STATE GEOLOGICAL SURVEY OF KANSAS

FRANKLIN D. MURPHY, M. D.,
Chancellor of the University, and ex officio Director of the Survey

FRANK C. FOLEY, Ph. D.,
State Geologist and Director

Division of Ground Water

V. C. FISHEL, B. S.,
Engineer in Charge

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GEOLOGY AND GROUND-WATER RESOURCES OF RAWLINS COUNTY, KANSAS

By KENNETH L. WALTERS
State Geological Survey of Kansas
Lawrence, Kansas

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GEOLOGY AND GROUND-WATER RESOURCES OF RAWLINS COUNTY, KANSAS

By Kenneth L. Walters

ABSTRACT

This report describes the geography, geology, and ground-water resources of Rawlins County in northwestern Kansas. The hydrologic and geologic information was obtained in the field during the summer of 1952. The field data upon which this report is based are given in tables; they include records of 226 wells, chemical analyses of water from 21 representative wells, and logs of 36 test holes and one well.

Rawlins County lies in the High Plains section of the Great Plains physiographic province. It is drained for the most part by Beaver Creek and its tributaries and by Sappa Creeks. The topography in general is an eastward sloping, gently rolling plain, deeply dissected along the valley walls of the principal streams. The climate is subhumid to semiarid, the average annual precipitation being about 18.5 inches. Farming is the principal industry of the county; wheat and cattle are the chief products.

The Pierre shale of late Cretaceous age underlies the entire county, and crops out in a few places along valley walls or floors. The Ogallala formation of Pliocene age overlies the Pierre shale and is one of the principal water-bearing formations of the county. The Meade formation of Kansan age, which overlies the Ogallala formation at a few isolated points, contains a bed of volcanic ash that has been worked on a small scale for commercial use. The Sanborn formation of Illinoian and Wisconsinan age overlies the Ogallala formation or the Meade formation where it is present. The Crete member of the Sanborn formation is composed of sand and gravel in a terrace position and yields moderate to large quantities of water to wells. Alluvium and undifferentiated low terrace deposits of Wisconsinan and Recent age yield quantities of water adequate for irrigation and municipal supplies.

The report contains a map showing the areas of outcrop of the rock formations and the location of test holes and wells for which records are given. The shape and slope of the water table in Rawlins County are shown by means of water-table contours. Geologic cross sections and a map showing the configuration of the bedrock surface are included in this report. Ground water in Rawlins County moves eastward and northeastward; the average slope of the water table is about 14 feet per mile. The depth to water ranges from less than 10 feet in some stream valleys to more than 200 feet in the highest upland areas.

The ground-water reservoir is recharged principally from rain and snow that fall within the county, by percolation from streams and depressions, and by underflow from adjacent areas. Ground water is discharged from the ground-water reservoir by seepage into streams, by transpiration and evaporation, by movement into adjacent areas, and by wells.

A small amount of land is irrigated from wells in Rawlins County. Additional irrigation wells can be developed in most of the major stream valleys.

Satisfactory irrigation wells can be developed from the Ogallala formation in western and southern Rawlins County, but construction and operating costs will be higher in relation to the yield than in the valley areas.

The analyses of samples of water from wells in Rawlins County indicate that the water is hard, but suitable for most purposes. In extreme northwestern Rawlins County the water may be locally of poor quality, owing to the influence of the underlying Pierre shale. In general water from the Ogallala formation is of better quality than water from the terrace deposits.

INTRODUCTION

Purpose and Scope of the Investigation

A program of investigation of the ground-water resources of Kansas was started in 1937 by the State Geological Survey of Kansas and the United States Geological Survey, in cooperation with the Division of Sanitation of the Kansas State Board of Health, and the Division of Water Resources of the Kansas State Board of Agriculture. The purpose of this program is to survey county areas and major stream valleys or irrigation districts to determine the availability of ground-water supplies. The present status of investigations resulting from this program is shown in Figure 1.

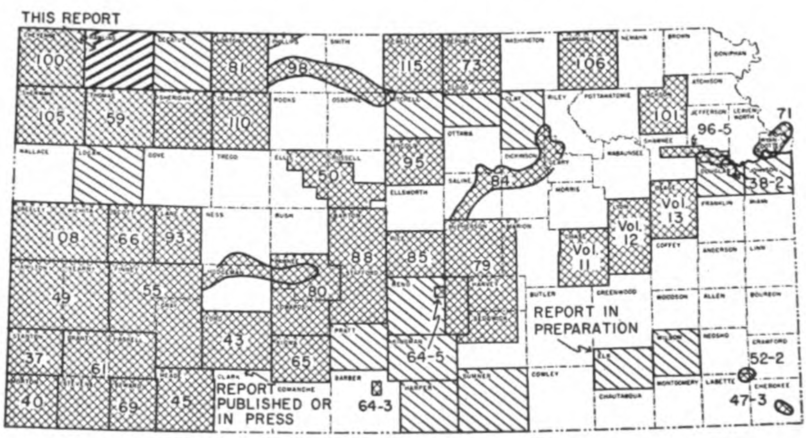


Fig. 1.—Index map of Kansas showing area covered by this report and areas for which cooperative ground-water reports have been published or are in preparation.

As a part of this program, an investigation of the geology and ground-water resources of Rawlins County was begun in June 1952. Ground water is one of the most important mineral resources in Rawlins County; all supplies of irrigation, domestic, and public water and most supplies of stock water are obtained from wells.

Irrigation with ground water is increasing rapidly in Rawlins County, and a series of dry years during times of relatively high prices for agricultural products would stimulate further the drilling of irrigation wells in the county. This investigation was made to determine the present utilization of ground water in the county, the depth of ground water below the land surface, the distribution and thickness of water-bearing materials beneath the surface, the chemical character of the ground water, and many other pertinent facts.

Previous Investigations

Papers by Haworth (1897, 1897a, 1913) discussed the geology and water resources of western Kansas. Johnson (1901, 1902), in his report on the utilization of the Southern High Plains, made special reference to the source, availability, and use of ground water in western Kansas, and Darton (1905) made a study of the geology and ground-water resources of the Central Great Plains. Elias (1931), in a report on the geology of Wallace County, described in detail most of the geologic formations that crop out in Rawlins County.

A description of the geology and ground-water resources of Rawlins and Decatur Counties was published by the State Geological Survey in 1937 (Elias, 1937). In 1940 Moore and others prepared a generalized report on the ground-water resources of the state. Investigations of the geology and ground-water resources of adjacent counties include Cheyenne County (Prescott, 1952), Sherman County (Prescott, 1953), Thomas County (Frye, 1945), Sheridan County (Bayne, 1956), and Decatur County (Biegler, in preparation). Beck and McCormack (1951) mapped the areal geology of Rawlins County and discussed the outcropping geologic formations in relation to their uses as construction materials.

Methods of Investigation

The field work upon which this report is based was done during the summer of 1952 and during a few days in the spring of 1953. The 226 wells and springs listed in Table 7 were inventoried and data pertaining to them obtained during this time. The depth to water level below the land surface and the total depth of most of the wells were measured with a steel tape.

Geologic mapping in the field was done on aerial photographs from field observations and stereoscopic study of the photographs. The geologic mapping was later transferred from the aerial photographs to a base map prepared by Bernita K. Mansfield from a county map prepared by the Soil Conservation Service. The illustrations were drafted in final form by Woodrow W. Wilson.

The character of the material overlying the Cretaceous bedrock surface was determined by drilling 31 test holes at strategic points in the county. These test holes were drilled with the portable hydraulic-rotary drilling machine owned by the State Geological Survey of Kansas and operated by William T. Connor and Norman W. Biegler. Samples of the well cuttings were collected and studied in the field by Biegler and logs of the test holes were prepared. These samples were later studied in the office under a binocular microscope. The altitudes of the ground surface at the test holes and of the measuring points of the wells were determined by Woodrow W. Wilson and Edwin Rhine by the use of a plane table and alidade.

Samples of water were collected from 18 wells; the samples were analyzed in the Water and Sewage Laboratory of the State Board of Health at Lawrence by Howard A. Stoltenberg, chemist. Analyses of three city supplies, on file with the State Board of Health, are included in this report.

Well-Numbering System

In this report, wells and test holes are numbered according to their location as given by the General Land Office system of land classification. The component parts of a well number are the township number, the range number, the section number, and lower-case letters to indicate the subdivisions of the section. The first letter denotes the quarter section; the second letter denotes the 40-acre tract; and the third letter, if used, indicates the 10-acre tract. The 160-acre, 40-acre, and 10-acre tracts are designated a, b, c, or d in a counterclockwise direction, beginning in the northeast quarter. If two or more wells are inventoried within the same 10-acre tract, the wells are numbered serially according to the order in which they were inventoried. An example of the well-numbering system is given in Figure 2.

Acknowledgments

Appreciation is expressed to the many residents of Rawlins County who supplied information and aided in the collection of field data. Special thanks are extended to the officials of the cities in Rawlins County for data on municipal water supplies.

The manuscript for this report has been reviewed critically by several members of the Federal and State Geological Surveys; by Robert Smrha, Chief Engineer, and George S. Knapp, Engineer, Division of Water Resources, Kansas State Board of Agriculture; and by Dwight Metzler, Director, and Willard Hilton, Geologist, Division of Sanitation, Kansas State Board of Health.

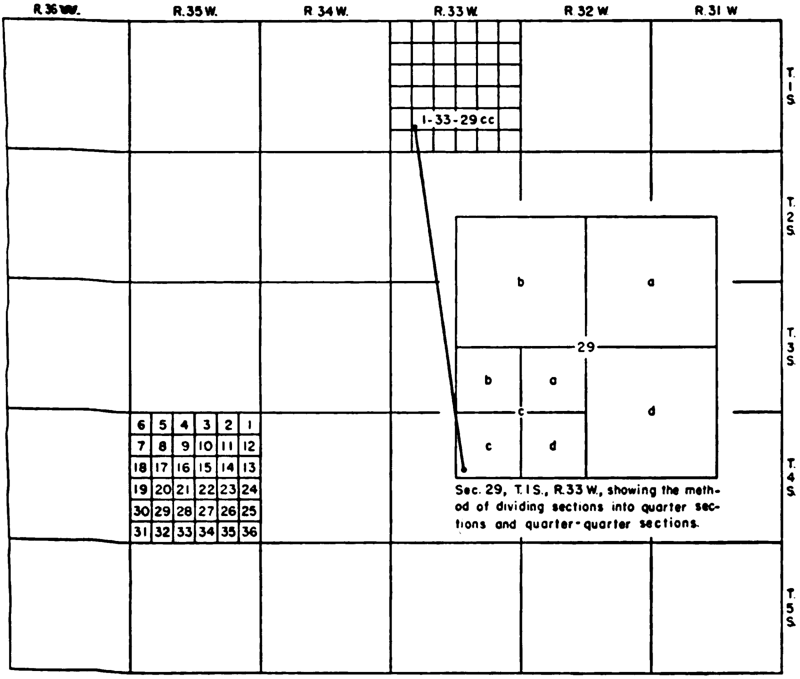


Fig. 2.—Map of Rawlins County illustrating the well-numbering system used in this report.

GEOGRAPHY

Location and Extent of the Area

Rawlins County is in the first row of counties south of Nebraska and in the second row of counties east of Colorado. Rawlins County is bounded on the west by Cheyenne County, on the south by Sherman and Thomas Counties, on the east by Decatur County, and on the north by Dundy, Hitchcock, and Red Willow Counties of Nebraska. The county contains 30 townships and has an area of about 1080 square miles.

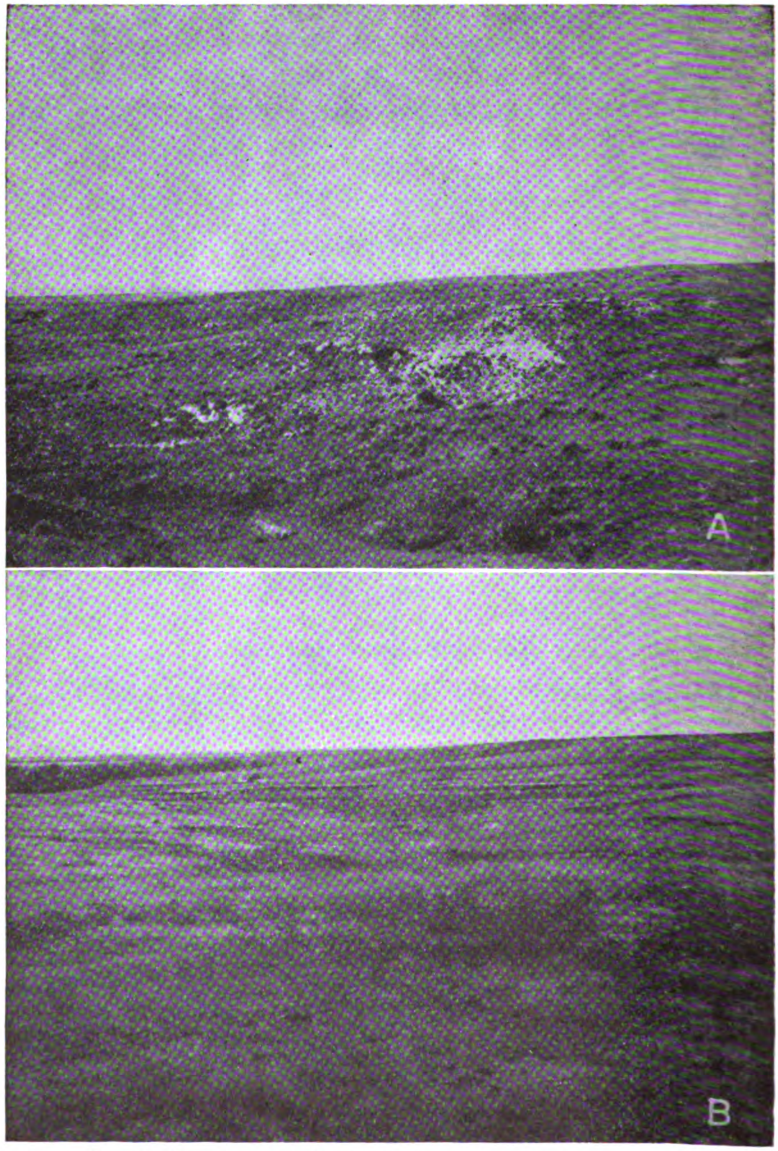


PLATE 2.—A, Mortar beds of the Ogallala formation exposed by erosion along a tributary to Beaver Creek, near the NE cor. sec. 23, T. 5 S., R. 36 W. B, View to the east illustrating the steep slope from the upland to the valley of North Fork Sappa Creek, sec. 23, T. 4 S., R. 32 W.

Topography and Drainage

Rawlins County lies entirely within the area designated by Fenneman (1931) as the High Plains section of the Great Plains physiographic province. The upland areas of the county consist of nearly flat to gently rolling terrain having many undrained depressions and a few shallow valleys. The upland surface of the county slopes generally eastward at a rate of about 10 to 14 feet to the mile. Areas bordering the major streams of the county are deeply dissected (Pl. 2) and have a very rugged topography that contrasts sharply with the nearly flat uplands. The areas of deep dissection extend about 2 or 3 miles on each side of the major streams, and in general the slopes are much steeper on the south side of streams than on the north side. The altitude of the flat valley areas of the county averages about 200 feet less than the flat upland areas.

Beaver Creek, which has its source in Colorado, is the largest stream in Rawlins County and with its tributaries drains about half the area of the county. Little Beaver Creek, which also has its source in Colorado, enters Rawlins County 9 miles north of the Sherman County line and joins Beaver Creek at Atwood. North Beaver Creek has its source north of McDonald and joins Little Beaver Creek near Blakeman. North Fork Sappa Creek, which originates about 6 miles east of the southwest corner of Rawlins County, is joined in eastern Rawlins County by Middle Fork Sappa Creek. South Fork Sappa Creek, which drains the southeast township of Rawlins County, joins North Fork Sappa Creek about 3 miles west of Oberlin in Decatur County. East Fork Burntwood Creek, which is the only creek in the county that does not flow in general northeasterly, is an ephemeral stream that flows north through the northwest township of Rawlins County.

Climate

The climate of Rawlins County is subhumid to semiarid and is characterized by slight to moderate precipitation, moderately high average wind velocity, and rapid rate of evaporation. During the summer the days are hot, but there is generally good wind movement and low relative humidity. Summer nights are generally cool. Winters are generally mild, except for short periods of severe cold.

The climate of Rawlins County is well suited to the raising of winter wheat. Moderate acreage of alfalfa is grown in the valleys where the water table is near the surface or where irrigation is practiced. Areas of the county that are unsuitable for cultivation are used for cattle grazing.

According to data presented by the United States Weather Bureau, the normal annual mean temperature at Atwood is 52.3° F. The normal monthly mean temperatures for June, July, and August, generally the hottest months, are 71.3° F., 78.0° F., and 75.4° F. respectively. The normal monthly mean temperatures for January and December, generally the coldest months, are 28.0° F., and 29.7° F., respectively. The growing season, the average interval between the last killing frost in the spring and the first killing frost in the fall, averages about 155 days and has ranged from 114 to 182 days. The average date for the last killing frost in the spring is May 3, the latest date for a killing frost in the spring is May 26. The average date for the first killing frost in the fall is October 5. The earliest date recorded for a killing frost in the fall is September 12.

The normal annual precipitation at Atwood is 18.53 inches. The recorded annual precipitation ranges from a minimum of 11.32 inches in 1934 to 29.68 in 1923. More than half the precipitation falls during the growing season from May through September when moisture is most needed. The normal monthly precipitation for the period 1898 through 1942 is given in Table 1.

TABLE 1.—*Normal monthly precipitation at Atwood, Kansas*

Month	Precipitation, inches	Month	Precipitation, inches
January	0.25	July	2.75
February	.49	August	2.63
March	.84	September	1.88
April	2.04	October	1.01
May	2.64	November	.64
June	2.75	December	.61

The annual precipitation and the cumulative departure from normal precipitation at Atwood are shown graphically in Figure 3.

Population

According to the 1950 Federal census the population of Rawlins County was 5,728. The average density of population was 5.3 per square mile as compared to 23.2 for the state. The population of Rawlins County was 6,618 in 1940 and 7,362 in 1930. The population of Atwood, the county seat of Rawlins County, in 1950 was 1,613; McDonald had a population of 426, and Herndon 321.

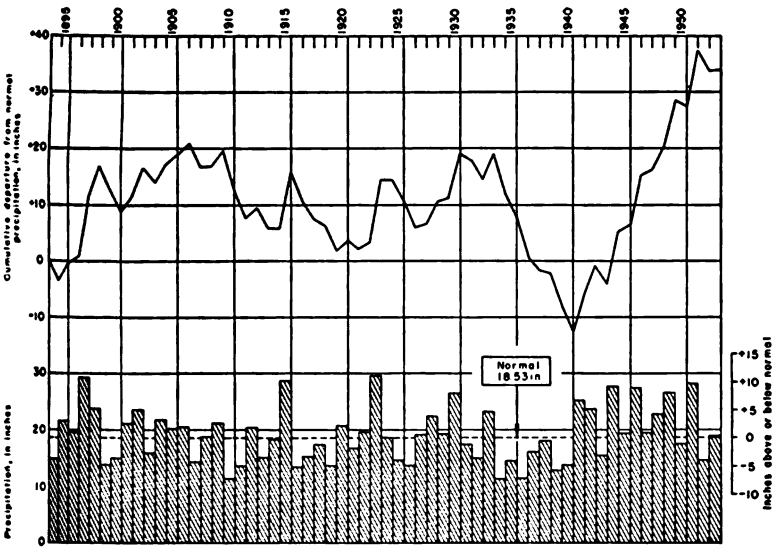


FIG. 3.—Annual precipitation and cumulative departure from normal precipitation at Atwood, Kansas.

TRANSPORTATION

Rawlins County is served by a branch line of the Chicago, Burlington, and Quincy Railroad, which leaves the main line at Orleans, Nebraska, and terminates at St. Francis in Cheyenne County. This line traverses the county east-west along Beaver Creek and Little Beaver Creek to a point between Blakeman and Beardsley, where it leaves the valley and continues west through Beardsley and McDonald.

U. S. Highway 36 passes east-west through Rawlins County through the city of Atwood. State Highway 25 passes through the approximate center of Rawlins County from north to south and intersects U. S. Highway 36 at Atwood. State Highway 117, which extends north-south between the Nebraska line and U. S. Highway 36, passes through Herndon. The rest of the county is served by many improved county and township roads.

GEOLOGY

Summary of Stratigraphy *

The rocks that crop out in Rawlins County are sedimentary in origin, Late Cretaceous (Gulfian), Pliocene, and Pleistocene in age, and most are unconsolidated.

The Pierre shale (Cretaceous), the oldest formation exposed in Rawlins County, crops out in only a few small areas of the county where younger beds have been eroded away. The Pierre shale underlies all of Rawlins County.

The Ogallala formation (Tertiary) overlies the Pierre shale in much of Rawlins County. Locally, erosion has removed all the Ogallala formation, and the Pierre shale is exposed.

Large upland areas of the county are blanketed by wind-blown silt (loess) of the Sanborn formation (Pleistocene). Several of the streams that cross the county have eroded into the Pierre shale and have then deposited sand, gravel, and silt, some now in terrace positions and some as alluvium on the present valley floors.

The areal extent of the geologic formations is shown on the geologic map (Pl. 1). Cross sections in Figures 4 and 5 show the general relation and extent of the formations. The character and ground-water supply of the formations in the county are described briefly in the generalized section (Table 2) and in more detail in the section on geologic formations and their water-bearing properties.

Geologic History and Geomorphology

PALEOZOIC ERA

Paleozoic rocks do not crop out in Rawlins County and are too deeply buried to be economically important other than as possible producers of oil or gas. Pre-Cambrian rocks, which have been found at depths ranging from about 4,500 feet to 5,250 feet in tests for oil and gas, are overlain by about 2,600 feet of Paleozoic sedimentary rocks. Throughout much of Paleozoic time the area was alternately submerged and elevated. Marine sediments that were deposited when the surface was below sea level were eroded during periods of emergence. Only a few hundred feet of Paleozoic rocks older than Mississippian age are reported in the subsurface of Rawlins County.

* 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.

TABLE 2.—*Generalized section of the surficial geologic formations in Rawlins County, Kansas

System	Series	Stage	Formation	Member	Thickness (feet)	Physical character	Water supply
Quaternary	Pleistocene	Wisconsinan and Recent	Undifferentiated low terrace deposits (includes Alluvium)		0–50	Sand, gravel, silt, and clay along stream valleys. Locally, very coarse gravel in the lower part.	Yields moderate to large supplies of moderately hard water to wells along the major streams; small supplies in tributary valleys.
		Wisconsinan	Sanborn formation	Bignell silt member	0–10	Massive, well-sorted silt, light yellow-gray to tan. Blankets the uplands in some places.	Above the water table; yields no water to wells.
				Peoria silt member	0–75	Massive well-sorted silt, light yellow-gray. Brady soil at top. Underlies uplands and slopes.	Above the water table in most places; generally does not yield water to wells.
		Illinoian		Loveland silt member	0–30	Massive silt, reddish-tan to tan.	Generally above the water table; does not yield water to wells.
				Crete sand and gravel member	0–45	Well-sorted sand, gravel, and silt.	Yields moderate to large quantities of water to wells.
		Kansan	Meade formation	Sappa and Grand Island members	0–10	Volcanic ash (Pearlette), silt, sand, and gravel. Recognized in Rawlins County only where volcanic ash is present. Occurs as high terrace remnants in a few places in central and west-central Rawlins County.	Above the water table; does not yield water to wells.
Tertiary	Pliocene		Ogallala formation	Kimball, Ash Hollow, and Valentine members	0–280	Sand, gravel, silt (partly cemented by calcium carbonate), impure limestone, volcanic ash, clay, and opaline sandstone.	Yields moderate to large quantities of water to wells.
Cretaceous	Gulfian		Pierre shale		400–1200	Black to deep-brown and gray shale. Locally, contains bentonitic beds and selenite crystals.	Does not yield water to wells.

* The classification is that of the State Geological Survey of Kansas.

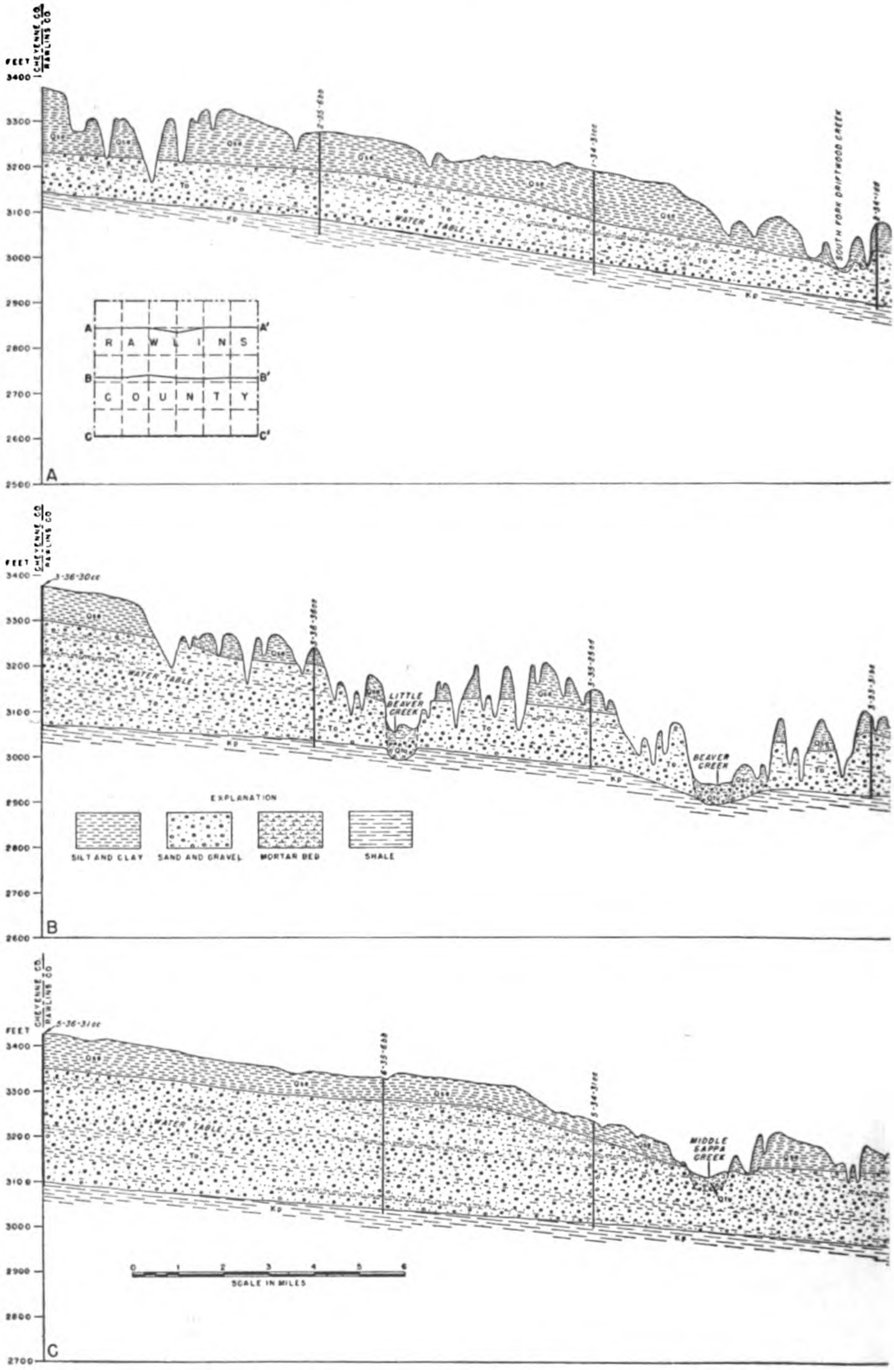
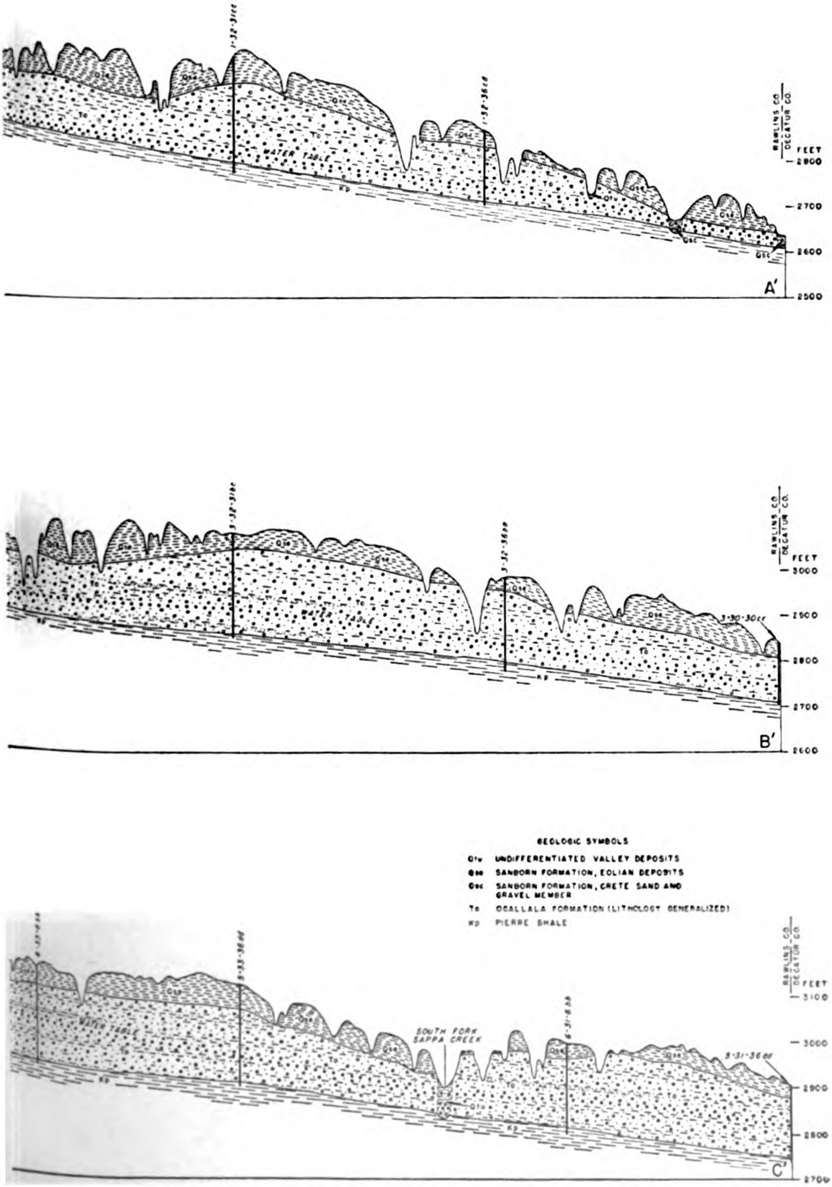


FIG. 4.—Geologic cross sections in Rawlins



County along lines A-A′, B-B′, and C-C′.

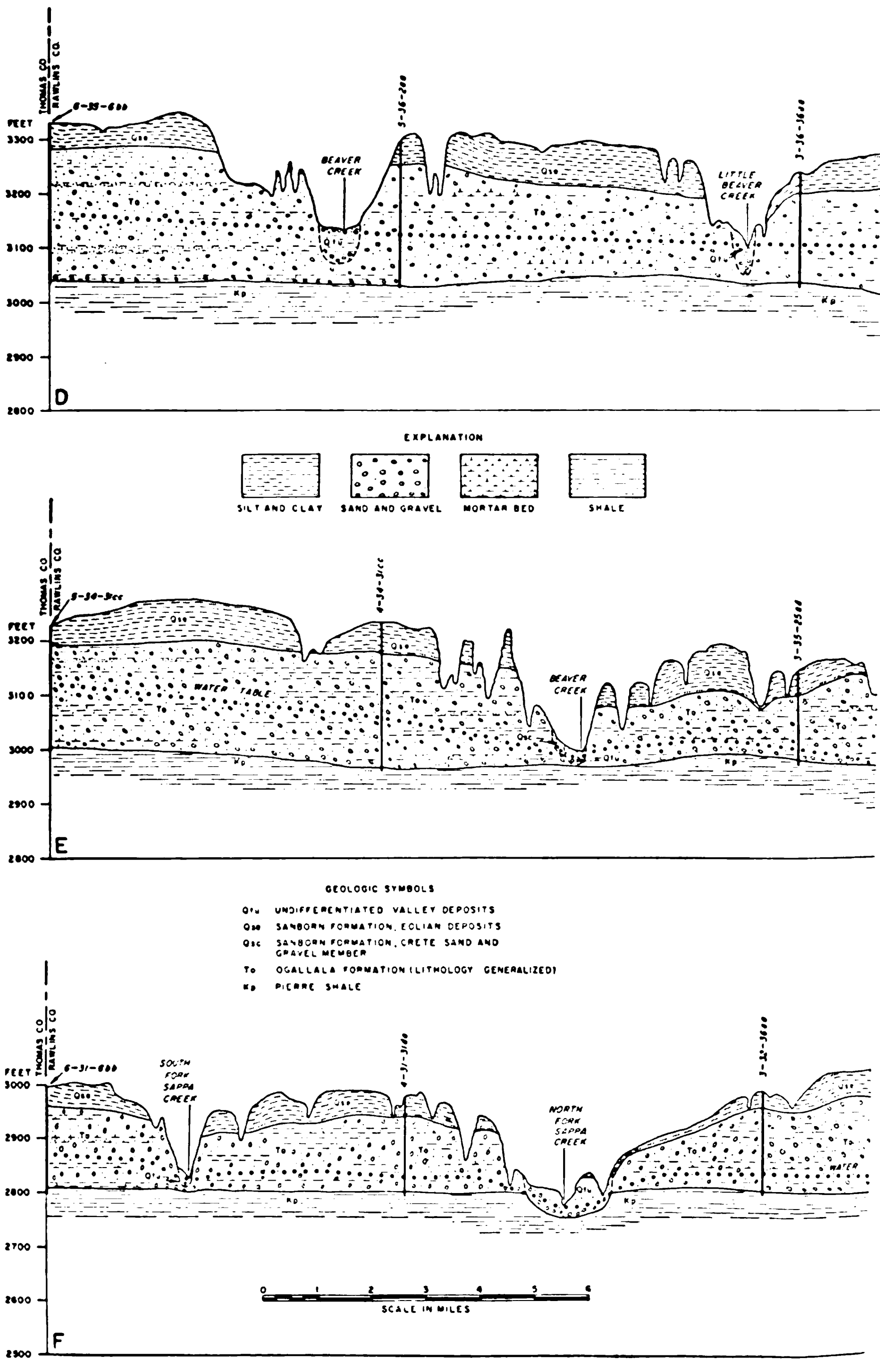
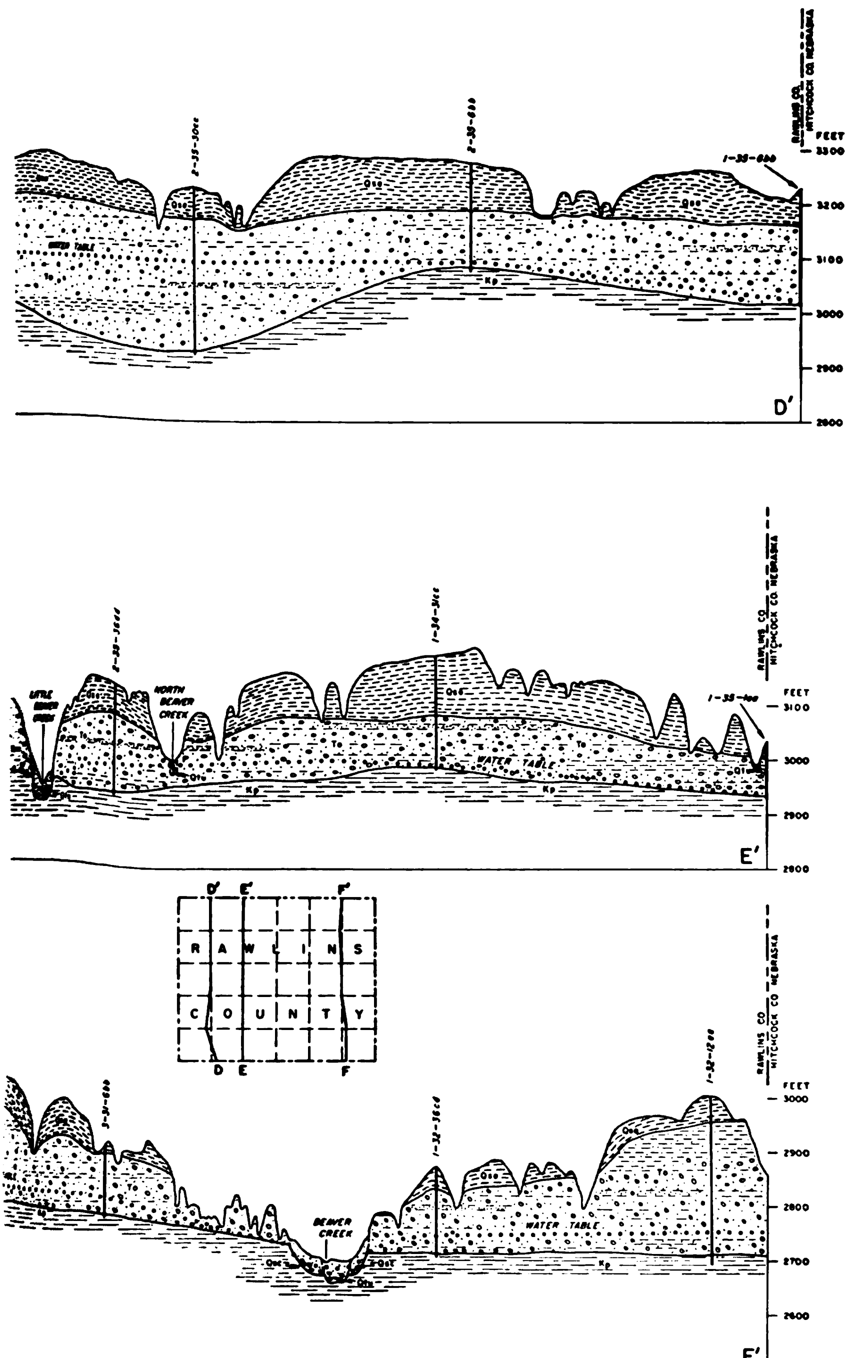


FIG. 5.—Geologic cross sections in Rawlins



County along lines D-D', E-E', and F-F'.

Mississippian, Pennsylvanian, and lower Permian rocks are mostly of marine origin, but toward the end of the Paleozoic era, nonmarine sediments and evaporites were deposited in greater quantities indicating a progressive emergence of the area.

Mesozoic Era

The sea withdrew from the area by the close of Paleozoic time and erosion was the dominant geologic process during much of early Mesozoic time. No deposits of Triassic age have been identified in the subsurface of the area. If Triassic beds were deposited, they subsequently were removed by erosion.

About 175 feet of rocks of probable Jurassic age (tentatively correlated with the Morrison formation) are known in the subsurface of Rawlins County. An erosion interval followed the deposition of these rocks; the area was probably above sea level during late Jurassic and early Cretaceous time. The area was again submerged during later Cretaceous time. The Dakota formation probably was deposited at or near sea level, and the overlying marine sediments were deposited in the deep late Cretaceous sea. Cretaceous rocks have a total thickness of about 2,000 feet in Rawlins County.

Cenozoic Era

Tertiary Period. During much of Tertiary time, the area was subjected to erosion, and the surface cut on the Cretaceous rocks became an eastward-sloping plain of low relief. In Pliocene time, streams originating in the Rocky Mountains shifted back and forth as they crossed the area, and spread a thick blanket of alluvial material (the Ogallala formation) on the eroded Cretaceous surface. At the close of Tertiary time the Ogallala surface was a nearly flat plain containing, according to some geologists, many fresh-water lakes in which the "Algal limestone", which caps the Ogallala formation, was formed.

Quaternary Period. A stream pattern that probably closely resembled the present drainage of Rawlins County began to form and to cut into the unconsolidated Ogallala sediments early in Pleistocene time. No deposits of Nebraskan age have been identified in Rawlins County, but by Kansan time the major streams were well established and alluvial deposits (Meade formation) of Kansan age occur as high-terrace remnants along several streams in the county. By Illinoian time the streams had cut to a lower level and stream deposits of that age (Crete sand and gravel member) were deposited about 30 to 40 feet lower than the Meade formation.

Late in the Pleistocene period a thick mantle of wind-transported silt (loess) was deposited over the area. This silt, which was picked up by the wind from the flood-plains of major rivers, was not deposited in one continuous period, but in three stages of deposition separated by soil-forming intervals. These three loess phases and the Crete sand and gravel member constitute the Sanborn formation.

The topography of the area since Sanborn deposition has been greatly modified by erosion and slumping. During and since late Wisconsinan time the streams have alluviated their valleys.

GROUND WATER

Principles of Occurrence

The following discussion of the occurrence of ground water has been adapted from Meinzer (1923) and the reader is referred to his report for a more detailed discussion. A general discussion of the principles of ground-water occurrence with special reference to Kansas has been presented by Moore and others (1940).

The rocks that make up the crust of the earth generally are not solid, but have many openings, called voids or interstices, which may contain air, natural gas, oil, or water. The many different kinds of rocks differ greatly in the number, size, shape, and arrangement of their interstices; therefore, the occurrence of water in any region is determined by the geology of the region.

The interstices or voids in rocks range in size from microscopic openings to the huge caverns found in some limestones. The porosity of a rock is expressed quantitatively as the percentage of the total volume of the rock that is occupied by interstices or that is not occupied by solid rock material. Uncemented gravel deposits having a uniform grain size have a high porosity, whereas deposits made up of a mixture of sand, clay, and gravel may have a very low porosity because the smaller particles occupy the space between adjacent large particles. Relatively soluble rock such as limestone, though originally dense, may become cavernous as a result of the removal of part of its substance through the solvent action of percolating water. Hard, brittle rock may acquire large interstices through fracturing that results from shrinkage or deformation of the rocks or through other agencies.

The permeability of a rock is its capacity for transmitting water under pressure and is measured by the rate at which the rock will transmit water through a given cross section under a given difference of head per unit of distance. A rock containing many very small interstices may be porous, but not very permeable; whereas, a coarser-grained rock may have a low porosity but will generally be much more permeable. The specific yield of a rock or soil, with respect to water, is the ratio of (1) the volume of water it will yield

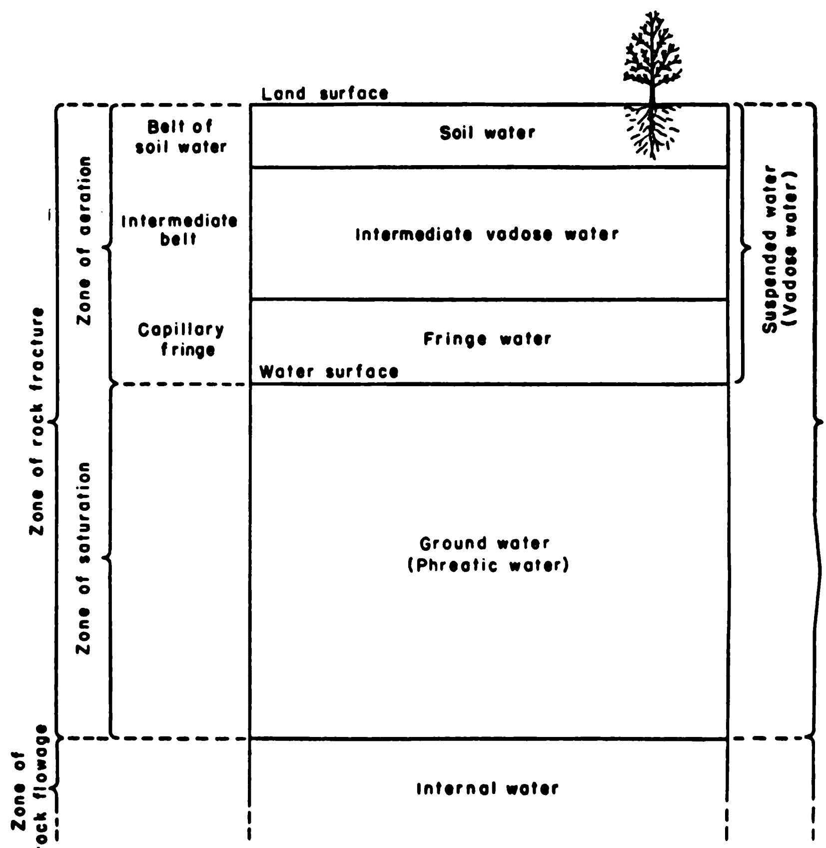


FIG. 6.—Diagram showing divisions of subsurface water. (From O. E. Meinzer)

by gravity after being saturated to (2) its own volume. This ratio is stated as a percentage. The specific retention of a rock is the ratio of (1) the volume of water it will retain against the pull of gravity after being saturated to (2) its own volume.

The permeable rocks that lie below a certain level are generally saturated with water under hydrostatic pressure. These saturated rocks are said to be in the zone of saturation (Fig. 6). The zone of saturation ordinarily extends down to a depth much greater than is reached by modern drilling methods. The term ground water is used to designate that part of the subsurface water within the zone of saturation. The upper surface of the zone of saturation when not formed by an impermeable body is called the ground-water table, or simply, the water table. In most places there is only one zone of saturation, but in certain localities the water may be hindered in its downward course by an impermeable or nearly impermeable bed to such an extent that it forms an upper zone of saturation, or perched water body, that is not associated with the lower zone of saturation.

All rocks above the water table are in the zone of aeration, which ordinarily consists of three parts; the belt of soil water at the surface; the intermediate belt, and the capillary fringe.

The belt of soil water contains water held by molecular attraction; it lies just below the land surface, and extends down to the maximum depth to which evaporation and plant action are effective. The water in the belt of soil water is not available to wells, but is of the utmost importance to agriculture. Before any water can percolate downward to the water table through this belt, the amount of water present must exceed that which will be held by adhesion. The thickness of the belt of soil water is determined by the texture of the rock or soil, and by the character of the vegetation.

The space between the lower limit of the belt in which water can be withdrawn by plant action and the upper limit of the capillary fringe forms an intermediate belt that is thick where the depth to the water table is great and may be absent where the water table is at or near the surface. In this belt the interstices in the rocks contain some water held by molecular attraction but also may contain appreciable quantities of water that is moving downward from the belt of soil moisture to the water table.

The capillary fringe lies directly above the water table and is formed by water held above the zone of saturation by capillary force. The water in the capillary fringe is not avaliable to wells, which must be deepened to the zone of saturation before water will enter them. The capillary fringe may be very thin in coarse-grained sediments, in which the capillary action is negligible, or it may be several feet thick in fine-grained sediments.

The Water Table and Movement of Ground Water

The water table has been defined as the upper surface of the zone of saturation. The zone of saturation is, in a sense, a ground-water reservoir just as a lake or river is a surface-water reservoir.

The water table is not a static, level surface; generally it is a sloping surface having many irregularities and is constantly changing. There are many causes of irregularities and fluctuations in the water table.

Ground water moves in the direction of slope of the water table, but this movement is very slow because of the frictional resistance offered by the small interstices through which the water must pass. In an area where conditions are suitable for rapid recharge, water may percolate down to the water table faster than it can spread laterally, so a mound or ridge is formed in the water table. Conversely, if water is withdrawn from the the zone of saturation faster

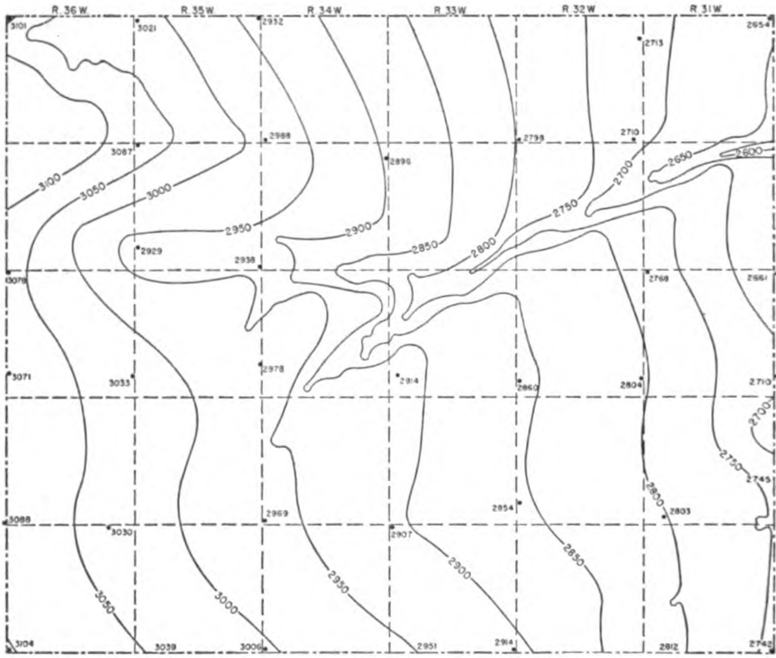


FIG. 7.—Map showing location of test holes, and configuration of the top of the Pierre shale by means of contours.

than it can flow in laterally, the water table is lowered locally, forming a cone or trough. The permeability of the water-bearing material has a significant effect upon the slope of the water table. For a given rate of flow the slope of the water table must be much steeper in a fine-grained deposit having a low permeability than in a coarse-grained, highly permeable deposit.

The configuration of the water table in Rawlins County is shown on Plate 1 by means of water-table contours. Each contour line connects points of equal altitude of the water table. The ground water moves in the direction of greatest slope of the water table; that is, at right angles to the water-table contours. The configuration of the water-table surface resembles the bedrock configuration (Fig. 7) and to a certain extent the topography.

The water table in Rawlins County has an average slope of about 14 feet to the mile. The general direction of movement of ground water in the county ranges from almost east to north-east. Near the valley walls of the lower reaches of Beaver Creek the water table has a very steep slope and the water moves toward Beaver Creek almost at right angles to the normal direction of movement in the county. In T. 1 S., R. 36 W., the water table is discontinuous and is not shown on Plate 1.

Ground-Water Recharge

The amount of water in storage in the zone of saturation does not remain constant, but fluctuates with the precipitation and rate of withdrawal. Water is continually being discharged from the ground-water reservoir by several processes. The water table subsides in times of drought and rises during times of precipitation.

All ground water in the Tertiary and Quaternary deposits of Rawlins County originally fell as rain or snow within the county, or in the adjacent area to the west or south. Water reaches the zone of saturation in Rawlins County by direct recharge from local precipitation, by recharge from streams and ponds, and by subsurface movement from outside the area.

RECHARGE FROM LOCAL PRECIPITATION

The normal annual precipitation in Rawlins County is about 18.5 inches, but only a small part of this amount enters the zone of saturation as recharge to the ground-water reservoir. A large part of the precipitation is evaporated and transpired and a small part leaves the county as surface runoff.

The type of material above the water table, the depth to the water table, the slope of the land surface, and the weather all have an effect upon the amount of recharge the ground-water reservoir will receive from local precipitation.

Much of Rawlins County is mantled by thick massive silt deposits of relatively low permeability, and recharge is much less in these areas than in areas where sand and gravel are exposed at the surface. In general, the areas mantled by loess are fairly flat and generally have many undrained depressions in which water collects during periods of moderate to heavy precipitation. It is in these parts of the county that a large part of the precipitation is returned to the atmosphere as water vapor by the processes of evaporation and transpiration.

Sand and gravel of the Ogallala formation are relatively permeable, and areas in which this formation crops out would be favorable for recharge except that the slope of the surface is generally steep and runoff is greater.

The valleys of the major streams receive considerable recharge because the material above the water table consists principally of sand and gravel.

A large part of the precipitation falls during the period from May through September when the vegetation is growing, temperatures and wind velocities are high, and humidity is low; consequently, the rate of evaporation and transpiration is high. Runoff resulting from torrential rains is much greater than that resulting from gentle rains, and runoff is also greater during winter rains that fall when the ground is frozen and impervious to infiltration.

RECHARGE FROM STREAMS AND PONDS

A stream whose surface is higher than the water table will contribute water to the zone of saturation and is said to be an influent stream. A stream whose surface is lower than the water table will receive water from the zone of saturation and is an effluent stream (Fig. 8).

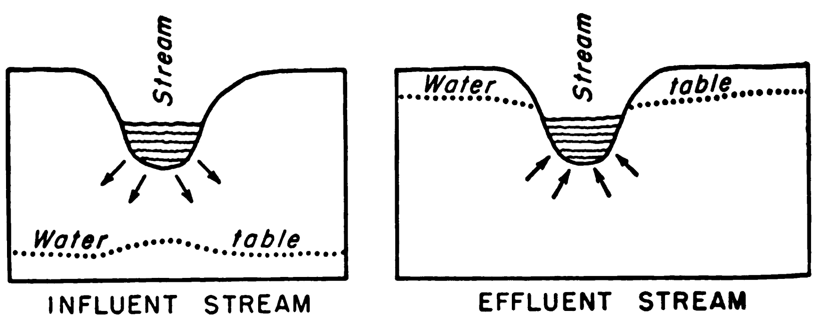


Fig. 8.—Diagrammatic sections showing influent and effluent streams.

The stream surface of Beaver Creek is below the water table and receives water from the ground-water reservoir, except after heavy precipitation when the stream flow is increased and water enters the alluvium along the stream.

The western parts of North Beaver Creek and Little Beaver Creek in Rawlins County are ephemeral (intermittent) streams; during periods of stream flow, water percolates downward from the stream beds to the water table.

Middle Fork Sappa Creek and South Fork Sappa Creek are very nearly at the same level as the water table and are probably alternately influent and effluent because of fluctuations in the surface of the streams and water table. North Fork Sappa Creek is an intermittent stream and is influent during periods of flow.

Most ponds and undrained depressions in Rawlins County are in the relatively impervious silt of the Sanborn formation and probably do not appreciably recharge the ground-water reservoir.

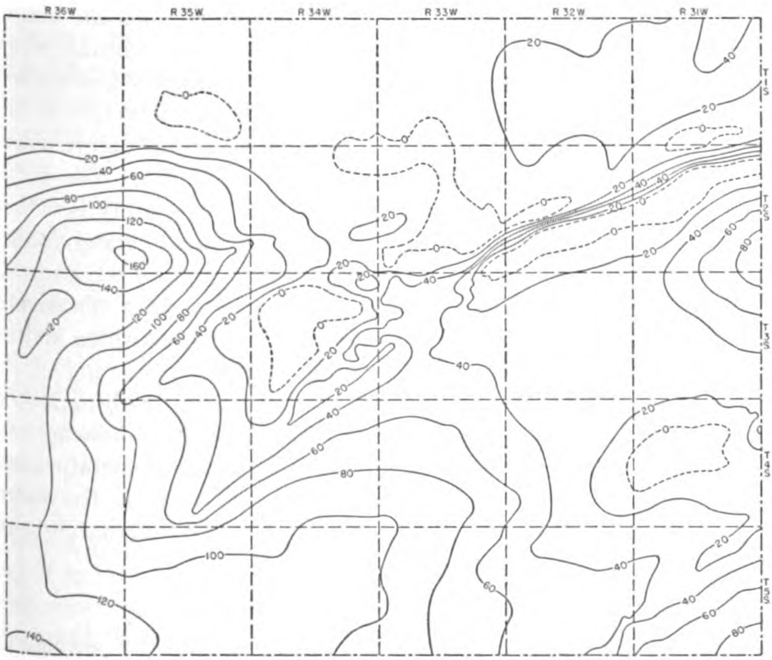


Fig. 9.—Map showing the thickness of saturated Tertiary and Quaternary deposits in Rawlins County.

RECHARGE FROM OUTSIDE AREAS

The slope of the water table (Pl. 1), the thickness of saturated material (Fig. 9), and the geologic cross sections (Fig. 4 and 5) indicate that much water enters the county by subsurface movement from the area to the west. Some water enters Rawlins County by subsurface movement from the area to the south. Very little water enters the county by subsurface flow along the west side of T. 1 S., R. 36 W., where the water table is discontinuous or absent.

Ground-water Discharge

Ground-water discharge is the removal, by any method, of water from the zone of saturation. Ground water is discharged in Rawlins County by transpiration and evaporation, by seepage into streams, by subsurface movement into adjacent areas, and by wells.

DISCHARGE BY TRANSPIRATION AND EVAPORATION

Transpiration is the process by which water is taken into the root system of plants directly from the zone of saturation, or from the capillary fringe just above it, and discharged into the atmosphere. The depth from which plants will lift the ground water differs with plant species and types of soil. Ordinary grasses and field crops will not send their roots more than a few feet in the search for water, but alfalfa, some trees, and certain desert plants are known to draw water from much greater depths. The water table along most of the major valleys in Rawlins County is within easy reach of such deep-rooting plants, and much water is discharged from the zone of saturation in this way.

Discharge of ground water by evaporation can take place only where the water table is within a few feet of the surface and in Rawlins County is limited to areas along streams.

That considerable ground water is discharged in Rawlins County by transpiration and evaporation is illustrated by the significant rise in the water table in valley areas in the fall when vegetation becomes dormant and evaporation decreases. The rise in the water table may be several feet although there may be no recharge from precipitation.

DISCHARGE BY SPRINGS AND SEEPS

Discharge of ground water in Rawlins County by springs is mostly in Beaver Creek valley and the small valleys tributary to Beaver Creek. Springs occur at the contact between the Pierre shale and the Ogallala formation. Water moving laterally at the base of the Ogallala formation on the top of the impermeable Pierre shale flows or seeps out at the surface where the top of the Pierre shale is exposed. Beaver Creek, which is an effluent stream, has many inconspicuous seeps along its entire course and receives considerable water from the ground-water reservoir.

DISCHARGE TO AREAS OUTSIDE THE COUNTY

The water-table contours on Plate 1 indicate that water leaves the county by subsurface flow along the east and north sides of the county. The map indicating thickness of saturated material (Fig. 9), however, shows very little saturated material along the north edge of the county, and only about one-third as much saturated material on the east side as there is on the west side of the county. The slope of the water table is about the same on the inflow and outflow sides of the county, and assuming that the permeability is uniform on the inflow and outflow sides of the county, much less water leaves the county by subsurface flow than enters the county by the same process. The water table in Rawlins County is in a state of approximate equilibrium, and as recharge from precipitation within the area is equal to or greater than the amount discharged by pumpage from wells, the reduction in the amount of the subsurface movement of ground water is probably due to transpiration and evaporation and discharge of ground water into streams.

DISCHARGE BY WELLS

Most supplies of domestic, stock, municipal, railroad, and irrigation water in Rawlins County are derived from wells. Although wells are the most obvious method of ground-water discharge, the quantity withdrawn by this method is not large when compared with the amount discharged by other means. The total quantity of water pumped annually from wells is not accurately known, but is probably about equal to 0.03 inch over the entire area of the county.

Principles of Recovery

When a well is at rest, the pressure of the water outside the well is equal to the pressure of the water inside the well. When water is removed from the well by pumping, the resulting drawdown or lowering of the water level produces a differential in head or pressure and water flows into the well. When water is being discharged from a well, the water table is lowered in an area around the well to form a depression in the water table that somewhat resembles an inverted cone. This depressed area is known as the cone of depression or the cone of influence. As the pumping rate of the well is increased, the drawdown becomes greater. When a well is first pumped, the water level will fall very rapidly; but as pumping is continued, the drawdown increases at a diminishing rate. When pumping is stopped, the recovery is rapid at first, but gradually tapers off and may continue for many hours or for several days.

The capacity of a well is the rate at which it will yield water continuously after the water stored in the well has been removed. The capacity depends upon how much the water level can be lowered, the thickness and permeability of the water-bearing bed, and the construction and condition of the well. The capacity of a well generally is expressed in gallons a minute.

The specific capacity of a well is the rate of yield per unit of drawdown and is expressed in gallons a minute per foot of drawdown. If a well yields 50 gallons of water per minute, and has a drawdown of 10 feet when pumped at that rate, the specific capacity of the well is 5 gallons a minute per foot of drawdown. In testing the specific capacity of a well, pumping is continued until the water level remains approximately stationary.

Utilization of Water

During this investigation, data on 226 wells in Rawlins County were obtained. All types of wells in all parts of the area were inventoried in order to get a representative tabulation of the wells in the county. Most of them were domestic or stock wells; 7 were municipal wells, 11 were irrigation wells, and 2 were railroad supply wells. Wells from which the pumping equipment had been removed and which did not seem to be in usable condition were classified as unused.

DOMESTIC AND STOCK SUPPLIES

Nearly all domestic and stock supplies in the county are obtained from wells. The domestic use of water generally includes drinking, cooking, washing, and in some cases, the disposal of sewage. Water supplies for those schools not served by public-supply systems are considered domestic. In general, ground water in Rawlins County, although hard, is suitable for most domestic and stock uses. In several small areas of Rawlins County, ground-water supplies are inadequate, and water for domestic use must be hauled.

PUBLIC SUPPLIES

Three municipalities in Rawlins County obtain public water supplies from wells. Each municipal supply is described briefly in the following paragraphs. The geologic characteristics and the water-bearing properties of the aquifers are discussed in the section on geologic formations and their water-bearing properties.

Atwood.—The city of Atwood in Beaver Creek valley obtains its water from two drilled wells near the water plant in the south part of town. Both wells extend into sand and gravel deposits underlying the Crete terrace surface upon which they are located. These wells are 65 feet deep and are cased with 12-inch steel casing equipped with a copper screen. They are equipped with turbine pumps powered by 40-horsepower electric motors. The static water level in each well is reported to be 40 feet below the land surface.

Water from the wells is pumped directly into the mains, the excess going into a 300,000-gallon concrete storage tank at the southeast corner of town. In August of 1952, the city of Atwood consumed about 14,900,000 gallons of water, which is the most ever used by the city up to that date. The chemical analysis of a composite sample of water from both wells is given in Table 3.

Herndon.—The city of Herndon obtains its water supply from two drilled wells penetrating sand and gravel of the terrace upon which the city is located. Well 2-31-3aa, in the northeast part of town, has a reported depth of 69 feet and a static water level of 45 feet below the land surface. This well is cased with 10-inch steel casing and is equipped with a turbine pump powered by a 10-horsepower electric motor. Well 2-31-3db, at the city water plant, has a reported depth of 61 feet and a static water level of 43 feet below the land surface. This well is cased with 12-inch steel casing and has a bronze screen 18 feet long. It is equipped with a turbine pump and a 15-horsepower electric motor. The bottom of this well is on Pierre shale, and the well when first drilled was pumped at the rate of 500 gallons per minute for a period of 9 hours.

Water is pumped from the wells directly into the mains, the excess going into a 55,000-gallon elevated steel storage tank in the northwest part of town. The chemical analysis of a composite sample of water from both wells is given in Table 3.

McDonald.—The city of McDonald obtains its water supply from a drilled well (3-36-21ba) near the water tower in the east part of town. This well is reported to be 302 feet deep and has a static water level of about 198 feet below the land surface. It is cased with 16-inch steel casing and is equipped with a turbine pump and a 40-horsepower electric motor. Two other wells near the city hall are maintained on a stand-by basis for emergency use. All three

TABLE 3.—*Analyses of water from typical wells in Rawlins County, Kansas*

Analyzed by Howard A. Stoltenberg. Dissolved constituents in parts per million.[a]

Well number	Depth, feet	Geologic source	Date of collection	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
1-31-7aa	240.5	Ogallala	9-23-52	60	281	43	0.06	36	14	39	244	14	9.0	0.7	4.9	148	148	0
1-31-35dd	22.0	Terrace deposits	9-23-52	55	495	31	.10	88	23	56	337	69	59	.6	2.6	314	276	38
1-33-8ad	152.3	Ogallala	9-23-52	60	301	43	1.5	37	15	42	232	21	13	1.1	15	154	154	0
1-35-13bc	148.7	do	9-23-52	59	335	58	.56	41	17	41	242	28	11	1.7	18	172	172	0
1-36-5dc	37.3	Terrace deposits	9-23-52	59	1,920	35	.38	322	86	159	415	983	52	.4	80	1,160	340	820
1-36-27cd	87.7	Ogallala	9-23-52	59	384	53	1.2	54	22	38	246	64	19	1.6	11	225	202	23
2-31-3aa and db1	61-69	Terrace deposits	5-1-52	....	690	29	.82	109	31	81	461	137	37	1.0	1.5	400	378	22
2-32-5bb	205.7	Ogallala	9-23-52	60	308	46	1.0	38	18	40	262	17	10	1.1	8.4	169	169	0
2-35-31da	117.1	do	9-24-52	59	312	50	1.0	51	17	25	239	26	11	1.5	12	197	196	1
3-31-23bb	88.5	do	9-23-52	59	317	48	.13	44	18	36	261	18	12	1.1	12	184	184	0
3-33-8db1 and 2	65	Terrace deposits	2-12-53	....	710	32	.06	111	35	93	498	131	44	1.6	14	421	408	13
3-33-31bc	165.5	Ogallala	9-25-52	61	314	50	2.6	41	18	37	254	22	10	1.3	10	176	176	0
3-34-1bd1 and 2	45	Terrace deposits	9-20-52	56	776	36	.14	96	40	123	484	189	51	1.6	1.0	404	397	7
3-35-24cb	50	do	9-20-52	57	423	40	.06	68	22	50	350	46	16	2.0	7.1	260	260	0
3-36-21ba	302	Ogallala	5-28-52	....	332	51	.08	37	16	46	220	28	15	1.7	28	158	158	0
4-31-15bb	30	Terrace deposits	9-24-52	51	501	35	1.5	78	22	75	454	49	16	1.0	.7	285	285	0
4-32-5ca	167.5	Ogallala	9-26-52	59	297	49	.82	47	18	26	264	12	8.0	1.2	6.2	191	191	0
5-31-23dd	136.1	do	9-26-52	59	313	46	.10	46	10	30	238	29	16	1.3	8.8	193	193	0
5-33-12ad	35	Terrace deposits	9-26-52	....	539	41	.14	84	31	67	470	60	22	1.1	1.0	337	337	0
5-34-1bb	128.0	Ogallala	9-25-52	....	336	56	.20	40	19	40	237	31	13	1.9	18	178	178	0
5-36-32aa	187.5	do	9-25-52	61	286	44	2.9	38	15	35	220	25	9.0	2.0	10	156	156	0

a. One part per million is equivalent to one pound of wells obtain water from the Ogallala formation. The chemical analysis of a sample of water from well 3-36-21ba is given in Table 3.

Water from the well is pumped directly into the mains, the excess going into a 50,000-gallon elevated steel storage tank. The average daily water consumption of McDonald is about 75,000 gallons.

INDUSTRIAL SUPPLIES

The Chicago, Burlington, and Quincy Railroad has two wells in Rawlins County that are used principally to provide water for filling locomotive boilers. Well 3-36-20ad, at McDonald, is a dug well 208 feet deep and about 16 feet in diameter. The well is walled with rock and equipped with a plunger pump powered by a kerosene engine. The average monthly pumpage from this well, which obtains water from the Ogallala formation, is about 90,000 gallons. At Herndon, the C. B. and Q. has a drilled well 40 feet deep, cased with 12-inch steel casing. It is equipped with a turbine pump and 5-horsepower electric motor. This well obtains water from terrace sand and gravel, but no information on yield or pumpage is available.

IRRIGATION SUPPLIES

Although irrigation is not being carried on extensively in Rawlins County, eleven of the wells listed in Table 7 are classed as irrigation wells. Of these, one well (2-32-15cc) did not have a pump installed, and well 2-32-13ad, although it had a pump, had not been used for several years. Wells 3-33-8cd and 3-33-17ba were being drilled in April 1953 and had not been used when they were inventoried. The other seven irrigation wells were being used to irrigate an average of about 40 acres per well. Alfalfa, corn, and grass are the principal crops irrigated in Rawlins County. A typical irrigation well and sprinkler system are shown in Plate 3. All irrigation wells inventoried in Rawlins County were in valley areas, and their depths ranged from 29 to 84 feet. Static water levels ranged from about 10 to 42 feet below land surface. The chemical analysis of water from well 3-35-24cb and an analysis of a composite sample from wells 3-34-1bd1 and 3-34-1bd2 are given in Table 3.

POSSIBILITIES OF FUTURE DEVELOPMENT OF IRRIGATION SUPPLIES

The economic feasibility of future development of irrigation supplies in Rawlins County depends upon the value of agricultural products compared to the cost of drilling and operating an irrigation well. The cost of drilling and operating an irrigation well de-

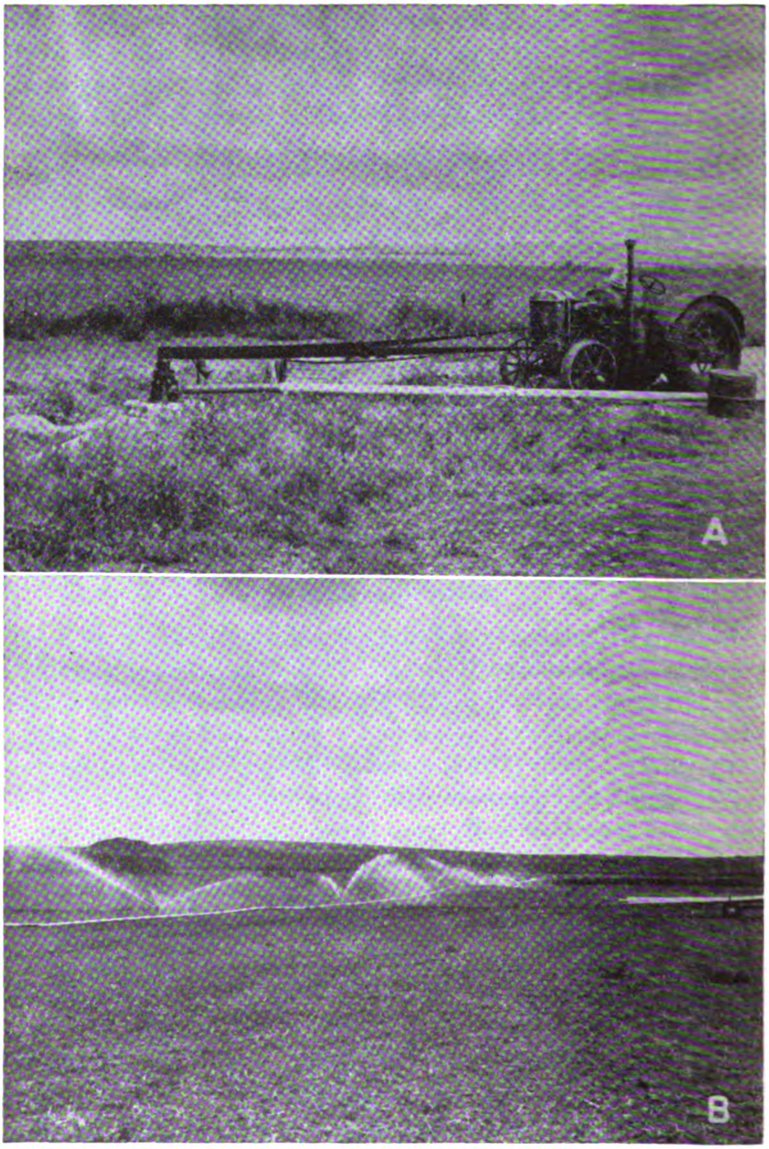


PLATE 3.—**A**, Irrigation well 3-35-24cb in Little Beaver Creek valley; **B**, Irrigation sprinkling system in operation, NW¼ SW¼ sec. 24, T. 3 S., R. 35 W., applying 450 gallons of water per minute to grass.

pends to a large extent on the depth to water and the thickness of saturated material.

At the time of the field work for this report, all irrigation wells in the county were in the valleys of the major streams. Wells can be drilled and operated economically in the valleys because the depth to water generally is not more than 20 feet. Also wells in the valleys generally have large yields because of the high permeability of the water-bearing material.

A satisfactory irrigation supply probably can be developed anywhere in the valleys of Beaver Creek, Little Beaver Creek, South Sappa Creek, and Middle Sappa Creek where there is 30 feet or more of saturated material. The water-bearing material, in general, is most permeable in the valleys of Beaver Creek and Little Beaver Creek, and as a result, wells have larger yields from the same thickness of saturated material than wells in South and Middle Sappa Creek valleys. Wells in the valleys of Rawlins County obtaining water from alluvium and terrace deposits yield 400 to 750 gallons per minute.

The saturated-thickness map (Fig. 9) shows that about 5 townships in the south and west parts of Rawlins County have 100 feet or more of saturated thickness. If test drilling is done to locate the most permeable areas in the Ogallala formation, satisfactory irrigation wells probably can be developed in much of the upland areas of these townships. Yields from the Ogallala formation would probably be less than from the alluvium and terrace deposits, and the cost of drilling and operation would be greater because of the greater depth to water.

Chemical Character of Ground Water

The chemical character of ground water in Rawlins County is indicated by the analyses given in Tables 3 and 5, and shown graphically in Figure 10. The analyses were made by Howard Stoltenberg in the Water and Sewage Laboratory of the Kansas State Board of Health. Samples of water were collected for chemical analysis from 18 wells distributed as uniformly as possible within the county and representing the principal water-bearing formations of the area. Analyses of the water from three municipal supplies are also included. The effect of the geologic character of the aquifer upon the quality of water is discussed in the section on geologic formations and their water-bearing properties. The results of the analyses of the water samples shown in Table 3 are given in parts per million. Factors for converting parts per million of mineral constituents to equivalents per million (Fig. 10) are given in Table 4.

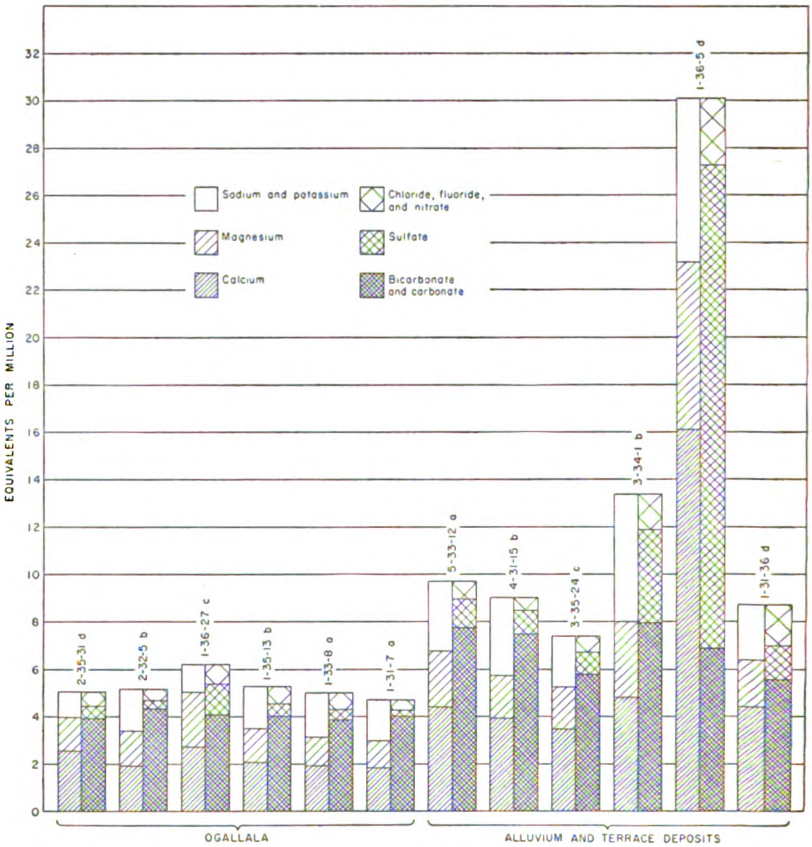


FIG. 10.—Graphic representation of analyses of water from the principal water-bearing formations in Rawlins County.

TABLE 4.—*Factors for converting parts per million of mineral constituents to equivalents per million*

CATION	Conversion factor	ANION	Conversion factor
Ca^{++}	0.0499	HCO_3^-	0.0164
Mg^{++}	.0822	SO_4^{--}	.0208
Na^+	.0435	Cl^-	.0282
		NO_3^-	.0161
		F^-	.0526

CHEMICAL CONSTITUENTS IN RELATION TO USE

The following discussion of the chemical constituents of ground water has been adapted in part from publications of the Federal Geological Survey and the State Geological Survey of Kansas.

Dissolved Solids.—When water is evaporated, the residue consists mainly of the mineral constituents given in the tables of analyses and generally includes a small quantity of organic material and some water of crystallization. Waters containing less than 500 parts per million of dissolved solids generally are satisfactory for domestic use except for difficulties resulting from their hardness or excessive iron content. Waters containing more than 1,000 parts per million are likely to include enough of certain constituents to cause a noticeable taste or to make the water unsuitable in some other respect.

The dissolved solids in 21 samples of water from Rawlins County ranged from 281 to 1,920 parts per million. Fifteen samples contained less than 500 parts per million, 5 samples contained between 500 and 1,000 parts per million, and only one sample contained more than 1,000 parts per million (Table 5).

Hardness.—The hardness of water, which is the property that generally receives the most attention, is recognized most commonly by its effects when soap is used with the water. Calcium and magnesium cause almost all the hardness of ordinary waters. These constituents are also the active agents in the formation of the greatest part of the scale formed in steam boilers and other vessels used to heat or evaporate water.

In addition to the total hardness, the table of analyses shows the carbonate hardness and the noncarbonate hardness. The carbonate hardness is due to the presence of calcium and magnesium bicarbonates and can be removed almost completely by boiling. This type of hardness is sometimes called "temporary" hardness as opposed to "permanent" or noncarbonate hardness due to the presence of sulfates or chlorides of calcium and magnesium, which cannot be removed by boiling. With reference to use with soap, the carbonate hardness and noncarbonate hardness do not differ. In general, water with noncarbonate hardness forms harder scale in steam boilers.

Water having a hardness of less than 50 parts per million is generally rated as soft, and treatment for the removal of hardness is not necessary under ordinary circumstances. Hardness between 50 and 150 parts per million does not interfere seriously with the use of water for most purposes, but the hardness does increase the amount of soap used, and its removal by a softening process is profitable for laundries and certain other industries. Water having a hardness in the upper part of this range will cause considerable scale in steam boilers. Hardness exceeding 150 parts per million is very noticeable, and if the hardness is 200 or 300 parts per million,

TABLE 5.—*Range in dissolved solids, hardness, fluoride, and nitrate in samples of water from typical wells in Rawlins County*

Range in parts per million	Number of samples	
	Ogallala formation	Terrace deposits
Dissolved solids		
250–300	3	0
301–400	10	0
401–500	0	2
501–600	0	2
601–1,000	0	3
More than 1,000	0	1
Hardness		
100–150	1	0
151–200	11	0
201–250	1	0
251–300	0	2
301–400	0	3
401–600	0	2
More than 600	0	1
Fluoride		
0–0.5	0	1
0.6–1.0	1	3
1.1–1.5	7	1
1.6–2.0	5	3
Nitrate (NO_3)		
0–10	6	6
11–20	6	1
21–30	1	0
31–80	0	1

water for household use is commonly softened. Where municipal water supplies are softened, an attempt generally is made to reduce the hardness to about 80 parts per million. The additional improvement from further softening of a public supply generally is not deemed worth the increase in cost.

The total hardness of 21 samples of water from Rawlins County ranged from 148 to 1,160 parts per million. Twelve samples had less than 200 parts per million total hardness, and 9 samples more than 200 parts per million. Only one sample had a noncarbonate hardness of more than 50 parts per million.

Iron.—Next to hardness, iron is the constituent of natural water that generally receives the most attention. The quantity of iron in ground waters may differ greatly from place to place although the water may be derived from the same formation. If a water contains more than several tenths of a part per million of iron, most of the iron may settle out as a reddish precipitate. Iron, present in sufficient quantity to give a disagreeable taste and to stain cooking utensils and plumbing, may be removed from most water by aeration and filtration, but some water requires the addition of lime or some other substance.

The iron content of 21 samples of water from Rawlins County ranged from 0.06 to 2.9 parts per million. Six samples contained 0.1 part per million or less.

Fluoride.—The fluoride content of drinking water is associated with the dental defect known as mottled enamel. Mottled enamel may appear on the teeth of children who drink water containing fluoride in excess of 1.5 parts per million during the period of formation of the permanent teeth. Concentrations of fluoride less than 1 part per million are known to prevent or lessen the incidence of tooth decay, and fluoride is now being added to some municipal supplies (Dean, 1938).

The fluoride content of samples of water from Rawlins County ranged from 0.4 to 2 parts per million. Of the 21 samples analyzed, 3 contained less than 1 part per million, 10 contained between 1 and 1.5 parts per million, and 8 contained more than 1.5 parts per million of fluoride.

Nitrate.—The use of water containing an excessive amount of nitrate in the preparation of a baby's formula can cause cyanosis or oxygen starvation. Some authorities advocate that water containing more than 45 parts per million of nitrate should not be used in formula preparation (Metzler and Stoltenberg, 1950). Water containing 90 parts per million of nitrate generally is considered very dangerous to infants, and water containing 150 parts per million may cause severe cyanosis. Cyanosis is not produced in adults and older children by the concentrations of nitrate found in drinking water. Boiling of water containing excessive nitrate does not render it safe for use by infants; therefore, only water that is known to have low nitrate content should be used for infants.

The nitrate content of the water from some wells is somewhat seasonal, being highest in the winter and lowest in the summer (Metzler and Stoltenberg, 1950). In general, water from wells that are most susceptible to surface contamination is likely to be high in nitrate concentrations.

The nitrate content of water from wells sampled in Rawlins County ranged from 0.7 to 80 parts per million. Only one sample contained more than 45 parts per million of nitrate.

Sulfate.—According to the U. S. Public Health Service drinking-water standards (1946), sulfate in water supplies used on interstate carriers should not exceed 250 parts per million. Water containing excessive amounts of sodium sulfate (Glauber's salt) or magnesium sulfate (Epsom salt) may have a laxative or other physiological effect and may be unsatisfactory for drinking.

The sulfate content of water samples from Rawlins County ranged from 12 to 983 parts per million. Only one sample contained more than 250 parts per million of sulfate.

WATER FOR IRRIGATION

This discussion of the suitability of water for irrigation is adapted from Agriculture Handbook 60 of the U. S. Department of Agriculture.

Successful irrigation depends upon not only the supplying of irrigation water to the land but also the control of the saline and alkali conditions of the soil. Quality of irrigation water, irrigation practices, and drainage conditions are involved in salinity and alkali control. Soil that was originally nonsaline and nonalkali may become unproductive if excessive soluble salts or exchangeable sodium are allowed to accumulate because of improper irrigation and soil-management practices or inadequate drainage.

In areas of sufficient rainfall and ideal soil conditions the soluble salts originally present in the soil or added to the soil with water are carried downward by the water and ultimately reach the water table. This process of dissolving and transporting soluble salts by the downward movement of water through the soil is called "leaching". If the amount of water applied to the soil is not in excess of the amount needed by plants, there will be no downward percolation of water below the root zone and an accumulation of mineral matter will form at that point. Likewise impermeable soil zones near the surface can retard the downward movement of water, resulting in water-logging of the soil and deposition of salts. Unless drainage is adequate, attempts at leaching may not be successful, because leaching requires the free passage of water through and away from the root zone.

The characteristics of an irrigation water that seem to be most important in determining its quality are: (1) total concentration of soluble salts; (2) relative proportion of sodium to other cations (magnesium, calcium, and potassium); (3) concentration of boron or other elements that may be toxic; and (4) under some conditions, the bicarbonate concentration as related to the concentration of calcium plus magnesium.

The total concentration of soluble salts in irrigation water can be adequately expressed, for purposes of diagnosis and classification, in terms of electrical conductivity. Electrical conductivity is a measure of the ability of the inorganic salts in solution to conduct an electrical current, and is usually expressed in terms of micromhos per centimeter. The electrical conductivity can be determined in the laboratory, or an approximation of the electrical conductivity may be obtained by multiplying the total equivalents per million (Table 4) of calcium, sodium, magnesium, and potassium by 100, or by dividing the total dissolved solids in parts per million by 0.64. In general, waters with electrical conductivity values below 750 micromhos are satisfactory for irrigation insofar as salt content is concerned, although salt-sensitive crops such as strawberries, green beans, and red clover may be adversely affected by irrigation water having an electrical conductivity value in the range of 250 to 750 micromhos. Waters in the range of 750 to 2,250 micromhos are widely used, and satisfactory crop growth is obtained under good management and favorable drainage conditions, but saline conditions will develop if leaching and drainage are inadequate. Use of waters with conductivity values above 2,250 micromhos is the exception, and very few projects can be cited where such waters have been used successfully.

In the past the relative proportion of sodium to other cations in irrigation water usually has been expressed simply as percent sodium. According to the U. S. Department of Agriculture, how-

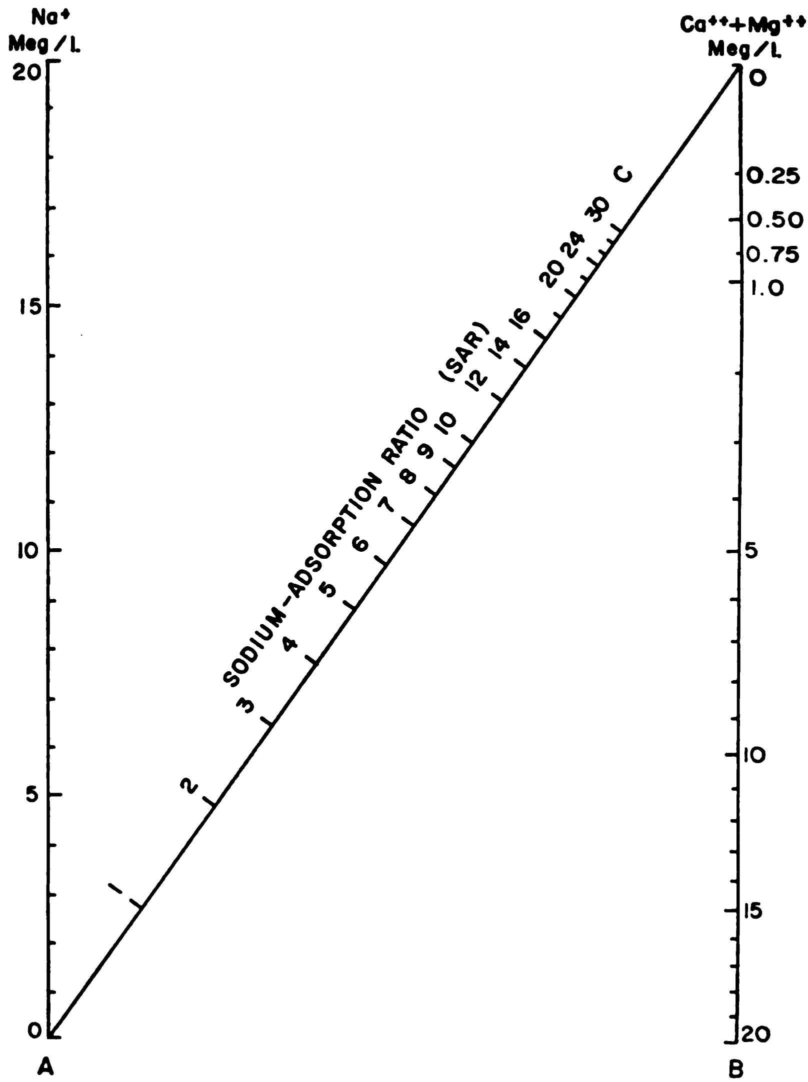


FIG. 11.—Nomogram for determining value of sodium-adsorption ratio of irrigation water.

ever, the sodium-adsorption ratio, used to express the relative activity of sodium ions in exchange reactions with soil, is a much better measure of the suitability of water for irrigation. The sodium-adsorption ratio may be determined by the formula

$$SAR = \frac{Na^{+}}{\sqrt{\frac{(Ca^{++} + Mg^{++})}{2}}}$$

where the ionic concentrations are expressed in equivalents per million. The sodium-adsorption ratio may also be determined by use of the nomogram shown in Figure 11. In using the nomogram to determine the sodium-adsorption ratio of a water, the concentration of sodium expressed in equivalents per million is plotted on the left-hand scale, (A) and the concentration of calcium plus magnesium expressed in equivalents per million is plotted on the right-hand scale (B). The point at which a line connecting these two points intersects the sodium-adsorption-ratio scale (C) determines the sodium-adsorption ratio of the water. When the sodium-adsorption ratio and the electrical conductivity of a water are known, the suitability of the water for irrigation can be determined by graphically plotting these values on the diagram shown in Figure 12. Low-sodium water (S1) can be used for irrigation on almost all soils with little danger of the development of harmful levels of exchangeable sodium. Medium-sodium water (S2) will present an appreciable sodium hazard in certain fine-textured soils, especially under low-leaching conditions. This water may be safely used on coarse-textured or organic soils with good permeability. High-sodium water (S3) may produce harmful levels of exchangeable sodium in most soils and will require special soil management, such as good drainage, high leaching, and additions of organic matter. Very high sodium water (S4) is generally unsatisfactory for irrigation unless special action is taken, such as addition of gypsum to the soil.

Low-salinity water (C1) can be used for irrigation of most crops on most soils with little likelihood that soil salinity will develop. Medium-salinity water (C2) can be used if a moderate amount of leaching occurs. Crops with moderate salt tolerances, such as potatoes, corn, wheat, oats, and alfalfa, can be irrigated with C2 water without special practices. High-salinity water (C3) cannot be used on soils with restricted drainage. Very high salinity water (C4) can be used only on certain crops and then only when special practices are followed.

Boron is essential to normal plant growth, but the quantity required is very small. Crops differ greatly in their boron tolerances, but in general it may be said that the ordinary field crops common to Kansas are not adversely affected by boron concentrations of less than one part per million. The boron content of water samples from Rawlins County was not determined; however, other investi-

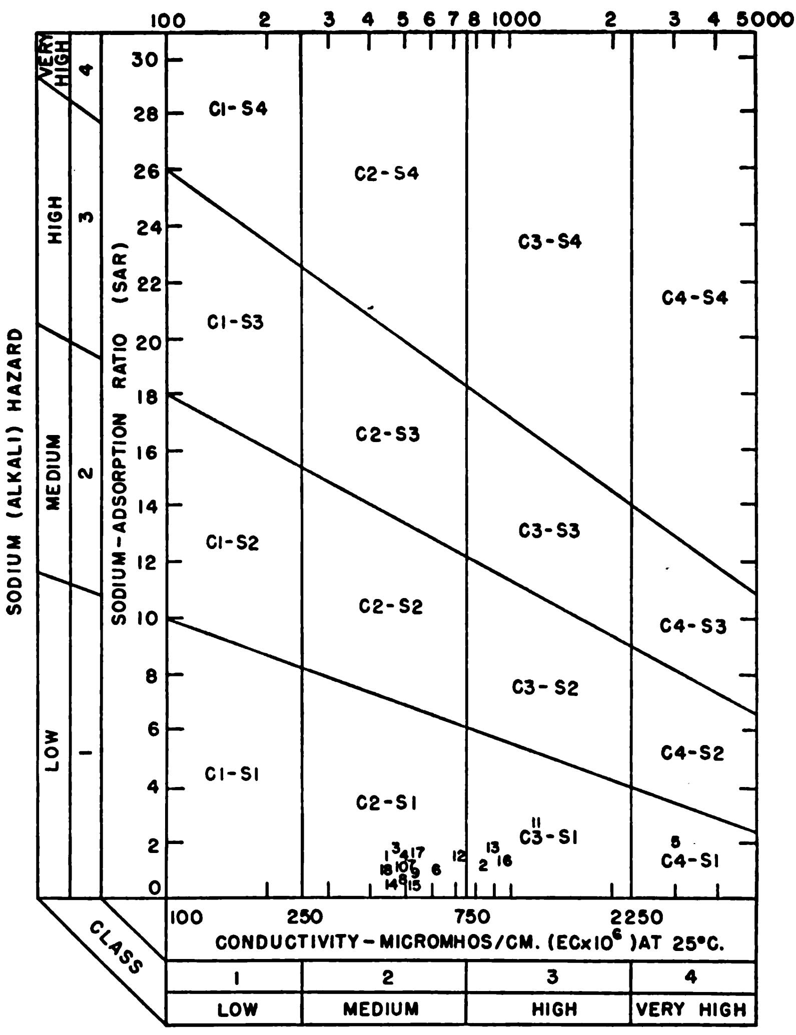


FIG. 12—Diagram showing classification of water for irrigation use in Rawlins County.

gations in the general area have not found excessive concentrations of boron in the water.

Prolonged use, under adverse conditions, of water having a high concentration of bicarbonate could have an undesirable effect upon the soil texture and plant growth. Ground water in Rawlins County (represented by analyses in Table 3) contained less than 1.25 equivalents per million "residual sodium carbonate" except for water from well 4-31-5bb, which contains 1.74 equivalents per million. Water containing more than 2.5 equivalents per million "residual sodium carbonate" is not suitable for irrigation; water containing 1.25 to 2.5 equivalents per million is marginal, and water containing less than 1.25 equivalents per million is probably safe.

Of the waters sampled in Rawlins County, only one (1-36-5dc) was entirely unsuitable for irrigation (Fig. 12). The high concentration of dissolved solids resulting in a very high salinity hazard in this water is probably due to mineralization of the water by the Pierre shale. Four of the samples collected, those from wells 1-31-36dd, 3-34-1bd1 and 2, 4-31-15bb, and 5-33-12ad, indicate a high salinity hazard and water from these wells should be used for

TABLE 6.—*Index numbers of water samples shown on Figure 12, and the sodium-adsorption ratio (SAR) and conductivity of the water samples.* (Analyses are given in Table 3.)

Well Number	Index number on Figure 12	SAR	Approximate conductivity
1-31-7aa	1	1.4	466
1-31-36dd	2	1.4	872
1-33-8ad	3	1.5	492
1-35-13bc	4	1.4	524
1-36-5dc	5	2.0	3,000
1-36-27cd	6	1.1	616
2-31-3aa and db1	..	1.8	1,150
2-32-5bb	7	1.3	512
2-35-31da	8	0.8	504
3-31-23bb	9	1.2	525
3-33-8db1 and 2	..	2.0	1,250
3-33-31bc	10	1.2	514
3-34-1bd1 and 2	11	2.7	1,340
3-35-24cb	12	1.3	737
3-36-21ba	..	1.6	517
4-31-15bb	13	1.9	897
4-32-5ca	14	0.8	497
5-31-23dd	15	0.9	517
5-33-12ad	16	1.6	965
5-34-1bb	17	1.3	530
5-36-32aa	18	1.2	465

irrigation only on soils having good drainage. The other 13 waters sampled are suitable for irrigation without special practices on most soils.

GEOLOGIC FORMATIONS AND THEIR WATER-BEARING PROPERTIES

Cretaceous System

GULFIAN SERIES

Pierre Shale

The Pierre shale underlies all of Rawlins County and crops out in many small areas along Beaver Creek, Little Beaver Creek, and North Fork Sappa Creek. The thickness of the Pierre shale underlying Rawlins County ranges from about 400 feet to about 1,200 feet, being thinnest in the southeast part of the county. Contours that show the topography of the Pierre shale surface have been plotted from test-hole data and are shown in Figure 7.

The Pierre shale of northwestern Kansas has been studied in detail by Elias (1931). It consists of gray, blue-gray, and black clayey shale containing zones of abundant concretions, thin beds of bentonite, and crystals of gypsum. Elias divided the Pierre shale into five named members and one unnamed unit. The members are, in ascending order: Sharon Springs shale, Weskan shale, Lake Creek shale, Salt Grass shale, an unnamed shale member, and Beecher Island shale. Probably all members of the formation are present under Rawlins County except the Beecher Island shale and the upper part of the unnamed shale unit.

The Pierre shale does not yield water to wells in Rawlins County, but acts as an impervious floor below the younger, water-bearing formations. Contact springs are common at outcrops of the Pierre shale because downward percolation of water is stopped by the impervious shale, and the water moves laterally along the contact until it is discharged at the outcrop.

In northwestern Rawlins County, streams have eroded deeply into the Pierre shale. Analyses of water from wells (1-36-5dc) deriving supplies from alluvial or terrace deposits along these streams show high concentrations of dissolved solids because the water has been in prolonged contact with the Pierre shale.

Tertiary System

PLIOCENE SERIES

Ogallala Formation

The Ogallala formation was named by Darton in 1899 (pp. 734, 735, 741-742, Pl. 84) from a locality in southwestern Nebraska. In 1920 Darton (p. 6) referred to the type locality as near Ogallala Station in western Nebraska. Elias (1931) made a study of the Ogallala formation in Wallace County and adjacent areas of western Kansas. In 1937 Elias described briefly the Ogallala formation in Rawlins and Decatur Counties, and later (Elias, 1942) described fossil seeds and other plant remains from the Ogallala formation. Lugn (1939) presented a classification of the Tertiary formations of Nebraska in which he regarded the Ogallala as a group containing the following formations in ascending order: Valentine, Ash Hollow, Sydney gravel, and Kimball. The State Geological Survey of Kansas classes the Ogallala as a formation containing the Valentine, Ash Hollow, and Kimball members. These members of the Ogallala formation were not distinguished in Rawlins County.

The Ogallala formation in Rawlins County consists of sand, gravel, silt, clay, sandy limestone, volcanic ash, quartzite, opal, and chert, and has a maximum known thickness of 246 feet (test hole 5-36-31cc).

Poorly sorted sand and gravel containing silt and clay is the most common lithology in the Ogallala formation and beds of such material are found at nearly all stratigraphic positions within the formation. These deposits are generally cross-bedded (Pl. 4) and interfinger with beds of well-sorted fine sand. Sand and gravel deposits that are partly or completely cemented by calcium carbonate form benches or scarps (Pl. 5) where weathered and are known as "mortar beds", owing to their resemblance to mortar and because of their early use as natural mortar material.

Layers of silt and silty clay crop out throughout the county and were penetrated in many test holes. These beds are gray, brown, pink, and greenish-gray.

A peculiar type of concentrically banded pink limestone, the "Algal limestone", marks the top of the Ogallala formation and crops out in the southwestern and north-central parts of the county. The average thickness of the "Algal limestone" in Rawlins County is about 18 inches.

A bed of volcanic ash, identified as the Reager bed (Carey and others, 1952), is exposed in the W½ SW¼ sec. 4, T. 4 S., R. 34 W.

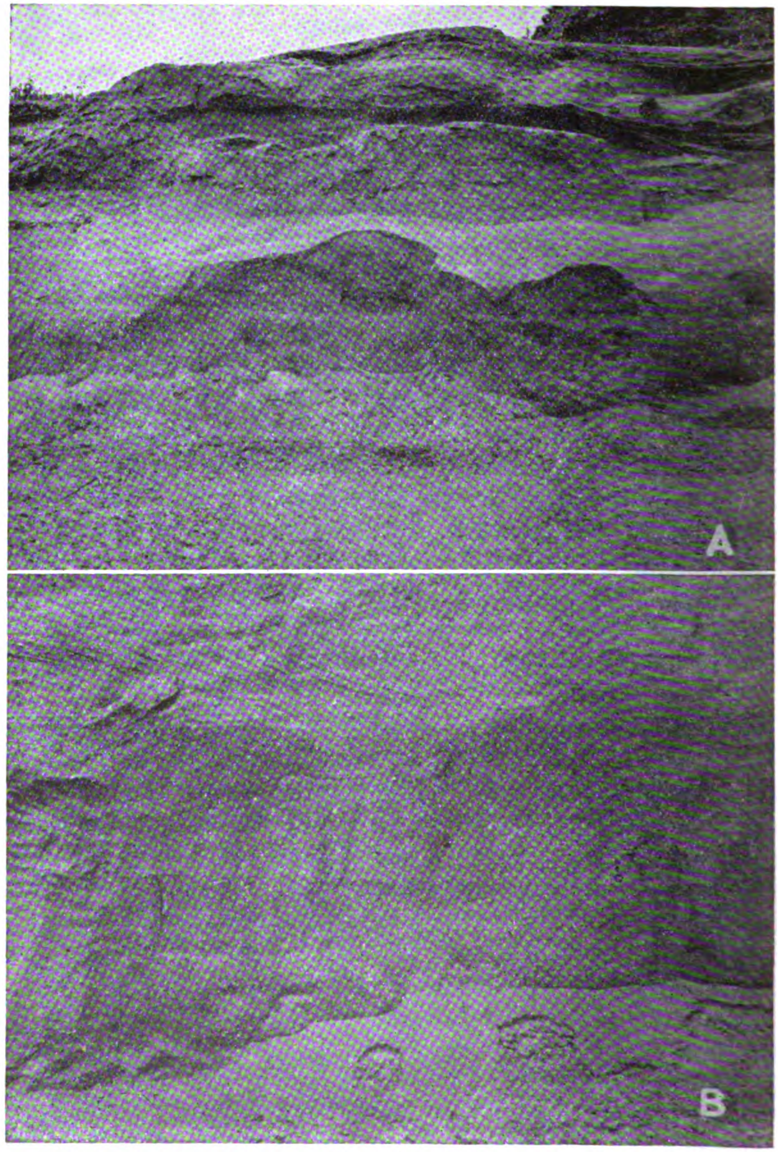


PLATE 4.—Uncemented sand and gravel, locally cross-bedded, in Ogallala formation, NW¼ sec. 11, T. 3 S., R. 33 W. **A**, General view of pit; **B**, Close view showing cross-bedding.

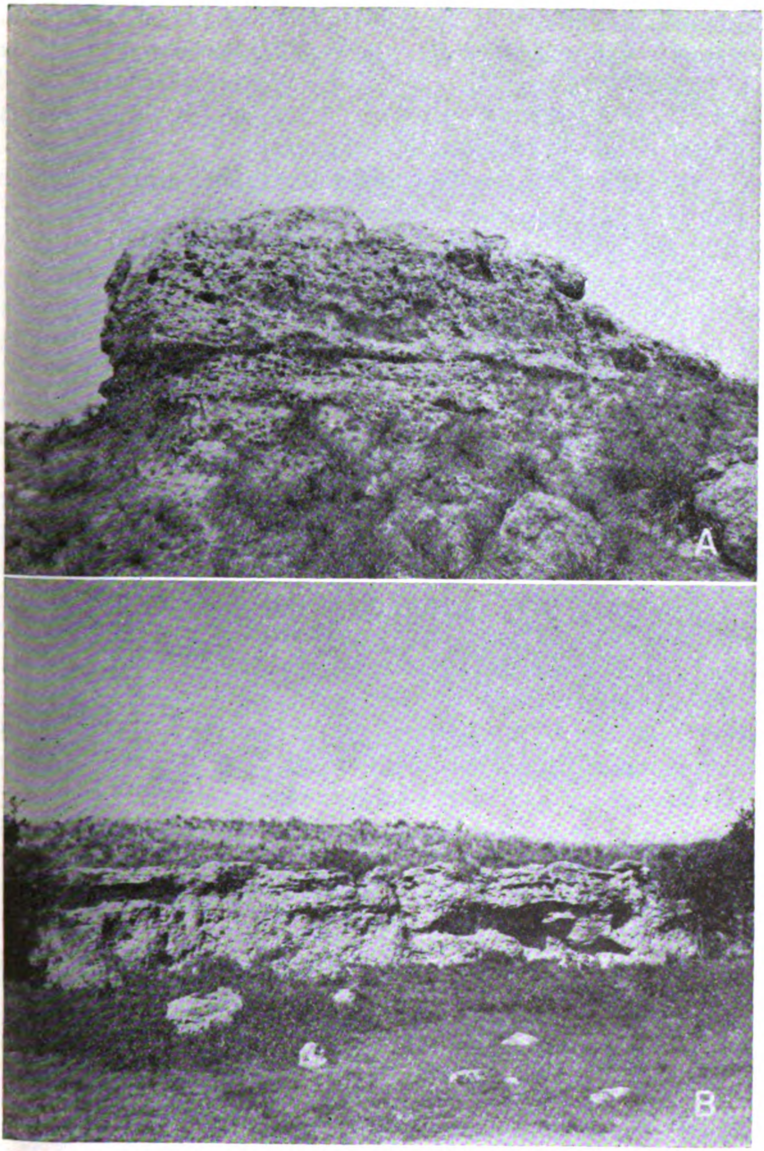


PLATE 5.—Mortar beds in Ogallala formation. A, SW¼ sec. 19, T. 2 S., R. 31 W.; B, Cen. sec. 1, T. 5 S., R. 36 W.

The Reager ash bed, which is about 2 feet thick at this locality, occurs near the middle of the Ash Hollow member of the Ogallala formation. Volcanic ash within the Ogallala formation also occurs in the NW¼ NW¼ sec. 33, T. 3 S., R. 34 W; the NE¼ NW¼ sec. 11, T. 3 S., R. 33 W.; the NE¼ NE¼ sec. 30, T. 4 S., R. 32 W., and the SE¼ SE¼ sec. 20, T. 5 S., R. 36 W.

The Ogallala formation in western Rawlins County contains irregular beds of white chert. The major constituents of the chert, according to Frye and Swineford (1946), are opal, chalcedony, and very fine grained crystalline calcium carbonate, with minor amounts of quartz and feldspar. The chert grades into almost pure opal within a short distance in some localities. Chert or chert and opal are exposed in the SE cor. sec. 9, T. 4 S., R. 36 W. (Pl. 6A); the SE¼ SE¼ sec. 34, T. 2 S., R. 36 W.; and at other localities in Rawlins County. The maximum thickness of chert observed in the county is about 12 feet.

Quartzite is present in the Ogallala formation in Rawlins County along the south side of Beaver Creek from the east county line to within a few miles east of Atwood, where the formation overlies the Pierre shale. The quartzite is light-green, generally contains many white feldspar grains, and is very hard. Most quartzite beds are lenticular, cross-bedded, and interbedded with loose green sand and clay. Very similar green sand and clay is exposed along South Fork Sappa Creek. The texture of the quartzite in the Ogallala formation ranges from fine-grained to conglomeratic. The thickness of the quartzite ranges from a feather edge to about 24 feet.

Measured section in the Ogallala formation in the SE¼ SE¼ sec. 20, T. 5 S., R. 36 W. From the level of creek channel at concrete culvert. (Measured by John C. Frye and A. B. Leonard).

	Thickness, feet
TERTIARY—Pliocene	
Ogallala formation	
7. Sand, coarse, and gravel, loose, tan; large quartz pebbles; top cemented to form mortar bed	18
6. Sand and gravel, lime-cemented to form mortar bed; forms ledge	1
5. Sand, fine to medium, loose, contains some silt	14
4. Sand, coarse, some gravel; contains quartz pebbles to ¾ inch in diameter, lime-cemented	1.5
3. Sand, fine to medium, tan; contains some silt	12
2. Volcanic ash, locally cemented, light-bluish-gray, contaminated with fine sand, and locally interbedded with fine to medium sand	1
1. Sand, fine to medium, tan, loose in lower part, cemented to form locally developed ledges in middle part	11
Total measured section	58.5

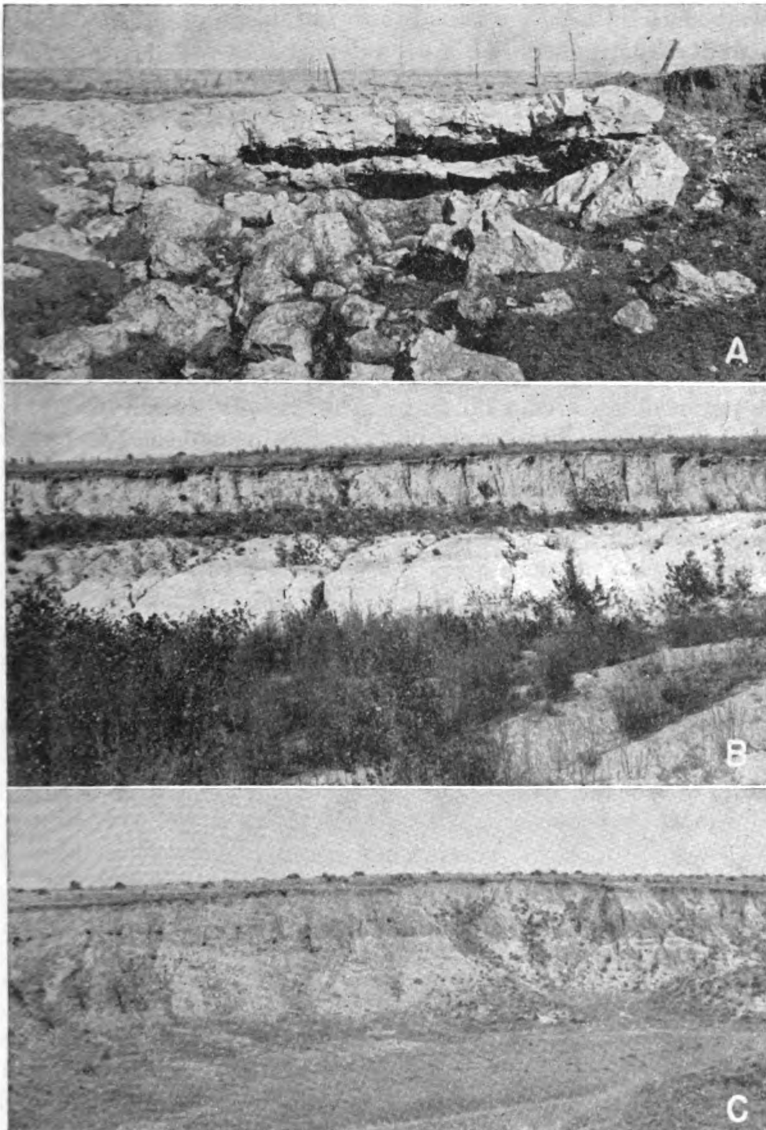


PLATE 6.—**A,** Opalized beds in Ogallala formation, SE cor. sec. 9, T. 4 S., R. 36 W.; **B,** Pearlette ash bed in Meade formation, SW¼ sec. 22, T. 3 S., R. 35 W.; **C,** Peoria silt member of Sanborn formation, overlying Ogallala formation, NW¼ sec. 19, T. 2 S., R. 31 W.

Small quantities of sand and gravel from the Ogallala formation have been used locally for road-surfacing material and in concrete. Quartzite from quarries near Herndon and Ludell has been used locally for building stone, rip-rap, and road-surfacing material. "Mortar beds" of the Ogallala formation have been used in small amounts in Rawlins County for building stone, but are not altogether satisfactory for this purpose. Ogallala chert has not been used as an economic mineral resource in Rawlins County.

The Ogallala formation is the principal source of ground water in Rawlins County and supplies moderate to large quantities of water to wells. All wells in the uplands as well as many springs that discharge at the contact between the Ogallala formation and the Pierre shale obtain their water from this formation. Although the permeability of the silt and clay beds within the formation is relatively low, the high permeability of uncemented sand and gravel beds and the great saturated thickness permit large yields of water from this formation. The municipal water supply for the city of McDonald and a large part of the domestic and stock supplies of the county are obtained from the Ogallala formation. No irrigation wells were known to be obtaining water from the Ogallala formation when the field work for this report was done. The chemical character of the water from the Ogallala formation is shown by analyses in Table 3 and a summary in Table 5, and by graphs in Figure 10. Water from the Ogallala formation has fairly uniform good quality regardless of location within the county.

Quaternary System

PLEISTOCENE SERIES

Pleistocene deposits in Rawlins County include the Meade formation, Sanborn formation, and undifferentiated low terrace and alluvial deposits.

Meade Formation

The Meade formation, as classified by the Kansas Geological Survey, is composed of a basal gravel member and an upper silt member. These members, the Grand Island and Sappa respectively, are equivalent to the Kansan age Grand Island and Sappa formations of the Nebraska Geological Survey. The Pearlette volcanic ash bed in the Sappa member has facilitated the correlation of Pleistocene deposits over a wide area of the mid-continent region.

In Rawlins County only the Sappa member of the Meade formation was recognized. It consists of about 14 feet of volcanic ash (Pl. 6B), which is underlain by a small but undetermined thickness of silty clay and sand. The level of deposition of the Meade formation, which is considerably higher than the Crete sand and gravel member of the Sanborn formation, is locally marked by a fairly prominent dissected terrace level, but deposits of the Meade formation could be recognized only where Pearlette volcanic ash was present. The Meade formation is not mapped on Plate 1, but deposits of Pearlette volcanic ash are shown. Both of the known deposits of Pearlette volcanic ash in the county have been mined commercially on a small scale.

Where observed, the Meade formation is above the water table and is not known to yield water to wells in Rawlins County.

Sanborn Formation

In the official classification of the Kansas Geological Survey (Frye and Leonard, 1952) the Sanborn formation includes, in ascending order, the following members: (1) Crete sand and gravel member; (2) Loveland silt member, commonly containing at its top the Sangamon buried soil; (3) unnamed early Wisconsinan alluvial deposits; (4) Peoria silt member; (5) unnamed late Wisconsinan alluvial deposits; and (6) Bignell silt member. The Sanborn formation of Kansas is unique in that it contains two unconformities and deposits of two stages. The Sanborn formation is retained in its present status by the Kansas Geological Survey because it is impracticable to differentiate between the silt members in ordinary field mapping.

The name Sanborn formation was first proposed by Elias (1931) to replace the old terms "Tertiary marl" or "Plains marl". He referred to a locality in the northwest corner of Cheyenne County, Kansas, where the formation is well exposed. Sanborn is a small town in Nebraska, just north of the Cheyenne County locality.

Crete sand and gravel member.—In Rawlins County the Crete sand and gravel member of the Sanborn formation occurs as channel fillings of ancestral streams that in late Illinoian time flowed approximately parallel to and 40 to 60 feet higher than the present major streams in the county.

The Crete sand and gravel member is well exposed in gravel pits in the SW¼ sec. 12, T. 2 S., R. 32 W., and in the NE¼ sec. 27, T. 3 S., R. 34 W. At these localities and elsewhere in the county, a thickness of at least 20 feet of sand and gravel is exposed. The sand and gravel grades upward into sandy silt of the Loveland silt member. Younger eolian silt mantles the terrace surface, resulting in a continuous slope down the valley side, so that an accurate determination of the terrace width is impossible without extensive test drilling.

Measured section of the Crete sand and gravel and Loveland silt members of the Sanborn formation in the SE¼ sec. 12, T. 2 S., R. 32 W.

	Thickness, feet
QUATERNARY—Pleistocene	
Sanborn formation	
Peoria silt member	
Silt, buff	4.0
Loveland silt member	
Silt, sandy, dark-buff, caliche at base	7.2
Silt, buff; contains some gravel	3.0
Crete sand and gravel member	
Sand, coarse; and fine to medium gravel	1.0
Sand and gravel, fine to coarse; caliche nodules at base	4.4
Sand, and coarse gravel, cross bedded	9.6
Sand, fine, well-sorted; grades laterally into gray-green silt; contains numerous snail shells	0.9
Sand, medium to coarse, contains some interbedded gravel (base not exposed)	5.0
Total measured section	35.1

The Crete sand and gravel member of the Sanborn formation yields moderate to large quantities of water to wells in the county. Municipal wells at Herndon and Atwood obtain water from the Crete sand and gravel member. Several irrigation wells in the county also obtain water from this member.

Loveland silt member.—In Rawlins County the Loveland silt member of the Sanborn formation overlies the Crete sand and gravel member adjacent to the major streams and rests directly upon the Ogallala formation in the uplands. Where the Loveland silt member overlies the Crete sand and gravel member, the contact is gradational and the deposits should be classed as Crete-Loveland. The Loveland silt member in upland positions is composed of massive, well-sorted, eolian silt. It is calcareous except in the upper part and is tan to reddish-brown. The top of the Loveland silt member is in many places marked by a prominent Sangamon soil, which is leached of calcium carbonate and has a blocky texture. The thickness of the Loveland silt member over most of Rawlins County is less than 20 feet, but one test hole (3-32-31bc) penetrated 42 feet of Loveland. Alluvial phases of the Loveland silt member are present in the valley area of the county, but are not mapped with the Sanborn formation on Plate 1.

Nearly everywhere in Rawlins County the Loveland member is above the water table and does not yield water to wells.

Peoria silt member.—The Peoria silt member of the Sanborn formation lies at the surface of most of the flat upland areas of the county and extends down to and mantles Crete terraces along the major streams. The Peoria silt member (Pl. 6C) is composed of massive eolian silt, tan to light-yellow, containing fossil snails. At localities where the Peoria silt member is overlain by Bignell loess, the top of the Peoria silt member is marked by the buried Brady soil. The thickness of the Peoria silt member in Rawlins County is commonly about 35 to 55 feet. Thicknesses as great as 80 feet were penetrated in some test holes. Alluvial phases of the Peoria silt member are present in the valley areas of the county, but are not mapped with the Sanborn formation on Plate 1.

The Peoria silt member is above the water table in Rawlins County and does not yield water to wells.

Bignell silt member.—The Bignell silt member of the Sanborn formation is recognized overlying the Peoria silt member in a few localities in Rawlins County. The Bignell silt member is similar in lithology to the Peoria silt member and can be recognized in mapping only where the Brady soil is developed on the Peoria silt member. The thickness of the Bignell silt member does not exceed a few feet in Rawlins County, and the member does not yield water to wells.

Alluvial phases of the Bignell silt member are present in the valley areas of the county, but are not mapped with the Sanborn formation on Plate 1.

Alluvium and Undifferentiated Terrace Deposits

Alluvial deposits occur in the bottoms of the stream valleys and in low terrace positions along many of the major valleys. The low terrace deposits, which are Wisconsinan and Recent in age, and the Recent alluvium are nearly identical in lithology and are mapped together on Plate 1.

The material in the upper part of the alluvium and low terraces is fine grained, being derived chiefly from the Sanborn formation. The lower part, especially along the major streams that are cut deep into the Ogallala formation, is composed of sand and gravel derived from the Ogallala. The known maximum thickness of these deposits is about 50 feet.

Alluvium and low terrace deposits resting on Pierre shale furnish moderate to large quantities of water to wells in eastern and central Rawlins County. In western Rawlins County the deposits overlie the Ogallala formation and except during rainy periods are not entirely saturated, and wells are generally extended into the Ogallala formation to get adequate water supplies. Deposits along East Fork Burntwood creek are very fine grained and furnish only small quantities of water. The chemical character of the water from alluvium and terrace deposits is shown by analyses in Table 3 and a summary in table 5, and by graphs in Figure 10. Water from terrace deposits has higher concentrations of dissolved solids than that from the Ogallala formation. These higher concentrations are primarily the result of solution of calcium carbonate and sulfates, and they are believed to be in part due to the influence of the underlying Pierre shale. Higher evapotranspiration rates in the valleys may also contribute to the higher concentration.

RECORDS OF TYPICAL WELLS AND SPRINGS

Records of 226 wells and springs inventoried in Rawlins County are given in Table 7. All information classed as "reported" was obtained from the owner, tenant, or driller. Depths of wells not classed as "reported" were measured and are given to the nearest tenth of a foot below the measuring point described in the tables; depths to water level not classed as "reported" were measured and are given to the nearest hundredth of a foot.

TABLE 7.—*Records of wells and springs in Rawlins County, Kansas*

WELL NUMBER (1)	Location	Owner or tenant	Type of well (2)	Depth of well, feet (3)	Diameter of well, in.	Type of casing (4)	Principal water-bearing bed: Character of material	Principal water-bearing bed: Geologic source	Method of lift (5)	Use of water (6)	Measuring point: Description	Measuring point: Distance above land surface, feet	Measuring point: Height above mean sea level, feet (7)	Depth to water level below measuring point, feet (8)	Date of measurement	REMARKS (Yield given in gallons a minute; drawdown in ft.)
	T. 1 S., R. 31 W.															
1-31-3cd	SE SW sec. 3	P. Schwartz	Dr	217.0	6	GI	Sand, gravel	Ogallala	Cy, W, H	N	Top of casing	1.6	2,927.4	211.55	6-10-52	
1-31-5da	NE SE sec. 5	Lizzie Green	Dr	222.1	6	GI	do	do	Cy, N	N	do	0.4	2,933.1	213.85	6-10-52	
*1-31-7aa	NE NE sec. 7	O. J. Sattler	Dr	240.5	6	GI	do	do	Cy, W	S	do	1.3	2,959.6	224.60	6-16-52	
1-31-10dd	SE SE sec. 10	J. Wudtke Est.	Dr	200.4	6	GI	do	do	Cy, N	N	do	3.0	2,901.1	185.53	6-10-52	
1-31-14dc	SW SE sec. 14	B. H. Green	Dr	198.7	6	GI	do	do	Cy, W, H	S	do	0.3	2,885.8	193.55	6-10-52	
1-31-17ba	NE NW sec. 17	George Clyde	Dr	209.9	3	GI	do	do	N, N	N	do	1.0	2,915.3	181.59	6-10-52	
1-31-28aa	NE NE sec. 28	Fed. Farm Mtg. Corp.	Dr	30.2	6	GI	do	do	Cy, W	S	do	0.7	2,735.8	22.89	6-11-52	
*1-31-36dd	SE SE sec. 36	J. Herzog	Dr	22.0	6	GI	do	Terrace deposits	Cy, W	S	do	0.1	2,635.5	6.60	6- 9-52	
	T. 1 S., R. 32 W.															
1-32-5ac	SW NE sec. 5	J. Willard	Dr	142.0	5	GI	do	Ogallala	Cy, N	N	do	0.4	2,915.0	138.70	8- 6-52	
1-32-9bc	SW NW sec. 9	C. D. Wicke	Dr	85.7	6	GI	do	do	Cy, W	S	do	0.9	2,879.9	75.53	8- 6-52	
1-32-14bd	SE NW sec. 14	R. Walsh	Dr	223.5	6	GI	do	do	Cy, W, H	S	do	0.4	2,977.8	219.80	9-25-52	
1-32-28bc	SW NW sec. 28	H. G. Reuber	Dr	164.4	6	GI	do	do	Cy, W	S	do	0.3	2,953.9	147.51	8-25-52	
1-32-35ad	SE NE sec. 35	Helen Bolte	Dr	152.5	6	GI	do	do	Cy, W	S	do	1.1	2,890.6	140.00	8- 1-52	
	T. 1 S., R. 33 W.															
1-33-2dd	SE SE sec. 2	E. Stolte	Dr	49.7	6	GI	do	Terrace deposits	Cy, W, H	S	do	0.3	2,853.4	44.03	8-25-52	
*1-33-8ad	SE NE sec. 8	J. F. Peterson	Dr	152.3	6	GI	do	Ogallala	Cy, W	S	Base of pump	2.8	2,998.2	146.40	8-14-52	
1-33-10cb	NW SW sec. 10	A. Vap	Dr	95.6	5	GI	do	do	Cy, W	S	Top of casing	0.2	2,932.9	89.05	8-14-52	
1-33-18aa	NE NE sec. 18	W. E. Prochazka	Dr	143.8	6	GI	do	do	Cy, W	S	do	0.5	3,015.0	135.00	8-25-52	
1-33-23dc	SW SE sec. 23	Henry W. Timm	Dr	180.0	5	GI	do	do	Cy, W	D, S	do	0.3	3,006	174.20	8-25-52	
1-33-28dd	SE SE sec. 28	B. M. Sawyer	Dr	195.1	5	GI	do	do	Cy, W	S	do	0.3	3,033.9	187.95	8-14-52	
1-33-29cc	SW SW sec. 29	Joseph Parker	Dr	125.3	5	GI	do	do	Cy, W, H	S	do	0.6	2,992.0	116.35	8- 4-52	
	T. 1 S., R. 34 W.															
1-34-2ac	SW NE sec. 2	R. E. Horinek	Dr	167.0	6	GI	do	do	Cy, W	S	do	0.5	3,040	151.60	4- 2-53	
1-34-4db	NW SE sec. 4	C. G. Kisling	Dr	98.7	5	GI	do	do	N, N	N	do	2.4	3,011.0	96.35	8-29-52	
1-34-5bd	SE NW sec. 5	F. Taunton Est.	Dr	126.3	6	GI	do	do	Cy, W, H	S	do	0.9	3,055.0	120.34	9- 2-52	
1-34-9bc	SW NW sec. 9	F. E. Bartosovsky	Dr	107.4	6	GI	do	do	Cy, W	S	do	0.3	3,020	94.20	4- 2-53	

1-34-14ad	SE NE sec. 14	F. J. Ruda	Dr	225.4	6	GI	do	do	Cy, W	N	do	0.4	3,113.9	217.60	8-28-52	
1-34-18da	NE SE sec. 18	Bertha Williams	Dr	208.4	6	GI	do	do	Cy, W, H	S	do	1.0	3,160.3	205.75	9- 2-52	
1-34-23cc	SW SW sec. 23	Church	Dr	191.0	6	GI	do	do	Cy, W	D	do	0.1	3,093.5	183.15	8-28-52	
1-34-30ac	SW NE sec. 30	B. A. Micek	Dr	237.4	6	GI	do	do	Cy, W	S	do	0.7	3,201.7	231.71	9- 2-52	
1-34-35dd	SE SE sec. 35	J. Dosbaba	Dr	134.5	6	GI	do	do	Cy, N	N	do	0.8	3,030.0	126.50	8-28-52	
	T. 1 S., R. 35 W.															
1-35-4ba	NE NW sec. 4	F. Sramek	Dr	118.5	6	GI	do	do	Cy, W	S	do	0.4	3,101.3	109.46	9- 5-52	
1-35-6ca	NE SW sec. 6	J. Vachuta	Dr	105.0	6	GI	do	do	Cy, W	S	do	0.6	3,159.0	94.03	9- 6-52	
1-35-8ab	NW NE sec. 8	F. Taunton Est.	Dr	138.6	6	GI	do	do	Cy, W	S	do	1.4	3,153.0	132.81	9- 6-52	
1-35-8db	NW SE sec. 8	do	Dr	167.9	6	GI	do	do	N, N	N	do	1.1	3,197.2	166.43	9- 5-52	
*1-35-13bc	SW NW sec. 13	A. Savage	Dr	148.7	6	GI	do	do	Cy, W	S	do	0.3	3,117.1	141.07	9- 2-52	
1-35-21cc	SW SW sec. 21	S. D. Christenson	Dr	218.7	6	GI	do	do	Cy, W, H	D, S	do	0.5	3,241.5	213.70	9- 5-52	
1-35-30cc	SW SW sec. 30	Paul Rech	Dr	174.0	6	GI	do	do	Cy, W	S	do	1.0	3,252.5	163.40	9- 6-52	
	T. 1 S., R. 36 W.															
1-36-2db	NW SE sec. 2	F. Taunton Est.	Dr	36.9	6	GI	do	Terrace deposits	Cy, W	S	do	0.9	3,038.0	33.18	9- 7-52	
*1-36-5dc	SW SE sec. 5	R. Gerdes	Dr	37.3	6	GI	do	do	Cy, W	S	do	3.6	3,052.8	24.87	9- 8-52	
1-36-6aa	NE NE sec. 6	Louise Gerdes	Du	110.0	72	R	do	Ogallala	Cy, W	S	Top of platform	0.2	3,182.3	104.98	9- 8-52	
*1-36-27cd	SE SW sec. 27	A. A. Rummel	Dr	87.7	6	GI	do	do	Cy, W	S	Top of casing	0.3	3,208.0	81.22	9- 8-52	
1-36-32ab	NW NE sec. 32	Wm. H. Harper	Dr	200	6	ST	do	do	Cy, W	D, S	....	....	3,331.7	189	....	
	T. 2 S., R. 31 W.															
*2-31-3aa	NE NE sec. 3	City of Herndon	Dr	69	10	ST	do	Crete	T, E	Ps	....	....	2,676.0	45	....	Analysis given in table 3 is of composite sample from wells 2-31-3aa and 2-31-3db
*2-31-3db	NW SE sec. 3	do	Dr	61	12	ST	do	do	T, E	Ps	....	....	2,662.0	43	....	½ ft. drawdown after pumping 9 hrs. at 500 g.p.m.
2-31-12aa	NE NE sec. 12	L. Wendelin	Dr	65.4	6	GI	do	Ogallala	Cy, W	S	Top of casing	0.6	2,727	49.50	4- 4-53	
2-31-13da	NE SE sec. 13	P. Wolfram	Dr	57.6	4	GI	do	do	Cy, W, H	S	do	0.0	2,736.8	40.75	6- 9-52	
2-31-21bd	SE NW sec. 21	F. Reipl	Dr	165.0	6	GI	do	do	Cy, W	S	do	0.3	2,885.2	151.83	8-25-52	
2-31-22aa	NE NE sec. 22	A. Unger	Dr	129.0	6	GI	do	do	Cy, H	N	do	2.3	2,845.5	170.30	6-11-52	
2-31-25bc	SW NW sec. 25	Mary Cox	Dr	126.4	6	GI	do	do	Cy, W, H	S	do	1.1	2,856.4	109.21	6- 9-52	
2-31-29cd	SE SW sec. 29	Anna Pummer	Dr	194.7	6	GI	do	do	Cy, W	S	do	1.1	2,946.2	170.30	8-25-52	
2-31-33aa	NE NE sec. 33	P. Steier	Dr	97.9	5	GI	do	do	Cy, W	S	do	0.9	2,871.3	93.14	6-11-52	
2-31-36bb	NW NW sec. 36	L. Portski	Dr	128.6	5	GI	do	do	Cy, W, H	S	do	0.1	2,862.3	109.51	6- 7-52	
	T. 2 S., R. 32 W.															
*2-32-5bb	NW NW sec. 5	C. Wicke	Dr	205.7	5	GI	do	do	Cy, W	S	do	0.6	2,994.7	190.05	8- 6-52	
2-32-13aa	NE NE sec. 13	P. Weishapl	Dr	23.6	6	GI	do	Terrace deposits	Cy, H	D	do	0.1	2,705.7	10.32	6-14-52	
2-32-13ad	SE NE sec. 13	do	Dr	42.7	24	ST	do	Crete	T	I	Base of pump	0.6	2,709.5	14.57	8- 1-52	Unused irrigation well
2-32-13ca	NE SW sec. 13	do	Dr	21.3	6	GI	do	Terrace deposits	N, W	N	Top of casing	0.3	2,716.2	17.00	6-16-52	

TABLE 7.—*Records of wells and springs in Rawlins County, Kansas—Continued*

Well Number (1)	Location	Owner or tenant	Type of well (2)	Depth of well, feet (3)	Diameter of well, in.	Type of casing (4)	Principal water-bearing bed: Character of material	Principal water-bearing bed: Geologic source	Method of lift (5)	Use of water (6)	Measuring point: Description	Measuring point: Distance above land surface, feet	Measuring point: Height above mean sea level, feet (7)	Depth to water level below measuring point, feet (8)	Date of measurement	REMARKS (Yield given in gallons a minute; drawdown in ft.)
	T. 2 S., R. 32 W.															
2-32-15cc	SW SW sec. 15	P. Weishapl	Du	28.9	42	C	Sand, gravel	Crete	N, N	N	Top of platform	1.2	2,738.8	21.75	8- 5-52	Unused irrigation well
2-32-26aa	NE NE sec. 26	A. Bolte	Dr	47.3	6	GI	do	Ogallala	Cy, W	S	Top of casing	2.1	2,818.0	45.38	6-16-52	
2-32-30bb	NW NW sec. 30	Public road	Dr	32.1	5	GI	do	Terrace deposits	Cy, H	N	do	0.2	2,776.1	26.80	8- 7-52	
	T. 2 S., R. 33 W.															
2-33-6cc	SW SW sec. 6	J. Horinek	Dr	191.1	5	GI	do	Ogallala	Cy, W	S	do	0.4	3,068.3	177.11	8-23-52	
2-33-9da	NE SE sec. 9	H. Wolters	Dr	197.1	5	GI	do	do	Cy, W	S	do	0.2	3,034.0	184.10	8-14-52	
2-33-20aa	NE NE sec. 20	M. Pavanni	Dr	184.1	4	GI	do	do	Cy, W	D, S	do	0.9	3,044.1	159.37	8-23-52	
2-33-28bc	SW NW sec. 28	A. Horinek	Dr	94.3	5	GI	do	do	Cy,W,H	S	do	0.3	2,960.6	89.28	8-14-52	
2-33-31ca	NE SW sec. 31	Rawlins Co. Farm	Dr	36.8	6	GI	do	Crete	Cy,H	N	do	0.6	2,857.3	19.80	8-23-52	
	T. 2 S., R. 34 W.															
2-34-3bb	NW NW sec. 3	F. Vap	Dr	108.5	6	GI	do	Ogallala	Cy, W	S	do	1.4	3,044.8	100.85	8-28-52	
2-34-10dd	SE SE sec. 10	W. S. Kendall Est.	Dr	158.2	6	GI	do	do	Cy, W	S	do	0.4	3,080.9	141.20	8-28-52	
2-34-21bb	NW NW sec. 21	B. Focke	Dr	150.3	5	GI	do	do	Cy, W	S	do	0.3	3,102.8	144.08	8-29-52	
2-34-24bd	SE NW sec. 24	H. V. Lintner	Dr	166	6	GI	do	do	Cy, W	D, S			3,075.3	160		
2-34-29ca	NE SW sec. 29	C. Focke	Dr	21.0	6	GI	do	Terrace deposits	Cy, H	N	Top of casing	0.3	2,942	11.00	4- 4-53	
	T. 2 S., R. 35 W.															
2-35-2aa	NE NE sec. 2	Church	Dr	205.4	6	GI	do	Ogallala	Cy, W	D	do	0.3	3,208.3	197.76	9- 2-52	
2-35-6cc	SW SW sec. 6	A. David	Dr	188.7	5	GI	do	do	N, N	N	do	0.0	3,282.6	181.05	9- 6-52	
2-35-13ab	NW NE sec. 13	P. Kopriva	Dr	188.4	6	GI	do	do	Cy, W	S	do	1.2	3,179.0	175.36	9- 3-52	
2-35-15bb	NW NW sec. 15	J. Sramek	Dr	198.8	6	GI	do	do	Cy, W	S	do	0.2	3,232.3	181.07	9- 5-52	
2-35-30bd	SE NW sec. 30	R. Frisbie	Dr	152.3	6	GI	do	do	Cy, W	S	do	1.9	3,228.0	136.34	9- 5-52	
*2-35-31da	NE SE sec. 31	H. C. Gaines	Dr	117.1	6	GI	do	do	Cy, W	S	do	1.3	3,180.6	89.06	9- 5-52	
2-35-34ca	NE SW sec. 34	F. W. Holub	Dr	50.0	6	GI	do	do	Cy, W	S	do	0.7	3,064.6	30.89	9- 5-52	
2-35-36bb	NW NW sec. 36	A. Skolout	Dr	31.2	6	GI	do	Terrace deposits	Cy, W	S	do	0.3	3,009.3	17.05	9- 3-52	
2-35-36dd	SE SE sec. 36	J. R. Skolout	Dr	151.0	6	GI	do	Ogallala	Cy, W	S	do	0.7	3,117	127.30	4- 4-53	

	T. 2 S., R. 36 W.															
2-36-4dc	SW SE sec. 4	L. L. Headrick	Dr	201.7	6	GI	do.	do.	Cy, W	S	do.	0.9	3,322.8	185.04	9- 8-52	
2-36-8dd	SE SE sec. 8	S. J. Horinek	Dr	227.4	5	GI	do.	do.	Cy, E	D, S	do.	0.8	3,355.6	211.30	9- 9-52	
2-36-11dc	SW SE sec. 11	D. Harper	Dr	206.8	5	GI	do.	do.	N, N	N	do.	1.1	3,313.6	195.53	9- 6-52	
2-36-18bb	NW NW sec. 18	A. W. Wilkins	Dr	231.6	6	GI	do.	do.	Cy, W	S	do.	0.8	3,375.6	214.93	9- 9-52	
2-36-19cd	SE SW sec. 19	H. D. Hughes	Dr	225.4	5	GI	do.	do.	N, N	N	do.	0.6	3,371.2	210.40	9- 9-52	
2-36-22bc	SW NW sec. 22	J. Knapp	Dr	217.6	6	GI	do.	do.	Cy, W	S	do.	0.2	3,342.2	203.80	9- 8-52	
2-36-26bb	NW NW sec. 26	C. A. Falconer	Dr	195.9	6	GI	do.	do.	N, N	N	do.	0.6	3,314.9	194.20	9- 6-52	
2-36-35cc	SW SW sec. 35	A. Briney	Dr	102.7	6	GI	do.	do.	Cy, W	S	do.	0.4	3,208.0	70.55	9- 6-52	
	T. 3 S., R. 31 W.															
3-31-1dd	SE SE sec. 1	C. G. Henningson	Dr	137.2	5	GI	do.	do.	Cy, W	N	do.	1.3	2,893.1	136.74	6- 5-52	
3-31-8ba	NE NW sec. 8	C. A. Falconer	Dr	196.8	6	GI	do.	do.	Cy, W	N	do.	.3	2,990.1	191.49	6-12-52	
3-31-10dd	SE SE sec. 10	A. W. Olsen	Dr	85.2	5	GI	do.	do.	Cy, W	S	do.	1.1	2,851.0	74.70	8-25-52	
3-31-23aa	NE NE sec. 23	N. C. Cederberg	Dr	127.7	6	GI	do.	do.	Cy, W	S	do.	0.7	2,873.3	106.88	6- 5-52	
*3-31-23bb	NW NW sec. 23	N. C. Cederberg	Dr	88.5	6	GI	do.	do.	Cy, W	S	do.	1.0	2,850.4	76.56	6- 5-52	
3-31-27da	NE SE sec. 27	C. W. Glad	Dr	97.3	5	GI	do.	do.	Cy, W	N	do.	1.1	2,861.8	91.12	6-11-52	
3-31-32ac	SW NE sec. 32	E. C. Carlson	Du	41.5	54	R	do.	do.	N, W	N	Top of platform	0.3	2,850.0	39.85	6-12-52	
3-31-33da	NE SE sec. 33	F. Nelson	Dr	98.1	5	GI	do.	do.	Cy, W	S	Top of casing	0.6	2,876.6	92.45	6-11-52	
3-31-36ab	NW NE sec. 36	S. E. Cederberg	Dr	91.6	6	GI	do.	do.	Cy, W	S	do.	1.3	2,839.8	91.17	6- 6-52	
	T. 3 S., R. 32 W.															
3-32-1dd	SE SE sec. 1	C. S. Bergling	Dr	175.9	5	GI	do.	do.	Cy, W	S	do.	0.5	2,977.1	163.40	6-13-52	
3-32-4ad	SE NE sec. 4	Stolte Estate	Dr	157.6	6	GI	do.	do.	Cy, W	S	do.	1.1	2,994.7	152.15	8- 5-52	
3-32-13cd	SE SW sec. 13	A. Carlson	Dr	184.5	6	GI	do.	do.	Cy, W	S	do.	0.2	3,008.2	182.00	8- 1-52	
3-32-17bc	SW NW sec. 17	H. Timm	Dr	198.4	6	GI	do.	do.	Cy, W	S	do.	1.8	3,073.1	193.10	8- 7-52	
3-32-23dd	SE SE sec. 23	N. E. Wancura	Dr	148.0	6	GI	do.	do.	Cy, W	S	do.	0.9	2,976.8	141.45	8- 1-52	
3-32-28ab	NW NE sec. 28	W. O. Lewis	Dr	176.8	6	GI	do.	do.	N, N	N	do.	1.2	3,031.0	168.50	8- 4-52	
3-32-35cc	SW SW sec. 35	E. E. Forster	Dr	177.7	6	GI	do.	do.	Cy, H	N	Base of pump	0.6	3,025.5	176.72	8- 2-52	
	T. 3 S., R. 33 W.															
3-33-3dc	SW SE sec. 3	Glenn Argabright	Dr	62	18	GI	do.	Terrace deposits	T, G	I	....	.....	2,822.8	22	....	Well goes to shale
3-33-4ac	SW NE sec. 4	C. E. Henneberger	Dr	16.0	6	GI	do.	do.	Cy, W, H	N	Top of casing	1.7	2,829.0	12.15	8-14-52	
3-33-8cd	SE SW sec. 8	Glynn Walker	Dr	52	18	GI	do.	Crete	....	I	....	.....	2,855	20	....	
*3-33-8db1	NW SE sec. 8	Central Kansas Power Co.	Dr	65	12	ST	do.	do.	T, E	Ps	....	.....	2,858.4	40	....	Well is in city water plant. Analysis given in Table 3 is of composite sample from wells 3-33-8db1 and 3-33-8db2.
*3-33-8db2	NW SE sec. 8	Central Kansas Power Co.	Dr	65	12	ST	do.	do.	T, E	Ps	....	.....	2,857.1	40	....	Well is located northwest of plant.

TABLE 7.—*Records of wells and springs in Rawlins County, Kansas—Continued*

WELL NUMBER (1)	Location	Owner or tenant	Type of well (2)	Depth of well, feet (3)	Diameter of well, in.	Type of casing (4)	Principal water-bearing bed: Character of material	Principal water-bearing bed: Geologic source	Method of lift (5)	Use of water (6)	Measuring point: Description	Measuring point: Distance above land surface, feet	Measuring point: Height above mean sea level, feet (7)	Depth to water level below measuring point, feet (8)	Date of measurement	REMARKS (Yield given in gallons a minute; drawdown in ft.)
	T. 3 S., R. 33 W.															
3-33-11cc	SW SW sec. 11	W. H. Fikan	.....	.....	.....	.....	Sand, gravel	Ogallala	.....	S	.....	.....	2,876.0	.....	.....	Contact spring estimated flow 3 g.p.m.
3-33-16db	NW SE sec. 16	F. J. Dozbaba	Dr	139.0	6	GI	do.	do.	Cy, W	N	Top of casing	0.1	3,041.2	132.60	8-13-52	
3-33-17ba	NE NW sec. 17	J. McIntoch	Dr	50	18	GI	do.	Terrace deposits	.....	I	.....	.....	2,864	20	.....	
3-33-18da	NE SE sec. 18	H. H. Orbert	Dr	21.3	6	GI	do.	do.	Cy, W	S	Top of casing	1.0	2,860	15.12	4- 1-53	
3-33-29aa	NE NE sec. 29	C. E. Henneberger	Dr	117.3	6	GI	do.	Ogallala	Cy, W	S	do.	1.2	3,039.7	91.43	8-13-52	
*3-33-31bc	SW NW sec. 31	H. F. Palmer	Dr	165.5	6	GI	do.	do.	Cy,W,H	S	do.	0.9	3,094.4	142.68	9-25-52	
3-33-36cb	NW SW sec. 36	L. A. Green	Dr	214.2	5	GI	do.	do.	Cy, W	N	do.	0.4	3,092.3	176.04	8-11-52	
	T. 3 S., R. 34 W.															
3-34-1ba	NE NW sec. 1	Wayne Brewster	Dr	36.3	18	ST	do.	Terrace deposits	T, E	I	Top of curb	1.2	2,859.6	12.65	9-21-52	
*3-34-1bd1	SE NW sec. 1	Wayne Brewster	Dr	45	18	ST	do.	do.	T, E	I	.....	.....	2,856.8	10	.....	West well Analysis given in Table 3 is of composite sample from wells 3-34-1bd1 and 3-34-1bd2.
*3-34-1bd2	SE NW sec. 1	Wayne Brewster	Dr	45	18	ST	do.	do.	T, E	I	.....	.....	2,856.2	10	.....	East well.
3-34-3ad	SE NE sec. 3	School district	Dr	33.3	6	GI	do.	Crete	Cy,W,H	D	Top of casing	1.1	2,901.3	29.11	8-24-52	
3-34-16cd	SE SW sec. 16	J. C. Simminger	Dr	153.2	6	GI	do.	Ogallala	N, N	N	do.	1.2	3,112.2	147.80	8-29-52	
3-34-18dd	SE SE sec. 18	G. N. Hawkins	Dr	193.7	6	GI	do.	do.	Cy, W	S	do.	0.7	3,164.0	185.35	9- 1-52	
3-34-26ab	NW NE sec. 26	R. L. Myers	Dr	12.6	6	GI	do.	Terrace deposits	N, N	N	do.	0.9	2,895.6	8.45	8-27-52	
3-34-28cd	SE SW sec. 28	A. E. Hardon	Dr	22.1	6	GI	do.	do.	Cy, N	N	do.	0.2	2,945.5	21.56	8-29-52	
	T. 3 S., R. 35 W.															
3-35-3da	NE SE sec. 3	C. B. and Q. R.R.	Dr	190.6	6	ST	do.	Ogallala	Cy, W	S	Top of platform	1.1	3,195.0	151.88	9- 4-52	
3-35-9cd	SE SW sec. 9	L. J. Munger	Dr	172.3	6	GI	do.	do.	Cy, H	S	Top of casing	0.3	3,230.8	164.30	9- 4-52	

3-35-14aa	NE NE sec. 14	F. E. Sramek	Dr	67.6	6	GI	do	do	Cy, W	S	do	1.1	3,051	55.60	4- 4-53	
3-35-23aa	NE NE sec. 23	E. E. Bishop	Dr	47.7	6	GI	do	Terrace deposits	Cy, N	N	do	0.3	3,001	35.91	4- 4-53	
*3-35-24cb	NW SW sec. 24	Delbert Hawkins	Dr	50	16	ST	do	Crete	Tr, T	I	.....	.....	3,001.9	25	.....	
3-35-27aa	NE NE sec. 27	Crofoot and Woodworth	Dr	22.4	6	GI	do	Terrace deposits	Cy, W	N	Top of casing	0.2	3,021.0	18.25	9- 3-52	
3-35-30ba	NE NW sec. 30	R. Vorhies	Dr	184.8	5	GI	do	Ogallala	Cy, W	S	do	1.0	3,256.7	160.65	9-18-52	
	T. 3 S., R. 36 W.															
3-36-1dd	SE SE sec. 1	E. H. Gardner	Dr	173.5	6	GI	do	do	Cy, W	N	do	0.1	3,264.6	157.60	9- 6-52	
3-36-7dd	SE SE sec. 7	D. R. Cooper	Dr	195.2	5	GI	do	do	N, N	N	do	0.4	3,364.7	188.32	9- 9-52	
3-36-10da	NE SE sec. 10	R. J. Jackson	Dr	165.3	6	GI	do	do	Cy, W	S	do	0.2	3,286.4	148.74	9- 6-52	
3-36-19ba	NE NW sec. 19	H. E. Archet	Dr	193.3	5	GI	do	do	Cy, W	S	do	0.3	3,377.5	188.93	9- 9-52	
3-36-20ad	SE NE sec. 20	C. B. & Q. R. R.	Du	208.0	192	R	do	do	Cy, K	RR	Top of door on east side of platform	1.9	3,368.2	197.04	9-23-52	
3-36-20bd	SE NW sec. 20	E. D. Madsen	Dr	102.4	5	GI	do	do	Cy, W	S	Top of casing	0.3	3,349.8	171.40	8- 4-52	
*3-36-21ba	NE NW sec. 21	City of McDonald	Dr	302	16	ST	do	do	T, E	Ps	.....	.....	3,359.5	198	6-15-48	Well is located at water tower.
3-36-21bb1	NW NW sec. 21	do	Dr	242	10	ST	do	do	Cy, D	Ps	.....	.....	3,365.4	235.90	.....	Well is located in city hall.
3-36-21bb2	NW NW sec. 21	do	Dr	250	10	ST	do	do	T, E	Ps	.....	.....	3,366.7	214.90	.....	Well is located east of city hall.
3-36-23bb	NW NW sec. 23	C. Sramek	Dr	102.7	5	GI	do	do	Cy, N	N	Base of hole in S. E. side of casing.	0.3	3,325.5	169.10	8- 4-52	
3-36-34ad	SE NE sec. 34	R. Williams	Dr	28.3	6	GI	do	Terrace deposits	Cy, W	S	Top of casing	1.7	3,153.0	13.66	9-18-52	
	T. 4 S., R. 31 W.															
4-31-8cc	SW SW sec. 8	V. V. Robbins	Dr	44.0	6	GI	do	do	Cy, W	S	do	0.6	2,806.6	28.65	6-13-52	
4-31-11bd	SE NW sec. 11	F. M. Artery	Dr	31.2	5	GI	do	do	Cy, H	N	do	0.2	2,752.3	23.63	6- 6-52	
4-31-12aa	NE NE sec. 12	Mary Henry	Dr	69.3	5	GI	do	Ogallala	Cy,W,H	N	do	1.1	2,764.1	60.80	6- 6-52	
*4-31-15bb	NW NW sec. 15	Vance Robbins	Dr	30	5	GI	do	Terrace deposits	Cy, G	S	.....	.....	2,756.9	15	.....	
4-31-16bc	SW NW sec. 16	L. Schmidt	Dr	44.5	6	GI	do	Crete	Cy, W	S	Top of casing	1.2	2,786.3	24.15	6-12-52	
4-31-18cc	SW SW sec. 18	J. E. Foster	Dr.	56.8	6	GI	do	Ogallala	N, N	N	do	0.3	2,843.6	46.55	6-13-52	
4-31-21ca	NE SW sec. 21	A. W. Erickson	Dr	168.2	6	GI	do	do	Cy, W	S	do	0.3	2,943.0	161.10	6-12-52	
4-31-26aa	NE NE sec. 26	A. G. Mosier	Dr	127.8	5	GI	do	do	Cy, W	S	do	0.5	2,894.8	120.90	6- 7-52	
4-31-29dc	SW SE sec. 29	V. F. Morton	Dr	183.3	4	GI	do	do	N, N	N	do	4.1	2,979.0	164.30	6-13-52	
	T. 4 S., R. 32 W.															
*4-32-5ca	NE SW sec. 5	C. Springer	Dr	167.5	6	GI	do	do	Cy, W	S	do	0.8	3,030.1	151.62	8-26-52	
4-32-9dd	SE SE sec. 9	J. E. Fikan	Dr	48.4	5	GI	do	do	Cy, W	S	do	0.9	2,898.2	41.71	8- 5-52	
4-32-12cb	NW SW sec. 12	M. Packard	Dr	121.6	5	GI	do	do	Cy,W,H	S	Top of curb	0.7	2,945.0	109.47	8- 2-52	
4-32-17ab	NW NE sec. 17	School district	Dr	100.3	6	GI	do	do	Cy, H	N	Top of casing	0.6	2,962.2	80.05	8- 7-52	
4-32-23cc	SW SW sec. 23	J. W. Shipley	Dr	136.7	5	GI	do	do	Cy, W	S	do	1.2	2,970.2	129.10	8- 2-52	
4-32-32aa	NE NE sec. 32	D. L. Raber	Dr	93.4	6	GI	do	do	Cy, W	S	do	0.4	2,964.2	81.70	8-26-52	

TABLE 7.—*Records of wells and springs in Rawlins County, Kansas—Continued*

Well Number (1)	Location	Owner or tenant	Type of well (2)	Depth of well, feet (3)	Diameter of well, in.	Type of casing (4)	Principal water-bearing bed: Character of material	Principal water-bearing bed: Geologic source	Method of lift (5)	Use of water (6)	Measuring point: Description	Measuring point: Distance above land surface, feet	Measuring point: Height above mean sea level, feet (7)	Depth to water level below measuring point, feet (8)	Date of measurement	REMARKS (Yield given in gallons a minute; drawdown in ft.)
	T. 4 S., R. 33 W.															
4-33-8ba	NE NW sec. 8	C. E. Henneberger	Dr	164.2	6	GI	Sand, gravel	Ogallala	Cy, W	N	Top of casing	0.6	3,118.7	155.48	8-15-52	
4-33-14da	NE SE sec. 14	A. Ruda	Dr	39.0	6	GI	do	Terrace deposits	Cy, W	S	do	0.6	2,953.0	29.73	9-26-52	
4-33-15dd	SE SE sec. 15	H. Waterman	Dr	78.6	5	GI	do	Ogallala	N, N	N	do	0.4	3,012.2	67.98	8-12-52	
4-33-18dd	SE SE sec. 18	W. B. Minney	Dr	103.3	5	GI	do	do	Cy, W	N	do	1.2	3,068.0	87.81	8-4-52	
4-33-27dd	SE SE sec. 27	School district	Dr	174.6	6	GI	do	do	Cy,W,H	D	do	0.2	3,117.0	159.25	8-12-52	
4-33-30ad	SE NE sec. 30	Mary Weuster	Dr	167.1	5	GI	do	do	Cy, H	N	do	0.4	3,134.5	141.46	8-4-52	
4-33-36ab	NW NE sec. 36	W. Brown	Dr	153.5	6	GI	do	do	Cy,W,H	D, S	do	1.2	3,058.9	126.60	8-26-52	
	T. 4 S., R. 34 W.															
4-34-9bb	NW NW sec. 9	G. Taylor	Dr	31.0	6	GI	do	do	Cy, W	S	do	0.1	2,982	24.52	4-1-53	
4-34-13ba	NE NW sec. 13	E. Messmaker	Dr	190.8	6	GI	do	do	Cy, W	S	do	0.5	3,162.2	176.10	8-27-52	
4-34-14da	NE SE sec. 14	H. E. Hafkey	Dr	155.3	6	GI	do	do	Cy, W	N	do	0.9	3,137.7	144.30	8-27-52	
4-34-18ba	NE NW sec. 18	E. Hill	Dr	16.2	6	GI	do	Terrace deposits	Cy, H	N	do	1.1	3,020.0	31.94	9-1-52	
4-34-28dd	SE SE sec. 28	H. T. Wistman	Dr	143.1	6	GI	do	Ogallala	Cy, W	N	At point where pump is cut in half	1.6	3,159.9	125.40	8-30-52	
4-34-31aa	NE NE sec. 31	C. H. Roesch	Dr	194.8	6	GI	do	do	Cy, W	S	Top of casing	0.2	3,220.7	184.20	9-1-52	
4-34-32ad	SE NE sec. 32	Stevens Chapel	Dr	140.1	6	GI	do	do	Cy, W	N	do	0.3	3,166.6	124.53	8-30-52	
	T. 4 S., R. 35 W.															
4-35-6dc	SW SE sec. 6	E. C. Duncan	Dr	167.5	6	GI	do	do	Cy, W	S	do	0.2	3,251.8	157.52	9-17-52	
4-35-8aa	NE NE sec. 8	D. L. Kyte	Dr	188.8	4	GI	do	do	Cy, W	N	do	1.3	3,268.0	186.06	9-16-52	
4-35-9dc	SW SE sec. 9	J. T. Joyce	Dr	182.4	5	GI	do	do	N, N	N	do	0.6	3,238.8	175.15	9-16-52	
4-35-20ab	NW NE sec. 20	F. Rummel	Dr	115.6	6	GI	do	do	Cy, W	N	do	0.9	3,172.4	90.35	9-17-52	
4-35-22bd	SE NW sec. 22	W. Wallace	Dr	168.4	5	GI	do	do	N, N	N	do	1.1	3,216.4	163.62	9-16-52	
4-35-26ab	NW NE sec. 26	C. H. Roesch	Dr	56.9	6	GI	do	Terrace deposits	Cy, H	N	do	0.2	3,048.0	38.86	9-4-52	
4-35-29dd	SE SE sec. 29	D. L. Andrews	Dr	165.6	6	GI	do	Ogallala	Cy, W	S	do	0.3	3,219.1	149.72	9-16-52	
	T. 4 S., R. 36 W.															
4-36-4ac	SW NE sec. 4	M. E. Berry	Dr	150.7	5	GI	do	do	Cy, W	N	do	0.7	3,325.2	146.94	9-18-52	
4-36-15cd	SE SW sec. 15	J. D. Caldon	Dr	168.4	6	GI	do	do	Cy, W	S	do	0.4	3,331.1	161.26	9-19-52	

4-36-17db	NW SE sec. 17	W. T. Hewitt	Dr	29.6	6	GI	Sand, gravel	Terrace deposits	Cy, W	S	Top of casing	1.0	3,217.7	21.49	9-19-52	
4-36-18cb	NW SW sec. 18	E. V. Horinek	Dr	30	6	GI	do.	do.	Cy, W	D, S			3,218	20		
4-36-19cb	NW SW sec. 19	L. Briney	Dr	169.8	6	GI	do.	Ogallala	Cy, W	S	Top of casing	0.5	3,373.8	151.23	9-20-52	
4-36-20dd	SE SE sec. 20	W. T. Hewitt	Dr	152.9	6	GI	do.	do.	Cy, W	S	Top of platform	0.6	3,320.3	135.12	9-19-52	
4-36-32bb	NW NW sec. 32	H. D. Harrison	Dr	212.6	6	GI	do.	do.	Cy, W	S	Top of casing	0.2	3,407.2	197.28	9-20-52	
	T. 5 S., R. 31 W.															
5-31-6cc	SW SW sec. 6	D. L. Raber	Dr	156.4	6	GI	do.	do.	N, N	N	do.	0.6	2,999.8	149.62	6-13-52	
5-31-14cc	SW SW sec. 14	Neruda Bros.	Dr	117	6	GI	do.	do.	Cy, W	D, S			2,921.5	100		
5-31-17dc	SW SE sec. 17	School district	Dr	101.1	6	GI	do.	do.	Cy, N	N	Top of casing	0.5	2,918.7	87.60	6-13-52	
•5-31-23dd	SE SE sec. 23	E. H. Treat	Dr	136.1	5	GI	do.	do.	Cy, W	S	do.	0.6	2,951.0	121.00	6-6-52	
5-31-27aa	NE NE sec. 27	C. A. Falconer	Dr	136.5	5	GI	do.	do.	N, W	N	do.	1.0	2,968.2	125.65	6-3-52	
5-31-32cc	SW SW sec. 32	Esther Strickland	Dr	127.7	6	GI	do.	do.	N, N	N	Top of curb	2.1	2,997.0	120.52	6-13-52	
5-31-34cd	SE SW sec. 34	E. Waterman	Dr	136.7	6	GI	do.	do.	Cy, W	S	Top of casing	0.9	2,987.4	129.40	6-12-52	
5-31-36ab	NW NE sec. 36	F. C. Janssen	Dr	110.4	5	GI	do.	do.	Cy, W	S	do.	0.6	2,906.7	78.14	6-6-52	
	T. 5 S., R. 32 W.															
5-32-17db	NW SE sec. 17	A. Ratcliff	Dr	157.0	6	GI	do.	do.	Cy, W	S	do.	0.7	3,049.8	127.60	8-7-52	
5-32-19dd	SE SE sec. 19	H. C. Bohme	Dr	149.9	5	GI	do.	do.	Cy, W	S	do.	0.7	3,081.2	138.10	8-12-52	
5-32-22aa	NE NE sec. 22	Cemetery	Dr	158.3	5	GI	do.	do.	Cy, W	D	do.	0.2	3,041.5	145.87	8-2-52	
5-32-25cc	SW SW sec. 25	Curtis Knudson	Dr	70	12	ST	do.	Terrace deposits	T, Tr	I			2,902.7	20		Reported draw-down of 20 ft. after 10 hours pumping at 500 g.p.m.
5-32-36cd	SE SW sec. 36	Ike Ryan	Dr	84	24	ST	do.	do.	T, G	I			2,915.4	42		
	T. 5 S., R. 33 W.															
5-33-7bd	SE NW sec. 7	F. Fikan	Dr	185.7	6	GI	do.	Ogallala	Cy, W	N	Top of casing	0.4	3,177.5	166.25	8-24-52	
5-33-9cd	SE SW sec. 9	F. Ruda	Dr	104.7	5	GI	do.	do.	Cy, W	S	do.	0.4	3,085.8	87.01	8-12-52	
•5-33-12ad	SE NE sec. 12	J. L. Pancake	Dr	35	6	GI	do.	Terrace deposits	J, E	D				24		
5-33-12db	NW SE sec. 12	J. L. Pancake	Dr	43.4	5	GI	do.	do.	Cy, W	S	Top of casing	1.1	2,960.3	29.20	8-12-52	
5-33-19dd	SE SE sec. 19	C. J. Bodger	Dr	72.4	6	GI	do.	Ogallala	Cy,W,H	D, S	do.	0.8	3,097.6	67.78	8-21-52	
5-33-21dd	SE SE sec. 21	F. Gatlin	Dr	33.8	5	GI	do.	Terrace deposits	N, W	N	do.	2.7	3,021.2	26.17	8-12-52	
5-33-23bd	SE NW sec. 23	V. J. Ruda	Dr	148.4	5	GI	do.	Ogallala	Cy, W	S	do.	0.4	3,109.8	137.12	8-12-52	
5-33-32cc	SW SW sec. 32	H. R. Ferguson	Dr	136.8	6	GI	do.	do.	Cy, N	N	do.	0.6	3,156.8	116.05	8-21-52	
5-33-34dd	SE SE sec. 34	C. E. Henneberger	Dr	154.6	5	GI	do.	do.	Cy, N	N	do.	1.0	3,140.7	139.28	8-12-52	
	T. 5 S., R. 34 W.															
•5-34-1bb	NW NW sec. 1	P. J. Roberts	Dr	128.0	5	GI	do.	do.	Cy, W	S	do.	0.6	3,137.8	118.40	8-26-52	
5-34-8cc	SW SW sec. 8	C. E. Henneberger	Dr	189.8	6	GI	do.	do.	Cy, W	S	do.	0.5	3,241.9	173.60	8-30-52	
5-34-9ba	NE NW sec. 9	J. J. Miller	Dr	172.5	6	GI	do.	do.	N, N	N	do.	0.8	3,201.6	147.99	8-30-52	
5-34-15aa	NE NE sec. 15	School district	Dr	183.7	6	GI	do.	do.	Cy,G,H	S	do.	0.4	3,218.5	174.91	8-26-52	
5-34-24dd	SE SE sec. 24	J. R. Ramey	Dr	37.6	6	GI	do.	Terrace deposits	Cy, N	N	Base of pump	0.7	3,080.1	35.59	8-24-52	
5-34-27dc	SW SE sec. 27	K. Studer	Dr	74.4	6	GI	do.	Ogallala	Cy, H	N	Top of casing	2.1	3,144.5	68.90	8-26-52	
5-34-29aa	NE NE sec. 29	C. M. Yoe	Dr	170.9	6	GI	do.	do.	Cy, W	N	do.	1.0	3,250.5	164.72	8-30-52	

TABLE 7.—*Records of wells and springs in Rawlins County, Kansas—Concluded*

Well Number (1)	Location	Owner or tenant	Type of well (2)	Depth of well, feet (3)	Diameter of well, in.	Type of casing (4)	Principal water-bearing bed: Character of material	Principal water-bearing bed: Geologic source	Method of lift (5)	Use of water (6)	Measuring point: Description	Measuring point: Distance above land surface, feet	Measuring point: Height above mean sea level, feet (7)	Depth to water level below measuring point, feet (8)	Date of measurement	REMARKS (Yield given in gallons a minute; drawdown in ft.)
	T. 5 S., R. 35 W.															
5-35-6bb	NW NW sec. 6	S. L. Burton	Dr	42.5	6	GI	Sand, gravel	Ogallala	N, N	N	Top of casing	0.8	3,129.9	32.19	9-17-52	
5-35-9ba	NE NW sec. 9	C. Dewey	Dr	209.7	6	GI	do.	do.	Cy, W	S	do.	0.2	3,291.2	195.62	9-16-52	
5-35-10cd	SE SW sec. 10	B. Ramey	Dr	180.5	6	GI	do.	do.	Cy, W	N	do.	0.3	3,267.2	167.48	9-16-52	
5-35-14cb	NW SW sec. 14	B. A. Harper	Dr	162.0	6	GI	do.	do.	Cy, W	S	do.	0.3	3,241.0	137.60	9- 4-52	
5-35-19dd	SE SE sec. 19	A. Ratcliff	Dr	182.3	6	GI	do.	do.	Cy, W	N	do.	0.2	3,325.2	176.07	9-17-52	
5-35-35bb	NW NW sec. 35	A. Eviriss	Dr	189.0	6	GI	do.	do.	Cy, N	N	do.	0.4	3,311.2	184.37	9- 4-52	
5-35-36dd	SE SE sec. 36	W. C. Mairvin	Dr	141.3	6	GI	do.	do.	Cy, W	N	do.	1.0	3,246.7	125.13	8-30-52	
	T. 5 S., R. 36 W.															
5-36-3ca	NE SW sec. 3	C. Dewey	Dr	138.2	6	GI	do.	do.	Cy, W	S	do.	0.1	3,275	99.87	9-19-52	
5-36-15bc	SW NW sec. 15	C. Dewey	Dr	103.1	6	GI	do.	do.	Cy, W	D	Base of pump	0.5	3,249.9	72.74	9-19-52	
5-36-21bb	NW NW sec. 21	School	Dr	30.3	6	GI	do.	Terrace deposits	Cy, H	D	Top of casing	0.4	3,208	7.80	4- 1-53	
5-36-30ba	NE NW sec. 30	T. J. Minor	Dr	79.2	6	GI	do.	Ogallala	Cy, W	S	do.	0.5	3,276.6	55.62	9-20-52	
*5-36-32aa	NE NE sec. 32	J. F. McKee	Dr	187.5	6	GI	do.	do.	Cy, W	S	do.	0.4	3,397.1	178.68	9-24-52	
5-36-32db	NW SE sec. 32	B. C. Briney	Dr	197.5	6	GI	do.	do.	Cy, W	S	do.	0.3	3,410.9	181.49	9-19-52	
5-36-35da	NE SE sec. 35	F. S. Miller	Dr	169.6	6	GI	do.	do.	Cy, H	N	do.	1.0	3,355.4	166.06	9-17-52	
	T. 6 S., R. 35 W.															
6-35-1ba	NE NW sec. 1		Dr	186.9	6	GI	do.	do.	N, N	N	do.	0.2	3,333	156.77	9-17-52	In Thomas County.

1. Well number: Well number gives the location of the well, as illustrated in Figure 2. Asterisk before well number indicates chemical analysis of water is given in Table 3.
2. Dr, drilled; Du, dug.
3. Reported depths below the land surface are given in feet; measured depths are given in feet and tenths below measuring point.
4. C, concrete; GI, galvanized sheet iron; R, rock; St, steel.
5. Method of lift: Ce, centrifugal; Cy, cylinder; J, jet; N, none; T, turbine. Type of power: D, diesel engine; E, electric; G, gas engine; H, hand operated; K, kerosene engine; N, none; Tr, tractor; W, windmill.
6. D, domestic; I, irrigation; N, none; Ps, public supply; RR, railroad; S, stock.
7. Where no measuring point is given, altitude is that of land surface at well.
8. Measured depths to water level are given in feet, tenths, and hundredths; reported depths to water level are given in feet.

LOGS OF TEST HOLES AND WELLS

The logs of 36 test holes and one well are given on the pages that follow. The test holes were drilled by the State Geological Survey with a hydraulic-rotary drill rig. The well log was provided by a private driller. Five of the test holes, as noted in the headings, were drilled on or near the county line as a part of earlier studies. The numbering system for test holes and wells is described in an earlier section of this report.

1-31-1aa. *Sample log of test hole in the NE¼ NE¼ sec. 1, T. 1 S., R. 31 W., 180 feet north of fence line, 40 feet west of road center; drilled June 1952. Surface altitude, 2,891.6 feet; depth to water level, 190.60 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Sanborn formation		
Peoria silt member		
Soil, silty, black	3	3
Silt, fossiliferous, calcareous, gray-green	14	17
Sand and silt, fine, clayey, tan	21	38
Loveland silt member		
Clay, compact, sandy, noncalcareous, brown	4	42
Clay, silty, calcareous, tan	10	52
TERTIARY—Pliocene		
Ogallala formation		
Clay, tan; contains some light-tan, limy and very sandy clay	35.5	87.5
Silt and silty lime, clayey, white; contains some gravel	4.5	92
Clay, sandy, limy, tan to gray	5.5	97.5
Sand, clayey, tan-red to gray	24.5	122
Sand, fine to coarse, and fine gravel	6	128
Sand, fine, cemented, tan-red	21	149
Sand, fine to coarse; contains some gravel, silt and clay	11	160
Clay, sandy, tan-red; contains some coarse sand and fine gravel	12	172
Clay, sandy, light-red; contains a few cemented sand stringers	5	177
Sand, fine, cemented; contains some red sandy clay	8	185
Clay, sandy and limy, tan to white; contains some gravel	7	192
Sand and gravel, fine to coarse, clayey	7	199
Clay, compact, silty, white	20	219
Clay, sandy, light-tan to light-gray; contains a few thin sand stringers	19	238
CRETACEOUS—Gulfian		
Pierre shale		
Clay to weathered shale, green-gray and yellow	16	254
Shale, clayey, gray	6	260

1-32-12aa. *Sample log of test hole in the NE¼ NE¼ sec. 12, T. 1 S., R. 32 W., 150 feet south of the NE cor. sec. 12, 12 feet west of road center; drilled June 1952. Surface altitude, 3,005.2 feet.*

	Thickness, feet	Depth, feet
Road fill	3	3
QUATERNARY—Pleistocene		
Sanborn formation		
Peoria silt member		
Silt, fossiliferous, calcareous, clayey, tan-gray	37	40
Loveland silt member		
Silt, blocky, weakly calcareous, brown	1	41
Silt, calcareous, clayey, tan-brown	7	48
TERTIARY—Pliocene		
Ogallala formation		
Clay, calcareous, silty to sandy, light-tan	87	135
Silt, compact, tan-white	3	138
Silt, sandy, red-brown	11	149
Silt, sandy, light-gray and gray-green	5	154
Silt, sandy, red-brown	11	165
Sand, fine to medium, clayey to silty	10	175
Sand, fine to medium, cemented, tan-brown	19	194
Clay, sandy, tan to light-tan	14	208
Sand, fine to medium, clayey, light-tan	20	228
Clay, sandy, light-tan	9	237
Sand, fine to coarse, clayey, tan-brown	9	246
Clay, compact, light-tan	5	251
Sand, fine to coarse, silty	7	258
Sand, cemented; contains a few stringers of tan sandy clay	24	282
Sand and gravel, fine to coarse	4	286
Sand, fine, cemented; contains thin opaline stringers and some green siltstone	2	288
Sand, fine to coarse	4	292
CRETACEOUS—Gulfian		
Pierre shale		
Shale, clayey, yellow-gray	10	302
Shale, clayey, gray to dark-gray	8	310

1-32-31cc. *Sample log of test hole in the SW¼ SW¼ sec. 31, T. 1 S., R. 32 W., 75 feet north of SW cor. sec. 31, 15 feet east of road center; drilled June 1952. Surface altitude, 3,025.5 feet.*

	Thickness, feet	Depth, feet
Road fill	3	3
QUATERNARY—Pleistocene		
Sanborn formation		
Peoria silt member		
Silt, clayey, calcareous, gray-green	29	32
Clay, silty, tan	4	36

	Thickness, feet	Depth, feet
Loveland silt member		
Clay, compact, silty, weakly calcareous, tan	3	39
Clay, compact, calcareous, light-tan	10	49
TERTIARY—Pliocene		
Ogallala formation		
Clay, sandy, tan	28	77
Clay, very sandy, tan-brown	16	93
Sand, fine to coarse; contains some fine gravel	9	102
Sand, fine to medium, cemented, clayey	11	113
Sand, fine, cemented, light-gray	14	127
Sand, fine, cemented; contains some white limy clay	4	131
Sand, cemented; contains some tan clay	10	141
Sand, medium to fine, cemented, tan-brown	4	145
Sand, fine, cemented	8	153
Clay, blocky, silty, tan-gray	14.5	167.5
Sand and silt, cemented, tan-brown	11.5	179
Clay, silty, tan	30	209
Sand, fine to medium; contains some tan-brown sandy clay	9	218
Sand, fine to coarse, silty	9	227
CRETACEOUS—Gulfian		
Pierre shale		
Clay to weathered shale, compact, limonite-stained, tan to yellow	10	237
Shale, yellow to gray	9.5	246.5
Shale, clayey, noncalcareous, black	3.5	250

1-32-36cd. *Sample log of test hole in the SE¼ SW¼ sec. 36, T. 1 S., R. 32 W., 5 feet west of the center of the south side of sec. 36, 13 feet north of road center; drilled June 1952. Surface altitude, 2,872.8 feet.*

	Thickness, feet	Depth, feet
Road fill	2.5	2.5
QUATERNARY—Pleistocene		
Sanborn formation		
Peoria silt member		
Silt, calcareous, tan-gray	27.5	30
Clay, very silty, calcareous, tan	5	35
Loveland silt member		
Clay, weakly calcareous, brown	1.5	36.5
Clay, silty, calcareous, tan	1.5	38
TERTIARY—Pliocene		
Ogallala formation		
Clay, sandy, limy, gray-white	1	39
Silt and fine sand, limy; contains some gravel	10.5	49.5
Sand, fine to medium, cemented, tan-white	16.5	66
Sand, fine to medium, partly cemented; contains some medium to coarse gravel	2	68
Sand, fine to coarse; contains fine to coarse gravel	18	86
Clay, silty, yellow to tan	21	107

	Thickness, feet	Depth, feet
Sand, fine, silty, tan-brown	9	116
Clay, compact, tan to yellow	19	135
Sand, fine to medium, silty	6	141
Sand and gravel, fine to coarse; contains some yellow silt	17	158
Gravel, fine to coarse	5	163
CRETACEOUS—Gulfian		
Pierre shale		
Shale, weathered, light-gray and yellow	5	168
Shale, clayey, noncalcareous, gray to dark-gray	2	170

1-34-31cc. *Sample log of test hole in the SW¼ SW¼ sec. 31, T. 1 S., R. 34 W., 20 feet east of the SW cor. sec. 31, 30 feet north of the road center; drilled June 1952. Surface altitude, 3,189.6 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Sanborn formation		
Soil, clay, tan-brown	2.5	2.5
Silt, fossiliferous, calcareous, tan to gray	19.5	22
Clay, compact, silty, tan-gray	7	29
Clay, compact, tan-brown	19	48
Clay, silty, calcareous, light-tan	4	52
Clay, silty and sandy, calcareous, tan	60	112
TERTIARY—Pliocene		
Ogallala formation		
Clay and silt, light-tan to white; contains some sand and fine gravel	4	116
Sand, fine to medium, cemented	21	137
Clay, very sandy, light-tan	18	155
Sand, fine to medium, clayey, tan	5	160
Sand, medium to coarse, silty, and fine to coarse gravel	12.5	172.5
Sand, fine to coarse, and fine gravel	25.5	198
Sand, fine to coarse, cemented, light-tan	4	202
CRETACEOUS—Gulfian		
Pierre shale		
Shale, weathered, yellow and yellow-gray	26	228
Shale, clayey, gray to light-gray	2	230

1-35-1aa. *Sample log of test hole in the NE¼ NE¼ sec. 1, T. 1 S., R. 35 W., 0.15 mile west of the NE cor. sec. 1, 8 feet south of road center on top of hill; drilled June 1952. Surface altitude, 3,035.5 feet.*

	Thickness, feet	Depth, feet
Road fill	1.5	1.5
QUATERNARY—Pleistocene		
Sanborn formation		
Peoria silt member		
Clay, compact, dark-brown	1	2.5
Silt, calcareous, tan to gray	14.5	17
Clay, silty, calcareous, tan	26	43

	Thickness, feet	Depth, feet
Loveland silt member		
Clay, silty, weakly calcareous, tan-brown	6	49
Clay, silty, calcareous, tan	13	62
TERTIARY—Pliocene		
Ogallala formation		
Clay, silty, tan; contains some gravel	5	67
Sand, fine to coarse, silty	1.5	68.5
Clay, sandy, red-brown	3	71.5
Sand and gravel, clayey	3.5	75
Clay, light-red; contains some fine gravel	3.5	78.5
Sand, fine to coarse	2	80.5
Sand, fine, limy, cemented	7.5	88
Sand, fine to coarse, clayey	8	96
Sand and gravel, fine to coarse	7	103
CRETACEOUS—Gulfian		
Pierre shale		
Shale, weathered, clayey, calcareous, yellow	4.5	107.5
Shale, clayey, noncalcareous, light-gray	1	108.5

1-35-6bb. *Sample log of test hole in the NW¼ NW¼ sec. 6, T. 1 S., R. 35 W., on west side of curving road about 50 feet south of the Kansas-Nebraska state line; drilled June 1952. Surface altitude, 3,229.6 feet.*

	Thickness, feet	Depth, feet
Road fill	3.5	3.5
QUATERNARY—Pleistocene		
Sanborn formation		
Peoria silt member		
Silt, calcareous, tan to gray	31.5	35
Clay, silty, tan; contains some fine sand	15	50
Sand, very fine; and brown calcareous silt	10	60
Clay, calcareous, sandy, tan	5	65
TERTIARY—Pliocene		
Ogallala formation		
Sand and clay, hard, partly cemented	7	72
Sand, clayey, light-tan	8	80
Sand, fine to coarse, silty; contains a few thin clay zones	110	190
Clay, blocky, yellow-green; contains some fine sand	6	196
Sand, fine to coarse; contains some fine gravel	5	201
Sand, coarse, and fine gravel	3	204
Sand, fine to medium, silty, cemented	5	209
CRETACEOUS—Gulfian		
Pierre shale		
Shale, weathered, clayey, calcareous, yellow	9	218
Shale, dark-gray to black	8	226

1-36-6bb. *Sample log of test hole in the NW¼ NW¼ sec. 6, T. 1 S., R. 36 W., on south shoulder of road, at top of hill about 0.15 mile east of the NW cor. of sec. 6; drilled June 1952. Surface altitude, 3,214.4 feet.*

	Thickness, feet	Depth, feet
Road fill	3	3
QUATERNARY—Pleistocene		
Peoria silt member		
Silt, clayey, calcareous, tan to gray	6	9
Silt, calcareous, tan to gray	59	68
TERTIARY—Pliocene		
Ogallala formation		
Sand, fine to coarse	7	75
Clay, sandy, tan-brown	5	80
Clay, compact, tan-brown	3	83
Clay, sandy, light-tan	3	86
Clay, silty, tan-yellow; contains some gravel	15	101
Sand, fine to medium; contains some tan silt	8	109
Sand, very clayey, limy, white	4	113
CRETACEOUS—Gulfian		
Pierre shale		
Clay, sandy, gray-green	4	117
Shale, weathered, clayey, yellow-gray	19	136
Shale, clayey, dark-gray to black	4	140

2-34-1dd. *Sample log of test hole in the SE¼ SE¼ sec. 1, T. 2 S., R. 34 W., 30 feet west of the SE cor. sec. 1, 18 feet north of road center; drilled June 1952. Surface altitude, 3,074.2 feet; depth to water level, 165.35 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Sanborn formation		
Peoria silt member		
Soil, clayey, black	2	2
Silt, fossiliferous, calcareous, clayey, tan-gray	29	31
Clay, very silty, tan	5	36
Loveland silt member		
Clay, compact, silty, weakly calcareous, brown	2	38
Clay, silty, calcareous, tan	1	39
Clay, silty, calcareous, light-tan	4	43
Clay, sandy, tan-brown	2.5	45.5
Clay, limy, light-tan	13.5	59
TERTIARY—Pliocene		
Ogallala formation		
Clay, soft, limy, white	6	65
Sand, fine	2	67
Clay, sandy, light-red	11	78
Sand, fine to medium, clayey	17	95
Sand, fine to medium, cemented; contains some light-tan clay	14	109

	Thickness, feet	Depth, feet
Clay, sandy, gray to tan	39	148
Clay, very sandy, gray; contains some fine gravel	4	152
Sand and gravel, fine to coarse; contains some clay	15	167
Sand and gravel, cemented, light-tan	5	172
Sand, fine to coarse; and fine gravel	6.5	178.5
CRETACEOUS—Gulfian		
Pierre shale		
Shale, weathered, tan and yellow	8.5	187
Shale, noncalcareous, gray to yellow	3	190

2-35-6bb. *Sample log of test hole in the NW¼ NW¼ sec. 6, T. 2 S., R. 35 W., 80 feet east of the NW cor. sec. 6, 10 feet south of road center; drilled June 1952. Surface altitude, 3,277.2 feet.*

	Thickness, feet	Depth, feet
Road fill	4.5	4.5
QUATERNARY—Pleistocene		
Sanborn formation		
Peoria silt member		
Silt, fossiliferous, calcareous, gray	20.5	25
Clay, soft, very silty, calcareous, tan-gray	32	57
Loveland silt member		
Clay, compact, noncalcareous, brown	6	63
Clay, calcareous, light-tan	3	66
Clay, silty, calcareous, tan; contains some sand	18	84
TERTIARY—Pliocene		
Ogallala formation		
Clay, blocky, silty, weakly calcareous, dark-brown	1	85
Clay, slightly calcareous, yellow	13	98
Clay, silty and sandy, noncalcareous	8	106
Clay, silty, calcareous, tan	27.5	133.5
Sand, limy cemented, light-tan	3.5	137
Sand, fine to medium, clayey, cemented	16	153
Sand, fine to coarse, cemented; contains some gravel	18	171
Sand and gravel, fine to coarse	7	178
Sand and gravel, hard, cemented	1.5	179.5
Sand, fine to medium; contains considerable white clay	10.5	190
CRETACEOUS—Gulfian		
Pierre shale		
Shale, weathered, gray	32	222
Shale, clayey, dark-gray to black	3	225

2-35-30cc. *Sample log of test hole in the SW¼ SW¼ sec. 30, T. 2 S., R. 35 W., 5 feet east of the SW cor. sec. 30, 18 feet north of road center; drilled June 1952. Surface altitude, 3,232.9 feet; depth to water level, 136.80 feet.*

	Thickness, feet	Depth, feet
Road fill	3	3
QUATERNARY—Pleistocene		
Sanborn formation		
Peoria silt member		
Silt and clay, weakly calcareous, dark-brown	3	6
Silt, clayey, calcareous, gray to tan	9	15
Silt, fossiliferous, calcareous, gray	6	21
Silt, clayey, calcareous, tan-brown	11	32
Clay, silty, tan, calcareous	21	53
Loveland silt member		
Clay, silty, weakly calcareous, tan-brown	2	55
Silt, calcareous, brown	2	57
TERTIARY—Pliocene		
Ogallala formation		
Silt, very limy, sandy, white	8	65
Sand, fine to coarse, and fine gravel, cemented	5	70
Silt, very limy, hard	2.5	72.5
Clay, silty, white	4.5	77
Opal, hard, cherty	1.5	78.5
Clay, bentonitic, light-gray	3.5	82
Opal, hard, cherty	.25	82.25
Clay, sandy, gray	5.75	88
Sand, fine, silty, white	1.5	89.5
Sand and gravel, clayey; partly cemented in thin stringers	12.5	102
Sand, fine to medium, limy, white	8	110
Sand, fine to coarse, silty and clayey	9	119
Sand, fine to coarse, and fine gravel	7	126
Sand, medium to coarse, and fine to coarse gravel	6	132
Sand, fine to coarse, cemented; contains a few thin limy clay beds	19	151
Sand, fine to coarse	5	156
Sand, fine to coarse, partly cemented; contains some gravel	19	175
Sand, medium, cemented in thin zones	41	216
Clay, blocky, tan to brown; contains some fine to medium sand	4	220
Sand, fine, loosely cemented	64	284
Sand, fine to coarse, clayey	8	292
Sand, fine, silty, cemented	5	297
Sand, fine to coarse, and fine to medium gravel	7	304
CRETACEOUS—Gulfian		
Pierre shale		
Shale, weathered, yellow-gray	5	309
Shale, clayey, dark-gray	6	315

2-35-36dd. *Sample log of test hole in the SE¼ SE¼ sec. 36, T. 2 S., R. 35 W., 100 feet west of the SE cor. sec. 36, 12 feet north of road center; drilled July 1952. Surface altitude, 3,130.0 feet; depth to water level, 143.1 feet.*

	Thickness, feet	Depth, feet
Road fill	2	2
QUATERNARY—Pleistocene		
Sanborn formation		
Peoria silt member		
Clay and silt, calcareous, brown	4	6
Silt, calcareous, tan	14	20
Silt, calcareous, light-tan	27	47
Loveland silt member		
Silt, weakly calcareous, tan	2	49
TERTIARY—Pliocene		
Ogallala formation		
Silt, sandy, limy, light-gray	1	50
Silt, limy; contains some fine gravel	4	54
Silt, sandy, white	10	64
Sand, medium to coarse, and fine to medium gravel	1	65
Sand, limy, cemented	7	72
Sand, medium to coarse	4	76
Sand, medium to coarse, and fine gravel	11	87
Sand, medium to coarse, cemented; contains some fine to medium gravel	1	88
Gravel, fine to medium	11	99
Silt, sandy, tan	9	108
Sand, fine	25	133
Sand, fine to medium	17	150
Sand, fine	20	170
Sand, fine, and tan silt	15	185
Sand, medium to coarse, and medium gravel	7	192
CRETACEOUS—Gulfian		
Pierre shale		
Shale, dark-gray to black	8	200

3-30-6bb. *Sample log of test hole in the NW¼ NW¼ sec. 6, T. 3 S., R. 30 W., Decatur County, 150 feet south of the center line of U. S. Highway 36, 18 feet east of the NW cor. sec. 6; drilled June 1952. Surface altitude, 2,932.9 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Sanborn formation		
Peoria silt member		
Silt, clayey, black to dark-brown	3	3
Silt, fossiliferous, calcareous, gray-tan	18	21
Clay, silty, calcareous, tan to tan-brown	6	27
Loveland silt member		
Clay, compact, weakly calcareous, dark-brown	3	30
Clay, silty, calcareous, tan	2	32
Clay, silty, calcareous, tan to gray	5	37

	Thickness, feet	Depth, feet
TERTIARY—Pliocene		
Ogallala formation		
Clay, sandy, calcareous, tan-brown	24	61
Silt, sandy, calcareous, tan-brown	20	81
Clay, silty, light-tan; contains considerable fine sand	8	89
Sand, fine to coarse, and fine to medium gravel	11	100
Clay, very sandy, limy	8	108
Sand, fine to medium, cemented; contains some red, sandy clay	20	128
Silt, and fine sand, gray to white	4	132
Sand and gravel, fine to coarse, clayey	5	137
Silt, and fine sand, very limy, gray to white	21	158
Silt, and fine sand, very limy, gray to white; contains some fine gravel	10	168
Clay, sandy, partly cemented, light-tan	24	192
Sand, medium to coarse, and fine gravel	21	213
Sand, fine, cemented; contains some gray clay and fine gravel	31	244
Sand, fine to medium, partly cemented; contains much tan clay	10	254
Clay, sandy, tan to gray	6	260
Clay, sandy, tan to gray; contains some fine gravel	12	272
CRETACEOUS—Gulfian		
Pierre shale		
Shale, weathered, noncalcareous, yellow	3	275
Shale, clayey, noncalcareous, dark-gray to black	5	280

3-30-30cc. *Sample log of test hole in the SW¼ SW¼ sec. 30, T. 3 S., R. 30 W., Decatur County, 80 feet east of the SW cor. sec. 30, 10 feet north of road center; drilled June 1952. Surface altitude, 2,840.0 feet; depth to water level, 98.70 feet.*

	Thickness, feet	Depth, feet
Road fill	3	3
QUATERNARY—Pleistocene		
Sanborn formation		
Peoria silt member		
Clay, silty, calcareous, tan	25	28
Loveland silt member		
Clay, compact, silty, slightly calcareous, tan-brown	4	32
Clay, very sandy, calcareous, reddish-tan	6	38
TERTIARY—Pliocene		
Ogallala formation		
Silt, limy, sandy, cemented, white	11.5	49.5
Sand, fine silty, cemented	5.5	55
Silt, very limy, hard, white	3.5	58.5
Clay, sandy, tan-gray	3.5	62
Sand, fine, cemented, light-gray	8.5	70.5
Sand, fine to coarse, and fine to medium gravel	9.5	80
Sand, cemented, limy, gray-white	5	85

	Thickness, feet	Depth, feet
Clay, sandy and limy, tan-gray	9	94
Sand and gravel, fine to coarse, partly cemented	4	98
Sand, fine to coarse, and fine gravel	6	104
Clay, compact, noncalcareous, tan-yellow	6	110
Sand, medium to coarse, and tan to yellow silty clay	3	113
Sand, medium to coarse, and fine to medium gravel	17	130
CRETACEOUS—Gulfian		
Pierre shale		
Shale, weathered, noncalcareous, yellow-gray	6	136
Shale, clayey, noncalcareous, gray	2	138

3-31-6bb. *Sample log of test hole in the NW¼ NW¼ sec. 6, T. 3 S., R. 31 W., on the section line, 25 feet south of the NW cor. sec. 6; drilled July 1952. Surface altitude, 2,914.0 feet; depth to water level, 99.00 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Sanborn formation		
Peoria silt member		
Silt, clayey, calcareous, tan to gray	9	9
Silt, clayey, calcareous, tan-brown	4	13
Clay, silty, calcareous, light-tan	2	15
TERTIARY—Pliocene		
Ogallala formation		
Sand and gravel, fine to coarse, cemented, light-tan to tan-brown	6	21
Sand, fine, and silty clay; contains some clay	6	27
Sand fine to coarse, clayey	2	29
Clay, sandy, gray	3	32
Sand, fine to coarse, silty, partly cemented	8	40
Sand, fine to coarse, and fine gravel	4	44
Sand, fine to coarse, cemented	32	76
Sand, fine to medium, silty	7	83
Sand, fine to coarse, silty, loosely cemented	10	93
Sand, fine to coarse, cemented; contains thin clay zones, and uncemented sand zones	13	106
Clay, very sandy, tan-gray	13	119
Sand, fine to coarse, clayey	4	123
Clay, sandy, tan to gray	4	127
CRETACEOUS—Gulfian		
Pierre shale		
Shale, weathered, clayey, yellow-gray	19	146
Shale, clayey, noncalcareous, black	3	149

3-32-31bc. *Sample log of test hole in the SW¼ NW¼ sec. 31, T. 3 S., R. 32 W., 0.25 mile south of the NW cor. sec. 31, 20 feet east of the road center; drilled July 1952. Surface altitude, 3,083.6 feet; depth to water level, 109.60 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Sanborn formation		
Peoria silt member		
Soil, clayey, noncalcareous, black	1	1
Silt, calcareous, tan to gray	30	31
Silt, clayey, red-brown	5	36
Loveland silt member		
Silt, weakly calcareous. dark-gray	3	39
Clay, soft, calcareous, light-tan	26	65
Clay, soft, silty, calcareous, light-tan	13	78
TERTIARY—Pliocene		
Ogallala formation		
Clay, sandy, light-tan	2.5	80.5
Sand, fine to coarse, clayey, light-tan	9.5	90
Sand, fine to medium, clayey	4	94
Clay, tan-brown; contains much gravel	5	99
Sand and gravel; contains considerable silt and clay	18	117
Clay, compact, tan-brown; contains some sand	3	120
Sand, fine to medium	4	124
Clay, sandy, tan-gray	1.5	125.5
Clay, sandy to silty, red-brown	3.5	129
Sand, fine to coarse, clayey, tan-gray	6	135
Sand and gravel, fine to coarse	23	158
Clay, sandy, tan	4	162
Sand, fine to medium; contains some silty clay	14	176
Clay, very sandy, gray-white	2	178
Sand, fine to medium; contains a few thin clay zones,	27	205
Sand, fine to coarse; contains some clay	19	224
CRETACEOUS—Gulfian		
Pierre shale		
Shale, weathered, yellow-gray	4	228
Shale, clayey, noncalcareous, black	2	230

3-32-36aa. *Sample log of test hole in the NE¼ NE¼ sec. 36, T. 3 S., R. 32 W., on the section line 800 feet south of the NE cor. sec. 36; drilled July 1952. Surface altitude, 2,987.8 feet.*

	Thickness, feet	Depth, feet
Road fill	4.5	4.5
QUATERNARY—Pleistocene		
Sanborn formation		
Peoria silt member		
Silt, fossiliferous, calcareous, tan to gray	24	28.5
Loveland silt member		
Clay, weakly calcareous, brown	1	29.5

TERTIARY—Pliocene

Ogallala formation

	Thickness, feet	Depth, feet
Clay, soft, limy, tan	5.5	35
Clay, sandy to silty, tan to white	11	46
Sand, silty and limy	5	51
Sand, partly cemented; contains some clay	27	78
Sand, fine to coarse	7	85
Sand, fine to medium, clayey, partly cemented	21	106
Sand, fine, very clayey	1	107
Sand, fine to medium, silty	2.5	109.5
Sand, loosely cemented, tan-brown	8.5	118
Sand and gravel, fine to coarse	7	125
Sand, fine to coarse, cemented	10	135
Sand, fine to medium, very limy, cemented	20	155
Clay, compact, silty, gray-green	3	158
Sand, fine to medium, cemented	6	164
Sand, fine to medium; contains some silt	4	168
Clay, compact, sandy, tan	4	172
Sand, fine to medium	10	182
Sand, fine to coarse; contains some gravel	2	184

CRETACEOUS—Gulfian

Pierre shale

	Thickness, feet	Depth, feet
Shale, weathered, yellow-gray	21.5	205.5
Shale, clayey, black	1.5	207

3-33-31ba. *Sample log of test hole in the NE¼ NW¼ sec. 31, T. 3 S., R. 33 W., 25 feet south and 10 feet east of the NW cor. of the NE¼ NW¼ sec. 31; drilled July 1952. Surface altitude, 3,090.8 feet; depth to water level, 143.50 feet.*

QUATERNARY—Pleistocene

Sanborn formation

Peoria silt member

	Thickness, feet	Depth, feet
Soil, clayey, noncalcareous, black	1.5	1.5
Silt, calcareous, tan-gray	9.5	11
Silt, fossiliferous, calcareous, tan-gray	23	34
Clay, silty, tan-brown	3	37

TERTIARY—Pliocene

Ogallala formation

	Thickness, feet	Depth, feet
Clay, silty, tan; contains some gravel	10	47
Clay, compact, limy, tan	5	52
Clay, silty, tan-brown; contains a few thin sand zones,	5	57
Sand, clayey, tan	6	63
Sand, fine to medium, red-brown; contains a trace of silt and clay	13	76
Sand, fine to coarse, and fine gravel	4	80
Sand, fine to medium, loosely cemented, tan	7.5	87.5
Sand, fine, cemented, tan-brown	8.5	96
Sand and gravel, fine to coarse	10	106
Sand, fine, cemented; contains some gravel	11	117

	Thickness, feet	Depth, feet
Sand, fine to coarse, silty	4	121
Sand, fine, cemented, light-tan	5	126
Sand, fine to coarse, loosely cemented	3	129
Sand, fine to medium, cemented, tan	6	135
Sand, medium to fine, light-gray	4	139
Sand, fine to medium; contains some silt	10	149
Sand, fine to medium	17	166
Sand, clayey, red-brown	11	177
CRETACEOUS—Gulfian		
Pierre shale		
Shale, clayey, noncalcareous, dark-gray to black	3	180

3-35-25ad. *Sample log of test hole in the SE¼ NE¼ sec. 25, T. 3 S., R. 35 W., on west side of road 0.1 mile north of the center of the east side sec. 25; drilled July 1952. Surface altitude, 3,143.5 feet; depth to water level, 144.20 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Sanborn formation		
Peoria silt member		
Soil, clayey, black	1.5	1.5
Silt, calcareous, tan-gray	19.5	21
Silt, calcareous, clayey, tan-brown	24	45
TERTIARY—Pliocene		
Ogallala formation		
Clay, sandy, tan; contains some gravel	4	49
Sand, fine to coarse, clayey	4	53
Clay, compact, limy, white	2	55
Sand, fine to medium, silty, green	5	60
Sand, fine to medium, clayey, brown	6	66
Sand and gravel, fine to coarse, silty, loosely cemented,	6	72
Sand, fine to medium, loosely cemented	12	84
Sand and clay, tan to gray	24	108
Sand, fine to coarse, clayey	12	120
Clay and sand, medium hard	20	140
Sand, fine to medium, cemented	18	158
Sand, fine to coarse	2	160
Clay, silty, tan to white; contains some fine sand	2	162
Sand, fine to medium, loosely cemented	3	165
CRETACEOUS—Gulfian		
Pierre shale		
Shale, weathered, yellow-gray	4	169
Shale, clayey, noncalcareous, gray to black	1	170

3-36-6bbb. *Sample log of test hole in the NW cor. sec. 6, T. 3 S., R. 36 W., drilled September 1950. Surface altitude, 3,386.8 feet. (Prescott, 1953)*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Sanborn formation		
Silt, black	2	2
Silt, clayey, calcareous, tan	88	90
Silt, clayey, tan; zones of soft caliche	42	132
TERTIARY—Pliocene		
Ogallala formation		
Clay, white, some fine sand and caliche	13	145
Mortar bed, tan	12	157
Clay, sandy, white to tan; contains caliche	28	185
Gravel, very fine, some medium to very coarse sand and caliche	7	192
Gravel, very fine, some coarse sand; contains sandy clay	37	229
Caliche, white	1	230
Mortar bed, tan	2.5	232.5
Sand, medium to coarse	6	238.5
Mortar bed, tan	58.5	297
Gravel, very fine, and coarse sand; contains thin beds of clay and caliche	15	312
CRETACEOUS—Gulfian		
Pierre shale		
Shale, yellow	6	318
Shale, dark-gray	5	323

3-36-21ba. *Driller's log of McDonald city well in the NE¼ NW¼ sec. 21, T. 3 S., R. 36 W., drilled by C. Robbins, 1948. Surface altitude, 3,359.5 feet; depth to water level, 198 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Sanborn formation		
Soil	7	7
Clay, yellow	119	126
TERTIARY—Pliocene		
Ogallala formation		
Magnesia	34	160
Sandstone	15	175
Sand, medium	3	178
Rock, porous	2	180
Rock, very hard	9	189
Gravel	7	196
Sand and rock	4	200
Magnesia rock	10	210
Cement	10	220
Sandstone	20	240

	Thickness, feet	Depth, feet
Sand and gravel	3	243
Clay, sandy, brown	19	262
Magnesia	2	264
Sand, fine	25	289
Sandstone	6	295
Plaster sand	7	302
Rock, cemented, very hard, white	3	305

3-36-30cc. *Sample log of test hole in the SW¼ SW¼ sec. 30, T. 3 S., R. 36 W., 10 feet north of road center, 100 feet east of the SW cor. sec. 30; drilled July 1952. Surface altitude, 3,377.0 feet.*

	Thickness, feet	Depth, feet
Road fill	2	2
QUATERNARY—Pleistocene		
Sanborn formation		
Peoria silt member		
Clay, blocky, silty, calcareous, gray	2	4
Silt, calcareous, gray	20	24
Clay, calcareous, silty, tan	32	56
Silt, soft, sandy, calcareous	9	65
Clay, compact, light-tan	10	75
TERTIARY—Pliocene		
Ogallala formation		
Clay, compact, sandy	5	80
Clay, silty, white; contains some sand	10	90
Sand, fine to coarse, loosely cemented	25	115
Sand, fine to coarse, clayey, tan	30	145
Sand, fine to coarse; contains some gravel	10	155
Sand and gravel, fine to coarse, loosely cemented	4	159
Sand, fine to medium, clayey	32	191
Sand and gravel, fine to coarse	2	193
Sand, fine to medium, clayey	39	232
Sand, fine to coarse, cemented	7	239
Sand and gravel, fine to coarse	7	246
Clay, sandy, gray	8	254
Sand, fine to medium, loosely cemented	11	265
Clay, sandy, tan-brown	3	268
Sand, fine to medium, clayey	38	306
CRETACEOUS—Gulfian		
Pierre shale		
Shale, weathered, yellow-gray	10	316
Shale, clayey, dark-gray to black	4	320

3-36-36aa. *Sample log of test hole in the NE¼ NE¼ sec. 36, T. 3 S., R. 36 W., 10 feet west of road center, 400 feet south of NE cor. sec. 36; drilled July 1952. Surface altitude, 3,239.7 feet; depth to water level, 135.40 feet.*

	Thickness, feet	Depth, feet
Road fill	1.5	1.5
QUATERNARY—Pleistocene		
Sanborn formation		
Peoria silt member		
Silt, calcareous, tan-gray	29.5	31
Silt, clayey, calcareous, tan-gray	10	41
Clay, silty, calcareous, tan-gray	6	47
TERTIARY—Pliocene		
Ogallala formation		
Clay, silty, light-tan; contains some gravel	8	55
Clay, sandy, calcareous, light-tan	10	65
Clay and sand, tan to white	11	76
Sand, fine to coarse; contains some coarse gravel	8	84
Sand, fine to medium, partly cemented; contains some thin clay zones	8	92
Sand, fine to coarse; contains some silt and fine to medium gravel	16	108
Sand, fine to medium; contains some sandy clay	9	117
Sand, fine to coarse, cemented	10	127
Sand, fine to coarse; contains some gravel	7	134
Sand, fine to coarse, clayey	4	138
Sand, fine to medium, cemented	4	142
Sand, fine to coarse; contains some gravel in stringers,	10	152
Sand, fine to coarse, cemented, light-tan	12	164
Clay, sandy, tan-brown	6	170
Sand, fine to coarse, clayey	7	177
Sand, fine to medium, partly cemented	25	202
Sand, fine, silty, tan-brown	5	207
CRETACEOUS—Gulfian		
Pierre shale		
Shale, weathered, yellow-gray	11.5	218.5
Shale, clayey, dark-gray to black	1.5	220

4-30-30bb. *Sample log of test hole in the NW¼ NW¼ sec. 30, T. 4 S., R. 30 W., in Decatur County, 10 feet east of road center, 40 feet south of the NW cor. sec. 30; drilled June 1952. Surface altitude, 2,847.0 feet; depth to water level, 92.50 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Sanborn formation		
Peoria silt member		
Silt, noncalcareous, brown	1	1
Silt, compact, clayey, noncalcereous, brown	1	2
Clay, silty, weakly calcareous, tan	10	12
Clay, silty, calcareous, tan	10	22

	Thickness, feet	Depth, feet
Loveland silt member		
Silt, compact, clayey, weakly calcareous, brown	4	26
Clay, compact, silty, calcareous, brown	5	31
Clay, silty, calcareous, tan	4.5	35.5
TERTIARY—Pliocene		
Ogallala formation		
Clay, silty and sandy; contains some gravel, tan-brown,	9.5	45
Sand, fine, silty, cemented	31	76
Sand, very silty, hard, cemented	11	87
Sand, fine to coarse, and fine gravel; contains a few thin cemented zones	15.5	102.5
CRETACEOUS—Gulfian		
Pierre shale		
Shale, weathered, yellow-gray	2.5	105
Shale, clayey, noncalcareous, dark-gray to black	5	110

4-31-31da. *Sample log of test hole in the NE¼ SE¼ sec. 31, T. 4 S., R. 31 W., 100 feet south and 15 feet west of the center of the east side of sec. 31; drilled July 1952. Surface altitude, 2,978.1 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Sanborn formation		
Peoria silt member		
Silt, clayey, noncalcareous, black	3	3
Silt, clayey, weakly calcareous, tan-gray	7	10
Silt, calcareous, tan-gray	4	14
Silt, fossiliferous, calcareous, gray	7	21
Clay, soft, silty, calcareous, tan	6	27
Loveland silt member		
Clay, compact, weakly calcareous, brown; contains a few grains of gravel	1	28
Clay, compact, calcareous, light-tan	7	35
TERTIARY—Pliocene		
Ogallala formation		
Sand, fine to coarse, clayey; contains some fine gravel,	4	39
Sand and gravel, fine to coarse	15	54
Sand, fine to medium, clayey	2	56
Sand, fine, very clayey, tan-brown	13	69
Sand, fine to medium, silty, loosely cemented	20	89
Sand and gravel; contains some clay	6	95
Sand, fine, cemented, brown	9	104
Silt, very limy, sandy, tan-white	24	128
Clay, silty to sandy, tan	9	137
Sand, fine to medium, silty	28	165
Clay, sandy, tan-yellow	2	167
Sand, fine to medium, silty	8	175
CRETACEOUS—Gulfian		
Pierre shale		
Shale, weathered, gray to yellow	2	177
Shale, clayey, black	3	180

4-32-30cc. *Sample log of test hole in the SW¼ SW¼ sec. 30, T. 4 S., R. 32 W., 45 feet north and 5 feet east of the SW cor. sec. 30; drilled July 1952. Surface altitude, 3,080.0 feet; depth to water level, 52.40 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Sanborn formation		
Peoria silt member		
Silt, clayey, noncalcareous, dark-brown	1.5	1.5
Clay, silty, noncalcareous, tan-gray	1.5	3
Silt, calcareous, tan	27.5	30.5
Loveland silt member		
Clay, noncalcareous, black	1	31.5
Clay, silty to sandy, calcareous, tan	15.5	47
TERTIARY—Pliocene		
Ogallala formation		
Silt, limy, medium hard, white	4	51
Sand, fine to coarse, cemented, tan-brown	10	61
Sand, fine to medium, cemented; contains some gravel,	3	64
Sand, coarse, and fine to coarse gravel	11	75
Sand and gravel, fine to coarse; contains a few thin clay zones	18	93
Sand, fine to coarse, and fine gravel	3	96
Sand and gravel, fine to coarse; contains cemented zones	2	98
Clay, silty, tan-brown; contains a few grains of gravel,	3	101
Sand, fine, cemented, very hard, gray	2	103
Clay, sandy, gray-brown	3	106
Sand, fine to coarse, and fine gravel, silty	4	110
Sand, fine to medium, cemented	15	125
Sand and gravel, partly cemented; contains silty clay	3	128
Clay, very sandy, light-tan	2	130
Sand, fine to coarse, clayey; cemented in thin zones	40	170
Sand, fine to coarse, silty, cemented	7	177
Clay, compact, sandy, yellow-green	8	185
Sand, fine to medium, silty, light-green	11	196
Clay, sandy, light-tan	8	204
Sand, fine to medium, clayey	16	220
Sand and gravel, fine to coarse; contains silt and clay,	6	226
CRETACEOUS—Gulfian		
Pierre shale		
Shale, weathered, yellow-gray	4	230
Shale, clayey, black, noncalcareous	5	235

4-34-31cc. *Sample log of test hole in the SW¼ SW¼ sec. 31, T. 4 S., R. 34 W., on west line sec. 31, 100 feet north of SW cor. sec. 31; drilled July 1952. Surface altitude, 3,236.0 feet; depth to water level, 180.20 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Sanborn formation		
Peoria silt member		
Silt, clayey, noncalcareous, black	2	2
Silt, calcareous, gray	30	32
Silt, clayey, calcareous, tan	6	38
Clay, compact, silty, light-tan	24	62
TERTIARY—Pliocene		
Ogallala formation		
Sand, fine, silty	8	70
Sand, fine, cemented	4	74
Sand and gravel, fine to coarse	3	77
Sand, fine; cemented in thin zones	16	93
Clay, very sandy, tan-brown	8	101
Clay, compact, sandy, light-tan	7	108
Sand, fine to medium, silty	5	113
Sand, fine; contains much clay	15	128
Sand, cemented, silty	11	139
Sand, fine to medium, silty; contains some interbedded clay and a few clay stringers	20	159
Sand, fine to coarse, silty, loosely cemented	10	169
Sand, fine to coarse, silty, loosely cemented; contains some blocky, yellow-green clay	3	172
Sand, fine to coarse, silty; contains a few cemented zones	33	205
Sand, fine to medium; slightly silty	62	267
CRETACEOUS—Gulfian		
Pierre shale		
Clay, silty to blocky, weakly calcareous, yellow-green,	7	274
Shale, clayey, noncalcareous, black	14	288

4-37-36ddd. *Sample log of test hole in the SE¼ SE¼ SE¼ sec. 36, T. 4 S., R. 37 W., drilled October 1950. Surface altitude, 3,384.7 feet; depth to water level, 171.4 feet. (Prescott, 1953)*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Sanborn formation		
Silt, dark-brown	3	3
Silt, light-brown to tan	63	66
TERTIARY—Pliocene		
Ogallala formation		
Caliche, white; contains opal fragments	16	82
Silt, sandy, brown	16	98
Sand, coarse to very coarse, and very fine gravel	17	115
Clay and silt, sandy, brown	8	123
Sand, medium to very coarse, and very fine gravel	12	135

	Thickness, feet	Depth, feet
Sand	45	180
Clay and silt, sandy, brown	30	210
Mortar bed	35	245
Clay, soft, white	6	251
Mortar bed	11	262
Clay, sandy, white	3	265
Mortar bed	7	272
Caliche, white	10	282
Sand, fine	8	290
Sand, fine to very coarse; contains a small amount of very fine gravel	7	297
CRETACEOUS—Gulfian		
Pierre shale		
Shale, weathered, buff to tan	7	304
Shale, blue to dark-gray	2.5	306.5

5-31-36dd. *Sample log of test hole in the SE¼ SE¼ sec. 36, T. 5 S., R. 31 W., 70 feet north, 30 feet west of the SE cor. sec. 36; drilled June 1952. Surface altitude, 2,905.2 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Sanborn formation		
Peoria silt member		
Silt, clayey, noncalcareous, black	1	1
Clay, silty, calcareous, tan-gray	8	9
Silt, calcareous, tan to gray	8	17
Clay, silty, calcareous, tan	5	22
Loveland silt member		
Clay, silty, calcareous, tan	6.5	28.5
TERTIARY—Pliocene		
Ogallala formation		
Clay, compact, blocky, tan-brown	1.5	30
Sand and gravel, fine to coarse; contains some light-tan sandy clay	5	35
Sand, fine to coarse, and fine gravel; contains some tan sandy clay	6	41
Clay, sandy, red-brown	3	44
Sand, fine to coarse, very clayey, red-brown	3	47
Sand, fine to coarse, and fine gravel	1	48
Clay, silty, tan-brown	2.5	50.5
Sand, fine to medium, loosely cemented	7.5	58
Sand, fine to coarse, and fine gravel	7	65
Sand, medium to coarse, clayey, brown	3	68
Sand, fine to coarse, clayey	6	74
Sand, fine, silty, cemented	4	78
Sand, fine to coarse, clayey, red-brown	12	90
Clay, brown to red; contains a few thin sand stringers,	9	99
Clay, gray; contains a few thin sandy silt stringers	9	108
Silt, light-gray	10	118

	Thickness, feet	Depth, feet
Sand, fine to coarse, clayey	10	128
Sand and gravel, fine to coarse	3	131
Clay, sandy, tan to gray	3	134
Sand, fine to coarse	14.5	148.5
Clay, sandy, light-gray	2.5	151
Sand and clay, limy, light-tan	5	156
Sand, fine to coarse; contains some silt	7	163
CRETACEOUS—Gulfian		
Pierre shale		
Shale, weathered, light-gray to yellow	7	170

5-33-6bb. *Sample log of test hole in the NW¼ NW¼ sec. 6, T. 5 S., R. 33 W., Rawlins County; 5 feet east, 30 feet south of the NW cor. sec. 6; drilled July 1952. Surface altitude, 3,191.0 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Sanborn formation		
Silt, clayey, noncalcareous, black	1	1
Clay, compact, silty, noncalcareous, dark-brown	2	3
Clay, silty, calcareous, tan	4	7
Silt, calcareous, gray	14	21
Clay, silty, calcareous, tan to brown	20	41
Clay, compact, calcareous, tan-brown	36	77
TERTIARY—Pliocene		
Ogallala formation		
Clay, silty, light-tan; contains some fine sand	7	84
Silt and fine sand, cemented, light-tan	5	89
Sand, fine to coarse, silty; contains some fine to medium gravel	10	99
Sand and gravel, fine to coarse; contains some gray sandy clay	20	119
Clay, very sandy	10	129
Sand and clay, silty, loosely cemented	10	139
Sand, fine to medium, clayey	15	154
Sand and gravel, fine to coarse	10	164
Sand, cemented, very hard	4	168
Sand, fine to coarse, and fine gravel	4	172
Sand and gravel, fine to coarse, clayey	13	185
Sand, fine to coarse; contains a few thin zones of sandy clay	10	195
Sand, fine to coarse, partly cemented	39	234
Clay, sandy, light-gray	4	238
Sand, fine to medium, silty	17	255
Clay, sandy, yellow-green	5	260
Sand, fine to coarse, silty	16	276
Gravel, fine to coarse	3	279
Sand, fine to coarse, silty	5	284
CRETACEOUS—Gulfian		
Pierre shale		
Shale, clayey, black	6	290

5-33-36dd. *Sample log of test hole in the SE¼ SE¼ sec. 36, T. 5 S., R. 33 W., 100 feet north, 8 feet west of the SE cor. sec. 36; drilled August 1952. Surface altitude, 3,127.0 feet; depth to water level, 145.15 feet.*

	Thickness, feet	Depth, feet
Road fill	3	3
QUATERNARY—Pleistocene		
Sanborn formation		
Peoria silt member		
Silt, calcareous, gray	25	28
Loveland silt member		
Clay, compact, weakly calcareous, brown	4	32
Clay, silty, calcareous, tan	23	55
TERTIARY—Pliocene		
Ogallala formation		
Clay, light-tan; contains some gravel	14	69
Clay, limy, tan-white; contains some sand and gravel	3	72
Sand and gravel, clayey	20	92
Sand and gravel, loosely cemented	6	98
Sand and very sandy clay; contains some gravel	40	138
Sand and gravel; contains some silt and clay	37	175
Clay, sandy, tan to gray	12	187
Sand, fine to coarse; contains a few thin clay stringers,	20	207
Sand, fine to medium; contains some silt and clay	6	213
CRETACEOUS—Gulfian		
Pierre shale		
Shale, weathered, yellow-gray	6	219
Shale, clayey, dark-gray	5	224

5-34-31cc. *Sample log of test hole in the SW¼ SW¼ sec. 31, T. 5 S., R. 34 W., 60 feet north, 5 feet east of the SW cor. sec. 31; drilled July 1952. Surface altitude, 3,236.5 feet; depth to water level, 113.70 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Sanborn formation		
Peoria silt member		
Silt, clayey, noncalcareous, black	2.5	2.5
Silt, calcareous, gray	9.5	12
Silt, calcareous, gray-tan	14	26
Clay, calcareous, tan to gray	9	35
Loveland silt member		
Clay, compact, silty, weakly calcareous, brown	3	38
TERTIARY—Pliocene		
Ogallala formation		
Clay, limy, gray to tan	13	51
Sand and gravel, clayey, partly cemented	7	58
Clay, sandy, tan to white	11	69
Sand and gravel, fine to coarse	10	79
Sand, fine to coarse, and fine gravel	50	129
Clay, sandy, brown	4	133
Sand, fine to coarse, and fine to medium gravel	14	147

	Thickness, feet	Depth, feet
Clay, brown; contains much fine gravel	2	149
Sand, fine to coarse, partly cemented; contains some tan clay	40	189
Sand, fine to coarse; contains some silt and yellow clay,	37	226
Sand and gravel, fine to coarse	4	230
CRETACEOUS—Gulfian		
Pierre shale		
Shale, weathered, yellow and gray	5	235
Shale, clayey, dark-gray	2	237

5-36-2aa. *Sample log of test hole in the NE¼ NE¼ sec. 2, T. 5 S., R. 36 W., on south shoulder of road about 0.2 mile west of the NE cor. sec. 2; drilled July 1952. Surface altitude, 3,298.5 feet; depth to water level, 172.90 feet.*

	Thickness, feet	Depth, feet
Road fill	2	2
QUATERNARY—Pleistocene		
Sanborn formation		
Peoria silt member		
Silt, calcareous, tan	33	35
Clay, very silty, calcareous, tan	7	42
Silt, clayey, calcareous, tan-brown	2	44
Loveland silt member		
Clay, compact, weakly calcareous, tan-brown	2	46
TERTIARY—Pliocene		
Ogallala formation		
Clay, silty and sandy, light-tan	9	55
Sand and gravel, fine to coarse	5	60
Sand, silty, partly cemented	16	76
Sand, fine to coarse, and fine gravel	3	79
Sand, fine, cemented, dark-brown	3	82
Clay, sandy, tan	7	89
Sand, fine to coarse, clayey, loosely cemented	20	109
Sand, coarse, and fine to coarse gravel	7	116
Clay, sandy, gray to tan	6	122
Sand, fine to coarse, clayey, partly cemented	18	140
Clay, sandy, tan to brown	8	148
Sand, fine to coarse, cemented	45	193
Sand, fine to coarse, silty, loosely cemented	24	217
Sand, fine to medium, cemented; contains a few thin clay stringers	10	227
Sand, fine to medium, loosely cemented	11	238
Clay, silty, tan to green	8	246
Sand, fine to medium; contains a few clay stringers	9	255
Sand, medium to coarse, silty, loosely cemented	13	268
CRETACEOUS—Gulfian		
Pierre shale		
Shale, clayey, gray to black	8	276

5-36-31cc. *Sample log of test hole in the SW¼ SW¼ sec. 31, T. 5 S., R. 36 W., 10 feet east, 20 feet north of the SW cor. sec. 31; drilled July 1952. Surface altitude, 3,427.7 feet; depth to water level, 180.25 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Sanborn formation		
Peoria silt member		
Silt, noncalcareous, black	2	2
Silt, calcareous, gray	37	39
Clay, calcareous, silty, tan-brown	6	45
Clay, very silty, calcareous, tan	33	78
TERTIARY—Pliocene		
Ogallala formation		
Sand and gravel, clayey, cemented	6	84
Sand and gravel; contains some silt and clay	26	110
Sand, fine to medium, very clayey	17	127
Sand, fine to coarse, and fine gravel	9	136
Clay, tan-brown; contains a few sand grains	3.5	139.5
Sand and gravel, clayey	25.5	165
Clay, sandy, tan-brown	4	169
Sand, fine to coarse, and coarse gravel	7	176
Clay, sandy, tan-brown	13	189
Clay, light-tan; contains much fine to medium gravel,	3	192
Sand and gravel, coarse to fine; contains some clay	16	208
Sand, fine to coarse	2	210
Clay, sandy, light-tan	16	226
Sand, fine to medium; contains some clay and considerable limy silt	81	307
Sand, fine to coarse, and fine gravel	17	324
CRETACEOUS—Gulfian		
Pierre shale		
Shale, weathered, yellow	5	329
Shale, clayey, dark-gray to black	7	336

6-31-6bb. *Sample log of test hole in the NW¼ NW¼ sec. 6, T. 6 S., R. 31 W., 66 feet east, 9 feet south of road intersection; drilled September 1943. Surface altitude, 2,997.9 feet; adapted from log 1, Thomas County (Frye, 1945, p. 88).*

	Thickness, feet	Depth, feet
Road fill	3	3
QUATERNARY—Pleistocene		
Sanborn formation		
Silt and very fine sand, yellow-gray; contains abundant snails	20	23
Silt, clay, and sand, light-buff to brown	11	34

	Thickness, feet	Depth, feet
TERTIARY—Pliocene		
Ogallala formation		
Gravel, sand, and silt, buff and gray; partly cemented by calcium carbonate	23	57
Silt and sand, pink-tan	7	64
Gravel and sand	21	85
Silt, sand, and caliche, gray and buff	27	112
Gravel and sand	6	118
Silt, sand, and caliche, grading downward into silt, clay, and caliche, gray	31	149
Sand, becoming coarser downward and containing some clay at base	37	186
CRETACEOUS—Gulfian		
Pierre shale		
Shale, dark-gray	14	200

6-33-6bb. *Sample log of test hole in the NW¼ NW¼ sec. 6, T. 6 S., R. 33 W., 102 feet east, 30 feet south of center of road intersection; drilled October 1943. Surface altitude, 3,159.0 feet; adapted from log 2, Thomas County, (Frye, 1945, p. 88).*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Sanborn formation		
Silt; contains admixtures of fine sand and clay in some zones and some nodules of caliche, tan to gray; contains abundant snails	33	33
Silt, sand, and caliche, gray-white	7	40
TERTIARY—Pliocene		
Ogallala formation		
Silt, sand, and gravel, buff; partly cemented by calcium carbonate	10	50
Gravel and sand, gray-buff to brown; contains some zones cemented by calcium carbonate	54	104
Silt and caliche, pink-tan; contains some clay and sand	18	122
Gravel, medium to fine, and sand; contains some silt,	8	130
Silt, sand, gravel, and caliche, gray to tan	30	160
Gravel and sand; cemented by calcium carbonate; gray to brown	9	169
Caliche, clay, and silt; contains some sand, light-tan to white	25	194
Gravel, fine, and sand	11	205
Silt, clay, sand, and gravel	3	208
CRETACEOUS—Gulfian		
Pierre shale		
Shale, light-blue-gray mottled with yellow-brown	2	210
Shale, blue-gray	5	215

6-35-6bb. *Sample log of test hole in the NW¼ NW¼ sec. 6, T. 6 S., R. 35 W., 39 feet south, 42 feet east of the center of road intersection; drilled September 1943. Surface altitude, 3,330.2 feet; adapted from log 3, Thomas County, (Frye, 1945, p. 89).*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Sanborn formation		
Silt, yellow-gray; contains abundant snails	50	50
TERTIARY—Pliocene		
Ogallala formation		
Silt, caliche, sand, and gravel, tan	29	79
Gravel and sand	21	100
Silt, caliche, sand, and gravel, buff	23	123
Gravel, sand, and caliche	34	157
Silt, caliche, sand, and gravel	53	210
Sand, medium to fine, loosely cemented with calcium carbonate	20	230
Silt and sand, contains caliche, gray	9	239
Sand, medium to fine	11	250
Silt, sand, and caliche, light brown	8	258
Sand and silt, buff	33	291
CRETACEOUS—Gulfian		
Pierre shale		
Shale, light-yellow grading downward to dark-gray	9	300

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26-1973

MAP OF RAWLINS COUNTY, KANSAS

Showing Geology, Water-Table Contours, Depth to Water in Wells, and Test Holes

State Geological Survey of Kansas

Bulletin 117
Plate 1

by Kenneth L. Walters
1952

EXPLANATION

QUATERNARY — PLEISTOCENE

Qtu — **Alluvium and undifferentiated Terrace Deposits**
Consists of silt and clay in the upper part, and sand and gravel in the lower part. Yields moderate to large quantities of water to wells along parts of Beaver and Sappa Creeks.

Qtc — **Crete sand and gravel member**
Consists of fine to medium gravel and minor amounts of silt and clay. Yields moderate to large quantities of water to wells.

Qs — **Sanborn formation**
Consists of yellow or tan to reddish-brown silt. Lies above the water-table and does not yield water to wells.

TERTIARY — PLIOCENE

To — **Ogallala formation**
Consists of sand, gravel, and silt; contains minor amounts of volcanic ash and quartzite. Yields moderate to large quantities of water to wells.

CRETACEOUS — GULFIAN

Kp — **Pierre shale**
Consists of dark-gray to black shale; contains minor amounts of bentonite and gypsum. Is not known to yield water to wells in Rawlins County.

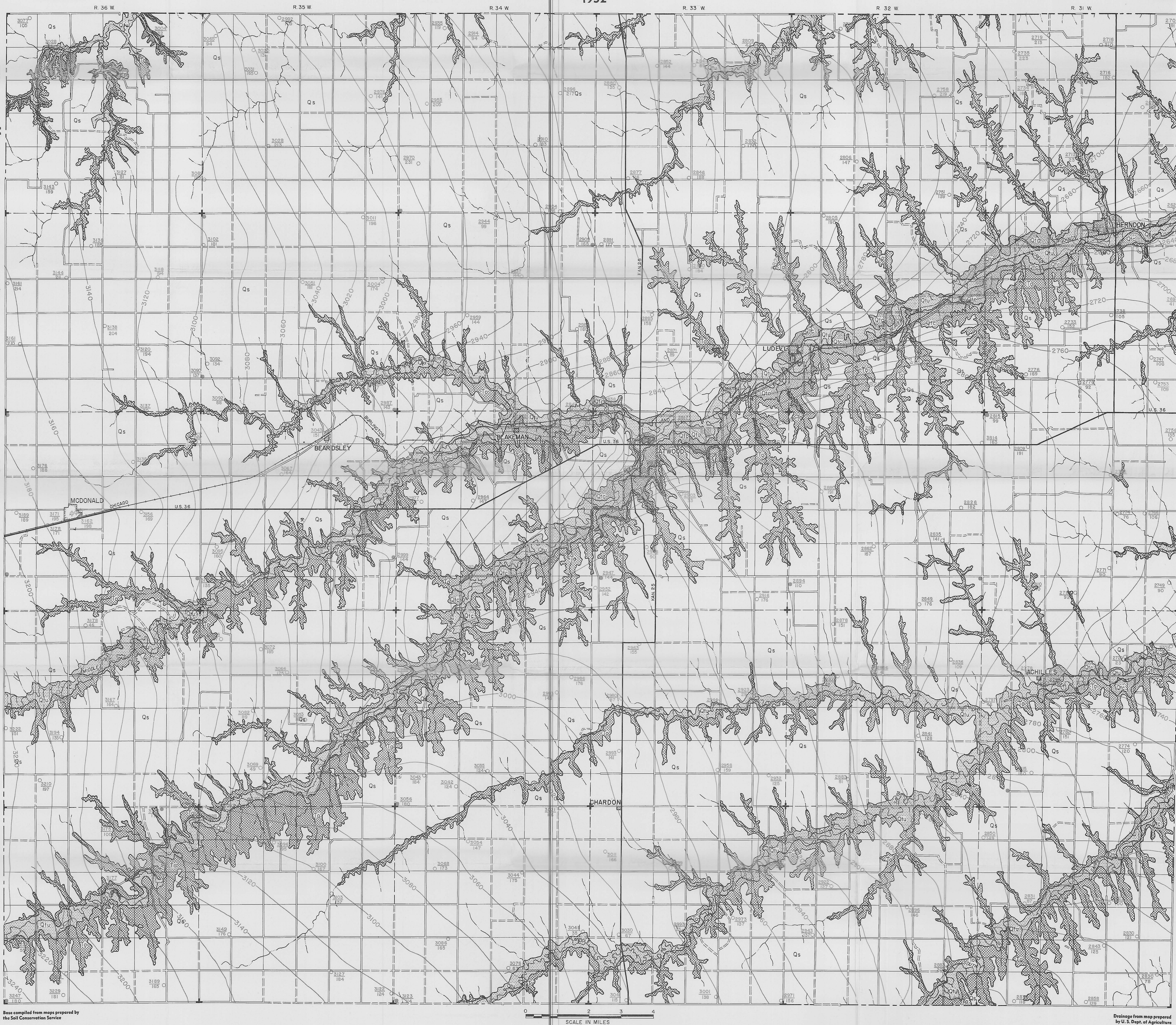
—3140— Water table contours based on instrumental levels

Contour interval 20 feet

3128/167 — Well location. Upper number refers to altitude of water level. Lower number refers to the depth to water level below land surface.

- Spring
- Domestic and stock wells
- Public supply well
- Irrigation well
- Test hole
- Railroad well
- Deposit of Pearlette volcanic ash

- Federal or State Highway
- Graded road
- Ungraded road
- Railroad
- County line (no road)
- Township line (no road)
- Section line (no road)
- Intermittent stream



Base compiled from maps prepared by the Soil Conservation Service

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