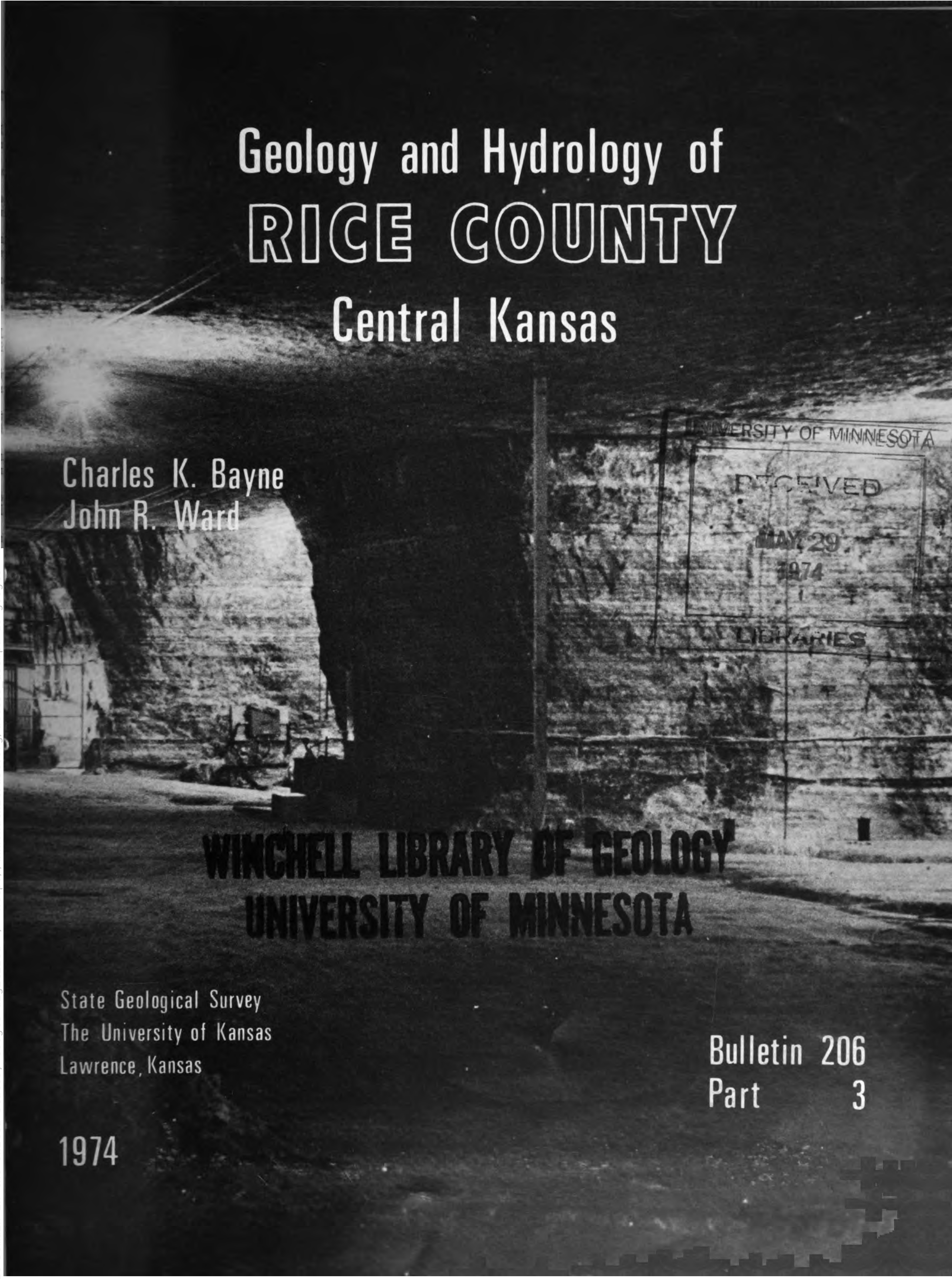

Geology and Hydrology of RICE COUNTY Central Kansas

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The University of Kansas
Lawrence, Kansas

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Cover photograph.

North Salt Mine Caverns used by Atomic Energy Commission in tests for storage of atomic waste, Lyons, Kansas. Courtesy of Atomic Energy Commission.

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BULLETIN 206 Part 3

Geology and Hydrology of Rice County, Central Kansas

By

Charles K. Bayne and John R. Ward

Prepared by the Kansas Geological Survey and the United States Geological Survey with the cooperation of the Division of Water Resources of the Kansas State Board of Agriculture and the Division of Environmental Health of the Kansas State Department of Health

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ABSTRACT

Sedimentary rocks of Paleozoic age and younger underlie Rice County to a depth ranging from 3,700 to 4,100 feet. The oldest formations that crop out are the Ninnescah Shale, Stone Corral Formation, and the Harper Sandstone of Early Permian age. These formations are unconformably overlain by rocks of Cretaceous age consisting of the Cheyenne Sandstone, Kiowa Formation, and Dakota Formation. Deposits of Pleistocene age that mantle most of the county are principally eolian sediments on the uplands and fluvial sediments in the valleys.

The principal aquifer is in the Pleistocene fluvial deposits where yields to irrigation wells of 1,000 gpm (gallons per minute) are common and, locally, yields may be as much as 2,000 gpm. Sandstone aquifers in the Kiowa and Dakota Formations commonly yield an adequate supply of water for domestic and stock wells, and may yield as much as 150 gpm.

The chemical quality of water in the Pleistocene deposits is a calcium bicarbonate type and is very hard. Water in the sandstone also is a calcium bicarbonate type where the overlying Pleistocene aquifer is in hydraulic connection. If an appreciable thickness of shale separates the aquifers, the water in the sandstone may be a sodium bicarbonate type. Highly mineralized water from formations below the Kiowa may occur at shallow depths as a result of local contamination by oil-field brines or industrial wastes.

The principal mineral resource in 1969 was petroleum produced from 76 oil fields and 19 gas fields. Salt deposits ranging in thickness from 200 to 400 feet are a potential resource that have been utilized to a minor extent.

INTRODUCTION

Rice County, in central Kansas (fig. 1), contains approximately 20 townships and is an area of 725 square miles. The area is in both the Dissected High Plains section of the Great Plains physiographic province and the Arkansas River Lowland section of the Central Lowlands province (Schoewe, 1949). Most of the county is drained by the Arkansas River and its tributaries, Cow Creek and Little Arkansas River. A few square miles in the northeast are drained by streams that are tributary to the Smoky Hill River.

Rice County is on the western margin of the subhumid climatic zone. The area is characterized by a predominance of sunshine, moderate precipitation, and moderate wind velocity. At Alden the mean annual temperature is 56° F and the normal annual precipitation is 25.86 inches, based on National Weather Service (formerly U.S. Weather Bureau) records for the period 1898-1952. The station was moved to Sterling in 1953 and new normals have not been established. The average length of the growing season is 181 days.

The well and test-hole numbers used in this report are given according to the U.S. Bureau of Land Management system of land division as follows: township, range, section, 160-acre tract or quarter section, 40-acre tract within the quarter section, and 10-acre tract within the quarter quarter section. As an example, well 19-9W-23dcc is in the SW¼SW¼SE¼ sec. 23, T. 19 S., R. 9 W. (fig. 2).

The area was originally studied by Fent (1950a). Many of the data in that report are used in this report. Data collected since that time, and especially data collected in the winter of 1970-71 during a study of the feasibility of using salt beds for storage of atomic wastes, are included in the present report.

GEOLOGY[1]

Wells drilled in the exploration for oil and gas have been the source of many data on the lithology and thickness of the rocks underlying Rice County.

Precambrian rocks consisting of granite, schist, and diabase, and clastic sedimentary rocks believed to be

[1] The classification and nomenclature of rock units used in this report are those of the Kansas Geological Survey and differ somewhat from those of the U.S. Geological Survey.

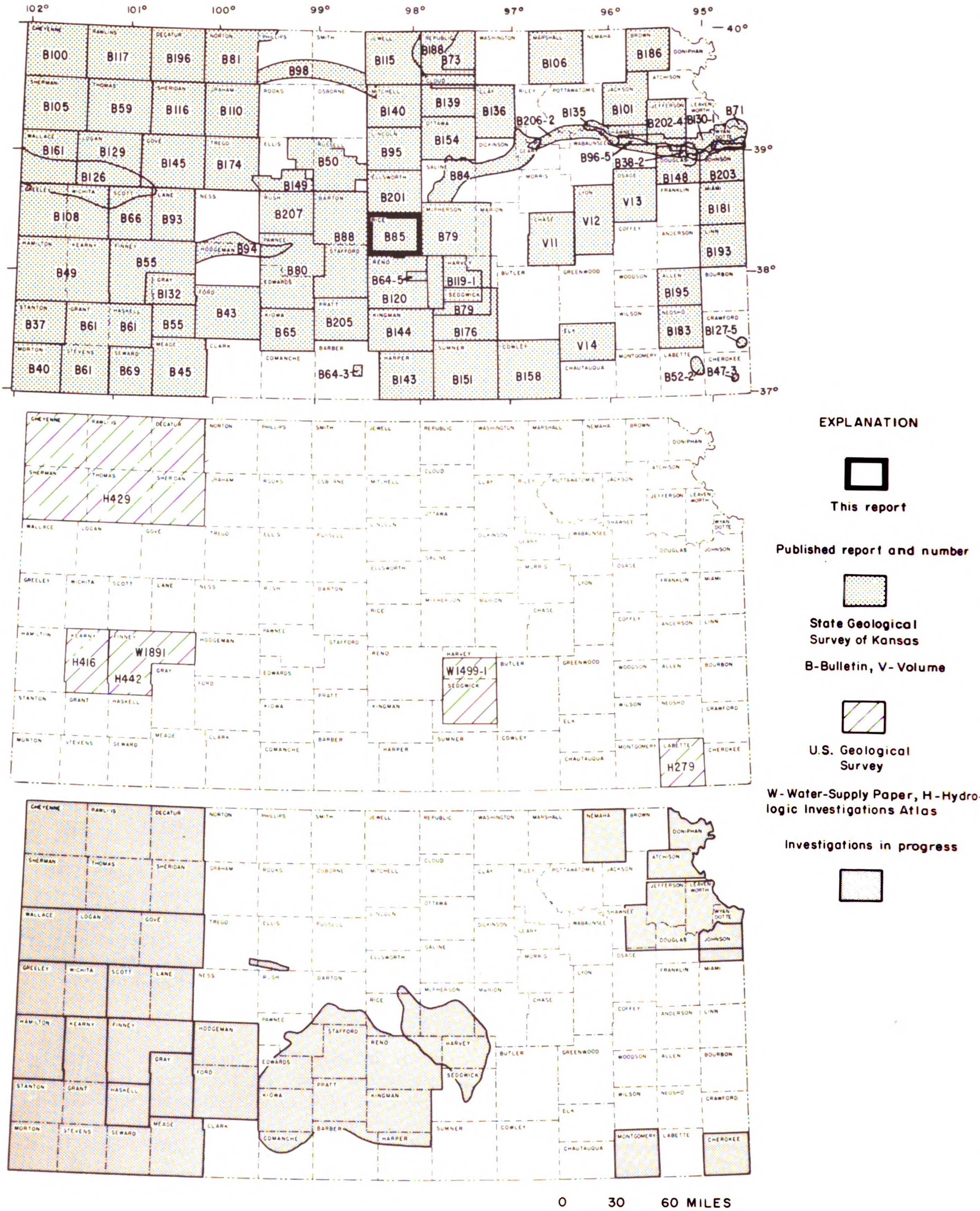


FIGURE 1.—Index maps showing area discussed in this report, and other areas for which ground-water reports have been published or are in preparation.

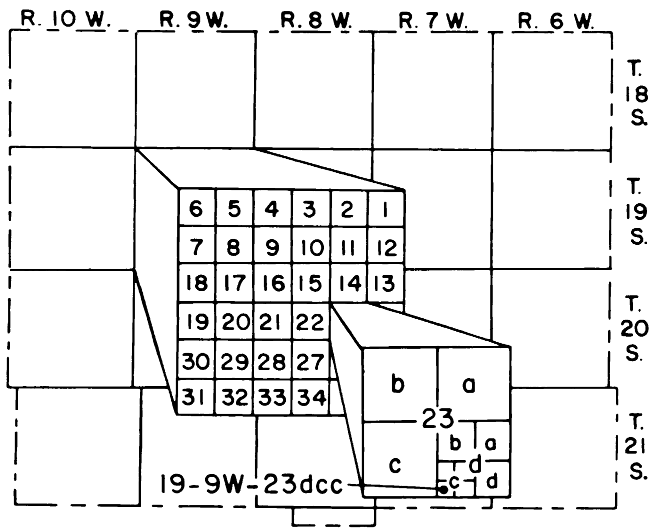


Figure 2.—Well-numbering system.

of Precambrian age underlie Paleozoic and younger rocks in the county (table 1) at depths ranging from 3,700 to 4,100 feet below land surface. Marine Cambrian and Ordovician rocks were deposited on the basement rocks. Silurian and Devonian rocks are absent. The pre-Mississippian uplift of the Ellis arch, which extends into the county from the northwest, caused tilting and beveling of the Cambrian and Ordovician rocks along the flanks of the uplift and caused the removal of any Silurian and Devonian rocks that may have been present. Mississippian rocks were deposited forming an angular unconformity with the rocks below. These Mississippian rocks were subsequently tilted and uplifted during the formation of the Central Kansas uplift and were eroded during Late Mississippian and Early Pennsylvanian time. Following this period of erosion, Pennsylvanian and Permian rocks were deposited.

The Permian formations that crop out in Rice County are all Early Permian in age. The red and green Ninnescah Shale is exposed in the valley walls of the Little Arkansas River in eastern Rice County. The Ninnescah is overlain by the Stone Corral Formation. Where the Stone Corral crops out, it consists of

Table 1.—Generalized section of geologic formations.

Era	System	Series	Stage	Stratigraphic Unit
Cenozoic	Quaternary	Pleistocene	Recent and Wisconsinan	Alluvium
				Terrace deposits
				Dune sand
				Bignell Formation
				Peoria Formation
			Illinoisan	Loveland Formation
			Kansan	Undifferentiated fluvial deposits
			Nebraskan	
	Tertiary	Pliocene		Ogallala Formation
Mesozoic	Cretaceous	Lower		Dakota Formation
				Kiowa Formation
				Cheyenne Sandstone
Paleozoic	Permian	Lower		Harper Sandstone
				Stone Corral Formation
				Ninnescah Shale
				Wellington Formation
	Pennsylvanian	Undifferentiated rocks (Includes Arbuckle Group of Late Cambrian and Early Ordovician age)		
	Mississippian			
	Ordovician			
	Cambrian			
Precambrian				

limestone and dolomite, but the formation contains much anhydrite and gypsum in the subsurface. The Harper Sandstone, which consists of red siltstone and very minor amounts of fine-grained sandstone, overlies the Stone Corral Formation and represents the uppermost Permian unit in Rice County.

Figure 3 shows the configuration of the base of the Stone Corral Formation. Minor structures on surficial or near-surface rocks are reflected in the deeper rocks and closure on shallow structure increases with depth. As an example, the structure shown near the SE cor. sec. 35, T.19 S., R.8 W., has about 70 feet of closure on the Stone Corral Formation, but this structure has more than 200 feet of closure on the Ordovician rocks.

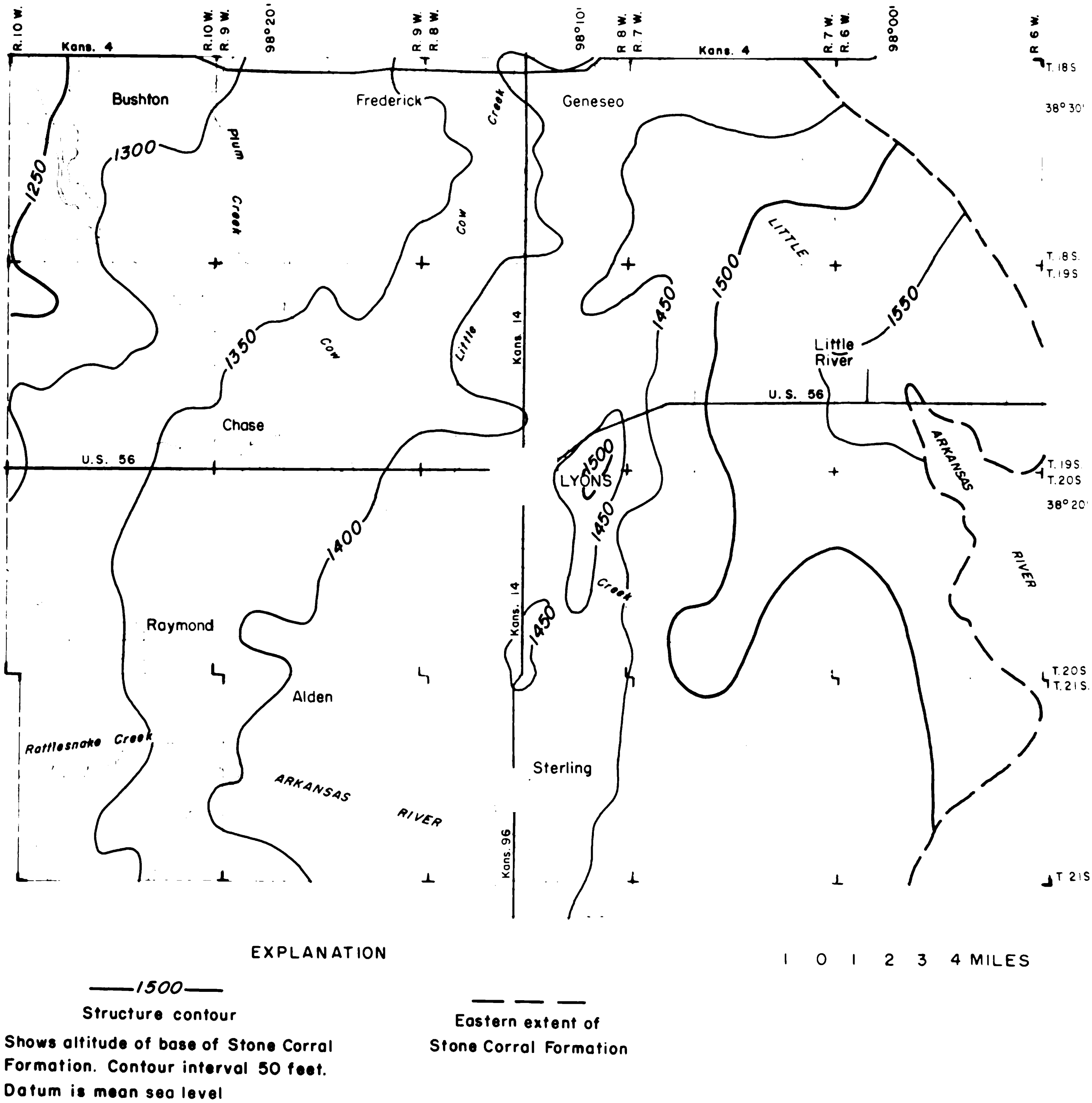


FIGURE 3.—Configuration of the base of the Stone Corral Formation.

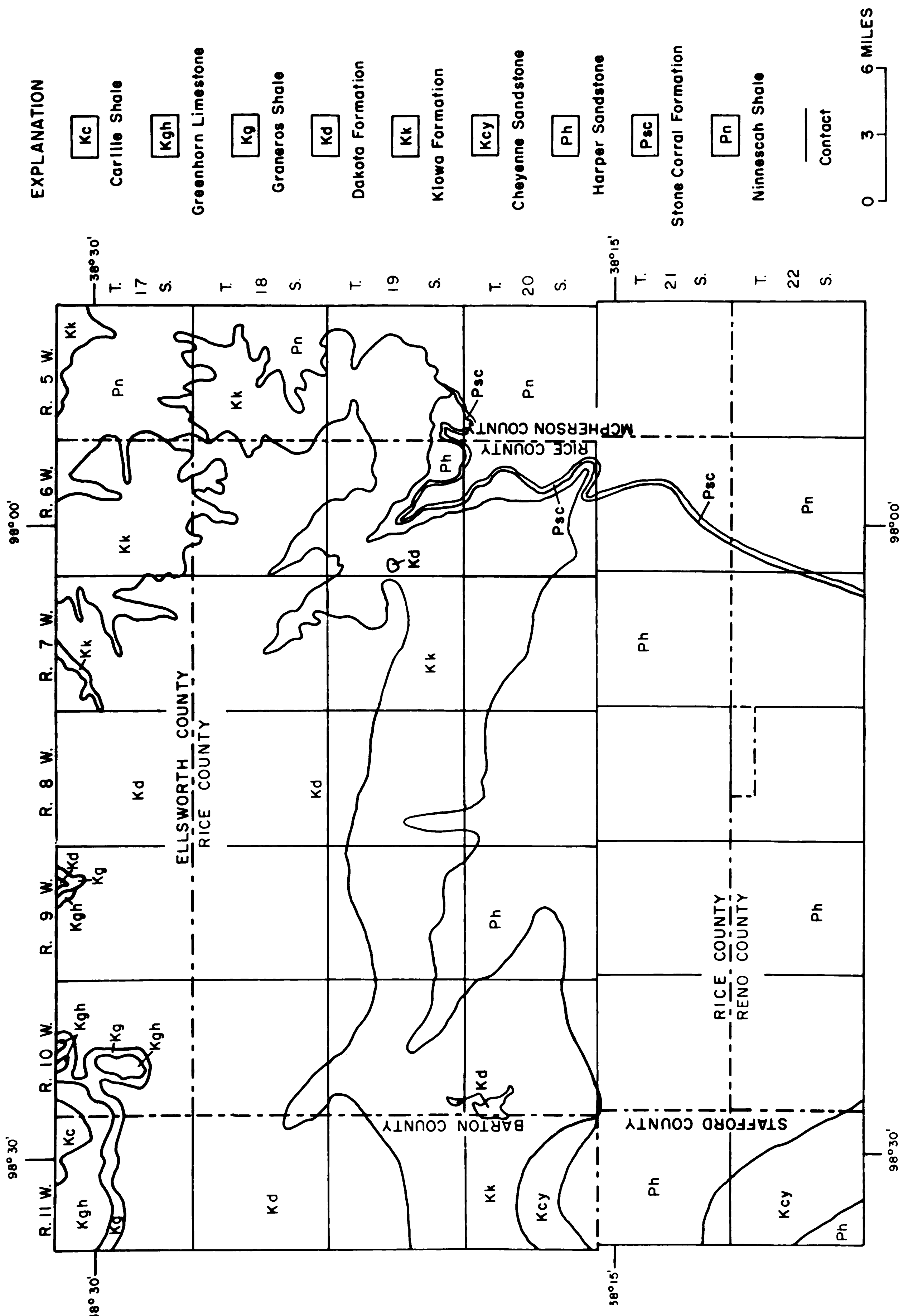


FIGURE 4.—Approximate distribution of geologic units on the bedrock surface in and near Rice County.

Rice County was subject to erosion during Triassic and Jurassic time, and Permian rocks younger than the Harper Sandstone probably were removed during this period. The erosion created a major unconformity that marks the contact of the Permian and the overlying Cretaceous rocks.

Deposition was renewed during Early Cretaceous time, and fine-grained sandstones and siltstones of the Cheyenne Sandstone were deposited in northwestern Rice County. This unit, which does not crop out in the county, is overlapped by the Kiowa Formation. The dark shales and fine-grained sandstones of the Kiowa were deposited in a nearshore marine environment. As these seas receded, silt, clay, and sand of the Dakota Formation were deposited in a lowlying nearshore nonmarine environment. Part of the material may have been deposited as offshore bars in a marine environment.

Deposition continued during Late Cretaceous time, but the many hundreds of feet of Upper Cretaceous rocks were removed by subsequent erosion. Thus, the Graneros Shale, Greenhorn Limestone, and Carlile Shale of Late Cretaceous age are not present in Rice County. The distribution of geologic units on the bedrock surface is shown on figure 4. The areal extent of four of the bedrock units above the Stone Corral Formation is shown on figure 5.

During the Tertiary period, little, if any, deposition occurred within Rice County. A mature caliche, believed to be a soil caliche that developed during late

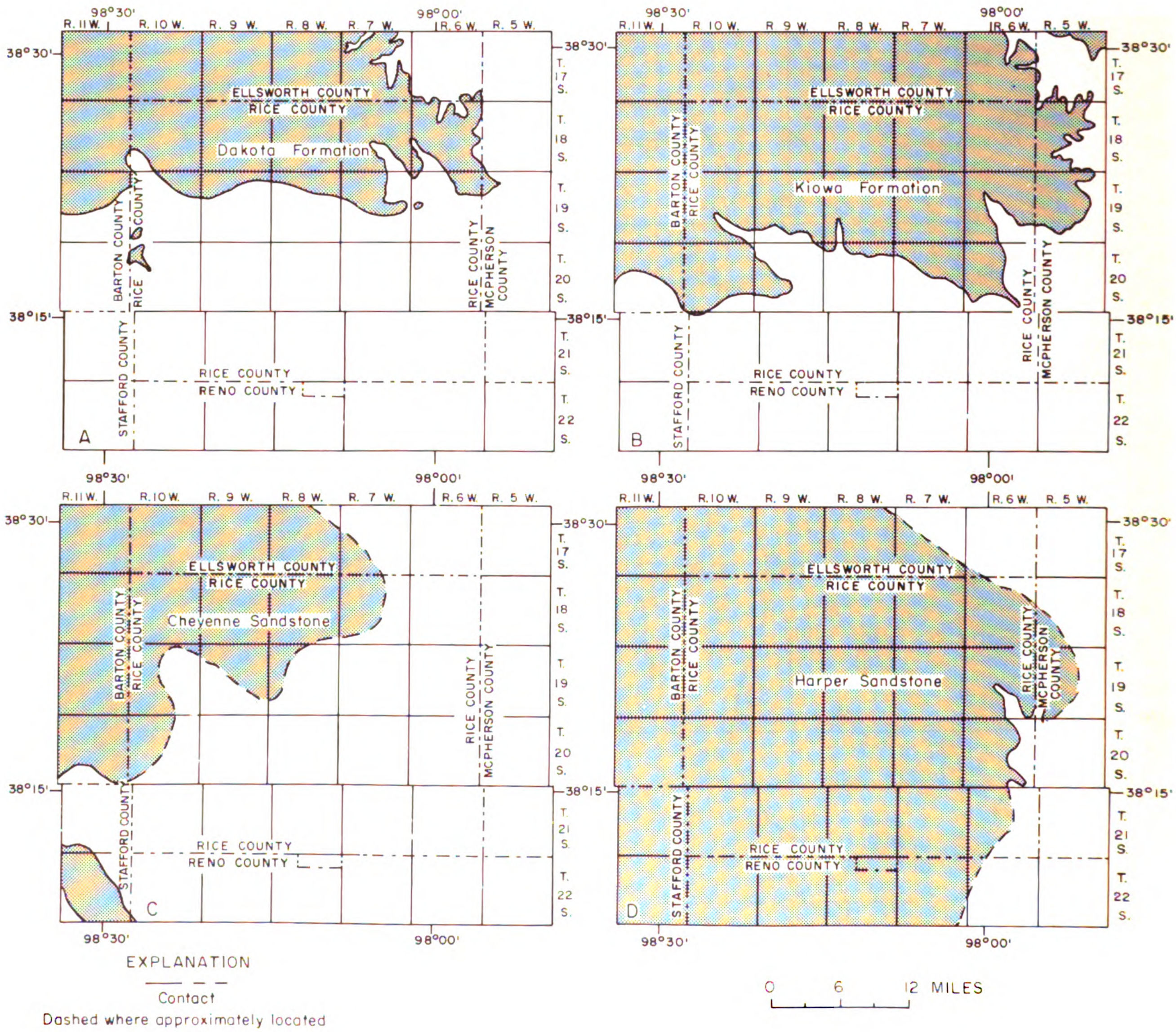


FIGURE 5.—Areal extent of four bedrock units above the Stone Corral Formation in and near Rice County.

Pliocene time, is present locally on the bedrock surface. This caliche is considered to represent the Ogallala Formation. At the end of Pliocene time, the area was one of low relief, sloping toward the east and southeast.

Renewed erosion during earliest Pleistocene time dissected the Pliocene erosional surface, and deep channels were eroded into the Permian and Cretaceous rocks. These channels, shown on the geologic sections (fig. 6), were partly filled with fluvial deposits during the Nebraskan Stage of the Pleistocene Series and partly reexcavated and filled during the Kansan Stage. In upland areas, the bedrock was probably exposed throughout early Pleistocene time. Figure 7 shows the configuration of the bedrock surface beneath the Pleistocene deposits.

During the Illinoisan Stage, loess and some water-laid silt were deposited. Coarse-grained fluvial deposits of this age are absent in the area. Loess and silt of Illinoisan age, which probably were deposited in most of Rice County, either were buried by Wissonsinan loess or were eroded by Wisconsinan streams.

The geohydrologic map (pl. 1) shows the distribution of the exposed geologic units in the county. Bedrock units crop out principally in the eastern and northeastern parts of the area; however, isolated outcrops of Kiowa and Dakota Formations occur throughout the area. The Ogallala Formation is represented only by isolated outcrops of soil caliche that rest directly on the bedrock.

The Pleistocene geology can be divided into many units. On the geologic map, however, units with similar water-bearing characteristics are grouped together into three main categories: loess, dune sand, and alluvium and terrace deposits.

Loess shown on the geohydrologic map probably represents three different formations. The Loveland Formation of Illinoisan age is present in the basal part of the loess in much of the area. Overlying the Loveland are the Peoria Formation (middle unit) and the Bignell Formation (upper unit) of Wisconsinan age. The loess, which comprises these three formations, occurs principally in upland areas and generally rests on bedrock. In part of the area, however, the loess overlies fluvial deposits in early Pleistocene channels shown on the bedrock-configuration map (fig. 7).

Dune sand overlies principally Wisconsinan and Recent alluvium and terrace deposits in the valleys of the Arkansas River and Cow Creek. Dune sand directly overlies Cretaceous bedrock locally in the west-central part of the county, and it overlies fluvial deposits in early Pleistocene channels in the western part of the county. In southeastern Rice County dune sand overlies Permian rocks.

Recent alluvium and Wisconsinan terrace deposits occur in the valleys of Arkansas River, Cow Creek, Little Arkansas River, and their principal tributaries. In the Arkansas River valley and Cow Creek valley, these deposits contain much arkosic sand and gravel derived from a source west of Rice County. In the Little Arkansas River valley and most tributary valleys, the deposits are fine grained and are derived primarily from local materials. Locally, in the Arkansas River valley and Cow Creek valley, these deposits overlie fluvial deposits in early Pleistocene channels.

GROUND WATER

Fresh water is obtained in Rice County from wells in unconsolidated Pleistocene deposits to depths of about 100 feet and from consolidated rocks to depths of about 220 feet. The best aquifers are the unconsolidated alluvium and terrace deposits in the valleys of the Arkansas River, Cow Creek, Little Arkansas River, and tributaries to these streams. Small quantities of fresh water are obtained from loess deposits in the uplands area and from dune sand. Aquifers in consolidated rocks are the shales, siltstones, and sandstones of Permian and Cretaceous age.

Deep Paleozoic Aquifers

Little water is contained in most of the deep Paleozoic rocks in Rice County. Small quantities of highly mineralized water are contained in Lower Permian rocks to a depth of several hundred feet below the Hutchinson Salt Member of the Wellington Formation. Some horizons are capable of yielding or receiving large quantities of water. About 260,000 barrels of brine are produced each day along with the production of oil. About 80,000 barrels per day of this brine is injected into the producing zones in the secondary recovery of oil. The remaining 180,000 barrels per day is disposed into rocks of Cambrian and Ordovician age (Arbuckle Group) under gravity head at depths ranging from 3,200 to 3,500 feet.

Permian Aquifers

A little water of poor quality is obtained from shallow wells in the weathered part of the Ninnescah Shale and the Harper Sandstone in Rice County. Small supplies of poor quality water are obtained locally from the Stone Corral Formation. In the area about 1 mile northeast of Lyons, wells in the Stone Corral have maximum yields ranging from about ½ to 3 gpm (gallons per minute). East of this area, near the outcrop, solution of evaporites probably has increased the permeability of the unit and somewhat larger quantities of water are available. North and northwest of

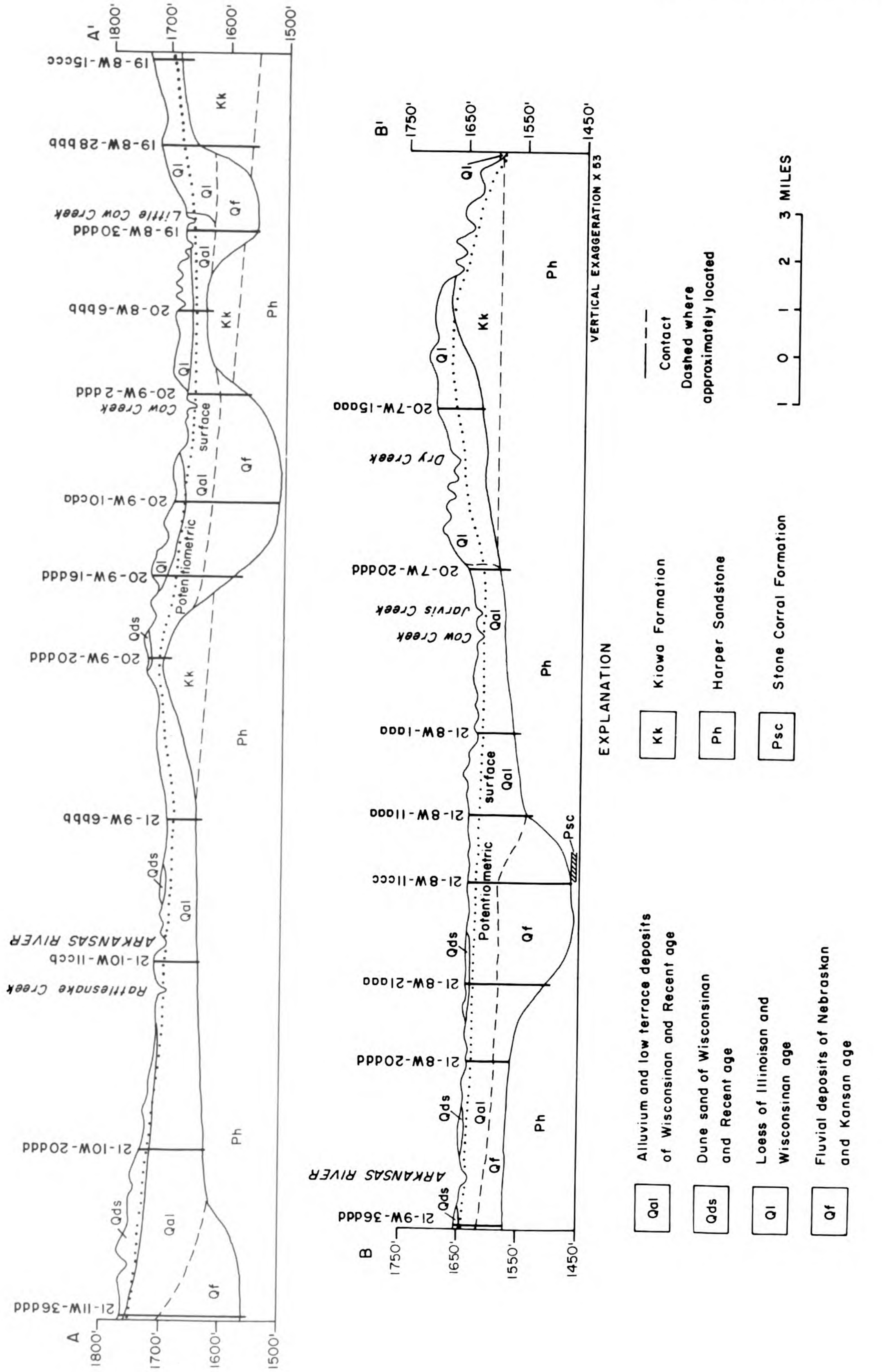
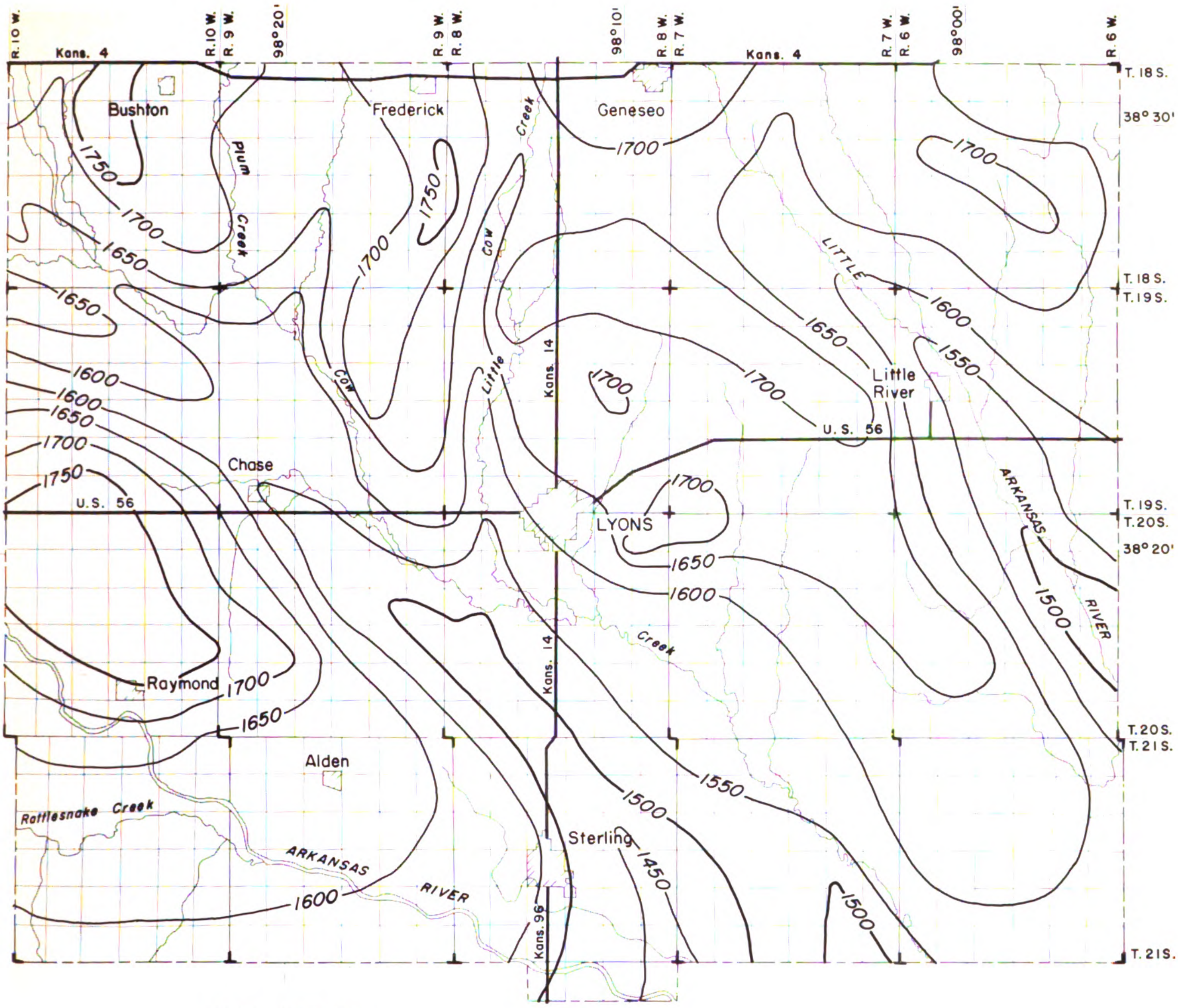


FIGURE 6.—Geologic sections. Traces of sections are shown on plate 1.



EXPLANATION

—— 1500 ——

Bedrock contour

Shows altitude of bedrock surface. Contour interval 50 feet. Datum is mean sea level

1 0 1 2 3 4 MILES

FIGURE 7.—Configuration of the bedrock surface beneath unconsolidated deposits.

Lyons, where the Stone Corral is more deeply buried, little or no water can be obtained from the unit.

Cretaceous Aquifers

The principal bedrock aquifers of Rice County are sandstone beds within the Kiowa and Dakota Formations of Cretaceous age. These sandstone beds pinch and swell laterally in thickness and are lithologically dissimilar. Therefore, the yields of wells in either the Kiowa or the Dakota may differ considerably over short distances. The Kiowa Formation in Rice County is about 140 feet thick where a full section is present; however, this unit has been eroded and thins to a feather edge toward the south and east. Probably no more than 150 feet of Dakota is present; the unit thins to a feather edge toward the south and east. Generally, about 30 percent of the Dakota section is composed of sandstone, whereas the percentage of sandstone in the Kiowa section is somewhat less. Sandstone may occur throughout the Dakota, but sandstone in the Kiowa generally is more prominent in the upper part.

Maximum yields to wells that can be expected from the Kiowa in the county is about 50 gpm. In areas where the sandstones in the upper part of the Kiowa have been eroded, little or no water can be obtained from the unit.

Yields to wells in the Dakota range from only a few gallons per minute where the unit is thin or where little sandstone is present to as much as 150 gpm where the unit is thick and more sandstone is present.

Many stock and domestic wells withdraw water from the Kiowa and Dakota in the county. Little River obtains part of its municipal water from the Kiowa Formation, and the cities of Bushton and Geneseo utilize the Dakota for their municipal supplies.

The Cheyenne Sandstone is present only in the extreme western and northwestern parts of the county. Water from the Cheyenne is highly mineralized.

Pleistocene Aquifers

Loess of Illinoisan and Wisconsinan age overlies bedrock in much of the upland areas of the county and locally overlies fluvial deposits in buried-channel areas (pl. 1). The loess is relatively thin in much of the area, but may be as much as 70 feet thick locally. Locally, the loess is partly saturated and yields small supplies of water to wells. In the channel areas, wells generally penetrate the loess and obtain water from the upper part of the fluvial deposits. Large quantities of water are available from the lower part of the fluvial deposits; however, this water is not used because of its poor quality.

Dune sand, which attains a maximum thickness of about 40 feet, overlies alluvium and terrace deposits in much of the valley of the Arkansas River and Cow Creek (pl. 1). Dune sand overlying a bedrock ridge formed on the Kiowa Formation, which extends southeastward from the NW cor. T.20 S., R.10 W., is thin and is not saturated. Northeast of the ridge, in an area where the dune sand overlies fluvial deposits of early Pleistocene age, the saturated thickness increases rapidly. In the southeastern part of the county, another dune sand area overlies the Kiowa Formation and Permian rocks. In areas where dune sand overlies Permian rocks, the dune sand generally is the principal source of water. In areas where water of good quality is available from underlying rocks, only a few wells utilize the dune sand for a water supply. Yields to wells from dune sand are generally less than 10 gpm.

The alluvium and terrace deposits in Rice County differ areally in lithology and, therefore, differ in water-bearing characteristics. Coarse sand and gravel in the alluvium and terrace deposits of the Arkansas River and Cow Creek valleys yield as much as 2,000 gpm to wells; average yields probably are nearer to 1,000 gpm (fig. 8). In the Little Arkansas River valley, the deposits are finer grained and well yields are smaller than those in the Arkansas River valley. The alluvium and terrace deposits in the tributary valleys are thin and contain much fine material. In these valleys, well yields locally may be as much as 100 gpm, but the yields more commonly range from 10 to 20 gpm.

Figure 9 shows the saturated thickness of the unconsolidated deposits in Rice County. The buried early Pleistocene channel, where the saturated thickness is more than 160 feet, is clearly defined. Many irrigation wells obtain water from the saturated unconsolidated deposits in the major stream valleys. Only the upper 60 to 80 feet of these deposits generally is utilized. Water from the basal part of the deposits generally is of inferior quality where the saturated thickness exceeds 80 feet.

Movement of Water

Plate 1 indicates, by means of contours, the shape of the potentiometric surfaces for the Pleistocene and Cretaceous aquifers and the direction of movement of water in an area of about 70 square miles around Lyons. Each contour connects points of equal altitude of water level and, at any point along a contour, water moves downgradient at right angles to the contour. Data collected by Fent in 1946 and data collected in 1970 are shown on plate 1; however, the contours are based on the 1970 data. Depths to water in wells measured in 1946 were little different from the depths in the same or nearby wells measured in 1970. The water levels in wells in this area, which fluctuate with changing weather conditions, probably were much lower during the drought in the middle 1950's.

Water in loess in the upland areas moves generally southward except near the Little Arkansas River valley, where the direction of movement is eastward toward the valley.

Water moves outward from the center of the dune sand area in the southeastern part of the county. The slope of the water table is steep (as implied by the range in the altitudes of the water level), which indicates that considerable recharge occurs and that these deposits are somewhat less permeable than the allu-

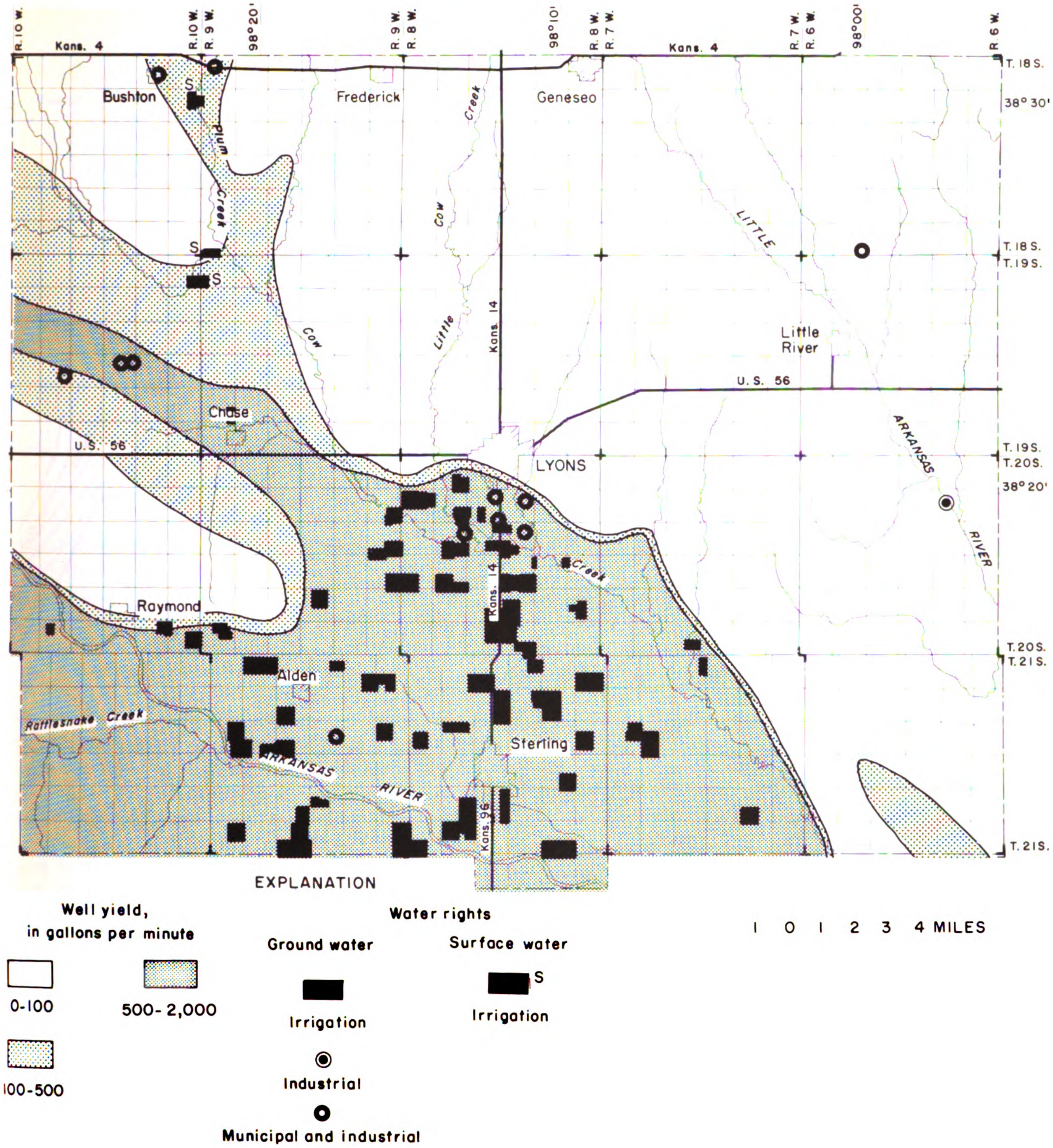


FIGURE 8.—Availability of water in unconsolidated deposits and location of water rights, 1970.

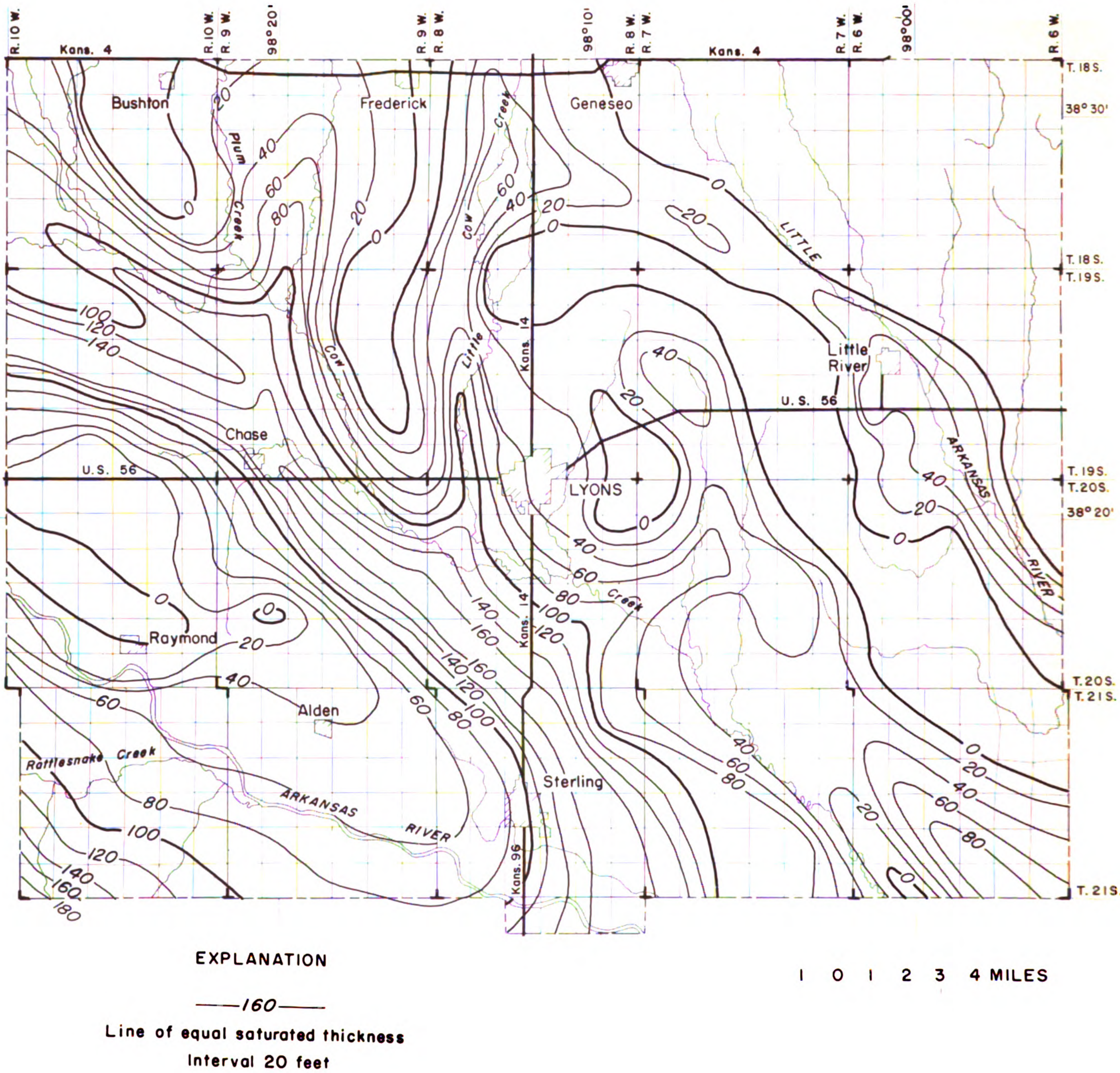


FIGURE 9.—Saturated thickness of unconsolidated deposits.

vium and terrace deposits. In the dune sand tract in the west-central part of the county, the high altitudes of the water levels and the steepness of the slope of the water table are a reflection of the bedrock high in the area.

In the Pleistocene deposits of the Arkansas River and Cow Creek valleys, the slope of the water table is more uniform and is not as steep as in other areas. The water moves in an east-southeast direction except near the principal streams where it moves toward the streams.

Water in the Pleistocene deposits is unconfined (water-table condition), and water in the bedrock aquifers is confined (artesian condition). When an artesian aquifer is penetrated by a drill hole, water will rise in the hole above the top of the aquifer. The generalized movement of ground water is shown on figure 10, which illustrates conditions near the city of Lyons. The potentiometric head in the bedrock units decreases with depth, allowing a slow downward movement of water through nearly impermeable confining layers. The potentiometric head in the Stone

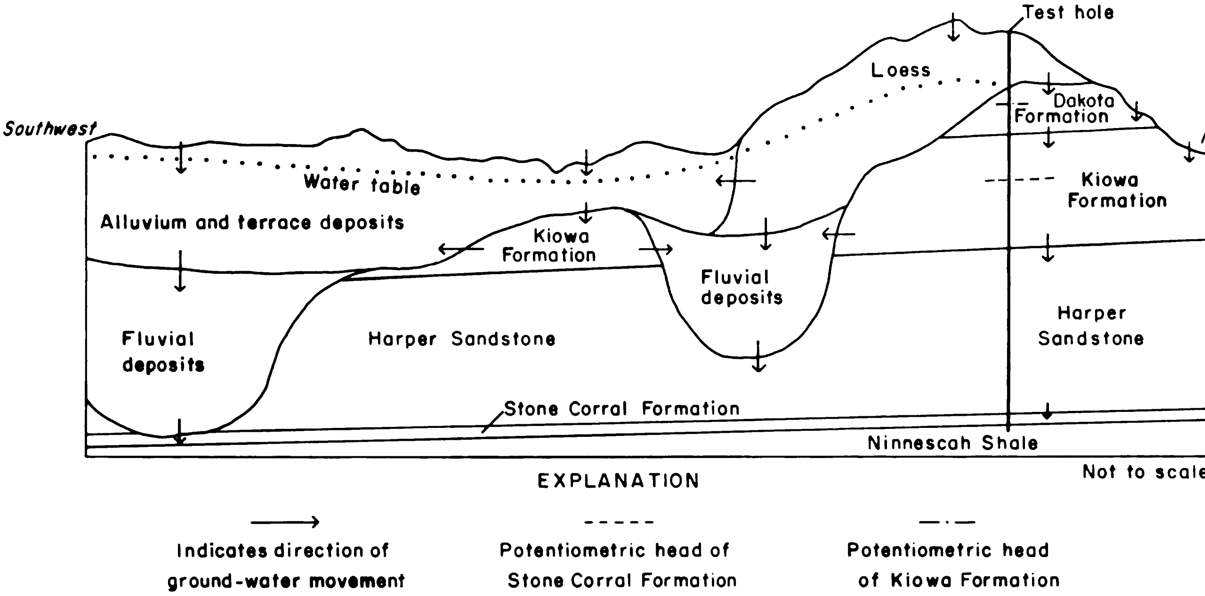


FIGURE 10.—Generalized movement of ground water.

Corral Formation raises water in a well to a few feet above the base of the Kiowa Formation, and the head in the Kiowa raises water in a well above the base of the overlying aquifer. In the area north of Lyons, the head in the Kiowa Formation (determined by packer tests in wells) raises water to an altitude near that of the unconfined water table in loess overlying the Kiowa. In these tests, the potentiometric head in the Kiowa in nearly all wells was one or two feet below the water table in the overlying Pleistocene aquifer. If the head on the overlying aquifer is lowered significantly, water can move upward from a deeper aquifer with a greater head. Where the potentiometric head is sufficiently high, water can move laterally from the bedrock aquifer into adjacent Pleistocene deposits, and, conversely, if the potentiometric head is lowered sufficiently, water can move into the bedrock aquifer from the Pleistocene deposits. The normal direction of movement of water from precipitation is downward into both bedrock and Pleistocene aquifers, with subsequent lateral movement of ground water from the bedrock to the Pleistocene aquifers. Lowering the head in the Kiowa aquifer could, in time, reverse the direction of water movement in the entire aquifer system.

CHEMICAL QUALITY OF WATER

Water samples for this report were obtained from 31 test holes, 35 domestic-supply wells, and 14 stream sites. Complete standard chemical analyses were performed by the Kansas State Department of Health. In addition, chemical-quality data were available from earlier reports, and from records for six public supplies (pl. 2).

Most water samples were collected from test holes and from domestic wells open to the entire thickness penetrated, which may encompass more than one aquifer. At a few locations, samples were obtained from sandstone aquifers isolated from shallow unconsolidated deposits. Samples from isolated Kiowa Formation and Stone Corral Formation aquifers were obtained at three locations north of Lyons (pl. 2).

Arbuckle Group

Of all the deep subsurface formations underlying Rice County, the Arbuckle Group generally contains the least concentrated brine; concentrations of chloride range from 10,000 to 20,000 mg/l (milligrams per liter). Within the Arbuckle Group, brines with the least concentration of mineral constituents generally occur in areas of structural high, which may indicate that the water is of meteoric origin. The water probably entered these rocks during pre-Mississippian and again in Early Pennsylvanian time when the Ellis arch was elevated, and the overlying rocks were eroded and beveled. Since that time, the chemical quality of this water has been degraded owing to intermixing with water in adjacent formations. The natural concentration of the brine probably has been increased significantly in local areas because of the large amount of oil-field brines of higher concentration that is injected into the Arbuckle Group through disposal wells.

Stone Corral Formation

Five water samples were obtained from the Stone Corral Formation; three were obtained while the formation was isolated from other aquifers by inflatable packers. Analysis of the samples indicates that the water is of poor quality. Four of the water samples taken downdip from the outcrop ranged from 4,980 to 6,430 mg/l in dissolved-solids concentration (pl. 2). The fifth sample, taken from well 19-6W-36cbc near the outcrop area, had a dissolved-solids concentration of 3,870 mg/l. The water from this well is known to have had a relatively low dissolved-solids concentration at one time, but pollution from oil-field brine has caused the quality to deteriorate to its present level.

Water from the Stone Corral Formation in Rice County is of the sodium chloride type; however, concentration of sulfate also is very high. The high sulfate content may be explained by the solution of gypsum, which is abundant in the formation. The high chloride concentration west of the outcrop area may have resulted from slow leaching of salt from deposits within the Stone Corral.

Kiowa and Dakota Formations

Waters from the Kiowa and Dakota Formations commonly are very hard and of the calcium bicarbonate type; they are very similar in quality to water in the unconsolidated deposits. The similarity of chemical type may indicate that the waters have comparative freedom of movement both laterally and vertically between the three aquifers. Where the Kiowa and Dakota aquifers are separated from the unconsolidated aquifer by an appreciable thickness of shale, the water may be of the sodium bicarbonate type. The calcium ion probably has been exchanged for the sodium ion through a natural softening process. The concentration of dissolved solids in waters from these formations generally ranges from 290 to 690 mg/l. In a few wells, however, the water has been contaminated by industrial brines, resulting in concentrations as high as 54,940 mg/l.

An indication of local hydraulic connection between the Kiowa and Stone Corral Formations was found during hydraulic tests of well 19-8W-27abb. An inflatable packer was used to isolate the aquifers during these tests. Pattern diagrams (fig. 11) showing quality of samples of water from the Kiowa and Stone Corral aquifers indicate the similarity of the waters. The water sample collected from the Kiowa Formation (fig. 11 B) was of the sodium chloride type, which is typical of water from the Stone Corral Formation (fig. 11 A). However, the proportion of the bicarbonate ion to other ions is higher in the Kiowa water

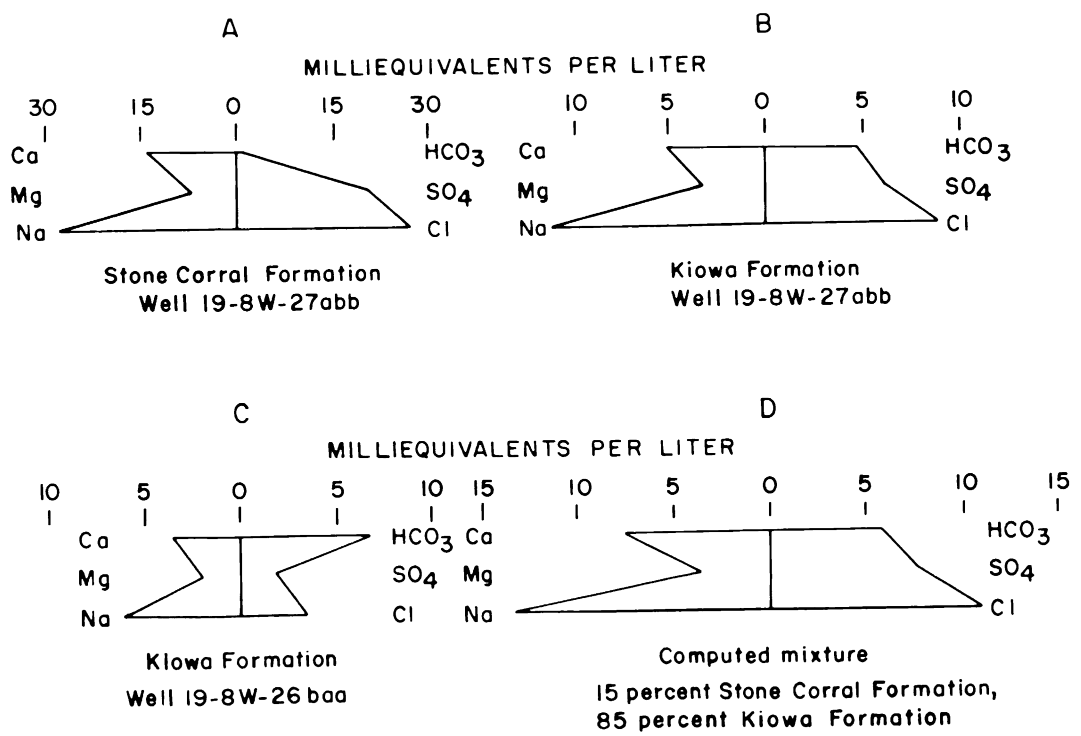


FIGURE 11.—Mixing of water in a well.

than in the Stone Corral water, and the total concentration of mineral constituents in the Kiowa water is lower.

The diagram for the analysis of water from well 19-8W-26baa (fig. 11 C) is typical for sodium bicarbonate water from the Kiowa Formation. The diagram of a computed mix (fig. 11 D) of 85 percent Kiowa water from this well and 15 percent Stone Corral water from well 19-8W-27abb is almost identical in shape and concentration with the diagram of Kiowa water from well 19-8W-27abb (fig. 11 B), which indicates probable mixing of waters from the two formations at this well. The potentiometric head in the Stone Corral aquifer is above the base of the Kiowa aquifer in well 19-8W-27abb, although it is below the potentiometric head in the Kiowa aquifer. If the head in the Kiowa aquifer is lowered sufficiently while the well is pumped and the Harper Sandstone separating the two aquifers is fractured or permeable, water from the Stone Corral could migrate into the Kiowa. The authors believe that such a condition existed at well 19-8W-27abb and that there was mixing of water from the two aquifers.

Pleistocene Deposits

Water collected from shallow unconsolidated deposits commonly is very hard and of the calcium bicarbonate type (pattern diagrams, pl. 2). A few samples were a softer water of the sodium bicarbonate type. Water of the sodium chloride type is present locally as a result of pollution from oil-field brine and solution of salt from surface operations of salt mines. Analyses of water from these deposits generally range from 200 to 480 mg/l dissolved solids. In a few wells, however, concentrations were much higher; the greatest known concentration of dissolved solids is 5,430 mg/l. Water with the least dissolved-solids concentration generally occurs in the dune sand and alluvium in the southern part of the county.

Streams

The major streams in the county were sampled at low-flow stage and all differ somewhat in the chemical quality of their water. Although the dissolved-solids concentration varies with stream discharge, the chemical type of the water for each stream seems to be consistent over a period of time (pl. 2). Analyses of water from Plum Creek and Little Arkansas River indicate a calcium bicarbonate type water of relatively low dissolved-solids concentration. Water in Cow Creek is of the sodium chloride type and appears to decrease in dissolved-solids concentration downstream. Locally, however, chloride concentration increases considerably as a result of industrial waste entering the stream. The Arkansas River upstream from Rattlesnake Creek contains water of the sodium sulfate type. Because water in Rattlesnake Creek is extremely high in sodium chloride concentration, water in the Arkansas River below the mouth of Rattlesnake Creek becomes a sodium chloride type water that also contains high concentrations of sulfate and dissolved solids. The quality of water of all the streams except Cow Creek has resulted largely from naturally occurring conditions. The quality of water in Cow Creek is to a large extent determined by industrial waste.

In Rice County ground water moves from the aquifers toward the streams. Generally the ground water, which is of better quality than the water in the streams during low-flow periods, tends to dilute the mineral concentration of the surface water. However, in areas where there has been industrial pollution, water of poorer quality may enter the stream from the aquifer.

MINERAL RESOURCES

Ceramic Materials

The Dakota and Kiowa Formations are the principal potential sources of ceramic materials in Rice County. The Dakota clays fire white, buff, and red, and are dominantly kaolinitic and noncalcareous. The clays of the Dakota have excellent qualities for use in the ceramic industry.

The Kiowa Formation, although largely clay, is not as desirable for use in the ceramic industry. The Kiowa clays have high shrinkage values, fire to undesirable dark colors, and tend to bloat when fired. They would be most useful in the manufacture of lightweight aggregate.

The geologic map shows the areas where the Dakota and Kiowa Formations crop out. The Dakota is poorly exposed, being overlain in much of the area by Pleistocene deposits. The Dakota and the Kiowa are not utilized in the county as ceramic material.

Salt

Salt underlies all of Rice County; thickness of the salt ranges from about 200 feet in the northeastern part of the county to about 400 feet in the south-central part. The salt occurs in the Hutchinson Salt Member of the Wellington Formation of Permian age. The mineral resources map (fig. 12) shows the thickness of salt in the county. The percentage of pure salt ranges from about 60 percent in the central and southwestern parts of the county to about 90 percent in the northern and eastern parts. Beds of shale and anhydrite occur throughout the salt beds. Rock salt has been mined at Little River and from two mines

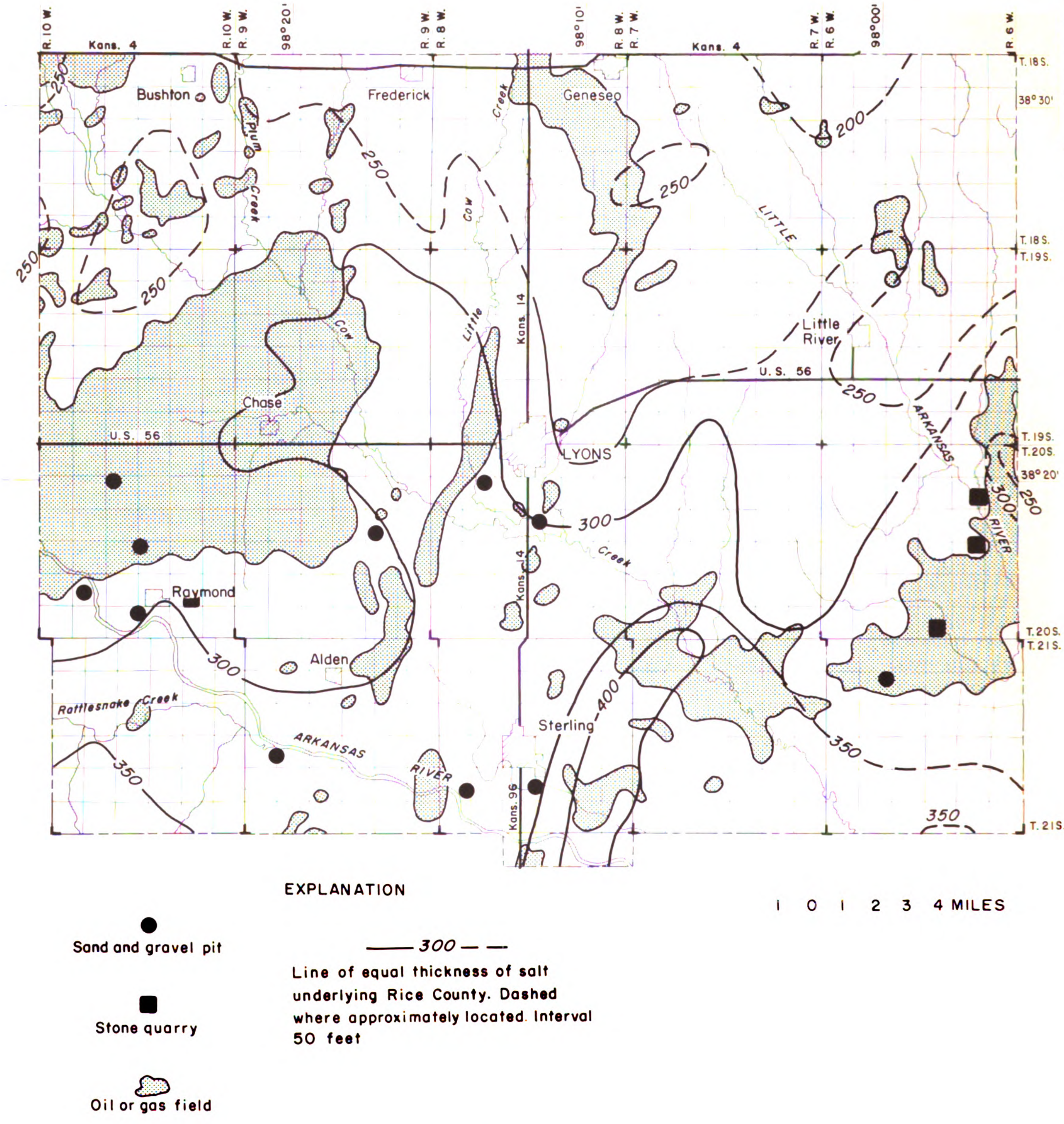


FIGURE 12.—Mineral resources of Rice County.

at Lyons. Salt has been produced by the brine process at Lyons and Sterling. Only one company produces salt in Rice County at present. The American Salt Co. at Lyons mines rock salt from a depth of about 1,000 feet and produces salt from brine.

Oil and Gas

Petroleum is the principal mineral resource in Rice County. Oil was first produced in the county in 1922, and gas was produced as early as 1888. In 1969, 76 fields produced oil and 19 produced gas in the county. In 1969, 4,587 thousand barrels of oil and 713,238 thousand cubic feet of gas were produced. Cumulative production after the first discovery was 277,348 thousand barrels of oil and 42,066,582 thousand cubic feet of gas in 1969. The mineral resources map shows the location and extent of oil and gas fields in Rice County.

Sand, Gravel, and Stone

In Rice County, road-surfacing material and concrete aggregate are mined from thick deposits of sand and gravel. Eleven pits have been opened for commercial production in the valleys of Arkansas River and Cow Creek; however, not all these pits are operating at present.

Sandstone has been quarried locally in limited quantities in Rice County for use as building stone. The Stone Corral Formation has been quarried along the west margin of the Little Arkansas River valley. This stone has been crushed and used as road material and concrete aggregate. The mineral resources map shows the location of sand and gravel pits and stone quarries in the county.

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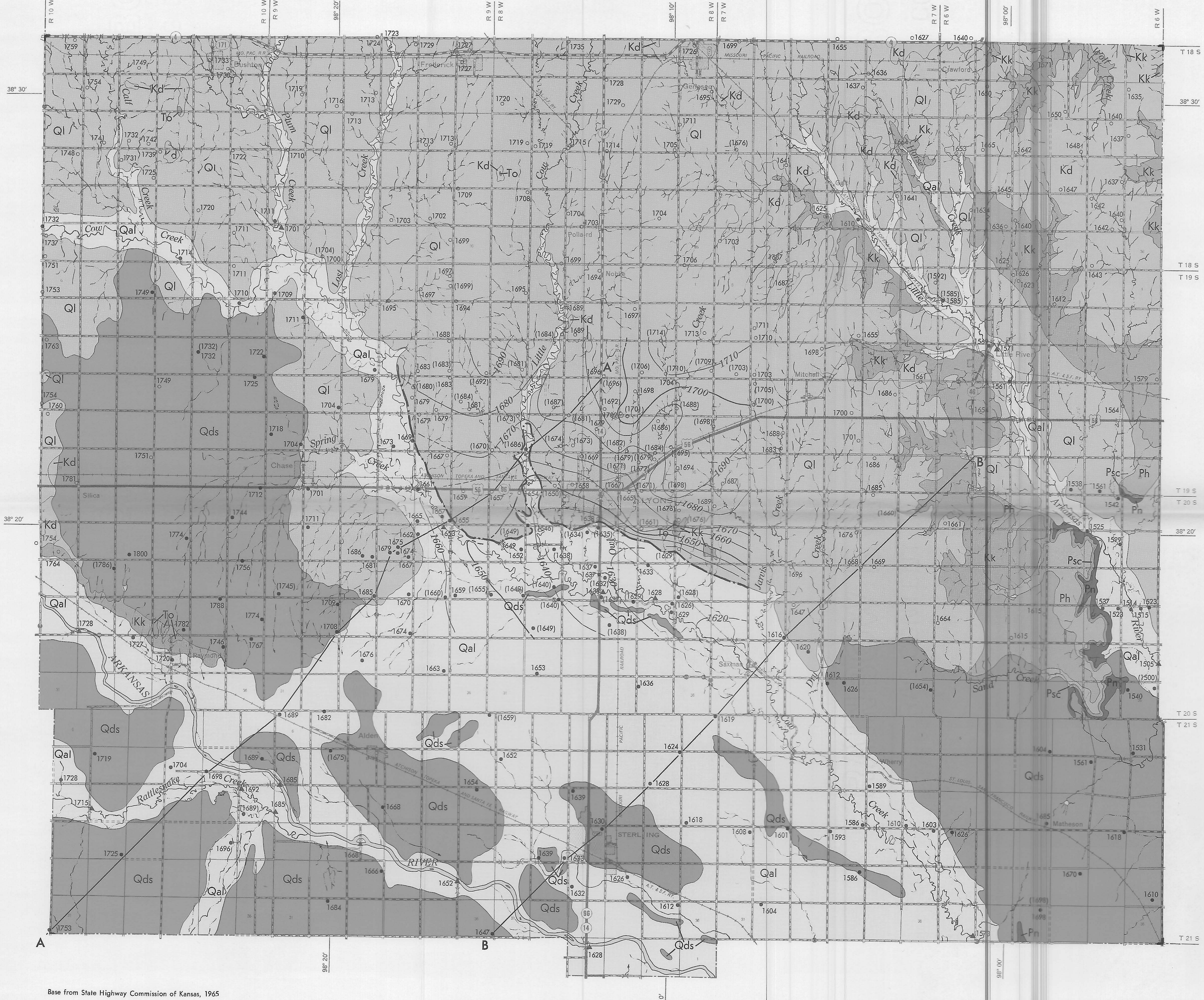
NOTE: Additional information on drillers' logs and well-inventory and water-analysis data is on file in the offices of the Kansas Geological Survey and the U.S. Geological Survey, Lawrence, Kansas 66045.

State Geological Survey
of Kansas

GEOHYDROLOGIC MAP OF RICE COUNTY, CENTRAL KANSAS

Bulletin 206
Part 3
Plate 1



EXPLANATION

QUATERNARY SYSTEM

Pleistocene Series

Qal — Alluvium and terrace deposits

Alluvium (Recent) consists of silt, sand, and gravel in the Arkansas Valley; yields brackish water to a few domestic and stock wells. Terrace deposits (Wisconsinan) consist of gravel, sand, and some silt in tributary valleys to the north. In Arkansas Valley yields large quantities of moderately hard water.

Qds — Dune sand

Medium sand, some fine sand and silt. Generally above the water table, but yields water to a few wells in the large dune tracts. Locally overlies fluvial deposits, which yield moderate to large quantities of water.

Ql — Loess

Silt, mostly eolian. Principally loess of Loveland Formation (Illinoisan) and Peoria Formation (Wisconsinan), but may contain some loess of Bignell Formation (Wisconsinan). Locally present in thin deposits in upland areas and overlies fluvial deposits in abandoned-channel areas. Yields small quantities of water to wells locally.

TERTIARY SYSTEM

Pliocene Series

To — Ogallala Formation

Soil caliche with distinctive pink banding occurring as thin deposits marking topography at end of Pliocene Epoch. Yields no water to wells.

CRETACEOUS SYSTEM

Lower Cretaceous Series

Kd — Dakota Formation

Clay, silt, shale, sandstone, and siltstone, locally cemented with hematite and limonite. Contains lignite and locally beds of quartzitic sandstone. Colors are white, red, gray, brown, and tan. Yields small to moderate quantities of water to wells from sandstone beds.

Kk — Kiowa Formation

Shale, fissile, light-gray, dark-gray, and black. Contains thin sandstone bodies throughout and a persistent thick light-colored sandstone at top. Beds of cone-in-cone, quartzitic sandstone, siltstone, and thin limestone are common. A marine molluscan fauna occurs in the limestone. Yields small to moderate quantities of water to wells from the sandstone.

PERMIAN SYSTEM

Lower Permian Series

Ph — Harper Sandstone

Red siltstone and fine-grained silty sandstone. Yields little or no water to wells in Rice County.

Psc — Stone Corral Formation

White and light-gray limestone and dolomite. Yields small quantities of mineralized water to wells in Rice County.

Pn — Ninnescah Shale

Shale, siltstone, and very fine grained silty sandstone. Yields little or no water to wells in Rice County.

Contact

A———A'
Trace of section

Boundary between Pleistocene and Cretaceous aquifers

• Well or test hole in Pleistocene aquifer

○ Well or test hole in Cretaceous aquifer

▲ Stream water-level-measurement site

(1704) 1700
Numbers are altitudes of water levels above mean sea level, in feet. Number in parentheses is 1970 measurement; number without parentheses is 1946 measurement

——*1640*------
Potentiometric contour

Shows altitude at which water level would have stood in tightly cased wells in Pleistocene and Cretaceous aquifers, 1970. Dashed where approximately located. Contour interval 10 feet. Datum is mean sea level

In this report small quantities refers to yields generally less than 10 gpm, moderate quantities 10-100 gpm, and large quantities 100-2,000 gpm

9°
True North
Magnetic North
APPROXIMATE MEAN DECLINATION, 1973

Scale 1:126 720

1 0 ½ 1 2 3 MILES

Base from State Highway Commission of Kansas, 1965

Illustration prepared by Lanna J. Hentsch

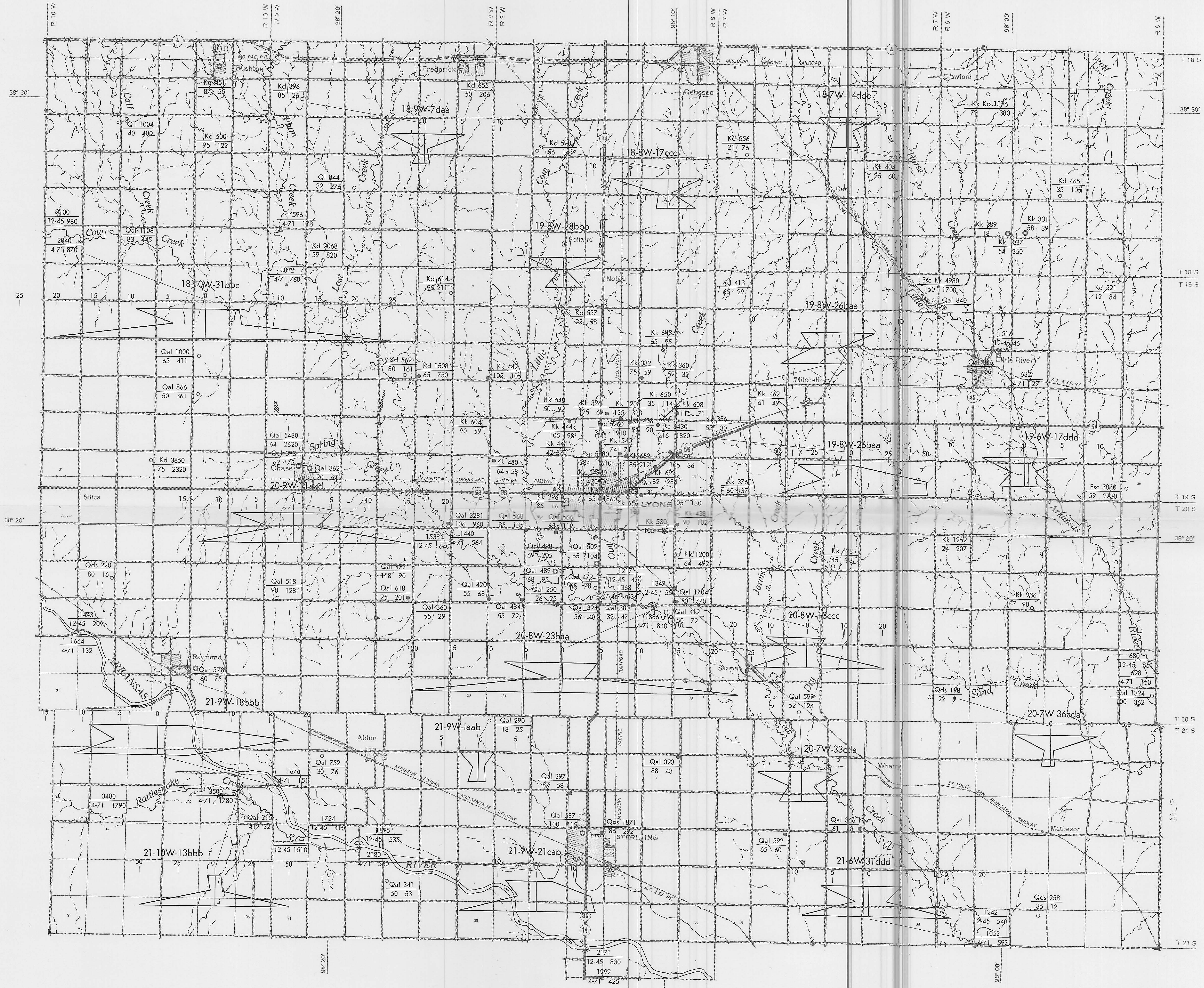
Prepared by the State Geological Survey of Kansas and the United States Geological Survey, with the cooperation of Division of Environmental Health of the Kansas State Department of Health and the Division of Water Resources of the Kansas State Board of Agriculture.

Geology and hydrology modified from Fent (1950a)

State Geological Survey of Kansas

MAP SHOWING WATER QUALITY IN RICE COUNTY, CENTRAL KANSAS

Bulletin 206
Part 3
Plate 2



Base from State Highway Commission of Kansas, 1965

Illustration prepared by Lanna J. Hentsch

Prepared by the State Geological Survey of Kansas and the United States Geological Survey, with the cooperation of Division of Environmental Health of the Kansas State Department of Health and the Division of Water Resources of the Kansas State Board of Agriculture.

Data in part from Fent (1950a)

EXPLANATION

GROUND WATER

• Test hole

○ Domestic or stock well

◉ Municipal well

○ Qal 323 / 88 43

Upper left symbol is aquifer (see list below); upper right number is concentration of dissolved solids, in milligrams per liter. Lower left number is depth of well or test hole below land surface, in feet; second number is concentration of chloride, in milligrams per liter

Qal — Alluvium and terrace deposits
Qds — Dune sand
Ql — Loess
Kd — Dakota Formation
Kk — Kiowa Formation
Psc — Stone Corral Formation

SURFACE WATER

△ Stream sampling site

△ 1242 / 12-45 540

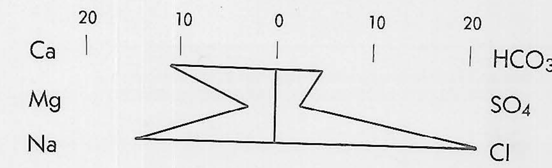
Upper number is concentration of dissolved solids, in milligrams per liter. Lower left number is month and year sample was collected; second number is concentration of chloride, in milligrams per liter

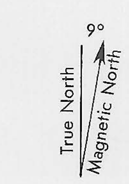
WATER QUALITY

Sample pattern diagram and well number

20-8W-13ccc

Concentration, in milliequivalents per liter





APPROXIMATE MEAN DECLINATION, 1973

Scale 1:126 720

1 0 ½ 1 2 3 MILES