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GEOLOGY AND GROUND-WATER RESOURCES OF WICHITA AND GREELEY COUNTIES, KANSAS

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GEOLOGY AND GROUND-WATER RESOURCES OF WICHITA AND GREELEY COUNTIES, KANSAS

By Glenn C. Prescott, Jr., John R. Branch, and Woodrow W. Wilson

ABSTRACT

This report describes the geography, geology, and ground-water resources of Wichita and Greeley Counties in western Kansas. The area consists of a flat to gently rolling plain, which slopes eastward [at] about 15 feet per mile. A short reach of Ladder Creek (Beaver) is the only perennially flowing stream in the two counties. Ephemeral streams, which flow only during and after heavy rains, are Whitewoman and Sand Creeks and the western reach of Ladder Creek. The climate is semiarid, the normal annual precipitation being about 17 inches in Wichita County and 16 inches in Greeley County. Agriculture is the principal occupation in the area, and wheat is the most important crop. A considerable area is irrigated; sugar beets and sorghums are the principal irrigated crops.

The outcropping rocks range in age from late Cretaceous to Recent; the Smoky Hill chalk member of the Niobrara formation, which is exposed along Whitewoman Creek in western Greeley County, is the oldest. The Niobrara is almost everywhere overlain by the Ogallala formation of Pliocene age. Generally the Ogallala is overlain by windblown silt of the Pleistocene Sanborn formation, but in places it is exposed along streams. The most recent deposits are dune sand and the alluvium along the streams. The Dakota formation, which is an important aquifer in parts of Kansas, is 300 to 450 feet beneath the Niobrara formation.

The ground water that is available to wells in Wichita and Greeley Counties is derived entirely from precipitation in the area or in areas immediately west and north. Ground water moves in a generally easterly direction with a gradient that varies inversely with the permeability of the water-bearing beds. The ground-water reservoir is recharged principally by precipitation within the area or within adjacent areas. Ground-water discharge takes place principally by pumping from wells, subsurface outflow, and evaporation and transpiration. Most of the domestic, stock, public, and irrigation supplies are obtained from wells. It is estimated that probably more than 2 billion gallons of water is pumped annually from wells in the area. Since 1947, ground-water recharge has been about equal to ground-water discharge.

The use of ground water for irrigation has increased greatly since 1946 and indications are that many more wells may be drilled and pumped without dangerously lowering the water table. Approximately 11,000 to 12,000 acres were irrigated in 1951. A map showing the thickness of water-bearing materials indicates that although much of the area has enough water-bearing material to support irrigation wells, parts of Wichita and Greeley Counties have little or none.

The Ogallala is the principal water-bearing formation in the area. Small amounts of water may also be obtained locally from alluvial deposits and from

cracks in the Niobrara formation. Two deep test wells to the Dakota formation have been drilled but, because of the poor quality of the water, have never been used.

The ground water in Wichita and Greeley Counties, though hard, is suitable for most purposes. Water from the Ogallala is generally high in fluoride and in some cases may be injurious to the teeth of children. Water from the Dakota, though soft, is unfit for irrigation because of a high content of sodium.

The field data upon which most of this report is based are given in tables; they include records of 417 wells, chemical analyses of 31 samples of water, and logs of 57 test holes and wells.

INTRODUCTION

Purpose and Scope of the Investigation

The investigation upon which this report is based is part of a program of ground-water investigations in Kansas begun in 1937 by the United States Geological Survey and the State Geological Survey of Kansas in co-operation with the Division of Water Resources of the Kansas State Board of Agriculture and the Division of Sanitation of the Kansas State Board of Health. The investigation in Wichita and Greeley Counties is similar to studies that have been completed in other counties in Kansas (Fig. 1). The progressive increase in the use of ground water for irrigation in western Kansas has created a need for ground-water studies in order to get an adequate understanding of the quantity and quality of the available supply, the probable safe yield of the ground-water reservoir, and the possibility of developing additional supplies. In order to determine the changes in ground-water storage, systematic measurements of water levels are being made in several wells in Wichita and Greeley Counties. This report gives the results of a study of the geology and ground-water resources of Wichita and Greeley Counties, begun in July 1947.

The investigation was made under the general direction of A. N. Sayre, chief of the Ground Water Branch of the U. S. Geological Survey, and under the immediate supervision of V. C. Fishel, district engineer in charge of ground-water work in Kansas.

Location and Extent of the Area

Greeley County is on the western border of Kansas, midway between the north and south boundaries of the State. Wichita County joins Greeley County on the east. The two counties cover an area of approximately 1,507 square miles and contain all or parts of 45 townships from T. 16 S. to T. 20 S. and from R. 35 W. to R. 43 W., inclusive.

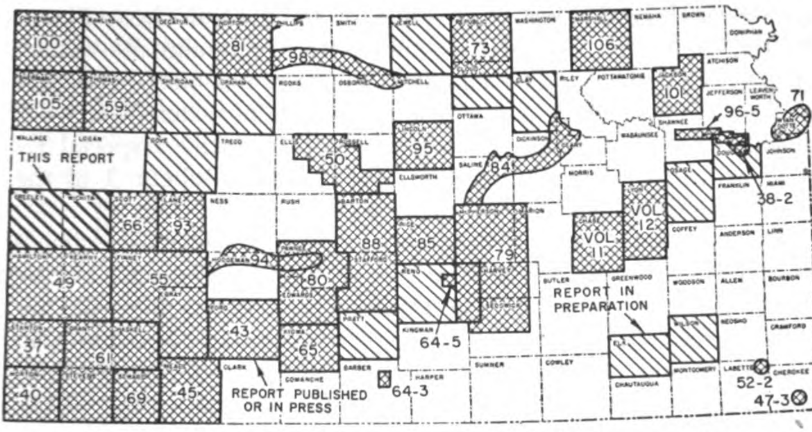

FIG. 1.—Map of Kansas showing area covered by this investigation and other areas for which cooperative ground-water reports have been made or are in preparation.

Previous Investigations

A detailed study of the geology and ground-water resources of Wichita and Greeley Counties has not previously been undertaken, but reference has been made to the geology and ground water of parts of the two counties in several earlier reports. A geologic reconnaissance of southwestern Kansas by Hay (1890) included the southern part of this area although it did not mention Wichita or Greeley County specifically.

In 1897 Haworth described the physiography of western Kansas and discussed the origin of the High Plains. In the same year Haworth (1897a) described the physical properties of Tertiary rocks in western Kansas. Sutton (1897) discussed history and irrigation law, described the State-financed experimental pumping station near Leoti (pp. 32-35), and included logs of two wells drilled at the site and the log of a dry hole drilled near Tribune in an attempt to establish an experimental pumping station in Greeley County. Haworth (1897b) mentioned the Wichita-Greeley area in reference to geology and ground water and included a geologic map of Kansas, geologic cross sections, and a reconnaissance hydrographic map of western Kansas. In 1897 Logan, in a report on the upper Cretaceous of Kansas, mentioned the occurrence of the Niobrara formation in Greeley County.

Johnson (1901, 1902) reported on the utilization of the High Plains, giving special attention to the source, availability, and use of ground water in western Kansas. In a preliminary report on the geology and ground-water resources of the central Great Plains, Darton (1905) briefly discussed the water supply and subsurficial geology of Wichita and Greeley Counties (pp. 300, 321). A report by Parker (1911) included chemical analyses of water from wells at Horace, Tribune, and Leoti. In 1913 (Haworth) a special report on well waters in Kansas was published as Bulletin 1 of the University Geological Survey of Kansas.

An important contribution to western Kansas geology was made by Elias (1931) in a report on the geology of Wallace County, which borders Greeley on the north. This bulletin gives the results of studies of Pleistocene, Pliocene, and Cretaceous deposits in western Kansas. In 1940 Moore and others prepared a generalized report on the ground-water resources of Kansas, and a study of the geology of southwestern Kansas by Smith (1940) was published. Reports by Ver Wiebe (1944, 1947) and Ver Wiebe and others (1948, 1952, 1953) contain paragraphs concerning oil and gas test wells drilled in the counties. In addition, co-operative ground-water reports on near-by counties have been published by the State Geological Survey of Kansas (McLaughlin, 1943; Latta, 1944; Waite, 1947). A significant contribution to Pleistocene geology was made in 1952 by the publication of a report by the State Geological Survey on the Pleistocene geology of Kansas (Frye and Leonard, 1952).

Methods of Investigation

Most of the data for this report were obtained during the summers of 1947 and 1948. Data were obtained on 417 wells, most of which were measured with a steel tape to determine the depth of the well and the depth to water level. Well owners and drillers were interviewed regarding the yield and drawdown of wells and the nature and thickness of water-bearing materials. A few suitable wells were designated as observation wells and periodic measurements have since been made to determine the fluctuations in water level. Pumping tests were made on several irrigation wells to determine the yield and drawdown of the wells and the permeability and transmissibility of the water-bearing strata. Samples of water collected from 29 representative wells, from 1 deep test well, and from Ladder Creek were analyzed for chemical character in the Water and Sewage Laboratory of the Kansas State Board of Health by Howard A. Stoltenberg, chemist.

The field work included the study and mapping of the surficial geology of the area and a geologic map (Pl. 1) was prepared. The character of the material beneath the surface was determined by drilling 50 test holes at selected points through the water-bearing formations to the underlying Niobrara chalky shales. The test holes were drilled with the portable hydraulic-rotary drilling machine (Pl. 3A) owned by the State Geological Survey of Kansas and operated by William T. Connor, Joseph G. Votaw, and Glenn C. Prescott. Samples of the drill cuttings were collected and studied in the field and later examined in the office with a binocular microscope. The altitudes of the land surface at the test holes and of the measuring points of wells were determined by level parties headed by Charles K. Bayne and Woodrow W. Wilson, using a plane table and alidade.

The wells shown on Plates 1 and 2 were located within the sections by use of an odometer. The base map used in these plates was prepared from county maps compiled by the State Highway Commission of Kansas. The drainage shown was adapted from a map issued by the Soil Conservation Service, United States Department of Agriculture.

Well-Numbering System

The well and test-hole numbers used in this report give the location of wells according to General Land Office surveys and in the following sequence: Township, range, section, quarter section or 160-acre tract, 40-acre tract, and 10-acre tract. The 160-acre, 40-acre, and 10-acre tracts are designated a, b, c, or d in a counterclockwise direction starting in the northeast quarter. If two or more wells are located within a 10-acre tract, the wells are numbered serially beginning with the first well measured. An example of this well-numbering system is shown in Figure 2.

Acknowledgments

We are indebted to the many residents of Wichita and Greeley Counties who gave permission to measure their wells and who supplied information regarding them. Special acknowledgment is made to farmers who allowed pumping tests to be made on their irrigation wells. C. W. Hibbard of the University of Michigan spent several days in the field with John Branch in August 1948. Thanks are due Ben Hasz and Kenneth Rutt, well drillers from Scott City and Leoti, respectively, who furnished well logs and other information. The water superintendents of Leoti and Tribune, Fred Mueller and Charles Barnes, respectively, were very co-operative.

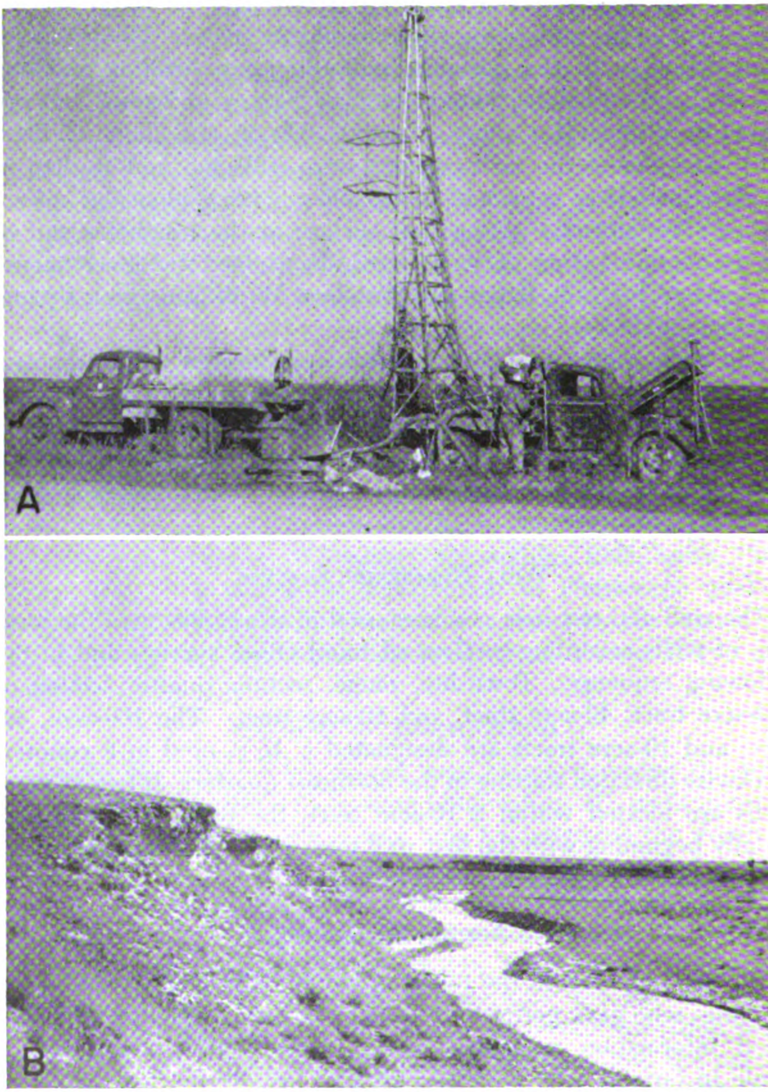

PLATE 3.—**A,** Portable drilling machine owned by the State Geological Survey of Kansas and used in drilling test holes in Wichita and Greeley Counties. **B,** Valley of Whitewoman Creek looking south, SE¼ sec. 22, T. 18 S., R. 38 W., Wichita County. Beds of the Ogallala formation crop out at left.

The manuscript for this report has been reviewed critically by several members of the Federal and State Geological Surveys; by Robert V. Smrha, chief engineer, and George S. Knapp, engineer, of the Division of Water Resources of the Kansas State Board of Agriculture; and by Dwight F. Metzler, director, and Willard O. Hilton, geologist, of the Division of Sanitation of the Kansas State Board of Health. The illustrations were drafted by Woodrow W. Wilson of the Federal Geological Survey.

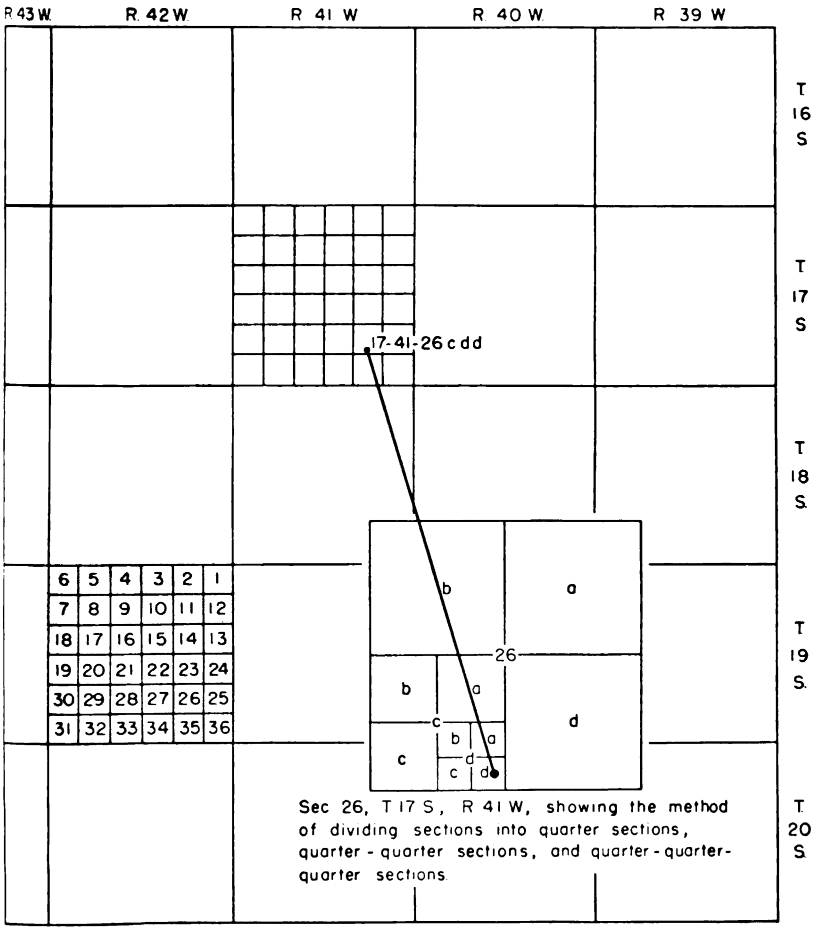

FIG. 2.—Map of Wichita and Greeley Counties illustrating the well-numbering system used in this report.

GEOGRAPHY

Topography and Drainage

Wichita and Greeley Counties lie within the High Plains section of the Great Plains physiographic province. The area consists of flat to gently rolling upland plains that are dissected in several areas by shallow valleys. The plains surface slopes gently eastward at the rate of about 15 feet to the mile from about 3,900 feet near the Colorado border to less than 3,100 feet at several places on the Wichita-Scott County line.

Wichita and Greeley Counties are crossed by Ladder (sometimes called Beaver) and Whitewoman Creeks. Ladder Creek enters from Wallace County and flows eastward near the northern border of Greeley County to the Wichita County line, where it turns and flows southeastward for several miles. Midway across Wichita County, Ladder Creek again flows in a general easterly direction until it reaches a point in Scott County a few miles northwest of Scott City. It then flows northward, joining Smoky Hill River in Logan County. Whitewoman Creek (Pl. 3B) rises in eastern Colorado, flows southeastward across Greeley and Wichita Counties into Scott County, and about 4 miles east of the Scott County line turns northeast, flowing into the Scott Basin, a large depressional area southeast of Scott City. Sand Creek, which rises in southwest Wichita County, parallels Whitewoman Creek across southern Wichita County, joining Whitewoman just east of the Scott County line. With the exception of Ladder Creek downstream from sec. 22, T. 17 S., R. 37 W., where springs provide water for a permanent flow, all streams in Wichita and Greeley Counties are intermittent. They contain flowing water only during and after heavy rains.

Common features of the upland plains in this area are shallow undrained depressions, which range from a few tens of feet to about half a mile in diameter (Pl. 4). After heavy rains many of these depressions become temporary ponds and some of the larger depressions, such as Dead Horse Lake in southwestern Greeley County, contain water for many weeks or months after rains.

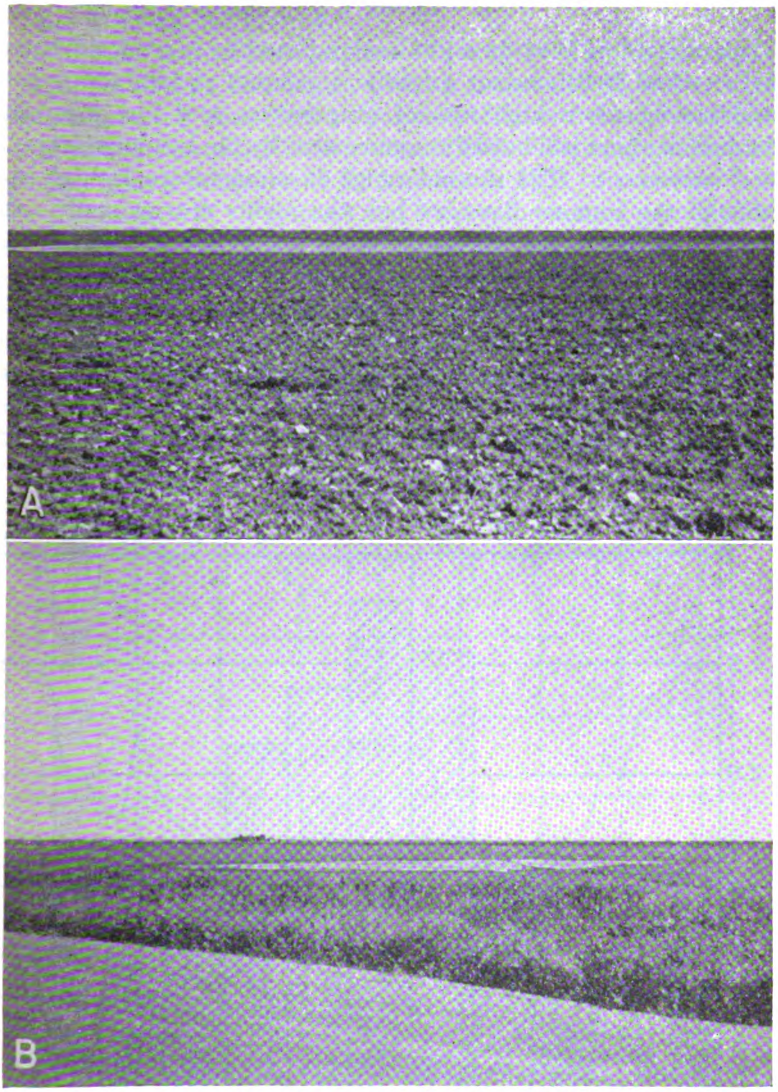

PLATE 4.—Undrained upland depressions. **A,** Undrained upland depression in plowed field in the SE¼ sec. 6, T. 18 S., R. 37 W., Wichita County. View is to the north. **B,** Undrained upland depression in pasture in the SE cor. sec. 18, T. 18 S., R. 35 W., Wichita County. View is to the northwest.

Climate

The climate of Wichita and Greeley Counties is semiarid and is characterized by abundant sunshine, moderate precipitation, good wind movement, a high rate of evaporation, and low humidity. The summer heat is relieved to some extent by the low humidity and wind movement. The diurnal range in temperature is high and although the summer days are hot, the nights are generally cool. As a rule the winters are moderate, there being only occasional short periods of severe cold weather and relatively little snowfall.

The amount of precipitation and its seasonal distribution are the chief limiting factors in crop growth. According to records of the U. S. Weather Bureau, approximately 77 to 78 percent of the annual precipitation falls in the 6 months from April through September when the growing season is at its height and moisture is needed.

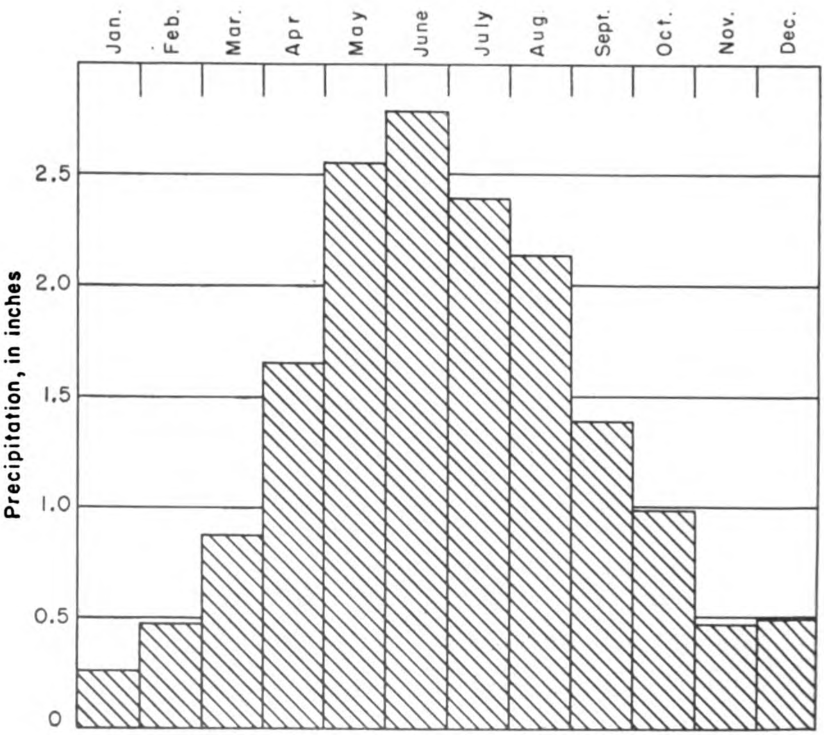

Fig. 3.—Graph showing normal monthly precipitation at Tribune.

The normal monthly precipitation during the period of record at Tribune is shown in Figure 3.

The normal annual precipitation at Leoti, in Wichita County, is 17.31 inches and at Tribune, in Greeley County 16.42 inches. The range at Leoti has been from a minimum of an estimated 7.80 inches in 1911 to a maximum of 29.48 inches in 1923. The range at Tribune has been from a minimum of 7.76 inches in 1934 to a maximum of 33.39 inches in 1915. Figures 4 and 5 show the annual precipitation and the cumulative departure from normal precipitation at Leoti and Tribune, respectively.

The normal annual temperature in the area is about 52.5°F. The lowest temperature on record in the area was -26°F. on January 12, 1912, at Leoti and the highest temperature on record was 111°F.,

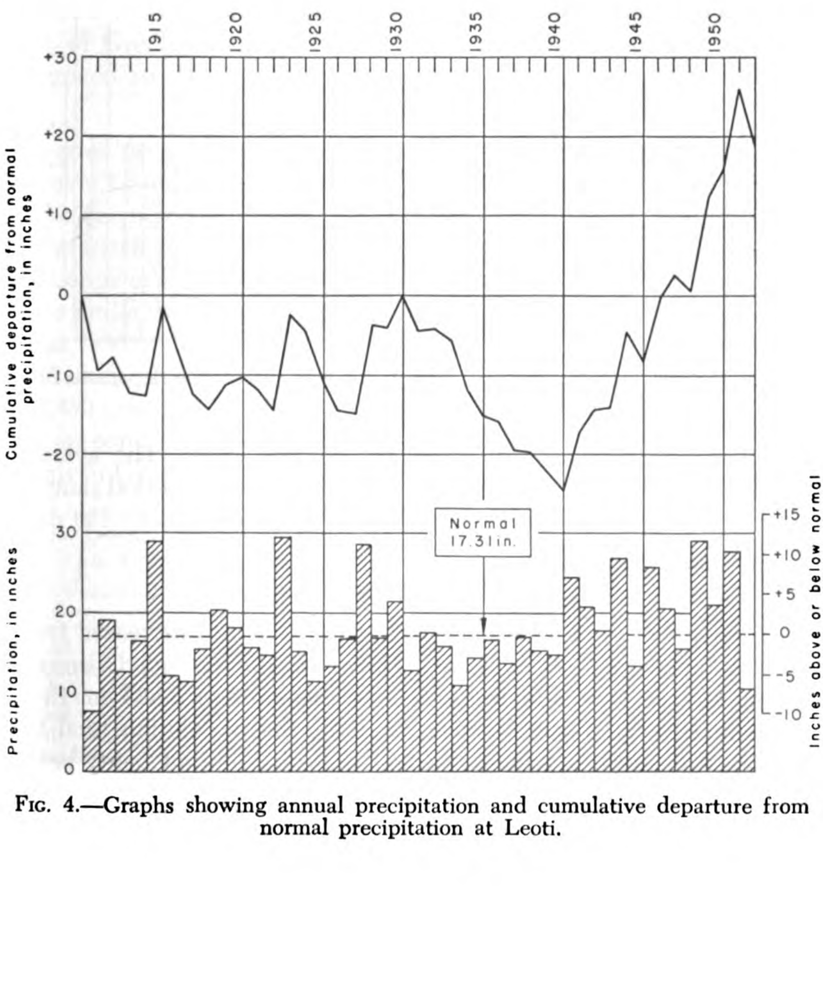

Fig. 4.—Graphs showing annual precipitation and cumulative departure from normal precipitation at Leoti.

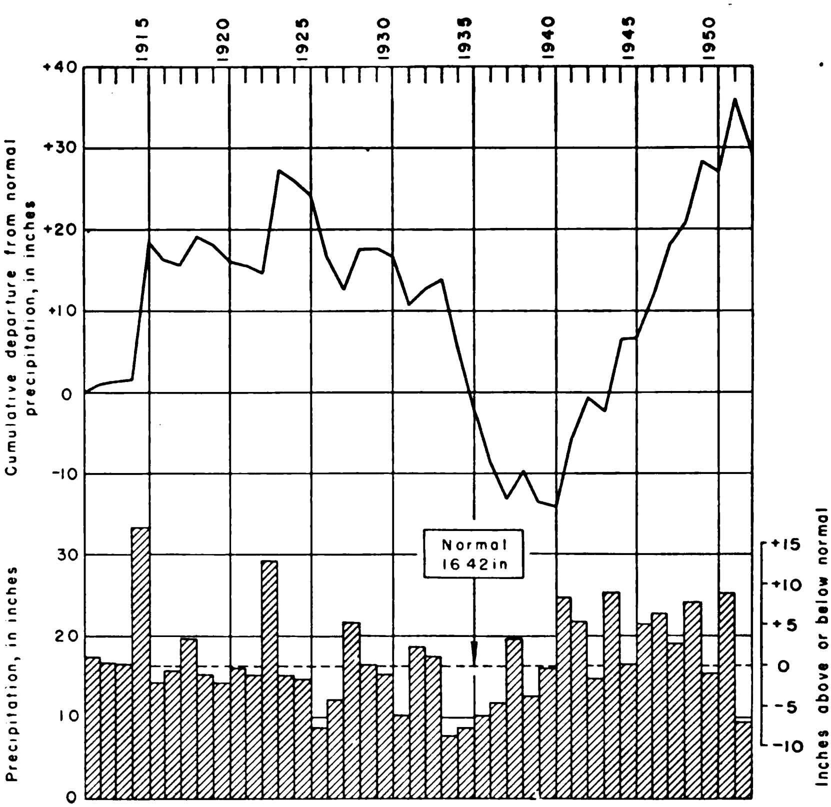

FIG. 5.—Graphs showing annual precipitation and cumulative departure from normal precipitation at Tribune.

which was first recorded at Leoti on July 13, 1934. The average length of the growing season is 162 days, the seasonal period ranging from 129 to 191 days in Wichita County and from 123 to 189 days in Greeley County.

POPULATION

The population of Wichita and Greeley Counties increased from 2,884 in 1920 to 4,291 in 1930. However, the extended drought during the next decade resulted in a decrease to 3,823 in 1940. According to the Federal census of 1950, the population total for the area had increased again to 4,650, that of Wichita County being 2,640 and that of Greeley County, 2,010. The population of Leoti rose from 392 in 1920 to 1,250 in 1950. The population of Tribune rose from 243 in 1920 to 1,010 in 1950. Horace had 212 inhabitants in 1920 and 258 in 1950. Among the 105 counties in Kansas, Wichita County ranks 100th and Greeley County 105th in population.

Transportation

Wichita and Greeley Counties are served by the main line of the Missouri Pacific Railway Company, which crosses from east to west through Leoti and Tribune. The principal hard-surfaced highway is Kansas Highway 96, which runs from east to west through the center of the area parallel to the railroad. Kansas Highway 27 extends from north to south across Greeley County, passing through Tribune. Kansas Highway 25 crosses Wichita County from north to south. From Leoti north to the Logan County line this highway is gravel-surfaced. Wichita and Greeley Counties are fairly well covered by improved section-line roads, except the southwestern part of Greeley County, which is sparsely populated and has few improved roads.

Agriculture

Agriculture is the dominant economic activity in Wichita and Greeley Counties; wheat is by far the most important crop. Other major crops include sorghums and barley (Table 1). The acreage of land irrigated has increased rapidly during the past decade. In 1951 approximately 11,000 to 12,000 acres, mainly in Wichita County, were under irrigation; the chief crops irrigated were sorghums and sugar beets.

Wichita and Greeley Counties have a total land area of about 964,480 acres, virtually all the land being in farms. According to a census conducted by the State Board of Agriculture, there were 110 farms in Greeley County and 297 farms in Wichita County in 1946.

Table 1.—*Acreage of principal crops grown in Wichita and Greeley Counties in 1950* (Kansas State Board of Agriculture, 1950, pp. 231, 363)

Crop	Wichita County	Greeley County
Wheat	121,000	159,000
Sorghums	33,060	34,820
All hay	1,880	160
Barley	870	1,300
Corn	480	20
Sugar beets	250	120
Oats	200	10
Rye	60	90
Total	157,800	195,520

Mineral Resources

Wichita and Greeley Counties have no known mineral resources of great economic value other than good soil and ground water. Sand and gravel deposits in the Ogallala formation and in the alluvium of Whitewoman Creek are worked to some extent for road-surfacing material. Chalk from the Smoky Hill chalk member of the Niobrara formation was formerly taken from a small quarry in sec. 28, T. 17 S., R. 42 W., in Greeley County for building stone. To the end of 1953 nine wildcat wells, six in Wichita County and three in Greeley County, have been drilled in attempts to discover oil or gas, but all have been unsuccessful.

GEOLOGY

Summary of Stratigraphy *

The rocks cropping out in Wichita and Greeley Counties range in age from Late Cretaceous to Recent (Pl. 1). The oldest rocks in the area belong to the Smoky Hill chalk member of the Niobrara formation (Pl. 5A). This formation crops out only in western Greeley County along Whitewoman Creek. The Pierre shale, which overlies the Niobrara formation in some other areas in western Kansas, does not crop out in Wichita and Greeley Counties.

The Ogallala formation of Tertiary (Pliocene) age unconformably overlies the Niobrara throughout these two counties (Pl. 5B). The Ogallala crops out in several places, the best exposures being along Ladder and Whitewoman Creeks. The undissected plains surface in the area is mantled by the wind-blown silt (loess) of the Sanborn formation of late Pleistocene age. Colluvial deposits, derived mainly from loess, cover some of the slopes. A small area several miles north of Horace is mantled by dune sand. The youngest deposits in the area consist of the late Wisconsinan Bignell silt member of the Sanborn formation, dune sand, and alluvium comprising the flood plains of Ladder, Whitewoman, and Sand Creeks.

The character and ground-water supply of the geologic formations are described briefly in Table 2 and in more detail in the section on geologic formations and their water-bearing properties. The stratigraphic relationships of the formations are shown in the geologic cross sections in Figures 6 and 7.

* The geologic classification and nomenclature of this report follow the usage of the State Geological Survey of Kansas and differ somewhat from those used by the U. S. Geological Survey.

Rocks Not Exposed

Directly beneath the Niobrara formation in Wichita and Greeley Counties are 300 to 450 feet of beds consisting mainly of shale and limestone. Included in these beds are the Carlile shale, the Green-

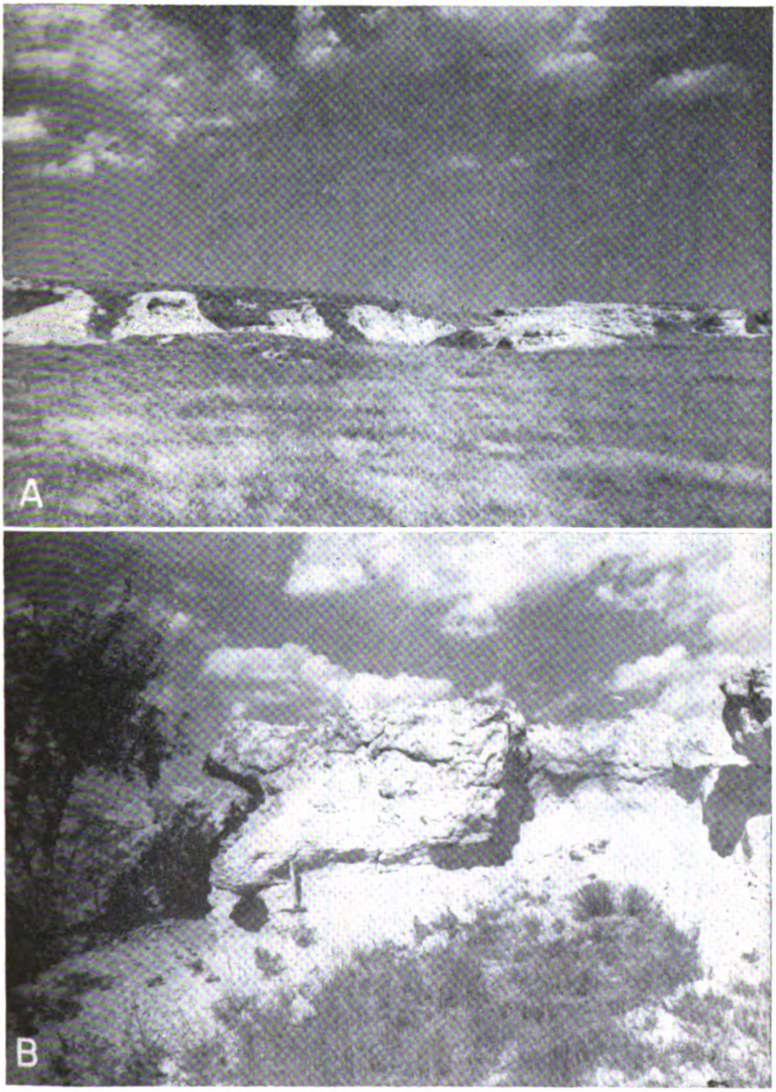

Plate 5.—Cretaceous and Tertiary rocks. **A,** Outcrop of the Smoky Hill chalk member of the Niobrara formation in sec. 28, T. 17 S., R. 42 W., Greeley County. **B,** Cemented bed of the Ogallala formation lying on Smoky Hill chalk in sec. 28, T. 17 S., R. 42 W., Greeley County. The contact is at the midpoint of the hammer handle.

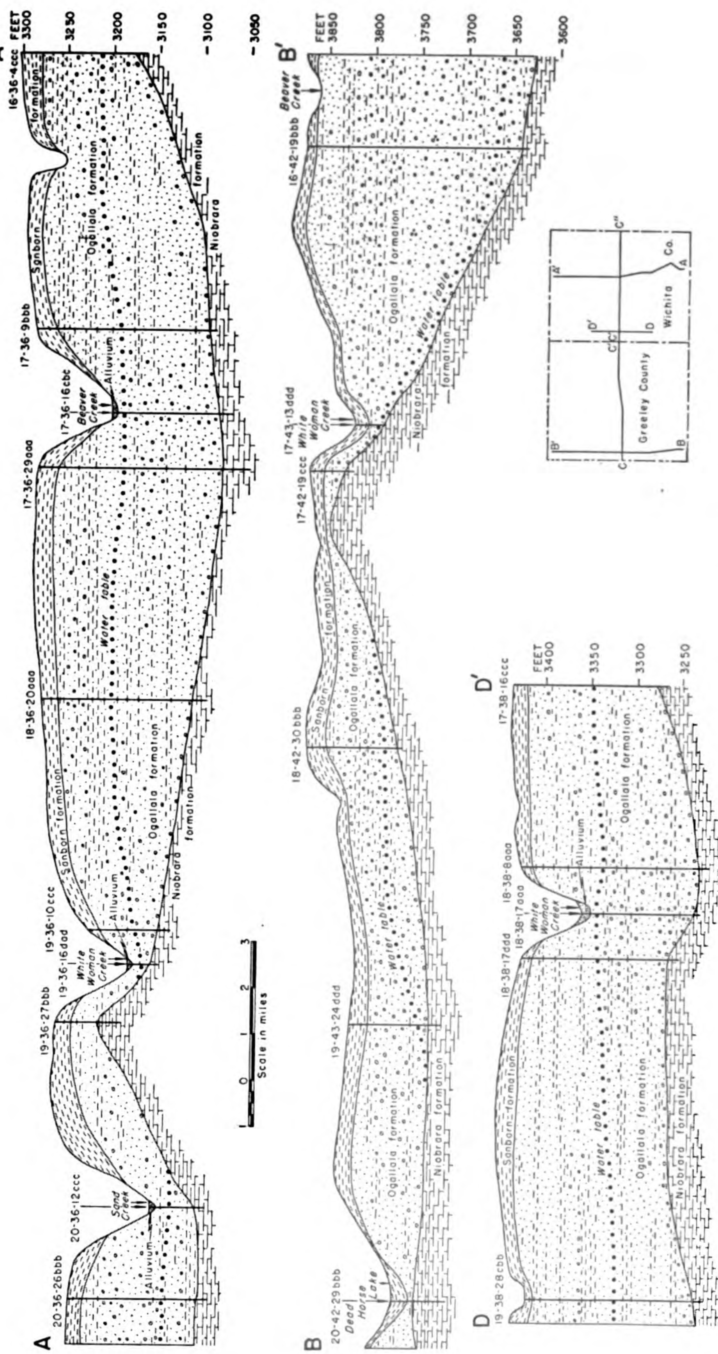

FIG. 6.—Geologic cross sections A-A', B-B', and D-D' through Wichita and Greeley Counties.

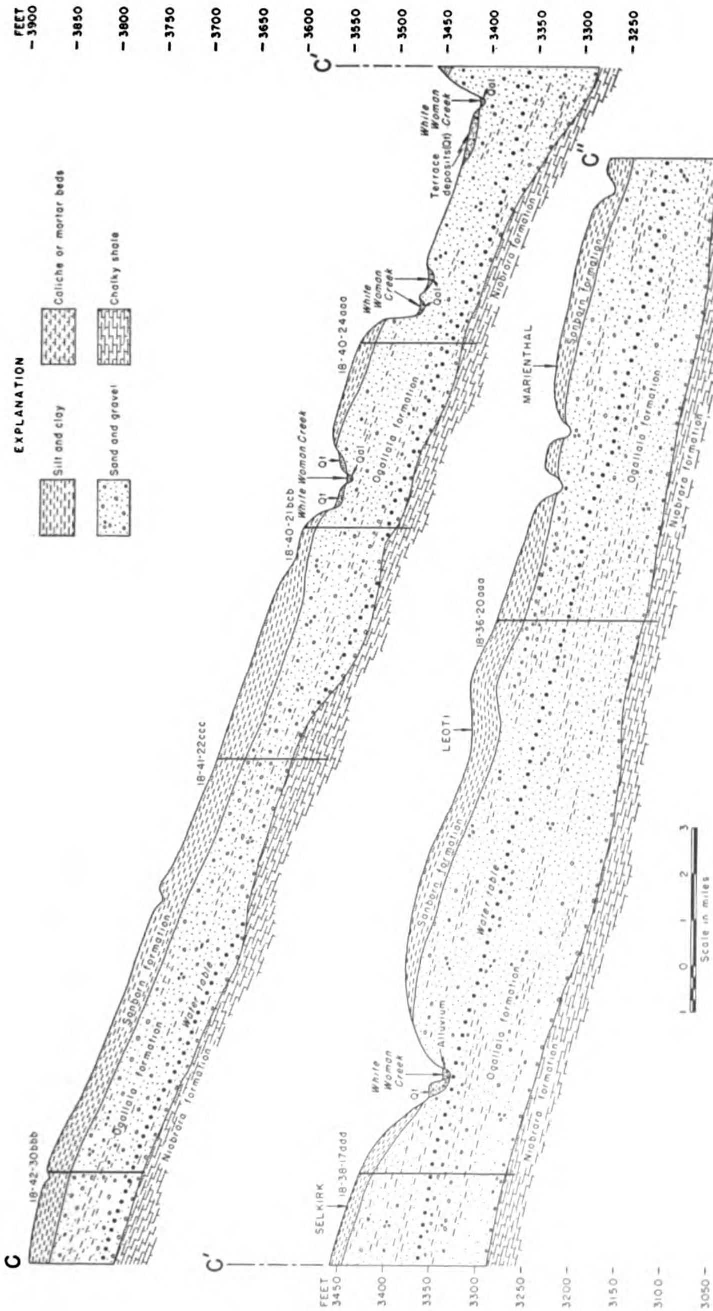

FIG. 7.—Geologic cross sections C-C′ and C′-C″ through Wichita and Greeley Counties.

TABLE 2.—*Generalized section of the geologic formations in Wichita and Greeley Counties, Kansas*

System	Series	Formation	Thickness, feet	Character	Water supply
Quaternary	Pleistocene*	Alluvium (includes terrace remnants)	0–30	Gravel, sand, silt, and clay comprising stream deposits in Ladder, Whitewoman, and Sand Creeks.	Commonly lies mainly above the water table but yields small amounts of water to wells in some areas.
		Dune sand	0–15±	Fine to medium sand. Mantles a very small area about 8 miles north of Horace. Dunes are stabilized by vegetation.	Lies above the water table. Area is too small to constitute an important area for groundwater recharge.
		Sanborn formation (includes colluvium)	0–30	Light-tan silt; locally contains sand and gravel at the base.	Generally lies above the water table and yields no water to wells.
Tertiary	Pliocene	Ogallala formation	0–245	Sand, gravel, and silt, predominantly calcareous; unconsolidated or may be well cemented; contains beds of "Algal limestone," opalized zones, and beds of clay.	The principal aquifer in Wichita and Greeley Counties; yields moderate to large supplies of water to wells in most of the area.
Cretaceous	Gulfian*	Niobrara formation	100–550±	Yellow chalky limestone and light-gray to yellow chalky shale.	Yields little or no water to wells in this area.

* Classification of the State Geological Survey of Kansas.

horn limestone, and the Graneros shale. These formations are generally very poor aquifers and therefore will not be discussed in detail. The Dakota formation underlies the Graneros shale and is an important aquifer in some areas in Kansas. It is discussed in more detail in the section on geologic formations and their water-bearing properties.

GEOMORPHOLOGY

The topography in Wichita and Greeley Counties has developed during Pliocene and Pleistocene times. Near the end of Cretaceous time the sea that had covered the western Kansas area during much of late Cretaceous time withdrew and the area was subjected to subaerial erosion. In early Tertiary time there was extensive uplift in the Rocky Mountain province and streams flowing eastward from this region crossed the Great Plains. While streams from the mountains were laying down extensive deposits to the north, western Kansas was being eroded. Any sediments that may have been deposited in earliest Tertiary time and varying thicknesses of Upper Cretaceous sediments were removed. In these counties the Pierre shale was completely removed and the Niobrara formation was deeply dissected in places. In Pliocene time conditions were reversed and streams from the Rockies deposited large quantities of sediments (Ogallala formation) over the High Plains of Kansas. As deposition progressed and stream valleys were filled and bedrock divides were topped, the streams shifted laterally and developed an extensive aggradational plain, which merged with the erosional plain in the Rocky Mountain region.

Near the end of the time of Ogallala deposition, the lateral shifting of stream channels due to low stream gradients and the choking of the channels with sediments may have resulted in the formation of a number of small water-table lakes. It is thought that the "Algal limestone," a distinctive hard bed of fresh-water limestone, which occurs at the top of the Ogallala formation in many localities, was precipitated in such small lakes by the fossil alga *Chlorellopsis bradleyi*, an alga whose living relatives are not known to precipitate calcium carbonate in running water (Elias, 1931).

In early Pleistocene time there was uplift of the land to the west and streams in western Kansas were rejuvenated. Erosion began and streams started to cut through the Pliocene deposits. The nature of events in this area during this part of the Pleistocene is not known because Nebraskan deposits have not been found. However, it is possible that during late Kansan and early Yarmouthian

PLATE 6.—**A,** Exposure of the Peoria silt member of the Sanborn formation where it is being cut by a tributary to Ladder Creek. View is west from highway 27 at the SE cor. sec. 5, T. 16 S., R. 40 W., Greeley County. **B,** Irrigation well 18-35-34abb, owned by D. J. Hutchins, being pumped at 2,100 gallons a minute.

time there may have been some stream deposition in the Wichita-Greeley area because deposits of the Meade formation have been identified east of this area in Scott County, along Ladder Creek. If sediments of the Meade formation were deposited in Wichita or Greeley Counties they since have been removed by erosion. During Illinoian time there may have been some deposition by streams in the area and some of the beds that have been referred to as basal Sanborn formation (Elias, 1931, p. 163) may be the Crete member of the Sanborn (Frye and Leonard, 1952). Later in the Pleistocene a mantle of wind-blown silt or loess was spread over this region. Three different loess sheets separated by two buried soils indicate that during the period of high winds there were intermediate times when winds were reduced and soils were formed. The oldest silt, the Loveland, was not deposited extensively over Wichita and Greeley Counties and is generally represented only by the buried Sangamon soil which formed on it. The Peoria silt member (Pl. 6A) is widespread in the area and reaches a maximum thickness of nearly 30 feet. The Bignell or upper silt member of the Sanborn is found only in a few scattered localities (Frye and Leonard, 1952). It is separated from the Peoria silt by the Brady soil.

During Recent time the area has undergone erosion which has formed much of its present topography. Streams have cut down through loess deposits into the Ogallala formation and in western Greeley County Whitewoman Creek has cut through the Ogallala into the Niobrara formation. The few small terrace remnants along Ladder, Whitewoman, and Sand Creeks indicate that in latest Pleistocene time these streams began a new cycle of erosion. The loess mantle has been modified by the action of sheet and rill wash, and some slopes are covered by colluvial deposits, derived mainly from loess, that have moved down from the uplands. These slope deposits are in places contiguous with alluvium in the valleys and the boundary between the two may be indistinct. In the upper part of the valley side slopes the colluvial deposits are generally also indistinguishable from the loess of the Sanborn formation.

Since the deposition of the loess many shallow undrained depressions have developed on the uplands in Wichita and Greeley Counties. The depressions range in diameter from a few tens of feet to about half a mile. After a heavy rainfall most of them hold water until it evaporates or moves downward to the water table. Plate 4 illustrates two typical undrained depressions and the locations of many of these depressions are shown on Plate 1 as intermittent ponds. The origin of these ponds has been a subject of much speculation and controversy among geologists working in the Great Plains (Frye, 1950). The depressions in the Wichita-Greeley area have been attributed to differential deposition or erosion of loess by the wind, to compaction and reorientation of silt particles, and perhaps, to a lesser extent, to animal action.

Latest Pleistocene time has been characterized by occasional high winds, as evidenced by a small sand-dune area several miles north of Horace.

GROUND WATER

Principles of Occurrence

The following discussion of the occurrence of ground water has been adapted from Meinzer (1923, pp. 2-102) and the reader is referred to his report for a more complete discussion of the subject.

All water beneath the surface of the earth is termed subsurface water. Below a certain level in the earth's crust the permeable rocks are generally saturated with water. The subsurface water that is in the zone of saturation is called ground water, whereas subsurface water above the zone of saturation is called suspended subsurface water or vadose water. The upper surface of the zone of saturation is the ground-water table or simply the water table. Ground water is the water that is available through wells and springs.

The ground water that is available through wells in Wichita and Greeley Counties is derived entirely from precipitation that falls as rain or snow within the area or in areas immediately to the west and north. Part of the water that falls as rain or snow is carried away by surface runoff and is discharged as stream flow, and part of it evaporates or is absorbed by growing vegetation and transpired into the atmosphere. The part that escapes runoff, evaporation, and transpiration percolates slowly through the soil and underlying strata and eventually joins the body of ground water in the zone of saturation.

The rocks that form the outer crust of the earth are generally not entirely solid but contain numerous open spaces, called voids or interstices. It is in these spaces that water, natural gas, or oil is found. There are many kinds of rocks and they differ greatly in the number, size, shape, and arrangement of their interstices, and hence in their water-bearing properties. The interstices in rocks range in size from microscopic openings to large caverns, which are found in some limestones. The open spaces are generally connected so that water may percolate from one to another, but in some rocks they are isolated and the water has little or no chance to percolate. The mode of occurrence of ground water in any region is determined, therefore, by the geological character of the region.

Hydrologic Properties of the Water-Bearing Materials

POROSITY AND SPECIFIC YIELD

The amount of water that can be stored in a rock depends upon the porosity of the rock. Porosity is expressed quantitatively as the percentage of the total volume of the rock that is occupied by interstices. A rock is said to be saturated when all its interstices are filled with water. The specific yield of a water-bearing formation is defined as the ratio of the volume of water that, after being saturated, the formation will yield by gravity to its own volume. The ratio is usually stated as a percentage. Specific yield is a measure of the yield of a water-bearing material when it is drained by a lowering of the water table.

PERMEABILITY AND TRANSMISSIBILITY

The amount of water a given rock can hold is determined by its porosity, but the rate at which it will transmit water or yield water to wells is determined by its permeability. The permeability of a water-bearing material is defined as its capacity for transmitting water under hydraulic head and is measured by the rate at which the formation will transmit water through a given cross section under a given difference of head per unit of distance. The coefficient of permeability in Meinzer's units may be expressed as the rate of flow of water in gallons a day through a cross-sectional area of 1 square foot under a hydraulic gradient of 100 percent at a temperature of 60° F. (Wenzel, 1942, p. 7). The field coefficient of permeability is the same except that it is not corrected for temperature. A rock containing small interstices may be very porous, but water may pass through it with difficulty, whereas a coarse-grained rock, although perhaps less porous, is generally more permeable and allows water to pass through it more freely because interstices are larger. Part of the water in all rocks is held by the force of molecular attraction, which in fine-grained rocks is great enough to hold most of the water against the force of gravity, thus resulting in a very low specific yield.

Gravel is the best water-bearing material in most of the world. Gravel deposits of uniform texture have high porosity, high permeability, and high specific yield. Sand, clay, or silt mixed with the gravel reduces its porosity, permeability, and specific yield. Sand ranks next to gravel as a water bearer. Sand has smaller interstices, however, and conducts water less readily, giving up a smaller proportion of water to wells. Sand particles, because of their small size, are readily carried into wells by water and may create difficult problems in drilling and pumping. The shale and chalk beds of the Niobrara in places contain water along joints and bedding planes, but they are generally unfavorable materials from which to obtain water. Several common types of open spaces or interstices and the relation of rock texture to porosity are shown in Figure 8.

Most of the ground water pumped in Wichita and Greeley Counties comes from sand and gravel beds in the Ogallala formation. Beds in the Ogallala are in places well cemented or may contain large amounts of fine sand, silt, or clay, but where relatively well-sorted deposits of sand and gravel are entered by wells large amounts of water may be obtained.

The coefficient of transmissibility is a function similar to the coefficient of permeability. It is defined as the number of gallons of water a day transmitted through each 1-foot strip extending the height of the aquifer under a unit gradient at the prevailing temperature of the water. The coefficient of transmissibility also may be expressed as the number of gallons of water a day transmitted through each section 1 mile wide extending the height of the aquifer under a hydraulic gradient of 1 foot per mile. The coefficient of transmissibility is equal to the field coefficient of permeability multiplied by the saturated thickness of the aquifer.

PUMPING TESTS

The permeability and transmissibility of water-bearing materials in Wichita and Greeley Counties were determined by four pumping tests using the recovery method developed by Theis (1935, p. 522) and also described by Wenzel (1942, pp. 94-97). The recovery formula is stated as follows:

$$T = \frac{264\, q \log_{10} t/t'}{s'}$$

in which T = coefficient of transmissibility, in gallons per day per foot

q = pumping rate, in gallons a minute

t = time since pumping began, in minutes

t′ = time since pumping stopped, in minutes

s′ = residual drawdown at the pumped well, in feet, at time t′

The residual drawdown (s′) at any time (t′) after pumping ceases, is computed by subtracting the static water level, extrapolated from the measurements made before pumping began, from the observed water-level measurement made at time t′. The ratio of $\log_{10} t/t'$ to s′ is determined graphically by plotting $\log_{10} t/t'$

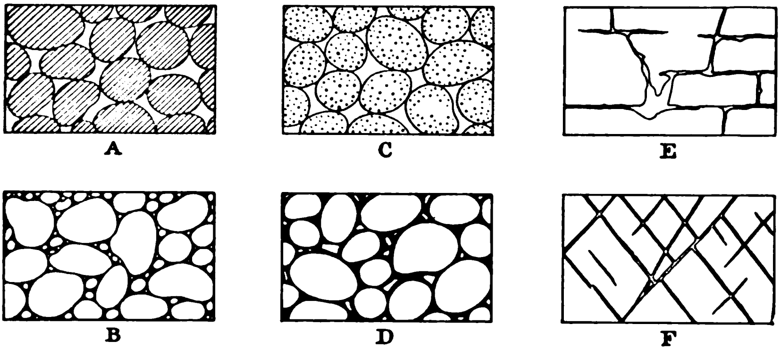

FIG. 8.—Diagram showing several types of rock interstices and the relation of rock texture to porosity. **A**, well-sorted sedimentary deposit having a high porosity; **B**, poorly sorted sedimentary deposit having low porosity; **C**, well-sorted sedimentary deposit consisting of pebbles that are themselves porous so that the deposit as a whole has a very high porosity; **D**, well-sorted sedimentary deposit whose porosity has been diminished by the deposition of mineral matter in the interstices; **E**, rock rendered porous by solution; **F**, rock rendered porous by fracturing. (From O. E. Meinzer.)

against corresponding values of s′. This procedure is simplified by plotting t/t′ on the logarithmic coordinate and s′ on the arithmetic coordinate of semilogarithmic paper (Fig. 9). If $\log_{10}$ t/t′ is taken over one log cycle it will become unity and s′ will be the difference in drawdown over one log cycle.

A pumping test on irrigation well 16-35-20ccc was made on August 17, 1948. The well was pumped for about 3½ hours, during which period the pumping rate (average 850 gallons per minute) and the drawdown were measured frequently. Recovery measurements were made for 2 hours after pumping ceased. The data used in the calculation of the coefficients of transmissibility and permeability are given in Table 3.

The computations are as follows:

$$T = \frac{264 \times 850 \times 1}{2.35} = 96{,}000 \text{ gpd/ft.}$$

$$P = \frac{96{,}000}{76} = 1{,}260 \text{ gpd/ft.}^2$$

The transmissibility is computed to be 96,000 gallons per day per foot, and the permeability, which is determined by dividing the transmissibility by the thickness of the aquifer, 76 feet, is 1,260 gallons per day per square foot.

Tables 4, 5, and 6 contain data for three other pumping tests, and Table 7 summarizes the four tests. Well 18-35-34abb had the largest yield, specific capacity (rate of yield per foot of drawdown), coefficient of transmissibility, and coefficient of permeability.

The Water Table and Movement of Ground Water

The water table is defined as the upper surface of the zone of saturation except where that surface is formed by an impermeable body (Meinzer, 1923a, p. 32). It does not remain stationary but fluctuates according to changes in recharge and discharge, barometric pressure, and other minor conditions.

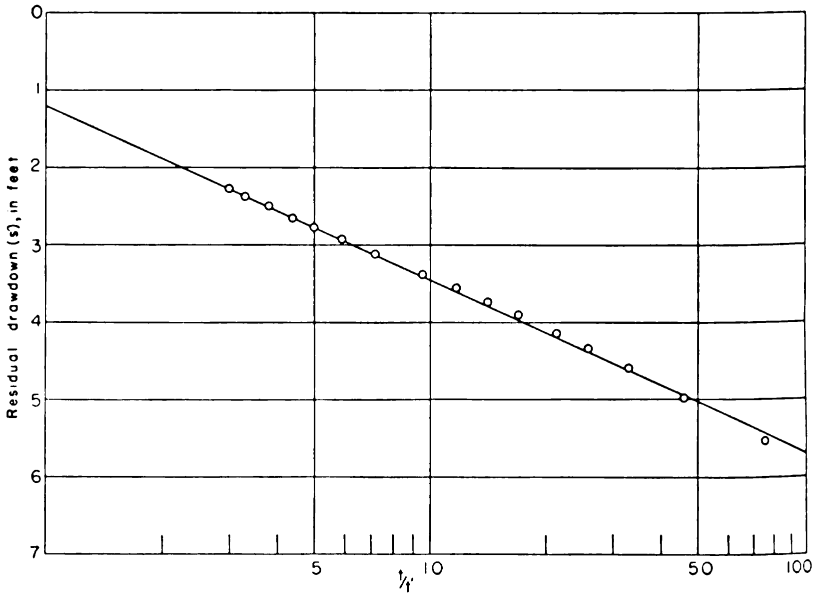

Fig. 9.—Curve for pumping test on well 16-35-20ccc obtained by plotting the residual drawdown against t/t'

TABLE 3.—*Data on pumping test of well 16-35-20ccc, August 17, 1948*

Time since pumping began, minutes (t)	Time since pumping ended, minutes (t′)	t/t′	Yield, gallons per minute	Depth to water level, feet	Drawdown, or residual drawdown, feet
0	....	....	....	110.60	....
25	....	....	810	128.35	17.75
55	....	....	827	128.78	18.18
85	....	....	826	128.98	18.38
115	....	....	819	129.09	18.49
195	....	....	818	129.25	18.65
205	....	....	1,132	134.32	23.72
215	....	....	1,269	....	....
227	3	75.7	....	116.13	5.53
229	5	45.8	....	115.59	4.99
231	7	33.0	....	115.20	4.60
233	9	25.9	....	114.93	4.33
235	11	21.4	....	114.73	4.13
238	14	17.0	....	114.51	3.91
241	17	14.2	....	114.34	3.74
245	21	11.7	....	114.16	3.56
250	26	9.6	....	113.98	3.38
260	36	7.2	....	113.72	3.12
270	46	5.9	....	113.53	2.93
280	56	5.0	....	113.38	2.78
290	66	4.4	....	113.26	2.66
305	81	3.8	....	113.10	2.50
320	96	3.3	....	112.97	2.37
335	111	3.0	....	112.87	2.27

TABLE 4.—*Data on pumping test of well 18-35-34abb, August 13, 1948*

Time since pumping began, minutes (t)	Time since pumping ended, minutes (t′)	t/t′	Yield, gallons per minute	Depth to water level, feet	Drawdown, or residual drawdown, feet
0	....	....	....	89.18	....
40	....	....	1,778	108.50	19.32
75	....	....	1,778	108.50	19.32
120	....	....	1,772	108.10	18.92
195	....	....	1,772	108.20	19.02
210	....	....	2,104	....	....
235	4	58.8	....	92.04	2.86
237	6	39.5	....	91.92	2.74
242	11	22.0	....	91.73	2.55
247	16	15.4	....	91.58	2.40
255	24	10.6	....	91.38	2.20
265	34	7.8	....	91.18	2.00
275	44	6.3	....	91.05	1.87
285	54	5.3	....	90.93	1.75
300	69	4.3	....	90.76	1.58
315	84	3.8	....	90.61	1.43

Table 5.—*Data on pumping test of well 18-35-36bcb, August 12, 1948*

Time since pumping began, minutes (t)	Time since pumping ended, minutes (t′)	t/t′	Yield, gallons per minute	Depth to water level, feet	Drawdown, or residual drawdown, feet
0	....	....	....	81.59	....
15	....	....	1,191	95.50	13.91
45	....	....	1,179	95.30	13.71
75	....	....	1,182	95.20	13.61
105	....	....	1,180	95.05	13.46
135	....	....	1,187	95.50	13.91
195	....	....	1,182	95.60	14.01
202	3	67.3	....	84.50	2.91
204	5	40.8	....	84.15	2.56
206	7	29.4	....	83.97	2.38
215	16	13.4	....	83.65	2.06
218	19	11.5	....	83.55	1.96
221	22	10.0	....	83.50	1.91
226	27	8.4	....	83.41	1.82
236	37	6.4	....	83.31	1.72
253	54	4.7	....	83.12	1.53
280	81	3.5	....	82.97	1.38
310	111	2.8	....	82.80	1.21
432	233	1.8	....	82.48	0.89

Table 6.—*Data on pumping test of well 18-38-31dbc, August 10, 1948*

Time since pumping began, minutes (t)	Time since pumping ended, minutes (t′)	t/t′	Yield, gallons per minute	Depth to water level, feet	Drawdown, or residual drawdown, feet
0	....	....	....	109.89	....
15	....	....	610	125.81	15.92
45	....	....	611	126.48	16.59
75	....	....	611	125.80	15.91
135	....	....	611	126.05	16.16
165	....	....	607	126.03	16.14
195	....	....	604	126.32	16.43
210	....	....	623	....	....
219	4	54.8	....	....	....
223	8	27.9	....	111.75	1.86
225	10	22.5	....	111.66	1.77
227	12	18.9	....	111.56	1.67
231	16	14.4	....	111.42	1.53
236	21	11.2	....	111.27	1.38
245	30	8.2	....	111.14	1.25
255	40	6.4	....	111.03	1.14
272	57	4.8	....	110.90	1.01
290	75	3.9	....	110.77	0.88
315	100	3.2	....	110.60	0.71
345	130	2.6	....	110.45	0.56
375	160	2.3	....	110.31	0.42

TABLE 7.—*Results of pumping tests made in Wichita County, using the Theis recovery method for determining permeability*

Well number	Discharge, gallons a minute	Drawdown, feet	Duration of pumping, minutes	Specific capacity*	Coefficient of transmissibility, gallons a day per foot	Approximate thickness of water-bearing material, feet	Coefficient of permeability, gallons a day per square foot
16–35–20ccc........	850	19	224	45	96,000	76	1,260
18–35–34abb........	1,800	19	231	95	365,000	54	6,800
18–35–36bcb........	1,180	14	192	85	270,000	50	5,400
18–38–31dbc........	610	17	215	33	126,000	38	3,300

* The specific capacity of a well is its rate of yield per unit of drawdown and is determined by dividing the rate of pumping in gallons a minute by the drawdown in feet.

SHAPE AND SLOPE OF THE WATER TABLE

The shape and slope of the water table are shown on Plate 1 by contour lines. Each contour line has been drawn through points on the water table having the same altitude, and collectively they show the configuration of the water surface just as topographic maps show the shape of the land surface. Ground water moves at right angles to the water-table contour lines in the direction of maximum slope.

Plate 1 shows that the ground water is moving through Wichita and Greeley Counties in a general easterly direction. Although the general slope of the water table is the same as the slope of the bedrock surface (Fig. 10), a comparison of the two maps indicates that irregularities in the bedrock floor are not reflected in the water table. Also, the water table is not a reflection of the surface topography. It is thought that in its eastern reach in Wichita County, Ladder Creek is a gaining stream; that is, it receives water from the ground-water body. However, the stream and the water table are apparently in approximate equilibrium, because on Plate 1 the contour lines cross the stream with little or no change in direction. If Ladder Creek were obtaining an appreciable amount of water from the ground-water body, the contour lines would have an upstream flexure, which would indicate that water was moving into the creek. Other factors that sometimes affect the shape of the water table are: pumping from wells, which may cause local depression; unequal additions to the ground-water body at different places; and recharge to the ground-water body by ephemeral streams. In this area, pumping of wells has as yet caused only local or temporary irregularities in the water table. Any effects of pumping are more than balanced by the slight general rise in the water table that has occurred since 1947. Also, the measurements given in Plate 1 are not for any particular month, time of year, or year, but were made irregularly during the period 1947 to 1951. It is obvious that any irregularities caused by pumping would not be evident. For the same reason, effects of unequal recharge at different places and recharge from ephemeral streams probably would not be apparent. A large amount of ground-water recharge undoubtedly takes place through the sandy bottoms of Whitewoman and Sand Creeks but the irregularities caused by such recharge would be only temporary and would not show up on a generalized map such as Plate 1.

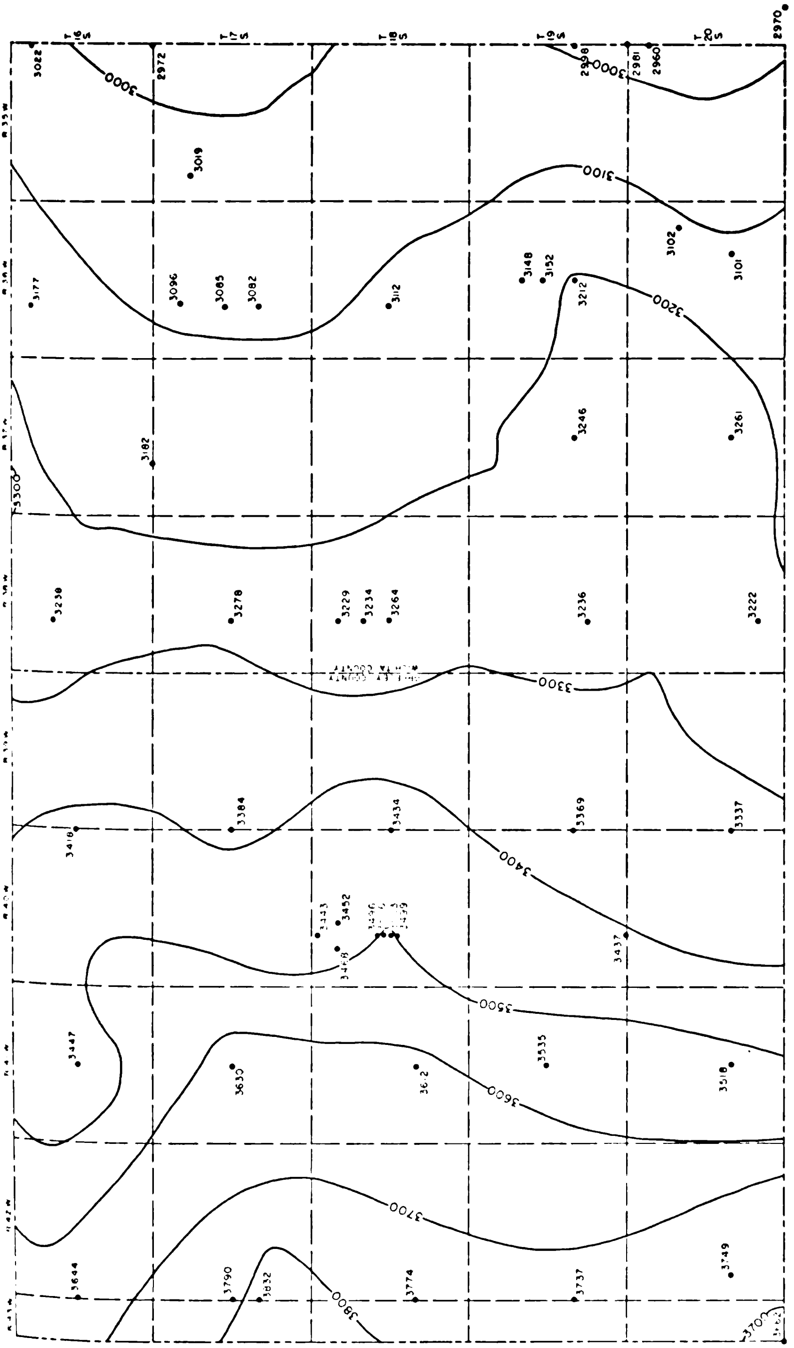

FIG. 10.—Map of Wichita and Greeley Counties showing the configuration of the bedrock surface beneath the Pliocene and Pleistocene deposits.

Differences in the permeability and thickness of the water-bearing beds probably cause the principal irregularities in the water table in Wichita and Greeley Counties. In general the slope of the water table varies inversely with the permeability of the water-bearing material. In areas where the water-bearing beds are relatively impermeable the slope of the water table steepens, but in areas where the beds are permeable, the water-table contour lines are farther apart. The permeability of the Ogallala formation is extremely variable because of changes in lithologic character from one place to another, and consequently the flow of ground water varies from place to place.

In parts of Wichita and Greeley Counties, especially in Greeley County, the water-table contour lines are dashed. In such areas there is little or no water-bearing material and the water table is thought to be discontinuous. Although wells of small capacity can be obtained locally in areas of discontinuous water table from the deposits along Whitewoman Creek, from the Ogallala formation, or possibly from cracks or crevices in the Niobrara formation, wells drilled in these areas will commonly be practically dry.

FLUCTUATIONS IN THE WATER TABLE

The water table is not a static surface but one that fluctuates much like the water surface in a lake. Its fluctuations are due principally to changes in recharge and discharge of the ground-water reservoir and to barometric fluctuations. If the amount of ground-water recharge exceeds the discharge the water level will rise and, conversely, if the discharge exceeds the recharge the water table will decline. Thus, changes in water levels in wells indicate to what extent the ground-water supply is being depleted or replenished.

The main factors controlling the rise of the water table in Wichita and Greeley Counties are precipitation that penetrates the ground and reaches the zone of saturation, seepage from streams and undrained depressions, and ground water that enters the area from the west and north. Factors controlling the decline of the water table are pumpage from wells, flow from springs and seeps, evaporation and transpiration, and eastward movement of ground water from the area. The factors that cause the water table to rise are discussed in the section on ground-water recharge and those that cause it to decline are discussed in the section on ground-water discharge.

In the summer of 1947, 13 wells in Wichita County and 12 wells in Greeley County were selected as observation wells to obtain information concerning fluctuations of the water table. Since that time periodic measurement of the water level in some of these wells has been made by Howard Corrigan of the Division of Water Resources of the Kansas State Board of Agriculture. Water-level measurements made in 1947 and 1948 have been published in U. S. Geological Survey Water-Supply Paper 1128. Later measurements will be published in subsequent water-supply papers.

Apparently ground-water discharge and ground-water recharge have been about equal since 1947 because the present water level is essentially the same as the water level in 1947. The water-level measurements in wells that are still being measured (some have been discontinued) are given in Table 14.

Ground-Water Recharge

Recharge is the addition of water to the ground-water reservoir and may be accomplished in several ways. All ground water available to wells in Wichita and Greeley Counties is derived from precipitation falling as rain or snow within the area or in near-by areas to the west and north. Part of the water that falls as precipitation is carried away by surface runoff, part evaporates, and some is absorbed by plants and returned to the atmosphere as water vapor by the process known as transpiration. Water that escapes runoff, evaporation, and transpiration percolates slowly down through the soil and underlying strata, and eventually reaches the zone of saturation.

The quantity of water that is carried away by surface runoff depends upon several factors: the intensity of the rainfall, the slope of the land, the type of soil, the kind and amount of vegetation, and the time of year.

More of the rainfall enters the ground during a long gentle rain than during a torrential downpour, when the percentage of runoff is large. The slope of the land is an important factor in determining runoff; the steeper the slope, the greater will be the amount of runoff. In general, runoff is greater in tightly compacted, fine-grained soil than in loose, sandy soil. Runoff is greater in winter when frozen ground prevents infiltration. A suitable vegetative cover will reduce the velocity of surface runoff and afford a better opportunity for water to seep into the soil.

The amount of water from precipitation that is lost by runoff in the Wichita-Greeley area is very small. Although rains are usually torrential and the soil is only moderately permeable, most of the slopes are gentle to moderate and much of the area is poorly drained.

According to Fishel (1952, p. 58) the annual runoff in Pawnee Valley in Ness and Hodgeman Counties, where the average annual precipitation is about 22 inches, is only 0.3 inch. In Cheyenne County, Kansas, the runoff from the area drained by South Fork Republican River is 0.68 inch (Prescott, 1953, p. 33). The runoff in the Wichita-Greeley area is probably less than the runoff in either the Pawnee Valley or the valley of South Fork Republican River in Cheyenne County.

Most of the water that reaches the land surface as precipitation never reaches the water table, however, because it is lost by evaporation and transpiration at the surface. A large percentage of the precipitation falls during the period from April through September when the temperature is high, the humidity is low, the wind movement is large, and, consequently, the rate of evaporation is high. According to the 32-year record at the Tribune Experiment Station, the average rate of evaporation from a free water surface during the months of the growing season is: April, 7.04 inches; May, 9.13 inches; June, 11.05 inches; July, 12.85 inches; August, 11.38 inches; and September, 8.56 inches (U. S. Weather Bureau, 1950, p. 4). The opportunity for evaporation greatly exceeds the amount of precipitation and thus much of the annual precipitation in the area is lost by evaporation.

During the growing season the amount of water absorbed by plants and transpired to the atmosphere as water vapor is large. The quantity of water lost by transpiration varies widely with different species of plants. The use of water by plants can be shown by stating the quantity of water consumed to produce a unit weight of plant matter. This quantity is designated the transpiration ratio. The transpiration ratios, in pounds of water per pound of dry matter, for a number of plants common in the Wichita-Greeley area are: wheat, 375; alfalfa, 829; buffalo grass, 308; and sunflower, 577 (Foster, 1948, p. 286).

The water that escapes runoff, evaporation, and transpiration percolates through the soil zone into the unsaturated material above the water table. When it reaches an amount greater than can be held by the capillary force opposing the pull of gravity, the excess water moves to the saturated zone. Such recharge is slight during the growing season. During the fall and winter, however, when evaporation and transpiration are at a minimum, recharge to the water table may be substantial if precipitation is sufficient and soil conditions are favorable.

Although the normal annual precipitation in Wichita and Greeley Counties is from 16 to 17 inches, probably only about one-tenth of an inch, or about 2.7 billion gallons, reaches the water table in the average year.

STREAMS

One of the principal sources of ground-water recharge in Wichita and Greeley Counties is the water lost from streams. With the exception of the eastern part of Ladder Creek in Wicihta County, all streams in the area flow only after periods of heavy rainfall. The alluvium in the valleys of Whitewoman, Ladder, and Sand Creeks is rather permeable and during periods of stream flow much water probably percolates down through the alluvium and reaches the body of ground water.

In August 1948 Branch observed the advance of water in the dry bed of Whitewoman Creek in the NW¼ sec. 23, T. 18 S., R. 38 W., approximately 26 miles from the Scott County line, after a storm that had occurred about 12 hours previously in the headwater area. As the water advanced, part of it sank immediately into the alluvial sand and gravel, resulting in the continuous displacement of air bubbles from the alluvium. The flow of water, which was about a foot deep, did not reach the Scott County line. It is probable that much of this water recharged the ground-water body.

SUBSURFACE MOVEMENT FROM ADJACENT AREAS

The water-table contour lines on Plate 1 indicate that ground water moves into the Wichita-Greeley area from the west and northwest. Calculations using Darcy's law for the movement of ground water indicate that approximately 1.8 billion gallons of water is added annually to the available supply of ground water by subsurface inflow. This represents a large part of the total annual recharge to the ground-water reservoir in Wichita and Greeley Counties.

IRRIGATION WATER

In areas that are irrigated extensively, ground-water recharge occurs by seepage from ditches and by downward percolation after the water has been spread on the fields. Probably very little recharge is derived from irrigation water in Wichita and Greeley Counties because of the rather impermeable loess cover, which retards downward seepage of water and thus increases the opportunity for evaporation and transpiration.

Ground-Water Discharge

Meinzer (1923a, p. 48) divided the discharge of subsurface water into vadose-water discharge, which is discharge of soil water not derived from the zone of saturation, and ground-water discharge or discharge from the saturated zone. Ground-water discharge takes place through evaporation and transpiration, through wells and springs, by seepage into streams, and by underground movement to adjacent areas.

TRANSPIRATION AND EVAPORATION

Water may be taken into the roots of plants directly from the zone of saturation and may be discharged from the plants by transpiration. The depth to which the roots of plants go for water varies with different kinds of plants and types of soil. Ordinary plants and grasses do not draw water from depths of more than a few feet, but alfalfa may obtain water from 20 or 30 feet below the surface—more, in places, and certain desert plants have been known to send their roots 50 or 60 feet to reach the water table (Meinzer, 1923, pp. 82-83).

In most of Wichita and Greeley Counties the water level is considerably below the root tips of plants. However, in certain areas along Whitewoman, Ladder, and Sand Creeks (Pl. 2) the water table is not far below the surface of the ground and plants may draw water directly from the ground-water body. Direct evaporation from the water table also is restricted to these areas.

SPRINGS AND SEEPS

The amount of water discharged from springs in Wichita and Greeley Counties is negligible. During the course of the investigation the only spring observed was along Ladder Creek in the SW¼ NE¼ sec. 23, T. 17 S., R. 37 W. However, it is probable that there are other springs on Ladder Creek between this point and the Scott County line.

Discharge by seepage into streams in Wichita and Greeley Counties is also negligible and is restricted to the eastern reach of Ladder Creek in Wichita County. This part of Ladder Creek is generally in equilibrium but at times receives water from the ground-water reservoir and at other times gives water to it. Its western reaches in western Wichita County and in Greeley County and Whitewoman and Sand Creeks lie entirely above the water table and therefore receive no water from the ground-water body.

WELLS

The discharge of water from wells is one of the most important methods of ground-water discharge in Wichita and Greeley Counties. Large amounts of water are pumped from irrigation wells in addition to that from public-supply, domestic, and stock wells. It is estimated that more than 2 billion gallons a year is pumped from wells, although this figure may vary considerably with precipitation, which affects the amount of water needed for irrigation.

SUBSURFACE MOVEMENT TO ADJACENT AREAS

As indicated by the water-table contour lines (Pl. 1), ground water leaves the area by subsurface flow, principally to the east. It is thought that this constitutes the principal means of ground-water discharge in the Wichita-Greeley area. Roughly 2.5 billion gallons of water leaves the area annually by this method. This outflow contributes a considerable amount of the water that is pumped for irrigation in Scott County.

Recovery of Ground Water

PRINCIPLES OF RECOVERY

When water is standing in a well there is equilibrium between the pressure of water within the well and the pressure of the water outside the well. When water is pumped from a well the pressure inside the well is reduced and water moves into the well from the surrounding aquifer. When water is being discharged from a well the water table in the vicinity of the well is lowered to form a depression somewhat resembling an inverted cone. This depression of the water table is known as the cone of depression and the distance that the water level is lowered at the well is called the drawdown (Fig. 11). The greater the pumping rate in a well, the greater is the drawdown. When pumping stops, the cone gradually fills with water from adjacent areas until equilibrium is again reached.

The capacity of a well can be defined as the maximum rate at which it will yield water after the pumping water level becomes approximately stabilized. The capacity depends on the quantity of water available, the thickness and permeability of the aquifer, and the construction and condition of the well itself. The capacity of a well is generally expressed in gallons a minute. The specific capacity of a well is its rate of yield per unit of drawdown and is determined by dividing the capacity in gallons a minute by the drawdown in feet.

When a well is pumped the water level drops rapidly at first, then more slowly, and it may continue to decline for several hours or days. When pumping ceases the water level rises rapidly at first, then more slowly, and it may continue to rise long after pumping has stopped.

DUG WELLS

Dug wells are wells that have been excavated, usually with pick and shovel. Because of their large diameter, generally 3 to 4 feet, they have a large storage capacity. Those in Wichita and Greeley Counties are cased with rock, iron, steel, or concrete, or are uncased. There are very few dug wells in these two counties, however, and most of these are in rather poor water-bearing material, in areas where the ground-water supply is not plentiful.

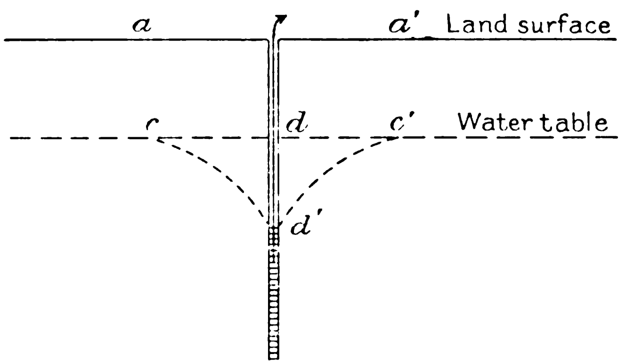

FIG. 11.—Diagrammatic section of a well that is being pumped.

DRIVEN WELLS

Driven wells are generally constructed by driving a 1¼- to 1½-inch pipe (equipped at the bottom with a screened drive point) below the water table. Included in the well inventory is only one of this type, well 20-37-13add, which is a stock well located in a small draw in southern Wichita County. This well was dug to about 16 feet, slightly below the water table, and a sand point is reported to have been driven from that depth to 24 feet in unconsolidated sand of the Ogallala formation.

DRILLED WELLS

Most of the wells in Wichita and Greeley Counties have been drilled by either a cable-tool or a hydraulic-rotary drill. The cable-tool method has been used in the drilling of most of the domestic and stock wells and the hydraulic-rotary method in drilling most of the large-diameter wells such as irrigation and public-supply wells. In the cable-tool or percussion method, a portable cable-tool drill mounted on a truck or trailer is used. Drilling is done by the alternate lifting and dropping of a heavy bit to produce a cutting action at the bottom of the hole. The crushed material in the hole is mixed with water added during the drilling and removed by a bailer or sand bucket. In the hydraulic-rotary method a hollow drill stem equipped with a cutting bit is rotated in the hole and cuttings are removed by circulating muddy water under high pressure down through the stem and up through the annular space between the drill stem and the hole. The cuttings are brought to the surface as fragments suspended in the mud. The mud serves also to plaster the walls of the hole, thereby preventing caving until casing is installed. In the reverse-rotary method, which is sometimes employed in the drilling of large-diameter wells, the direction of flow of water is reversed, and cuttings are carried up through the drill stem and discharged into a pit at the surface.

Most of the drilled wells in Wichita and Greeley Counties obtain water from unconsolidated or only partly consolidated deposits of the Ogallala formation. Wells in these deposits are generally cased to the bottom, to prevent caving of the walls, with galvanized iron, steel, or iron casing. In some wells the water may enter only through the open end of the casing, but in most wells the casing below the water table is perforated or a well screen is used to increase the intake area. The selection of the proper size of perforations is important in the construction of a well and may determine the capacity and life of a well. If the perforations are too large, fine material may filter through and fill the well; if the perforations are too small they may become clogged and prevent the free entrance of water. Commonly a slot size that will pass from 30 to 60 percent, by size, of the water-bearing material is selected. The coarser particles remaining around the screen form a natural gravel packing, which increases the effective diameter and therefore the capacity of the well.

Many of the wells of large diameter, such as municipal and irrigation wells, that have been drilled in the last several years are gravel packed. In constructing a well of this type in the Wichita-Greeley area, a hole of large diameter (about 30 inches) is first drilled and temporarily cased with blank casing. A well screen or perforated casing is centered opposite the water-bearing beds and enough unperforated casing, generally 16 to 18 inches in diameter, to reach the surface is added. The space between the two casings is filled with sorted gravel of a grain size slightly larger than the openings in the screen or perforated casing, and also slightly larger than that of the water-bearing material. The outer casing is then withdrawn to uncover the screen and to allow the flow of water from the water-bearing material through the gravel packing. The envelope of well-sorted gravel that surrounds the well increases the effective diameter of the well and decreases the velocity of water leaving the formation. This reduction in velocity reduces the movement of fine sand into the well. The friction of water entering the well is reduced and the drawdown and consequently the cost of pumping are reduced. If the water-bearing formation contains sufficient coarse material, the addition of a gravel pack around the screen may not increase the yield of a well appreciably.

For more details on the drilling and development of wells the reader is referred to reports by Bennison (1947), Rohwer (1940), and Davison (1939).

METHODS OF LIFTS AND TYPES OF PUMPS

Most domestic and stock wells in Wichita and Greeley Counties are equipped with cylinder pumps which are operated by windmills, electricity, or gasoline engines, or in a few cases by hand. Most of the cylinder pumps have the cylinder or working barrel below the water level and are of the lift type which discharges water at the surface or to near-by elevated storage tanks. A few wells are equipped with jet pumps, which use a stream of water under pressure to raise the water.

Most of the irrigation wells in the area are equipped with vertical turbine pumps operated by gasoline, diesel-fuel, or butane-gas engines or by electricity (Pl. 6b). One irrigation well inventoried is equipped with a vertical centrifugal pump. The municipal wells at Leoti, Tribune, and Horace have vertical turbines powered by electricity.

UTILIZATION OF GROUND WATER

During the course of the investigation information on 417 wells in the Wichita-Greeley area was obtained. Most of the irrigation wells and all the public-supply and industrial wells in the area were visited, and all available data concerning them were collected. Records of wells are listed in Tables 15 and 16. The principal uses of water are described below.

DOMESTIC AND STOCK SUPPLIES

All domestic supplies in the rural areas and in the towns of Selkirk, Coronado, and Marienthal in Wichita County, and in Whitelaw in Greeley County, which have no municipal water supplies, are obtained from wells. Most of the water used by livestock also comes from wells, although small amounts may be obtained from undrained depressions, stock ponds, or creeks. Ground water in both counties is moderately hard but is satisfactory for most domestic and stock purposes.

PUBLIC SUPPLIES

At Leoti in Wichita County and at Tribune and Horace in Greeley County public supplies are obtained from wells.

Leoti.—Leoti, the county seat of Wichita County, obtains its water supply from three wells (18-37-13cca, 18-37-13dca1, and 18-37-13dca2), all of which are within the city limits and derive their water from the Ogallala formation. Well 18-37-13dca1 is reported to be about 166 feet deep and its depth to water on August 24, 1948, was measured to be 71.05 feet. Well 18-37-13dca2 is reported to be 162 feet deep and its water level was measured at 71.94 feet on the same day. Both wells have 12-inch steel casing and are pumped by electrically driven vertical turbine pumps. Well 18-37-13cca was drilled in the fall of 1950. It is 170 feet deep, has 12-inch steel casing, and its depth to water is 73 feet. During a pumping test in November 1950 the well was pumped at about 700 gallons a minute. (The log of this well is included at the end of this report.) The pumps deliver water from the 3 wells directly into the mains, the excess being stored in a 50,000-gallon elevated tank. In 1948 the average daily consumption of water in Leoti was 150,000 gallons. The water is of good quality and is not treated.

Tribune.—Prior to the fall of 1949, Tribune, the county seat of Greeley County, obtained its water from four wells within the city limits. These wells, which had yields ranging from 30 to 60 gallons a minute, did not furnish an adequate supply for the city. In 1949 a well (18-40-5dad) was drilled 3 miles north of Tribune and was tested at a maximum yield of 450 gallons a minute. This well is reported to be 192 feet deep and to have a static water level of about 128 feet; it has an 18-inch steel casing. In 1950 it was used exclusively to supply the water for Tribune. However, well 18-40-29aca was maintained in readiness to be used as a standby in case of an emergency. Data on wells 18-40-5dad and 18-40-29aca are given in Table 16. The Tribune municipal wells pump directly into the mains, the excess going to a 50,000-gallon elevated storage tank. The water is not treated.

Horace.—Horace obtains its water from two wells located about 2 miles north of the town. Well 18-40-7cbb is an 80-foot dug well, about 12 feet in diameter and cased with concrete; it has a static water level of about 60 feet. Well 18-40-7cbc, also reported to be about 80 feet deep, is a drilled well and is cased with 10-inch steel casing. The yields of these wells are reported as 50 and 30 gallons a minute respectively. Water is piped from the wells to the mains in town and the excess water is stored in an elevated wooden tank having a capacity of 65,000 gallons. The water is not treated.

INDUSTRIAL SUPPLIES

At present ground water is not used for industrial purposes in Wichita and Greeley Counties. Until about 1949, wells 18-38-20acc and 18-38-20acd at the town of Selkirk were used by the Missouri Pacific Railroad to fill the boilers of steam locomotives. During 1949 the railroad converted to diesel engines. The wells were sold and are now used for irrigation.

In 1901 the Missouri Pacific Railroad drilled a 1,370-foot test hole to the Dakota formation in an attempt to obtain sufficient water at Horace. Failure to do so was instrumental in transferring the railroad shops from Horace at that time. The driller's log of this well is included at the end of this report.

IRRIGATION SUPPLIES

According to the 1940 Federal census, 256 acres of crop land were irrigated by 8 wells and harvested in Wichita County in 1939; no acreage was irrigated in Greeley County. During the next 10 years, however, especially from 1946 to 1950, irrigation in Wichita and Greeley Counties increased considerably. In the summers of 1947 and 1948 when most of the field work of this investigation was done, information was obtained on 30 irrigation wells, 28 in Wichita County and 2 in Greeley County. By the end of 1951 a further, though incomplete, inventory showed a total of 66 irrigation wells in Wichita County and 7 in Greeley County. The acreage under irrigation is not known definitely but is probably between 10,000 and 12,000 acres in Wichita County and from 1,000 to 1,500 acres in Greeley County.

The amount of water pumped annually for irrigation is not known, but probably it is somewhat less than 1 acre-foot per irrigated acre.

The yields of 12 irrigation wells were tested during the summer of 1948. Average yields ranged from 370 to 1,800 gallons a minute. Only one well tested had a yield of less than 500 gallons a minute. Well 18-35-34abb was pumped at about 1,800 gallons a minute for 3¼ hours, at the end of which time the drawdown was 19 feet. Before the test ended the pumping rate was increased to 2,100 gallons a minute for half an hour. No measurement of drawdown was made at this rate of pumping.

Of the wells tested, drawdowns ranged from 14 to 44 feet and specific capacities ranged from 19 to 95 gallons a minute per foot of drawdown (Table 8). The tests emphasized that the irrigation wells in Wichita and Greeley Counties differ greatly in yield and

TABLE 8.—*Yield, total lift, drawdown, and specific capacity of irrigation wells in Wichita and Greeley Counties*

Well number	Date of test, 1948	Discharge, gallons a minute	Total lift, feet	Drawdown, feet	Specific capacity, gallons a minute per foot of drawdown
16-35-20ccc	August 17	820*a* 1,270*b*	130	19	45
16-36-7bcb	August 18	570	104	18	32
16-42-22acb	August 16	680*a* 811*b*	....	....	....
17-36-26caa	August 25	670*a* 910*b*	....	....	....
18-35-27dcc	August 13	1,270	....	....	....
18-35-34abb	August 13	1,800*a* 2,100*b*	108	19	95
18-35-36bcb	August 12	1,180	104	14	85
18-35-36cbc	August 12	680	....	....	....
18-36-18ddc	August 18	820	131	44	19
18-38-30bbb	August 19	370	....	....	....
18-38-30dbb	August 19	675	149	28	24
18-38-31dbc	August 10	610	127	17	33

a Normal pumping rate.
b Maximum pumping rate.

over-all efficiency. Many factors determine the yield of a well, including the method of construction, the character and thickness of the water-bearing formation, the diameter of the casing, the type of perforations or well screen, and the location of the perforated casing or screen.

POSSIBILITIES OF FURTHER DEVELOPMENT OF IRRIGATION SUPPLIES

The quantity of water that can be pumped from an underground reservoir without causing excessive permanent lowering of the water table depends on the quantity of annual recharge to the reservoir. If water is withdrawn faster than it is replenished, the water table will decline and the supply eventually will be nearly depleted. The feasibility of developing additional water supplies for irrigation from wells in Wichita and Greeley Counties depends on the rate of replenishment of the underground reservoir and on other geologic, hydrologic, and economic factors.

Figure 12, a map showing the thickness of water-bearing Pliocene and Pleistocene deposits, indicates that, although parts of southern Wichita County and several areas in Greeley County have no water-bearing material, much of the area has a considerable thickness of saturated sediments. The maximum thickness is about 170 feet on the northern border of Greeley County. In order to determine the volume of ground water contained in the saturated materials, the volume of saturated sediments was first determined by multiplying the area between each pair of contour lines on Figure 12 (measured with a planimeter) by the average saturated thickness. This was then multiplied by the specific yield of the sediments (assumed to be 15 percent). The volume of saturated sediments was found to be 45.4 million acre-feet and the volume of water was found to be 6.8 million acre-feet. The volume of saturated deposits and the total volume of water available for pumping is given by townships in Table 9. Theoretically, if completely drained, 6.8 million acre-feet of water would be available from the saturated sediments. Actually, however, much less than this amount would be economically recoverable. As the water table declined, yields also would decline and pumping lifts would be so increased as to make pumping infeasible. Although a discussion of economic factors is beyond the scope of this report, the depth to ground water in the parts of Wichita and Greeley Counties that have sufficient water-bearing material seem not to prohibit the drilling and pumping of irrigation wells.

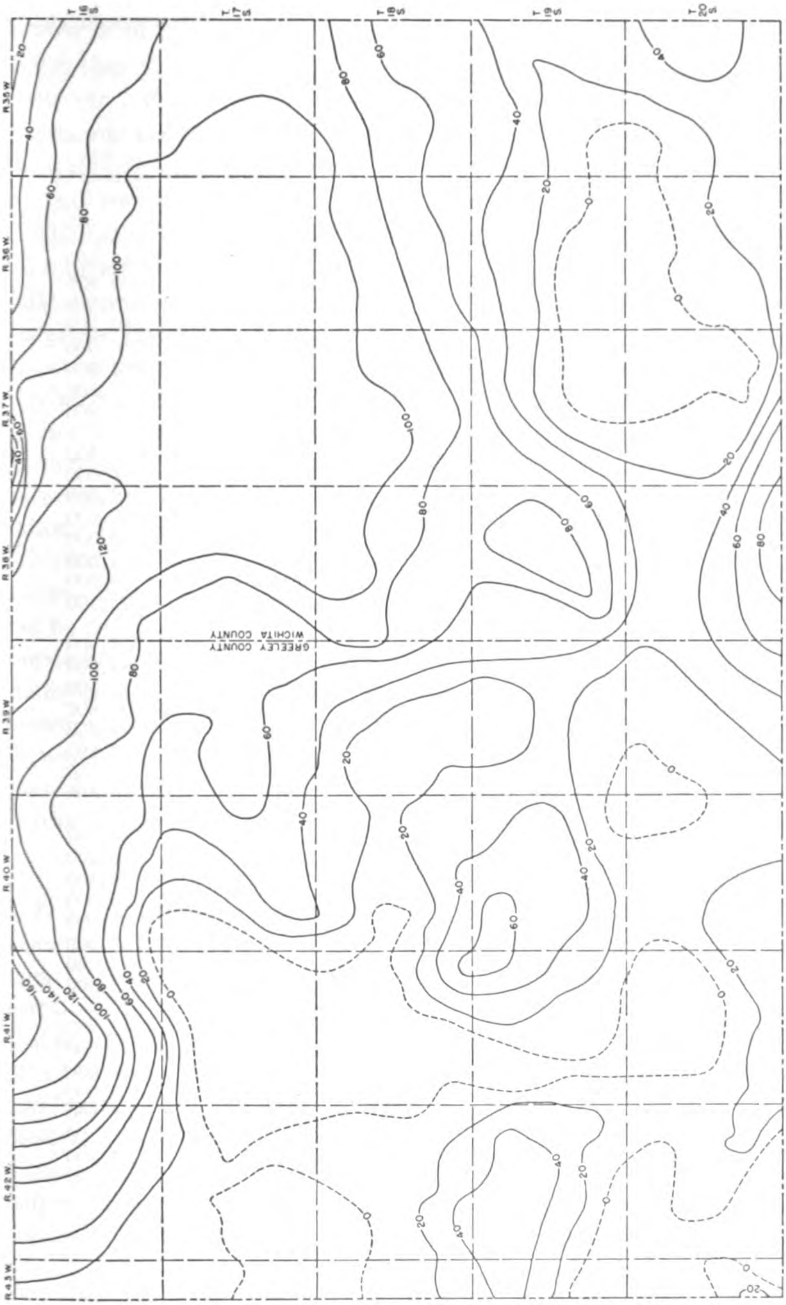

FIG. 12.—Map showing the saturated thickness of Pliocene and Pleistocene deposits in Wichita and Greeley Counties.

TABLE 9.—*Volume of saturated water-bearing materials in Wichita and Greeley Counties and volume of water available for pumping based on a specific yield of 15 percent*

(1) Township	(2) Volume of water-bearing materials, acre-feet	(3) Volume of water, acre-feet (15 percent of column 2)
T. 16 S., R. 35 W.	1,230,000	184,500
T. 16 S., R. 36 W.	1,772,000	265,800
T. 16 S., R. 37 W.	2,171,000	325,800
T. 16 S., R. 38 W.	2,738,000	410,500
T. 16 S., R. 39 W.	2,173,000	326,000
T. 16 S., R. 40 W.	1,764,000	264,500
T. 16 S., R. 41 W.	2,517,000	377,100
T. 16 S., Rs. 42 and 43 W.	1,357,000	203,500
T. 17 S., R. 35 W.	2,196,000	329,100
T. 17 S., R. 36 W.	2,534,000	380,000
T. 17 S., R. 37 W.	2,534,000	380,000
T. 17 S., R. 38 W.	1,547,000	232,000
T. 17 S., R. 39 W.	1,440,000	216,000
T. 17 S., R. 40 W.	757,000	113,600
T. 17 S., R. 41 W.	64,000	9,600
T. 17 S., Rs. 42 and 43 W.	174,000	26,100
T. 18 S., R. 35 W.	1,592,000	238,800
T. 18 S., R. 36 W.	1,919,000	288,000
T. 18 S., R. 37 W.	2,218,000	332,500
T. 18 S., R. 38 W.	2,005,000	300,800
T. 18 S., R. 39 W.	650,000	97,400
T. 18 S., R. 40 W.	519,000	77,800
T. 18 S., R. 41 W.	141,000	21,500
T. 18 S., Rs. 42 and 43 W.	311,000	46,600
T. 19 S., R. 35 W.	612,000	91,800
T. 19 S., R. 36 W.	428,000	64,200
T. 19 S., R. 37 W.	656,000	98,400
T. 19 S., R. 38 W.	1,466,000	220,000
T. 19 S., R. 39 W.	452,000	67,800
T. 19 S., R. 40 W.	916,000	137,500
T. 19 S., R. 41 W.	381,000	57,200
T. 19 S., Rs. 42 and 43 W.	818,000	122,500
T. 20 S., R. 35 W.	619,000	92,800
T. 20 S., R. 36 W.	275,000	41,200
T. 20 S., R. 37 W.	300,000	45,000
T. 20 S., R. 38 W.	1,086,000	162,900
T. 20 S., R. 39 W.	414,000	62,100
T. 20 S., R. 40 W.	304,000	45,600
T. 20 S., R. 41 W.	224,000	33,600
T. 20 S., Rs. 42 and 43 W.	155,000	23,200
Total volume	45,429,000	6,813,300

At the present time essentially no ground water is being withdrawn from storage; that is, the amount of water pumped by wells is less than the amount of water added annually to the ground-water reservoir. If the present rate of recharge from precipitation continues and the rate of pumping does not increase appreciably, there is no danger of lowering the water level beyond the economic limit of use.

The measurements of the water level given in Tables 14, 15, and 16 indicate that the water in wells was generally slightly higher in 1951 than it was in 1947 or 1948, when first measured. Although irrigation increased during this period, precipitation was generally above average, and ground-water recharge exceeded ground-water discharge.

The total amount of recharge in Wichita and Greeley Counties is roughly 4.5 billion gallons a year, 1.8 billion gallons coming from subsurface inflow and 2.7 coming from recharge from local precipitation. The amount of water pumped from wells is approximately 2 billion gallons a year and the amount to leave the area by subsurface flow is about 2.5 billion gallons a year. Although it should not be concluded that the amount of pumping could be doubled, it is apparent that many more irrigation wells could be drilled and pumped without danger of seriously lowering the water table. However, care should be exercised in the spacing and location of wells, and measurement of the water level in observation wells should be continued in order that remedial action might be taken before the lowering became excessive.

Chemical Character of Water

The chemical character of ground water in Wichita and Greeley Counties is shown by 29 analyses of water from typical wells in the area (Tables 10, 11). In addition, one sample was taken from a test hole drilled to the Dakota formation and one was taken from Ladder Creek. Figure 13 shows graphically the chemical character of water from the Ogallala formation, alluvium, Dakota formation, and from Ladder Creek. The samples were analyzed by Howard A. Stoltenberg, chemist, in the Water and Sewage Laboratory of the Kansas State Board of Health, at Lawrence. The analyses show only the dissolved mineral content and do not indicate the sanitary condition of the water.

CHEMICAL CONSTITUENTS IN RELATION TO USE

The following discussion of the chemical constituents of ground water in relation to use has been adapted from publications of the U. S. Geological Survey and the State Geological Survey of Kansas.

Dissolved solids.—When water is evaporated the residue consists mainly of the mineral constituents listed below and generally includes a small quantity of organic material and water of crystallization. The kind and quantity of the soluble mineral constituents in water determine its suitability for use. Water with less than 500 parts per million of dissolved solids generally is satisfactory for

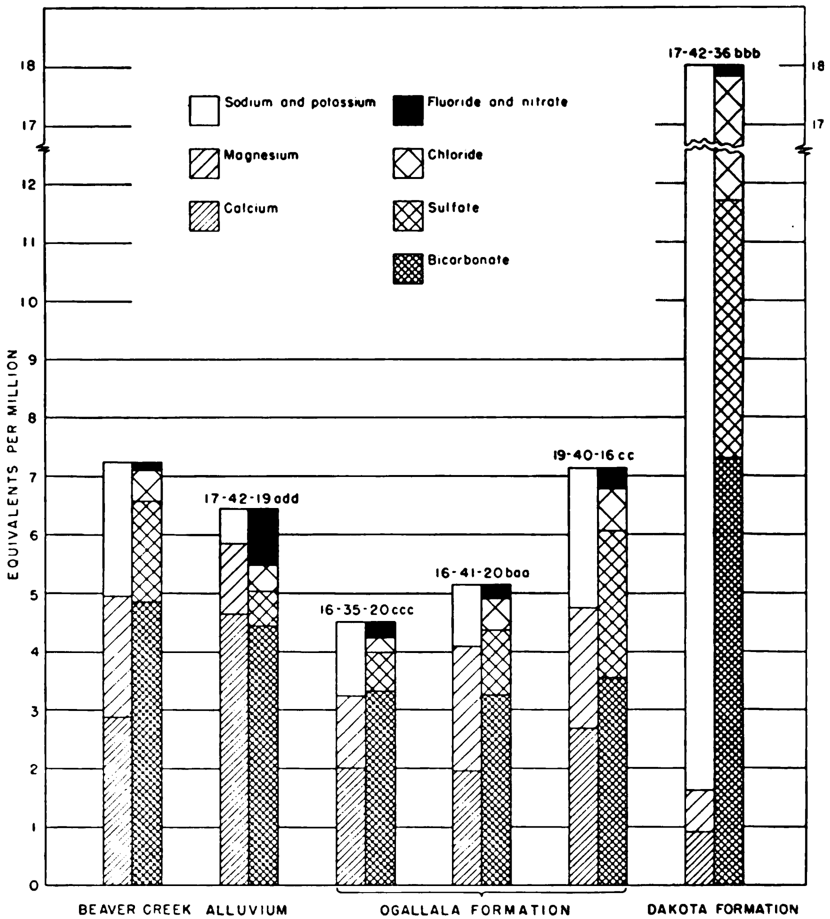

Fig. 13.—Graphical analyses of six water samples from Wichita and Greeley Counties.

TABLE 10.—*Analyses of water from typical wells in Wichita County*

Analyzed by H. A. Stoltenberg. Dissolved constituents given in parts per million[a], and in equivalents per million[b] (in italics)

Well No.	Depth (feet)	Geologic source	Date of collection, 1947	Temperature (°F)	Dissolved solids	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium and potassium (Na+K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Hardness as $CaCO_3$: Total	Hardness as $CaCO_3$: Carbonate	Hardness as $CaCO_3$: Noncarbonate
16-35-20ccc	189	Ogallala	Oct. 11	59	257	19	2.1	40 *2.00*	15 *1.23*	29 *1.28*	202 *3.31*	32 *0.67*	9.0 *0.25*	2.0 *0.10*	11 *0.18*	162	162	0
16-37-13cbb	88	do	Oct. 11	59	257	21	0.52	40 *2.00*	17 *1.40*	26 *1.13*	202 *3.31*	32 *0.67*	9.0 *0.25*	2.6 *0.14*	9.7 *0.16*	170	166	4
16-38-27ccc	28	do	Oct. 11	56	398	35	0	61 *3.04*	25 *2.06*	36 *1.58*	254 *4.17*	58 *1.21*	25 *0.70*	1.9 *0.10*	31 *0.50*	255	208	47
17-35-8bcb	....	Beaver Creek	Oct. 11	....	412	23	4.0	58 *2.89*	25 *2.06*	53 *2.31*	296 *4.85*	83 *1.73*	19 *0.54*	1.9 *0.10*	2.7 *0.04*	248	242	6
17-35-22dcc	95	Ogallala	Oct. 11	58	351	41	0.34	58 *2.89*	21 *1.73*	26 *1.13*	210 *3.44*	66 *1.37*	22 *0.62*	2.6 *0.14*	11 *0.18*	231	172	59
17-36-17daa	33.0	do	Oct. 11	57	368	32	0.38	62 *3.09*	25 *2.06*	32 *1.40*	307 *5.03*	48 *1.00*	15 *0.42*	1.1 *0.06*	2.4 *0.04*	258	252	6
18-37-8bcb	113.0	do	Oct. 13	58	289	43	0.86	41 *2.05*	20 *1.64*	23 *1.00*	199 *3.26*	41 *0.85*	12 *0.34*	2.0 *0.10*	8.8 *0.14*	184	163	21
18-37-13ddc	98	do	Oct. 14	59	340	39	0.03	56 *2.79*	22 *1.81*	23 *0.99*	189 *3.10*	42 *0.87*	40 *1.13*	2.2 *0.12*	23 *0.37*	230	155	75
18-38-17aad	49.0	do	Oct. 11	59	198	25	0.05	42 *2.10*	10 *0.82*	6.9 *0.30*	138 *2.26*	28 *0.58*	4.0 *0.11*	1.1 *0.06*	13 *0.21*	146	113	33
18-38-31dbc	148.0	do	Oct. 13	59	225	37	2.2	32 *1.60*	16 *1.32*	17 *0.76*	178 *2.92*	16 *0.33*	6.0 *0.17*	1.6 *0.08*	11 *0.18*	145	146	0
19-35-8add	80	do	Oct. 13	58	451	43	0.05	62 *3.09*	39 *3.21*	30 *1.30*	232 *3.80*	91 *1.89*	55 *1.55*	2.2 *0.12*	15 *0.24*	315	190	125
19-37-12cad	69.0	do	Oct. 13	58	278	40	0.13	42 *2.10*	20 *1.64*	19 *0.82*	202 *3.31*	35 *0.73*	12 *0.34*	0.7 *0.04*	8.8 *0.14*	187	166	21
19-38-25bbb	97.0	do	Oct. 16	59	342	47	0.27	46 *2.30*	20 *1.64*	34 *1.47*	200 *3.28*	68 *1.41*	17 *0.48*	1.6 *0.08*	10 *0.16*	197	164	33
20-35-15bbb	88	do	Oct. 13	58	198	11	0.18	47 *2.34*	7.7 *0.63*	15 *0.67*	193 *3.16*	10 *0.21*	5.0 *0.14*	0.4 *0.02*	6.6 *0.11*	148	148	0
20-37-13add	24	do	Oct. 13	57	385	26	0.46	100 *4.99*	17 *1.40*	7.6 *0.33*	333 *5.46*	12 *0.25*	5.0 *0.14*	0.4 *0.02*	53 *0.85*	320	273	47

[a] One part per million is equivalent to one pound of substance per million pounds of water or 8.33 pounds per million gallons of water.
[b] An equivalent per million is a unit chemical equivalent weight of solute per million unit weights of solution. Concentration in equivalents per million is calculated by dividing the concentration in parts per million by the chemical combining weight of the substance or ion.

TABLE 11.—*Analyses of water from typical wells in Greeley County*

Analyzed by H. A. Stoltenberg. Dissolved constituents given in parts per million[a], and in equivalents per million[b] (in italics)

Well No.	Depth (feet)	Geologic source	Date of collection, 1947	Temperature (°F)	Dissolved solids	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium and potassium (Na + K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Hardness as $CaCO_3$		
																Total	Carbonate	Noncarbonate
16-40-27ccd	75	Ogallala	Oct. 2	58	325	35	0.15	46 *2.30*	23 *1.89*	27 *1.17*	198 *3.25*	73 *1.52*	13 *0.37*	1.6 *0.08*	8.8 *0.14*	210	162	48
16-41-20baa	153.0	do	Oct. 2	57	308	38	0.29	39 *1.95*	26 *2.14*	24 *1.05*	198 *3.25*	54 *1.12*	19 *0.54*	2.0 *0.10*	8.0 *0.13*	204	162	42
16-42-20daa	200	do	Oct. 2	59	303	24	1.7	41 *2.05*	22 *1.81*	28 *1.22*	176 *2.89*	69 *1.44*	15 *0.42*	1.4 *0.07*	16 *0.26*	193	144	49
17-39-3bbc	110.0	do	Oct. 3	59	275	24	0.30	67 *3.34*	13 *1.07*	7.8 *0.34*	220 *3.61*	28 *0.58*	8.0 *0.23*	0.3 *0.02*	19 *0.31*	220	180	40
17-41-28bcc	132.0	do	Oct. 1	60	353	25	0.50	64 *3.19*	20 *1.64*	22 *0.94*	187 *3.07*	88 *1.83*	14 *0.39*	0.9 *0.05*	27 *0.43*	242	154	88
17-42-19add	30	Alluvium	Oct. 2	56	391	33	5.1	93 *4.64*	15 *1.23*	13 *0.5*	271 *4.44*	29 *0.60*	16 *0.45*	0.5 *0.03*	58 *0.93*	294	222	72
17-42-36bbb	1,140	Dakota	Dec. 17, 1948	....	1,065	8.4	1.8	18 *0.90*	8.8 *0.72*	377 *16.40*	446 *7.31*	212 *4.41*	217 *6.12*	3.0 *0.16*	1.1 *0.02*	81	81	0
18-40-1ddc	90.0	Ogallala	Oct. 3, 1947	58	202	21	0.10	40 *2.00*	13 *1.07*	12 *0.50*	185 *3.03*	12 *0.25*	4.0 *0.11*	0.9 *0.05*	8.0 *0.13*	154	152	2
18-40-17ddb	55	do	Oct. 2	58	502	26	0.15	128 *6.39*	16 *1.32*	27 *1.18*	416 *6.82*	44 *0.92*	20 *0.56*	0.1 *0.01*	36 *0.58*	386	341	45
18-42-22ddd	110.0	do	Oct. 1	58	494	27	0.40	71 *3.54*	38 *3.12*	36 *1.56*	231 *3.79*	170 *3.54*	20 *0.56*	1.1 *0.06*	17 *0.27*	333	190	143
19-40-16cc	126.0	do	Sept. 30	60	430	27	0.27	54 *2.69*	25 *2.06*	55 *2.38*	217 *3.56*	120 *2.50*	26 *0.73*	2.4 *0.13*	14 *0.22*	238	178	60
19-41-2baa	130	do	Oct. 1	....	404	23	0.32	44 *2.20*	26 *2.14*	55 *2.38*	194 *3.18*	122 *2.54*	27 *0.76*	1.9 *0.10*	8.8 *0.14*	217	159	58
19-42-35add	95	do	Oct. 1	58	608	17	1.3	67 *3.34*	31 *2.55*	94 *4.08*	210 *3.44*	245 *5.10*	48 *1.35*	1.0 *0.05*	2.0 *0.03*	294	172	122
20-39-3dd	191.0	do	Oct. 13	59	314	23	0.29	38 *1.90*	21 *1.73*	38 *1.66*	178 *2.92*	71 *1.48*	22 *0.62*	1.5 *0.08*	12 *0.19*	182	146	36
20-41-5bac	150	do	Sept. 30	60	603	19	0.21	70 *3.49*	32 *2.63*	82 *3.55*	170 *2.79*	257 *5.34*	45 *1.27*	1.6 *0.08*	12 *0.19*	306	140	166
20-41-10aa	170	do	Sept. 30	60	517	19	0.38	59 *2.94*	30 *2.47*	69 *3.02*	188 *3.08*	203 *4.22*	30 *0.85*	1.8 *0.09*	12 *0.19*	270	154	116

[a] One part per million is equivalent to one pound of substance per million pounds of water or 8.33 pounds per million gallons of water.
[b] An equivalent per million is a unit chemical equivalent weight of solute per million unit weights of solution. Concentration in equivalents per million is calculated by dividing the concentration in parts per million by the chemical combining weight of the substance or ion.

TABLE 12.—***Summary of the chemical character of the samples of water from Wichita and Greeley Counties***

Range in parts per million	Number of samples			
	Dakota formation	Ogallala formation	Alluvium	Ladder Creek
Dissolved solids				
100–200	....	2	....	....
201–300	....	7	....	....
301–400	....	11	1	....
401–500	....	4	....	1
501–600	....	2	....	....
More than 600	1	2	....	....
Total hardness				
0–100	1	....	....	....
101–200	....	11	....	....
201–300	....	13	1	1
301–400	....	4	....	....
Fluoride				
0–0.5	....	4	1	....
0.6–1.0	....	4	....	....
1.1–1.5	....	5	....	....
1.6–2.0	....	10	....	1
2.1–2.5	....	3	....	....
2.6–3.0	1	2	....	....
Iron				
Less than 0.10	....	4	....	....
.10–.20	....	5	....	....
.21–.30	....	6	....	....
.31–.50	....	7	....	....
.51–1.0	....	2	....	....
1.1–2.0	1	2	....	....
2.1–3.0	....	2	....	....
3.1–6.0	....	....	1	1

domestic use, except for difficulties resulting from hardness or occasionally excessive iron content. Water with more than 1,000 parts per million is likely to contain enough of certain mineral constituents to produce a noticeable taste or to make the water unsuitable in some other respect.

The dissolved solids in samples of water from Wichita and Greeley Counties ranged from 198 to 1,065 parts per million. Five samples contained more than 500 parts per million but only one sample contained more than 1,000 parts per million (Table 12). The water is therefore suitable generally for most ordinary uses, in respect to dissolved solids.

Hardness.—The hardness of water is most commonly recognized by the quantity of soap needed to produce a lather in washing and by the curdy precipitate that forms before a permanent lather is obtained. Calcium and magnesium cause practically all the hardness of ordinary water and are the active agents in the formation of the greater part of all the scale formed in steam boilers and in other vessels in which water is heated or evaporated.

Hardness is of two types, carbonate hardness and noncarbonate hardness. Carbonate hardness is caused by calcium and magnesium bicarbonate and, because it can be removed almost entirely by boiling, it is often called temporary hardness. Noncarbonate, or permanent, hardness is caused by sulfates, chlorides, nitrates, and fluorides of calcium and magnesium and cannot be removed by boiling. In use with soap there is no difference between carbonate and noncarbonate hardness. In general, noncarbonate hardness forms harder scale on steam boilers.

Water having a hardness of less than 50 parts per million is considered as soft, and treatment to remove hardness is unnecessary. Hardness of 50 to 100 parts per million does not seriously interfere with the use of soap for most purposes but does increase the consumption of soap, and its removal by a softening process may be profitable for laundries or other industries using large quantities of soap. Hardness of more than 150 parts per million is easily noticeable and water having more than 200 parts per million is sometimes treated to soften it. Where municipal water supplies are softened the hardness is usually reduced to 100 parts per million or less.

Samples of water collected in Wichita and Greeley Counties were moderately hard. Total hardness ranged from 81 to 386 parts per million.

Silica.—Silica is a mineral constituent of most ground water. The silica in a water may be deposited with other scale-forming constituents in steam boilers, but otherwise it has no effect on the use of water for most purposes.

Iron.—Normally if ground water contains much more than 0.2 to 0.3 part per million of iron, the excess will separate out and settle as a reddish sediment when exposed to the air. Iron, which may be present in sufficient quantity to give a disagreeable taste or to stain cooking utensils or bathroom fixtures, may be removed from most water by aeration and filtration, but some water requires additional treatment.

The maximum amount of iron in water samples collected in Wichita and Greeley Counties was 5.1 parts per million, in a sample from alluvium. One sample contained no iron; only nine samples contained less than 0.2 part per million.

Fluoride.—Fluoride is generally present only in small concentrations in ground water, but it is desirable to know the amount of fluoride in water that is used by children. Fluoride in water has been shown to be associated with the dental defect known as mottled enamel, which may appear on the teeth of children who, during the formation of the permanent teeth, drink water containing too much fluoride. Dean (1936, p. 1270) described as follows the mottling effects of fluoride in drinking water used by children:

> From the continuous use of water containing about 1 part per million, it is probable that the very mildest forms of mottled enamel may develop in about 10 percent of the group. In waters containing 1.7 or 1.8 parts per million, the incidence may be expected to rise 40 or 50 percent, although the percentage distribution would be largely of the very mild and mild types. At 2.5 parts per million an incidence of about 75 to 80 percent might be expected, with possibly 20 to 25 percent of all cases falling into the moderate or severe type. A scattering few may show the moderately severe type.
>
> At 4 parts per million, the incidence is, in general, in the neighborhood of 90 percent, and as a rule, 35 percent or more of the children are classified as moderate or worse. In concentrations of 6 parts per million or higher an incidence of 100 percent is not unusual.

More recent studies have shown that concentrations of fluoride too small to cause objectionable mottling of tooth enamel—up to 1.0 to 1.5 parts per million—may help to prevent tooth decay. The United States Public Health Service (1946) has published standards that limit the amount of mineral constituents permissible in drinking water that is used in interstate commerce. The suggested maximum amount of fluoride is 1.5 parts per million.

The fluoride content of water samples collected in Wichita and Greeley Counties ranged from 0.1 to 3.0 parts per million. Of the

31 samples collected 17 contained more than 1.5 parts per million.

Nitrate.—The presence of nitrate in water was given new significance a few years ago when it was discovered that water high in nitrate might cause cyanosis in infants when used in the preparation of the baby's formula (Metzler and Stoltenberg, 1950). In cyanosis the baby becomes drowsy and listless and the skin takes on a blue color. In less severe cases recovery may take place in 8 to 24 hours if a change is made to water of low nitrate content, but death may result if the water supply is not changed. Nitrate in drinking water does not cause cyanosis in adults but may be responsible for certain digestive disorders.

Nitrate is derived from nitrate-bearing rocks and minerals in the water-bearing formations and from direct flow of nitrate-bearing surface water into the well or to percolation of surface water into the well from the soil zone at the top of the well. Soils, especially during the fall and winter, contain high concentrations of nitrate derived principally from plants, from animal wastes, and from nitro-bacterial action. Being very soluble, nitrate is readily dissolved from the soils by rainfall and carried into wells. Because privies, cesspools, and barnyards are sources of organic nitrogen, a large amount of nitrate in well water may indicate also the presence of harmful bacteria.

The Kansas State Board of Health considers that about 45 parts per million is the safe limit of nitrate (as NO_3), and to use water in excess of this amount in the preparation of an infant's formula may be dangerous. All water samples from Wichita and Greeley Counties contained nitrate, but only two contained more than 45 parts per million, the maximum concentration being 58 parts per million. Both wells were shallow, located in draws, and poorly covered. In addition, one was dug. Dug wells are usually less tightly sealed at the surface and less adequately cased than drilled wells, and as a consequence are more subject to contamination.

WATER FOR IRRIGATION

The suitability of a water for irrigation depends mainly on the total quantity of dissolved mineral constituents and the percentage of sodium. The quantity of chloride may be large enough to affect the use of the water, and boron in some areas may be present in sufficient amounts to be harmful to plants. The total concentration of dissolved constituents may be expressed in terms of parts per million of dissolved solids, of total equivalents per million of anions and cations, or in terms of electrical conductivity. Electrical conductivity is a measure of the ability of inorganic salts in solution to conduct an electric current, and it is related to the concentration of dissolved solids. Approximate values for electrical conductivity can be obtained by multiplying total equivalents per million of anions or cations by 100, or by dividing dissolved solids in parts per million by 0.7 (Wilcox, 1948, pp. 4-5). The percentage of sodium is found by dividing the quantity of sodium, given in equivalents per million, by the sum of the quantities of calcium, magnesium, sodium, and potassium, also in equivalents per million, and expressing the result as a percentage.

The classification of water for irrigation use is shown in Table 13. (Wilcox, 1948a):

TABLE 13.—*Permissible limits for electrical conductivity and percentage of sodium of several classes of irrigation water*

Classes of water		Electrical conductivity (micromhos at 25° C)	Percent sodium
Rating	Grade		
1	Excellent.....	less than 250..................	less than 20
2	Good........	250–750..................	20–40
3	Permissible...	750–2,000................	40–60
4	Doubtful.....	2,000–3,000................	60–80
5	Unsuitable....	more than 3,000...............	more than 80

Although the permissible limits of sodium and electrical conductance may vary with the type of soil, the crops, and the drainage, water containing more than 60 percent sodium or water having an electrical conductance of more than 2,000 is generally unfit for irrigation. With the exception of water from experimental well 17-42-36bbb, drilled to the Dakota formation, all samples of water from Wichita and Greeley Counties are within the limits of safety suggested by Wilcox. No analysis was made for boron but it is probable that the quantity of boron was insufficient to be harmful to plants (Leonard, 1952, pp. 74, 76).

SANITARY CONSIDERATIONS

The analyses of water given in Tables 10 and 11 show only the amounts of dissolved mineral matter in the water and do not indicate its sanitary quality. The water in a well may contain mineral matter that imparts an objectionable taste or odor and yet may be free from harmful bacteria and may be safe for drinking. On the other hand, the water in a well may be clear and palatable and yet may contain harmful bacteria. An abnormal amount of certain mineral constituents, such as nitrate or chloride, sometimes indicates pollution.

Dug wells are more easily contaminated than properly constructed drilled wells, but great care should be taken to protect from pollution every well used for domestic or public supply. Drilled wells on the uplands generally penetrate relatively impervious silt above the water table and are less subject to pollution than shallow wells in valleys, where pervious sandy material may extend from the surface to the water table. Every well should be tightly sealed and, if possible, should be located in a raised area to prevent surface drainage from running into it. Wells should not be located near possible sources of contamination such as buildings, barnyards, or cesspools.

QUALITY OF WATER IN STREAMS

A sample of water for analysis was taken from Ladder Creek on October 11, 1947, in eastern Wichita County in the SW¼ NW¼ sec. 8, T. 17 S., R. 35 W. Wichita County had received only a trace of precipitation in the first 10 days of October and only 0.81 inch of rainfall during September. Greeley County had received 0.04 inch of precipitation in the first 10 days of October and 0.67 inch during September. Because of the small amount of precipitation during September and October it is thought that the flow of Ladder Creek, which was only a few gallons a minute, was derived almost entirely from ground water. The chemical character of water from Ladder Creek was very similar to that of water collected from Ogallala and alluvial deposits in Wichita and Greeley Counties.

GEOLOGIC FORMATIONS AND THEIR WATER-BEARING PROPERTIES

Cretaceous System

GULFIAN SERIES-COLORADO GROUP

Dakota Formation

The Dakota formation does not crop out in Wichita or Greeley County and it yields no water to wells in the area. However, the Dakota formation contains water and is an important aquifer in the Syracuse upland to the south, in Hamilton and Kearny Counties (McLaughlin, 1943, pp. 124-125). Two known attempts to obtain water from the Dakota formation have been made in Greeley County. In 1901 the Missouri Pacific Railway Company drilled a well at Horace to obtain water for use by the railroad. The Dakota is reported to have been reached at 1,050 feet and penetrated to a depth of 1,350 feet, where the Permian redbeds were encountered (Parker, 1911, pp. 101-102). The water in the Dakota rose to about 800 feet below the surface. The well was never used extensively. In 1948 another experimental well was drilled in the NW cor. sec. 36, T. 17 S., R. 42 W., in an area where shallow water supplies are scarce, to see if there was enough water in the Dakota formation of proper quality for irrigation. Analysis of a bailer sample of water from the well indicated that the water contained too much sodium to be used for irrigation. The well is not used. During the course of an investigation of the geology and ground-water resources of Hamilton and Kearny Counties (McLaughlin, 1943, p. 154) the record of a well drilled in the SE cor. sec. 8, T. 21 S., R. 41 W., 2 miles south of the Greeley County line, was obtained. It was reported that this well entered the Dakota fromation at 800 feet and that water rose to within 350 feet of the surface. At the time of the investigation the well was used for domestic and stock purposes.

Details concerning the character and the thickness of the Dakota formation in Wichita and Greeley Counties are lacking. Sandstone and variegated shale and clay are the predominant materials in the Dakota, but the percentages of the constituents in the two counties are not known.

The Dakota formation is characteristically lenticular, and consequently it varies considerably in thickness. According to Parker (1911, pp. 101-102) the Dakota was 300 feet thick in the deep well drilled at Horace. However, rocks belonging to the Kiowa shale and the Cheyenne sandstone, which underlie the Dakota, may be included in this thickness. The probable range in thickness of the Dakota is from 200 to 300 feet. The entire area is underlain by the Dakota formation.

Graneros, Greenhorn, and Carlile Formations

Above the Dakota formation, and below the Niobrara formation are 300 to 450 feet of deposits which consist mainly of shale and limestone. Included in this thickness are the Graneros shale, Greenhorn limestone, and Carlile shale, in ascending order. These formations do not crop out in Wichita and Greeley Counties. As they are generally very poor aquifers and yield no water to wells in these counties, they will not be discussed.

Niobrara Formation

The uppermost Cretaceous beds in Wichita and Greeley Counties consist of chalk and chalky shale of the Smoky Hill member of the Niobrara formation. This member crops out along Whitewoman Creek on the western border of Greeley County. The lower member of the Niobrara formation, the Fort Hays limestone member, does not crop out in the area.

Fort Hays limestone member.—The Fort Hays limestone member consists of thick massive beds of chalky limestone and chalk separated by very thin beds of chalky shale and bentonite. The limestone and chalk beds commonly range in thickness from less than a foot to a few feet, and where unweathered they are light to dark gray. Weathered exposures of Fort Hays limestone in near-by areas are white, tan, buff, or cream. None of the test holes drilled in Wichita and Greeley Counties penetrated the Fort Hays limestone, but test hole 23, drilled in the SE¼ SW¼ sec. 32, T. 20 S., R. 34 W., in southwestern Scott County, penetrated 65 feet of Fort Hays chalk and chalky shale (Waite, 1947, p. 187). This limestone probably underlies the entire area, but its range in thickness is not known. It yields no water to wells in Wichita and Greeley Counties.

Smoky Hill chalk member.—The Smoky Hill chalk member, which overlies the Fort Hays limestone member, consists of chalk and chalky shale. The beds contain numerous limonitic concretions and shells of *Inoceramus grandis* and *Ostrea congesta.* Where unweathered these beds are light to dark gray, but exposures in Greeley County are weathered to yellow, orange, or tan. Although the thickness of the Smoky Hill member in these counties is not known in detail, in southeastern Wichita County it is judged to be less than 100 feet (Waite, 1947, p. 187, log 23) and it probably reaches a maximum thickness of 550 to 600 feet in the northern part of Greeley County. The Smoky Hill chalk and chalky shale underlies all of Wichita and Greeley Counties and serves as an impervious floor beneath the overlying water-bearing sediments. It prevents the downward percolation of water in much the same manner as the floor of a tank. No wells in the area are known to obtain water from the Smoky Hill chalk, but it may locally contain very small amounts of water along bedding planes or fractures.

Tertiary System

PLIOCENE SERIES

Ogallala Formation

Character.—The Ogallala formation in Wichita and Greeley Counties consists of sand, gravel, silt, and clay and lesser amounts of sandy limestone and opal. To the north in Wallace County (Elias, 1931) beds of volcanic ash, diatomaceous marl, bentonitic clay, and silicified beds (Frye and Swineford, 1946) are found. The character of the Ogallala is indicated by the logs of test holes included in this report.

Most of the materials composing the formation are poorly sorted, and gradations from one lithologic type to another take place within short distances. Individual beds are characteristically lenticular and, with the exception of the "Algal limestone" at the top, cannot be traced very far.

Sand is the most common constituent of the Ogallala formation, occurring at all horizons. The sand ranges in size from very fine to very coarse and is composed predominantly of quartz with lesser amounts of feldspar and other minerals. Beds of uniform well-sorted sand are found in some places, but most of the sand is mixed with silt, clay, or gravel. Beds of gravel are encountered in test drilling, but usually they contain sand or silt. Sand and gravel beds in the Ogallala may be well cemented to form hard beds of sandstone or conglomerate. In many places the materials have been so firmly cemented with calcium carbonate as to produce a series of hard ledges, interbedded with only slightly cemented beds. These hard beds of sandstone usually form rough, weathered benches and cliffs, and they have been called "mortar beds" because of their resemblance to old mortar. Calcium carbonate is the most common cementing material in the Ogallala formation, but in places sand and gravel deposits are cemented with ferruginous or siliceous cement. Some sand and gravel beds in the Ogallala, particularly those that supply water to irrigation wells in Wichita and Greeley Counties, contain little or no cementing material. Structurally, the sand and gravel deposits may be even-bedded, irregularly cross-bedded, or may have no apparent bedding.

Beds of sandy silt are very common in the Ogallala. The color of the silt is gray, red, brown, tan, buff, or white where it contains a large amount of calcium carbonate. Some of the silt deposits are bedded, but many are structureless, and have a superficial resemblance to wind-blown silt or loess. Silt layers commonly contain stringers, nodules, or pipettes of calcium carbonate.

In addition to occurring as cementing material, nodules, or stringers, calcium carbonate also occurs in beds of caliche or limestone. The term caliche as used here refers to deposits of soft calcium carbonate that are thought either to have been deposited a short distance beneath the land surface from surface water that contained calcium bicarbonate or to have been precipitated from ground water by the loss of carbon dioxide at times when the water table was near the surface. However, the "Algal limestone" which caps the Ogallala formation in many areas is thought to have been deposited in shallow lakes, as explained previously. It has a maximum thickness of about 4 feet in the Wichita-Greeley area. In typical outcrops it is hard and weathers to a reddish knobby, irregular surface. The "Algal limestone" has been recognized in test holes drilled in the area (as in test hole 20-38-29ddd), and it also crops out on several hills (for example, NW¼ sec. 23, T. 18 S., R. 38 W.).

Distribution and thickness.—The Ogallala formation underlies all of Wichita and Greeley Counties except an area in western Greeley County along Whitewoman Creek. There a bedrock high exists and the Ogallala, which was originally very thin, has been removed, exposing the underlying Smoky Hill chalk member. The Ogallala is covered by the Sanborn formation, slope deposits, or alluvium throughout much of the Wichita-Greeley area, but it crops out in several places, principally along Ladder, Whitewoman, and Sand Creeks (Pl. 7). The thickness of the Ogallala formation encountered in test drilling ranged from 194 feet in test hole 20-38-29ddd to 15 feet in test hole 19-36-16dad in Wichita County and from 243 feet in test hole 16-41-15ccc to 8 feet in test hole 20-42-29bbb in Greeley County. The thickness of the formation in various areas is indicated in the cross sections (Figs. 6 and 7) and in the logs of test holes given in this report.

Age and correlation.—In 1899 Darton (pp. 732, 734) applied the name Ogallala formation to deposits formerly called "Tertiary grit" and considered by Hay (1895, p. 570) to be of Miocene age. Darton named the formation for a locality in southwestern Nebraska and considered the formation to be of late Tertiary or Pliocene(?) age. In 1920 (p. 6) he designated the type locality as being near Ogallala Station in western Nebraska. Since the work of Darton, the most important studies of the stratigraphy of the Ogallala in western Kansas have been made by Elias (1931), Smith (1940), and Frye and Leonard (1949). In 1943 McLaughlin described the Ogallala formation in Hamilton and Kearny Counties, and in 1947 Waite described the Ogallala in Scott County.

The Ogallala formation ranges in age from early Pliocene or possibly late Miocene to late Pliocene. The Ogallala has been subdivided into three members, which are in ascending order the Valentine, Ash Hollow, and Kimball. No attempt was made to differentiate the members in Wichita and Greeley Counties, but all the members may be present. As Elias (1931) described the "Algal limestone" bed in Wallace County to the north as defining the top of the formation, it seems certain that the Kimball member and Ash Hollow member at least are present in these counties.

Water supply.—In Wichita and Greeley Counties, as in much of the High Plains, the Ogallala formation is the principal water-bearing formation. A few wells of small capacity obtain water from alluvial deposits and it is possible that a small amount of water may be obtained from cracks or bedding planes in the Niobrara formation, but all irrigation wells, all public-supply wells, and most of the domestic and stock wells derive their water from the Ogallala. The Ogallala supplies water also to small springs along Ladder Creek. The yields of wells tapping the Ogallala formation in Wichita and Greeley Counties range from a few gallons a minute for domestic and stock wells of small capacity to 1,800 gallons a minute from irrigation wells of large capacity (well 18-35-34abb, Table 8). The largest yields from the Ogallala are obtained from the coarser materials, which generally are in the lower part of the formation. Figure 12 indicates that water-bearing deposits reach a maximum thickness of about 170 feet in the area. Logs of test holes show that much of the water-bearing material is composed of sand and gravel; therefore the amount of water in storage is large.

Water samples were collected from 28 wells that derive their water from the Ogallala formation. Analyses of the samples are given in Tables 10 and 11, graphical analyses of a few samples are given in Figure 13, and a summary of some of the chemical char-

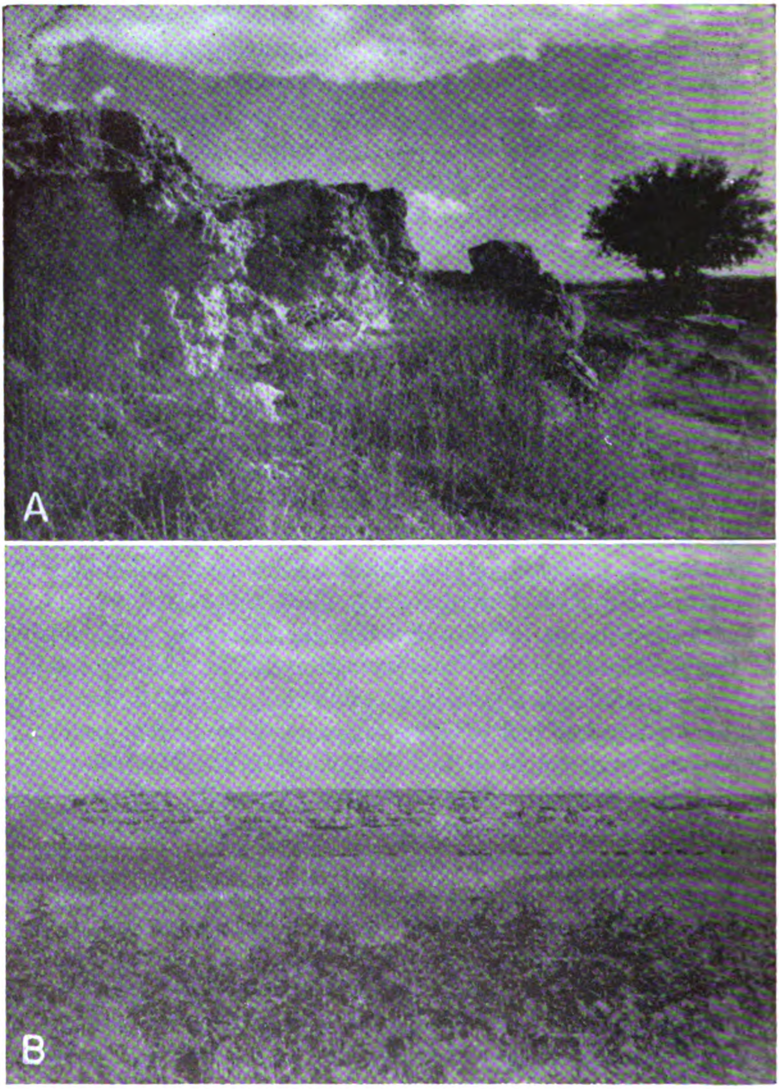

PLATE 7.—Outcrops of the Ogallala formation. **A,** View of rough, weathered beds of the Ogallala formation in sec. 28, T. 17 S., R. 42 W., Greeley County. **B,** Bluff formed by beds of the Ogallala formation. View is in NW¼ sec. 18, T. 17 S., R. 36 W., Wichita County, looking east across valley of Ladder Creek.

acteristics of the water is given in Table 12. Analyses indicate that the water is slightly hard but of good quality both for domestic use and for irrigation. The hardness ranges from 146 to 386 parts per million; 24 samples had less than 300 parts per million hardness, and

4 had between 300 and 400 parts. Water from the Ogallala formation in some places contains enough fluoride to cause mottling of children's teeth, the amount ranging from 0.1 to 2.6 parts per million. Thirteen samples contained 1.5 parts per million or less; 15 samples contained more than 1.5 parts per million.

Quaternary System

PLEISTOCENE SERIES

Sanborn Formation

The term Sanborn formation was first used in 1931 by Elias (pp. 163-181) for deposits consisting mainly of silt. The type locality was in northwestern Cheyenne County, Kansas, and the deposits were named for the town of Sanborn, Nebraska, located just north of the type locality. Sanborn formation was used to replace such terms as "Plains marl" and "Tertiary marl" used by Hay (1895) and other early workers in the central Great Plains region for deposits later recognized as consisting mainly of loess. Several more recent reports further describe, subdivide, and correlate the Sanborn formation in the western Kansas area. Some of the more noteworthy of these reports are by Frye and Fent (1947), Frye, Swineford and Leonard (1948), Frye and A. R. Leonard (1949), Frye and A. B. Leonard (1951), Swineford and Frye (1951), A. B. Leonard (1951), and Frye and A. B. Leonard (1952). This report uses the classification and correlation of the Sanborn formation as described by Frye and A. B. Leonard (1952).

Character.—The Sanborn formation in Wichita and Greeley Counties is divided into three silt members, the Loveland, Peoria, and Bignell, and a sand and gravel member, the Crete.

The Crete sand and gravel member is the oldest member of the Sanborn formation. It is composed predominantly of pebbles of quartz, quartzite, basalt, flint, and jasper. The Loveland silt member, which is the next oldest, consists of massive reddish-brown silt. At the top is a weathered zone, oxidized to a dark reddish brown, that contains a concentration of lime in the form of nodules and stringers of caliche in the lower part. This upper weathered part of the Loveland is classed as the Sangamon soil. The Peoria silt member, which consists of tan to light-brown silt, lies above the Sangamon soil. The Peoria is capped in a few localities in Wichita and Greeley Counties by a dark soil, the Brady soil, which is somewhat thicker than the modern topsoil. The Bignell silt member which overlies the Brady soil lithologically resembles the Peoria member but nowhere in the area exceeds a thickness of 4 or 5 feet.

Distribution and thickness.—As shown on Plate 1, the Sanborn formation underlies the surface of a large part of Wichita and Greeley Counties and was penetrated by most of the test holes drilled in the area. The Peoria silt member is the thickest and most widespread unit of the Sanborn; its thickness ranges from a featheredge to 27 feet in the test holes. The extent of the Loveland is not known; it was recognized in only a few of the test holes and its outcrops are scarce. However, the Sangamon soil can be seen in some plowed fields on hillsides, where it occurs as a dark band on the slope below the crest of the hill. The maximum thickness of the Loveland silt in Wichita and Greeley Counties is not known, but in test hole 20-37-21aaa in Wichita County 8 feet of reddish-brown silt was thought to represent the Loveland. The occurrence of the Bignell loess in the area is sporadic. The only recorded outcrop of the Bignell is in the NW¼ sec. 9, T. 16 S., R. 40 W., Greeley County.

Age and correlation.—The Sanborn formation ranges in age from Illinoian to Mankatoan. The Loveland, Peoria, and Bignell silt members of the Sanborn have been traced from southern Kansas northward to Nebraska, where they are called the Loveland, Peorian, and Bignell loess, respectively. They have been traced farther across Nebraska to western Iowa and to southeastern South Dakota. In Nebraska the Peorian loess has been found above Iowa till and has been established as post-Iowan in age. The Loveland loess underlies the Iowa till in places and thus is of pre-Iowan age (Condra, Reed, and Gordon, 1947, p. 48).

Fossil snails are listed by Frye and A. B. Leonard (1951, Fig. 4) from the Sanborn formation in Wichita and Greeley Counties.

Fossil snails from the Peoria silt member of the Sanborn formation in Wichita and Greeley Counties (identified by A. Byron Leonard).

Discus shimeki	*Pupilla muscorum*
Helicodiscus singleyanus	*Vallonia gracilicosta*
Helicodiscus parallelus	*Succinea avara*
Hawaiia minuscula	

Water supply.—In the uplands of Wichita and Greeley Counties the Sanborn formation lies above the water table and yields no water to wells. In a few isolated areas where the water table is close to the surface of the ground, it is possible that meager amounts of water can be obtained from the Sanborn formation or from slope deposits, which are virtually indistinguishable from the Sanborn.

Dune Sand

A thin deposit of dune sand mantles a small area in Greeley County, in sec. 1, T. 17 S., R. 41 W. The fine to medium sand that comprises this deposit probably has been blown by the wind from some near-by outcrop of the Ogallala formation. The thickness of the dune sand probably does not exceed 10 feet. The dune sand is above the water table and yields no water to wells.

Alluvium

General features.—Alluvial deposits occur along the bottoms of Whitewoman and Ladder Creeks and along the eastern extremity of Sand Creek. A few scattered remnants of terrace deposits occur in places along these creeks but the deposits are not materially different from alluvium and will be considered with it. The alluvium of Whitewoman Creek is composed principally of silt, sand, and gravel that were derived from the Ogallala formation, and to a lesser degree of silt and clay derived from the Sanborn formation and slope deposits. The alluvium of Whitewoman Creek is difficult to distinguish from the Ogallala formation in drill cuttings, but the maximum thickness of the alluvium in the area is thought to be about 30 feet. The alluvium of Ladder Creek is also composed of sand, gravel, and silt, but in general it is finer than the alluvium of the Whitewoman and contains a higher percentage of material derived from the Sanborn formation and slope wash. The alluvium in test hole 17-35-7add, which was drilled in the valley of Ladder Creek, was composed mainly of silt and clay. One of the layers was a 10-foot bed of dark-blue mucky clay, which was high in organic material. No test holes were drilled along Sand Creek and the thickness and character of the alluvium there are not known.

Water Supply.—Only one sample of water was obtained from a well tapping alluvial deposits. The analysis of this sample is given in Table 11 and is shown graphically in Figure 11. The sample contained 391 parts per million of dissolved solids, 294 parts per million of total hardness, and 0.5 part per million of fluoride. In general, the quality of the water is similar to that from the Ogallala formation.

RECORDS OF WATER LEVELS IN OBSERVATION WELLS

The measurements of the water levels in seven observation wells in Wichita and Greeley Counties are given in Table 14. This table includes measurements from the beginning of record in 1947 through December 1952.

TABLE 14.—*Water levels, in feet below land surface, in observation wells 1947-1952*

Date	Water level	Date	Water level	Date	Water level
		Well 16-37-26abb			
July 21, 1947	87.50	June 17, 1949	87.26	Oct. 10, 1950	87.25
Sept. 7, 1947	88.28	Aug. 11, 1949	87.50	Dec. 11, 1950	87.32
Apr. 19, 1948	87.34	Oct. 13, 1949	90.48	Feb. 11, 1951	87.34
June 15, 1948	87.35	Dec. 16, 1949	90.52	Apr. 24, 1951	87.29
June 23, 1948	87.27	Feb. 24, 1950	87.54	June 10, 1951	87.29
July 23, 1948	87.33	Apr. 26, 1950	87.70	Aug. 14, 1951	82.22
Oct. 14, 1948	87.30	June 26, 1950	87.35	Oct. 18, 1951	87.20
Dec. 15, 1948	87.37	Aug. 16, 1950	87.27	Dec. 10, 1951	87.12
Apr. 14, 1949	86.40				
		Well 16-41-20ba			
Aug. 5, 1947	130.10	May 24, 1949	130.88	Mar. 29, 1951	130.50
Sept. 6, 1947	130.07	July 20, 1949	133.02	May 29, 1951	130.10
Mar. 22, 1948	130.75	Sept. 28, 1949	132.71	June 19, 1951	130.56
May 19, 1948	130.15	Nov. 23, 1949	131.02	Sept. 27, 1951	130.51
June 24, 1948	130.06	Jan. 25, 1950	130.55	Nov. 6, 1951	130.35
July 14, 1948	130.15	Mar. 21, 1950	130.50	Jan. 17, 1952	130.17
July 24, 1948	130.10	May 11, 1950	130.44	Mar. 18, 1952	130.22
Sept. 20, 1948	130.65	July 26, 1950	130.25	May 26, 1952	130.30
Nov. 12, 1948	130.33	Sept. 21, 1950	131.24	July 15, 1952	130.07
Jan. 6, 1949	127.96	Oct. 14, 1950	130.50	Sept. 23, 1952	130.16
Mar. 4, 1949	129.70	Jan. 9, 1951	130.60	Nov. 10, 1952	130.07
		Well 17-40-22ccd			
Aug. 7, 1947	140.18	July 20, 1949	139.04	Mar. 29, 1951	139.25
Sept. 6, 1947	138.50	Sept. 28, 1949	141.01	May 29, 1951	139.44
Mar. 22, 1948	138.50	Dec. 23, 1949	141.51	June 19, 1951	139.15
May 19, 1948	141.72	Jan. 25, 1950	138.92	Sept. 27, 1951	138.03
June 24, 1948	136.53	Mar. 21, 1950	139.67	Jan. 17, 1952	138.18
July 14, 1948	145.40	May 11, 1950	139.31	Mar. 18, 1952	138.16
July 24, 1948	138.70	July 26, 1950	140.95	May 25, 1952	138.12
Sept. 20, 1948	146.59	Sept. 21, 1950	139.27	July 15, 1952	138.15
Nov. 12, 1948	146.78	Oct. 14, 1950	139.00	Sept. 23, 1952	138.21
Mar. 4, 1949	142.20	Jan. 1, 1951	139.00	Nov. 10, 1952	138.67
May 24, 1949	139.28				
		Well 18-35-14bb			
Aug. 19, 1947	83.00	June 17, 1949	83.26	June 18, 1951	82.43
Sept. 7, 1947	82.96	Aug. 11, 1949	81.33	Aug. 14, 1951	82.30
Apr. 19, 1948	82.95	Oct. 12, 1949	83.37	Oct. 18, 1951	82.13
June 15, 1948	83.05	Dec. 16, 1949	83.30	Dec. 10, 1951	82.10
June 23, 1948	82.88	Feb. 24, 1950	83.18	Feb. 27, 1952	81.89
July 23, 1948	82.91	Aug. 16, 1950	83.09	Apr. 10, 1952	81.89
Aug. 16, 1948	83.03	Oct. 10, 1950	83.01	June 11, 1952	81.78
Oct. 14, 1948	83.04	Dec. 11, 1950	83.27	Aug. 25, 1952	81.34
Dec. 15, 1948	83.28	Feb. 8, 1951	82.59	Oct. 15, 1952	81.84
Feb. 17, 1949	83.22	Apr. 24, 1951	82.50	Dec. 22, 1952	81.97
Apr. 14, 1949	83.28				

TABLE 14.—*Water levels, in feet below land surface, in observation wells 1947-1952—Concluded*

Date	Water level	Date	Water level	Date	Water level
		Well 18-41-26aa			
Aug. 6, 1947	101.66	Jan. 6, 1949	101.79	May 11, 1950	100.37
Sept. 5, 1947	101.65	Mar. 4, 1949	102.74	July 26, 1950	100.35
Mar. 22, 1948	101.67	May 24, 1949	101.60	Sept. 21, 1950	100.45
May 19, 1948	101.00	July 20, 1949	101.76	Jan. 9, 1951	100.48
June 24, 1948	102.90	Sept. 28, 1949	100.42	Mar. 29, 1951	100.40
July 14, 1948	101.61	Oct. 14, 1949	101.32	May 29, 1951	100.49
July 24, 1948	101.65	Nov. 23, 1949	100.45	June 19, 1951	100.43
Sept. 20, 1948	100.21	Jan. 25, 1950	100.25	Sept. 27, 1951	100.46
Nov. 12, 1948	101.78	Mar. 21, 1950	100.44	Nov. 6, 1951	100.33
		Well 19-43-25aad			
Aug. 7, 1947	90.70	May 24, 1949	100.69*	May 29, 1951	93.34
Sept. 5, 1947	91.57	July 20, 1949	94.00	June 19, 1951	92.07
May 19, 1948	93.40	Sept. 21, 1949	91.57	Sept. 27, 1951	91.20
June 24, 1948	91.64	Sept. 28, 1949	93.31	Jan. 17, 1952	89.99
July 14, 1948	94.33	Oct. 14, 1949	90.04	Mar. 18, 1952	90.88
July 24, 1948	91.64	Nov. 23, 1949	94.79	May 26, 1952	90.79
Sept. 20, 1948	100.66	May 11, 1950	92.34	July 15, 1952	90.85
Nov. 12, 1948	93.05	July 26, 1950	91.68	Sept. 23, 1952	90.74
Jan. 6, 1949	92.25	Jan. 9, 1951	91.42	Nov. 10, 1952	90.71
Mar. 4, 1949	91.60				
		Well 20-36-14dad			
Aug. 4, 1947	94.87	June 17, 1949	95.02	Feb. 8, 1950	94.80
Sept. 8, 1947	94.90	Aug. 11, 1949	96.52	Apr. 24, 1950	94.76
Apr. 19, 1948	94.96	Oct. 13, 1949	95.14	June 18, 1950	94.74
June 16, 1948	94.82	Dec. 16, 1949	94.99	Aug. 14, 1950	94.68
June 23, 1948	94.80	Feb. 24, 1950	94.97	Oct. 18, 1950	94.69
July 23, 1948	94.90	Apr. 26, 1950	95.35	Dec. 10, 1950	94.66
Aug. 16, 1948	94.94	June 26, 1950	94.88	Feb. 27, 1952	94.54
Oct. 14, 1948	94.86	Aug. 16, 1950	94.86	June 11, 1952	94.25
Dec. 15, 1948	94.97	Oct. 10, 1950	94.86	Aug. 25, 1952	95.70
Feb. 17, 1949	94.90	Dec. 11, 1950	94.83	Oct. 15, 1952	94.40
April 14, 1949	94.99			Dec. 22, 1952	94.37

* Pumping from well 25 feet east.

RECORDS OF REPRESENTATIVE WELLS

Descriptions of the wells visited in Wichita and Greeley Counties are given in Tables 15 and 16. All reported information was obtained from the owner or tenant. Measured depths of wells are given to the nearest tenth of a foot below measuring point; reported depths are given in feet below land-surface datum. Measured depths to water level are given to the nearest tenth or hundredth of a foot; reported depths are given in feet. An explanation of the well-numbering system is given on page 11.

TABLE 15.—*Records of wells in Wichita County*

Well No.	Owner or tenant	Type of well (1)	Depth of well (feet) (2)	Diameter of well (inches)	Type of casing (3)	Principal water-bearing bed: Character of material	Principal water-bearing bed: Geologic source	Method of lift (4)	Use of water (5)	Measuring point: Description	Measuring point: Distance above land surface (feet)	Measuring point: Height above mean sea level (feet)	Depth to water level below measuring point (feet) (6)	Date of measurement	REMARKS (Yield given in gallons a minute; drawdown in feet)
T. 16 S., R. 35 W.															
16-35-1dc	E. M. Carson	Dr	....	6	GI	Sand, gravel	Ogallala	Cy, W	S	Top of casing	3.0	3,134 2	80.63	4-26-51	Originally dug, later recased.
16-35-3da	Blair Kough	Dr	11.5	6	GI	do	do	Cy, H	D,S	do	1.5	3,090.2	7.43	5-7-51	
16-35-6aa	O. T. Redding	Dr	67 0	6	GI	do	do	Cy, W	S	do	2.0	3,192.4	59.37	5-7-51	
16-35-6aab	do	Dr	108 5	6	GI	do	do	Cy, W	S	do	0.7	3,210.4	73.9	7-7-48	
16-35-7cb	F. W. and R. Wuthnow	Dr	86.0	6	GI	do	do	Cy, N	N	do	0.5	3,220.4	74.81	5-7-51	Unused stock well.
16-35-8aa	Blair Kough	Dr	82.0	6	GI	do	do	Cy, W	S	do	0.5	3,182.6	62.65	5-9-51	
16-35-10ada	Paul D. Rishel	Dr	101.0	6	GI	do	do	Cy, W	S	do	0.6	3,182.0	81.4	7-28-47	
16-35-10cc	M. Hargrove	Dr	109.0	6	GI	do	do	Cy, W	S	Top of plank	1.0	3,191.3	101 53	5-7-51	
16-35-14cdc	J. W. Nuss	Dr	121.5	6	GI	do	do	Cy, W	D, S	Base of pump	1.1	3,190.6	115.20	7-6-48	
16-35-20ccc	F. F. Miller	Dr	189	18	S	do	do	T, B	I	Hole in pump base	0.5	3,231.7	109.25	11-16-50	Chemical analysis.
													103.74	5-7-51	
16-35-22ad	V. M. Stucky	Dr	124.0	6	GI	do	do	Cy, W	S	Top of casing	1.0	3,194.2	113.06	5-7-51	
16-35-24aa	F. L. Carson	Dr	126.0	6	GI	do	do	Cy, N	N	do	0.5	3,167.8	113.30	5-7-51	Unused domestic well.
16-35-24cc	D. Hollinger	Dr	117.0	6	GI	do	do	Cy, N	N	do	0	3,180.0	113.56	5-4-51	Unused domestic and stock well.
16-35-26add	F. H. Taylor	Dr	122.5	6	GI	do	do	Cy, W	N	do	1.3	3,184.2	112.6	7-28-47	Abandoned.
													112.32	5-4-51	
16-35-28db	Arthur Wiles	Dr	109.0	6	GI	do	do	N, N	N	do	1.0	3,208.1	105.54	5-4-51	Unused stock well.
16-35-31dab	Henry O. Burns	Dr	201	18	S	do	do	T, G	I	Hole in pump base	0.4	3,230.2	102.45	11-16-50	
													98.21	5-7-51	
16-35-32dd	H. F. Sutton	Dr	116.0	6	GI	do	do	Cy,H	N	do	0.5	3,213.4	103.65	5-4-51	Unused domestic and stock well.
16-35-34cb	G. S. Barr	Dr	112.0	6	GI	do	do	Cy, N	N	do	1.5	3,204.0	108.88	5-4-51	Unused domestic well.
T. 16 S., R. 36 W.															
16-36-2ca	L. F. Harper	Dr	135	18	S	do	do	T, D	I	do	0.5	3,268.3	93.48	5-9-51	Estimated yield, 1,000.
16-36-3cc	R. Hobson	Dr	130	18	S	do	do	T, D	I	Plug in pump	1.0	3,285.0	87.60	5-9-51	
16-36-3dcc	Leonard Harper	Dr	138.0	18	S	do	do	T, G	I	do	0.2	3,278.0	87.03	8-14-47	
													86.99	5-9-51	

16-36-4cc	**G. E. Withroder**	**Dr**	**112**			do.	do.	T, D	I	Hole in pump base	0.5	3,301.8	89.41	6-14-51	
16-36-7bcb	**Richard Hobson**	**Dr**	**130**	18	S	do.	do.	T, D	I	do.	0	3,326.7	82.90	8-16-48	Yield, 550
													82.68	6-16-48	
16-36-13cb	**L. M. Fletcher**	**Dr**	**135.0**	6	GI	do.	do.	Cy, W	D, S	Top of casing	0.2	3,245.6	82.10	7-7-48	
													81.80	5-9-51	
16-36-14bc	B. I. Lake	Dr	95.0	6	GI	do.	do.	Cy, W	S	Top of concrete curb	0.5	3,251.5	76.57	5-9-51	
16-36-17ab	P. D. Buell	Dr	165			do.	do.	T, D	I	Hole in pump base	0.5	3,300.1	83.95	6-14-51	
16-36-18ada	Richard Hobson	Dr	58.5	6	GI	do.	do.	Cy, W	S	do.	1.2	3,267.0	38.40	7-7-48	
16-36-20ad	E. C. Edwards	Dr		6	GI	do.	do.	Cy, W	S	do.	0.5	3,250.1	37.35	5-9-51	
16-36-21bd	R. E. Landon	Dr		5	GI	do.	Alluvium	Cy, W	N	do.	1.5	3,222.7	14.44	5-9-51	Unused stock well.
16-36-22cca	Harley Ford	Dr	32.5	6	GI	do.	Alluvium and Ogallala	Cy, W	S	Base of pump	0.3	3,217.8	19.18	7-7-48	
16-36-26bb	Ila Hudson	Dr	130.0	5	GI	do.	Ogallala	Cy, W	S	Hole in pump base	0.5	3,229.5	51.26	5-9-51	
16-36-28dd	Earnest Hooker	Dr		5	GI	do.	Alluvium and Ogallala	Cy, W	D, S	Top of casing	0.3	3,279.9	81.35	5-9-51	
16-36-29cdd	O. B. Stiles	Dr	106.0	6	GI	do.	do.	Cy, W	D, S	do.	0.1	3,308.1	94.69	7-26-47	
													87.07	5-9-51	
16-36-34ad	W. J. Miller	Dr		5		do.	do.	Cy,W,G	S	Base of pump	2.0	3,267.3	92.58	5-9-51	
16-36-36bb	Mabel K. Burns	Dr	23.5	6	GI	do.	Alluvium and Ogallala	Cy, W	S	do.	1.0	3,174.0	17.25	7-7-48	
													16.37	5-9-51	
T. 16 S., R. 37 W.															
16-37-1cb	Phillip Shell	Dr		6	GI	do.	Ogallala	Cy, W	D	Top of casing	0.5	3,334.9	75.85	5-2-51	
16-37-2bcb	Kenneth Woods	Dr	80.5	6	GI	do.	do.	Cy, W	D, S	Top of concrete curb	0.2	3,354.0	67.73	7-21-47	
													67.56	5-2-51	
16-37-4ba	H. H. Barr	Dr		6	GI	do.	do.	Cy, W	D	Top of casing	0.5	3,367.2	73.36	5-2-51	
16-37-6aa	E. R. Langley	Dr	97.0	6	GI	do.	do.	Cy, W	S	Base of pump	1.0	3,399.8	75.9	7-8-48	Reportedly drilled to shale.
													76.60	5-2-51	
16-37-8ba	M. E. C. Langley	Dr		6	GI	do.	do.	Cy, W	S	Top of curb	0	3,382.9	69.63	5-2-51	
16-37-9da	G. W. Dickey	Dr	112	6	GI	do.	do.	Cy, W	S	Top of casing	0.5	3,368.6	73.74	5-2-51	
16-37-12ccc	E. L. Woods	Dr	95.5	6	W	do.	do.	Cy, W	D, S	Top of board cover	1.5	3,339.7	81.57	7-21-47	
16-37-13bbc	Chester Pearson	Dr	143	18	S	do.	do.	T, D	I	Hole in pump base	0.6	3,330.6	78.14	11-16-50	
													77.65	6-14-51	
16-37-13cbb	do.	Dr	88	6	GI	do.	do.	Cy,H,W	D, S				57	10-11-47	Chemical analysis.
16-37-13cd	do.	Dr		5	GI	do.	do.	Cy, W	S	Top of casing	0.5	3,287.7	44.11	5-9-51	
16-37-14cb	I. B. Ganson	Dr	100.5	6	GI	do.	do.	Cy, W	D	Base of pump	0.8	3,354.9	80.10	7-7-48	
16-37-14cc	do.	Dr		6	GI	do.	do.	Cy, W	S	do.	0	3,357.0	82.64	5-2-51	
16-37-18dd1	Maude B. Adams	Dr	85.5	6	GI	do.	do.	Cy, W	D, S	do.	0.5	3,383.0	71.20	8-7-48	
16-37-18dd2	do.	Dr		6	GI	do.	do.	Cy, W	S	Top of casing	1.0	3,384.3	68.76	5-8-51	
16-37-22dd	E. Lewis	Dr				do.	do.	Cy, W	S	Top of board cover	0.5	3,356.3	84.93	5-8-51	
16-37-25db	H. Hoffman	Dr		5	GI	do.	do.	Cy, H	N	Top of casing	0.8	3,330.9	87.92	5-9-51	Unused domestic well.
16-37-26abb	Richard O. Hobson	Dr	96.5	6	GI	do.	do.	Cy, W	O	Top of concrete curb	0.5	3,350.0	88.00	7-21-47	
													87.83	5-2-51	

TABLE 15.—*Records of wells in Wichita County—Continued*

Well No.	Owner or tenant	Type of well (1)	Depth of well (feet) (2)	Diameter of well (inches)	Type of casing (3)	Principal water-bearing bed: Character of material	Principal water-bearing bed: Geologic source	Method of lift (4)	Use of water (5)	Measuring point: Description	Measuring point: Distance above land surface (feet)	Measuring point: Height above mean sea level (feet)	Depth to water level below measuring point (feet) (6)	Date of measurement	REMARKS (Yield given in gallons a minute; drawdown in feet)
T. 16 S., R. 37 W.															
16-37-30ac	H. E. Thurston	Dr	220	....	......	Sand, gravel	Ogallala	T, D	I	Plug in side of pump	0.5	3,392.4	81.24	3-29-51	
16-37-31cc	A. Berning	Dr	....	6	GI	do	do	Cy, W	S	Top of casing	0.5	3,379.4	77.99	5-28-51	
16-37-32ccc	D. Perry	Dr	87.0	6	GI	do	do	Cy, W	D	Top of pump base	0.6	3,378.2	86.21	11-18-50	Not in use.
													83.97	5-8-51	
T. 16 S., R. 38 W.															
16-38-2abb	Harry C. Wines	Dr	87.0	6	GI	do	do	Cy, W	D	Base of pump	1.2	3,433.8	65.3	7-8-48	
16-38-4ccc	D. R. Ganson	Dr	79.0	6	GI	do	do	Cy, W	S	Top of casing	0.2	3,460.5	75.05	7-8-48	Abandoned.
16-38-5bc	Mary L. Johnson	Dr	....	6	GI	do	do	Cy, W	S	do	0.5	3,474.6	71.05	5-20-51	
16-38-9dd	School district	Dr	83.5	6	GI	do	do	Cy, H	D	do	0.5	3,437.1	71.49	5-19-51	
16-38-10ab	Bueller	Dr	210	....	......	do	do	T	I	Plug in side of pump	1.0	3,446.1	78.56	3-29-51	
16-38-12cdc	L. Nelson	Dr	90.5	6	GI	do	do	Cy, W	D	Top of concrete curb	0.5	3,413.1	74.4	7-8-48	
													74.32	5-19-51	
16-38-15ddd	....	Dr	72.0	6	GI	do	do	Cy, W	D	Base of pump	0.3	3,418.4	67.6	7-12-48	
													67.90	5-19-51	
16-38-16ac	V. Watt	Dr	215	....	......	do	do	T, D	I	Plug in side of pump	1.0	3,440.6	73.75	3-29-51	
16-38-16bb	do	Dr	200	18	......	do	do	T, D	I	do	1.0	3,440.4	65.31	3-29-51	
16-38-17bbb	P. R. Woodbury	Dr	105.5	6	GI	do	do	Cy, W	S	Base of pump	0.9	3,460.9	69.8	7-8-48	
													69.94	5-20-51	
16-38-20dd	Anna L. Schrader	Dr	35.0	6	GI	do	Alluvium and / or Ogallala	Cy, W, E	D, S	do	0.2	3,392.3	12.75	7-10-48	
													12.14	3-19-51	
16-38-24bb	J. H. Mitchell	Dr	210	....	......	do	Ogallala	T, D	I	....	......	....	......	....	
16-38-24bc	do	Dr	....	....	......	do	do	Cy, W	S	Top of cog wheel base	1.0	3,406.0	74.25	5-20-51	
16-38-27ccc	E. H. Dierks	Dr	28	5	GI	do	do	Cy, W	D, S	Top of casing	0.5	3,369.9	21.10	5-19-51	Chemical analysis
16-38-30ddd	G. F. Moore	Dr	102.0	7	GI	do	do	Cy, W	D, S	Base of pump	1.4	3,445.0	66.2	7-12-48	
16-38-32dc	J. J. Bauck	Dr	....	6	GI	do	do	N, N	N	Top of casing	0.5	3,444.2	81.38	5-17-51	
16-38-35cb	E. L. Brandner	Du, Dr	70	....	......	do	do	T, T	I	....	......	....	......	....	
16-38-36dd	H. K. Hibbard	Dr	87.5	6	GI	do	do	Cy, W	S	Base of pump	0.4	3,380.9	75.6	7-12-48	Abandoned.
T. 17 S., R. 34 W.															
17-34-30cbb	....	Dr	98.0	6	GI	do	do	N, N	N	Top of casing	1.0	3,161.0	92.69	7-5-48	Located in Scott County; abandoned.

T. 17 S., R. 35 W.															
17-35-5dd	P. P. McKey	Dr	66.0	6	GI	do	do	Cy, N	N	do	0.4	3,153.3	40.84	7-28-47	Abandoned.
17-35-8abb	E. H. Smith			6	GI	Sand	Alluvium	N, N	N	do	0	3,128.6	14.05	5-4-51	
17-35-8da	P. P. McKey			14	C	do	Alluvium and / or Ogallala	HC, G	I	Top of concrete casing	0	3,122.0	15.26	5-4-51	
17-35-13aaa	Ava Hargrove	Dr	116.0	6	GI	do	Ogallala	Cy, W	S	Base of pump	0.8	3,152.9	92.20	7-6-48	Abandoned stock well.
													91.80	5-2-51	
17-35-13acb	L. B. Hargrove	Dr	39.5	6	GI	do	do	Cy, W	S	Top of casing	0.6	3,089.6	26.23	7-6-48	
17-35-17cc	C. C. Roth	Dr	100.0	6	GI	Sand, gravel	do	Cy, W	S	do	0.5	3,208.1	90.36	5-2-51	
17-35-18acb	Grant Shumard	Dr	195	18	S	do	do	T, B	I	Base of pump	0	3,225.7	97.0	5-15-47	Reportedly drilled to shale.
													96.94	5-4-51	
17-35-18cbc	do	Dr	120.0	6	GI	do	do	Cy, W	D, S	Top of casing	0.5	3,222.1	91.69	7-29-47	
17-35-22bb	Dwaine Meisenheimer	Dr	117.5	5	GI	do	do	Cy, H	D	do	0.2	3,200.1	100.39	7-29-47	
													100.04	4-20-51	
17-35-22dcc	do	Dr	95	6	GI	do	do	Cy, W	D, S				87	10-11-47	Chemical analysis
17-35-27bc	L. C. Beeson			6	GI	do	do	Cy, W	D	Top of casing	2.0	3,191.0	85.56	5-4-51	
17-35-28cc	C. F. Moulton	Dr	99.0	12		do	do	N, N	N	Top of tin cover	1.0	3,207.3	89.42	4-18-51	
17-35-30cb	G. Knobbe	Dr	218	18		do	do	T, D	I	Top of concrete curb	0	3,235.2	94.12	4-19-51	
17-35-31cc	Tony Baker	Dr	200	18		do	do	T, B	I	Plug in side of pump	0.5	3,234.0	92.41	4-11-51	
17-35-36bb	E. Wikoff	Dr	194			do	do	T, NG	I	do	1.0	3,177.3	96.13	4-11-51	
T. 17 S., R. 36 W.															
17-36-2bcc	K. E. Sentney	Dr	117.5	6	GI	do	do	Cy, W	N	Base of pump	0.5	3,266.4	104.9	7-7-48	Abandoned.
													98.81	5-9-51	
17-36-4ca	M. B. Wood	Dr	116.0	6	GI	do	do	Cy, W	S	Top of casing	2.0	3,274.4	88.91	5-8-51	
17-36-5dcc	John Tschumper	Dr	99.0	6	GI	do	do	Cy, W	S	do	1.0	3,292.3	96.46	7-26-47	
													94.29	5-8-51	
17-36-8cc	H. L. Washington	Dr	87.0			do	do	Cy, W	S	do	1.0	3,266.8	67.38	5-8-51	
17-36-10ad	School district	Dr	29.0	6	GI	do	do	Cy, H	D	do	0	3,188.3	24.54	5-8-51	
17-36-11aaa	Bertha Schwindt	Dr	30.5	6	GI	do	Alluvium and / or Ogallala	Cy, W	S	do	0.8	3,172.0	24.75	7-7-48	
													23.85	5-9-51	
17-36-11dd	John Schwindt	Dr	111.0	6	GI	do	Ogallala	Cy, W	N	do	0.5	3,246.7	101.01	5-8-51	Unused domestic and stock well.
17-36-14cb	do	Dr	96.0	5	GI	do	do	Cy, W	D	do	0.1	3,238.4	87.69	7-25-47	
17-36-16aa	C. S. Heath		22.0	6	GI	do	do	Cy, W	S	do	0	3,191.2	16.86	5-2-51	
17-36-17daa	John Schwindt	Dr	33.0	6	GI	do	do	J, E	D	do	—7.1	3,204.7	10.44	7-26-47	Chemical analysis.
													18.01	5-8-51	
17-36-19dd	do	Dr	106	10		do	do	T, B	I				8		
17-36-20da	J. Gerstberger	Dr	130			do	do	T, B	I	Plug in side of pump	0.5	3,238.7	48.72	4-20-51	
17-36-23bcc	John Schwindt	Dr	240	16	I	do	do	T, B	I	Land surface	0	3,258.1	89.0	7-25-47	
													100.14	4-20-51	
17-36-26caa	Lloyd Mathes	Dr	219	18	S	do	do	T, D	I					8-25-48	
17-36-26cdd	Henry N. Asmussen	Dr	89.0	6	GI	do	do	Cy, W	D, S	Top of wood cover	1.5	3,239.7	81.57	7-21-47	
17-36-27bb	do	Dr	122.0	6	GI	do	do	Cy, W	S	Top of casing	1.0	3,266.7	94.71	5-2-51	

TABLE 15.—*Records of wells in Wichita County—Continued*

Well No.	Owner or tenant	Type of well (1)	Depth of well (feet) (2)	Diameter of well (inches)	Type of casing (3)	Principal water-bearing bed: Character of material	Principal water-bearing bed: Geologic source	Method of lift (4)	Use of water (5)	Measuring point: Description	Measuring point: Distance above land surface (feet)	Measuring point: Height above mean sea level (feet)	Depth to water level below measuring point (feet) (6)	Date of measurement	REMARKS (Yield given in gallons a minute; drawdown in feet)
T. 17 S., R. 36 W.															
17-36-28abb	J. F. Gerstberger	Dr	111.0	6	GI	Sand, gravel	Ogallala	Cy, W	S	Top of casing	0.8	3,274.0	95.97	11-15-50	
17-36-28bac	do	Dr	201	18	S	do	do	T, B	I	Hole in pump base	0.3	3,277.6	95.17	4-19-51	
17-36-29ddd	C. F. Moulton	Dr	99.0	6	GI	do	do	Cy, H	D	Top of casing	0.2	3,282.7	92.65	7-25-47	
17-36-31ad	G. A. Rowton	Dr	107.5	6	GI	do	do	N, N	N	do	2.5	3,295.1	92.59	5-2-51	
17-36-33bd	W. F. Ihde	Dr	....	5	GI	do	do	N, N	N	Top of SE bolt near casing	0	3,275.2	90.96	4-19-51	
17-36-34dcc	Lloyd Mathes	Dr	88.0	6	G	do	do	Cy, W	S	Top of casing	0.8	3,258.0	75.48	7-25-47	
17-36-35ab	do	Dr	216	....	......	do	do	T, D	I	Hole in pump base	0	3,251.3	94.01	4-19-51	
T. 17 S., R. 37 W.															
17-37-1cbb	John M. Meyer	Dr	91.0	6	GI	do	do	Cy, W	D	Base of pump	0.7	3,327.7	81.9	7-8-48	
													81.96	5-2-51	
17-37-3bcc	A. E. Lewis	Dr	101.5	6	GI	do	do	Cy, W	D	do	3.3	3,357.9	85.85	7-12-48	
													86.00	5-8-51	
17-37-7aa	Leonard Kiefer	Dr	....	6	GI	do	do	N, N	N	Top of casing	1.0	3,368.1	81.67	5-8-51	
17-37-8ba	do	Dr	180	....	......	do	do	T, D	I	Plug in side of pump	1.0	3,365.4	85.15	3-29-51	
17-37-8cc	do	Dr	....	6	GI	do	do	Cy, H	N	Top of casing	0.5	3,327.2	44.97	5-8-51	Unused domestic well.
17-37-10ad	A. E. Lewis	Dr	....	6	GI	do	do	Cy, W	D, S	Base of pump	1.0	3,324.9	77.28	5-2-51	
17-37-13ccc	H. H. Schwindt	Dr	105.5	6	GI	do	do	Cy, W	S	Top of concrete curb	0.2	3,317.1	78.76	7-21-47	
17-37-22bb	E. Langley	......	....	6	GI	do	do	Cy, H	N	Base of pump	1.0	3,283.8	25.44	5-8-51	
T. 17 S., R. 38 W.															
17-38-2aba	Leslie Crouch	Dr	59.0	6	GI	do	do	Cy, W	S	Top of curb	0.2	3,371.6	47.10	7-12-48	
17-38-2bab	do	Dr	120.5	24	GI	do	do	VC, T	I	do	1.2	3,347.1	19.05	7-12-48	
													16.83	3-29-51	
17-38-4baa	Mary Kiefer	Dr	87.5	6	GI	do	do	Cy, W	D, S	Top of casing	0.7	3,431.4	80.90	7-31-47	
													82.88	3-29-51	
17-38-6bdd	J. A. Bryan	Dr	109.5	6	GI	do	do	Cy, W	S	Base of pump	0.9	3,463.7	86.7	7-12-48	
													86.00	5-17-51	
17-38-12dc	John Bauck	Dr	....	....	......	do	do	T, D	I	do	0.5	3,330.1	21.70	5-8-51	

17-38-13ab	L. E. Gorsuch	Dr	....	....	......	do.	Alluvium and Ogallala	Cy, W	N	Hole in pipe	1.5	3,318.8	10.69	5-8-51	Unused domestic and stock well.
17-38-14ccd	John C. Rauck	Dr	99.0	6	GI	do.	Ogallala	Cy, G	S	Base of pump	0.2	3,407.8	85.2	7-13-48	
													84.92	5-7-51	
17-38-17da	L. Oldham	Dr	....	6	GI	do.	do.	Cy, W	N	Top of casing	1.5	3,432.2	85.55	5-17-51	Unused domestic and stock well.
17-38-18dd	F. H. Kleyman	Dr	110	6	GI	do.	do.	Cy, W	D, S	Base of pump	3.4	3,456.0	96.4	7-12-48	
													96.58	5-17-51	
17-38-24ac	John Bauer	Dr	210	....	......	do.	do.	T, P	I	Hole in pump base	0.5	3,303.7	86.76	3-29-51	
17-38-26bb	do.	Dr	....	6	GI	do.	do.	Cy, W	N	Top of casing	0.3	3,410.5	88.70	5-17-51	Unused domestic and stock well.
17-38-27cd	A Gribben	Dr	100.5	6	GI	do.	do.	Cy, W	D, S	Top of wooden cover	2.1	3,414.8	92.3	7-13-48	
17-38-31dd	R. M. Shaw	Dr	....	6	GI	do.	do.	Cy, W	S	Top of disc cover	0.8	3,452.4	95.39	5-17-51	
17-38-36ccd	H. F. Grusing	Dr	100.0	6	GI	do.	do.	Cy, W	D, S	Top of casing	0.4	3,399.3	90.22	7-21-47	
													89.91	5-14-51	
T. 18 S., R. 35 W.															
18-35-2ac	Leo Meeker	Dr	172	....	......	do.	do.	T, NG	I	Hole in pump base	0	3,177.8	87.50	4-18-51	
18-35-5bb	Joseph Herman	Dr	....	....	......	do.	do.	T	I	....	......	....	....	....	
18-35-8bbc	Theo. Bulware	Dr	187	20	S	do.	do.	T, E	I	Top of casing	0	3,318.2	85.51	4-11-51	
18-35-9ac	Anton Berning	Dr	119.0	22	GI	do.	do.	T, T	I	do.	1.0	3,200.5	84.11	8-21-47	
													83.05	4-19-51	
18-35-13bb	A. C. Felt	Dr	95.0	6	GI	do.	do.	Cy, W	N	do.	0.5	3,166.4	78.77	4-27-51	Abandoned stock well.
18-35-13cbb	A. H. Conrardy	Dr	135	18	S	do.	do.	T, B	I	Base of pump	1.0	3,166.2	78.7	8-21-47	
													77.78	4-11-51	
18-35-14bbb	A. C. Felt	Dr	95.0	5	GI	do.	do.	Cy, H	D, O	Top of casing	0.2	3,183.6	83.2	8-19-47	
													82.67	4-30-51	
18-35-14dc	A. H. Conrardy	Dr	....	....	......	do.	do.	Cy	I	Hole in pump base	0	3,171.4	80.14	4-11-51	
18-35-17bb	Tony Baker	Dr	168	....	......	do.	do.	......	I	....	......	....	....	....	
18-35-17ddc	Catholic Church	Dr	108.0	6	GI	do.	do.	Cy, W	P	Top of curb	0.5	3,207.8	81.8	8-24-48	
													80.99	4-19-51	
18-35-27cb	Frank Kohl	Dr	145	18	S	do.	do.	T, G	I	Top of casing	0.3	3,196.2	84.0	10-19-48	
18-35-27cc	do.	Dr	144	18	S	do.	do.	T, B	I	Hole in pump base	0.5	....	83.52	4-18-51	
18-35-27dcc	Don J. Hutchins	Dr	145	18	S	do.	do.	T, D	I	do.	0	3,190.6	89.02	8-13-48	
													85.30	4-18-51	
18-35-31dd	John Meyer	Dr	82.0	6	GI	do.	do.	Cy, W	N	Top of casing	1.0	3,213.3	80.05	4-18-51	Unused domestic well.
18-35-32bb	Victor Kerschen	Dr	....	6	GI	do.	do.	Cy, W	S	do.	1.0	3,160.7	28.43	4-18-51	
18-35-33bc	A. A. Gerstberger	Dr	....	6	GI	do.	do.	Cy, W	S	do.	1.0	3,171.1	48.99	4-18-51	
18-35-34abb	Don J. Hutchins	Dr	143	18	S	do.	do.	T, B	I	Hole in pump base	0	3,192.0	89.18	8-13-48	
													84.89	4-18-51	
18-35-36bcb	B. B. Conrardy	Dr	132.0	18	S	do.	do.	T, D	I	do.	0.5	3,170.1	81.59	8-12-48	Yield, 1,180.
													81.44	4-18-51	
18-35-36cbe	John Kessler estate	Dr	129.0	16	S	do.	do.	T, G	I	do.	0.6	3,178.4	84.55	11-15-50	
													84.98	4-18-51	

TABLE 15.—*Records of wells in Wichita County—Continued*

Well No.	Owner or tenant	Type of well (1)	Depth of well (feet) (2)	Diameter of well (inches)	Type of casing (3)	Principal water-bearing bed: Character of material	Principal water-bearing bed: Geologic source	Method of lift (4)	Use of water (5)	Measuring point: Description	Measuring point: Distance above land surface (feet)	Measuring point: Height above mean sea level (feet)	Depth to water level below measuring point (feet) (6)	Date of measurement	REMARKS (Yield given in gallons a minute; drawdown in feet)
T. 18 S., R. 36 W.															
18-36-2db	H. B. Kuehler	Dr	198	18	......	Sand, gravel	Ogallala	T	I	....		....	....	....	
18-36-3da	P. E. Metheney	Dr	....	5	GI	do	do	Cy, W	S	Top of casing	0.5	3,247.5	84.34	4-19-51	
18-36-9bb	F. Kestner	Dr	190	18	......	do	do	T, B	I	Hole in side of pump	1.0	3,281.4	81.62	4-20-51	
18-36-14bd	Ruth Zinn	Dr	69.0	6	GI	do	do	Cy, W	D, S	Top of curb	2.6	3,233.1	59.8	7-24-48	
													58.56	4-18-51	
18-36-15dd	O. W. Mickel	Dr	165	18	......	do	do	....	I	....	......	....	....	....	
18-36-16dc	A. L. Walk	Dr	....	6	GI	do	do	N, N	N	Top of casing	0.5	3,269.0	76.28	4-18-51	
18-36-18ddc1	Roy E. Gwin	Dr	174	18	S	do	do	T, B	I	Hole in pump base	1.0	3,296.2	84.74	8-18-48	Yield, 820.
													83.45	4-20-51	
18-36-18ddc2	do	Dr	102.0	6	GI	do	do	Cy, W	S	Top of casing	0.3	3,297.7	85.55	7-24-47	
18-36-24ac	Alva Kreitzer	Dr	59.0	6	GI	do	do	Cy, W	S	do	1.5	3,200.4	54.58	7-1-48	
													53.31	4-18-51	
18-36-24ba	do	Dr	120	......	......	do	do	T, G	I	....	......	3,211.5	70	4-18-51	
18-36-31ab	F. E. Clark	Dr	......	6	GI	do	do	Cy, H	N	Top of casing	0.5	3,286.8	75.74	4-18-51	
18-36-36cc	E. L. Richardson	Dr	100.0	6	GI	do	do	Cy, W	S	do	1.0	3,219.6	71.30	4-19-51	
T. 18 S., R. 37 W.															
18-37-2ad	J. E. Fisher	Dr	157	6	S	do	do	Cy, W	D	do	0.5	3,320.8	85.14	5-2-51	Reportedly drilled to shale.
18-37-3bd	D. F. and G. C. Jaeger	Dr	....	10	......	do	do	T	I	Base of pump	1.0	3,345.6	85.80	3-22-51	
18-37-4daa	Joe C. Graber, Jr.	Dr	94.0	6	GI	do	do	Cy, W	S	Top of concrete curb	1.8	3,351.0	87.96	7-21-47	
													87.55	5-14-51	
18-37-8bcb	Owen V. Crouch	Dr	113.0	6	GI	do	do	Cy, W	D, S	Top of casing	1.2	3,372.8	82.50	7-24-47	Chemical analysis
18-37-8bcc	do	Dr	95.0	6	GI	do	do	Cy, W	D, S	do	1.5	3,372.9	75.20	7-24-47	
18-37-11dcc	L. L. Barngrover	Dr	82.5	5	GI	do	do	Cy, N	N	do	0.4	3,318.0	72.70	7-31-47	Abandoned.
18-37-13ac	....	Dr	......	5	GI	do	do	Cy, W	N	do	0.6	3,300.4	70.70	5-2-51	Unused domestic well.
18-37-13cca	City of Leoti	Dr	170	12	S	do	do	T, E	P	....	......	3,307.5	73	11-21-50	Drilled in 1950.
18-37-13dca1	do	Dr	166	12	S	do	do	T, E	P	Hole in pump base	1.0	3,302.5	71.05	8-24-48	
18-37-13dca2	do	Dr	162	12	S	do	do	T, E	P	do	1.0	3,302.8	71.94	8-24-48	
18-37-13ddc	J. F. Moore	Dr	98	5	GI	do	do	Cy, H, W	D, S	....	......	....	61	9-14-47	Chemical analysis
18-37-16ad	H. Rolf	Dr	85.0	6	GI	do	do	Cy, W	N	Top of casing	0	3,344.4	77.17	5-14-51	Unused domestic and stock well.

18-37-16cdd	H. J. Barr	Dr	85.0	6	GI	do	do	Cy, W	D	Top of concrete cover	0.1	3,352.9	83.00	7-22-47	
18-37-19aad	do	Dr	153	18	S	do	do	T, G	I	Bottom of opening in pump base	0.7	3,370.2	89.11 86.32	11-10-50 3-27-51	
18-37-23cbb	Trix Jones	Dr	97.5	6	GI	do	do	Cy, W	S	Top of casing	0	3,323.0	71.05 70.22	7-22-47 3-27-51	
18-37-24add	Vernon Downs	Dr	74.0	6	GI	do	do	Cy, W	D	Base of pump	0.9	3,297.0	70.1	3-27-51	
18-37-25caa	Dale D. Perry	Dr	91.0	6	GI	do	do	Cy, W	D, S	Top of curb	1.2	3,309.6	78.42	7-2-48	
18-37-28ac	H. A. Gibson	Dr	178.5	18	S	do	do	T, B	I	Top of hole in side of pump base	0.5	3,345.4	82.23 81.51	8-21-48 3-22-51	
18-37-34bb	G. Wikoff	Dr	135	12	S	do	do	T, NG	I	Hole in side of pump	1.0	....	59.26	7-12-51	Reportedly drilled to shale.
18-37-34cb	do	Dr	58	....	....	do	do	T, G	I	....	....	....	19	....	
T. 18 S., R. 38 W.															
18-38-1cb	Robert Hill	Dr	203	....	....	do	do	T, D	I	....	....	....		....	
18-38-4bcc	Mrs. A. R. Brandner	Dr	107.5	6	GI	do	do	Cy, W	D	Base of pump	0.4	3,430.5	95.5	7-13-48	
18-38-8cbc	Jessie P. Saville	Dr	61.5	6	GI	do	do	Cy, W	S	do	2.6	3,392.0	40.9 38.40	7-13-48 5-17-51	
18-38-9dd	W. Reimer	Dr	....	....	GI	do	do	Cy, W	S	Top of casing	0.5	3,432.4	91.23	5-17-51	
18-38-14cdd	Weslie W. Krey	Dr	47.5	6	GI	do	do	Cy, W	D, S	Top of concrete curb	0.7	3,356.9	42.35 41.73	7-21-47 4-23-51	
18-38-17aad	W. Reimer	Dr	49.0	5	GI	do	do	Cy,H,W	S	do	1.5	3,393.2	44.70 45.29	11-15-50 5-17-51	Chemical analysis
18-38-20acc	J. A. Reimer	Dr	143.0	8	S	do	do	T, E	I	Hole in pump base	3.0	3,442.8	93.52	3-27-51	Formerly well of Missouri Pacific Railroad.
18-38-20acd	do	Dr	145.5	8	S	do	do	T, E	I	....	....	3,437.8	90	3-27-51	do
18-38-20bc	W. R. Gorsuch	Dr	175	16	GI	do	do	T, D	I	Hole in pump base	1.0	3,443.1	98.64	3-27-51	
18-38-27dd	L. D. Baum	Dr	76.0	6	GI	do	do	Cy, W	S	Base of pump	0	3,385.8	66.20 63.57	7-13-48 4-23-51	
18-38-30bbb	W. R. Gorsuch	Dr	176	18	S	do	do	T, E	I	Top of measuring hole	1.0	3,464.6	109.34	3-27-51	
18-38-30bcc	do	Dr	176	18	S	do	do	T, E	I	....	....	....	....	....	
18-38-30dbb	do	Dr	163.0	18	S	do	do	T, D	I	Top of casing	2.5	3,463.1	119.05	8-19-48	
18-38-31dbc	C. F. Durham	Dr	148.0	16	S	do	do	T, B	I	Top of hole in pump base	0.8	3,454.5	109.89 103.64	8-10-48 4-1-51	Chemical analysis; Yield, 600.
18-38-36dd	Alf Krenzel	Dr	....	6	GI	do	do	Cy, N	N	Top of casing	0.5	3,374.8	79.03	3-27-51	Unused domestic and stock well.
T. 19 S., R. 35 W.															
19-35-2aaa	Fred Wilken	Dr	111	18	S	do	do	T, D	I	Top of concrete curb	0.8	3,158.2	72.18 67.78	11-15-50 4-17-51	Reportedly drilled to shale.
19-35-4dda	Jake Hagelgantz	Dr	95.0	6	GI	do	do	Cy, H	D	Top of casing	0.7	3,197.1	78.52 79.18	7-31-47 4-18-51	
19-35-5cb	Scott Carothers	Dr	142	....	....	do	do	T, D	I	....	....	....	....	....	
19-35-6add	W. A. Langenberg	Dr	87.0	6	GI	do	do	Cy, W	D, S	Top of casing	1.1	3,216.5	84.49	7-1-48	
19-35-8add	Ted Rapier	Dr	80	6	GI	do	do	Cy,H,W	D, S	....	....	....	79	10-13-47	Chemical analysis.

TABLE 15.—*Records of wells in Wichita County—Continued*

Well No.	Owner or tenant	Type of well (1)	Depth of well (feet) (2)	Diameter of well (inches)	Type of casing (3)	Principal water-bearing bed: Character of material	Principal water-bearing bed: Geologic source	Method of lift (4)	Use of water (5)	Measuring point: Description	Measuring point: Distance above land surface (feet)	Measuring point: Height above mean sea level (feet)	Depth to water level below measuring point (feet) (6)	Date of measurement	REMARKS (Yield given in gallons a minute; drawdown in feet)
T. 19 S., R. 35 W.															
19-35-16baa	H. S. Carothers	Dr	100.0	6	GI	Sand, gravel	Ogallala	Cy, W	S	Top of casing	0	3,193.4	73.97	7-3-48	
													73.55	4-18-51	
19-35-23ab	A. Risse	Dr	120.5	6	GI	do	do	Cy, W	S	Base of pump	0.2	3,154.7	114.11	7-3-48	
													108.64	4-18-51	
19-35-29bb	Isabell D. Carter	Dr	53.0	6	GI	do	do	Cy, W	S	do	0.2	3,138.9	34.60	7-3-48	
													32.29	4-19-51	
19-35-34da	A. Sell	Dr	43.0	6	GI	do	do	Cy, W	S	Top of casing	3.0	3,094.4	41.02	7-3-48	
T. 19 S., R. 36 W.															
19-36-4ddd	L. B. Splitter	Dr	105.0	6	GI	do	do	Cy, H	D	Base of pump	1.0	3,258.7	85.90	7-1-48	
													84.21	4-18-51	
19-36-14aaa	E. S. Leisman	Du	72.5	...	...	do	do	Cy, W	D, S	do	1.0	3,219.6	65.28	7-1-48	
19-36-15bb	Mike Palkowitsh	Dr	112	16	...	do	do	T, D	I	...	...	...	44	...	
19-36-15cd	A. E. Freeland	...	...	6	...	do	Alluvium	N, N	N	Top of casing	0.2	3,175.1	12.23	4-19-51	
T. 19 S., R. 37 W.															
19-37-1bdc	Mike Palkowitsh	Dr	91.5	5	GI	do	Ogallala	Cy, W	D, S	Top of concrete curb	0.5	3,294.5	71.80	7-23-47	
													71.40	4-23-51	
19-37-2ccc	do	Dr	29.0	6	GI	do	Alluvium and / or Ogallala	Cy, W	D, S	Top of casing	0.4	3,250.2	15.49	7-25-47	
													15.03	4-23-51	
19-37-12acb	W. E. Willis	Dr	27.0	6	GI	do	do	Cy, W	D, S	Base of pump	1.0	3,231.5	19.60	7-2-48	
19-37-12cad	B. G. Krentzer	Dr	69.0	5	GI	do	Ogallala	Cy,H,W	D	Top of casing	0.5	3,260.0	46.54	11-16-50	See chemical analysis.
													46.56	5-1-51	
19-37-20cbb	Fred B. Lienmann	Dr	112.0	6	GI	do	do	Cy, W	D, S	Top of concrete curb	1.1	3,377.3	94.10	7-23-47	
19-37-22aaa	A. A. Krenzel	Dr	98.3	5	GI	do	do	Cy, W	D, S	do	0.6	3,325.9	97.45	7-23-47	
													94.42	4-23-51	
19-37-25add	Guy Fender	Dr	91.0	6	GI	do	do	Cy, W	D	Base of pump	0.7	3,305.7	76.73	7-2-48	
													76.60	4-23-51	

19-37-31bb	A. C. Buck	Dr	89.5	5	GI	do	do	Cy, W	D	Top of casing	3.2	3,377.4	73.45	8-4-47	
													73.07	4-23-51	
19-37-31dc	Ethel B. Leader	Dr	....	6	GI	do	do	Cy, W	N	do	0	3,386.7	94.23	5-1-51	Unused domestic and stock well.
19-37-32ac	Alex Appl	Dr	56.5	6	GI	do	do	Cy,W,G	S	Base of pump	0.7	3,322.3	51.15	7-14-48	
19-37-34dd	Henry C. Toland	Du	....	40	C	do	Alluvium	Cy, G	S	Bottom of plank cover	5.0	3,279.4	23.04	5-1-51	
T. 19 S., R. 38 W.															
19-38-1ac	W. H. Krenzel	Dr	132	6	GI	do	Ogallala	Cy, W	S	Base of pump	0	3,387.9	96.0	5-30-48	Reportedly drilled to shale.
													89.22	4-23-51	
19-38-7abb	Earl Perry	Dr	174	18	S	do	do	T, B	I	Hole in pump base	0	3,463.6	123.30	11-16-50	
													123.02	3-27-51	
19-38-8cbb	C. F. Durham	Dr	164.5	6	GI	do	do	Cy, W	S	Base of pump	1.1	3,450.2	114.6	7-14-48	
19-38-21cc	E. G. Burch	Dr	....	6	GI	do	do	Cy, W	N	do	0.5	3,429.7	108.16	5-1-51	Unused stock well.
19-38-22ac	T. C. Krenzel	Dr	123.5	6	GI	do	do	Cy, W	S	do	1.0	3,433.0	111.1	7-14-48	
19-38-25bbb	Les H. Roberts	Dr	97.0	5	GI	do	do	N, N	N	Top of casing	0	3,398.5	91.27	11-15-50	Chemical analysis. Well has been abandoned since water sample was collected in 1947
													91.09	4-23-51	
19-38-27caa	Phil Teeter	Dr	131.5	6	GI	do	do	Cy, W	S	Base of pump	0.6	3,398.8	89.1	7-14-48	
													86.17	4-23-51	
19-38-33abb	N. R. and E. Grant	Dr	132.0	6	GI	do	do	Cy, W	S	do	1.5	3,433.0	118.8	7-14-48	
T. 20 S., R. 35 W.															
20-35-3aa	W. J. Keller	Dr	137.0	6	GI	do	do	Cy, W	D, S	do	1.5	3,174.3	126.8	7-3-48	
20-35-7adc	A. and H. Holstein	Dr	108.0	6	GI	do	do	Cy, W	S	do	1.0	3,178.0	90.95	7-2-48	
20-35-14da	A. and L. Buerkle	Dr	63.5	6	GI	do	do	Cy, W	S	do	0	3,084.2	53.55	7-2-48	
20-35-15bbb	A. T. Warrington	Dr	88	6	GI	do	do	Cy, W	D, S	....	......	3,129.2	76	7-13-47	Chemical analysis.
20-35-15bc	do	Dr	80.5	....	......	do	do	T, G	I	Base of pump	0.5	3,112.2	58.32	4-19-51	
20-35-15cbd	do	Dr	49.0	6	GI	do	do	Cy, W	S	do	1.0	3,103.6	48.55	7-2-48	
20-35-16ddd	L. W. Henry	Dr	102.5	6	GI	do	do	Cy, H	D	do	0.4	3,152.4	95.29	7-2-48	Abandoned school well.
													94.90	4-19-51	
20-35-28cdd	A. Horton	Dr	141.0	6	GI	do	do	Cy, W	S	do	0	3,188.3	133.65	7-2-48	
T. 20 S., R. 36 W.															
20-36-4add	Mary Flora	Dr	77.0	6	GI	do	do	Cy, N	N	Top of casing	0.2	3,226.6	61.10	7-1-48	Abandoned.
20-36-10ab	C. G. Hetzler estate	Dr	53.0	6	GI	do	do	Cy, W	N	do	1.0	3,184.0	38.83	4-19-51	
20-36-12acc	J. P. Scheuerman	Dr	69.5	6	GI	do	do	Cy, W	D, S	Base of pump	1.2	3,162.2	59.50	7-3-48	
20-36-14dad	Elmer Hartman	Dr	115.5	6	GI	do	do	Cy, N	O	Top of casing	0.5	3,225.8	105.37	8-4-47	
20-36-17bbd	L. G. Henry	Du	21.5	....	......	do	Alluvium and / or Ogallala	Cy, W	D, S	Top of board cover	2.4	3,232.0	17.6	7-2-48	
20-36-21bbb	H. W. Kuhlmann	Dr	118.0	6	GI	do	Ogallala	Cy, W	S	Base of pump	0.3	3,257.9	94.45	7-2-48	
20-36-30cdd	A. J. Collingwood	Dr	114.5	6	GI	do	do	Cy, W	S	Top of casing	0.5	3,285.3	107.7	7-1-48	
20-35-35daa	Ethel Reweris	Dr	115.0	4	GI	do	do	Cy, W	S	Base of pump	1.5	3,226.7	103.46	7-2-48	

TABLE 15.—*Records of wells in Wichita County—Concluded*

Well No.	Owner or tenant	Type of well (1)	Depth of well (feet) (2)	Diameter of well (inches)	Type of casing (3)	Principal water-bearing bed: Character of material	Principal water-bearing bed: Geologic source	Method of lift (4)	Use of water (5)	Measuring point: Description	Measuring point: Distance above land surface (feet)	Measuring point: Height above mean sea level (feet)	Depth to water level below measuring point (feet) (6)	Date of measurement	REMARKS (Yield given in gallons a minute; drawdown in feet)
T. 20 S., R. 37 W.															
20-37-1dac	L. G. Henry	Du	32.5	....	......	Sand, gravel	Alluvium and / or Ogallala	Cy, W	S	Top of casing	2.0	3,240.6	16.7	7-1-48	
20-37-13add	Neil Phillips	Du,Dn	24	48	R,IP	do	Ogallala	Cy, W	S	Top of plank cover	1.3	3,249.1	13.20	11-15-50	Chemical analysis.
20-37-14dac	Gus Hahn	Dr	21.5	6	GI	do	do	Cy, W	D	Base of pump	0.2	3,259.4	14.4	7-1-48	
20-37-16bc	L. O. Lile	Dr	47.5	6	GI	do	do	Cy,W,G	S	do	1.0	3,311.6	26.55	7-14-48	
20-37-20ccc	J. P. Stevenson	Dr	114.5	5	GI	do	do	Cy, W	S	do	0.2	3,357.4	92.00	8-4-47	
T. 20 S., R. 38 W.															
20-38-12bcd	J. S. Friesen	Dr	99.5	6	GI	do	do	Cy, W	S	do	0.3	3,382.0	87.8	7-14-48	
20-38-18add	E. E. Hoard	Dr	140.0	6	GI	do	do	N, N	N	Top of casing	0	3,446.4	135.80	8-4-47	Abandoned.
20-38-36bbb	Warren Strong	Dr	144.5	6	GI	do	do	Cy, W	S	Base of pump	0.3	3,395.7	112.3	7-14-48	

1. Dn, driven; Dr, drilled; Du, dug.
2. Reported depths are given in feet below land surface; measured depths are given in feet and tenths to the nearest half foot below measuring point.
3. C, concrete; GI, galvanized iron; I, iron; IP, iron pipe; R, rock; S, steel; W, wood.
4. Type of pump: Cy, cylinder; HC, horizontal centrifugal; J, jet; N, none; T, Turbine; VC, vertical centrifugal. Type of power: B, butane gas; D, diesel; E, electricity; G, gasoline; H, hand; N, none; NG, natural gas; P, propane gas; T, tractor; W, wind.
5. D, domestic; I, irrigation; N, not in use; O, observation; P, public supply; S, stock.
6. Measured depths to water are given in feet, tenths, and hundredths; reported depths are given in feet.

TABLE 16.—*Records of wells in Greeley County*

Well No.	Owner or tenant	Type of well (1)	Depth of well (feet) (2)	Diameter of well (inches)	Type of casing (3)	Principal water-bearing bed: Character of material	Principal water-bearing bed: Geologic source	Method of lift (4)	Use of water (5)	Measuring point: Description	Measuring point: Distance above land surface (feet)	Measuring point: Height above mean sea level (feet)	Depth to water level below measuring point (feet) (6)	Date of measurement	REMARKS (Yield given in gallons a minute; drawdown in feet)
T. 15 S., R. 40 W.															
15-40-35dda	Ethel Burnett	Dr	93.0	6	S	Sand, gravel	Ogallala	Cy, W	S	Base of pump	1.4	3,598.0	61.7	7-20-48	Located in Wallace County.
													61.19	7-16-51	
T. 16 S., R. 39 W.															
16-39-1bd	J. F. Weaver	Dr	....	6	GI	do	do	Cy, W	S	Top of casing	0.5	3,435.0	14.05	5-20-51	
16-39-3da	do	Dr	100.0	6	GI	do	do	N, N	N	do	1.0	3,513.4	73.91	5-20-51	
16-39-4ad	do	Dr	75.5	6	GI	do	do	Cy, W	S	do	0	3,517.4	63.0	8-5-47	
													62.29	5-20-51	
16-39-6cb	E. Bates	Dr	68.0	6	GI	do	do	Cy, W	S	Base of pump	0.5	3,539.9	42.97	5-28-51	
16-39-7aa	....	Dr	50.0	6	GI	do	do	Cy, W	S	Top of casing	0.5	3,509.7	24.82	5-28-51	
16-39-7dd	E. Bates	Dr	....	6	GI	do	do	Cy, W	S	Top of pump base	1.0	3,541.4	60.33	5-28-51	
16-39-8ca	H. A. Johnson	......	33.0	6	GI	do	do	N, N	N	Top of casing	1.4	3,507.1	29.07	5-20-51	
16-39-9bc	R. M. McAllister	Dr	46.0	6	GI	do	do	Cy, W	S	Top of tin over casing	1.0	3,492.3	27.15	5-20-51	
16-39-10aa	C. L. Reimer	......	24.0	6	GI	do	Alluvium	N, N	N	Top of casing	0.5	3,456.4	17.09	5-20-51	
16-39-10ba	Sarah J. Sides	Dr	54.0	6	GI	do	Ogallala	Cy, W	S	do	1.0	3,479.8	36.98	5-20-51	Unused stock well.
16-39-10cd	School district 21	Dr	104.5	5	GI	do	Ogallala	Cy, H	D	do	0.2	3,523.7	82.95	8-5-47	
16-39-12bd	J. F. Weaver	......	19.0	6	GI	do	Alluvium	Cy, W	S	do	0.5	3,429.2	15.30	11-27-51	
													82.80	5-20-51	
16-39-12dd	T. F. Rozean	Dr	16.0	6	GI	do	do	N, N	N	do	0.4	3,416.6	11.25	7-8-48	
													10.92	5-20-51	
16-39-18da	E. Bates	Dr	112.5	6	GI	do	do	Cy, W	S	do	0.8	3,580.7	106.2	7-20-48	
													105.85	5-28-51	
16-39-24bd	R. M. McAllister	Dr	81.0	6	GI	do	do	Cy, W	S	do	1.0	3,472.9	65.68	5-28-51	
16-39-26ad	G. C. Zink	Dr	106.0	5	S	do	do	Cy, W	D	Base of pump	0.4	3,493.7	85.7	7-20-48	
													85.34	5-28-51	
16-39-28da	G. H. Mitchell	Dr	90.0	6	GI	do	do	Cy, W	D, S	Top of metal plate	0	3,526.4	86.25	5-28-51	
16-39-33cc	Charles Rozean	Dr	107.5	6	GI	do	do	Cy, W	D, S	Base of pump	1.5	3,521.5	75.0	7-20-48	

TABLE 16.—*Records of wells in Greeley County—Continued*

Well No.	Owner or tenant	Type of well (1)	Depth of well (feet) (2)	Diameter of well (inches)	Type of casing (3)	Principal water-bearing bed: Character of material	Principal water-bearing bed: Geologic source	Method of lift (4)	Use of water (5)	Measuring point: Description	Measuring point: Distance above land surface (feet)	Measuring point: Height above mean sea level (feet)	Depth to water level below measuring point (feet) (6)	Date of measurement	REMARKS (Yield given in gallons a minute; drawdown in feet)
T. 16 S., R. 40 W.															
16-40-2cb	A. Sell	Dr	51.5	6	GI	Sand, gravel	Ogallala	Cy, W	S	Top of curbing	0.2	3,566.0	39.5	7-20-48	
													38.32	7-13-51	
16-40-2da	T. M. Boulware	Dr	53.0	6	GI	do.	do.	Cy, W	S	Edge of casing	0.2	3,550.3	35.92	7-22-47	
													36.29	5-28-51	
16-40-6bb	H. Hoffman	Dr	112.0	6	GI	do.	do.	N, N	N	Top of casing	0	3,677.6	102.83	7-13-51	
16-40-9cb1	Ben Raines et al.	Dr	138.0	6	GI	do.	do.	Cy, W	D, S	Top of casing	0.8	3,677.4	122.9	7-20-48	
16-40-9cb2	do.	Dr		6	GI	do.	do.	Cy, W	S	do.	0.5	3,676.2	125.50	7-13-51	
16-40-10aa	A. Sell	Dr	63.0	6	GI	do.	do.	Cy, W	S	Top of 4-inch x 4-inch block	1.0	3,590.0	59.33	7-13-51	
16-40-14da	T. H. Ochsner	Dr	128.0	6	GI	do.	do.	Cy, W	S	Top of casing	1.0	3,613.4	110.90	5-28-51	
16-40-18aac	Cecil Sebastian	Dr	214	20	I	do.	do.	T, D	I	Hole in pump base	0.5	3,695.8	120.83	11-20-50	
16-40-18add	do.	Dr	129.0	6	GI	do.	do.	Cy, W	D, S	Top of curbing	1.0	3,687.6	123.5	7-22-48	
16-40-27ccd	Earnest Kysar	Dr	75	5	GI	do.	do.	Cy, W	S	Top of casing	0.5	3,592.0	69.91	7-13-51	Chemical analysis.
16-40-28bb	O. L. Wilson	Dr	98.0	6	GI	do.	do.	Cy, W	S	Top of curbing	1.9	3,636.6	85.2	7-20-48	
													78.00	7-13-51	
16-40-35abb	B. L. Brunswig	Dr	118.5	18	S	do.	do.	N, N	N	Top of casing	0.3	3,581.0	75.59	11-20-50	Drilled as irrigation well, but not used.
16-40-36bb	do.	Dr	84.0	6	S	do.	do.	Cy, W	S	do.	0.7	3,570.9	68.05	7-20-48	
T. 16 S., R. 41 W.															
16-41-5caa	R. Murphy	Dr	135.5	6	GI	do.	do.	Cy, W	S	do.	0	3,741.0	118.0	7-22-48	
16-41-9db	P. V. Johnson	Dr	115	4	GI	do.	do.	Cy, W	S	do.	1.1	3,713.0	109	7-22-48	
16-41-12bd	J. A. Hoffman	Dr	199.0	6	S	do.	do.	Cy, W	D, S	do.	2.0	3,675.1	94.2	7-22-48	
													94.78	7-18-51	
16-41-14da	do.	Dr	133.0	6	GI	do.	do.	Cy, W	S	do.	0.8	3,707.3	123.9	7-22-48	
													124.52	7-18-51	
16-41-20bab	James Howell	Dr	153.0	6	GI	do.	do.	Cy, W	S, O	do.	0.4	3,741.4	130.50	8-5-47	Chemical analysis.
16-41-26dd	Schneider and Sell	Dr	160.5	6	GI	do.	do.	Cy, W	S	Top of curbing	1.1	3,706.0	136.40	7-27-48	
													136.80	7-16-51	
16-41-30bb	A. J. Dyke	Dr	142.0	6	GI	do.	do.	Cy, W	N	Northwest corner of hole under pump	0	3,763.0	138.76	7-18-51	Unused stock well.
16-41-32aa	R. F. Nolan	Dr	196.0	6	S	do.	do.	Cy, W	D, S	Top of curbing	1.8	3,770.9	164.1	7-27-48	
													164.26	7-18-51	

T. 16 S., R. 42 W.															
16-42-2bb	H. Anger	Dr	26.0	....	....	do	do	T, D	I	....	....	....	....	....	
16-42-6aa	E. K. Beedy	Dr	181.5	6	GI	do	do	Cy, W	S	Top of curbing	1.2	3,838.0	179.5	7-30-48	
16-42-9aba	H. and R. Sloan	Dr	213.0	6	GI	do	do	Cy, W	S	Top of casing	0.2	3,524.0	170.05	7-30-48	
													169.78	7-16-51	
16-42-10dd	L. A. Young	Dr	198.0	6	S	do	do	Cy, W	S	do	0.5	3,808 0	179.56	7-16-51	
16-42-11ad	B. F. Montgomery	Dr	163.0	6	GI	do	do	Cy, W	D, S	Base of pump	0.2	3,784.2	158.5	7-30-48	
16-42-12ad	M. E. Markwell	Dr	....	....	S	do	do	Cy, W	D	Top of 2½-inch pipe	0	3,769.0	146.81	7-18-51	
16-42-18dd	M. R. Rusco	Dr	212	6	GI	do	do	Cy, W	D	Hole in pump base	2.5	3,862.2	194.69	7-18-51	
16-42-20daa	Enoch Sandstedt	Dr	200	4	GI	do	do	Cy, W, G	D, S	....	....	....	178	10-2-47	Chemical analysis.
16-42-22acb	L. A. Young	Dr	235	18	S	do	do	T, D	I	Hole in pump base	0	3,818.2	174.1	8-16-48	
16-42-22db	do	Dr	240	....	....	do	do	T, E	I	South edge of casing	0.5	....	175.38	4-2-51	
16-42-22dd	do	Dr	190.5	5	S	do	do	Cy, W	S	Base of pump	0.8	3,808.1	168.3	7-27-48	
16-42-28cd	George Gano	Dr	168.5	6	GI	do	do	Cy, W	D, S	Top of casing	2.1	3,820.6	163.7	7-30-48	
16-42-30da	Phil H. Cooper	Dr	171.5	6	GI	do	do	N, N	N	Top of curbing	0.5	3,844.9	171.2	7-30-48	Abandoned.
T. 16 S., R. 43 W.															
16-43-14cb	Luther and Warren	Dr	250.0	6	GI	do	do	Cy, G	D, S	Hole in pump base	1.0	3,928.2	247.30	7-16-51	
16-43-26aa	F. W. Halber et al.	Dr	210.0	5	GI	do	do	Cy, N	N	Top of curbing	0.4	3,894.4	205.43	8-12-47	Abandoned.
													205.60	7-16-51	
T. 17 S., R. 39 W.															
17-39-1cc	F. H. Kingman	Dr	71.0	6	GI	do	do	Cy, W	S	Top of pump base	1.0	3,451.0	50.78	5-28-51	
17-39-2cd	Bill Miller	Dr	115.0	6	GI	do	do	Cy, W	D, S	Base of pump	1.0	3,500.8	97.9	7-20-48	
17-39-3bbc	Floyd Kleyman	Dr	110.0	5	GI	do	do	Cy, W	D, S	Top of plate	0.4	3,513 3	96.15	11-16-50	Chemical analysis.
17-39-6aa	L. R. Kiefer	Dr	112.0	6	GI	do	do	Cy, W	N	Top of casing	0.5	3,552.6	107.54	5-28-51	Unused stock well; reported to be poor well.
17-39-10dd	D. G. Mitchell	Dr	120.0	6	GI	do	do	Cy, H	N	do	0.5	3,506.6	101.52	5-28-51	Former school well.
17-39-13dc	A. Kleyman	Dr	108.0	6	GI	do	do	Cy, W	D, S	do	2.4	3,479.0	98.8	7-19-48	
17-39-16dc	Grace Burgard	Dr	119.0	6	GI	do	do	Cy, W	S	Top of curbing	1.2	3,544.0	115.1	7-19-48	
													114.75	5-28-51	
17-39-17cb	H. R. Green	Dr	110.0	6	GI	do	do	Cy, W	S	Top of casing	0.5	3,547.1	102.14	5-28-51	
17-39-20dd	E. Legard	Dr	121.0	6	GI	do	do	Cy, W	D, S	do	0.5	3,542.4	108.77	5-28-51	
17-39-25dc	E. Hoard	Dr	119.5	7	S	do	do	Cy, G	D	do	1.1	3,465.6	103.0	7-19-48	
17-39-32cdd	H. J. Ross	Dr	142.0	6	S	do	do	Cy, W	S	do	1.0	3,553.6	116.5	7-19-48	
T. 17 S., R. 40 W.															
17-40-1da	A. E. Smith	Dr	140.0	6	GI	do	do	N, N	N	do	0.5	3,579.6	132.60	5-28-51	New well.
17-40-5cb	C. P. Woods	Dr	161.5	6	GI	do	do	Cy, W	S	Top of curbing	1.2	3,651.4	145.1	7-21-48	
													145.53	7-18-51	
17-40-13bb	Calvin C. Doty	Dr	139.0	6	GI	do	do	Cy, W	D, S	do	1.1	3,600.0	133.7	7-22-48	
17-40-14aa	do	Dr	147.0	6	S	do	do	Cy, W	S	Top of casing	0.5	3,593.8	130.55	7-18-51	
17-40-16ccc	G. F. Coupland	Dr	162.0	6	S	do	do	Cy, W	S	Base of pump	2.1	3,633.4	142.2	7-22-48	
17-40-16dc	E. T. Wears	Dr	148.0	6	GI	do	do	Cy, W	D, S	Top of hole in pump base	1.0	3,626 6	137.42	7-18-51	

TABLE 16.—*Records of wells in Greeley County—Continued*

Well No.	Owner or tenant	Type of well (1)	Depth of well (feet) (2)	Diameter of well (inches)	Type of casing (3)	Principal water-bearing bed: Character of material	Principal water-bearing bed: Geologic source	Method of lift (4)	Use of water (5)	Measuring point: Description	Measuring point: Distance above land surface (feet)	Measuring point: Height above mean sea level (feet)	Depth to water level below measuring point (feet) (6)	Date of measurement	REMARKS (Yield given in gallons a minute; drawdown in feet)
T. 17 S., R. 40 W.															
17-40-22ccd	R. V. Gibson	Dr	150.0	5	GI	Sand, gravel	Ogalala	Cy, W	O	Top of casing	0.1	3,620.8	140.28	8-7-47	Unused domestic and stock well.
													138.92	7-18-51	
17-40-29dd	C. R. Clift	Dr	157.0	6	GI	do	do	Cy, W	D, S	Base of pump	0.5	3,630.8	126.1	7-22-48	
17-40-30bcb	A. Sell	Dr	156.0	6	GI	do	do	Cy, W	S	Top of curbing	0.6	3,648.5	133.4	7-21-48	
													132.94	7-18-51	
17-40-31ca	A. E. Smith	Dr	146.0	6	GI	do	do	Cy, W	S	Top of casing	1.0	3,647.0	130.64	7-18-51	
17-40-34bb	H. Gibson	Dr	134.0	6	GI	do	do	Cy, W	S	Top of 4-inch plank	0	3,577.3	92.55	7-18-51	
17-40-36bd	H. G. Ochsner	Dr	139.0	6	GI	do	do	Cy, W	S	Top of casing	1.0	3,578.9	119.22	5-28-51	
T. 17 S., R. 41 W.															
17-41-8cc	Grace H. Bjork	Dr	117.5	6	GI	do	do	N, N	N	do	0	3,750.3	115.0	7-21-48	Abandoned.
													115.90	7-18-51	
17-41-12dd	A. Sell	Dr	199.5	6	GI	do	do	Cy, W	S	Base of pump	1.0	3,701.0	192.3	7-21-48	
													194.32	7-18-51	
17-41-26cd	Oscar Zimmerman	Dr	191.0	6	GI	do	do	Cy, W	D, S	do	1.2	3,706.4	159.5	7-21-48	
17-41-28bcc	H. Wendelburg	Dr	132.0	6	GI	do	do	N, N	S	Top of casing	0	3,747.5	117.24	11-17-50	Chemical analysis.
17-41-30ddd	R. Darland	Dr	112.0	5	GI	do	do	Cy, W	N	do	0.4	3,741.4	89.83	8-6-47	Abandoned.
T. 17 S., R. 42 W.															
17-42-2ab	D. Steel	Dr	169.0	6	GI	do	do	N, N	N	do	1.0	3,818.0	164.6	7-27-48	
													162.40	7-18-51	
17-42-19add	J. P. Ahlgrim	Dr	30	5	GI	do	Alluvium	Cy, W	D, S	....	......	....	20	10-2-47	Chemical analysis.
17-42-28bcc	F. S. Luther	Dr	23.5	5	GI	do	Alluvium and / or Ogallala	Cy, W	N	Top of casing	2.3	3,778.7	18.34	8-6-47	Abandoned.
17-42-36bbb	Greeley Lands, Inc.	Dr	1,140	8	N	Sandstone	Dakota	N, N	N	....	......	....	....	12-17-48	Chemical analysis (bailer sample). Test hole; well never finished.
T. 17 S., R. 43 W.															
17-43-24ba	Harry Simpson	Du	14.5	30	I	Sand, gravel	Alluvium	Cy, W	S	Top of casing, west side	1.0	3,812.5	10.85	7-30-48	

T. 18 S., R. 39 W.															
18-39-1cc	Gerald White	Dr				do	Ogallala	T, D	I						
18-39-4da	W. T. Rauch	Dr	112.0	6	GI	do	do	Cy, W	S	Top of casing	1.0	3,509.5	103.32	5-28-51	
18-39-10add	H. Richardson	Dr	133.0	5	GI	do	do	N, N	N	do	0.4	3,491.0	109.9	8-5-47	Abandoned.
													109.54	5-28-51	
18-39-19ab	Mrs. Robert Pringle	Dr	83.0	6	GI	do	do	Cy, W	S	do	0.5	3,502.6	71.92	5-28-51	
18-39-21dd	J. S. Davison	Dr	142.0	7	GI	do	do	Cy, W	S	Base of pump	3.1	3,502.3	114.2	7-19-48	
													112.85	5-28-51	
18-39-22dd	H. E. Reynolds	Dr	120.0	6	S	do	do	N, N	N	Top of casing	0	3,487.8	116.3	8-9-48	New well in 1948.
18-39-35aa	H. Waltner	Dr	129.5	6	GI	do	do	Cy, W	S	Base of pump	0.2	3,482.0	120.0	7-13-48	Abandoned.
T. 18 S., R. 40 W.															
18-40-1ddc	R. A. Fleming	Dr	90.0	6	GI	do	do	Cy, W	D, S	Top of casing	0.8	3,537.6	71.80	11-18-50	Chemical analysis.
18-40-2dd	R. J. Anderson	Dr	130.0	6	GI	do	do	Cy, W	S	do	1.4	3,593.0	119.3	7-19-48	
18-40-4cb	J. J. Oschner	Dr	161			do	do	T, E	I	Base of pump	1.0	3,615.3	125.8	9-19-51	
18-40-5dad	City of Tribune	Dr	192	18	S	do	do	T, E	P				128		
18-40-5dd	A. E. Smith	Dr	158.0	6	GI	do	do	Cy, W	D	Top of curbing	0.4	3,624.7	130 2	7-22-48	
18-40-7cbb	City of Horace	Du	80	144	C	do	do	T, E	P				60	11-20-50	
18-40-7cbc	do	Dr	80	10	S	do	do	T, E	P				67	11-20-50	
18-40-11bb	W. Byerley	Dr	87.0	6	GI	do	do	Cy, W	S	Base of pump	0.3	3,545.1	70.64	7-19-48	
													70.80	7-18-51	
18-40-13ad	W. H. Mallory	Dr	84.0	6	GI	do	do	Cy, W	S	Top of casing	0.5	3,521.8	70.05	7-18-51	
18-40-17ddb	Neil McLeod	Dr	55	5	GI	do	do	Cy, W	D, S				30	10-2-47	Chemical analysis.
18-40-28ddd	A. G. Fecht	Dr	108.5	6	GI	do	do	Cy, W	S	Top of casing	1.1	3,586.8	103.18	8-23-48	
18-40-29aca	City of Tribune	Dr	128.0	12	S	do	do	T, E	P	Top of hole in south side of pump base	1.2	3,600.5	109.10	11-20-50	
18-40-30aaa	B. F. Brinkman	Dr	118.0	6	GI	do	do	Cy, W	S	Base of pump	1.1	3,626.3	109.9	8-4-48	
18-40-34aa	E. H. Heckert	Dr	11.6	6	GI	do	do	Cy, W	N	Top of casing	0.2	3,560.7	86.2	8-21-47	Abandoned.
T. 18 S., R. 41 W.															
18-41-3ddc	Bert Beady	Dr	83.0	6	GI	do	do	Cy, W	D, S	Base of collar	0.5	3,644.6	81.9	7-21-48	
18-41-12aa	C. R. Wacker	Dr	64.0	6	GI	do	do	Cy, W	D, S	Top of casing	0.4	3,592.0	59.55	7-21-48	
18-41-15bd	Harriet Kinman	Dr	68.0	6	GI	do	do	Cy, W	S	do	2.1	3,664.5	57.1	8-3-48	
18-41-21bb	Aaron Sell	Dr	96.0	6	GI	do	do	Cy, W	S	do	1.0	3,704.0	73.2	8-3-48	
18-41-26aa	do	Dr	113.5	5	GI	do	do	Cy, W	O	do	0	3,663.5	101.66	8-6-47	Abandoned.
18-41-35dc	J. V. Kuttler	Dr	119.5	6	GI	do	do	Cy, W	S	Top of curbing	0.9	3,691.1	118.4	8-4-48	
T. 18 S., R. 42 W															
18-42-21cc	A Sell et al.	Dr	98.0	6	GI	do	do	Cy, W	S	Base of pump	0.9	3,830.2	88.6	8-3-48	
18-42-22ddd	Lewis Boles	Dr	110.0	6	GI	do	do	Cy,H,W	D, S	Top of casing	1.0	3,800.9	99.28	11-17-50	Chemical analysis.
18-42-25aaa	G. E. Gano	Dr	107.5	6	GI	do	do	Cy, W	S	Base of pump	0	3,749.4	98.1	8-3-48	
18-42-27ac	E. H. Boles	Dr	106.0	6	GI	do	do	Cy, W	S	Top of casing	0.9	3,803.5	96.1	8-3-48	
18-42-33dc	W. D. Kelly	Dr	65.5	6	GI	do	do	Cy, W	S	Top of wood cover	0	3,804.0	64.6	8-3-48	

TABLE 16.—*Records of wells in Greeley County—Concluded*

Well No.	Owner or tenant	Type of well (1)	Depth of well (feet) (2)	Diameter of well (inches)	Type of casing (3)	Principal water-bearing bed		Method of lift (4)	Use of water (5)	Measuring point			Depth to water level below measuring point (feet) (6)	Date of measurement	REMARKS (Yield given in gallons a minute; drawdown in feet)
						Character of material	Geologic source			Description	Distance above land surface (feet)	Height above mean sea level (feet)			
T. 18 S., R. 43 W.															
18-43-12dd	Ora D. Osburn	Du	57.0	40	C	Sand, gravel	Ogallala	Cy, G	D, S	Top of curbing	2.2	3,851.2	54.9	7-30-48	
18-43-23dd	U. S. Turley	Dr	99.5	6	GI	do.	do.	Cy, W	D	Top of casing	0	3,885.0	82.2	8-3-48	Pumps down quickly.
18-43-26da	O. T. Hatfield	Dr	77.5	6	GI	do.	do.	Cy, W	D	do.	0	3,866.3	66.3	8-3-48	
T. 19 S., R. 39 W.															
19-39-4ba	Dale E. Taylor	Dr	148.5	6	GI	do.	do.	Cy, W	D	Base of pump	0.3	3,512.0	138.29	8-23-48	
19-39-7ba	J. Allen	Du	134.0	48	N	do.	do.	N, N	N	Top of wood cover	0	3,546.2	129.2	8-23-48	Abandoned.
19-39-12ac	Earl Perry	Dr	170	.....	.....	do.	do.	T, G	I	Edge of pump base	1.0	3,477.9	131.36	3-27-51	
19-39-14abb	M. Oerke	Dr	157.5	6	GI	do.	do.	Cy, W	D, S	Top of curbing	0.4	3,491.0	146.03	8-23-48	
19-39-20da	J. V. Kuttler	Dr	141.0	6	GI	do.	do.	Cy, W	D, S	Top of beams over casing	0.5	3,508.7	134.83	8-23-48	
T. 19 S., R. 40 W.															
19-40-1ab	Fred Helms	Dr	133.5	6	GI	do.	do.	Cy, W	D, S	Base of pump	1.8	3,557.2	119.21	8-23-48	
19-40-16cc	R. W. Vogt	Dr	126.0	6	GI	do.	do.	Cy, W	D, S	Top of curbing	1.1	3,608.3	119.1	8-5-48	Chemical analysis.
19-40-17dd	do.	Dr	138.0	6	S	do.	do.	Cy, W	D, S	Top of casing	2.1	3,613.9	123.5	8-4-48	
T. 19 S., R. 41 W.															
19-41-1dd	J. Jaque	Dr	122.5	6	GI	do.	do.	Cy, W	D	Base of pump	1.8	3,674.7	111.8	8-4-48	
19-41-2baa	G. S. Waldren	Dr	130	6	GI	do.	do.	Cy, W	D, S	.....	.....	.....	122	10-1-47	Chemical analysis.
19-41-8bb	Anna Wetzel	Dr	140.0	6	GI	do.	do.	Cy, W	D, S	Top of curbing	0.2	3,729.2	128.7	8-4-48	
19-41-16aa	Birdie A. Floyd	Dr	152.0	6	GI	do.	do.	Cy, W	S	Base of pump	1.4	3,695.4	145.8	8-4-48	Abandoned.
19-41-17cb	A. Pearson	Dr	138.0	6	GI	do.	do.	Cy,W,G	D, S	Top of curbing	1.8	3,721.7	124.85	8-4-48	
19-41-22aa	L. L. Allen et al.	Dr	149.5	6	GI	do.	do.	Cy, W	D, S	Base of pump	1.0	3,680.0	139.1	8-5-48	
19-41-26aa	G. F. Coupland	Dr	154.5	6	S	do.	do.	Cy, W	D	do.	1.0	3,666.1	140.2	8-5-48	
T. 19 S., R. 42 W.															
19-42-6dc	G. E. Gano	Du	62.0	72	.....	do.	do.	N, N	N	Top of wood cover	0	3,829.7	38.6	8-3-48	Abandoned.
19-42-11ad	N. Hobart	Dr	79.0	6	GI	do.	do.	Cy, W	S	Base of pump	0.5	3,761.0	56.95	8-3-48	
19-42-15aa	J. Olivier	Du	67.5	20	GI	do.	do.	Cy, W	D	Top of casing	0.9	3,780.6	55.4	8-3-48	
19-42-32ca	J. Pittman	Dr	105.5	6	GI	do.	do.	N	N	do.	0.5	3,796.8	94.4	8-5-48	Abandoned.
19-42-33da	do.	Dr	98.5	6	GI	do.	do.	Cy, W	S	Board on top of casing	0.5	3,767.9	88.1	8-5-48	

19-42-34da	do.	Dr	105.5	6	GI	do.	do.	Cy, W	D, S	Top of curbing	1.4	3,763.8	96.05	8-5-48	
19-42-35add	J. C. Stanley	Dr	95	6	GI	do.	do.	Cy,H,G	D				85	10-1-47	Chemical analysis.
19-42-36bc	M. J. Tipton	Dr	99.5	5	GI	do.	do.	Cy, W	N	Top of casing	0.1	3,738.9	86.06	8-7-47	Abandoned.
T. 19 S., R. 43 W.															
19-43-11da	G. B. Matthews	Dr	81.0	6	GI	do.	do.	Cy, W	S	do.	0.6	3,853.1	46.8	8-3-48	
19-43-25da	L. Nietfield	Dr	101.5	6	GI	do.	do.	Cy, W	O	Top concrete curbing	1.1	3,821.0	91.8	8-7-47	Abandoned.
T. 20 S., R. 39 W.															
20-39-3dd	Lee Toadvine	Dr	191.0	6	GI	do.	do.	Cy, W	D, S	Base of pump	0.6	3,501.0	178.27	8-23-48	Chemical analysis.
20-39-18aa	J. A. Watson	Dr	225.0	6	GI	do.	do.	Cy, W	D, S	Top of collar	0.4	3,537.8	198.13	8-23-48	
20-39-19aa	J. M. Watson	Dr	171.5	6	GI	do.	do.	Cy, W	S	Top of curbing	1.1	3,520.0	170.5	8-23-48	
20-99-33aa	W. H. Klein	Dr	205.5	6	GI	do.	do.	Cy, W	N	Top of casing	0	3,499.0	192.15	8-18-47	Abandoned.
T. 20 S., R. 40 W.															
20-40-12ab	G. W. Case	Dr	210.5	6	GI	do.	do.	Cy, W	D	Top of curbing	0	3,548.6	209.0	8-23-48	
20-40-34bb	E. F. Ogle	Dr	196.0	6	GI	do.	do.	Cy, W	D	Top of beams	0.4	3,572.0	191.3	8-4-48	
T. 20 S., R. 41 W.															
20-41-5bac	F. W. Tuttle	Dr	150	6	GI	do.	do.	Cy, E	D, S				138	9-30-47	Chemical analysis.
20-41-7ab	L. B. Grisell	Dr	131.5	6	GI	do.	do.	Cy, W	D	Top of casing	0.2	3,703.0	108.4	8-4-48	
20-41-10aa	J. J. Goering	Dr	170	6	GI	do.	do.	Cy, E	D, S	Base of pump	0.5	3,656.3	166.2	8-5-48	Yield, 3. Chemical analysis.
20-41-23aa	W. R. Houston	Dr	183.0	6	GI	do.	do.	Cy, W	D, S	Top of curbing	0.8	3,641.9	168.05	8-4-48	
20-41-33aa	C. DeVaney	Dr	129.0	5	GI	do.	do.	Cy, W	D	Top of casing	0.6	3,652.0	116.7	8-21-47	
T. 20 S., R. 42 W.															
20-42-19aa	L. W. Payton	Dr	62.5	8	GI	do.	do.	Cy, W	D, S	Top of curbing	1.1	3,785.9	56.15	8-5-48	
20-42-21bb	P. J. P. Schrag	Du	47.5	60		do.	do.	Cy, W	D, S	do.	1.1	3,777.7	44.8	8-5-48	
T. 21 S., R. 41 W.															
21-41-4ab	Paul G. Burns	Dr	128.0	6	GI	do.	do.	Cy, W	D	Top of casing	0.5	3,666.4	116.8	8-4-48	Located in Hamilton County.

1. Dr, drilled; Du, dug.
2. Reported depths are given in feet below land surface; measured depths are given in feet and tenths to the nearest half foot below measuring point.
3. C, concrete; GI, galvanized iron; I, iron; N, none; S steel.
4. Type of pump; Cy, cylinder; N, none; T, turbine. Type of power; B, butane gas; D, diesel; E, electricity; G, gasoline; H, hand; N, none; W, wind.
5. D, domestic; I, irrigation; N, not in use; O, observation; P, public supply; S, stock.
6. Measured depths to water are given in feet, tenths, and hundredths; reported depths are given in feet.

LOGS OF WELLS AND TEST HOLES

Listed on the following pages are the logs of 57 wells and test holes in Wichita, Greeley, and adjacent counties. Included are: the logs of 26 test holes in Wichita County and 24 test holes in Greeley County drilled by the State Geological Survey during the course of the investigation; 1 test hole drilled during the study of the geology and ground-water resources of Scott County; 1 test hole drilled during the study of the geology and ground-water resources of Hamilton and Kearny Counties; 2 irrigation wells in Wichita County; 1 of the municipal wells at Leoti; and 2 deep test wells to the Dakota formation. The locations of the test holes drilled by the State Geological Survey of Kansas are shown in Figure 12. The samples from the test holes were collected and studied in the field by Prescott, who supervised the drilling and prepared the logs of the holes.

Logs entitled "sample logs" were of wells drilled by the State Geological Survey for which samples were collected.

16-35-1ddd. *Sample log of test hole in the SE cor. sec. 1, T. 16 S., R. 35 W.; drilled September 1947. Surface altitude, 3,174.5 feet.*

	Thickness, feet	Depth, feet
Road fill, black	4	4
QUATERNARY—Pleistocene		
Sanborn formation		
Silt, clayey, light-brown	21	25
TERTIARY—Pliocene		
Ogallala formation		
Clay, silty, calcareous, white	5	30
Mortar bed and caliche	20	50
Caliche, very sandy, white	20	70
Sand, fine to medium, compact, slightly calcareous, brown; contains coarse sand and fine to medium gravel	10	80
Gravel, fine to medium, and coarse sand	9	89
Sand, fine, brown	12	101
Sand, coarse to medium; contains fine, partly cemented brown sand	19	120
Sand, medium to coarse; contains fine to coarse gravel,	10	130
Sand, coarse to medium; contains fine gravel and sand,	23	153
CRETACEOUS—Gulfian		
Niobrara formation—Smoky Hill chalk member		
Shale, soft, chalky, calcareous, yellow-brown	9	162
Shale, calcareous, gray	18	180

16-35-31dab. ***Drillers log of irrigation well of Henry O. Burns in the NW¼ NE¼ SE¼ sec. 31, T. 16 S., R. 35 W.; drilled by Ben Hasz Drilling Co.***

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Sanborn formation		
Topsoil	20	20
TERTIARY—Pliocene		
Ogallala formation		
Gypsum rock and clay	25	45
Gypsum rock	13	58
Sand	3	61
Sandstone	14	75
Clay	15	90
Clay, sandy	37	127
Sand, fine	19	146
Rock	7	153
Sand, fine	21	174
Clay, sandy	3	177
Sand	3	180
Gravel	19	199
CRETACEOUS—Gulfian		
Niobrara formation—Smoky Hill chalk member		
Yellow clay	3	202

16-35-36ddd. ***Sample log of test hole in the SE cor. sec. 36, T. 16 S., R. 35W.; drilled August 1947. Surface altitude, 3,170.3 feet.***

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Sanborn formation		
Silt, black	3	3
Silt, brown	6	9
Clay and silt, compact, brown	11	20
TERTIARY—Pliocene		
Ogallala formation		
Clay, silt, and fine sand, compact, calcareous, tan	17	37
Gravel, fine, and coarse sand	2	39
Mortar bed, hard, white	3	42
Silt, sandy, calcareous, tan	7	49
Mortar bed, white to tan	21	70
Mortar bed, sandy, white to tan	20	90
Sand, coarse to medium; contains silt and fine sand	40	130
Sand, coarse to medium; contains fine sand and fine caliche fragments	20	150
Sand, medium; contains clayey silt and fine sand	10	160
Sand, coarse to medium	20	180
Gravel, fine, and coarse sand	10	190
Gravel, medium to fine	8	198
CRETACEOUS—Gulfian		
Niobrara formation—Smoky Hill chalk member		
Shale, calcareous, black	9	207

16-36-4ccc. *Sample log of test hole in the SW cor. sec. 4, T. 16 S., R. 36 W.; drilled September 1947. Surface altitude, 3,301.7 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Sanborn formation		
Silt, dark-brown	4	4
Silt, light-brown	19	23
TERTIARY—Pliocene		
Ogallala formation		
Clay, silty, white	4	27
Clay, silty; contains sand and gravel	5.5	32.5
Mortar bed, hard, calcareous, white to brown	20.5	53
Gravel, medium to fine, and coarse sand	3	56
Sand, coarse to medium; contains fine gravel	4	60
Sand, coarse, and fine gravel; contains medium to coarse gravel	10	70
Sand, coarse, and fine gravel; contains medium to fine sand	10	80
Sand, coarse, and fine gravel; contains medium gravel,	1.5	81.5
Sand, fine, and brown sticky silt	1.5	83
Gravel, fine, and coarse sand	6	89
Sand, fine, and brown compact silt	4	93
Sand, coarse, and fine gravel	7	100
Sand, coarse to medium; contains fine sand and silt	10	110
Limestone, impure, hard, white	2	112
Sand, coarse, and fine gravel	10	122
Clay, sandy, yellow	3	125
CRETACEOUS—Gulfian		
Niobrara formation—Smoky Hill chalk member		
Shale, chalky, yellow	7	132
Shale, chalky, gray	3	135

16-37-33ccc. *Sample log of test hole in the SW cor. sec. 33, T. 16 S., R. 37 W.; drilled November 1950. Surface altitude, 3,367.3 feet. Water level, 80.5 feet below land surface, Nov. 18, 1950.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Sanborn formation		
Peoria silt member		
Silt, black	2	2
Silt, tan	8	10
Loveland silt member		
Silt, reddish-brown (Sangamon soil)	3	13
TERTIARY—Pliocene		
Ogallala formation		
Silt, clay, sandy, calcareous, cream-colored	7	20
Caliche, cream to reddish-brown	32	52
Mortar bed	16	68
Sand, fine to coarse	3	71
Mortar bed, soft	19	90
Silt, clay, and very fine to fine sand, brown	13	103

	Thickness, feet	Depth, feet
Sand, fine to very coarse, and fine gravel; contains a small amount of medium to coarse gravel	17	120
Sand, fine to very coarse, and fine to medium gravel; contains silt and clay	10	130
Sand, fine to coarse; contains silt and clay and very coarse sand	10	140
Sand, fine to coarse; contains very coarse sand and fine to medium gravel	45	185
CRETACEOUS—Gulfian		
Niobrara formation—Smoky Hill chalk member		
Shale, yellow	5	190
Shale, gray	3	193

16-38-16bbb. *Sample log of test hole in the NW cor. sec. 16, T. 16 S., R. 38 W.; drilled October 1947. Surface altitude, 3,444.9 feet. Water level, 62.3 feet below land surface, October 29, 1947.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Sanborn formation		
Silt, hard, black	3	3
Silt, hard, light-brown	15	18
TERTIARY—Pliocene		
Ogallala formation		
Clay, sandy, light-tan	3	21
Silt and fine sand, plastic, calcareous, brown to light-tan	8	29
Gravel, coarse to fine, and coarse sand	12	41
Silt and fine sand, plastic, calcareous, brown	15	56
Sand, coarse to medium, and fine to coarse gravel	10	66
Silt and fine sand, plastic, calcareous, light-tan	4	70
Silt and fine sand, plastic, light-green	10	80
Silt and fine sand, plastic, brown; contains medium to coarse sand	42	122
Sand, medium to coarse, and fine to coarse gravel; contains some plastic light-tan fine sand and silt	8	130
Sand, coarse, and fine to coarse gravel	8	138
Silt and fine sand, plastic, calcareous, yellow-brown	2	140
Sand, medium to coarse, and fine to coarse gravel; contains plastic yellow-brown silt and fine sand	10	150
Sand, medium to coarse, and fine to coarse gravel	12	162
Sand, medium to coarse, and fine to medium gravel; contains some plastic yellow-brown silt and fine sand from 174 to 178 feet	18	180
Sand, fine to coarse, and fine to coarse gravel	10	190
Sand, fine to coarse	16	206
Silt and fine sand, plastic, yellow	1	207
CRETACEOUS—Gulfian		
Niobrara formation—Smoky Hill chalk member		
Shale, yellow	2	209
Shale, calcareous, gray	1	210

16-40-24aaa. *Sample log of test hole in the NE cor. sec. 24, T. 16 S., R. 40 W.; drilled October 1947. Surface altitude, 3,592.1 feet. Water level, 105.4 feet below land surface, October 8, 1947.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Sanborn formation		
Silt, dark-brown	3	3
Silt, light-brown	15	18
TERTIARY—Pliocene		
Ogallala formation		
Caliche, hard, light-tan	16	34
Sand, medium to coarse, and fine to coarse gravel	6	40
Mortar bed; contains a small amount of caliche and coarse gravel	10	50
Mortar bed	10	60
Sand, fine to coarse, and fine to coarse gravel, partly consolidated; contains some tan clay	10	70
Sand, fine to coarse, and fine gravel; contains some sandy brown clay	10	80
Sand, coarse, and fine to coarse gravel; contains gray clay from 87 to 90 feet	10	90
Sand, coarse, and fine to coarse gravel	11	101
Sand, coarse to medium, and fine to coarse gravel; contains tan clay	9	110
Sand, fine, and silt, sticky, plastic; contains some coarse sand and fine to coarse gravel	12	122
Clay, sandy, light-tan	8	130
Clay, fine sand, and silt, light-tan	8	138
Sand, fine to coarse, and fine gravel; contains a small amount of clay	12	150
Sand, coarse to medium, and fine to medium gravel	10	160
Sand, coarse to medium, and fine to coarse gravel	10	170
Gravel, coarse to fine, and yellow clay	4	174
CRETACEOUS—Gulfian		
Niobrara formation—Smoky Hill chalk member		
Shale, chalky, gray	6	180

16-41-15ccc. *Sample log of test hole in the SW cor. sec. 15, T. 16 S., R. 41 W.; drilled October 1947. Surface altitude, 3,703.9 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Sanborn formation		
Silt, dark-brown	2	2
Silt, light-brown	12	14
TERTIARY—Pliocene		
Ogallala formation		
Sand, medium to fine; contains a small amount of coarse sand	2	16
Clay and silt, calcareous, tan	4	20
Clay, calcareous, gray	8	28

	Thickness, feet	Depth, feet
Sand, medium to coarse	7	35
Clay, calcareous, gray	13	48
Sand, medium to coarse	1	49
Clay, gray	1	50
Clay, gray, containing some coarse sand and fine gravel	6	56
Clay, gray, and gray plastic fine sand and silt	4	60
Clay, white to light-tan	6	66
Silt and fine sand, plastic, brown	4	70
Silt and fine sand, plastic, light-tan; contains some coarse sand	5	75
Silt and fine sand, plastic, brown; contains medium to coarse sand and fine gravel	12	87
Sand, medium to coarse, and fine to coarse gravel	3	90
Silt and fine sand, clayey, brown; contains medium to coarse sand	7	97
Sand, coarse, and fine to medium gravel; contains tan plastic fine sand and silt	3	100
Sand, coarse, and fine to coarse gravel	6	106
Silt and fine sand, plastic; contains medium to coarse sand and fine to coarse gravel	4	110
Sand, coarse, and fine to coarse gravel; contains some plastic silt and fine sand	10	120
Silt and fine sand, plastic, light-tan; contains medium to coarse sand and fine gravel	10	130
Silt and fine sand, plastic, light-tan; contains some medium to coarse sand	20	150
Sand, fine to coarse, and silt; contains fine gravel	12	162
Clay, hard, calcareous, green	1	163
Sand, fine to coarse, and silt	7	170
Sand, fine to coarse, and fine to medium gravel; contains green to white clay	10	180
Sand, fine to coarse, and fine to medium gravel	10	190
Sand, medium to coarse, and fine gravel	10	200
Sand, coarse, and fine to medium gravel; contains some medium sand	20	220
Sand, fine to coarse	24	244
Sand, coarse, and fine to medium gravel; contains some yellow clay	6	250
Sand, medium to coarse, and fine to coarse gravel	7	257
CRETACEOUS—Gulfian		
Niobrara formation—Smoky Hill chalk member		
Shale, chalky, yellow	3	260
Shale, gray	6	266

16-42-19bbb. *Sample log of test hole in the NW cor. sec. 19, T. 16 S., R. 42 W.; drilled October 1947. Surface altitude, 3,873.8 feet. Water level, 203.6 feet below land surface, October 10, 1947.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Sanborn formation		
Silt, dark-brown	1	1
Silt, sandy, hard, light-brown	9	10
TERTIARY—Pliocene		
Ogallala formation		
Caliche, hard, sandy; "Algal limestone" at top	10	20
Caliche, hard, sandy, gray; contains some gray clay	8	28
Mortar bed	60	88
Sand, fine to coarse	6	94
Silt and fine sand, plastic, light-tan; medium to coarse sand and fine to coarse gravel	16	110
Sand, medium to coarse, and fine to coarse gravel	20	130
Sand, coarse, and fine to coarse gravel; contains plastic silt and fine sand	10	140
Sand, medium to coarse, and fine gravel	10	150
Sand, medium to coarse, and fine to coarse gravel	13	163
Sand, coarse, and fine to medium gravel; contains some light-tan clay and silt	13	176
Clay and silt, light-tan; contains some coarse sand and fine to medium gravel	4	180
Silt and fine sand, plastic, light-tan; contains some medium sand	30	210
Sand, medium to coarse; contains fine sand and silt and a small amount of fine gravel	10	220
Sand, coarse, and fine to medium gravel	5	225
Sand, medium to coarse, and fine gravel	2	227
Sand, coarse, and fine to medium gravel; contains sandy yellow-brown clay	3	230
CRETACEOUS—Gulfian		
Niobrara formation—Smoky Hill chalk member		
Clay, calcareous, yellow-brown	4	234
Chalk, yellow-brown	3	237
Shale, blue-gray	3	240

17-35-7add. *Sample log of test hole in the SE cor. NE¼ sec. 7, T. 17 S., R. 35 W.; drilled October 1947. Surface altitude, 3,132.1 feet. Water level, 10.7 feet below land surface, October 29, 1947.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Alluvium		
Silt, dark-brown	3	3
Silt, light-brown	7	10
Clay, limy, gray	7	17
Clay, limy, blue	10	27
TERTIARY—Pliocene		
Ogallala formation		
Sand, fine to coarse; contains fine gravel	3	30
Gravel, fine to coarse; contains fine to coarse sand	14	44

	Thickness, feet	Depth, feet
Sand, fine, and silt, plastic, yellow-brown; contains medium to coarse sand from 48 to 50 feet	6	50
Sand, fine to coarse; contains fine gravel	30	80
Sand, fine to coarse, and fine gravel; contains some plastic yellow-brown fine sand and silt from 88 to 90 feet	10	90
Sand, medium to coarse, and fine gravel; contains plastic yellow-brown silt and fine sand	10	100
Clay, sandy, limy, yellow	13	113
CRETACEOUS—Gulfian		
Niobrara formation—Smoky Hill chalk member		
Shale, calcareous, blue-gray	5	118

17-36-9bbb. *Sample log of test hole in the NW cor. sec. 9, T. 17 S., R. 36 W.; drilled September 1947. Surface altitude, 3,283.9 feet. Water level, 93.0 feet below land surface, September 14, 1947.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Sanborn formation		
Silt, dark-brown	3	3
Silt, light-brown; contains snail shells	15.5	18.5
Silt, sticky, light-brown	1.5	20
TERTIARY—Pliocene		
Ogallala formation		
Caliche, white	10	30
Limestone, sandy, impure	8	38
Silt, sandy, brown to white	5	43
Caliche, hard, white; contains some opal	11	54
Silt, sandy, brown	9	63
Sand, medium	14.5	77.5
Silt, sandy, brown	2.5	80
Silt, sandy, sticky, brown; contains medium sand	44	124
Caliche, white	6	130
Sand, fine to medium	40	170
Sand, fine to medium; contains silt	12	182
Sand, coarse, and fine to medium gravel	6	188
CRETACEOUS—Gulfian		
Niobrara formation—Smoky Hill chalk member		
Shale, clayey, calcareous, weathered, yellow	4	192
Shale, calcareous, gray	4	196

17-36-16cbc. *Sample log of test hole in the SW¼ NW¼ SW¼ sec. 16, T. 17 S., R. 36 W.; drilled September 1947. Surface altitude, 3,192.6 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Alluvium		
Silt, black	4	4
Silt, brown	2	6
Sand, fine to medium	4	10
Sand, coarse to medium; contains fine gravel	17	27

	Thickness, feet	Depth, feet
TERTIARY—Pliocene		
Ogallala formation		
Gravel, fine to medium; contains some coarse gravel	13	40
Gravel, fine, and coarse to medium sand	20	60
Sand, coarse to medium, and fine gravel	20	80
Sand, coarse to medium; contains fine gravel	20	100
Sand, coarse, and fine gravel	8	108
CRETACEOUS—Gulfian		
Niobrara formation—Smoky Hill chalk member		
Shale, calcareous, weathered, yellow	12	120
Shale, calcareous, yellow	7	127
Shale, calcareous, blue-gray	3	130

17-36-29aaa. *Sample log of test hole in the NE cor. sec. 29, T. 17 S., R. 36 W.; drilled September 1947. Surface altitude, 3,279.9 feet. Water level,* 93.5 *feet below land surface, September 14, 1947.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Sanborn formation		
Silt, dark-brown	4	4
Silt, light-brown	14	18
Silt, clayey, light-brown	6	24
TERTIARY—Pliocene		
Ogallala formation		
Clay, calcareous, white	4	28
Caliche, hard, white	22	50
Caliche, white to brown	10	60
Sand, medium to fine, semiconsolidated, brown	10	70
Sand, medium to fine, semiconsolidated, brown; contains coarse sand	10	80
Sand, fine and silt, brown; contains fragments of white caliche	13	93
Sand, medium to coarse, reddish-brown; contains fine sand and silt	5	98
Sand, coarse to medium, pinkish; contains fine gravel and sand	12	110
Sand, coarse and fine gravel; contains some medium to fine sand	11	121
Caliche, white	2	123
Sand, medium, pink	7	130
Sand, coarse to medium	7	137
Sand, fine, and silt, sticky	3	140
Sand, medium, pink	13	153
Sand, fine, semiconsolidated	3	156
Sand, medium, pink	31	187
Sand, coarse; contains fine gravel	11	198
CRETACEOUS—Gulfian		
Niobrara formation—Smoky Hill chalk member		
Shale, weathered, calcareous, yellow	2	200
Shale, calcareous, yellow	28	228
Shale, calcareous, gray	2	230

17-38-16ccc. *Sample log of test hole in the SW cor. sec. 16, T. 17 S., R. 38 W.; drilled September 1947. Surface altitude, 3,434.8 feet. Water level, 90.2 feet below land surface, September 25, 1947.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Sanborn formation		
Silt, dark-brown	2	2
Silt, sticky, light-brown	12	14
TERTIARY—Pliocene		
Ogallala formation		
Clay, white	4	18
Caliche, sandy, white	2	20
Caliche, sandy, white to light-tan	8	28
Silt, sandy, light-green	2	30
Caliche, white to light-brown; contains medium to fine gravel and brown sandy silt	10	40
Silt, sandy, brown to light-gray	10	50
Sand, medium to coarse, and fine gravel, partly cemented, brown	10	60
Sand, coarse to medium, and fine to medium gravel	7	67
Silt, sandy, brown; contains fine gravel	3	70
Silt, sandy, brown to light-tan	10	80
Sand, fine, and silt	5	85
Silt, sandy, light-brown	15	100
Sand, fine, and silt	8	108
Sand, fine, and silt, compact, brown	2	110
Sand, fine, and silt	5	115
Silt, sandy, white	13	128
Sand, fine to coarse	10	138
Silt, sandy, yellow	2	140
Sand, fine to medium, and silt; contains some coarse sand	10	150
Sand, fine to medium, and silt	7	157
CRETACEOUS—Gulfian		
Niobrara formation—Smoky Hill chalk member		
Shale, clayey, calcareous, yellow	10	167
Shale, calcareous, gray	3	170

17-39-19bbb. *Sample log of test hole in the NW cor. sec. 19, T. 17 S., R. 39 W.; drilled October 1947. Surface altitude, 3,573.6 feet. Water level, 116.5 feet below land surface, October 8, 1947.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Sanborn formation		
Silt, dark-brown	2	2
Silt, light-brown	16	18
TERTIARY—Pliocene		
Ogallala formation		
Clay, white	4	22
Mortar bed, hard, white	4	26
Mortar bed, light-brown	11	37
Sand, medium to coarse, and fine gravel	4	41

	Thickness, feet	Depth, feet
Sand, fine to coarse, and fine to coarse gravel; partly cemented from 50 to 60 feet	19	60
Sand, coarse, and fine to coarse gravel; contains some tan clay from 67 to 70 feet	10	70
Clay, sandy, tan	5	75
Mortar bed, hard, tan	7	82
Sand, coarse, and fine to coarse gravel	5	87
Clay, gray, and a small amount of coarse gravel	2	89
Sand, medium to coarse, and fine to medium gravel	8	97
Mortar bed	13	110
Silt and fine sand, plastic; contains fine to coarse gravel	10	120
Silt and fine sand, sticky, plastic, and medium to coarse sand; contains a small amount of fine gravel,	17	137
Sand, fine to medium	3	140
Sand, coarse, and fine to medium gravel	7	147
Sand, coarse, and fine to coarse gravel; contains light-tan clay	3	150
Sand, coarse, and fine to medium gravel	5	155
Gravel, fine to coarse; contains light-tan clay	5	160
Sand, coarse, and fine to coarse gravel; contains light-tan clay	10	170
Sand, medium to coarse, and fine to medium gravel	10	180
Sand, coarse, and fine to coarse gravel; contains yellow clay from 189 to 190 feet	10	190
CRETACEOUS—Gulfian		
Niobrara formation—Smoky Hill chalk member		
Shale, calcareous, yellow	7	197
Shale, calcareous, gray	3	200

17-41-22bbb. *Sample log of test hole in the NW cor. sec. 22, T. 17 S., R. 41 W.; drilled September 1947. Surface altitude, 3,715.3 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Sanborn formation		
Silt, dark-brown	0.5	0.5
Silt, light-brown	17.5	18
TERTIARY—Pliocene		
Ogallala formation		
Clay, light-tan; contains some fine to medium gravel	2	20
Sand, medium to coarse	3	23
Clay, light-tan	2	25
Sand, coarse, and fine gravel	5	30
Sand, coarse, and fine to medium gravel	10	40
Gravel, fine to medium	10	50
Clay, sandy, light-tan; contains coarse to medium gravel	8	58
Silt, sandy, light-tan	2	60
Clay, sandy, light-brown; contains some fine to medium sand from 68 to 70 feet	10	70

	Thickness, feet	Depth, feet
Sand, coarse, and fine gravel	5	75
Sand, coarse, and fine to medium gravel; contains some clay and coarse gravel	5	80
Caliche, hard	5	85
CRETACEOUS—Gulfian		
Niobrara formation—Smoky Hill chalk member		
Shale, calcareous, yellow-brown	23	108
Shale, gray	4	112

17-42-19ccc. *Sample log of test hole in the SW cor. sec. 19, T. 17 S., R. 42 W.; drilled October 1947. Surface altitude, 3,868.5 feet.*

	Thickness, feet	Depth, feet
No sample recovered	30	30
TERTIARY—Pliocene		
Ogallala formation		
Sand, fine to coarse	1	31
Sand, coarse, and fine to coarse gravel	2	33
Sand, medium to coarse, and fine gravel; contains some clay	3.5	36.5
CRETACEOUS—Gulfian		
Niobrara formation—Smoky Hill chalk member		
Shale, chalky, yellow	12	48.5
Shale, calcareous, blue-gray	1.5	50

Drillers log of test hole in NW cor. sec. 36, T. 17 S., R. 42 W., drilled in November 1948, by Western Drilling Company.

	Thickness, feet	Depth, feet
Topsoil	3	3
Soil, dark, tight	3	6
Clay, yellow	16	22
Sand and gravel, medium; contains some limestone	3	25
Clay, sandy, yellow; contains a few pebbles	9	34
Clay, sticky, yellow	16	50
Clay, sandy, yellow; contains small layers of medium gravel,	10	60
Shale, weathered, sticky, yellow	17	77
Shale, blue; contains some small hard layers of slate shale	440	517
Shale, blue; drills fairly hard (about 10 feet an hour) becomes lighter in color	63	580
Shale, soft, gray; contains some light-gray fragments	25	605
Shale, gray; drills hard, rough; contains light-gray fragments,	12	617
Shale, fairly soft, gray; contains hard layers of slate shale, 6 inches to 1 foot through	23	640
Shale, fairly soft, light-gray	25	665
Shale, hard, white	15	680
Shale, white; becomes softer, drills faster	30	710
Shale, very sandy, iron-gray; soft drilling	75	785
Shale, blue; fairly soft drilling	50	835
Slate shale, hard, blue	11	846

	Thickness, feet	Depth, feet
Shale, hard, blue; contains some small fragments of Dakota sandstone	14	860
Shale, hard, blue	38	898
Slate shale, hard, black	17	915
Dakota sandstone, hard drilling; very little sample coming up, some fine sand settling in ditch, mud keeps getting heavy	48	963
Dakota sandstone, very hard drilling; put on 2⅞ inch rock bit at 970 feet	72	1,035
Dakota sandstone, soft, fairly easy drilling (10 feet in 30 minutes)	39	1,074
Very hard layer; no returns	3	1,077
Soft drilling (10 feet in 15 minutes), no returns	38	1,115
Tight drilling (1 hour for 10 feet), getting a few cuttings of blue shale	20	1,135
Hard drilling (2 hours, 2 feet); getting fine cuttings of hard blue shale	5	1,140

17-43-13ddd. *Sample log of test hole in the SE cor. sec. 13, T. 17 S., R. 43 W.; drilled October 1947. Surface altitude, 3,819.8 feet. Water level, 24.6 feet below land surface, October 10, 1947.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Sanborn formation		
Silt, dark-brown	1	1
Silt, light-brown	15	16
TERTIARY—Pliocene		
Ogallala formation		
Clay, calcareous, gray	5	21
Sand, medium to coarse; contains some fine to coarse gravel	9	30
CRETACEOUS—Gulfian		
Niobrara formation—Smoky Hill chalk member		
Chalk, yellow	4	34
Shale, calcareous, blue-gray	4	38

18-36-20aaa. *Sample log of test hole in the NE cor. sec. 20, T. 18 S., R. 36 W.; drilled September 1947. Surface altitude, 3,274.5 feet. Water level, 78.0 feet below land surface, September 12, 1947.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Sanborn formation		
Silt, hard, clayey, dark-brown	4	4
Silt, light-brown	6	10
Silt, clayey, light-brown	8	18
TERTIARY—Pliocene		
Ogallala formation		
Clay, light-gray	2	20
Caliche, sandy, soft, light-gray	10	30

	Thickness, feet	Depth, feet
Sand, coarse to medium; contains fine to coarse gravel,	15	45
Clay	2	47
Sand, coarse to medium; contains fine gravel	3	50
Caliche, hard, white; contains opal	10	60
Caliche, limestone, hard, brown to white; contains silt and fine sand	14	74
Silt, sandy, brown	6	80
Sand, medium to fine, and silt	40	120
Sand, fine, and silt, yellow	10	130
Sand, fine to medium, and silt	10	140
Sand, fine to coarse	10	150
Sand, coarse to medium; contains fine gravel	12	162
CRETACEOUS—Gulfian		
Niobrara formation—Smoky Hill chalk member		
Shale, calcareous, yellow-brown	9	171
Shale, calcareous, gray; contains a small amount of yellow shale	2	173
Shale, calcareous, gray	7	180

18-37-13cca. *Driller's log of well in the NE¼ SW¼ SW¼ sec. 13, T. 18 S., R. 37 W.; drilled for the City of Leoti in November 1950. Surface altitude, 3,307.5 feet. Don Rogers, driller (Ben Hasz Drilling Co.).*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Sanborn formation		
Topsoil	18	18
TERTIARY—Pliocene		
Ogallala formation		
Gyp and clay	11	29
Hard rock	21	50
Sand rock	15	65
Clay	10	75
Sand rock	10	85
Sand and clay	3	88
Clay	2	90
Clay and rock	5	95
Clay	25	120
Sand and clay	5	125
Sand	13	138
Sand and clay	5	143
Sand, fine, good	2	145
Clay	19	164
Sand	4	168
Clay	2	170

18-38-8aaa. *Sample log of test hole in the NE cor. sec. 8, T. 18 S, R. 38 W.; drilled September 1947. Surface altitude, 3,424.1 feet. Water table, 90.4 feet below land surface, September 19, 1947.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Sanborn formation		
Silt, dark-brown	2	2
TERTIARY—Pliocene		
Ogallala formation		
Silt, light-brown	8	10
Clay, light-gray	3	13
Sand, medium, red; contains silt and fine sand	9	22
Caliche, sandy, hard, white	13	35
Silt, sandy, hard, reddish-brown	15	50
Sand, fine to coarse, and fine gravel, partly consolidated	8	58
Clay, silty, gray	2	60
Clay, silty, gray; contains sand	7	67
Clay and silt, brown; contains fine to medium sand	3	70
Silt, sandy, hard, brown	10	80
Silt, sandy, brown; contains clay	6	86
Sand, medium to fine	4	90
Sand, medium to coarse; contains fine sand	6	96
Silt and fine sand, clayey, light-tan	2	98
Sand, medium to fine	2	100
Sand, medium to fine; contains coarse sand	6	106
Clay, soft, yellow	10	116
Sand, medium; contains fine sand	2	118
Sand, coarse, and fine to medium gravel	2	120
Clay, light-tan	7	127
Clay, sandy, light-tan	10	137
Sand, fine to medium	3	140
Sand, coarse to medium	5	145
Gravel, fine, and coarse sand	5	150
Sand, coarse to medium, and fine gravel	8	158
Clay, brown; contains fine gravel and coarse sand	2	160
Gravel, fine to medium; contains silty clay	7	167
Clay, calcareous, soft, brown	9	176
Sand, coarse to medium, and fine gravel	4	180
Sand, coarse, and fine gravel; contains layers of brown silty clay	10	190
Sand, coarse, and fine gravel	5	195
CRETACEOUS—Gulfian		
Niobrara formation-Smoky Hill chalk member		
Shale, soft, calcareous, yellow	6	201
Shale, calcareous, gray	5	206

18-38-17aaa. *Sample log of test hole in the NE cor. sec. 17, T. 18 S., R. 38 W.; drilled October 1947. Surface altitude, 3,355.5 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Alluvium		
Silt, sandy, light-brown	0.5	0.5
Gravel, coarse to fine; contains coarse sand	19.5	20
TERTIARY—Pliocene		
Ogallala formation		
Sand, medium to coarse, and fine gravel	4	24
Clay, sandy, yellow-brown; contains fine to coarse sand and fine gravel from 39 to 42 feet	18	42
Gravel, fine, and medium to coarse sand	7	49
Clay, sandy, yellow-brown; contains fine to coarse sand from 54 to 59 feet	10	59
Gravel, fine to coarse; contains coarse to medium sand, and plastic silt and fine sand from 63 to 65 feet	11	70
Sand, coarse, and fine to coarse gravel	10	80
Gravel, fine to coarse; contains fine to coarse sand	10	90
Gravel, fine to medium; contains medium to coarse sand and light-brown plastic silt and fine sand	13	103
Clay, sandy, yellow-brown	3	106
Sand, medium to coarse, and fine to medium gravel; contains a small amount of clay	4	110
Gravel, fine to coarse; contains yellow-brown sandy clay in thin layers	12	122
CRETACEOUS—Gulfian		
Niobrara formation—Smoky Hill chalk member		
Shale, calcareous, gray	6	128

18-38-17ddd. *Sample log of test hole in the SE cor. sec. 17, T. 18 S., R. 38 W.; drilled September 1947. Surface altitude, 3,422.2 feet. Water level, 77.8 feet below land surface, September 18, 1947.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Sanborn formation		
Silt, dark-brown	2	2
Silt, light-brown	6	8
TERTIARY—Pliocene		
Ogallala formation		
Clay, sandy, white	2	10
Caliche, white; contains fine to medium gravel and coarse sand	10	20
Caliche, sandy, white; contains many dendrites and fragments of opal	10	30
Caliche, white; contains opal fragments	4	34
Sand, medium to fine; contains coarse sand	6	40
Sand, fine to medium	10	50
Sand, fine to medium, and silt; contains gray clay	10	60
Sand, fine to coarse, and silt and fine gravel	7.5	67.5

	Thickness, feet	Depth, feet
Gravel, fine	2.5	70
Gravel, fine, and coarse sand	2	72
Clay, light-brown; contains silt and fine sand	5	77
Sand, fine to medium; contains coarse sand	3	80
Sand, fine to medium; contains coarse sand and fine gravel	10	90
Sand, fine to medium; contains coarse sand	3	93
Clay, sandy, yellow; contains fine gravel	7	100
Sand, fine to medium; contains yellow clay	10	110
Sand, fine to medium; contains coarse sand	11	121
Clay, yellow	2	123
Sand, fine to medium	22	145
Sand, coarse to medium	5	150
Sand, coarse to medium; contains fine sand and fine gravel	8	158
CRETACEOUS—Gulfian		
Niobrara formation—Smoky Hill chalk member		
Shale, soft calcareous, yellow	5	163
Shale, calcareous, gray	7	170

18-38-20bb. *Drillers log of irrigation well of Walter R. Gorsuch in the NW¼ NW¼ sec. 20, T. 18 S., R. 38 W. Buell Scott, driller.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Sanborn formation		
Soil	18	18
TERTIARY—Pliocene		
Ogallala formation		
Gyp-like rock	36	54
Sand	3	57
Hard rock	11	68
Clay	24	92
Sand, soft	3	95
Sand, hard	5	100
Sand, soft, with hard streaks	7	107
Hard rock; contains yellow clay	2	109
Clay, soft, yellow	16	125
Sand	19	144
Sand and clay, hard	2	146
Clay, white, and sand	4	150
Sand	9	159
Sand, hard, coarse	9	168
Sand, extra coarse	5	173
CRETACEOUS—Gulfian		
Niobrara formation—Smoky Hill chalk member		
Shale, yellow	4	177
Shale, dark	2	179

18-40-5ada. *Sample log of test hole in the NE¼ SE¼ NE¼ sec. 5, T. 18 S., R. 40 W.; drilled October 1947. Surface altitude, 3,615.8 feet. Water level, 121.1 feet below land surface, October 4, 1947.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Sanborn formation		
Silt dark-brown	0.5	0.5
Silt, light-brown	10.5	11
TERTIARY—Pliocene		
Ogallala formation		
Caliche, light-tan; contains a small amount of sand and gravel	6	17
Sand, coarse, and fine to coarse gravel; contains some plastic fine sand and silt	3	20
Sand, medium to coarse, and fine to coarse gravel	7	27
Silt, and fine sand, plastic, white to light-gray	1	28
Sand, medium to coarse, and fine to medium gravel	6	34
Sand, fine, and silt, plastic; contains some medium to coarse sand and fine gravel	6	40
Sand, fine to coarse, partly consolidated	6	46
Sand, fine to coarse, and fine gravel; contains some brown clay and silt	9.5	55.5
Sand, fine, and silt, sticky, light-tan	4.5	60
Sand, fine to coarse, and fine to medium gravel; contains brown to gray clay	10	70
Sand, fine; contains medium to coarse sand; partly cemented	8	78
Silt and fine sand, sticky, light-tan	2	80
Silt and fine sand; contains some medium to coarse sand and fine gravel	5	85
Sand, fine to coarse, and silt; contains fine gravel	5	90
Sand, coarse, and fine to coarse gravel	10	100
Sand, coarse, and fine to medium gravel; contains plastic yellow clay from 107 to 122 feet	22	122
Sand, medium to coarse, and fine to medium gravel	10	132
Sand, coarse, and fine to coarse gravel	8	140
Gravel, fine to coarse	17	157
Gravel, coarse; contains some coarse sand and gray clay	3	160
Sand, medium to coarse, and fine gravel	5	165
Gravel, fine to coarse, and coarse sand	4	169
Gravel, coarse, and yellow clay	3.5	172.5
CRETACEOUS—Gulfian		
Niobrara formation—Smoky Hill chalk member		
Shale, chalky, yellow	8.5	181
Shale, calcareous, gray	2	183

18-40-8baa. *Sample log of test hole in the NE cor. NW¼ sec. 8, T. 18 S., R. 40 W.; drilled October 1947. Surface altitude, 3,631.3 feet. Water level, 130.6 feet below land surface, October 6, 1947.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Sanborn formation		
Silt, dark-brown	1	1
Silt, light-brown	16	17
TERTIARY—Pliocene		
Ogallala formation		
Caliche, soft, light-tan	3	20
Caliche, soft, sandy, light-tan to brown	10	30
Mortar bed, light-tan	19	49
Silt, sandy, plastic, light-tan	7	56
Sand, fine to coarse, and fine to coarse gravel; contains some plastic fine sand and silt	5	61
Silt and clay, sandy, calcareous, light-tan	9	70
Silt and fine sand, plastic; contains some medium to coarse sand	10	80
Silt and clay, sandy, yellow-brown; contains fine to coarse gravel from 90 to 100 feet	20	100
Silt and fine sand; contains some coarse sand and fine to medium gravel from 105 to 107 feet	10	110
Sand, fine and silt; contains coarse sand and fine gravel and a small amount of yellow-brown clay	12	122
Clay, sandy, calcareous, yellow-brown	15	137
Sand, medium to coarse, and fine to medium gravel	3	140
Sand, medium to coarse, and fine to coarse gravel; contains yellow clay	5	145
Sand, fine	2	147
Sand, coarse, and fine to coarse gravel; contains some yellow silt and clay from 150 to 152 feet	5	152
Clay, sandy, yellow; contains some coarse sand and fine to medium gravel	2	154
Sand, coarse, and fine to coarse gravel; contains some yellow clay	4	158
Silt and fine sand, sticky, brown	5	163
CRETACEOUS—Gulfian		
Niobrara formation—Smoky Hill chalk member		
Clay, calcareous, yellow to white	7	170
Chalk, soft, yellow	4.5	174.5
Shale, soft, calcareous, gray	2.5	177

18-40-9baa. *Sample log of test hole in the NE cor. NW¼ sec. 9, T. 18 S., R. 40 W.; drilled October 1947. Surface altitude, 3,611.8 feet. Water level, 117.4 feet below land surface, October 8, 1947.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Sanborn formation		
Silt, dark-brown	3	3
Silt, light-brown	8	11
Clay, calcareous, light-tan	5	16

Tertiary—Pliocene

Ogallala formation	Thickness, feet	Depth, feet
Silt and clay, sandy, light-tan	4	20
Mortar bed	8	28
Sand, coarse, and fine to coarse gravel	9	37
Mortar bed	8	45
Silt and fine sand, sticky, plastic; contains some coarse sand and fine to coarse gravel	5	50
Sand, fine to coarse, and fine to medium gravel; contains a small amount of silt	10	60
Sand, coarse, and fine to medium gravel	4	64
Clay, light brown; contains coarse sand and fine to coarse gravel	6	70
Sand, medium to coarse, and fine gravel; contains fine sand and silt and light-tan clay; contains more clay from 80 to 90 feet	20	90
Clay, yellow to light-tan; contains some coarse to medium sand	20	110
Clay, tan	9	119
Sand, medium to coarse, and fine gravel; contains some yellow clay from 128 to 130 feet	11	130
Clay, sandy, yellow-brown	6	136
Sand, coarse, and fine to medium gravel; contains some sandy yellow clay	14	150
Clay, sandy, yellow	10	160
Cretaceous—Gulfian		
Niobrara formation—Smoky Hill chalk member		
Shale, soft, calcareous, yellow	5	165
Shale, calcareous, gray	5	170

18-40-16cbb. *Sample log of test hole in the NW cor. SW¼ sec. 16, T. 18 S., R. 40 W.; drilled September 1947. Surface altitude, 3,598.0 feet. Water level, 89.5 feet below land surface, September 26, 1947.*

Quaternary—Pleistocene

Sanborn formation	Thickness, feet	Depth, feet
Silt, dark-brown	2	2
Silt, light-brown	18	20
Tertiary—Pliocene		
Ogallala formation		
Silt and fine sand, hard, brown	7	27
Sand, medium to coarse	3	30
Sand, medium to coarse, and some fine gravel	4	34
Silt and fine sand, clayey, brown; contains some coarse sand and fine gravel	6	40
Silt and very fine sand, brown	5	45
Sand, fine to medium, partly cemented	5	50
Silt and fine sand, partly cemented, brown	16	66

	Thickness, feet	Depth, feet
Sand, fine to medium, and silt	4	70
Sand, fine to coarse, and fine gravel; contains some silt and clay	10	80
Sand, fine to coarse, and fine gravel	16	96
Silt and fine sand, clayey, tan	6	102
CRETACEOUS—Gulfian		
Niobrara formation—Smoky Hill chalk member		
Shale, chalky, yellow	8	110
Shale, calcareous, gray	3	113

18-40-17dda. *Sample log of test hole in the NE¼ SE¼ SE¼ sec. 17, T. 18 S., R. 40 W.; drilled September 1947. Surface altitude, 3,562.0 feet. Depth to water level, 49.0 feet below land surface, September 26, 1947.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Sanborn formation		
Silt, dark-brown	1	1
Silt, light-brown; contains sand from 10 to 15 feet	14	15
TERTIARY—Pliocene		
Ogallala formation		
Sand, coarse, and fine to medium gravel	9	24
Silt, sandy, partly cemented, light-tan	4	28
Sand, fine to medium; contains a small amount of gravel from 30 to 39 feet	11	39
Silt and fine sand, partly cemented, white	3	42
Sand, coarse, and fine gravel; contains some medium gravel	9	51
Clay and silt, sandy, light-brown; contains some fine gravel	2	53
Sand, coarse, and fine gravel; contains a small amount of clay	3	56
CRETACEOUS—Gulfian		
Niobrara formation—Smoky Hill chalk member		
Shale, chalky, yellow	12	68
Shale, calcareous, gray	2	70

18-40-21bbb. *Sample log of test hole in the NW cor. sec. 21, T. 18 S., R. 41 W.; drilled September 1947. Surface altitude, 3,562.4 feet. Water level, 52.6 feet below land surface, September 26, 1947.*

	Thickness, feet	Depth, feet
Road fill	7	7
QUATERNARY—Pleistocene		
Sanborn formation		
Silt, light-brown	1	8
Silt, light-tan	1	9
TERTIARY—Pliocene		
Ogallala formation		
Sand, medium to coarse	1	10
Sand, medium to coarse, and fine gravel; contains some medium gravel and a small amount of clay	10	20

	Thickness, feet	Depth, feet
Sand, coarse, and fine to medium gravel; contains some coarse gravel and caliche fragments	10	30
Sand, medium to coarse; contains some fine gravel	5	35
Clay, gray	2	37
Sand, fine, partly cemented	3	40
Sand, fine to coarse, partly cemented	7	47
Sand, medium to coarse; contains some fine gravel	3	50
Sand, coarse, and fine gravel; contains light-tan plastic fine sand and silt	6	56
Sand, medium to coarse, and fine gravel	3	59
CRETACEOUS—Gulfian		
Niobrara formation—Smoky Hill chalk member		
Shale, soft, calcareous, yellow	13	72
Shale, calcareous, gray	4	76

18-40-21bcb. *Sample log of test hole in the NW¼ SW¼ NW¼ sec. 21, T. 18 S., R. 40 W.; drilled September 1946. Surface altitude, 3,602.2 feet. Water level, 86.6 feet below land surface, September 26, 1947.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Sanborn formation		
Silt, dark-brown	1	1
Silt, light-brown	24	25
TERTIARY—Pliocene		
Ogallala formation		
Mortar bed	9	34
Sand, medium to coarse	2	36
Clay, gray	2	38
Sand, medium to coarse, and fine gravel; contains some medium to coarse gravel	2	40
Mortar bed	8	48
Sand, fine, and silt	2	50
Sand, fine	3	53
Silt, and fine sand, partly cemented, white to brown	12	65
Sand, medium	3	68
Silt and fine sand, partly cemented, light-brown	5	73
Sand, medium; contains some coarse sand	2	75
Sand, fine, and silt	2	77
Silt, sandy, hard, white to brown	3	80
Silt, sandy, light-tan	5	85
Sand, coarse to medium; contains some fine gravel	5	90
Sand, coarse, and fine to medium gravel	2	92
Clay, soft, yellow-brown	6	98
Sand, coarse, and fine gravel	2	100
Sand, coarse, and fine to medium gravel; contains some coarse gravel, medium sand, and yellow clay,	3	103
CRETACEOUS—Gulfian		
Niobrara formation—Smoky Hill chalk member		
Shale, soft, calcareous, yellow	9	112
Shale, calcareous, gray	3	115

18-40-24aaa. *Sample log of test hole in NE cor. sec. 24, T. 18 S., R. 40 W.; drilled September 1947. Surface altitude, 3,542.9 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Sanborn formation		
Silt, dark-brown	2	2
Silt, light-brown	25	27
TERTIARY—Pliocene		
Ogallala formation		
Clay, sandy, white to light-tan	2	29
Caliche, hard, white	11	40
Clay, silty, gray; contains a thin rusty layer at 40 feet,	7	47
Silt, sandy; contains some fine gravel	3	50
Sand, fine to medium	8	58
Caliche, white	2	60
Silt, sandy, light-brown	8	68
Sand, fine to medium	12	80
Sand, medium to coarse; contains some fine gravel	13	93
Silt and fine sand, clayey, light-tan	7	100
Silt and fine sand, partly cemented, light-tan to white,	9	109
CRETACEOUS—Gulfian		
Shale, soft, calcareous, yellow	5.5	114.5
Shale, calcareous, gray	5.5	120

18-41-22ccc. *Sample log of test hole in the SW cor. sec. 22, T. 18 S., R. 41 W.; drilled September 1947. Surface altitude, 3,692.2 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Sanborn formation		
Silt, dark-brown	2	2
Silt, light-brown	13	15
TERTIARY—Pliocene		
Ogallala formation		
Sand, medium to coarse, and fine to medium gravel	3	18
Silt and fine sand, plastic, brown	7	25
Silt and fine sand, brown; contains some coarse sand and fine gravel	4	29
Silt, sandy, hard, calcareous, light-tan	2	31
Silt, sandy, plastic	9	40
Clay, gray	1	41
Sand, medium to coarse, and fine to medium gravel	9	50
Silt and fine sand, plastic, brown; contains coarse sand and fine gravel	10	60
Silt and fine sand; contains coarse to medium sand and fine gravel	10	70
Silt, sandy, light-tan; contains fine to medium gravel	10	80
CRETACEOUS—Gulfian		
Niobrara formation—Smoky Hill chalk member		
Shale, soft, calcareous, yellow-brown to light-tan	10	90
Shale, chalky, yellow-brown	30	120

Drillers log of well for Missouri Pacific Railroad at Horace, in the NE¼ sec. 24, T. 18 S., R. 41 W.; drilled November 1901. Total depth, 1,370 ft. Surface altitude, 3,626± feet. Water level, 825 feet below land surface.

	Thickness, feet	Depth, feet
Gravel cemented, mixed with clay and lime	55	55
Clay, gravel, and lime (mixed)	45	100
Shale, gray	447	547
Limestone, white	73	620
Shale, brown	430	1,050
Dakota sandstone	110	1,160
Shale	90	1,250
Dakota sandstone	75	1,325
Shale, pure, gray	45	1,370

18-42-30bbb. *Sample log of test hole in the NW cor. sec. 30, T. 18 S., R. 42 W.; drilled October 1947. Surface altitude, 3,868.4 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Sanborn formation		
Silt, dark-brown	2	2
Silt, light-brown; sandy from 10 to 19 feet	17	19
TERTIARY—Pliocene		
Ogallala formation		
Clay, sandy, light-tan	9	28
Sand, medium to coarse, and fine gravel, reddish	2	30
Sand, medium to coarse, and fine to coarse gravel, reddish; contains some fine sand	14	44
Sand, coarse, and fine to coarse gravel; contains gray clay	6	50
Clay, gray	2	52
Sand, coarse, and fine to coarse gravel; contains gray clay	10	62
Clay, gray	2	64
Sand, medium to coarse, and fine to coarse gravel; contains some gray clay	6	70
Sand, fine to coarse, and some fine to coarse gravel, partly cemented	10	80
Sand, medium to coarse, and fine to medium gravel	10	90
Sand, coarse, and fine to coarse gravel	4	94
CRETACEOUS—Gulfian		
Niobrara formation—Smoky Hill chalk member		
Shale, yellow	4	98
Shale, calcareous, gray	2	100

19-35-24ddd. *Sample log of test hole in the SE cor. sec. 24, T. 19 S., R. 35 W.; drilled August 1947. Surface altitude, 3,138.4 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Sanborn formation		
Silt, black	3	3
Silt, compact, light-brown	15	18

	Thickness, feet	Depth, feet
TERTIARY—Pliocene		
Ogallala formation		
Silt, sandy, sticky, calcareous, white	22	40
Sand, fine to medium	25	65
Clay	2	67
Sand, fine to medium, compact	23	90
Sand, coarse to medium	17	107
Sand, fine, clayey	2	109
Sand, coarse to medium; contains a small amount of gravel	24	133
Clay, silty, brown	7	140
CRETACEOUS—Gulfian		
Niobrara formation—Smoky Hill chalk member		
Shale, calcareous, soft, yellow-brown	13	153

19-35-36ddd. *Sample log of test hole in the SE cor. sec. 36, T. 19 S., R. 35 W.; drilled August 1947. Surface altitude, 3,060.7 feet. Water level, 46.8 feet below land surface, August 29, 1947.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Alluvium		
Silt, dark-brown	4	4
Clay, silt, and fine sand	14	18
Sand, fine to medium	2	20
TERTIARY—Pliocene		
Ogallala formation		
Sand, medium to coarse	16	36
Sand, fine, and silt	6	42
Sand, medium to coarse	13.5	55.5
Clay, buff; contains sand (probably resulting from caving)	14.5	70
Clay, silt, and fine sand, compact	10	80
CRETACEOUS—Gulfian		
Niobrara formation		
Shale, calcareous, yellow-brown	10	90

19-36-10ccc. *Sample log of test hole in the SW cor. sec. 10, T. 19 S., R. 36 W.; drilled September 1947. Surface altitude, 3,223.0 feet. Water level, 50.4 feet below land surface, September 12, 1947.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Sanborn formation		
Silt, black	1	1
Silt, light-brown	5	6
Silt, hard, clayey, light-brown	12	18
TERTIARY—Pliocene		
Ogallala formation		
Sand, fine to medium	2	20
Sand, coarse; contains fine to medium gravel	10	30
Sand, coarse to medium; contains fine gravel	8	38
Clay	2	40
Sand, coarse to medium, and fine to coarse gravel	10	50

	Thickness, feet	Depth, feet
Sand, coarse, and fine gravel	3	53
Gravel, medium	2	55
Sand, coarse, and fine gravel	5	60
Gravel, fine to medium, and coarse to medium sand	15	75
CRETACEOUS—Gulfian		
Niobrara formation—Smoky Hill chalk member		
Shale, calcareous, yellow	5	80
Shale, calcareous gray	10	90

19-36-16dad. *Sample log of test hole in the SE¼ NE¼ SE¼ sec. 16, T. 19 S., R. 36 W.; drilled September 1947. Surface altitude, 3,176.9 feet. Water level, 15.3 feet below land surface, September 12, 1947.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Alluvium		
Silt, dark-brown	0.5	0.5
Sand, fine; contains silt	4.5	5
Sand, medium to fine	5	10
TERTIARY—Pliocene		
Ogallala formation		
Sand, medium to coarse; contains silt and fine sand	10	20
Sand, medium to coarse	5	25
CRETACEOUS—Gulfian		
Niobrara formation—Smoky Hill chalk member		
Shale, calcareous, gray	7	32

19-36-27bbb. *Sample log of test hole in the NW cor. sec. 27, T. 19 S., R. 36 W.; drilled September 1947. Surface altitude, 3,256.8 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Sanborn formation		
Silt, dark-brown	1	1
Silt, hard, clayey, light-brown	16	17
TERTIARY—Pliocene		
Ogallala formation		
Clay, silty, light-brown	8	25
Caliche, white	5	30
Silt, sandy, white to light-brown	15	45
CRETACEOUS—Gulfian		
Niobrara formation—Smoky Hill chalk member		
Shale, chalky, calcareous, yellow	25	70

19-37-28aaa. *Sample log of test hole in the NE cor. sec. 28, T. 19 S., R. 37 W.; drilled November, 1950. Surface altitude, 3,349.4 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Sanborn formation		
Peoria silt member		
Silt, black	2	2
Silt, tan	8	10
Loveland silt member		
Silt, reddish-brown (Sangamon soil)	4	14

	Thickness, feet	Depth, feet
TERTIARY—Pliocene		
Ogallala formation		
Silt and clay, sandy	9	23
Mortar bed	34	57
Sand, fine to very coarse, contains some fine to medium gravel	13	70
Sand, fine to coarse	33	103
CRETACEOUS—Gulfian		
Niobrara formation—Smoky Hill chalk member		
Shale, yellow	7	110

19-38-28cbb. *Sample log of test hole in the NW cor. SW¼ sec. 28, T. 19 S., R. 38 W.; drilled September 1947. Surface altitude, 3,416.3 feet. Water level, 98.0 feet below land surface, September 18, 1947.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Sanborn formation		
Silt, dark-brown	1	1
Clay, light-brown to white	6	7
TERTIARY—Pliocene		
Ogallala formation		
Silt, sandy, brown	5	12
Caliche, sandy, white	7	19
Sand, medium	1	20
Sand, medium to coarse	2	22
Silt, sandy, hard, brown	2	24
Sand, medium to fine	3	27
Silt, sandy, hard, brown	12	39
Sand, fine to medium, and coarse sand	1	40
Sand, fine to coarse, and fine gravel	17	57
Gravel, fine to medium	2	59
Silt and fine sand, clayey, brown	1	60
Silt, sandy, clayey, brown; contains gravel	5	65
Caliche, hard, white; contains sandy silt	5	70
Caliche, hard, white	4	74
Caliche, hard, white; contains brown silt	6	80
Silt, sandy, sticky, brown	10	90
Sand, fine, and silt; contains coarse to medium sand	10	100
Silt, sandy, sticky, light-brown to white	19	119
Sand, medium to fine, and silt	1	120
Sand, fine to medium, and silt; contains coarse sand	15	135
Sand, fine to medium	15	150
Sand, fine to medium; contains yellow clayey silt and clay	10	160
Sand, medium to coarse; contains fine sand	5	165
Clay, calcareous, yellow-brown	7	172
Sand, coarse, and fine gravel	8	180
CRETACEOUS—Gulfian		
Niobrara formation—Smoky Hill chalk member		
Shale, soft calcareous, yellow	6	186
Shale, calcareous, gray	2	188

19-39-30bbb. *Sample log of test hole in the NW cor. sec. 30, T. 19 S., R. 39 W.; drilled October 1947. Surface altitude, 3,546.0 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Sanborn formation		
Silt, dark-brown	1	1
Silt, light-brown	18	19
TERTIARY—Pliocene		
Ogallala formation		
Clay, sandy, plastic, light-tan	6	25
Silt and fine sand, plastic, light-brown	3	28
Clay, white	4	32
Silt and fine sand, plastic, light-brown	1	33
Sand, medium to coarse, and fine to coarse gravel; contains some white clay from 39 to 42 feet	40	73
Silt and fine sand, plastic, brown; contains some coarse gravel	6	79
Silt and fine sand, calcareous, plastic, white	3	82
Clay, sandy, tan	4	86
Sand, medium to coarse	3	89
Silt and fine sand, plastic, light-tan	1	90
Silt and fine sand	3	93
Clay, sandy, brown	3	96
Sand, medium to coarse	2	98
Silt and fine sand	2	100
Sand, medium to coarse	5	105
Sand, medium to coarse, and fine to coarse gravel; contains some light-tan plastic silt and fine sand; contains some gray clay from 108 to 110 feet	5	110
Clay, sandy, gray	8	118
Sand, medium to coarse; contains some fine to coarse gravel	5	123
Silt and fine sand, plastic, light-tan; contains some medium to coarse sand and fine gravel	19	142
Sand, coarse, and fine to coarse gravel	11	153
Sand, medium to coarse; contains some fine to medium gravel	4	157
Sand, coarse, and fine to coarse gravel	20	177
CRETACEOUS—Gulfian		
Niobrara formation—Smoky Hill chalk member		
Shale, chalky, yellow to yellow-brown	19	196
Shale, calcareous, gray	4	200

19-40-33ccc. *Sample log of test hole in the SW cor. sec. 33, T. 19 S., R. 40 W.; drilled October 1947. Surface altitude, 3,605.4 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Sanborn formation		
Silt, dark-brown	1	1
Silt, sandy, light-brown	10	11

TERTIARY—Pliocene	Thickness, feet	Depth, feet
Ogallala formation		
Clay, sandy, light-tan	5	16
Silt, and fine sand, plastic, light-brown; contains medium to coarse sand from 18 to 20 feet	4	20
Silt and fine sand, plastic, light-tan; contains medium to coarse sand and fine gravel	4	24
Gravel, fine to coarse; contains some plastic fine sand and silt	1	25
Silt and fine sand, sticky, plastic, light-tan	3	28
Clay, sandy, calcareous, tan	2	30
Sand, fine, and silt, plastic, tan	4	34
Sand, medium to coarse, and fine to coarse gravel; contains gray clay from 50 to 55 feet	21	55
Clay, gray	3	58
Sand, medium to coarse, and fine gravel; contains some gray clay	2	60
Gravel, fine to coarse; contains some medium to coarse sand; contains brown clay from 60 to 61 feet	10	70
Sand, medium to coarse, and fine to coarse gravel	4	74
Clay, soft, calcareous, white	10	84
Silt and fine sand, sticky, gray	8	92
Sand, medium to coarse, and fine to coarse gravel	9	101
Silt and fine sand, sticky, light-tan; contains some medium to coarse sand	9	110
Clay, sandy, gray	5	115
Sand, medium to coarse, and fine to coarse gravel; contains gray clay from 119 to 120 feet	5	120
Sand, fine to medium; contains some coarse sand	15	135
Sand, medium to coarse, and fine to medium gravel; contains some yellow clay from 140 to 143 feet	8	143
Clay, sandy, calcareous, light-tan; contains some coarse gravel	5	148
Gravel, fine to medium, and coarse sand	1	149
Clay, calcareous, yellow-brown	1	150
Silt, and fine sand, calcareous, plastic, light-brown	12	162
Sand, fine to coarse	6	168

19-41-16ddd. *Sample log of test hole in the SE cor. sec. 16, T. 19 S., R. 41 W.; drilled October 1947. Surface altitude, 3,691.2 feet. Depth to water level, 137.0 feet below land surface, October 23, 1947.*

QUATERNARY—Pleistocene	Thickness, feet	Depth, feet
Sanborn formation		
Silt, dark-brown	1	1
Silt, light-brown	8	9
Sand, fine, and silt	1	10
TERTIARY—Pliocene		
Ogallala formation		
Silt and clay, sandy, light-tan	5	15
Sand, medium to coarse, and fine gravel; contains some light-tan clay	4	19

	Thickness, feet	Depth, feet
Clay, sandy, calcareous, light-tan	8	27
Clay, silty, calcareous, light-tan; contains brown plastic silt and fine sand	2	29
Silt and fine sand, plastic, brown	6	35
Sand, coarse, and fine to coarse gravel; contains some medium sand and brown clay	15	50
Sand, medium to coarse, and fine to coarse gravel; contains some light-tan plastic fine sand and silt from 57 to 70 feet	20	70
Sand, medium to coarse, and fine to medium gravel; contains some coarse gravel	10	80
Sand, medium to coarse, and fine to coarse gravel; contains gray clay from 88 to 90 feet	10	90
Clay, gray; contains medium to coarse sand and coarse gravel	10	100
Clay, gray	5	105
Sand, medium to coarse, and fine to coarse gravel	5	110
Sand, medium to coarse, and fine gravel; contains some sandy clay from 118 to 120 feet	10	120
Sand, medium to coarse, and fine gravel	6	126
Silt and fine sand, plastic, brown; contains some coarse sand and fine to coarse gravel	4	130
Sand, medium to coarse; contains fine gravel and brown clay	10	140
Sand, medium to coarse, and fine to medium gravel	6	146
Silt and fine sand, plastic, brown, and medium to coarse sand; contains a small amount of fine to coarse gravel	5	151
Silt and fine sand, plastic, brown, and medium to coarse sand	5	156
CRETACEOUS—Gulfian		
Niobrara formation—Smoky Hill chalk member		
Shale, chalky, yellow-brown	13.5	169.5
Shale, calcareous, gray	2.5	172

19-43-24ddd. *Sample log of test hole in the SE cor. sec. 24, T. 19 S., R. 43 W.; drilled October 1947. Surface altitude, 3,820.4 feet. Depth to water level, 74.5 feet below land surface, October 17, 1947.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Sanborn formation		
Silt, dark-brown	1	1
Silt, light-brown	9	10
Silt, sandy, calcareous, tan	8	18
TERTIARY—Pliocene		
Ogallala formation		
Clay, sandy, calcareous, yellow-brown	4.5	22.5
Sand, medium to coarse; contains some fine gravel	7.5	30
Sand, medium to coarse, and fine gravel; contains some medium gravel	10	40

	Thickness, feet	Depth, feet
Sand, medium to coarse, and fine to coarse gravel	14	54
Clay, silty, brown; contains a small amount of sand	4	58
Clay, sandy, white	2	60
Silt and fine sand, sticky, white	3	63
Sand, medium to coarse, and fine gravel	7	70
Sand, medium to coarse, and fine to coarse gravel; contains a light-tan layer of clay from 74 to 75 feet,	7	77
Clay, sandy, light-tan	5	82
Sand, coarse, and fine to medium gravel	1	83
CRETACEOUS—Gulfian		
Niobrara formation—Smoky Hill chalk member		
Chalk, soft, yellow	13	96
Shale, calcareous, gray	2	98

20-34-32cd. *Sample log of test hole in the SE¼ SW¼ sec. 32, T. 20 S., R. 34 W., Scott County; drilled 1940. Surface altitude, 3,089.5 feet. Water level, 94 feet below land surface.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene and TERTIARY—Pliocene		
Sanborn and Ogallala formations		
Silt, sandy, dark	1.5	1.5
Silt and fine sand, limy, tan; contains gastropod shells,	11	12.5
Silt and fine sand, pinkish-brown; contains thin limy zones	5.5	18
Caliche, soft, tan to light-tan	6	24
Sand, fine to medium, pinkish-brown; contains some silt	2.5	26.5
Caliche, soft, tan-gray, and limy clay	6.5	33
Clay, tan-gray	5	38
Sand, medium, to medium gravel, brown	16.5	54.5
Sand, medium, to coarse gravel, brown; contains a few lime-cemented zones	37	95.5
Silt, sandy, light gray-yellow	8	103.5
Silt, sandy, soft, lime-cemented, light-gray; contains lenses of brown fine to medium sand; also contains fragments of *Celtis willistoni* (?) and *Biorbia fossilia* (?)	15.5	119
CRETACEOUS—Gulfian		
Niobrara formation—Smoky Hill chalk member		
Chalk, silty, soft, light-yellow to light-gray	15	134
Shale, chalky, soft, dark blue-gray; contains few fragments of white bentonite	6	140
Shale, chalky, soft, dark blue-gray; contains interbedded lighter-gray hard sandy shale	14	154
Fort Hays limestone member		
Shale, chalky, dark-gray to white	10	164
Chalk, light-gray to white	3	167
Shale, chalky, light-gray to dark-gray	5	172
Chalk, light-gray to white	12	184

	Thickness, feet	Depth, feet
Shale, chalky, dark-gray	1	185
Chalk, light-gray to white	15	200
Shale, chalky, light-gray to white	19	219
Carlile shale—Blue Hill shale member		
Shale, sandy, noncalcareous, dark-gray	33	252
Shale, sandy, light-to dark-gray	1.5	253.5
Shale, clayey, noncalcareous, dark-gray to black	16.5	270

20-35-1ddd. *Sample log of test hole in the SE cor. sec. 1, T. 20 S., R. 35 W.; drilled August 1947. Surface altitude 3,140.0 feet.*

	Thickness, feet	Depth, feet
Road fill	7	7
TERTIARY—Pliocene		
Ogallala formation		
Caliche, sandy, white	8	15
Caliche, hard, sandy, white	2	17
Caliche, sandy, white; contains traces of "Algal limestone"	11	28
Sand, fine to medium, partly consolidated	11	39
Sand, medium	6	45
Sand, medium; contains coarse sand and fine gravel	15	60
Sand, coarse to medium	4	64
Sand, medium, partly consolidated	2	66
Sand, coarse to medium, and fine gravel	18	84
Sand, medium to fine	16	100
Sand, coarse to medium, and fine gravel	20	120
Sand, coarse to medium	23	143
Clay, soft, yellow-brown	15	158
Sand, medium to fine; contains gray shale particles	22	180
CRETACEOUS—Gulfian		
Niobrara formation—Smoky Hill chalk member		
Shale, weathered, clayey	9	189
Shale, gray, calcareous	9	198

20-36-12ccc. *Sample log of test hole in the SW cor. sec. 12, T. 20 S., R. 36 W.; drilled September 1947. Surface altitude, 3,149.5 feet. Water level, 20.6 feet below land surface, September 14, 1947.*

	Thickness, feet	Depth, feet
Silt, black (topsoil)	0.5	0.5
TERTIARY—Pliocene		
Ogallala formation		
Sand, medium to coarse	9.5	10
Sand, medium to coarse; contains fine gravel and fine sand	15	25
Clay, soft, sandy, light-brown	9	34
Sand, coarse to medium	3	37
Silt, sandy, clayey, white	0.5	37.5
Sand, medium	4.5	42
Silt and fine sand, white to light-brown	5.5	47.5

	Thickness, feet	Depth, feet
CRETACEOUS—Gulfian		
Niobrara formation—Smoky Hill chalk member		
Shale, sandy, calcareous, yellow-brown	7.5	55
Shale, calcareous, gray	5	60

20-36-26bbb. *Sample log of test hole in the NW cor. sec. 26, T. 20 S., R. 36 W.; drilled September 1947. Surface altitude, 3,238.6 feet. Water level, 100.2 feet below land surface, September 14, 1947.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Sanborn formation		
Silt, dark-brown	1	1
Silt, light-brown	13	14
TERTIARY—Pliocene		
Ogallala formation		
Clay, white; contains a small amount of sand	8	22
Silt, sandy, clayey, calcareous, light-tan	14	36
Sand, coarse to medium, and fine gravel	8	44
Gravel, fine to medium, and coarse to fine sand	6	50
Sand, coarse to fine, and fine gravel	10	60
Sand, coarse to medium	10	70
Sand, coarse, and medium to fine gravel	12	82
Gravel, medium to coarse	1	83
Gravel, medium to fine, and coarse sand	7	90
Sand, coarse, and fine gravel	9	99
Clay, tan	1	100
Sand, coarse to medium	10	110
Sand, coarse, and fine to medium gravel	7	117
Silt and clay	3	120
Silt and fine sand, tan	14	134
Silt, clayey, white	4	138
CRETACEOUS—Gulfian		
Niobrara formation—Smoky Hill chalk member		
Shale, chalky, yellow-brown	7	145
Shale, calcareous, gray	5	150

20-37-21ddd. *Sample log of test hole in the SE cor. sec. 21, T. 20 S., R. 37 W.; drilled November 1950. Surface altitude, 3,332.0 feet. Water level, 63.7 feet below land surface, November 18, 1950.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Sanborn formation		
Peoria silt member		
Silt, dark-brown	2	2
Silt, tan	6	8
Loveland silt member		
Silt, reddish-brown	8	16
TERTIARY—Pliocene		
Ogallala formation		
Silt and clay, calcareous, cream-colored	4	20
Silt and clay, sandy; contains soft white caliche	8	28
Sand, fine to coarse	2	30
Sand, fine to very coarse, and fine to medium gravel	15	45

	Thickness, feet	Depth, feet
Mortar bed	5	50
Sand, fine to very coarse, and fine to medium gravel, partly cemented; contains some coarse gravel from 60 to 64 feet	14	64
Silt and clay, sandy, calcareous, cream-colored	7	71
CRETACEOUS—Gulfian		
Niobrara formation—Smoky Hill chalk member		
Shale, yellow	25	96
Shale, gray	2	98

20-38-29ddd. *Sample log of test hole in the SE cor. sec. 29, T. 20 S., R. 38 W.; drilled September 1947. Surface altitude, 3,432.4 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Sanborn formation		
Silt, dark-brown	1	1
Silt, light-brown	13	14
TERTIARY—Pliocene		
Clay, white	2	16
Ogallala formation		
Limestone ("Algal"), hard, impure, white to red	4	20
Limestone, hard, white, and caliche	6	26
Silt, sandy, clayey, brown	11	37
Sand, medium to coarse	3	40
Sand, coarse, and fine gravel	10	50
Sand, coarse, and fine to medium gravel; contains fine sand	8	58
Silt, sandy, clayey, light-brown	2	60
Sand, fine to coarse, and fine gravel	10	70
Sand, coarse, and gray sandy silt	2	72
Sand, fine to coarse; contains fine gravel	17	89
Gravel, medium	1	90
Sand, medium to coarse, and fine gravel	5	95
Silt, sandy, clayey, light-tan	10	105
Sand, medium; contains clay	3	108
Sand, medium	2	110
Sand, medium; contains light-tan sandy clay	10	120
Sand, medium to fine, and light-tan sandy silt	10	130
Silt, sandy, clayey, light-tan to brown; contains fine to medium sand	20	150
Sand, fine to coarse; contains silt	10	160
Sand, fine to medium; contains light-tan clayey sandy silt	10	170
Sand, fine, and light-tan clayey silt	10	180
Sand, fine to medium, and silt	20	200
Silt and fine sand, plastic; contains a small amount of coarse to medium sand	10	210
CRETACEOUS—Gulfian		
Niobrara formation—Smoky Hill chalk member		
Shale, soft, calcareous, yellow	8	218
Shale, calcareous, gray	9	227

20-40-25aaa. *Sample log of test hole in the NE cor. sec. 25, T. 20 S., R. 40 W.; drilled October 1947. Surface altitude, 3,554.0 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Sanborn formation		
Silt, dark-brown	1	1
Silt, light-brown	12	13
TERTIARY—Pliocene		
Ogallala formation		
Mortar bed, white to brown	14	27
Silt and fine sand, calcareous, plastic, brown	5	32
Gravel, fine to coarse, and medium to coarse sand; contains some yellow clay	8	40
Sand, coarse, and fine to coarse gravel; contains some plastic brown silt and fine sand	3	43
Silt and fine sand, plastic, brown to light-tan; contains some coarse gravel from 48 to 50 feet	7	50
Gravel, coarse to fine; contains some coarse sand and some sandy yellow clay	10	60
Sand, coarse, and fine to coarse gravel; contains yellow-brown clay from 60 to 65 feet	10	70
Gravel, coarse to fine; contains some coarse sand	23	93
Silt and fine sand, plastic, light-tan; contains some fine to coarse gravel	7	100
Silt and fine sand, calcareous, plastic, brown	12	112
Clay, silty, gray; contains some coarse sand and fine to coarse gravel	18	130
Sand, coarse, and fine to coarse gravel	15	145
Silt and fine sand, plastic, light-tan; contains some coarse to medium sand and fine to coarse sand	10	155
Sand, coarse, and fine to coarse gravel; contains some light-tan plastic fine sand and silt	5	160
Sand, medium to coarse, and fine to coarse gravel; contains some plastic yellow-brown silt and fine sand	20	180
Silt and fine sand, plastic, brown; contains medium to coarse sand and fine to coarse gravel	10	190
Sand, coarse to medium, and fine to coarse gravel	8	198
Silt and fine sand, plastic; contains medium to coarse sand and fine to coarse gravel	19	217
CRETACEOUS—Gulfian		
Niobrara formation—Smoky Hill chalk member		
Shale, yellow	6	223
Shale, gray	5	228

20-41-21ddd. *Sample log of test hole in the SE cor. sec. 21, T. 20 S., R. 41 W.; drilled October 1947. Surface altitude, 3,660.3 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Sanborn formation		
Silt, dark-brown	1	1
Silt, hard, light-brown	6	7
TERTIARY—Pliocene		
Ogallala formation		
Clay, sandy, calcareous, light-tan	6	13
Silt and fine sand, sticky, light-tan; contains some coarse sand	12	25
Gravel, fine to coarse; contains some coarse sand	26.5	51.5
Gravel, fine to coarse, and coarse sand; contains some yellow-brown to gray clay	8.5	60
Gravel, fine to coarse; contains some medium to coarse sand	8	68
Silt and fine sand, plastic, white; contains some coarse gravel	2	70
Sand, fine to coarse, and fine gravel	2	72
Gravel, fine to coarse, and medium to coarse sand; contains some white plastic silt and fine sand	8	80
Sand, fine to coarse, and fine to coarse gravel; contains some brown sticky plastic fine sand and silt	10	90
Silt and fine sand, plastic, brown; contains some fine to coarse gravel	10	100
Sand, medium to coarse, and fine to medium gravel; contains some brown plastic fine sand and silt	10	110
Sand, coarse, and fine to coarse gravel	6	116
Gravel, coarse, and yellow clay	2	118
Clay, soft, yellow	2	120
Gravel, fine to coarse; contains light-tan sticky fine sand and silt	10	130
Sand, coarse, and fine to coarse gravel; contains yellow-brown clay	12	142
CRETACEOUS—Gulfian		
Niobrara formation—Smoky Hill chalk member		
Chalk, yellow	5	147
Shale, soft, calcareous, gray	5	152

20-42-29bbb. *Sample log of test hole in the NW cor. sec. 29, T. 20 S., R. 42 W.; drilled October 1947. Surface altitude, 3,771.3 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Sanborn formation		
Silt, dark-brown	0.5	0.5
Silt, hard, light-brown	13.5	14
TERTIARY—Pliocene		
Ogallala formation		
Silt and fine sand, hard, light-tan	8	22
CRETACEOUS—Gulfian		
Niobrara formation—Smoky Hill chalk member		
Chalk, soft, yellow-brown	25	47
Chalk, light-gray	3	50
Chalk, yellow-brown to light-gray	5	55
Shale, calcareous, light-gray	3	58

21-43-3bbb. *Sample log of test hole in the NW cor. sec. 3, T. 21 S., R. 43 W.; Hamilton County, drilled in 1941. Surface altitude, 3,783.9 feet.* Water *level, 99 feet below land surface.*

	Thickness, feet	Depth, feet
TERTIARY and QUATERNARY—Pliocene and Pleistocene		
Soil, silty, brown	3	3
Sand, brown; contains some gravel and caliche	29.5	32.5
Gravel, fine to coarse, brown	17.5	50
Silt and clay, greenish-gray	4	54
Silt and sand, tan	6	60
Sand, coarse, to coarse gravel; brown	18.5	78.5
Sand, tan to gray	2.5	81
Sand and caliche, gray	5	86
Silt and sand, tan	4	90
Sand and caliche, tan to gray	4	94
Silt, sand, and gravel; tan	15.5	109.5
Gravel, fine to coarse, brown	12.5	122
CRETACEOUS—Gulfian		
Niobrara formation—Smoky Hill chalk member		
Shale, chalky, brown	8	130

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AREAL GEOLOGY OF WICHITA AND GREELEY COUNTIES, KANSAS

With Water-Table Contours

by John R. Branch
1948

State Geological Survey of Kansas

Bulletin 108
Plate 1

MAP OF WICHITA AND GREELEY COUNTIES, KANSAS

Showing the depths to Water Level and the Location of Wells for which Records are given

by Glenn C. Prescott, Jr., and Woodrow W. Wilson

1948

State Geological Survey of Kansas

Bulletin 108
Plate 2

Base modified from map prepared by State Highway Commission of Kansas

Drainage from map prepared by U.S. Dept. of Agriculture