7	110	K	1,090	--	--	C,W	S	
* 401	do	do	1955	134	7	134	K	1,071	--	--	C,W	S	Water sand reported at 130-134 ft.
* 402	Rayburn Chokas	do	1953	110	5-1/2	110	K	1,005	55	--	J,E, 3/4	D	Water sands reported at 40 and 90-100 ft.
601	J. L. Golightly	--	1951	165	6	165	K	980	14.9	Apr. 24, 1964	N	N	
* 801	Hollis Beane	Edward Thomas	1962	128	7 5-1/2	100 128	K	1,915	60	--	C,E, 1-1/4	D,S	Water sands reported at 70-95 and 105-128 ft.

See footnote at end of table.

Table 3.--Records of wells and springs, Montague County--Continued

Well	Owner	Driller	Date completed	Depth of well (ft)	Casing: Diameter (in.)	Casing: Depth (ft)	Water-bearing unit	Altitude of land surface (ft)	Water level: Below land-surface datum (ft)	Water level: Date of measurement	Method of lift	Use of water	Remarks
*19-27-901	W. B. Sills	--	1959	180	6	180	K	1,020	120	--	S,E, 2-1/2	D,S	
* 902	Jim Barnett	Albert Lee	1963	140	5-1/2	140	K	968	50	--	S,E, 1/2	D,S	Water sands reported at 85 and 137-140 ft.
* 28-701	C. C. Edwards	Edward Thomas	1963	198	7	198	K	910	70	--	J,E, 1-1/2	D,S	Water sands reported at 70-94 and 178-198 ft. Reported yield 30 gpm.
* 801	Forestburg Independent School District	Albert Lee	1959	200±	--	200	K	1,180	120	--	C,E, 3/4	P	Water sand reported at 140-200 ft. Supplies school of about 150 students.
* 802	G. D. Wylie	Bill Richardson	1963	345	6-5/8 4-1/2	215 345	K	1,160	270	--	S,E, 3/4	D	Water sands reported at 185-188, 198-202, and 320-340 ft.
* 803	Forestburg Water Supply Corp.	Jimmy Biffle	1964	459	9-5/8	418	K	1,160	--	--	S,E, 10	P	6-in. well screen at 428-431 and 446-450 ft. Reported yield 35-50 gpm.
* 33-201	W. F. Gossett	Jack McBride	1944	300	7	300	C	1,050	72.6	Apr. 8, 1964	N	N	Water sand reported at 190-280 ft. Owner plans to install pump and use well for livestock.
34-301	Sunset Public School	-- Hunter	1958	110	--	--	K	983	--	--	N	N	Not used in 1964. Previously used for public supply.
* 302	B. F. Huddleston	Jewitt Hunter	1945	110	6	110	K	985	60	--	J,E, 1	D	Water sand reported at 80-85 ft.
303	G. E. Richardson	Edward Thomas	1963	485	8-5/8 7	130 485	C	998	120	--	S,E, 3	P	Water sand reported at 440-480 ft. Reported yield 35 gpm.
* 304	do	do	1863	490	8-5/8 7	135 490	C	995	120	--	S,E, 5	P	Water sand reported at 445-485 ft. Reported yield 35 gpm.
* 36-201	J. J. Monroe, Jr.	Ray Kelly	1958	126	6	126	K	940	77.1	Apr. 22, 1964	C,E, 1/2	D,S	
202	do	do	1963	132	6	132	K	980	49.1	Apr. 23, 1964	N	D,S	Owner plans to install pump.
301	Olin Merrett	--	1945	200	5	200	K	1,124	135.4	Apr. 6, 1964	C,W	S	
* 37-101	Mrs. Lena Merrett	--	1946	224	6	200	K	1,121	189.5	do	C,W	D,S	

* Chemical analysis of water shown in Table 4.

Table 4.--Chemical analyses of water from wells and springs, Montague County

(Analyses are in parts per million except specific conductance and pH.)

Analyses performed by Texas State Department of Health except as indicated by footnote.

Well	Owner	Depth of well (ft)	Date of collection	Silica (SiO_2)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids	Total hardness as $CaCO_3$	Specific conductance (Micromhos at 25°C)	pH
19-02-902	D. A. Boutwell	163	Sept. 19, 1963	9	2	1	262	550	13	36	46	2.0	<0.4	640	8	1,055	8.5
903	Mrs. D. G. Gardner, Sr.	204	do	9	1	1	250	530	24	35	28	1.6	< .4	611	6	1,040	8.6
904	Mrs. George C. Gray	140	Sept. 25, 1963	10	11	6	261	620	--	51	29	2.7	16.0	695	51	1,115	8.3
905	Jack Crownover	190	do	9	2	1	265	550	17	41	39	2.7	< .4	650	7	1,060	8.6
906	do	190	do	9	2	2	273	560	19	41	43	2.6	< .4	666	13	1,105	8.6
907	Vester Molsbee	125	do	10	27	26	181	483	--	39	86	1.7	19.0	625	177	1,080	8.1
908	Jack Crownover	190	do	14	72	54	23	510	--	19	6	.9	13.0	451	404	770	7.9
03-201	W. B. McGaughy	150	June 17, 1964	10	3	2	386	850	--	30	62	8.6	< .4	920	16	1,530	8.1
301	S. D. Howard	219	Mar. 5, 1964	9	1	1	450	750	11	75	186	7.4	7.0	1,119	9	1,880	8.5
402	T. L. Hancock	67	Apr. 13, 1964	9	40	13	224	245	--	13	296	.7	< .4	720	151	1,360	7.6
501	Mrs. Dorothy C. Reed	175	Aug. 20, 1963	11	173	97	170	336	--	75	620	.4	< .4	1,309	830	2,410	7.5
502	S. D. Howard	125	Feb. 20, 1964	9	82	25	49	321	--	114	26	.4	1.5	467	309	766	7.8
503	John Crownover	100	Apr. 18, 1964	10	14	3	204	447	--	61	34	1.2	< .4	550	47	912	7.9
504	do	99	do	15	63	12	81	317	--	13	69	.3	12.0	421	208	755	7.5
505	do	48	do	16	56	11	53	257	--	13	48	.4	16.0	339	187	601	7.5
701	Vester Molsbee	125	Sept. 25, 1963	9	26	10	1,020	464	--	24	1,360	2.6	< .4	2,684	108	4,750	7.7
702	J. J. Beckham	72	Oct. 3, 1963	7	69	20	1,270	329	--	162	1,810	.9	< .4	3,503	255	6,000	7.5
703	S. F. Loy Estate	60	Oct. 7, 1963	16	94	25	58	283	--	24	126	.7	21.0	506	339	910	7.3
704	Charlie Dodd	72	Oct. 10, 1963	16	49	16	17	232	--	23	11	1.0	< .4	247	189	421	7.2
705	Petroleum Investment Co.	75	do	15	42	14	19	149	--	20	42	.3	< .4	225	161	410	7.0
707	The Pure Oil Co.	100	do	17	66	19	43	132	--	16	143	.3	1.0	370	244	735	7.2
710	Petroleum Investment Co.	100	do	17	54	16	31	120	--	25	98	.5	< .4	301	199	578	7.0
711	Mrs. Pearl N. Jones	119	do	17	82	20	63	398	--	60	26	.7	< .4	468	289	758	7.2
712	Mrs. H. F. Wilton	173	do	10	46	11	237	388	--	219	97	.5	< .4	813	161	1,300	7.8

See footnotes at end of table.

Well	Owner	Depth of well (ft)	Date of collection	Silica (SiO_2)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids	Total hardness as $CaCO_3$	Specific conductance (Micromhos at 25°C)	pH
19-03-713	Lesley Combs	280	Oct. 4, 1963	10	2	1	227	483	8	41	37	0.9	<0.4	565	7	949	8.5
714	Mrs. V. B. Howard	112	Oct. 14, 1963	18	100	13	26	256	--	100	23	1.0	< .4	410	302	649	7.6
715	R. F. Boutwell	145	do	21	95	12	25	251	--	90	24	.6	< .4	393	287	625	7.3
717	T. B. Gist	150	do	16	94	27	99	383	--	187	42	.5	< .4	656	348	1,004	7.3
718	Ben Cunningham	200	do	16	74	24	109	378	--	133	49	.5	< .4	588	282	945	7.6
719	J. A. Lampkin	129	do	15	35	13	136	334	--	99	41	1.2	< .4	500	140	825	7.6
720	Prairie Valley High School	225	Oct. 17, 1963	13	52	17	160	386	--	156	44	.6	< .4	634	197	990	7.8
721	Continental Oil Co.	134	Oct. 31, 1963	17	35	10	20	144	--	20	21	.5	< .4	195	129	352	7.1
801	W. Meekins	137	Oct. 14, 1963	12	129	33	263	510	--	494	53	1.2	< .4	1,241	458	1,730	7.7
802	The Pure Oil Co.	111	Oct. 10, 1963	15	105	27	120	159	--	16	343	.3	< .4	709	376	1,400	7.4
803	R. A. Cunningham	111	Oct. 14, 1963	16	181	50	75	312	--	96	328	1.0	< .4	902	660	1,610	7.4
804	Fred Cunningham	126	Oct. 11, 1963	21	66	15	39	129	--	69	94	.5	5.0	373	230	652	7.0
806	Fred Salmon	120	Oct. 18, 1963	17	115	25	42	354	--	112	55	1.4	< .4	540	390	883	7.2
807	Bridwell Oil Co.	108	Oct. 31, 1963	13	308	48	57	211	--	25	630	.4	< .4	1,183	970	2,330	7.4
808	Walsh & Watts Oil Co.	150	Feb. 11, 1964	14	128	30	116	329	--	360	35	.6	< .4	843	443	1,330	7.5
809	E. D. Grant	360	do	8	16	5	1,060	510	--	116	1,320	2.3	< .4	2,781	60	5,200	8.1
04-401	John J. Moore	205	May 5, 1961[a] Feb. 10, 1964	10 9	.5 2	.1 1	193 188	465 461	6 13	8.8 9	14 12	.2 .2	.5 < .4	462 466	2 7	753 794	8.4 8.7
402	S. E. Howard	205	do	19	96	22	98	439	--	76	72	.5	< .4	597	331	1,067	7.3
403	W. T. Fox	212	Apr. 18, 1964	10	1	1	186	442	5	24	16	.4	< .4	460	6	760	8.4
701	Jimmy Howard	268	Feb. 6, 1964	10	1	1	202	448	16	18	25	.6	< .4	493	4	880	8.8
702	J. G. Howard Estate	--	do	10	2	1	205	434	17	20	25	.8	< .4	500	7	866	8.8
703	Phil Howard	150	Feb. 11, 1964	9	2	1	215	427	17	26	50	.5	< .4	533	7	953	8.8
801	R. C. Haralson	212	Nov. 5, 1963	7	6	4	202	423	7	35	59	.4	< .4	525	31	926	8.4
05-701	H. D. Hoover	160	Feb. 18, 1964	8	3	1	204	422	--	50	43	1.1	< .4	516	14	908	8.3
702	Ray Dowd	225	Feb. 19, 1964	9	10	4	158	397	4	25	23	.9	< .4	528	41	744	8.5
09-101	Mrs. J. M. Turner	65	Sept. 3, 1963	11	30	37	440	720	--	132	275	.6	97	1,374	227	2,250	7.8

See footnotes at end of table.

Table 4.--Chemical analyses of water from wells and springs, Montague County--Continued

Well	Owner	Depth of well (ft)	Date of collection	Silica (SiO_2)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids	Total hardness as $CaCO_3$	Specific conductance (Micromhos at 25°C)	pH
19-09-102	Mrs. Cora Williamson	50	Sept. 4, 1963	12	38	50	372	620	--	132	328	1.5	38	1,275	301	2,150	7.6
103	L. M. Staley Estate	527	Nov. 14, 1963	9	7	1	1,050	790	--	480	800	3.3	< .4	2,739	23	4,550	8.3
201	G. T. Hughes	40	Sept. 3, 1963	13	121	87	124	433	--	58	147	1.1	385	1,152	660	1,780	7.6
202	Mrs. Jewel Castleberry	72	Sept. 4, 1963	13	42	20	149	510	--	35	23	1.0	34	571	189	913	7.8
203	C. O. Seeds	75	Sept. 3, 1963	12	43	37	111	477	--	31	32	1.0	33	538	258	905	7.7
204	Magnolia Pipeline Co.	700	Sept. 4, 1963	9	3	2	550	730	11	60	376	1.0	< .4	1,369	12	2,340	8.5
205	H. C. Hughes	175	do	8	8	2	1,140	740	--	550	920	1.6	< .4	2,994	28	4,650	8.2
206	do	30	Sept. 5, 1963	14	59	43	48	361	--	25	20	1.0	91.0	477	325	784	7.6
207	Magnolia Pipeline Co.	622	Sept. 4, 1963	10	3	1	540	710	--	66	376	.7	< .4	1,349	11	2,290	8.3
208	W. C. Hughes Estate	354	June 7, 1964	10	6	3	910	880	--	478	530	3.7	2.0	2,380	25	3,750	8.1
301	Buck Boren	21	Sept. 5, 1963	21	155	112	600	1,110	--	302	700	.8	< .4	2,436	850	3,850	7.4
303	Roy C. Fitts, Jr.	20	do	19	101	25	53	364	--	48	86	.6	< .4	515	356	874	7.3
305	O. F. Walker	29	do	22	194	62	590	930	--	305	660	.8	< .4	2,288	740	3,600	7.3
501	Gold-Burg Independent School District	200	May 8, 1961[a]	10	4.5	1.8	887	780	--	544	520	3.1	.2	2,350	18	3,730	7.9
			Mar. 6, 1964	8	5	2	910	780	--	550	540	4.0	< .4	2,404	22	3,720	8.2
502	C. W. Chandler	200	Aug. 8, 1963	9	6	1	690	920	--	468	222	5.0	< .4	1,853	22	2,800	7.9
503	do	90	do	15	41	19	59	285	--	28	28	.8	< .4	331	180	557	7.5
506	D. J. Leeper	105	Aug. 28, 1963	8	5	3	340	570	5	112	119	2.6	1.0	880	28	1,500	8.4
507	J. G. Etheridge	83	do	12	63	73	256	520	--	110	315	.9	18.0	1,106	458	1,920	7.4
508	Walten E. Wilton	220	do	8	8	3	1,040	700	--	810	630	.6	< .4	2,844	33	4,360	8.3
509	J. H. Moody Estate	196	Aug. 30, 1963	9	12	4	1,160	730	--	620	950	2.0	4.0	3,119	47	4,920	8.0
510	J. E. Rushing	325	Sept. 5, 1963	9	2	2	560	850	--	184	247	5.1	< .4	1,428	10	2,330	8.2
511	J. B. Blevins	325	do	10	11	7	298	464	--	99	170	1.1	.5	824	56	1,420	8.0
512	J. M. Capps	305	Dec. 13, 1955[a]	10	4.6	1.1	655	944	16	254	265	--	2.2	1,670	16	2,660	8.4
			Sept. 13, 1963	9	4	1	680	1,010	--	253	259	3.6	< .4	1,707	13	2,680	8.2
513	L. H. Campbell	200	Nov. 14, 1963	9	5	3	920	700	--	560	610	3.8	< .4	2,454	25	3,910	8.1
514	J. A. Staley	188	do	8	5	3	920	740	--	590	580	3.8	< .4	2,474	24	3,910	8.2

See footnotes at end of table.

Table 4.--Chemical analyses of water from wells and springs, Montague County--Continued

Well	Owner	Depth of well (ft)	Date of collection	Silica (SiO_2)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids	Total hardness as $CaCO_3$	Specific conductance (Micromhos at 25°C)	pH
19-09-601	William G. Hawkins	200	Aug. 23, 1963	10	5	1	600	910	--	140	304	4.1	<0.4	1,508	16	2,500	7.9
603	do	200	do	9	3	1	610	960	--	180	277	4.0	< .4	1,552	11	2,500	8.3
604	L. E. and H. D. Milam	390	do	9	3	1	374	700	--	56	133	4.0	< .4	924	14	1,550	8.1
605	J. R. Blevins	100	Sept. 5, 1963	9	4	1	590	780	--	281	232	2.0	.5	1,504	13	2,390	8.2
606	H. B. Moss	352	Sept. 9, 1963	9	3	1	448	720	--	113	168	4.1	< .4	1,114	12	1,830	8.5
607	L. H. Campbell	386	do	9	17	20	489	670	--	106	362	.5	< .4	1,330	125	2,260	7.8
608	W. A. Parr	160	Sept. 13, 1963	14	77	55	202	421	--	151	237	1.1	29.0	976	421	1,660	7.5
801	J. A. Staley	725	Nov. 14, 1963	10	3	1	412	640	--	103	181	4.5	< .4	1,035	12	1,740	8.3
802	F. T. Leeper	206	Dec. 6, 1963	9	2	1	580	860	17	111	296	5.5	< .4	1,443	9	2,400	8.4
803	Wilmer Seay	520	do	8	35	15	930	730	--	362	880	3.8	< .4	2,589	148	4,230	8.2
804	do	520	do	9	9	4	390	690	14	93	146	6.0	< .4	1,009	42	1,700	8.5
901	Harold and Warren Seay	100	Aug. 29, 1963	14	50	10	100	345	--	18	47	.5	10.0	425	164	722	7.5
902	L. A. Mitchell	158	Apr. 22, 1964	7	5	1	660	770	--	162	441	4.7	2.0	1,660	16	2,790	8.3
10-201	N. M. Miller	150	Sept. 11, 1963	11	84	72	470	570	--	520	369	.4	< .4	1,810	510	2,780	7.7
202	Mrs. D. G. Gardner, Sr.	385	Sept. 20, 1963	9	1	1	435	940	--	73	47	6.0	< .4	1,032	7	1,640	8.3
203	Jack Kidwell	112	Sept. 19, 1963	13	87	144	640	680	--	146	1,040	1.0	5.5	2,415	810	4,140	7.5
301	Billy Miles	303	Sept. 11, 1963	9	1	1	309	580	23	82	55	1.6	< .4	765	6	1,240	8.7
302	Scott Phillips	297	Sept. 19, 1963	7	7	8	455	710	--	130	196	4.0	13.0	1,169	50	1,940	8.2
401	Hardy Seay	250	Aug. 29, 1963	11	7	2	262	580	--	32	57	1.1	< .4	655	27	1,100	7.9
402	do	150	do	9	6	--	740	600	--	179	680	3.2	< .4	1,915	15	3,250	8.0
403	do	50	do	12	12	6	179	372	--	35	84	.6	< .4	511	56	887	7.8
404	do	263	Nov. 16, 1944[a]	--	--	--	--	538	--	70	108	--	--	--	12	--	--
			Aug. 29, 1963	9	2	2	313	530	--	89	107	2.3	< .4	781	10	1,330	8.2
405	do	240	Nov. 16, 1944[a]	--	--	--	--	668	--	60	103	--	--	--	12	--	--
			Aug. 29, 1963	10	1	1	351	660	--	66	104	3.5	< .4	865	6	1,450	8.2
502	Miss Bessie Grant	250	Aug. 23, 1963	9	1	1	276	580	15	60	43	2.1	< .4	695	6	1,100	8.5
503	E. B. Henson	77	Aug. 26, 1963	10	27	26	385	416	--	152	330	.7	68.0	1,209	175	2,050	7.8

See footnotes at end of table.

Table 4.--Chemical analyses of water from wells and springs, Montague County--Continued

Well	Owner	Depth of well (ft)	Date of collection	Silica (SiO_2)	Cal-cium (Ca)	Magne-sium (Mg)	Sodium (Na)	Bicar-bonate (HCO_3)	Car-bonate (CO_3)	Sul-fate (SO_4)	Chlo-ride (Cl)	Fluo-ride (F)	Ni-trate (NO_3)	Dis-solved solids	Total hardness as $CaCO_3$	Specific conductance (Micromhos at 25°C)	pH
19-10-504	Willard Grigsby	550	Aug. 27, 1963	10	5	--	481	620	--	52	362	3.1	<0.4	1,215	12	2,150	8.1
505	do	700	do	4	11	14	1,250	530	--	76	1,590	1.1	< .4	3,211	84	5,450	8.2
508	Sudie Stowe Estate	100	Aug. 28, 1963	14	78	19	24	401	--	10	7	.4	< .4	376	272	648	7.4
509	Wichita River Oil Co.	150	Aug. 30, 1963	9	2	1	359	570	--	147	119	2.4	< .4	920	8	1,550	8.3
510	W. H. Farmer	254	do	9	2	1	274	520	--	34	100	.8	< .4	676	7	1,152	8.3
511	M. C. Swearingen	32	Sept. 9, 1963	13	225	166	242	405	--	142	540	1.1	650.0	2,174	1,250	3,400	7.6
512	do	79	do	11	40	65	530	690	--	108	580	.7	5.5	1,679	367	2,900	7.9
513	Mrs. A. W. Coleman	410	do	9	1	1	270	610	12	40	29	2.4	< .4	660	6	1,095	8.5
516	Chris Uselton	207	do	9	7	3	800	650	--	184	700	5.0	< .4	2,030	28	3,400	8.0
601	Mrs. R. L. Winter	230	Sept. 13, 1963	10	68	56	470	780	--	147	397	1.8	40.0	1,574	398	2,600	7.7
602	Jack Crain	397	do	9	1	1	328	640	12	86	64	2.6	< .4	815	7	1,350	8.5
603	James R. Roper	230	Sept. 20, 1963	8	2	2	483	730	14	182	184	5.8	< .4	1,239	9	2,000	8.5
604	Clayton C. Menasco	56	do	15	131	58	200	364	--	36	463	.5	9.0	1,095	570	2,010	7.6
605	R. W. Jones	315	Sept. 25, 1963	9	1	1	279	550	26	60	36	2.3	< .4	691	8	1,115	8.7
606	Vester Molsbee	130	Sept. 20, 1963	9	3	2	353	640	--	76	115	1.2	< .4	875	13	1,490	8.1
607	Bob Weaver	180	Sept. 25, 1963	9	2	1	410	640	14	194	105	4.7	< .4	1,055	9	1,700	8.5
608	David Sappington	254	do	9	1	1	313	600	--	92	69	3.0	< .4	785	5	1,260	8.3
609	A. B. Cardwell	102	do	11	214	88	970	1,390	--	1,260	421	2.6	15.0	3,664	890	4,850	7.5
610	do	291	Sept. 26, 1963	10	1	--	244	520	22	33	28	1.8	< .4	596	4	980	8.7
611	W. L. Hightower	157	do	8	3	1	326	451	17	144	128	2.3	3.0	851	13	1,410	8.7
612	L. R. Sawyer	127	do	8	8	7	380	466	7	200	200	2.0	13.0	1,053	52	1,750	8.5
613	do	265	do	10	9	7	264	530	12	56	73	.9	14.0	711	52	1,165	8.5
614	Lee Ashcraft	160	Sept. 30, 1963	15	75	28	64	270	--	35	126	.3	7.0	483	303	891	7.5
615	Jack Davis	133	Sept. 26, 1963	9	33	49	430	810	--	233	232	.9	19.0	1,409	283	2,250	7.9
616	G. T. Pults	100	do	10	21	33	450	780	--	149	271	.5	< .4	1,324	187	2,200	8.0
617	Jack Crow	185	Sept. 30, 1963	12	41	59	314	730	--	230	144	.9	< .4	1,159	347	1,850	7.9
618	W. V. Waters	305	Sept. 26, 1963	9	1	1	275	560	19	63	32	2.3	< .4	676	5	1,115	8.6

See footnotes at end of table.

Well	Owner	Depth of well (ft)	Date of collection	Silica (SiO_2)	Cal-cium (Ca)	Magne-sium (Mg)	Sodium (Na)	Bicar-bonate (HCO_3)	Car-bonate (CO_3)	Sul-fate (SO_4)	Chlo-ride (Cl)	Fluo-ride (F)	Ni-trate (NO_3)	Dis-solved solids	Total hardness as $CaCO_3$	Specific conductance (Micromhos at 25°C)	pH
19-10-701	Hardy Seay	50	Nov. 16, 1944[a]	--	--	--	--	243	--	9	11	--	--	--	118	--	--
			Aug. 29, 1963	16	31	8	54	237	--	10	13	0.3	<0.4	249	113	424	7.7
702	do	70	Aug. 29, 1963	14	39	11	39	192	--	37	18	.2	< .4	252	142	432	7.4
703	do	50	do	17	37	9	64	222	--	14	48	.3	< .4	298	131	530	7.6
704	do	390	Nov. 16, 1944[a]	--	--	--	--	537	--	70	92	--	--	--	21	--	--
			Aug. 29, 1963	10	2	1	288	500	--	72	96	1.1	< .4	716	9	1,230	8.2
706	Weldon W. Porter	452	Mar. 24, 1964	10	5	1	207	444	--	23	45	1.0	< .4	510	15	859	8.3
707	H. B. Moss	575	Apr. 22, 1964	10	6	3	700	750	--	53	610	4.2	< .4	1,760	27	3,070	8.2
801	Johnny Carminati	205	Aug. 22, 1963	9	1	1	319	540	--	60	139	1.4	< .4	796	6	1,350	8.1
802	L. C. Coker	285	Aug. 23, 1963	10	3	2	115	284	--	13	15	.6	< .4	299	14	486	8.1
803	C. R. Bailey	55	Sept. 5, 1963	17	225	86	115	279	--	187	320	.3	384	1,468	910	2,200	7.4
804	do	285	do	9	1	1	229	510	13	15	16	1.6	< .4	541	5	878	8.7
806	I. H. Copeland	300	Mar. 23, 1964	8	4	1	337	454	12	132	162	2.5	< .4	649	14	1,510	8.6
902	G. M. Hendricks	110	Aug. 5, 1963	11	53	61	139	510	--	107	89	.8	7.0	721	384	1,190	8.2
903	Travis S. Lemon	180	Aug. 22, 1963	10	4	2	194	461	--	48	11	.7	< .4	496	20	784	7.7
904	Howard Paine	150	do	10	1	1	211	459	17	21	18	.7	< .4	507	5	825	8.7
905	Roy Duncan	64	do	28	77	56	92	332	--	95	104	.8	102	721	421	1,180	7.3
906	do	100	do	18	66	39	99	367	--	103	52	.8	61	624	325	1,000	7.4
970	J. T. Thompson	125	Aug. 26, 1963	9	1	1	256	460	12	42	81	1.0	< .4	626	5	1,050	8.5
11-101	Mrs. J. G. Mays	190	Sept. 19, 1963	7	32	16	342	630	--	104	149	3.1	22.0	990	245	1,620	7.8
102	Mrs. H. F. Wilton	190	Oct. 10, 1963	9	2	1	194	398	19	29	33	.6	< .4	488	7	822	8.8
103	John Harper	230	Oct. 4, 1963	9	1	1	309	610	15	103	36	3.3	< .4	780	5	1,260	8.6
104	Floyd Begley	147	Oct. 17, 1963	9	3	1	281	469	24	124	42	2.1	13	732	14	1,140	8.8
105	Lesley Combs	250	Nov. 5, 1963	10	1	1	288	540	29	87	36	2.3	< .4	716	8	1,190	8.8
201	S. J. Young	200	Nov. 8, 1963	16	121	45	135	540	--	262	45	.5	< .4	896	490	1,360	7.2
301	H. D. Brandon	133	Oct. 15, 1963	18	151	41	116	464	--	370	27	1.2	< .4	954	550	1,320	7.5
		224[b]	Feb. 11, 1964	8	2	1	201	426	24	36	7	1.0	< .4	494	8	847	8.9
302	B. R. Bowling	140	Apr. 30, 1964	11	3	1	219	510	--	38	18	1.1	< .4	540	12	899	8.1

See footnotes at end of table.

Table 4.--Chemical analyses of water from wells and springs, Montague County--Continued

Well	Owner	Depth of well (ft)	Date of collection	Silica (SiO_2)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids	Total hardness as $CaCO_3$	Specific conductance (Micromhos at 25°C)	pH
19-11-401	Joe B. Brown	160	Aug. 1, 1963	10	3	1	285	500	5	53	103	1.1	<0.4	706	13	1,150	8.4
402	Glenn O. Wilson	60	Aug. 2, 1963	20	75	40	131	296	--	84	157	.6	84	739	350	1,250	7.1
403	Miss Lula Bouldin	267	do	10	1	--	221	510	23	25	10	1.1	< .4	541	3	865	8.7
404	Mrs. John N. Bellah	90	do	14	91	48	185	346	--	165	223	.8	39	934	424	1,600	7.2
405	John Weaver	109	do	15	110	54	138	395	--	120	157	.5	124	909	500	1,550	7.2
406	E. L. McNabb	20	Aug. 5, 1963	14	104	51	216	311	--	195	243	.8	155.0	1,132	471	1,800	7.1
407	L. R. Sawyer	272	Sept. 26, 1963	9	2	2	276	600	--	65	33	2.3	< .4	685	9	1,110	8.3
408	Cecil Keck	325	Sept. 27, 1963	9	1	1	242	570	5	45	13	1.7	< .4	600	5	960	8.4
409	O. M. Molsbee, Jr.	90	Oct. 2, 1963	13	37	18	90	354	--	22	38	.5	< .4	390	164	678	7.9
412	O. T. Molsbee	190	Oct. 22, 1963	7	16	19	220	489	--	33	99	1.0	< .4	632	116	1,115	8.0
413	Waymon Tipton	100	do	10	21	9	11	61	--	23	16	.2	19	139	89	245	7.1
414	Mrs. Pearl Molsbee	270	Oct. 2, 1963	7	1	1	265	550	19	46	33	2.3	< .4	641	5	1,071	8.6
415	R. D. Teasley	196	Oct. 18, 1963	12	40	53	293	510	--	98	297	1.0	< .4	1,041	316	1,790	7.7
416	T. P. Skinner	229	Oct. 22, 1963	9	3	2	250	520	25	39	34	1.3	<4.0	626	17	1,050	8.7
417	Mrs. Billie Molsbee	252	do	4	6	3	155	381	--	30	15	.7	.5	407	27	695	8.3
501	Fred Salmon	280	Oct. 18, 1963	9	1	1	301	610	26	57	38	4.1	< .4	740	5	1,194	8.8
602	G. H. Fooshee	262	Nov. 5, 1963	9	1	1	181	395	20	30	6	.6	< .4	439	7	746	8.7
603	C. M. Russell	190	Feb. 10, 1964	9	1	1	178	393	17	41	5	.5	< .4	450	6	777	8.8
701	City of Nocona	727	July 8, 1944[a]	11	4.6	1.4	487	736	--	53	286	3.0	1.2	1,210	18	--	8.4
702	do	388	Nov. 17, 1944[a]	13	2.6	.7	210	503	--	30	12	1.6	1.5	532	10	--	8.4
			May 5, 1961	11	1.2	.4	219	501	6	31	16	1.7	--	532	4	864	8.3
704	do	600	Nov. 17, 1944[a]	--	2.7	2.1	221	542	--	34	11	--	1.2	574	15	--	8.4
705	do	600	July 7, 1944[a]	--	--	--	--	566	--	42	13	--	--	--	6	--	--
707	do	600	Nov. 17, 1944[a]	8.4	3.8	.9	282	647	--	53	19	4.0	1.8	708	13	--	8.4
708	do	525	July 7, 1944[a]	--	--	--	--	551	--	44	13	--	--	--	8	--	--
709	do	371	Nov. 10, 1944[a]	--	2.1	.4	205	498	--	20	16	--	1.2	518	6	--	8.4
710	do	422	July 7, 1944[a]	--	--	--	--	--	--	--	9	--	--	--	--	--	--

See footnotes at end of table.

Table 4.--Chemical analyses of water from wells and springs, Montague County--Continued

Well	Owner	Depth of well (ft)	Date of collection	Silica (SiO_2)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids	Total hardness as $CaCO_3$	Specific conductance (Micromhos at 25°C)	pH
19-11-714	Wallace K. Myers	386	July 29, 1963	10	1	1	252	470	10	67	71	0.7	<0.4	641	4	1,090	8.5
715	J. M. Land	67	do	12	108	47	232	459	--	242	263	.7	5.5	1,137	463	1,950	7.5
716	do	167	do	7	34	26	139	344	--	73	98	.8	< .4	545	190	945	7.7
717	do	175	do	7	72	58	202	440	--	259	184	.6	1.0	996	418	1,700	7.6
718	W. H. Patterson	150	do	15	92	35	69	192	--	85	93	.1	170.0	652	373	1,050	7.6
719	N. C. Field	275	do	9	5	5	375	510	--	127	207	.7	1.0	981	32	1,700	8.2
720	Mrs. M. M. Gilbert	128	do	10	27	25	151	454	--	29	71	.7	.5	539	170	945	7.7
721	O. M. Allison	138	do	10	4	2	213	510	--	29	13	1.0	< .4	521	18	875	8.2
723	J. B. Samples	220	Aug. 1, 1963	11	8	7	277	500	--	39	138	.5	< .4	726	48	1,250	7.9
724	Otto Menasco	35	do	13	112	49	79	157	--	121	94	.3	312	860	483	1,300	7.1
725	Ruth and Kate Davis	243	July 31, 1963	9	3	2	309	495	--	149	99	.7	< .4	819	16	1,350	8.3
726	Mrs. G. M. Utt	230	do	10	1	1	201	467	--	12	37	.4	< .4	493	6	810	8.3
727	Mrs. P. F. Lesh	265	Aug. 1, 1963	10	2	2	219	488	19	22	10	.9	< .4	522	9	860	8.6
728	Nathan E. Allred	250	July 31, 1963	7	1	--	228	311	120	17	9	.7	< .4	532	3	925	9.7
730	Aubrey Charles	185	Aug. 2, 1963	9	2	2	225	510	--	21	36	.7	< .4	551	10	890	8.3
731	G. H. Fooshee	55	Aug. 5, 1963	11	130	226	1,020	870	--	960	1,210	1.0	14	3,998	1,250	5,700	7.6
733	Virginia Lee Johnson	313	Aug. 6, 1963	7	23	15	221	500	--	63	76	1.1	9	666	120	1,078	8.2
734	J. W. Marshall	420	do	12	15	10	182	478	--	16	59	.6	< .4	527	80	886	7.9
735	Boyd Burnett	180	do	10	1	--	221	530	--	23	11	1.1	< .4	531	3	850	7.7
736	E. T. Honeycutt	21	Aug. 7, 1963	13	105	62	194	338	--	259	273	.7	18.0	1,088	520	1,750	7.3
737	T. B. Cunningham	35	Aug. 8, 1963	8	71	41	224	560	--	165	136	.9	5.0	926	346	1,500	8.0
738	P. M. Martin	150	do	12	30	17	44	226	--	25	24	.7	< .4	264	146	465	7.6
739	Eligie Skinner	72	do	14	75	40	226	276	--	219	265	1.0	21	1,000	353	1,640	7.3
740	Lee Cardwell	50	do	13	100	49	248	350	--	210	285	.9	60	1,142	454	1,870	7.4
741	Jack Mercer	516	do	9	1	1	222	540	--	25	11	1.3	< .4	536	5	855	8.3
742	Virgle Vineyard	280	Aug. 23, 1963	9	1	1	254	580	19	31	14	.6	< .4	615	5	1,010	8.6
743	Mrs. Joe Benton	325	Nov. 27, 1963	9	2	1	390	299	16	59	386	1.3	< .4	1,008	9	1,860	8.8

See footnotes at end of table.

Table 4.--Chemical analyses of water from wells and springs, Montague County--Continued

Well	Owner	Depth of well (ft)	Date of collection	Silica (SiO_2)	Cal-cium (Ca)	Magne-sium (Mg)	Sodium (Na)	Bicar-bonate (HCO_3)	Car-bonate (CO_3)	Sul-fate (SO_4)	Chlo-ride (Cl)	Fluo-ride (F)	Ni-trate (NO_3)	Dis-solved solids	Total hardness as $CaCO_3$	Specific conductance (Micromhos at 25°C)	pH
19-11-744	Claude Underwood	113	Aug. 9, 1963	9	3	2	224	510	--	37	28	3.9	<0.4	561	16	906	8.2
745	Newt Clary	38	do	12	287	405	236	375	--	49	1,770	2.0	22	2,969	2,380	5,550	7.6
746	John E. Zachary	115	Aug. 21, 1963	11	5	1	231	520	--	56	26	2.0	< .4	586	15	930	8.2
747	C. A. Richardson	285	do	9	3	1	234	510	--	35	36	1.5	< .4	571	11	940	8.2
749	J. H. Howell	85	do	7	30	4	295	590	--	55	136	1.2	< .4	820	89	1,350	8.1
750	Mrs. Eula K. McGuire	56	do	9	4	1	287	570	16	44	68	1.2	< .4	710	17	1,160	8.8
751	Boyd Burnett	34	do	7	44	49	149	355	--	59	192	.5	1.5	680	313	1,200	7.6
752	J. E. A. Burnett	185	do	12	55	1,710	2,450	379	--	219	9,600	.5	< .4	14,207	8,400	>12,000	6.6
754	do	150	Aug. 22, 1963	15	31	11	322	600	--	161	139	.4	< .4	975	123	1,560	7.6
755	Mrs. Pearl Young	175	do	9	1	1	241	540	8	31	25	1.2	< .4	586	6	935	8.5
756	Gettes McCool	176	do	10	8	2	230	530	--	30	51	1.1	< .4	591	30	984	7.8
801	Mrs. Joe Benton	347	Nov. 30, 1963	10	1	1	209	455	29	21	11	1.0	< .4	509	5	861	9.0
901	Roy Pollock	332	Feb. 13, 1963	10	1	1	188	312	16	108	17	.5	< .4	492	5	850	8.8
12-101	O. H. Lane	287	Dec. 2, 1963	9	3	1	139	296	13	25	19	< .2	< .4	360	10	610	8.9
102	Pete Uselton	238	Nov. 30, 1963	9	4	1	144	323	--	37	23	.2	< .4	376	16	637	8.1
104	Mrs. Adis Miller	204	Feb. 10, 1964	9	2	2	201	453	4	21	33	.2	< .4	500	11	879	8.4
201	H. H. Durham	195	do	11	30	10	91	328	--	16	27	< .1	< .4	343	119	638	7.6
401	L. D. Godwin	285	Nov. 30, 1963	9	1	1	159	323	24	31	12	.2	< .4	396	5	665	9.0
402	C. R. Reed	225	Dec. 5, 1963	17	99	22	29	351	--	30	65	< .2	< .4	432	336	772	7.4
601	Midland Oil Co.	112	May 7, 1964	15	95	29	53	379	--	75	54	.3	< .4	510	358	865	7.4
602	H. J. Terry	145	Oct. 30, 1963	17	110	34	39	404	--	43	74	< .1	21.0	535	415	948	7.4
603	Mrs. Minnie Cannon	160	Feb. 21, 1964	21	75	18	31	295	--	17	48	.2	4.0	360	261	637	7.4
604	Continental Oil Co.	300	June 20, 1957	--	19	31	142	240	--	--	195	--	--	612	--	--	7.4
			Feb. 21, 1964	9	57	14	139	304	--	18	176	.2	< .4	566	201	986	7.5
701	L. L. Newland	235	Dec. 5, 1963	9	1	1	155	333	17	31	5	.2	< .4	381	6	632	8.8
702	A. J. Godwin	110	June 6, 1964	14	920	317	790	303	--	72	3,530	.2	< .4	5,800	3,600	9,460	7.0
703	W. M. Goldsmith	230	July 29, 1964	17	84	23	39	350	--	4	60	.2	< .4	399	306	718	7.1

See footnotes at end of table.

Table 4.--Chemical analyses of water from wells and springs, Montague County--Continued

Well	Owner	Depth of well (ft)	Date of collection	Silica (SiO_2)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids	Total hardness as $CaCO_3$	Specific conductance (Micromhos at 25°C)	pH
19-13-101	A. R. Agee	187	Feb. 18, 1964	15	70	39	24	453	--	8	6	<0.2	<0.4	390	336	700	7.4
102	O. A. King	120	Feb. 19, 1964	13	86	46	72	368	--	35	158	.2	< .4	593	404	1,140	7.4
401	Seitz & Comegys Oil Co.	205	do	9	72	22	124	342	--	28	160	.3	< .4	596	270	1,130	7.5
17-201	Mrs. Joe Benton	317	Nov. 21, 1963	8	2	1	471	560	34	194	218	4.2	< .4	1,206	9	2,040	8.8
202	do	310	do	8	2	1	483	600	--	211	245	4.5	< .4	1,255	9	2,060	8.2
203	do	310	do	8	2	2	491	610	10	204	245	3.6	< .4	1,270	9	2,110	8.5
301	B. C. Lovette	235	Mar. 23, 1964	8	7	1	471	630	--	215	207	3.9	< .4	1,220	20	2,030	8.1
501	Mrs. Joe Benton	225	Nov. 21, 1963	8	3	1	500	620	13	204	269	3.9	< .4	1,305	11	2,250	8.6
502	do	500	do	9	2	2	428	530	22	149	232	3.3	< .4	1,111	10	1,900	8.8
601	Gold-Burg Independent School District	114	Mar. 6, 1964	15	25	21	86	299	--	36	36	.8	< .4	368	147	636	7.7
602	Wilburn Cross	225	Mar. 17, 1964	11	1	1	190	379	11	31	35	.5	< .4	467	4	777	8.6
603	B. C. Lovette	215	Mar. 21, 1964	12	22	12	138	377	--	44	40	.4	< .4	458	103	767	8.3
701	Wilburn Cross	341	Mar. 19, 1964	10	2	1	260	530	18	44	43	2.8	< .4	641	8	1,063	8.8
901	City of Bowie	360	Mar. 21, 1964	9	1	1	232	442	13	69	42	1.6	< .4	585	6	981	8.7
18-102	B. C. Lovette	400	Mar. 24, 1964	10	1	1	173	373	18	15	14	.6	< .4	421	4	692	9.0
104	Weldon Porter	350±	do	10	2	1	183	415	7	16	19	.8	< .4	443	8	740	8.5
201	A. N. Arveson	160	Nov. 13, 1963	13	44	12	239	530	--	33	149	1.0	24.0	781	159	1,390	7.7
202	do	270	do	9	1	1	248	487	22	33	52	1.4	< .4	603	7	1,032	8.7
204	do	165	do	9	1	1	248	500	25	37	26	3.0	< .4	596	6	1,004	8.8
205	Joe Pippin	275	do	10	1	1	240	460	19	40	59	1.5	< .4	596	4	1,018	8.7
301	E. T. Honeycutt	206	Aug. 7, 1963	9	3	1	448	399	--	148	360	1.1	< .4	1,167	13	1,950	8.1
302	Frank Martin	280	Nov. 21, 1963	9	4	6	205	327	23	44	85	.6	25.0	564	35	1,004	8.7
303	Johnnie Carminati	145	Nov. 20, 1963	14	68	28	123	498	--	37	73	.3	1.5	586	284	1,054	7.7
304	J. G. Dyer	280	Nov. 22, 1963	10	1	1	187	336	25	25	48	.3	< .4	459	6	815	9.1
306	S. D. Howard	222	Mar. 5, 1963	11	2	1	156	392	--	14	15	.4	< .4	391	8	638	7.8
401	Herman G. Heard	--	Oct. 8, 1963	9	1	1	150	332	--	16	34	.3	< .4	371	5	633	8.1

See footnotes at end of table.

Table 4.--Chemical analyses of water from wells and springs, Montague County--Continued

Well	Owner	Depth of well (ft)	Date of collection	Silica (SiO_2)	Cal-cium (Ca)	Magne-sium (Mg)	Sodium (Na)	Bicar-bonate (HCO_3)	Car-bonate (CO_3)	Sul-fate (SO_4)	Chlo-ride (Cl)	Fluo-ride (F)	Ni-trate (NO_3)	Dis-solved solids	Total hardness as $CaCO_3$	Specific conductance (Micromhos at 25°C)	pH
19-18-402	Mrs. Odessa Yowell	--	Nov. 13, 1963	9	2	1	402	760	14	47	119	4.7	<0.4	974	8	1,650	8.6
403	E. S. Johnson	368	do	10	1	1	159	346	18	15	15	.5	< .4	394	6	661	8.7
404	Gordon Heard	205	Mar. 10, 1964	9	3	2	153	320	7	18	37	.3	< .4	385	12	661	8.6
405	James Henry	220	Mar. 13, 1964	9	2	1	148	338	--	14	21	.2	< .4	358	9	604	8.2
406	Weldon Porter	385	Mar. 24, 1964	10	2	1	168	394	7	16	14	.7	< .4	413	7	689	8.6
501	Gordon Heard	207	Mar. 11, 1964	12	7	3	133	314	--	15	29	.3	3.5	361	32	599	7.9
502	James Henry	104	Mar. 13, 1964	15	700	353	1,470	249	--	100	4,400	.9	< .4	7,174	3,200	11,540	7.2
503	A. V. Corpening	240	Mar. 20, 1964	9	1	1	159	349	10	8	22	.4	< .4	383	5	650	8.8
702	Gordon Heard	350±	Mar. 10, 1964	9	2	1	149	334	--	17	22	.3	< .4	360	9	609	7.9
703	do	110	do	13	46	22	68	349	--	17	32	.3	< .4	373	206	656	7.7
704	Herman G. Heard	--	Mar. 13, 1964	1	640	176	5,500	29	--	< 3	10,300	.9	< .4	16,585	2,320	>12,000	6.7
705	Jack Slayden	34	Jan. 11, 1966	18	444	60	297	301	--	20	1,220	.2	< .4	2,210	1,360	3,950	7.2
			May 9, 1966	22	440	58	357	304	--	22	1,270	.4	< .4	2,320	1,340	4,045	7.1
706	John H. Angove	90	Jan. 11, 1966	16	72	35	52	364	--	31	67	.2	2.5	455	325	775	7.7
707	Gordon Heard	480	do	15	69	28	38	343	--	42	39	.1	< .4	400	290	680	7.4
708	Ben Parker Estate	100±	Jan. 13, 1966	15	107	36	40	497	--	34	47	.1	< .4	520	419	895	7.8
709	Lillie Bates, et al.	135	do	15	77	28	43	376	--	17	53	.1	< .4	418	305	735	7.5
710	O. H. McNatt, Jr.	24	do	9	65	13	23	222	--	16	46	.2	< .4	284	216	515	7.6
801	Herman G. Heard	163	Mar. 13, 1964	15	36	18	70	339	--	15	21	.3	< .4	338	163	594	7.8
19-101	City of Nocona	505	May 7, 1953[a]	15	5	2	161	293	24	44	18	--	.4	435	21	--	8.8
106	T. P. Skinner	300	Oct. 23, 1963	12	2	1	160	324	23	26	18	.3	< .4	405	8	680	8.9
107	G. H. Fooshee	232	do	8	10	5	166	360	--	31	46	.5	20.0	467	45	794	8.0
108	do	265	do	11	13	4	200	367	--	44	95	.3	.5	554	50	961	7.9
109	J. P. Clingingsmith Estate	250	Nov. 20, 1963	9	1	1	176	355	18	33	23	.4	< .4	440	6	753	8.9
110	Leroy Priddy	243	Nov. 22, 1963	10	1	1	168	321	34	27	21	.3	< .4	417	6	714	9.1
202	S. E. Bell Estate	219	Nov. 27, 1963	22	77	23	59	190	--	109	115	.2	< .4	503	287	890	7.0
203	J. S. Etter	224	do	14	64	20	63	272	--	106	36	.3	< .4	442	241	748	8.0

See footnotes at end of table.

Table 4.--Chemical analyses of water from wells and springs, Montague County--Continued

Well	Owner	Depth of well (ft)	Date of collection	Silica (SiO_2)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids	Total hardness as $CaCO_3$	Specific conductance (Micromhos at 25°C)	pH
19-19-301	J. S. Etter	224	Nov. 27, 1963	15	72	25	55	320	--	87	37	0.2	3.0	447	284	782	7.6
401	G. E. Richardson	300	Feb. 14, 1964	10	13	4	85	261	--	18	9	.2	< .4	267	52	475	8.0
402	Nortex Oil Corp.	1,000	Feb. 13, 1964	10	4	1	320	393	8	30	256	1.3	< .4	820	14	1,570	8.6
701	G. E. Richardson	260	Feb. 14, 1964	12	17	6	78	262	--	20	8	.3	< .4	270	69	460	8.1
702	do	260	May 5, 1961	12	12	6.3	89	263	--	20	6.8	.3	2.5	278	56	458	7.7
			Feb. 14, 1964	11	18	2	86	264	--	19	7	.3	< .4	273	54	471	8.1
801	Henry Corado	197	May 4, 1964	21	106	23	51	333	--	95	70	.3	< .4	530	360	903	7.0
802	Mrs. Lois Bell	225	Apr. 30, 1964	5	214	60	56	143	--	600	105	.3	< .4	1,110	780	1,590	6.8
20-601	City of Saint Jo	430	June 5, 1946[a]	17	102	33	34	408	--	96	13	.4	3.8	504	390	--	7.4
			May --, 1953	24	94	33	39	--	--	76	18	.1	<4.0	500	370	--	8.0
			Nov. --, 1954	--	102	50	1	--	--	98	21	.1	.4	504	460	--	7.5
			Mar. 4, 1964	19	100	31	26	400	--	89	12	.3	< .4	477	379	790	7.5
602	do	700	May --, 1953	17	14	7	275	--	--	42	213	.1	2.7	790	65	--	8.3
			Nov. --, 1954	--	10	4	287	--	--	48	209	.4	.4	760	42	--	7.8
			Mar. 4, 1964	10	12	3	283	390	--	39	205	.4	1.5	742	43	1,320	7.7
603	do	747	Feb. --, 1954	2	27	12	305	--	--	61	288	.4	4.0	940	117	--	7.8
			Oct. --, 1956	--	21	5	328	--	--	56	285	.4	1.6	1,008	75	--	7.6
			Mar. 4, 1964	13	56	20	87	362	--	84	19	.2	1.5	315	224	776	7.6
25-201	L. C. Foster	242	Mar. 19, 1964	9	1	1	199	339	13	50	59	.7	< .4	498	4	854	8.8
501	Leonard Martin	410	Apr. 8, 1964	8	4	2	462	471	--	37	403	2.2	< .4	1,150	19	2,060	8.0
26-103	Jack Slayden	81	Jan. 11, 1966	15	106	21	32	367	--	44	49	.2	< .4	449	352	760	7.3
104	N. J. Spikes	--	Jan. 12, 1966	13	118	43	54	417	--	61	119	.1	16.0	630	470	1,165	7.5
105	Herman Fox	80	Jan. 13, 1966	12	119	18	25	375	--	39	51	.3	< .4	448	369	760	7.5
106	Bessie Henry	97	do	14	104	24	30	360	--	22	67	.3	< .4	438	358	765	7.5
201	Union Texas Petroleum	500	Apr. 23, 1964	8	39	21	51	317	--	14	17	.2	< .4	306	185	555	7.7
			Jan. 13, 1966	9	36	22	54	312	--	17	15	.1	< .4	306	182	540	7.7
202	do	742	Jan. 13, 1966	9	8	4	124	318	--	20	14	.7	< .4	336	34	560	8.2
203	do	670	May 11, 1966	16	4	2	135	327	--	22	14	.6	< .4	355	19	577	7.7
204	Jake Bridgewater	83	May 10, 1966	22	107	6	112	451	--	47	75	.1	8.0	600	293	968	7.3
205	Radio Station KBAN	47	May 11, 1966	21	116	5	69	415	--	48	40	.2	5.0	510	312	837	7.2
206	The Westerner Bowling Alley	--	do	17	129	16	28	333	--	34	86	.2	27.0	500	387	859	7.3

See footnotes at end of table.

Table 4.--Chemical analyses of water from wells and springs, Montague County--Continued

Well	Owner	Depth of well (ft)	Date of collection	Silica (SiO_2)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids	Total hardness as $CaCO_3$	Specific conductance (Micromhos at 25°C)	pH
19-26-207	Mrs. Ray Harlow	120	May 11, 1966	25	102	8	82	425	--	42	47	0.4	8.0	520	286	838	7.4
301	Union Texas Petroleum	413	Apr. 23, 1964	8	38	22	51	320	--	15	17	.2	< .4	308	188	560	7.6
			Jan. 13, 1966	9	35	23	54	312	--	19	15	.2	< .4	308	182	540	7.7
302	do	253	Jan. 13, 1966	17	163	9	70	414	--	48	139	.1	7.0	660	445	1,130	7.2
			May 10, 1966	21	165	9	70	416	--	48	138	.2	4.0	660	449	1,050	7.2
303	do	375	Apr. 23, 1964	9	58	10	132	329	--	50	113	.7	< .4	540	186	956	7.6
			May 11, 1966	15	153	13	83	427	--	57	147	.4	< .4	680	437	1,120	7.3
304	do	384	Apr. 23, 1964	8	38	22	47	311	--	13	17	.2	< .4	298	187	546	7.7
			Jan. 13, 1966	9	37	22	52	310	--	14	16	.2	< .4	302	181	530	7.8
305	Clifton Brooks	35	May 10, 1966	29	116	12	91	417	--	50	98	.4	34.0	660	341	1,062	7.1
306	E. R. Moore	90	do	24	157	29	67	421	--	66	164	.3	6.0	720	510	1,200	7.1
401	Service Pipeline Co.	154	May 8, 1961[a]	9.6	51	32	58	290	--	33	79	.1	.2	406	258	735	7.4
			May 5, 1964	9	54	32	48	285	--	26	77	.2	< .4	386	267	724	7.9
601	B. E. Freeman	60	May 10, 1966	22	226	11	98	422	--	106	246	.2	13.0	930	610	1,550	7.1
602	J. T. Floyd	65	do	24	120	14	94	431	--	57	93	.2	6.0	620	359	992	7.2
603	Mrs. John L. Prater	112	do	22	164	17	87	426	--	64	158	.3	17.0	740	480	1,210	7.3
27-101	Fred Salmon	110	Oct. 19, 1963	19	256	71	92	417	--	149	434	.3	12.0	1,238	930	2,110	7.1
401	do	134	Oct. 18, 1963	14	149	49	75	427	--	51	234	.2	< .4	783	570	1,400	7.6
402	Rayburn Chokas	110	Apr. 7, 1964	17	109	43	15	460	--	24	39	.5	28.0	500	449	884	7.5
801	Hollis Beane	128	do	29	81	31	20	365	--	21	25	.4	17.0	403	328	682	7.4
901	W. B. Sills	180	do	20	68	20	37	301	--	58	21	.3	8.0	380	253	637	7.3
902	Jim Barnett	140	Apr. 22, 1964	32	121	36	65	54	--	343	86	.4	90.0	800	452	1,176	7.0
28-701	C. C. Edwards	198	do	17	92	45	60	373	--	156	61	.3	< .4	610	415	1,007	7.5
801	Forestburg Independent School District	200±	May 5, 1961[a]	24	102	19	21	355	--	67	12	.2	--	420	332	666	6.9
			Apr. 23, 1964	22	105	18	16	357	--	66	9	.2	< .4	412	336	683	7.5
802	G. D. Wylie	345	Apr. 24, 1964	11	102	13	13	350	--	40	7	.2	< .4	358	310	626	7.4
803	Forestburg Water Supply Corp.	459	July 27, 1964	20	250	110	--	320	--	19	20	--	--	580	360	--	7.2
			Nov. 6, 1964	20	79	29	28	365	--	69	14	.2	< .4	418	319	690	7.4
33-201	W. F. Gossett	300	Apr. 8, 1964	11	30	13	92	281	--	54	33	.4	3.0	374	129	644	7.7
34-302	B. F. Huddleston	110	Feb. 14, 1964	9	10	1	199	447	2	30	51	1.2	< .4	523	32	935	8.4

See footnotes at end of table.

Table 4.--Chemical analyses of water from wells and springs, Montague County--Continued

Well	Owner	Depth of well (ft)	Date of collection	Silica (SiO_2)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids	Total hardness as $CaCO_3$	Specific conductance (Micromhos at 25°C)	pH
19-34-304	G. E. Richardson	490	Feb. 14, 1964	10	4	2	207	432	10	26	51	1.3	<0.4	521	17	934	8.6
36-201	J. J. Monroe, Jr.	126	Apr. 23, 1964	20	112	33	43	442	--	43	72	.2	< .4	540	414	949	7.4
37-101	Mrs. Lena Merrett	224	Apr. 6, 1964	14	91	16	23	310	--	76	10	.2	< .4	384	292	642	7.3

[a] Analysis by U.S. Geological Survey.
[b] Well deepened after first water sample collected.

Table 5.--Reported brine production and disposal in 1961, Montague County

Area shown on Figure 10	Field name[a]		Disposal in pits (bbl)	Disposal in injection wells (bbl)	Total brine production (bbl)
1	McGaughy/Ellenburger		0	54,000	54,000
	Spanish Fort/Crinoidal Sd.		0	897,170	897,170
	Spanish Fort/2700 Sand		365	2,648	3,013
	County Regular		67,299	17,082,875	17,150,174
		Total	67,664	18,036,693	18,104,357
2	County Regular		0	58,000	58,000
		Total	0	58,000	58,000
3	County Regular		0	15,300	15,300
		Total	0	15,300	15,300
4	Illinois/Bend		0	250,390	250,390
		Total	0	250,390	250,390
5	Staley/Conglomerate		0	3,600	3,600
	Staley/Conglomerate, Lower		0	360	360
		Total	0	3,960	3,960
6	Ringgold, East/2nd Conglomerate		0	94,565	94,565
	Ringgold, East/4th Conglomerate		0	110,230	110,230
	Ringgold, East/5th Conglomerate		0	5,000	5,000
	County Regular		7,200	0	7,200
		Total	7,200	209,795	216,995
7	Ringgold, East		0	14,070	14,070
		Total	0	14,070	14,070
8	Milam/Conglomerate		1,200	0	1,200
	Milam, N.E./Caddo Conglomerate		365	2,000	2,365
	Seay/Caddo Conglomerate		0	8,030	8,030
		Total	1,565	10,030	11,595
9	Ringgold		1,095	342,486	343,581
		Total	1,095	342,486	343,581
10	Stoneburg, North/Strawn		720	0	720
		Total	720	0	720

See footnotes at end of table.

Table 5.--Reported brine production and disposal in 1961, Montague County--Continued

Area shown on Figure 10	Field name[a]		Disposal in pits (bbl)	Disposal in injection wells (bbl)	Total brine production (bbl)
11	Belcherville		2,190	91,615	93,805
	Belcherville, S./Conglomerate		0	0	0
	Belcherville, South/2nd Congl.		800	0	800
	Lerner/Caddo Congl. Lower		0	1,125	9,125
	Lerner/Caddo Conglomerate, Upper		0	0	0
	Lerner/1st Conglomerate		0	9,125	9,125
	Lerner/2nd Conglomerate		0	3,650	3,650
	Lerner/3rd Conglomerate		0	18,250	18,250
	Lerner/4550 Strawn		0	3,650	3,650
	Maguire		0	0	0
	Paine-McGaw/Strawn		0	0	0
	Rogers & Rogers		16,334	117,750	152,234[b]
	Whitson		0	63,025	63,025
	Whitson/Strawn, Lower		0	480	480
	County Regular		300	90,000	90,300
		Total	19,624	406,670	444,444
12	Dodson		0	293,655	293,655
		Total	0	293,655	293,655
13	Seago		0	6,000	6,000
		Total	0	6,000	6,000
14	Alma/Strawn		13,830	0	13,830
	Bowers/Penn.		0	0	0
	Bowers, South		0	23,000	23,000
	Bowers/Strawn		23,277	380,000	403,277
	Bowers/3100 Strawn		14,500	0	14,500
	Bowers Pool		86,113	116,076	202,189
	Childress/Strawn		0	18,980	18,980
	Fleming/Strawn		0	0	0
	Smada/2500 Strawn		3,000	0	3,000
	County Regular		63,731	1,936,896	2,000,627
		Total	204,451	2,474,952	2,679,403
15	Howard/Conglomerate		0	0	0
		Total	0	0	0
16	Jockey/Conglomerate		0	0	0
	Sanders		0	730	730
	Sanders/Caddo 3rd Congl., Upper		0	425	71,928[c]
	Sanders/Conglomerate, Lower		0	6,075	6,075
	Sanders/Conglomerate, Upper		0	7,150	7,150
		Total	0	14,380	85,883
17	Carminati		365	0	365
	Clingingsmith/Basal Congl.		....	Not reported ...	....
	Clingingsmith/Caddo Congl. E		0	15,180	15,180
	Clingingsmith/Conglomerate		30,030	0	30,030
	Clingingsmith/Strawn		0	14,000	14,000
	Minor, N./Conglomerate		0	730	730
		Total	30,395	29,910	60,305

See footnotes at end of table.

Table 5.--Reported brine production and disposal in 1961, Montague County--Continued

Area shown on Figure 10	Field name[a]		Disposal in pits (bbl)	Disposal in injection wells (bbl)	Total brine production (bbl)
18	Nocona, South/Caddo		0	0	0
		Total	0	0	0
19	Etter/Bend Conglomerate		0	32,800	32,800
	Etter/Conglomerate, Upper		0	70,700	70,700
	Fooshee/Strawn		0	0	0
	McNabb/Conglomerate, Lower		1,800	0	1,800
	McNabb/Conglomerate, Upper		2,000	0	2,000
	McNabb, NW./Conglomerate		0	13,000	13,000
	County Regular		1,000	0	1,000
		Total	4,800	116,500	121,300
20	Bonita		0	127,750	127,750
		Total	0	127,750	127,750
21	Threadgill/Strawn		0	109,500	109,500
		Total	0	109,500	109,500
22	Miller/Conglomerate		0	1,266	1,266
	Roberts/2nd Conglomerate		0	0	0
	Stoneburg		1,875	1,080	2,955
	Stoneburg/1st Conglomerate		1,260	0	1,260
	Stoneburg/4th Conglomerate		1,260	0	1,260
	Underwood-Ray/Conglomerate		1,150	630	1,780
		Total	5,545	2,976	8,521
23	Chapman-McFarlin		0	66,680	66,680
		Total	0	66,680	66,680
24	B & M/Conglomerate		1,750	0	1,750
	Hildreth		5,455	144,397	149,852
	Hildreth/Conglomerate, Lower		0	0	0
	Hildreth/#2 Congl. Unit		0	1,587,000	1,587,000
	Hildreth/Reese		3,840	0	3,840
	Hildreth/Strawn 5500, Lower		0	0	0
	Hildreth/4700 Strawn		0	0	0
	Johnstar/Conglomerate		910	58,060	58,970
	Kennedy/Caddo		712	9,455	10,167
	Kennedy/Conglomerate		3,360	110,115	113,475
	Lewis-Stuart/Caddo		1,825	43,070	44,895
	Lewis-Stuart/Conglomerate		547	57,540	58,087
	Lewis-Stuart/Strawn		0	720	720
	Magee		5,650	0	5,650
	Queens Peak		1,652	44,165	45,817
	Wales/Viola		0	0	0
	Wales/6240 Conglomerate		0	0	0
		Total	25,701	2,054,522	2,080,223
25	Minor, West		66	154,200	154,266
		Total	66	154,200	154,266

See footnotes at end of table.

Table 5.--Reported brine production and disposal in 1961, Montague County--Continued

Area shown on Figure 10	Field name[a]	Disposal in pits (bbl)	Disposal in injection wells (bbl)	Total brine production (bbl)
26	Engle/Cotton	36,000	0	36,000
	Engle/Strawn	0	167,048	167,048
	Engle/2nd Conglomerate	15,000	85,000	100,000
	Gronow/Strawn	9,125	0	9,125
	Miami Fenoglio/2nd Congl.	5,475	0	5,475
	Minor/Conglomerate	0	76,015	76,015
	Ulbig/Conglomerate	730	0	730
	Wagg/Conglomerate	1,245	0	1,245
		Total 67,575	328,063	395,638
27	JayDee/Strawn	150	0	150
	JayDee/1st Conglomerate	200	0	200
	JayDee/2nd Conglomerate	0	5,475	5,475
	Mallard, North/Congl.	0	54,750	54,750
	Trans/Caddo Conglomerate	9,430	0	9,430
	Trans/Caddo, Upper	6,570	0	6,570
		Total 16,350	60,225	76,575
28	Dye Creek/Conglomerate	0	0	0
	Dyemound/Bend Conglomerate	0	28,800	28,800
	Dyemound, S./Bend Conglomerate	57,250	0	60,209[d]
	Dyemound, South/Strawn	0	0	0
	Dyemound, South/7050 Zone	2,190	0	2,190
		Total 59,440	28,800	91,199
29	Cheyenne/6500 Conglomerate	1,800	57,900	59,700
	George Engle/Conglomerate	0	42,705	42,705
	Saint Jo, SW./Conglomerate	0	70,080	70,080
	Saint Jo, SW./6300 Congl.	0	91	91
	Saint Jo, W./Conglomerate	7,070	58,500	65,570
	Saint Jo, West/6300 Conglomerate	0	21,140	21,140
		Total 8,870	250,416	259,286
30	An-Son/Conglomerate	0	73,780	73,780
	An-Son/Viola	2,040	0	2,040
		Total 2,040	73,780	75,820
31	Boedeker	2,555	11,680	14,235
	Boedeker/Conglomerate	0	0	0
	Boedeker, SE./Viola Limestone	0	16,480	16,480
	Boedeker, Southeast	0	0	0
		Total 2,555	28,160	30,715
32	Bowie/Viola Limestone	0	63,510	63,510
	Brashear/Pennsylvania Lime	2,920	0	2,920
	Denver/Caddo	0	65,532	65,532
	Mueller	2,190	300	2,490
	Richardson-Mueller/Caddo	24,497	13,764	38,261
		Total 29,607	143,106	172,713

See footnotes at end of table.

Table 5.--Reported brine production and disposal in 1961, Montague County--Continued

Area shown on Figure 10	Field name[a]		Disposal in pits (bbl)	Disposal in injection wells (bbl)	Total brine production (bbl)
33	Hundley/Caddo		10	0	10
	Hundley/Conglomerate		10,910	33,100	44,010
	Hundley, East/4800 Strawn		0	0	0
	Hundley, East/5200 Strawn		730	0	730
	Hundley, Strawn		5,840	22,480	28,320
	Hundley		0	0	0
		Total	17,490	55,580	73,070
34	Gifford		0	0	0
	Osage/Conglomerate		0	0	0
	Osage, East/Viola Lime		0	0	0
	Osage		0	0	0
	County Regular		985	41,380	42,365
		Total	985	41,380	42,365
35	Boedeker, South/Viola Lime		1,300	0	1,300
	Boedeker, SW./Conglomerate		1,095	0	1,095
	Bowie, SW./1st Conglomerate		0	0	0
	Bowie, SW./4th Conglomerate		0	1,825	1,825
	Eanes/Caddo		0	0	0
	Eanes/Conglomerate		0	0	0
	Eanes, Northeast/5750 Congl.		0	0	0
	Eanes/Viola Lime		0	0	0
	MPS/Ellenburger		2,500	0	4,103[e]
	Newport, Caddo		0	0	0
	Younger, West/Ellenburger, North		0	0	0
	Younger, W/Caddo Congl. Lower A-1.N.		0	0	0
	Younger, W./Caddo Congl. Lower Z.B.N.		0	0	0
	Bowie, Southwest		0	0	0
		Total	4,895	1,825	8,323
36	Dimock/Viola Lime		1,700	0	1,700
		Total	1,700	0	1,700
37	Higgs/Conglomerate		65	0	65
	Sunset/Conglomerate-A-		0	0	0
	Sunset/Conglomerate-B-		....	Not reported ...	....
	Sunset/Conglomerate-C-		0	0	0
		Total	65	0	65
38	Fruitland/Caddo		500	0	500
		Total	500	0	500
39	Aries/Caddo		3,535	0	3,535
	Aries/Conglomerate		0	0	0
	Aries, East/6220 Conglomerate		0	0	0
	Aries/Strawn		913	0	913
	Aries, West/Caddo		0	0	0
	Aries, West/5100		5,700	0	5,700
		Total	10,148	0	10,148

See footnotes at end of table.

Table 5.--Reported brine production and disposal in 1961, Montague County--Continued

Area shown on Figure 10	Field name[a]	Disposal in pits (bbl)	Disposal in injection wells (bbl)	Total brine production (bbl)
40	McCoco/Caddo Congl.	0	0	0
		Total 0	0	0

SUMMARIES

Area and type of disposal	Barrels in 1961	Percent
Montague County Totals		
Injection wells	25,809,754	97.4
Open surface pits	591,046	2.2
Miscellaneous	22,712	.1
Unknown	71,503	.3
Total salt water	26,495,015	
Trinity River Watershed in Montague County		
Injection wells	373,780	69.7
Open surface pits	158,097	29.5
Miscellaneous	4,562	.9
Total salt water	536,439	
Red River Watershed in Montague County		
Injection wells	25,435,974	98.0
Open surface pits	432,949	1.7
Miscellaneous	18,150	.1
Unknown	71,503	.3
Total salt water	25,958,576	
Montague County Regular Field		
Injection wells	19,224,451	99.3
Open surface pits	140,515	.7
Total salt water	19,364,966	
All Fields Except Montague County Regular		
Injection wells	6,585,303	92.4
Open surface pits	450,531	6.3
Miscellaneous	22,712	.3
Unknown	71,503	1.0
Total salt water	7,130,049	

[a] Field name assigned by the Railroad Commission of Texas.
[b] Includes 18,150 barrels disposed of by methods other than pits and injection wells in the Rogers and Rogers field in Area 11.
[c] Includes 71,503 barrels disposed of by methods not reported in the Sanders/Caddo 3rd Congl., Upper field in Area 16.
[d] Includes 2,959 barrels disposed of by methods other than pits and injection wells in the Dyemound, S./Bend Conglomerate field in Area 28.
[e] Includes 1,603 barrels disposed of by methods other than pits and injection wells in the MPS/Ellenburger field in Area 35.

Table 6.--Chemical analyses of oil-field brines, Montague County

(Analyses are in parts per million except specific gravity and pH.)

From Rowland Laxon and others, 1960, Resistivities and chemical analyses of formation waters from the west central Texas area: West Central Texas Section of the Society of Petroleum Engineers of A.I.M.E.; and BJ Service, Inc., 1960, The chemical analyses of brines from some fields in north and west Texas: A.I.M.E.

Zone of production	Field	Average depth (ft)	Area shown on Figure 10	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Specific gravity	pH
Canyon	Spanish Fort	1,650	1	15,810	2,449	45,150	4	26	104,495	1.138	4.8
Do.	Bowers	2,800	14	22,010	1,811	52,750	20	137	125,950	1.166	4.2
Strawn	Childress	2,475	14	16,400	3,251	41,955	--	21	113,250	1.134	3.4
Do.	Illinois-Bend	3,500	4	15,149	2,697	46,810	2	9	106,900	1.139	3.9
Do.	Rogers & Rogers	4,652	11	21,250	2,790	55,000	4	14	129,800	1.176	3.8
Do.	Bonita	5,400	20	18,605	2,536	55,700	--	227	126,000	1.165	3.6
Do.	Gronow Strawn	5,830	26	20,555	2,420	49,350	--	152	119,350	1.156	3.6
Do.	Aries	5,400	39	16,240	1,280	50,600	93	21	110,400	1.146	5.9
Do.	do	5,400	39	15,500	1,653	51,600	89	12	111,700	1.146	5.5
Do.	do	5,400	39	14,630	1,818	49,750	96	10	107,900	1.142	5.0
Bend	Dodson	5,122	12	19,210	2,571	56,200	--	125	128,000	1.171	3.2
Do.	Milam Conglomerate	5,701	8	17,575	2,823	56,450	74	221	126,100	1.163	6.0
Do.	do	5,700	8	17,530	2,906	56,200	82	193	126,050	1.162	5.7
Do.	Sanders	5,975	16	21,320	2,640	57,695	--	153	134,500	1.178	3.7
Do.	Chapman-McFarland	6,000	23	18,300	2,420	56,300	--	137	126,100	1,165	3.5
Bend	Mueller-Caddo	6,000	32	15,710	2,577	50,810	74	28	113,700	1.148	6.7
Do.	Staley	6,000	5	20,270	2,450	55,300	--	212	128,050	1.167	3.5
Do.	Hundley Conglomerate	6,260	33	17,410	2,685	52,500	42	52	119,500	1.158	6.7
Do.	Miller Conglomerate	6,260	22	15,360	790	63,600	8	7	127,450	1.168	6.5
Viola	Bowie-Viola	6,470	32	14,080	2,550	60,450	134	110	125,200	1.165	7.0

APPENDIX

SUPPLEMENTARY DISCUSSIONS OF QUALITY OF WATER, GEOLOGY, AND HYDROLOGY

SUPPLEMENTARY DISCUSSIONS OF QUALITY OF WATER, GEOLOGY, AND HYDROLOGY

Geology of North-Central Texas

Regional Structure

The counties included by the Texas Water Development Board in the study of ground-water resources in north-central Texas are in the Grand Prairie and Osage Plains geographic provinces of Texas. The Grand Prairie region is defined as a belt of counties west of the Balcones fault zone and north of the Llano uplift, and has been described as a modified northeastward continuation of the Edwards Plateau. At the surface in the Grand Prairie region are Cretaceous rocks of the Comanche Series dipping gently to the east and southeast. Some faulting is exhibited in the Cretaceous formations near the Balcones zone, but in general no major structural features are reflected by these beds other than the regional eastward dip. To the west of the Grand Prairie region is the Osage Plains province extending from the Edwards Plateau and Llano uplift northward to the Red River. Surface formations in the Osage Plains of north-central Texas are of Pennsylvanian and Permian age except where these rocks are overlain locally by remnants of Cretaceous sediments or Recent alluvial deposits. Pennsylvanian and Permian beds of the region form a westward dipping homocline with an average dip of 50 feet per mile. Formations significant to the occurrence of ground water under study in the Osage Plains have not been affected by major structural deformation. The principal, large, buried structural features, illustrated in Figure A1, include the Bend flexure, the Red River uplift, the Muenster arch, the Fort Worth basin, eastern Midland shelf, and the Concho arch.

Depositional History

The geologic environment in which the rock units underlying north-central Texas were laid down and the stratigraphic relationship of these units one to another determine the character of the water-bearing formations, which are the sources of ground water. Structural movement and crustal settling and shifting, which followed the deposition of the rocks in the area, influenced the mode of occurrence of ground water. An understanding of these complex historical events is important to a comprehension of how ground water occurs and how it can best be developed.

The sequence of geologic events significant to the occurrence of ground water in north-central Texas began in Pennsylvanian time, and continued through the deposition of Permian rocks throughout most of the area, Cretaceous sediments over a large part of the area, and Pleistocene to Recent alluvial sediments found at the surface in local areas and along most of the streambeds.

The Pennsylvanian and Permian seas that deposited sediments in the north-central Texas area were shallow--probably less than 100 feet deep. This is evidenced by the large amounts of sandstone, the repetition and extent of coal deposits, and the presence of frequent local unconformities. Present also are conglomerates, mud cracks, ripple marks, cross-bedding, and fossils that are found in a shallow-water environment. Thus, ground water occurs in this area in formations of sediments deposited very nearly horizontally in shallow seas

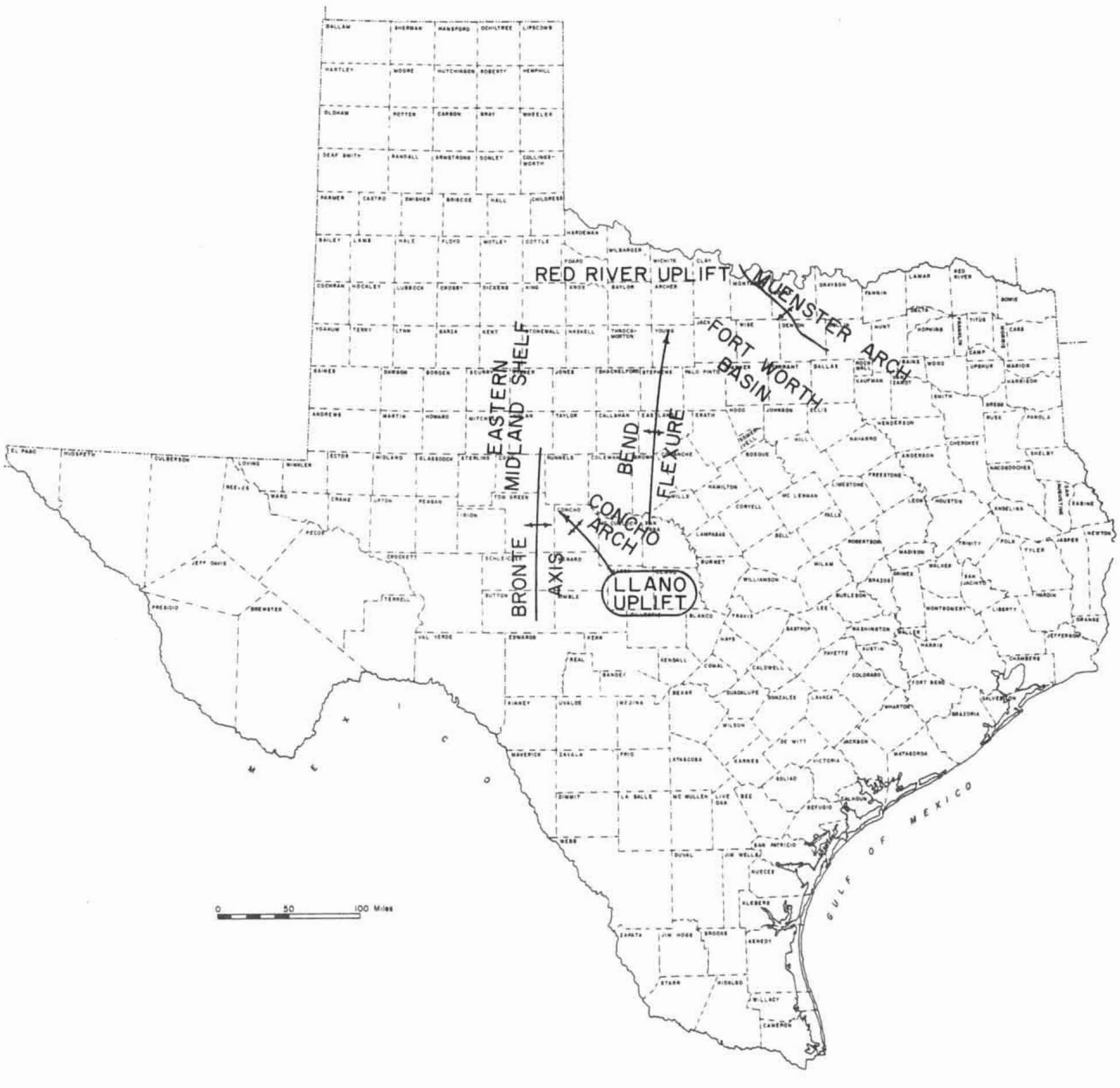

Figure A1

Major Structural Features in North-Central Texas

Texas Water Development Board in cooperation with the Texas Water Pollution Control Board

that were alternately advancing and retreating. Such a depositional environment resulted in a complex system of lateral and vertical changes in the character of the materials deposited. Few widespread continuous mantles of sediments such as those that characterize the Gulf Coast region of Texas are found. However, in contrast to the local, discontinuous, highly variable, shallow-water, clastic deposits characteristic of these periods, certain limestone units are relatively widespread. These limestones were deposited in extensive shallow seas advancing from the north and east, and are traceable as continuous units throughout much of the area under study. Thus, these limestone beds, while only locally significant as water-bearing units, are extremely important as horizon markers in indentifying the age and character of the intervening sediments.

Pennsylvanian Deposition

The upper Pennsylvanian rocks of north-central Texas include the Strawn, Canyon, and Cisco Groups, each of which has been subdivided into several formations and members. In the Colorado River basin the Strawn Group is composed principally of alternating beds of sandstone and shale, probably representing near-shore deposits with the source area for the sediments being a land mass to the east and northeast, which is now concealed under younger strata. Beds of the Strawn Group overlap to the west so that the total thickness of the group is probably not greater than 1,200 feet at any one point. Cretaceous rocks overlying these older beds in the area of the Bend flexure prevent tracing individual units of the Strawn on the surface from the Colorado River basin into the Brazos River basin. In general, the Strawn of the Colorado River basin contains coarser sediments than in the Brazos River basin, although beneath the Cretaceous sediments to the north in Wise County the Strawn again assumes a near-shore facies marked by coal beds and lenses of sand and sandy shale.

The Canyon Group in north-central Texas is characterized by thick limestone beds alternating with shale, and contains relatively little sandstone. The source of the sediments in the Canyon was again from the east, and was lower than during Strawn deposition as shown by the decrease of terrigineous clastic material, which marked much of the Strawn deposition. Sandstone lenses occurring in the Canyon Group, of extreme importance to the occurrence of ground water in local areas, probably were deposited in channels formed during periods of nonmarine occurrence. In Jack and Wise Counties the character of Canyon sediments--conglomerates, irregular sands, and several coal beds--indicates an approach to the shoreline. Also in the southern region of the Colorado River basin some conglomerates are found in the basal Canyon. The surface expression of the Canyon Group in the Brazos River basin is separated by Cretaceous rocks from Canyon beds in the Colorado River basin, and no definitive stratigraphic correlation of individual formations has been traced from one basin into the other.

There was no widespread erosion of Canyon deposits except perhaps in the western Llano area. Tectonic activity to the north included the gradual uplift of the Red River arch, possible folding in the Wichita system, and other disturbances in the mid-continent area. Canyon sedimentation was also affected by the continued development of the eastern Midland shelf and the subdued, but still prominent, Concho arch and the Bronte axis.

Sedimentation continued into Cisco time, as evidenced by the lack of a marked unconformity between the Canyon and Cisco strata. Local disconformities and channeling are apparent in both the outcrop areas of these beds and in the subsurface, indicating that the shelf environment of late Canyon time became more and more deltaic locally during Cisco time. The Cisco Group in the north-central Texas region is comprised chiefly of shale, sandstone, conglomerate, and limestone, with local coal beds. Eastward the sand and conglomerate deposits increase in thickness while to the west the conglomerate and the coal disappear. In the northern part of the area the limestone disappears from the Cisco Group as deposition occurred in a nonmarine or partially marine facies.

Deposition in the late Pennsylvanian was affected by uplift in the Llano area as the initial westward tilting of the Concho foreland began toward the Midland basin. This westward tilting was to continue throughout Permian time. The Bend flexure, previously called the Bend arch, which extends from the Llano area to the Red River uplift, came into existence during late Pennsylvanian and early Permian times as a result of the differential subsidence of the Midland basin and the eastern Midland shelf, and the consequent westward tilting of the Concho foreland.

Permian Deposition

No major unconformity marks the contact between Pennsylvanian and Permian rocks, indicating relatively continuous deposition from the Cisco of the upper Pennsylvanian into the Wichita of the lower Permian. Local disconformities and channeling are apparent both in the surface and the subsurface, however, with the shoreline of the Permian sea having oscillated back and forth while it continued its slow migration toward the west as the tilting of the Concho foreland into the Midland basin progressed. The extensive Permian sea was shallow over north-central Texas, resulting in deposition of sediments under widely varying conditions.

Rocks of the Wichita Group have been mapped at the surface from the Red River to the Llano uplift. In the Colorado River basin the Wichita Group, representing the oldest Permian deposition, is characterized by marine shale and limestone facies, while northward the marine beds decrease in importance and red beds become more prominent. Near the Red River, deposition of the Wichita Group was in a marginal marine environment marked chiefly by a red-bed facies of shale and sandstone. Deposition was apparently continuous in the Wichita, and no pronounced unconformities have been found in this group.

Cretaceous Deposition

The close of Wichita deposition marked the end of Palezoic time in north-central Texas, and great changes in the position of the land masses in Texas were to characterize the beginning of the Mesozoic in the State. The early Mesozoic was a period of continental elevation, and no Triassic deposition is known to have occurred in the area included in this study. This period of non-deposition continued through the Jurassic, and the first marine deposition that occurred in north-central Texas after the close of the Permian was in early Cretaceous times. As a result of the massive change in land-surface elevation in the first half of the Mesozoic, however, drainage in the Texas area had been reversed by the time Cretaceous deposition began. Instead of northwesterly drainage into inland Paleozoic seas, drainage from the earliest Cretaceous period onward was toward the southeast in the direction of what is now the Gulf of Mexico. Thus the regional dip of Cretaceous rocks overlying the Pennsylvanian and Permian sediments of north-central Texas is toward the southeast.

West of an irregular, northeast-trending line through Brown, Eastland, Jack, Wise, and Montague Counties, the only Cretaceous rocks remaining after extensive periods of erosion are remnants and outliers that, although not extensive, are locally significant as sources of ground water and as recharge areas for underlying older rocks. East of this irregular line Cretaceous beds are found at the surface in a continuous band eastward to the outcrop of Eocene rocks.

All of the known Cretaceous deposition in the area of study belongs to the Comanche Series. The Comanche has been divided into the Trinity, Fredericksburg, and Washita Groups. Generally, all of the Comanche sediments belong to a near-shore or shallow-water environment.

Quality of Ground Water

All ground water contains dissolved mineral constituents. The type and concentration depends upon the source, movement, and the environment of the ground water. Water derived from precipitation is relatively free of mineral matter, but because water has considerable solvent power, it dissolves minerals from the soil and rocks through which it passes. Therefore, the differences in chemical character of ground water reflect in a general way the nature of the geologic formations and the soils that have been in contact with the water. The concentration of dissolved solids generally increases with depth, especially where the movement of the water is restricted. Rocks deposited under marine conditions will contain brackish or highly mineralized water unless flushing by fresh water has been accomplished. This flushing action will occur in the outcrop area and to a limited distance downdip, depending in part upon the permeability of the rocks.

The chemical quality of ground water that has not been artificially altered is relatively constant, as is the temperature of ground water, which makes it highly desirable for many uses.

In addition to the natural mineralization of water that occurs in its environment, the quality of ground water can also be affected by man. Municipal and domestic sewage systems (including septic tanks), industrial waste, and oil-field brine that is improperly disposed of can enter into ground water and render it unfit for most uses.

Including among the factors determining the suitability of ground water as a supply are the limitations imposed by the contemplated use of the water. Criteria have been developed to cover most categories of water quality, including bacterial content, physical characteristics, and chemical constituents. Water-quality problems associated with the first two categories can usually be alleviated economically, but the revoval of undesirable chemical constituents can be difficult and expensive. For many purposes the dissolved-solids content constitutes a major limitation on the use of water. One general classification of water based on dissolved-solids content (Winslow and Kister, 1956, p. 5) is as follows:

Description	Dissolved-solids content (ppm)
Fresh	Less than 1,000
Slightly saline	1,000 to 3,000
Moderately saline	3,000 to 10,000
Very saline	10,000 to 35,000
Brine	More than 35,000

The United States Public Health Service has established standards of drinking water to be used on common carriers engaged in interstate commerce. The standards are designed primarily to protect the traveling public, and are often used to evaluate public water supplies. According to these standards, chemical constituents should not be present in the water supply in excess of the listed concentration shown in the following table, except where other more suitable supplies are not available. Some of the standards adopted by the U.S. Public Health Service (1962, p. 7-8) are as follows:

Substance	Concentration (ppm)
Chloride (Cl)	250
Fluoride (F)	(*)
Iron (Fe)	.3
Manganese (Mn)	.05
Nitrate (NO_3)	45
Sulfate (SO_4)	250
Total dissolved solids	500

* When fluoride is present nautrally in drinking water, the concentration should not average more than the appropriate upper limit shown in the following table.

Annual average of maximum daily air temperatures (°F)	Recommended control limits of fluoride concentrations (ppm)		
	Lower	Optimum	Upper
50.0 - 53.7	0.9	1.2	1.7
53.8 - 58.3	.8	1.1	1.5
58.4 - 63.8	.8	1.0	1.3
63.9 - 70.6	.7	.9	1.2
70.7 - 79.2	.7	.8	1.0
79.3 - 90.5	.6	.7	.8

Water having concentration of chemical constituents in excess of the recommended limits may be objectionable for many reasons. Water containing an excess of 45 ppm of nitrate has been related (Maxcy, 1950, p. 271) to the incidence of infant cyanosis (methemoglobinemia or "blue baby" disease). The high concentrations of nitrate may be an indication of pollution from organic matter, commonly sewage. Iron and manganese in excessive concentrations cause reddish-brown or dark gray precipitates, which stain clothing and plumbing fixtures. Sulfate in water in excess of 250 ppm may produce a laxative effect, and water containing chloride exceeding 250 ppm may have a salty taste. Fluoride in concentrations of about 1 ppm may reduce the incidence of tooth decay, but excessive concentration may cause teeth to become mottled (Dean, Arnold, and Elvove, 1942, p. 1155-1159).

Hardness in water is caused principally by calcium and magnesium. Excessive hardness causes increased consumption of soap, and induces the formation of scale in hot water heaters and water pipes. The following table shows the commonly accepted standards and classifications of water hardness:

Hardness range (ppm)	Classification
60 or less	Soft
61 to 120	Moderately hard
121 to 180	Hard
More than 180	Very hard

Water that is suitable for industrial use may not be acceptable for human consumption, and different standards may apply. Ground water used for industry may be classified into four principal categories: cooling water, boiler water, process water, and water used for secondary recovery of oil by water injection.

Although cooling water is usually selected on the basis of its temperature and source of supply, its chemical quality is also significant. Any characteristic that may adversely affect the heat-exchange surfaces is undesirable. Substances such as magnesium, calcium, iron, and silica may cause the formation of scale. Another objectionable feature that may be found in cooling water is corrosiveness caused by calcium and magnesium chloride, sodium chloride in the presence of magnesium, acids, and the gases oxygen and carbon dioxide.

The production of steam requires high quality-of-water standards. Under the extreme temperature and pressure conditions the problems of corrosion and incrustation are intensified. Under these conditions the presence of silica becomes undesirable as it forms a hard scale or incrustation.

Water coming in contact with, or incorporated into, manufactured products is termed "process water" and is subject to a wide range of quality requirements. These requirements involve physical, biological, and chemical factors. Water used in the manufacture of textiles must be low in dissolved-solids content and free of iron and manganese, which could cause staining. The beverage industry normally requires water free of iron, manganese, and organic substances.

Water used for injection in the secondary recovery of oil is generally that water taken from the oil reservoir. However, this water--usually brine--must generally be supplemented in order to meet the requirements of volume. Careful control must be exercised over the injected water with regard to suspended solids, dissolved gases, microbiological growths, and mineral constituents. Suspended solids in the water, of course, can cause plugging of the reservoir. Hydrogen sulfide, carbon dioxide, and oxygen all have corrosive effects on the well equipment, and oxygen reacting with the metallic ions, primarily iron (Fe^{+++}), will cause plugging of the reservoir. Organisms, iron bacteria, algae, and fungi have an effect of plugging the reservoir or pumping equipment, and the sulfate reducers have a corrosive effect.

Insofar as the mineral constituents are concerned, iron and manganese are undesirable as they cause plugging in injection wells. Sulfates are of interest from a standpoint of deposition. Water that is high in sulfate should not be mixed with water containing appreciable amounts of barium, for this would result in formation of barium sulfate with a very low solubility. The pH value is also significant when corrosion control and the solubilities of calcium carbonate and iron are considered. The higher the pH, the more difficult it is to maintain iron in solution and to keep calcium scale from forming.

Ground-Water Hydrology

In north-central Texas the occurrence of ground water is erractic, and there are no large, continuous, prolific ground-water aquifers such as those found in the High Plains region of Texas and in the Gulf Coast. However, ground-water occurrences in north-central Texas conform to the same fundamental principle as those in other areas of the State.

Hydrologic Cycle

The water available for use by man--whether as rain, streamflow, water from wells, or spring discharge--is captured in transit, and after its use and reuse is returned to the hydrologic cycle from which it came. This cycle is illustrated in Figure A2. Graphically, Figure A2 shows the continuing movement of water from the oceans through evaporation to precipitation and its return either directly or ultimately to the ocean.

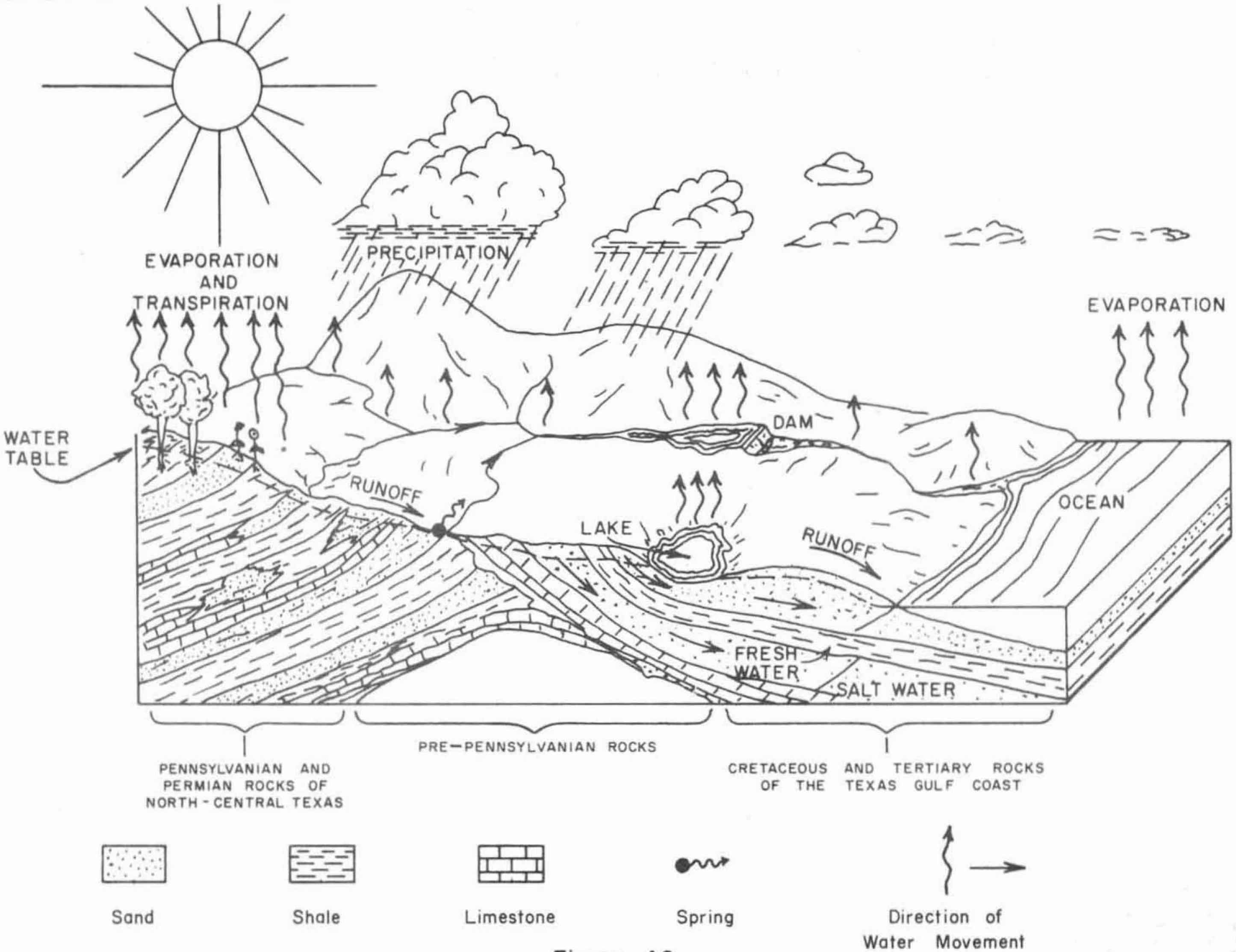

Figure A2
Hydrologic Cycle

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Ground-Water Occurrence and Movement

The geologic history of sedimentary deposition and erosion are primary factors controlling the occurrence and movement of ground water in the north-central Texas area. The rocks found in the shallow subsurface range from sporadic, uncemented, clastic beds to the more widespread, continuous, cemented or compacted shales, sandstone, and limestones. In uncemented rocks such as sand, gravel, and clay, water occurs in the spaces between individual particles, whereas in well cemented or compacted sedimentary rocks it occurs chiefly in cracks and fissures produced by earth movement or contraction, and in openings formed by solution where the rocks are soluble. If these openings are isolated, the movement of ground water is hindered. However, most openings are interconnected so as to permit ground water to move through them. The essential factor is that ground water of usable quality is continually moving from the point at which it entered the ground-water body, called the recharge area, to points of discharge, generally at lower elevations, either in stream drainage or through wells.

Recharge is the process by which water is added to an underground water-bearing formation, whether by precipitation on the outcrop of the formation or by seepage losses from surface streams or lakes on the outcrop. Factors that limit the amount of recharge received by a formation are the amount and frequency of precipitation, the area and extent of the outcrop, the topography, the type and amount of vegetation, the condition of the soil in the outcrop area, and the capacity of the formation to accept recharge. Discharge is the process by which water is removed from the formation, either through surface drainage or through wells.

The direction and rate of movement of water through a porous medium, such as an underground geologic formation, is influenced by a variety of factors, which include the nature of the formation itself and the external pressures applied on it as well as the fundamental physical laws of gravity and momentum. These factors include surface tension, friction, atmospheric pressure where the formation encounters the earth's surface, paths of differential permeability, effects of heavy local withdrawals or injection of water, and climatic changes affecting rates of recharge. In north-central Texas, ground-water movement is not constant in either direction or rate. The environment through which it moves is a heterogeneous complex of sedimentary deposits varying in porosity, permeability, and angle of repose. Thus it is not easy, and frequently not even possible in the light of present knowledge, to determine precisely the route water will take from the point of recharge to the points at which it is once again discharged at the ground surface. In the area of this study, however, this route generally is circuitous and probably of relatively short geographic extent. As a consequence, a landowner whether private or public has a particular need for understanding the hydrologic factors affecting the occurrence of ground water. Only by a carefully discriminating study of the geologic environment of his immediate locality can he determine the availability of ground water for beneficial use, or the means required to protect available ground water from pollution.