Ground-Water Resources of the Kansas City, Kansas, Area

By

V. C. FISHEL

UNIVERSITY OF KANSAS PUBLICATIONS
STATE GEOLOGICAL SURVEY OF KANSAS
Bulletin 71
1948

THE UNIVERSITY OF KANSAS
STATE GEOLOGICAL SURVEY OF KANSAS

DEANE W. MALOTT, M. B. A., LL. D.,
Chancellor of the University, and ex officio Director of the Survey

RAYMOND C. MOORE, Ph. D., Sc. D.,
State Geologist and
Director of Research

JOHN C. FRYE, Ph. D.,
Executive Director

Division of Ground Water

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

BULLETIN 71

GROUND-WATER RESOURCES OF THE KANSAS CITY, KANSAS, AREA

By V. C. FISHEL

with analyses by

H. A. STOLTENBERG

Prepared by the State Geological Survey of Kansas and the United States Geological Survey, with the coöperation of the Division of Sanitation of the Kansas State Board of Health and the Division of Water Resources of the Kansas State Board of Agriculture

Printed by authority of the State of Kansas
Distributed from Lawrence

UNIVERSITY OF KANSAS PUBLICATIONS

FEBRUARY, 1948

PRINTED BY
FERD VOILAND, JR., STATE PRINTER
TOPEKA, KANSAS
1948

21-7167

STATE OF KANSAS

FRANK CARLSON, *Governor*

STATE BOARD OF REGENTS

DREW McLAUGHLIN, *Chairman*

JERRY E. DRISCOLL
FRED M. HARRIS
MRS. LEO HAUGHEY
WILLIS N. KELLY
LESTER McCOY
LA VERNE B. SPAKE
GROVER POOLE
OSCAR STAUFFER

MINERAL INDUSTRIES COUNCIL

B. O. WEAVER ('49), *Chairman*
LESTER McCOY ('48)
J. E. MISSIMER ('48)
J. A. SCHOWALTER ('48)
K. A. SPENCER ('49)
W. L. STRYKER ('49)
BRIAN O'BRIAN ('51) *Vice-Chairman*
M. L. BREIDENTHAL ('50)
HOWARD CAREY ('50)
JOHN L. GARLOUGH ('50)
JOHN B. ALLISON ('51)
O. W. BILHARZ ('51)

STATE GEOLOGICAL SURVEY OF KANSAS

DEANE W. MALOTT, M. B. A., LL. D., Chancellor of the University of Kansas, and ex officio Director of the Survey

RAYMOND C. MOORE, Ph. D., Sc. D., State Geologist and Director of Research

JOHN C. FRYE, Ph. D., Executive Director

BASIC GEOLOGY

STRATIGRAPHY, AREAL GEOLOGY, AND PALEONTOLOGY

John M. Jewett, Ph. D., Geologist
Lowell R. Laudon, Ph. D., Geologist *
A. B. Leonard, Ph. D., Paleontologist *
Marjorie Bradley, Stenographer
John W. Koenig, B. S., Assistant
Virginia C. Perkins, B. A., Assistant

PUBLICATIONS AND RECORDS

Betty J. Hagerman, Secretary
Grace Muilenburg, B. S., Draftsman
Jane Koenig, B. A., Draftsman
Dorothy M. Jindra, B. F. A., Draftsman
Bernice C. McClintock, Clerk-Typist

MINERAL RESOURCES

OIL AND GAS

Earl K. Nixon, A. B., Geologist
Vivian Barnes, Stenographer
Walter A. Ver Wiebe, Ph. D., Geologist *
Arden D. Brown, Well Sample Curator

MINERAL RESOURCES

INDUSTRIAL MINERALS AND CERAMICS

Norman Plummer, A. B., Ceramist
Ada Swineford, M. S., Geologist
W. H. Schoewe, Ph. D., Geologist *
Robert M. Dreyer, Ph. D., Geologist *
E. D. Kinney, M. E., Metallurgist *
William B. Hladik, Laboratory Technician
W. P. Ames, A. B., Laboratory Assistant
Ethel W. Owen, Laboratory Assistant
Carrie B. Thurber, Laboratory Assistant

GEOCHEMISTRY

Russell T. Runnels, B. S., Chemist
Marjorie Utter, B. S., Chemist
Nancy S. Hambleton, B. S., Chemist
Albert C. Reed, Assistant Chemist

SOUTHEAST KANSAS FIELD OFFICE

George E. Abernathy, E. M., Ph. D., Geologist
Christine Notari, Stenographer

WICHITA WELL SAMPLE LIBRARY

Ethelyn McDonald, M. A., Well Sample Curator
Della B. Cummings, Clerk

COÖPERATIVE PROJECTS WITH UNITED STATES GEOLOGICAL SURVEY

GROUND-WATER RESOURCES

V. C. Fishel, B. S., Engineer in Charge
Alvin R. Leonard, A. B., Geologist
Delmar W. Berry, A. B., Geologist
Glenn C. Prescott, M. S., Geologist
Howard G. O'Connor, B. S., Geologist
Charles K. Bayne, A. B., Instrumentman
W. W. Wilson, Scientific Aide
Janet Stevens, Stenographer

MINERAL FUELS RESOURCES

Wallace Lee, E. M., Geologist in Charge

TOPOGRAPHIC SURVEYS

C. L. Sadler, Division Engineer
Max J. Gleissner, Section Chief
J. P. Rydeen, Topographer

SPECIAL CONSULTANTS: Ray Q. Brewster, Ph. D., Chemistry; Eugene A. Stephenson, Ph. D., Petroleum Engineering.

COÖPERATING STATE AGENCIES: *State Board of Agriculture, Division of Water Resources,* George S. Knapp, Chief Engineer; Robert Smrha, Assistant Chief Engineer; *State Board of Health, Division of Sanitation,* Ben L. Williamson, Chief Engineer and Director; Ogden S. Jones, Geologist.

* Intermittent employment only.

CONTENTS

ILLUSTRATIONS

TABLES

GROUND-WATER RESOURCES OF THE KANSAS CITY, KANSAS, AREA

By V. C. Fishel

ABSTRACT

This report describes the ground-water resources in the industrial areas in the Missouri and Kansas River Valleys in Kansas City, Kansas, and the Kansas River Valley extending from Kansas City to Bonner Springs, Kansas. The part of the Missouri River Valley considered is known as the Fairfax Industrial District and comprises about 4 square miles. The Kansas River Valley area in Kansas City, Kansas, includes five industrial districts—the Woodswether, Central, Rosedale, Armourdale, and Argentine Districts. The five districts have a combined area of about 7 square miles. The climate is subhumid, the normal annual precipitation being 36.19 inches.

The bedrock underlying the part of the Missouri and Kansas River Valleys in the Kansas City area is in the Missourian Series of the Pennsylvanian System. The Missourian Series has a total thickness of about 600 feet and is characterized especially by prominence of numerous limestone beds separated by thin deposits of clayey to somewhat sandy shale. Broadly speaking, these rocks do not yield water to wells at large rates, but they supply much of the ground water for farm wells on the upland in Wyandotte County.

The alluvium in the Kansas and Missouri River Valleys consists of stream-laid deposits, probably including glacial outwash, that range in texture from clay and silt to sand and very coarse gravel. The thickness of the alluvium in a cross section of the Missouri River Valley, as determined by 11 test holes, averages 95 feet and the valley at the cross section is 2.1 miles wide. The average thickness of the alluvium in five cross sections in the Kansas River Valley ranges from 51 feet in a cross section near Bonner Springs to 77 feet in a cross section on Central Avenue in Kansas City. The width of the Kansas River Valley at the cross sections ranges from 1.0 to 1.6 miles. The ground water in the alluvium consists largely of water that has fallen as rain or snow and has percolated through the soil and subsoil materials to the water table.

The water table in the Fairfax District is from about 6 to 15 feet below the land surface. In the East Armourdale and Central Districts the water table generally is about 20 to 36 feet below the land surface, but at a few local points of heavy pumping it is somewhat lower. In the West Armourdale and Argentine Districts it ranges from 12 to 27 feet below the land surface and in the valley west of Argentine it ranges from about 10 to 30 feet below the land surface.

Two pumping tests were made in the Fairfax District, one test by the Corps of Engineers in 1944 and another test by the Layne-Western Company in 1941. From the data obtained it was computed that the alluvium in the Fairfax District has a coefficient of permeability of about 3,000 gallons a day per square foot.

Most of the wells constructed in recent years are of the gravel-pack type and are about 16 inches in diameter. The yields of 51 wells and the drawdowns for most of these wells are given. Twenty-two of the wells are in the Missouri River Valley and have an average yield of 980 gallons a minute and an average specific capacity of 180 gallons a minute per foot. Twenty-nine of the wells are in the Kansas River Valley and have an average yield of 650 gallons a minute and an average specific capacity of 60.

The industrial use of ground water in the Kansas City, Kansas, area is almost entirely for cooling and condensing purposes. It amounts to about 35,000,000 gallons a day and includes about 17,400,000 gallons a day in the Fairfax District, about 10,300,000 gallons a day in the East Armourdale and Central Districts, about 6,600,000 gallons a day in the Argentine and West Armourdale Districts, and about 700,000 gallons a day in the Kansas River Valley west of Kansas City.

The ground water in the alluvium in the Missouri and Kansas River Valleys is very hard and contains large amounts of iron. Of 75 samples of water collected in the area all but 3 contained more than 2.0 parts per million of iron and most of the samples contained more than 5.0 parts. The samples of water from the Missouri River Valley and from the Kansas River Valley west of Kansas City contained less than 100 parts per million of chloride but the samples collected in the Argentine, Armourdale, and Central Districts contained much greater amounts of chloride; 13 samples contained more than 200 parts per million of chloride and 5 samples contained more than 1,000 parts.

The report contains a map of the area showing the locations of wells and test holes. Maps that include only the area within Kansas City show contours on the bedrock and the thickness of the saturated alluvium. The field data upon which most of this report is based are given, including records of 81 wells and 86 test holes and chemical analyses of the water from 75 wells and test holes. Logs of 126 test holes and wells are given, including 59 test holes put down by the State Geological Survey.

INTRODUCTION

Purpose and scope of the investigation.—The investigation upon which this report is based was begun in July 1943 as part of a program of ground-water investigations in Kansas by the United States Geological Survey and the State Geological Survey of Kansas in coöperation with the Division of Sanitation of the Kansas State Board of Health and the Division of Water Resoures of the Kansas State Board of Agriculture. Similar investigations are being conducted in several other areas in Kansas.

For many years there has been a steady increase in the use of ground water for industrial purposes in Kansas City, Kansas. During the war this increase was greatly accelerated by the needs of military and naval establishments and by the need for increased production from many old industrial plants and from many large new war plants. The increasing development of water for industrial use has made it necessary that a better understanding of the hydrology of this area be acquired.

Location and extent of the area.—This report considers chiefly the industrial areas in the Missouri and Kansas River Valleys in Kansas City, Kansas, and the Kansas River Valley extending from Kansas City to Bonner Springs, Kansas. Kansas River joins Missouri River in Kansas City, Kansas. Most of the area considered in the report is within Wyandotte County, Kansas, but small areas are in Johnson County, Kansas, and Jackson and Platte Counties, Missouri. The part of the Missouri River Valley herein considered is known as the Fairfax Industrial District and comprises about 4 square miles. The Kansas River Valley area in Kansas City, Kansas, includes five industrial districts which are, beginning at the mouth of the river, the Woodswether, Central, Rosedale, Armourdale, and Argentine Districts. The five districts have a combined area of about 7 square miles. The location of the area is shown in Figure 1.

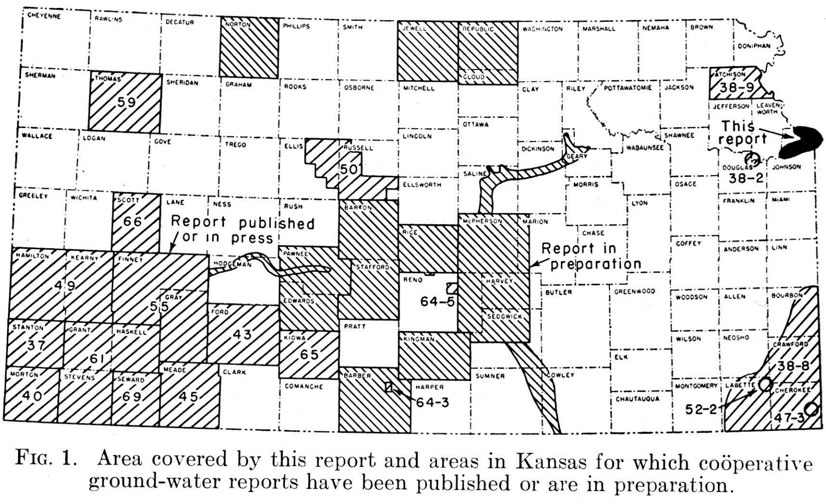

FIG. 1. Area covered by this report and areas in Kansas for which coöperative ground-water reports have been published or are in preparation.

Previous investigations.—The more important papers that have a bearing on the geology and ground-water resources of the Kansas City, Kansas, area are cited below. Many of the investigations in this area have been concerned with the stratigraphy of the Pennsylvanian rocks. Earlier investigations on the stratigraphy of the Pennsylvanian rocks of Kansas are discussed by Moore (1935) who gives an excellent bibliography for each Pennsylvanian formation. In 1902, Bailey prepared a special report on mineral waters in Kansas which includes the analyses of some waters from the bedrock formation in the Kansas City area. In 1917, McCourt and others of the Missouri Bureau of Geology and Mines published a report on the geology of Jackson County, Missouri, which is adjacent to Kansas City, Kansas. This report includes a short chapter on underground water. Reports by Newell (1935) and by Jewett and Newell (1935) on the geology of Johnson, Miami, and Wyandotte Counties were also published. In 1940, Moore prepared a generalized report on the ground-water resources of Kansas, which includes references to the rocks cropping out in the Kansas City area.

A report (Meinzer and Wenzel, 1946, p. 160) on water levels and artesian pressures in the United States in 1943 contains a chapter on the observation-well program in Wyandotte County. Additional reports of this series will be published annually. A report on the availability of ground-water supplies for national defense industries in Kansas discusses briefly the availability of ground-water supplies in the Kansas and Missouri River Valleys. (Lohman and others, 1942, pp. 29-32.)

Methods of Investigations.—The investigation upon which this report is based was begun in the summer of 1943 when I spent about 2 months in the area. Well owners and drillers were interviewed regarding the nature and thickness of the water-bearing formations penetrated by the wells and all available logs were collected. Information regarding the yields of wells, water levels in wells, temperature of the water, chemical character of the water, and the use of ground water was obtained.

Samples of water were collected from 23 wells and 51 test holes and were analyzed by H. A. Stoltenberg, chemist, in the Water and Sewage Laboratory of the Kansas State Board of Health at Lawrence. In addition an analysis of water from the public supply at Bonner Springs was supplied by the Kansas State Board of Health, making a total of 75 analyses for the area. The determinations of free carbon dioxide and pH of the water were made by Mr. Stoltenberg at the well site with portable apparatus.

During the summer of 1944, 59 test holes (Pl. 1) were drilled in the area by O. S. Fent and Milford Klingaman, using the portable hydraulic-rotary rig owned by the State Geological Survey of Kansas. Samples of drill cuttings were collected and studied in the field by Mr. Fent and were later examined in the office by me. Additional logs were made available by the Layne-Western Company; by the Corps of Engineers, U. S. Army; and by the chief engineers of some of the industrial plants.

Altitudes of the measuring points were established at some of the wells and of the land surface, at each of the test holes put down by the drilling rig. The levels were run from benchmarks of the United States Coast and Geodetic Survey by Charles K. Bayne and Ray Miles, using a plane table and telescopic alidade.

Field data were compiled on topographic maps of the U. S. Geological Survey and the base map for Plate 1 was prepared from these maps.

Acknowledgments.—I am indebted to the many residents of the area who kindly supplied information regarding ground-water conditions. Acknowledgment is given for the fine coöperation of all the industrial-plant engineers who made available much information regarding the wells of their respective plants. Harry Higgins, Industrial Engineer for the Union Pacific Railroad Company, supplied much information regarding the Fairfax Industrial District and made available many well logs.

Acknowledgment is given to the Corps of Engineers, U. S. Army, for permitting me to participate in several pumping tests conducted by the Corps of Engineers in the Fairfax Industrial District. Data collected during the pumping tests and logs of test holes were made available. I spent several days in the field and office with W. A. Wall and R. A. Sackewitz in connection with the pumping tests.

Many wells and test holes have been drilled in the Missouri and Kansas River Valleys in the Kansas City area by the Layne-Western Company. Special acknowledgment is given to R. O. Joslyn and L. H. Heckman, President and Vice-President, respectively, for making available well records collected by their company over a period of many years of operation in this area. P. S. Judy, president of Air-Made Well Company, supplied much information regarding ground-water conditions in the Kansas City area and gave permission to use his drainage well as an observation well (No.138).

Clifton Roberts, Vice-President of the Kansas City, Kansas, Chamber of Commerce, supplied information concerning industries. J. M. Jewett of the State Geological Survey of Kansas supplied much information regarding the geology and ground-water resources of the area in advance of the field work and generously gave much help and advice during the course of the investigation.

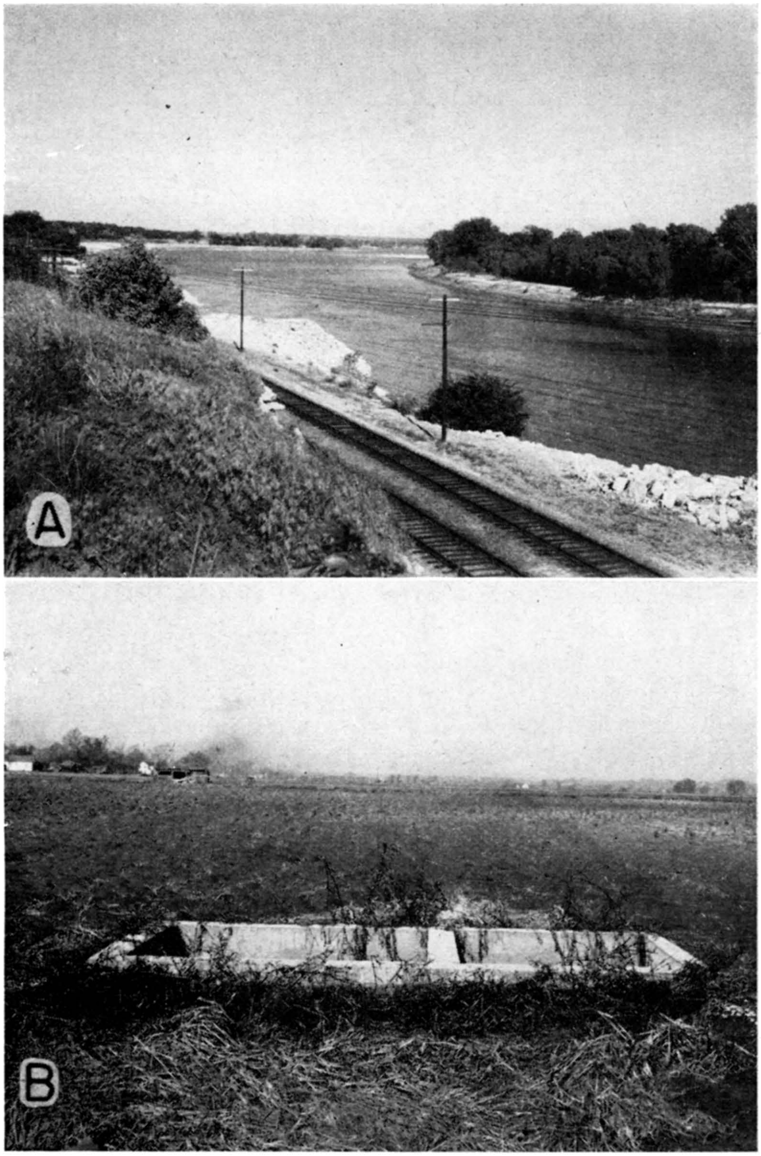

PLATE 2. *A*, Kansas River Valley looking east from a point about 1 mile west of Muncie on Highway K-32. *B*, Well 138 in the Kansas Valley, which is used as a drainage well.

The manuscript for this report has been critically reviewed by several members of the Federal Geological Survey; by R. C. Moore, Director of Research, and J. C. Frye, Executive Director of the State Geological Survey of Kansas; by George S. Knapp, Chief Engineer of the Division of Water Resources, Kansas State Board of Agriculture; and by Paul D. Haney, Director, and Ogden S. Jones, Geologist, of the Division of Sanitation, Kansas State Board of Health. The manuscript was edited by Betty Hagerman and the illustrations were drafted in final form under the supervision of Eileen Martin and Robyn Ashby Addis.

GEOGRAPHY

Topography and Drainage

The land surface consists of rolling uplands occupying the divide between Kansas and Missouri Rivers, and a relatively large area occupied by the stream valleys (Pls. 1 and 2A). The area covered by the valleys of the two rivers and their principal tributaries includes a considerable part of Wyandotte County. The flood plain of the Missouri River, which adjoins the county ranges from 2 to more than 3 miles in width, and that of Kansas River averages slightly more than 1 mile, being somewhat narrower in Wyandotte County than in many areas to the west. High bluffs rise above the flood plains of both rivers.

Culture and Resources

The following statements are based in part on data furnished by the Chamber of Commerce of Kansas City, Kansas, and in part on the 1940 census by the U. S. Bureau of the Census.

Kansas City, Kansas, is situated in Wyandotte County and has an area of 21 square miles. In 1940 Wyandotte County had a population of 154,071, of which 121,458 were in Kansas City. The population of Kansas City has increased considerably since 1940 as a result of the construction of several large war plants in the area and the enlargement and conversion of existing industries for war purposes.

The numerous industries in Kansas City, Kansas, include meat packing, flour milling, grain storage, walnut lumber milling, dairying, soap manufacturing, petroleum refining and distribution, fibre box and bag manufacturing, and steel fabricating. In 1940 there were 270 industrial plants in the city.

The Kansas City area is served by 12 railroad trunk lines, 3 air lines, and 53 motor-truck lines. It is the center of a network of excellent highways, including U. S. Highways 24, 40, 50, 69, 73, and 169 and Kansas Highways 5, 10, 32, 58, and 132.

Improvement of the Missouri River channel between St. Louis and Kansas City has linked this city with the inland waterways system which serves many ports including those of the Gulf of Mexico and the Great Lakes. Completion of work now under way will provide navigable water as far north as Omaha, Nebraska, and Sioux City, Iowa.

Climate

The Kansas City, Kansas, area is in a region well supplied with rainfall, especially during the growing season. In common with parts of the country far removed from large bodies of water, it is subject to hot periods during the summer season and to severe drops

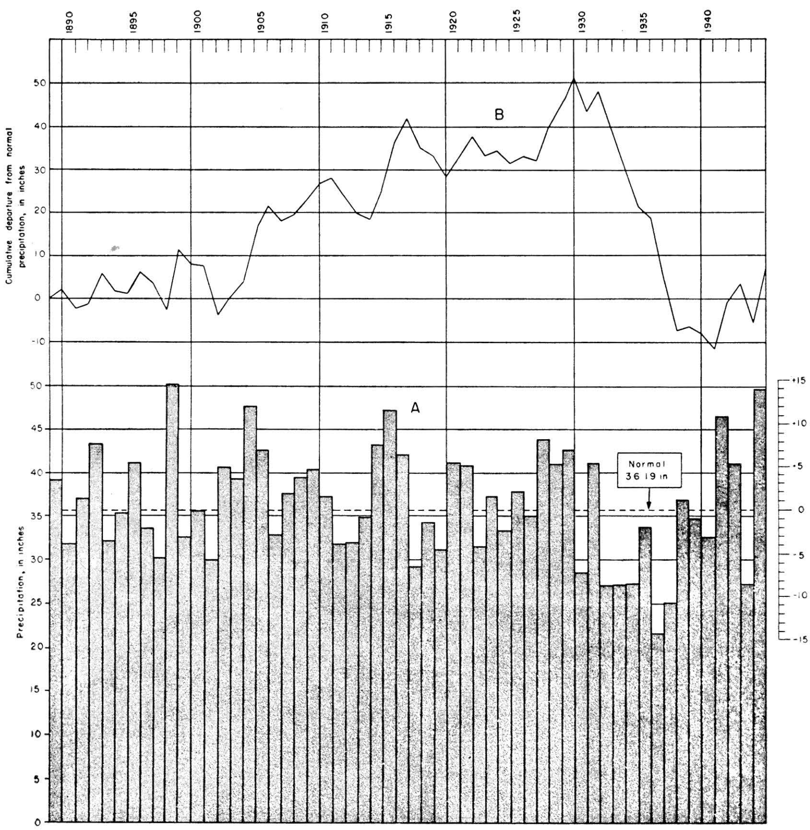

FIG. 2. Annual precipitation and cumulative departure from normal precipitation at Kansas City, Missouri.

in temperature during the winter. During the summer hot spells temperatures may reach 100° to 105° F. for several days in succession and at night the temperature may not drop much below 70° to 75°. Cold waves occasionally sweep in from the plains to the northwest, and, if the ground is covered with snow, cold weather may persist for several weeks, although temperatures below zero rarely persist as long as three days.

According to the records of the U. S. Weather Bureau's station at

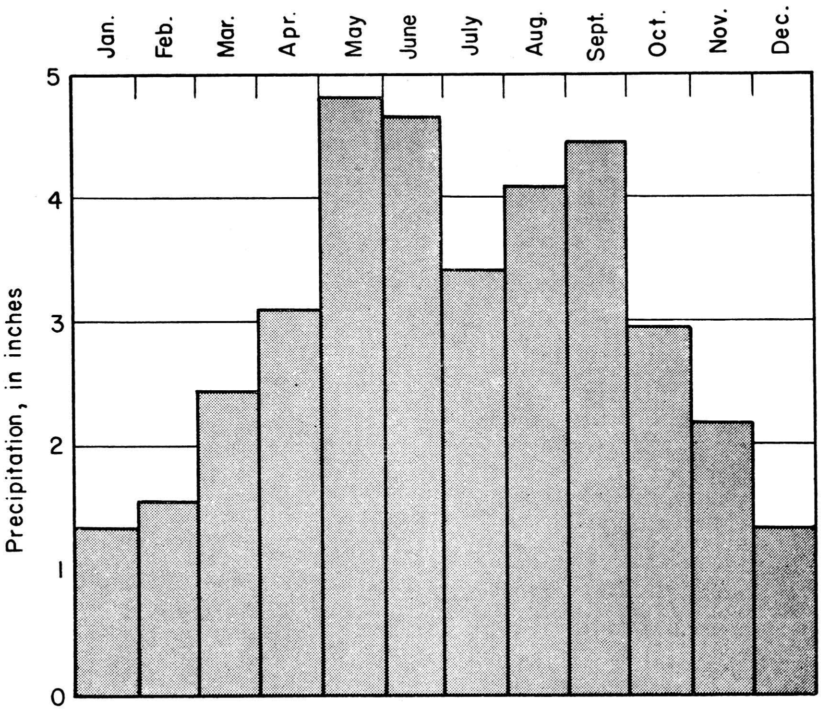

FIG. 3. Monthly distribution of precipitation at Kansas City, Missouri.

Kansas City, Missouri, the greatest annual precipitation on record in this area was 50.25 inches in 1898. The normal precipitation is 36.19 inches (Fig. 2). The greatest precipitation is during the summer months and the least precipitation is during December, January, and February (Fig. 3).

The mean annual temperature in this area is 54.4° F., but the highest temperature recorded was 108° F., and the lowest was -22° F. The average date of the last killing frost in the spring is April 9, but killing frosts have occurred as late as May 25. The first killing frost in the fall has occurred as early as September 30, but its average date is October 28. The average length of the growing season is 202 days.

GEOLOGY IN RELATION TO GROUND WATER

This report is chiefly concerned with the geology and the occurrence of ground water in the alluvium in the Kansas and Missouri River Valleys. Brief consideration is given, however, to the underlying bedrock which is in the Pennsylvanian System and to the glacial drift and loess of Pleistocene age.

Pennsylvanian System

The bedrock underlying the Kansas City area belongs to the Kansas City, and Lansing groups of the Missourian Series of the rock classification called the Pennsylvanian System (Jewett and Newell, 1935, pp. 159-185; Moore, 1940, pp. 43-48).

The Missourian Series has a total thickness of about 600 feet and is characterized especially by numerous limestone beds separated by clayey to somewhat sandy shale. Broadly speaking, these rocks are not good aquifers, but they supply much of the ground water for farm wells on the upland in Wyandotte County. During years of low precipitation many of these farm wells either go dry or yield inadequate supplies of water for domestic and stock needs. Limestones that are water-bearing near the outcrops include especially the Stanton, Plattsburg, Wyandotte, Iola, and Dennis limestones.

Quaternary System

The consolidated rocks of this area are to a large extent overlain by much younger unconsolidated materials. These deposits consist of glacial drift and loess of Pleistocene age and alluvium of Pleistocene and Recent age.

PLEISTOCENE SERIES

During Pleistocene time the northern part of the United States was invaded by several successive ice sheets or glaciers, some of which reached to and in some places beyond the Missouri and Kansas River Valleys. According to Darton (1915, p. 5):

> In the earlier part of the glacial epoch, called the Kansan stage, the ice sheet extended from the north halfway across northeastern Kansas, reaching the present valley of Kansas River and in places extending a few miles south of it. Probably the ice sheet had much to do with determining the position of the Kansas River Valley, for the river began at that time to flow in its

present general course. This ice sheet covered about 4,000,000 square miles in northern North America about 300,000 years ago and endured for a long time. It was several thousand feet thick, and it accumulated at a time when the fall of snow was in excess of melting and evaporation. Its southern edge was in the zone where melting kept pace with the advance of the ice, and apparently in some stages of its existence its margin remained at the same place for a long time. Its flow was due mainly to the thickness of the ice, for the land does not at all slope downward to the south, which was the direction of the movement.

As the glacier moved along it picked up large quantities of rock and soil. This material was slowly carried southward and in some areas accumulated at the southern edge of the ice in a deposit known as a terminal moraine. When melting gained on the rate of advance the glacial front receded and the clay, sand, gravel, and boulders which the ice had contained were left behind in a sheet covering the rocks of the country. This deposit is called till or drift.

According to Jewett and Newell (1935, p. 185):

The oldest deposits of Pleistocene age recognized in Wyandotte County are isolated remnants of till of Kansan age occurring in places on the hilltops. These deposits are rare and consist of a heterogeneous association of erratics, worn boulders of local limestone, and sand. The foreign boulders and pebbles consist mainly of Sioux quartzite, with numerous granites and metamorphic rocks.

These glacial deposits are located above the water table in Wyandotte County and, consequently, are of little importance as a source of ground water.

PLEISTOCENE AND RECENT SERIES

Loess.—Younger deposits of probable Pleistocene age include the widespread loess, a yellowish to brownish fine-grained silt found bordering the valleys. The loess covering is thickest along the edge of the bluff of Missouri River, where in some places it attains a thickness of more than 50 feet. Farther from the edges of the valley it is much thinner and gradually becomes indistinguishable from the soil covering. The loess is absent along the north side of Kansas River between Edwardsville and Bonner Springs, probably having been removed by erosion inasmuch as it is continuous along the south wall of the valley. South of Bonner Springs loess covers the indurated formations as far west as Loring. The eastern part of Wyandotte County is covered by an irregular layer of loess, effectively hiding the underlying formations in the vicinity of Kansas City.

Some farms in Wyandotte County obtain meager ground-water supplies from wells in loess. The loess is very porous, but its fine texture makes it relatively impervious. Where water-bearing, it yields a low flow into wells, and although these wells may afford a steady source of supply, none of them yield large quantities of water.

Alluvium.—Alluvium of Recent age and probably some of Pleistocene age occurs in the Kansas and Missouri River Valleys and some of their larger tributaries. The alluvium consists of stream-laid deposits that range in texture from clay and silt to sand and very coarse gravel. The character of the alluvium varies greatly depending on its origin and mode of deposition. Much of the alluvium in the Kansas Valley near Kansas City probably is of glacial origin, having been deposited as glacial outwash by the swollen streams that emanated from the melting ice sheets. Test holes were drilled along five lines across the Kansas Valley and along one line across the Missouri Valley to determine the thickness and character of the alluvium in the two valleys. Another line of test holes was drilled across part of the Missouri Valley. The cross sections and locations of the cross sections are shown in Plate 1, and the logs of the test holes are given at the end of this report. As shown by the cross sections, the thickness of the alluvium in the Kansas Valley ranges from about 51 to 77 feet. The width of the Kansas Valley at the cross sections ranges from 1.0 to 1.6 miles. The alluvium in the Missouri Valley averages 95 feet in thickness and the valley at that cross section is 2.1 miles wide. The thickness of the alluvium and the width of the valley at each cross section are given in Table 1.

TABLE 1. *Thickness of the alluvium and width of valley for five cross sections in the Kansas River Valley and one cross section in the Missouri River Valley*

VALLEY	Cross section	Number of test holes	Width (miles)	Average thickness. (feet)
Missouri	A–A′	11	2.1	95
Kansas	C–C′	7	1.4	77
Kansas	D–D′	5	1.2	76
Kansas	E–E′	8	1.6	71
Kansas	F–F′	7	1.0	61
Kansas	G–G′	10	1.2	51

The logs and cross sections (Pl. 1) indicate that the material above the water table is not as permeable as that at greater depth. Several feet of the surficial material is composed largely of silt and clay but most of it is slightly sandy. The surficial material is underlain by gravel and sand interbedded with lenses of silt and clay.

The altitudes and shape of the surface of the bedrock beneath the alluvium in the Kansas and Missouri River Valleys in the Kansas City area are shown in Figure 4 by contour lines, based on the records of the test holes drilled by the State Geological Survey, records of test holes supplied by the Corps of Engineers, U. S. Army, and reported depths to bedrock in many industrial wells. In general, the valleys have wide and relatively flat bedrock floors. The bedrock rises abruptly from the channels beneath the valley and crops out at an altitude of approximately 760 feet along the marginal areas.

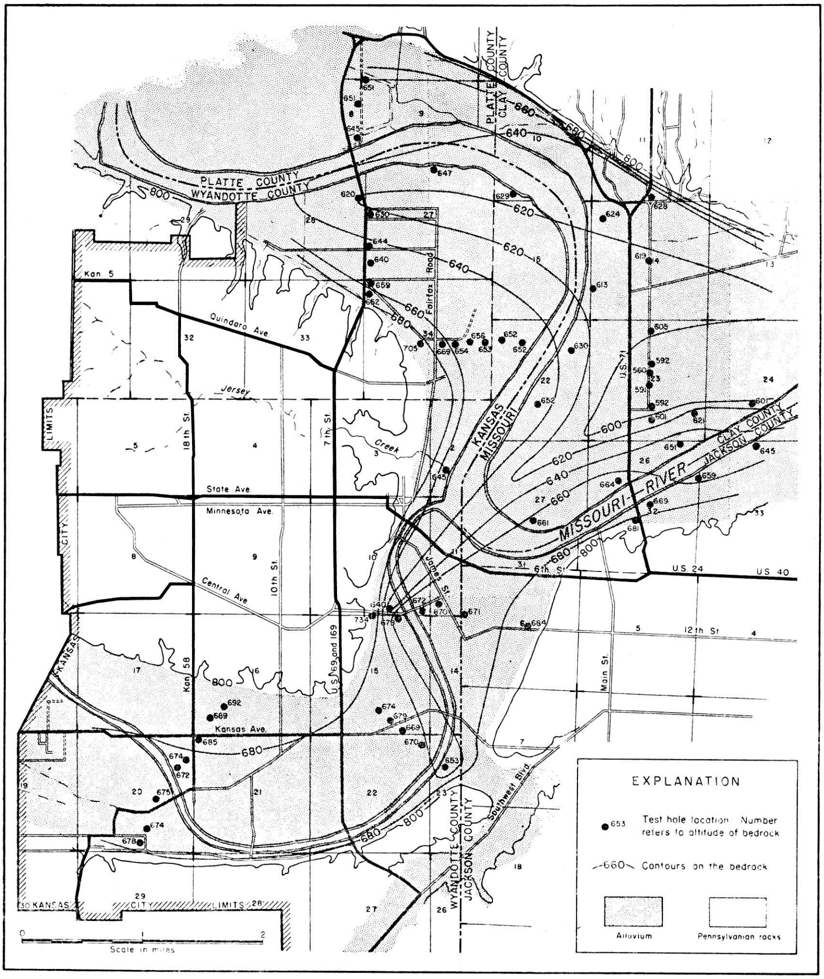

Fig. 4. Contours on the bedrock in the Kansas and Missouri River Valleys in the Kansas City, Kansas, area.

Test holes drilled by the Corps of Engineers revealed the presence of a deep and narrow channel extending northeastward from the mouth of the Kansas River. It will be noted in cross section C-C′ (Pl. 1) that there is a deep narrow channel near the western edge of the valley, and that in cross section D-D′ (Pl. 1) the bedrock is low at test hole 101. No evidence is available, however, to indicate that the channel extends farther up the Kansas River Valley. There is a possibility that this channel extends up Turkey Creek Valley and that it was formed during Pleistocene time. According to McCourt and others (1917, pp. 81-82):

> During the Tertiary epoch there are indications that the drainage was to the east. . . . Turkey Creek then flowed across the site of Kansas City, joining the Big Blue near its mouth. . . . When the ice front pushed south, it came to the large river that occupied the present Kansas and lower Missouri Valleys. The ice front was probably lobed and it seems that two of these lobes pushed across the river, one into the northern part of Kansas City and one into the region near Sibley, at first damming back the streams and then forcing them across low points on the divides. The Kansas was in this way forced into the former valley of Turkey Creek. . . . With the melting of the Kansan glacier, . . . the new streams thus formed received large quantities of water from the melting of later ice sheets in the northern states. Turkey Creek took advantage of the new opening into the Kansas and abandoned its pre-glacial valley.

SOURCE, OCCURRENCE, AND MOVEMENT OF THE GROUND WATER

Throughout most of the land area of the earth the rock formations in a certain zone are fully saturated with water. The lower limit of this zone is found at a variable but generally great depth, below which the pressure is so great that pores capable of holding water cannot exist in the rocks. The upper surface of the zone of saturation is known as the water table, and in different places it may lie at the surface or at depths as much as several hundred feet below the surface, depending on the character of the rocks and the climate. The water in the upper part of the zone of saturation is generally replenished from precipitation, some of which reaches the water table by percolation downward through the soil. Normally the water that reaches the water table moves slowly toward the streams and discharges into them. Before all the ground water above stream level can be drained away, more water is generally added from the surface, keeping the water table somewhat above stream level in the inter-stream tracts, though fluctuating as the recharge is momentarily more or less than the discharge. Owing to the continuous process of draining and the intermittent nature of recharge, the water table is in continuous fluctuation.

The ground water in the alluvium of the Kansas and Missouri River Valleys consists largely of water that has fallen in the form of rain and snow and has percolated through the soil and subsoil materials to the water table. In areas of heavy pumping of ground water, as in parts of the Kansas River area in Kansas City, Kansas, the water table may be lower than the water surface in the river and the aquifer may receive recharge from the river.

The water in the alluvium occurs in the interstices between particles of clay, silt, sand, and gravel. The rate at which water moves through these materials depends on the hydraulic gradient, or slope of the water table, and on the size and shape of the interstices. The amount of water available for pumping also depends on the thickness of the saturated alluvium. Water moves freely through coarse gravels even under low hydraulic gradients, whereas it moves with extreme slowness through compact clay even under high hydraulic gradients. Although considerable quantities of water may move through beds of compact clay over very long periods of time, these deposits are regarded as being essentially impervious, and their importance with respect to ground water in some places is merely that they may serve as confining beds for water in adjacent beds of more permeable material.

The approximate rate of movement of the water through the gravel, sand, and silt can be obtained by application of the following formula given by Wenzel (1942, p. 71, equation 49): $v = \frac{PI}{p}$. Where v is the average velocity of the ground water, P is the coefficient of permeability, I is the hydraulic gradient, and p is the porosity. If P is defined in Meinzer's units (gallons per day per square foot under a hydraulic gradient of 100 percent and a temperature of 60° F.), if I is given in feet per mile, and if p is given in percentage, v will be given in feet per day by the following formula: $v = \frac{PI}{395\ p}$.

The coefficient of permeability of the water-bearing material at well 16, as determined by a pumping test, is about 3,000 gallons a day per square foot. The hydraulic gradient is about 5 feet to the mile. For an assumed porosity of 30 percent the average velocity of the ground water can be computed by the above formula as follows:

$$v = \frac{3{,}000 \times 5}{395 \times 30} = 1.3 \text{ feet per day.}$$

For silt having a coefficient of permeability of 10 gallons a day per square foot and a porosity of 30 percent the ground water would have a velocity of about 0.05 inch per day under a hydraulic gradient of 5 feet to the mile.

The depths to water level in the wells and test holes that were measured during the course of this investigation are given in Table 9 and are also shown on Plate 1. The depths to water level in many of the test holes are shown on the cross sections in Plate 1 and are also given in logs of wells and test holes at the end of this report.

The water table in the Fairfax District lies from about 6 to 15 feet below the land surface, but it may be considerably lower in

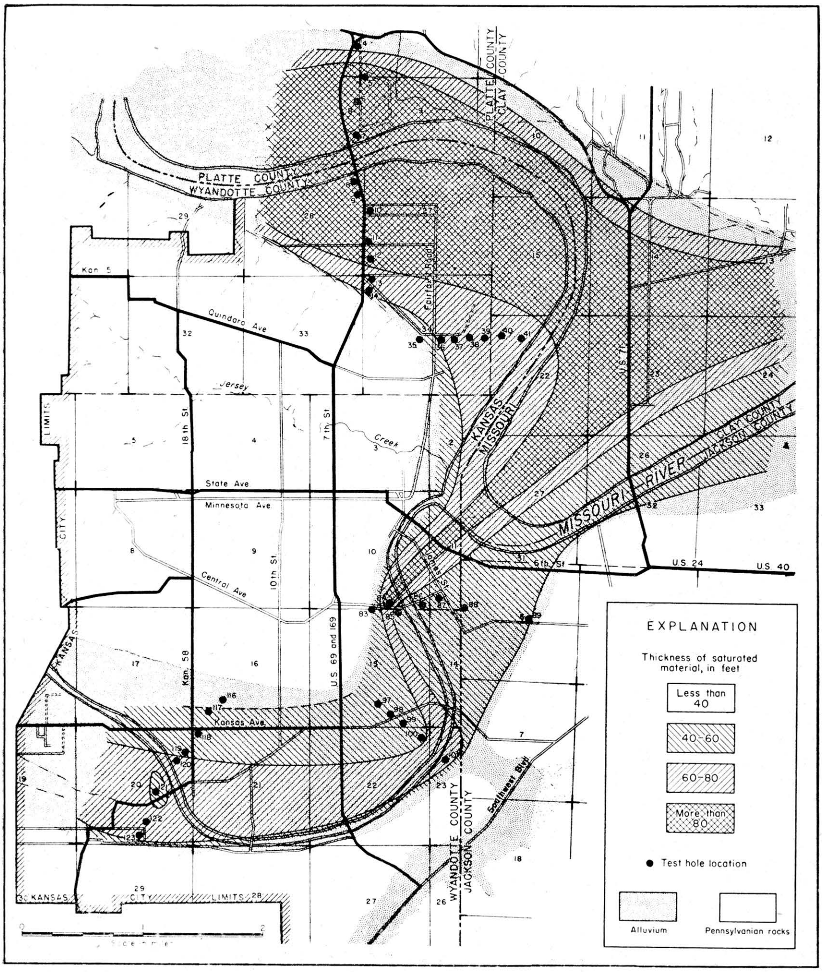

FIG. 5. Thickness of the saturated alluvium in the Kansas and Missouri River Valleys in the Kansas City, Kansas, area.

local cones of depression near pumped wells. In the East Armourdale and Central Districts the water table generally is about 20 to 36 feet below the land surface, but at a few local points of heavy pumping it is somewhat lower. In the West Armourdale and Argentine Districts it ranges from 12 to 27 feet below the land surface and in the valley west of Argentine it ranges from about 10 to 30 feet below the land surface. In the valley west of Argentine the depth to the water table depends more on the topography and drainage than on the utilization of ground water.

The approximate thickness of the saturated alluvium in the Kansas and Missouri River Valleys is shown in Figure 5. The Missouri Valley includes a large area having a saturated thickness of more than 80 feet, and at test hole 9 the saturated thickness is more than 100 feet. A narrow strip having a saturated thickness of more than 80 feet extends up the Kansas Valley as far as Central Avenue. Other factors being equal, the largest yields from wells would be expected in the area having a saturated thickness of more than 80 feet. Most of the alluvium in the Kansas Valley in Kansas City, Kansas, has a saturated thickness ranging from 40 to 60 feet, but in a strip extending from the Argentine District to the Missouri Valley the saturated thickness ranges from 60 to 80 feet. The thickness of the saturated alluvium decreases toward the edges of the valleys, where along narrow strips it ranges from a featheredge to 40 feet.

PERMEABILITY OF THE WATER-BEARING MATERIALS

The permeability of water-bearing materials may be determined by laboratory tests of samples of the materials, by determinations of ground-water velocity in the field, and by pumping tests made on wells that draw water from the materials.

The pumping-test method, which was the only method applied in this area, was used to determine the permeability of the alluvium in the Fairfax District. The particular technique used consists of pumping a well that penetrates water-bearing material whose permeability is to be determined, and observing the decline of the water level in several observation wells near the pumped well. The method is based on the consideration that, after approximate equilibrium is established in the shape of the water table around a pumped well, equal quantities of water move toward the well in a given unit of time through a successive series of coaxial cylindrical surfaces around the well. Because the areas of the large cylinders through which the water percolates are greater than the areas of the smaller cylinders, the velocity of the ground water passing through them is proportionately less, and the hydraulic gradients are proportionately smaller. According to Darcy's fundamental law the discharge, Q, through any of the concentric cylindrical sections of water-bearing material, is equal to PiA, and the permeability of the material, P, equals $\frac{Q}{iA}$ where i is the hydraulic gradient at a point on the cone of depression around the discharging well and A is the area of the cylindrical surface at the point where i is determined. Wenzel (1942, pp. 77-79) presents the following formula, known as the Thiem formula, for determining the permeability of water-bearing materials:

$$P = \frac{Q\ (\log_e r_2 - \log_e r_1)}{\pi\ (h_2^2 - h_1^2)}$$

where Q is the discharge of the pumped well, and h_1 and h_2 are the thicknesses of the saturated material at two observation wells located at distances of r_1 and r_2, respectively, from the pumped well. In the above equation $h_2^2 - h_1^2 = (h_2 + h_1)\ (h_2 - h_1 = 2m\ (h_2 - h_1)$ where m is the average thickness of the saturated water-bearing material. It is taken as the average thickness of the saturated material at the observation wells after the water levels have declined to an approximate "equilibrium" condition. Then:

$$P = \frac{Q\ (\log_e r_2 - \log_e r_1)}{2\pi\ m\ (h_2 - h_1)}$$

If the rate of pumping is given in gallons a minute and the logarithms are converted to base 10, the above formula for the permeability in Meinzer's units becomes:

$$P = \frac{527.7\,q}{m} \frac{(\log_{10} r_2 - \log_{10} r_1)}{(h_2 - h_1)}$$

$$= \frac{527.7\,q}{m} \frac{\Delta \log_{10} r}{\Delta h}.$$

The coefficient of permeability as defined by Meinzer is expressed as the number of gallons of water a day, at 60° F., that is conducted laterally through each mile of the water-bearing bed under investigation (measured at right angles to the direction of flow) for each foot of thickness of the bed, and for each foot per mile of hydraulic gradient (Stearns, 1927, p. 148). The value of $\frac{\Delta \log_{10} r}{\Delta h}$ is obtained by making use of the straight line relation that exists when the altitudes or drawdowns of the water levels in the observation wells are plotted on a linear scale against the distances of the observation wells from the pumped well on a logarithmic scale. The value of $\frac{\Delta \log_{10} r}{\Delta h}$ is given by the slope of the straight line. If values of $\frac{\Delta \log_{10} r}{\Delta h}$ are selected from the straight line with values of r between 10 and 100 feet (or between 100 and 1,000 feet), $\Delta \log_{10} r$ becomes unity, and the formula becomes: $P = \frac{527.7 q}{m \Delta h}$.

Pumping tests were made on well 16 (Pl. 1) by the Corps of Engineers, U. S. Army, during January and February, 1944, and on well 49 (plant well 6) at the Phillips Petroleum Company by Layne-Western Company in July 1941.

Pumping Test on Well 16

A series of pumping tests was made on well 16 (Pl. 3) by the Corps of Engineers in January and February, 1944. The data for these tests were kindly made available by the Corps of Engineers. The well is located about 350 feet east of the south end of the bridge across the Missouri River on U. S. Highways 69 and 169 and about 160 feet (south) from the landward toe of the levee along Missouri River. Well 16 was constructed especially for these tests and was later filled in. It was drilled to a depth of 95 feet and was cased with 12-inch porous concrete drain tile. The saturated alluvium was about 105 feet thick at the well.

Thirty-eight observation wells were constructed along three equally spaced radial lines (A, B, and C) extending out from the pumped well. Line A extended to the north and was perpendicular to the river, line B extended to the southeast, and line C extended to the southwest. The observation wells in each line were located at distances of 5, 15, 35, 75, and 155 feet from the pumped well. The observation wells at each of these points were sunk to three different depths roughly representing penetrations of 25, 50, and 75 percent of the saturated thickness (Pl. 3). The pumped well penetrated approximately 70 percent of the saturated thickness, and a series of pumping tests was performed using the well at this depth. Then the well was plugged at several depths in succession, and the tests repeated at each of these depths to determine the effects of the partially penetrating well. Each series of tests included pumping the well at different discharge rates until the water levels in the observation wells reached equilibrium. The altitudes of the water levels for approximate equilibrium conditions in the observation wells having a penetration of 50 percent are given in Table 2 for 14 of the tests.

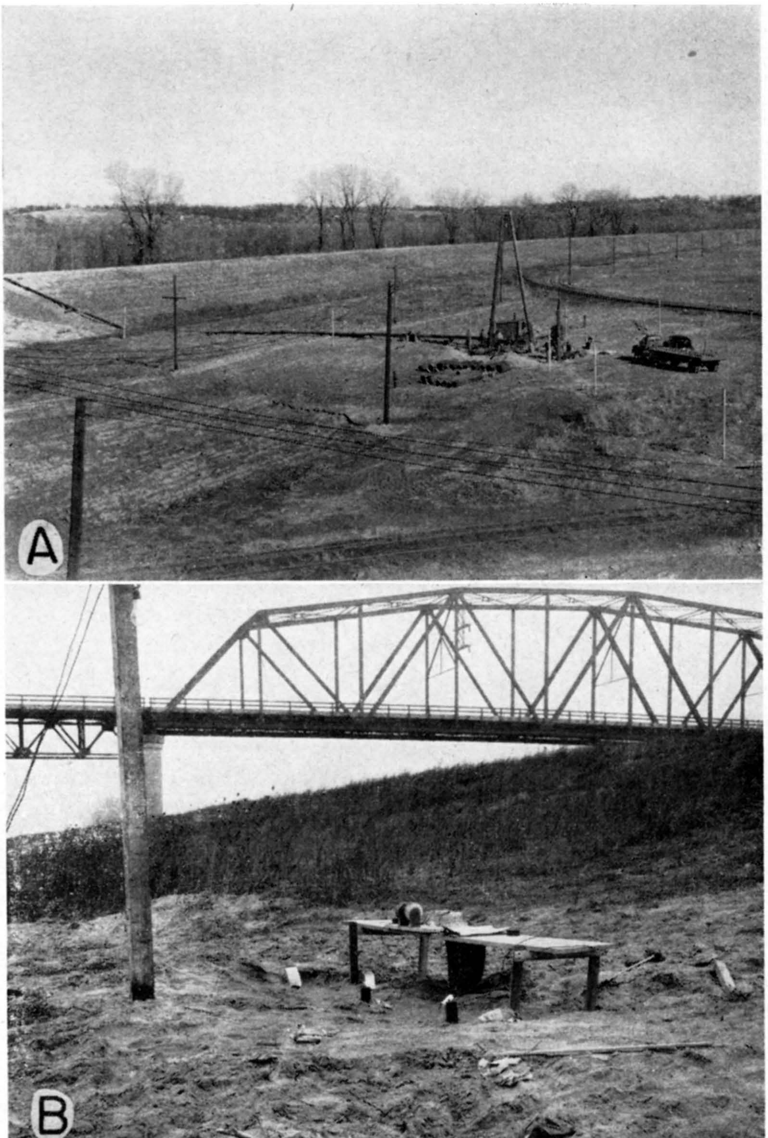

PLATE 3. *A*. Pumping test on well 16 in the Fairfax District, facing east from the bridge on U. S. Highways 69 and 169. *B,* Close-up view showing tops of three observation wells that are located at each point and the electrical apparatus for measuring the water levels.

The altitudes of the water levels for each test given in Table 2 were plotted on semilogarithmic paper against the distances of the observation wells from the pumped well as shown on Figure 6 for test 1. The altitudes of the water level for r at distances of 10 and 100 feet were obtained from the straight lines. The difference in altitude at distances of 10 and 100 feet is equal to Δ h in the above equation for computing the coefficient of permeability. The coeffi-

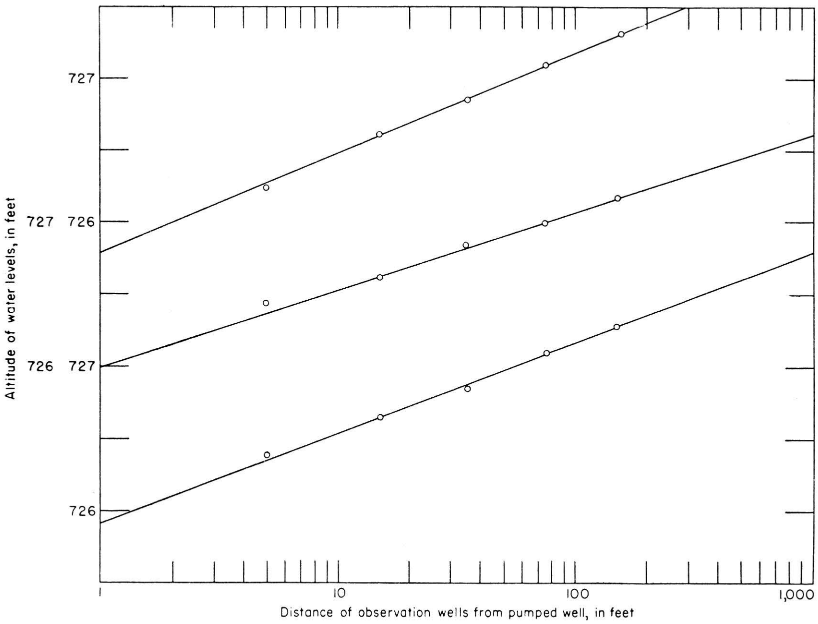

Fig. 6. Altitude of water levels plotted against the distance of the observation wells from the pumped well during the test on well 16.

cients of permeability were computed for each line of wells for each test and are given in Table 3. The average thickness of the saturated material at the observation wells during the pumping tests was variable but was approximately 100 feet. The error involved in using the approximate thickness of 100 feet is inappreciable compared to the probable errors caused by the change in stage of the river and the partial penetration of the pumped well. The average coefficient of permeability of 3,030 gallons a day per square foot given in Table 3 is believed to be of the right order of magnitude, but it may be somewhat low due to only partial penetration of the pumped well.

TABLE 2. *Altitudes of water levels in observation wells during pumping test on well 16*

(Add 720 to the altitudes given below to convert them to feet above mean sea level.)

Test No.		1	2	3	4	5	8	9	10	11	14	15	16	17	18
Date, 1944		Jan. 23	Jan. 23	Jan. 24	Jan. 24	Jan. 26	Feb. 1	Feb. 8	Feb. 9	Feb. 9	Feb. 15	Feb. 16	Feb. 17	Feb. 18	Feb. 18
Time		8:00 a. m.	6:00 p. m.	8:00 a. m.	11:59 p. m.	9:30 a. m.	11:59 p. m.	6:00 p. m.	10:00 p. m.	11:59 a. m.	10:00 p. m.	2:00 p. m.	11:59 p. m.	8:00 a. m.	2:00 p. m.
Rate of pumping (gallons a minute)		415	610	850	400	745	250	160	235	90	270	285	395	585	775
Well No.	(*r*) (feet)	Altitude of water levels													
3A	5	5.74	5.14	4.31	5.64	5.54	7.35	7.22	6.83	7.50	4.67	4.08	4.07	3.28	2.48
5A	15	6.12	5.68	5.13	6.28	6.44	7.67	7.42	7.16	7.57	5.07	4.63	4.40	3.84	3.40
7A	35	6.36	6.14	5.77	6.60	6.96	7.83	7.53	7.36	7.61	5.33	4.95	4.68	4.28	3.88
10A	75	6.71	6.44	6.33	6.93	7.58	8.27	7.75	7.64	7.93	5.53	5.17	4.76	4.54	4.33
13A	155	6.92	6.76	6.83	7.24	7.97	8.23	7.87	7.78	7.78	5.27	4.93	4.84	4.48	4.35
14C	5	5.89	5.37	4.53	6.68	5.77	7.37	7.15	6.77	7.42	4.73	4.13	3.88	3.18	2.50
16C	15	6.15	5.76	5.24	6.35	6.22	7.65	7.35	7.13	7.47	5.10	4.70	4.24	3.62	3.12
18C	35	6.35	6.10	5.73	6.76	6.82	7.73	7.38	7.21	7.56	5.28	4.88	4.50	4.03	3.69
20C	75	6.59	6.42	6.21	6.84	7.25	8.00	7.58	7.46	7.64	5.67	5.25	4.80	4.44	4.20
23C	155	6.78	6.68	6.77	6.98	7.56	8.12	7.67	7.42	7.70	5.82	5.43	5.22	5.02	4.84
26B	5	5.93	5.42	4.68	5.92	5.84	7.15	7.17	6.82	7.42	4.80	4.24	4.10	3.38	2.74
28B	15	6.12	5.81	5.30	6.30	6.44	7.63	7.36	7.14	7.52	5.18	4.70	4.34	3.80	3.40
30B	35	6.34	6.13	5.80	6.62	6.89	7.82	7.44	7.30	7.54	5.43	5.00	4.56	4.14	3.84
32B	75	6.48	6.37	6.14	6.76	7.06	7.90	7.50	7.40	7.55	5.57	5.15	4.80	4.49	4.26
35B	155	6.66	6.60	6.50	6.88	7.34	8.00	7.54	7.48	7.54	5.90	5.53	5.18	4.96	4.82

TABLE 3. *Coefficients of permeability computed for well 16 in the Fairfax District*

Test No.	Rate of pumping (gallons a minute)	Penetration (percent)	Stage of river (feet above sea level)	Coefficient of permeability (g pd/sq. ft.) (a)			
				Line			
				A	B	C	Average
1	415	68	728.0	3,165	4,040	3,410	3,540
2	610	68	728.3	3,025	4,160	3,525	3,570
3	850	68	728.3	2,990	3,740	3,370	3,370
4	400	52	729.5	2,180	3,585	4,410	3,390
5	745	52	730.2	2,480	4,330	2,985	3,265
8	250	37	728.5	2,235	3,990	2,395	2,870
9	160	37	728.1	1,875	4,965	2,280	3,040
10	235	37	728.1	1,900	4,750	2,940	3,195
11	90	37	728.1	1,450	6,630	1,935	3,340
14	270	52	724.8	1,980	2,005	1,950	1,980
15	285	52	724.2	1,660	1,775	1,605	1,680
16	395	68	723.7	4,065	3,190	2,230	3,160
17	585	68	....	3,035	3,400	2,645	3,025
18	775	68	723.5	3,125	3,330	2,610	3,020
Average	....	....	....	2,510	3,850	2,730	3,030

(a) The coefficient of permeability is given for a temperature of 53° F. which was the temperature of the ground water at the time of the test.

PUMPING TEST ON WELL 49

Well 49 (Plant well 6) at the Phillips Petroleum Company was drilled by the Layne-Western Company in July 1941. It is 85.8 feet deep and has a diameter of 26 inches. Five observation wells were drilled on a line running north-northeast and south-southwest through the well. The line of wells makes an angle of about 20 degrees with a line running north and south through well 49. A pumping test was made by the Layne-Western Company on July 11, 1941, and the data from this test were kindly made available by the Layne-Western Company. Water-level and discharge measurements made during the pumping test are given in Table 4.

The drawdowns of the water level at 6:30 p. m. in wells 49B, 49C, and 49D are plotted in Figure 7 against the distances of the observation wells from the pumped well. From Figure 7 it is found that the change in drawdown (Δ s) over one cycle of the semilogarithmic

TABLE 4. *Depths to water level and discharge measurements made during the pumping test on well 49 on July 11, 1941*

Well No.		49	49A	49B	49C	49D	49E
Direction from well 49		....	NNE	SSW	SSW	SSW	SSW
Distance from well 49 (feet)		....	250	240	470	690	935
TIME	Rate of pumping (gallons a minute)	Depth to water level (feet)					
12:30 p.m.	0	17.00	15.58	17.79	18.08	20.87	20.25
1:30.....	980	32.17	16.17	18.25	18.12	20.87	20.25
2:30.....	1,000	35.00	16.33	18.37	18.23	20.90	20.25
3:30.....	1,000	35.00	16.46	18.46	18.25	20.90	20.25
4:30.....	1,000	35.00	16.58	18.54	18.29	20.90	20.25
5:30.....	1,000	35.00	16.67	18.60	18.37	20.92	20.25
6:30.....	1,000	35.00	16.71	18.67	18.42	20.92	20.25

paper is 1.81 feet. The rate of pumping (q) was 1,000 gallons a minute, and the thickness (m) was about 86.6 feet. Substituting these values in the formula we obtain:

$$P = \frac{527.7 \times 1{,}000}{86.6 \times 1.81} = 3{,}370 \text{ gallons per day per sq. ft.}$$

The temperature of the water at the time of the pumping test was not determined; hence no correction was made in the above computation for temperature. The two pumping tests indicate that the water-bearing materials in the Fairfax District have a permeability of somewhat more than 3,000 gallons a day per square foot. Coefficients of permeability of less than 100 are said to be low, coefficients between 100 and 1,000 are said to be medium, and coefficients above 1,000 are considered as being high. Hence, the water-bearing materials in the Fairfax District are very permeable.

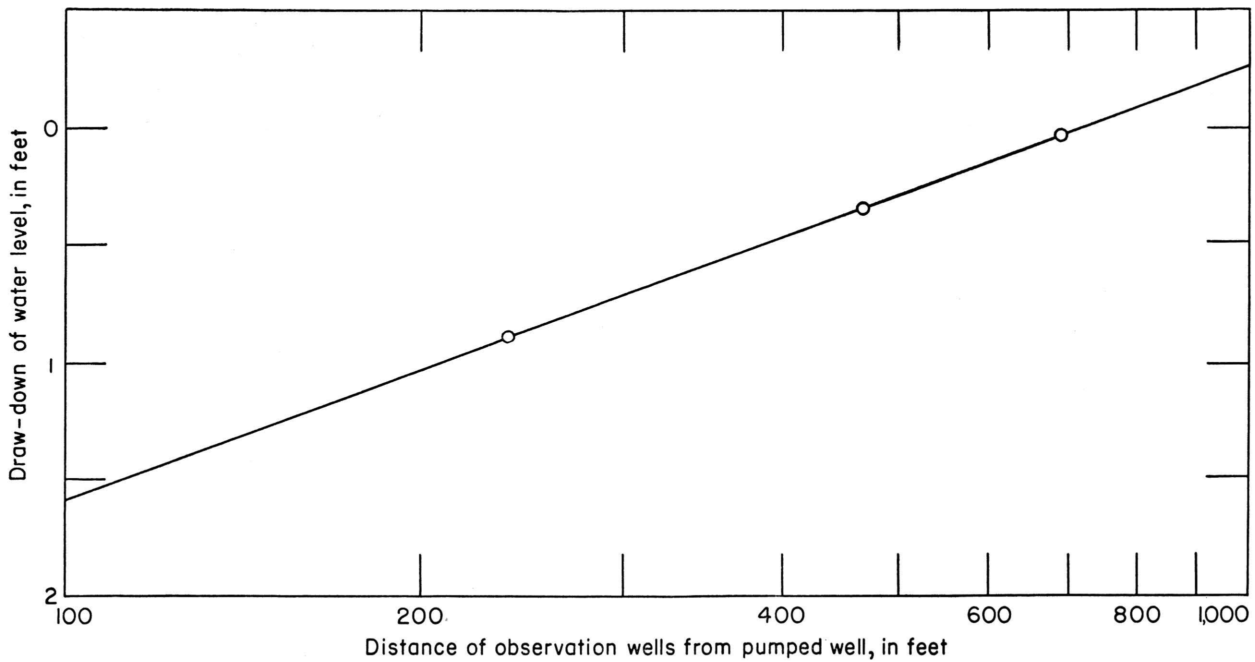

Fig. 7. Drawdowns of water levels plotted against the distance of the observation wells from the pumped well during the test on well 49.

YIELD OF WELLS

The yield of a well depends upon the well construction, the permeability of the water-bearing materials, the thickness of the saturated water-bearing materials, and the source of recharge. As soon as a pump begins discharging water from a well, a hydraulic gradient is established from all directions toward the well and the water table is lowered around the well. The water table soon assumes a form comparable to an inverted cone. Some water-bearing material will be dewatered by the decline of the water table and the water drained from this material will percolate to the pumped well. Thus, for a short time after pumping begins most of the water that is pumped from a well comes from the dewatered sediments comparatively close to the pumped well. As pumping continues a hydraulic gradient that is essentially an equilibrium gradient will be established close to the pumped well and water will be transmitted to the well through the water-bearing material in approximately the amount that is being pumped.

The construction of wells in the Kansas and Missouri River Valleys controls to a large extent their yields. Most of the wells constructed in recent years are of the gravel-pack type and are about 16 inches in diameter. A well of this type maintains a high yield over a period of several years only if the well is properly constructed so that the gravel-pack and screen do not become clogged with fine sand, thereby largely shutting off the movement of water into the well.

The ground water in the Kansas and Missouri Valleys contains a high amount of iron and carbonates (see Quality of Water); hence it may be that some of the wells fail after prolonged pumping as a result of encrustation formed on the screens by these substances. Aeration of the water-bearing materials within the cone of depression during periods of excessive rates of pumping may result in a precipitation of the iron and carbonates which would deposit on the screen and tend to clog the interstices in the sand and gravel near the screen. Several wells in the Kansas and Missouri Valleys in Kansas City and vicinity whose yields had declined over a period of years have been acidized with very successful results. The yields of several of the wells were more than doubled by acidization and the yield of one well was increased from 45 gallons a minute before acidization to 280 gallons a minute after acidization.

The specific capacity of a well is its rate of yield per unit of drawdown, and is usually stated in gallons a minute per foot of drawdown. For example, well 23, one of the wells at North American Aviation Company, Incorporated, was reported to yield 1,500 gallons a minute with a drawdown of about 5 feet. Its specific capacity, therefore, is about 300 gallons a minute per foot of drawdown.

The yields of 51 wells and the drawdowns for most of these wells are given in Table 9. Twenty-two of the wells are in the Missouri River Valley and twenty-nine are in the Kansas Valley. The wells in the Missouri Valley have an average yield of 980 gallons a minute and an average specific capacity of 60. The saturated water-bearing materials in the Missouri Valley are thicker and more permeable than those in the Kansas Valley; hence the wells in the Missouri Valley would be expected to have greater specific capacities. The greater specific capacities of the wells in the Fairfax District is also due to better and more modern methods of well construction.

3—7167

CHEMICAL CHARACTER OF GROUND WATER

The general chemical character of the ground waters in the alluvium of the Kansas and Missouri River Valleys in and adjacent to Kansas City, Kansas, is shown in Table 5 by the analyses of water from 23 wells and 50 test holes distributed as uniformly as practicable within the area. Included in the table are analyses of one sample from a public water supply (Bonner Springs) and one sample of water collected from the Missouri River during the pumping test on well 16 by the Corps of Engineers. The samples of water were analyzed by Howard A. Stoltenberg, chemist, in the Water and Sewage Laboratory of the Kansas State Board of Health.

The analyses of water given in Table 5 indicate only the amounts of dissolved mineral matter in the water and do not indicate the sanitary quality of the water. It is assumed that in Kansas City ground water will be used only for industrial purposes and the following discussion is based on that assumption. The packing companies are prohibited from using the water for any purpose for which it might come in contact with the meat.

An analysis of a typical water from four of the districts (Fairfax, Central, Argentine, and valley area west of Kansas City) is shown in Figure 8.

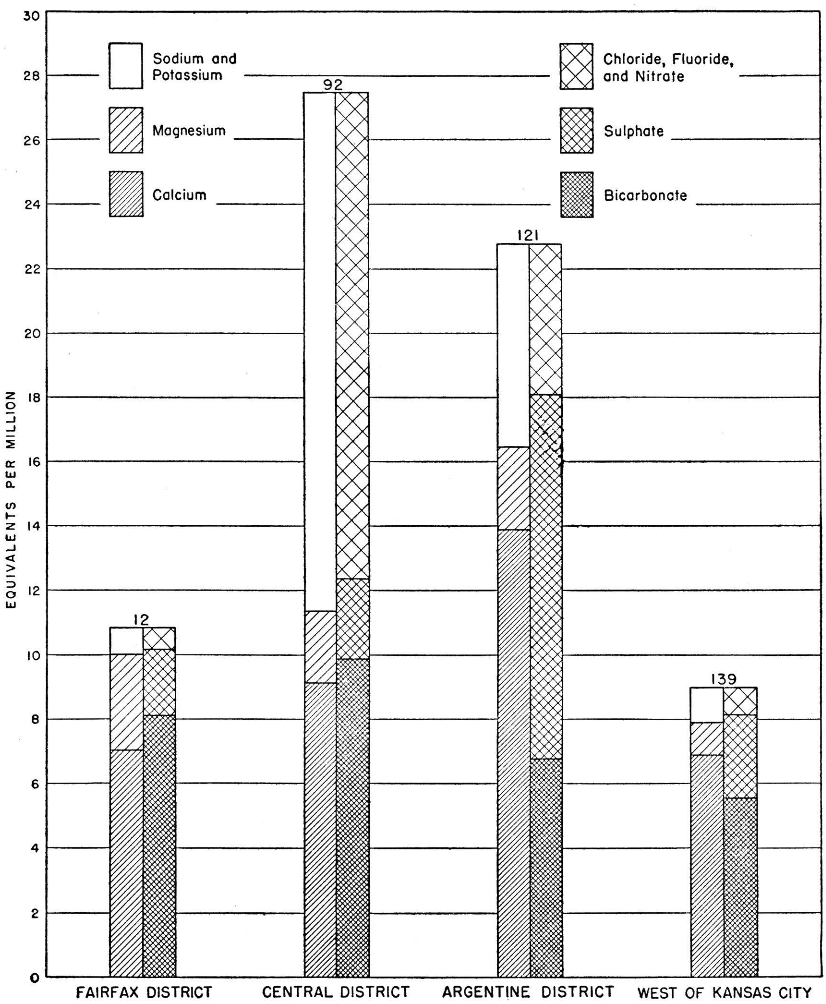

FIG. 8. Analyses of typical ground waters from four industrial districts considered in this report.

TABLE 5. *Analyses of water from wells and test holes in the alluvium of the Kansas and Missouri River Valleys in the Kansas City, Kansas, area*

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

No. on Plate 1	OWNER	Location	Depth (feet)	Date of collection	Temperature (°F)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium and potassium (Na+K) (*c*)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	pH	Carbon dioxide (CO_2)	Total dissolved solids (*c*)	Hardness (calculated as $CaCO_3$) Total	Carbonate	Noncarbonate
		T. 10 S., R. 25 E.																		
8	Test hole	SE cor. NE NE sec. 28	104	Aug. 15, 1944	56	7.5	95 *4.74*	22 *1.81*	40 *1.76*	349 *5.72*	100 *2.08*	16 *.45*	0.3 *.02*	2.2 *.04*	......	......	458	328	286	42
9	do.	NE SE NE sec. 28	124	Aug. 14, 1944	57	6.4	96 *4.79*	22 *1.81*	34 *1.48*	365 *5.99*	82 *1.70*	12 *.34*	0.2 *.01*	2.2 *.04*	......	......	437	330	300	30
10	do.	SW cor. NW sec. 27	115	Aug. 11, 1944	60	9.7	134 *6.69*	32 *2.63*	37 *1.63*	458 *7.51*	137 *2.85*	19 *.54*	0.2 *.01*	2.5 *.04*			600	466	376	90
11	do.	SW cor. NW SW sec. 27	102	Aug. 10, 1944	58	18.0	141 *7.04*	36 *2.96*	19 *.81*	495 *8.12*	97 *2.02*	22 *.62*	0.1 *.01*	2.3 *.04*	......	......	583	500	406	94
12	do.	NW cor. SW SW SW sec. 27	105	Aug. 3, 1944	62	6.8	140 *6.99*	35 *2.88*	41 *1.78*	478 *7.84*	142 *2.95*	29 *.82*	0.2 *.01*	2.1 *.03*	......	......	635	494	392	102
13	do.	NW NW NW sec. 34	87	Aug. 9, 1944	58	18.0	183 *9.13*	40 *3.29*	36 *1.55*	575 *9.43*	130 *2.70*	64 *1.80*	0.1 *.01*	2.1 *.03*	......	......	761	621	472	149
14	do.	NW NW NW sec. 34	82	July 29, 1944	58	24.0	207 *10.33*	42 *3.45*	28 *1.22*	527 *8.64*	211 *4.39*	68 *1.92*	0.2 *.01*	2.8 *.04*	......	......	846	689	432	257
16	do.	NW NW sec. 27	95.5	Jan. 24, 1944	53	9.2	96 *4.79*	24 *1.97*	35 *1.51*	309 *5.07*	127 *2.64*	18 *.51*	0.3 *.02*	2.1 *.03*	......	......	466	338	254	84
16	do.	NW NW sec. 27	95.5	Feb. 2, 1944	53	12.0	118 *5.89*	28 *2.30*	35 *1.51*	342 *5.61*	168 *3.49*	20 *.56*	0.3 *.02*	2.5 *.04*	......	......	555	410	280	130
16	do.	NW NW sec. 27	95.5	Feb. 18, 1944	53	8.3	94 *4.69*	23 *1.89*	34 *1.49*	318 *5.22*	115 *2.39*	15 *.42*	0.3 *.02*	1.3 *.02*	......	......	450	329	261	68
......	Missouri river	NW NW sec. 27	......	Jan. 24, 1944	34	......	86 *4.29*	33 *2.71*	70 *3.04*	250 *4.10*	245 *5.10*	25 *.70*	1.0 *.05*	5.8 *.09*	......	......	591	350	205	145
17	North American Aviation Co.	NE NW sec. 27	105	Nov. 2, 1943	56	12	115 *5.74*	31 *2.55*	22 *.98*	427 *7.00*	91 *1.89*	12 *.34*	0.2 *.01*	1.8 *.03*	6.9	75	498	414	350	64
25	Milk Producers Marketing Co.	NW SE sec. 27	......	Oct. 14, 1943	58	17	161 *8.03*	44 *3.62*	34 *1.49*	637 *10.45*	59 *1.23*	50 *1.41*	0.1 *.01*	2.5 *.04*	6.9	116	686	582	522	60
26	Freuhauf Trailer Co.	SW SE sec. 27	73.2	Nov. 23, 1943	......	19	168 *8.38*	45 *3.70*	14 *.62*	617 *10.12*	99 *2.06*	17 *.48*	0.1 *.01*	1.8 *.03*	......	......	672	604	506	98
8	Aircraft Accessories Corp.	NW NE sec. 34	......	Nov. 23, 1943	52	16	153 *7.63*	41 *3.37*	9.9 *.43*	614 *10.07*	46 *.96*	13 *.37*	0.1 *.01*	1.5 *.02*	......	......	588	550	504	46
32	Modification Center	NW NW sec. 35	85.3	Nov. 23, 1943	57	19	150 *7.48*	42 *3.45*	25 *1.09*	680 *11.15*	24 *.50*	12 *.34*	0.2 *.01*	1.5 *.02*	......	......	614	680	24	12

34	Sealbright Co., Inc.	SW NE sec. 34	60	Nov. 2, 1943	60	14	194 *9.68*	54 *4.44*	20 *.87*	644 *10.56*	174 *3.62*	27 *.76*	0.1 *.01*	2.2 *.04*	7.0	90	807	706	528	178
35	Test hole	NE NE SW sec. 34	35.5	Aug. 4, 1944	59	......	205 *10.23*	44 *3.62*	35 *1.52*	456 *7.48*	291 *6.05*	63 *1.78*	0.3 *.02*	2.3 *.04*	......	......	869	692	374	318
36	do	NW NW SE sec. 34	71	Aug. 8, 1944	58	11	252 *12.57*	65 *5.34*	39 *1.71*	473 *7.76*	493 *10.25*	55 *1.55*	0.3 *.02*	2.7 *.04*	......	......	1,154	473	493	55
37	do	NW NE SE sec. 34	77	Aug. 7, 1944	57	14	174 *8.68*	47 *3.86*	22 *.98*	548 *8.99*	152 *3.16*	47 *1.32*	0.1 *.01*	2.4 *.04*	......	......	732	627	450	177
39	do	SW NW NW sec. 34	88	Aug. 21, 1944	58	8.2	129 *6.44*	42 *3.45*	20 *.89*	583 *9.56*	37 *.77*	15 *.42*	0,1 *.01*	1.3 *.02*	......	......	544	494	478	16
40	do	SE NW NW sec. 22	89	Aug. 19, 1944	60	11	131 *6.54*	43 *3.53*	27 *1.18*	655 *10.74*	7.8 *.16*	11 *.31*	0.1 *.01*	1.9 *.03*	......	......	560	504	504*e*	0
41	do	SE NE NW sec. 22	89	Aug. 19, 1944	59	8.0	105 *5.24*	28 *2.30*	34 *1.49*	429 *7.04*	72 *1.50*	16 *.45*	0.2 *.01*	2.0 *.03*	......	......	480	377	352	25
		T. 11 S., R. 25 E.																		
69	Federal Cold Storage Co	SW SW sec. 2	100	Nov. 2, 1943	64	8.3	96 *4.79*	28 *2.30*	46 *2.00*	320 *5.25*	150 *3.12*	24 *.68*	0.3 *.02*	1.5 *.02*	7.0	39	514	354	262	92
78	Kansas City Dressed Beef Co	SE SE sec. 10	77.5	Nov. 2, 1943	61	20	293 *14.62*	46 *3.78*	1148 *49.94*	673 *11.04*	308 *6.41*	1780 *50.20*	0.2 *.01*	42 *.68*	7.0	95	3,974	920	552	368
79	National Laboratories Corp	SE SE sec. 10	......	Nov. 23, 1943	......	14	348 *17.36*	42 *3.45*	471 *20.49*	748 *12.27*	507 *10.54*	605 *17.06*	0.2 *.01*	88 *1.42*			2,449	1,040	614	426
80	Maurer Packing Co	SW SW sec. 11	......	Nov. 23, 1943	61	10	169 *8.43*	25 *2.06*	1395 *60.70*	786 *12.89*	167 *3.47*	1920 *54.14*	0.2 *.01*	42 *.68*	......	......	4,121	524	524*f*	0
81	Meyer Kornblum Packing Co	SE SE sec. 10	67	Nov. 2, 1943	58	20	239 *11.93*	47 *3.86*	256 *11.12*	849 *13.92*	89 *1.85*	391 *11.03*	0.0 *.00*	6.6 *.11*	7.0	117	1,473	790	696	94
85	Test hole	SE SW SE sec. 10	69	July 24, 1944	61	12	189 *9.43*	31 *2.55*	644 *28.03*	644 *10.56*	116 *2.41*	955 *26.93*	0.2 *.01*	6.2 *.10*	......	......	2,275	599	528	71
86	do	SE SE SE sec. 10	77	July 24, 1944	61	19	274 *13.67*	41 *3.37*	1297 *56.43*	705 *11.56*	194 *4.04*	2045 *57.67*	0.2 *.01*	12 *.19*	......	......	4,235	852	578	274
87	Test hole	SW SW SW sec. 11	68	July 28, 1944	62	15	286 *14.27*	47 *3.86*	2469 *107.41*	562 *9.22*	191 *3.97*	3980 *112.24*	0.2 *.01*	6.2 *.10*	......	......	7,275	906	461	445
88	do	SW NW sec. 6	79	July 26, 1944	61	22	442 *22.06*	81 *6.66*	878 *38.20*	532 *8.72*	462 *9.61*	1720 *48.50*	0.2 *.01*	5.3 *.08*	......	......	3,876	1,436	436	1,000
92	Swift and Co	SW SE sec. 15	80	Nov. 22, 1943	60	13	183 *9.13*	27 *2.22*	370 *16.11*	600 *9.84*	121 *2.52*	525 *14.80*	0.2 *.01*	18 *.29*	......	......	1,557	568	492	76
95	Standard Rendering Co	NE NE sec. 22	......	Oct. 14, 1943	65	4	117 *5.84*	21 *1.73*	202 *8.80*	523 *8.58*	40 *.83*	234 *6.60*	0.2 *.01*	22 *.35*	7.3	28	902	378	378*g*	0
96	Sambol Packing Co	NE NE sec. 22	......	Oct. 14, 1943	......	.81	82 *4.09*	15 *1.23*	88 *3.82*	348 *5.71*	36 *.75*	89 *2.51*	0.3 *.02*	9.3 *.15*	7.5	13	494	266	266*h*	0
97	Test hole	NW SW SE sec. 15	68	July 19, 1944	60	27	359 *17.91*	39 *3.21*	91 *3.97*	506 *8.30*	640 *13.31*	122 *3.44*	0.2 *.01*	2.1 *.03*	......	......	1,533	1,056	415	641
98	do	SE SW SE sec. 15	68	July 19, 1944	60	32	366 *18.26*	33 *2.71*	67 *2.93*	544 *8.92*	602 *12.52*	86 *2.42*	0.2 *.01*	2.0 *.03*	......	......	1,460	1,048	446	602
99	do	NE cor. NW NE sec. 22	72	July 20, 1944	61	17	228 *11.38*	22 *1.81*	100 *4.33*	460 *7.54*	314 *6.53*	121 *3.41*	0.2 *.01*	2.0 *.03*	......	......	1,034	660	377	283
100	do	SE NE NE sec. 22	77	July 20, 1944	64	2.7	68 *3.39*	18 *1.48*	201 *8.74*	472 *7.74*	48 *1.00*	170 *4.79*	0.2 *.01*	4.4 *.07*	......	......	748	244	244*i*	0
101	do	NW SW NW sec. 23	98	July 21, 1944	61	5.1	284 *14.17*	38 *3.12*	94 *4.09*	499 *8.18*	404 *8.40*	168 *4.74*	0.2 *.01*	3.0 *.05*	......	......	1,246	864	409	455

TABLE 5. *Analyses of water from wells and test holes in the alluvium of the Kansas and Missouri River Valleys in the Kansas City, Kansas, area—Concluded*

No. on Plate 1	Owner	Location	Depth (feet)	Date of collection	Temperature (°F)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium and potassium (Na+K) (c)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	pH	Carbon dioxide (CO_2)	Total dissolved solids (c)	Hardness (calculated as $CaCO_3$)		
																		Total	Carbonate	Noncarbonate
105	Wilson and Co.	SW NE sec. 22	......	Nov. 23, 1943	......	7.1	158 *7.88*	26 *2.14*	240 *10.46*	437 *7.17*	156 *3.24*	350 *9.87*	0.2 *.01*	12 *.19*	......	......	1,168	501	358	143
108	Midwest Cold Storage Co.	NE SW sec. 22	93.5	....	59	3.7	105 *5.24*	22 *1.81*	62 *2.68*	364 *5.97*	43 *.89*	100 *2.82*	0.2 *.01*	2.2 *.04*	7.1	29	520	352	298	54
111	Colgate-Palmolive-Peet Co.	NW NW sec. 21	......	Oct. 14, 1943	61	21	399 *19.91*	35 *2.88*	129 *5.62*	595 *9.76*	650 *13.52*	180 *5.08*	0.2 *.01*	2.2 *.04*	6.8	168	1,714	1,140	488	652
117	Test hole	SE SW SW sec. 16	65	July 18, 1944	63	32	438 *21.86*	47 *3.86*	156 *6.79*	498 *8.17*	815 *16.95*	260 *7.33*	0.3 *.02*	2.6 *.04*	......	......	2,000	1,286	408	878
118	do.	NW cor. sec. 21	68	July 17, 1944	62	17	276 *13.77*	36 *2.96*	78 *3.37*	416 *6.82*	487 *10.13*	110 *3.10*	0.2 *.01*	2.2 *.04*	......	......	1,214	836	341	495
119	do.	SE NE NE sec. 20	78	July 15, 1944	62	5.6	114 *5.69*	17 *1.40*	55 *2.41*	361 *5.92*	109 *2.27*	45 *1.27*	0.2 *.01*	2.0 *.03*	......	......	528	354	296	58
120	do.	NW SE NE sec. 20	78	July 10, 1944	61	2.2	73 *3.64*	11 *.90*	45 *1.95*	256 *4.20*	80 *1.66*	21 *.59*	0.2 *.01*	1.8 *.03*	......	......	362	227	210	17
121	do.	NE NW SE sec. 20	68	July 29, 1944	64	9.2	278 *13.87*	31 *2.55*	146 *6.37*	411 *6.74*	545 *11.34*	166 *4.68*	0.2 *.01*	1.3 *.02*	......	......	1,382	821	337	484
123	do.	SW SW SE sec. 20	72	July 7, 1944	59	25	229 *11.43*	33 *2.71*	489 *21.26*	366 *6.00*	312 *6.49*	810 *22.84*	0.1 *.01*	3.6 *.06*	......	......	2,085	707	300	407
129	Proctor and Gamble Manuf'g Co.	SE SE sec. 17	76	Nov. 2, 1943	61	8.4	146 *7.28*	23 *1.89*	63 *2.74*	442 *7.25*	126 *2.62*	71 *2.00*	0.2 *.01*	2.1 *.03*	7.0	64	661	458	362	96
131	Sinclair Refining Co.	NW NW sec. 20	......	Oct. 14, 1943	......	15	212 *10.58*	24 *1.97*	30 *1.30*	492 *8.07*	216 *4.49*	44 *1.24*	0.3 *.02*	2.0 *.03*	6.8	122	789	628	404	224
133	do.	NE NW sec. 20	70	Oct. 14, 1943	......	416	461 *23.00*	97 *7.97*	311 *13.54*	814 *13.55*	1271 *26.44*	164 *4.62*	0.5 *.03*	4.2 *.07*	6.1	......	3,132	1,548	668	880
		T. 11 S., R. 24 E.																		
139	Test hole	NW SE sec. 21	61	June 20, 1944	61	16	138 *6.89*	12 *.99*	26 *1.11*	337 *5.53*	128 *2.66*	27 *.76*	0.1 *.01*	1.7 *.03*	......	......	517	394	276	118
140	do.	NW SE sec. 21	74	June 15, 1944	......	11	126 *6.29*	13 *1.07*	24 *1.06*	334 *5.48*	87 *1.81*	39 *1.10*	0.1 *.01*	1.2 *.02*	......	......	468	368	274	94
141	do.	SW SW sec. 22	54.5	June 16, 1944	......	8.6	133 *6.64*	11 *.90*	9.9 *.43*	351 *5.76*	88 *1.83*	12 *.34*	0.1 *.01*	1.7 *.03*	......	......	440	377	288	89
142	do.	SW SW sec. 22	55	July 5, 1944	60	2.8	74 *3.69*	16 *1.32*	51 *2.22*	266 *4.36*	116 *2.41*	15 *.42*	0.2 *.01*	1.8 *.03*	......	......	410	250	218	32
143	do.	SW SW sec. 22	67.5	June 16, 1944	......	14	145 *7.24*	12 *.99*	4.8 *.21*	377 *6.18*	91 *1.89*	12 *.34*	0.1 *.01*	1.3 *.02*	......	......	469	412	309	103
144	do.	NE NW sec. 27	76	June 17, 1944	59	15	288 *14.37*	22 *1.81*	18 *.79*	338 *5.54*	533 *11.09*	10 *.28*	0.3 *.02*	2.4 *.04*	......	......	1,058	809	277	532

145	do.	NE NW sec. 27	48	June 19, 1944	......	5.3	154 *7.68*	17 *1.40*	64 *.28*	445 *7.30*	84 *1.75*	9.0 *.25*	0.3 *.02*	2.5 *.04*	......	......	501	454	365	89
147	A. T. and S. F. Railway	NE SW sec. 28	69.9	Nov. 22, 1943	......	12	197 *9.83*	18 *1.48*	21 *.91*	465 *7.63*	149 *3.10*	44 *1.24*	0.1 *.01*	15 *.24*	......	......	689	566	382	184
149	Camp Theodore Naish	*T. 11 S., R. 23 E.* SW NW sec. 27	......	Nov. 22, 1943	......	.48	157 *7.83*	21 *1.73*	5.5 *.24*	407 *6.67*	128 *2.66*	13 *.37*	0.1 *.01*	5.8 *.09*	......	......	534	478	334	144
150	Test hole	NW SE sec. 28	68	June 23, 1944	66	2.8	149 *7.44*	14 *1.15*	35 *1.52*	306 *5.02*	184 *3.83*	44 *1.24*	0.2 *.01*	.66 *.01*	......	......	583	430	251	179
151	do.	NW SE sec. 28	68	June 22, 1944	59	11	189 *9.43*	18 *1.48*	15 *.66*	346 *5.67*	239 *4.97*	32 *.90*	0.2 *.01*	.97 *.02*	......	......	678	546	284	262
152	do.	NW SE sec. 28	71	June 21, 1944	65	20	158 *7.88*	14 *1.15*	49 *2.15*	332 *5.44*	218 *4.53*	42 *1.18*	0.2 *.01*	1.3 *.02*	......	......	668	452	272	180
153	do.	SE cor. SW sec. 28	55	June 27, 1944	60	16	140 *6.99*	14 *1.15*	18 *.77*	425 *6.97*	72 *1.50*	14 *.39*	0.2 *.01*	2.4 *.04*	......	......	489	407	348	59
154	do.	NW NE sec. 33	55	June 28, 1944	60	12	108 *5.39*	13 *1.07*	24 *1.06*	368 *6.04*	51 *1.06*	14 *.39*	0.2 *.01*	1.5 *.02*	......	......	408	323	302	21
155	do.	NW NE sec. 33	52	June 29, 1944	58	25	127 *6.34*	11 *.90*	14 *.61*	377 *6.18*	62 *1.29*	12 *.34*	0.2 *.01*	1.8 *.03*	......	......	442	362	309	53
156	do.	SW NE sec. 33	56	July 1, 1944	62	10	129 *6.44*	13 *1.07*	8.3 *.36*	337 *5.53*	91 *1.89*	15 *.42*	0.1 *.01*	1.5 *.02*	......	......	436	376	276	100
157	do.	NW SE sec. 33	51	July 1, 1944	59	10	102 *5.09*	14 *1.15*	6.7 *.29*	265 *4.35*	82 *1.70*	16 *.45*	0.1 *.01*	1.3 *.02*	......	......	365	312	218	94
158	do.	NE SW sec. 33	41.5	July 3, 1944	60	4.2	128 *6.39*	14 *1.15*	3.2 *.14*	348 *5.71*	73 *1.52*	15 *.42*	0.1 *.01*	1.5 *.02*	......	......	413	377	286	91
160	Lone Star Cement Co.	NE SW sec. 28	80	Oct. 25, 1943	61	.21	127 *6.34*	16 *1.32*	36 *1.57*	281 *4.61*	135 *2.81*	61 *1.72*	0.2 *.01*	5.3 *.08*	7.0	38	521	383	230	153
161	Test hole	NE SW sec. 28	85.5	June 24, 1944	66	21	104 *5.19*	8.8 *.72*	25 *1.08*	240 *3.94*	108 *2.25*	27 *.76*	0.3 *.02*	1.5 *.02*	......	......	416	296	197	99
162	do.	SE SE sec. 29	63	June 24, 1944	60	52	131 *6.54*	10 *.82*	2.5 *.11*	312 *5.12*	86 *1.79*	18 *.51*	0.1 *.01*	2.4 *.04*	......	......	458	368	256	112
163	do.	SE SE sec. 29	72.5	June 26, 1944	59	14	138 *6.89*	12 *.99*	1.6 *.07*	334 *5.48*	90 *1.87*	20 *.56*	0.1 *.01*	2.1 *.03*	......	......	445	394	274	120
165	City of Bonner Springs	SW NE sec. 32	57	1944	......	......	113 *5.64*	16 *1.32*	5.5 *.24*	331 *5.43*	70 *1.46*	9.0 *.25*	0.3 *.02*	2.6 *.04*	......	......	435	348	271	77
167	Test hole	NE cor. SW SW sec. 32	44	June 27, 1944	60	58	85 *4.24*	13 *1.07*	25 *1.08*	317 *5.20*	31 *.64*	15 *.42*	0.3 *.02*	6.6 *.11*	......	......	392	266	260	6

a. One part per million is equivalent to one pound of substance per million pounds of water or 8.33 pounds per million gallons of water.
b. An equivalent per million is a unit chemical equivalent weight of solute per million unit weights of solution. Concentration in equivalents per million is calculated by dividing the concentration in parts per million by the chemical combining weight of the substance or ion.
c. Calculated.
d. Sample collected from Missouri river adjacent to well 16.
e. Total alkalinity, 537 parts per million; excess alkalinity, 33 parts per million.
f. Total alkalinity, 644 parts per million; excess alkalinity, 120 parts per million.
g. Total alkalinity, 429 parts per million; excess alkalinity, 51 parts per million.
h. Total alkalinity, 286 parts per million; excess alkalinity, 20 parts per million.
i. Total alkalinity, 387 parts per million; excess alkalinity, 143 parts per million.

Chemical Constituents in Relation To Use

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

The dissolved solids ranged from 437 to 1,154 parts per million in 21 samples collected in the Missouri River Valley in the Fairfax District and ranged from 365 to 1,058 parts in 53 samples collected in the Kansas River Valley between Bonner Springs and Kansas City, Kansas. The 30 samples of water collected in the Kansas River Valley within Kansas City (Argentine, Armourdale, and Central Districts) contained dissolved solids ranging from 362 to 7,275 parts per million. The samples from 20 of the 28 wells in the Kansas River Valley within Kansas City contained more than 1,000 parts per million of dissolved solids. The quantities of dissolved solids in the samples of water analyzed are summarized in Table 6 and are shown graphically in Figure 9.

Hardness.—The hardness of water, which is the property that receives the most attention as a general rule, is most commonly recognized by its effects when soap is used with the water in washing. Calcium and magnesium cause almost all the hardness of ordinary water. These constituents are also the active agents in the formation of the greater part of all the scale formed in steam boilers and in other vessels in which water is heated or evaporated.

In addition to the total hardness, the tables of analyses show the carbonate hardness and the noncarbonate hardness. The carbonate hardness is that due to the presence of calcium and magnesium bicarbonates which are almost entirely precipitated by boiling. In some reports this type of hardness is called temporary hardness. The noncarbonate hardness is due to the presence of sulfates or chlorides of calcium and magnesium; it is not removed by simply bringing the water to the boiling point, and has sometimes been called permanent hardness. With reference to use with soaps, there

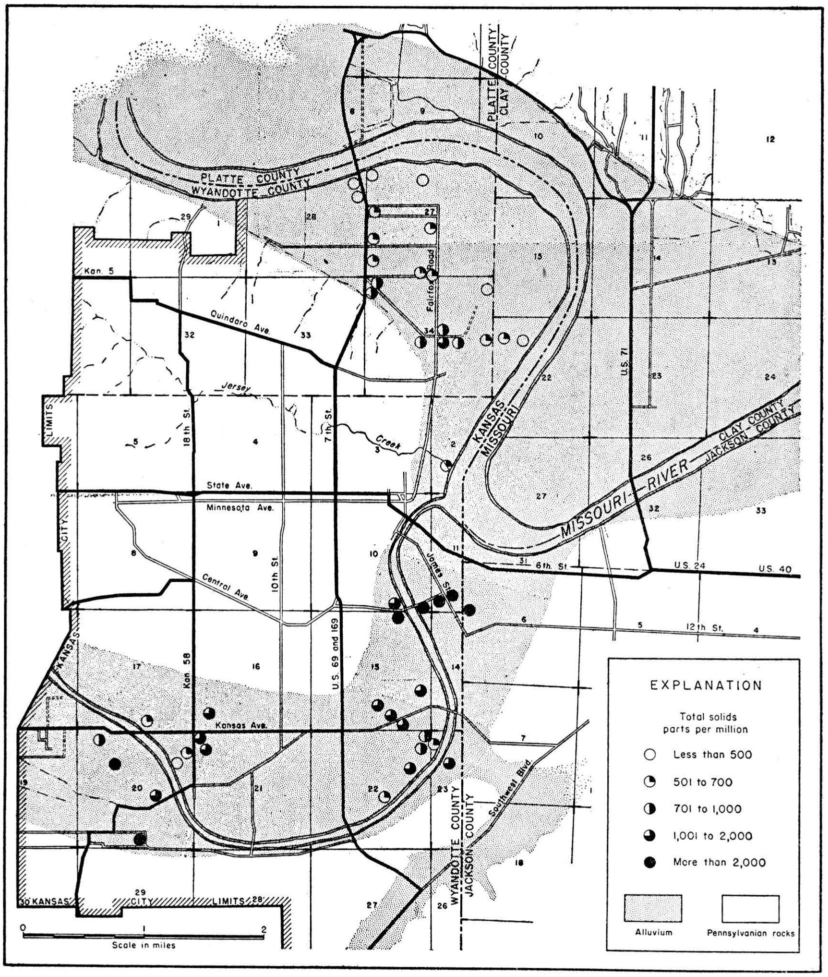

FIG. 9. Dissolved solids in the waters in the alluvium in the Kansas and Missouri River Valleys.

is no difference between the carbonate and noncarbonate hardness. In general, the noncarbonate hardness forms harder scale in steam boilers.

Water having a hardness of less than 50 parts per million generally is rated as soft, and its treatment for the removal of hardness under ordinary circumstances is not necessary. Hardness between 50 and 150 parts per million does not seriously interfere with the use of water for most purposes; however, it does slightly increase

TABLE 6. *Summary of the chemical characteristics of the samples of water collected from wells in the alluvium in the Kansas and Missouri River Valleys in the Kansas City, Kansas, area*

Range in parts per million	Number of samples			
	Fairfax district	East Armourdale and Central districts	West Armourdale and Argentine districts	Kansas Valley west of Kansas City, Kansas
DISSOLVED SOLIDS				
301- 400	....	....	1	2
401- 500	5	1	0	12
501- 700	10	1	2	8
701-1,000	5	2	1	1
1,001-2,000	1	7	4	0
2,001-3,000	0	2	1	0
3,001-4,000	0	2	1	0
4,001-5,000	0	2	0	0
5,001-8,000	0	1	0	0
HARDNESS				
201- 300	0	2	1	3
301- 400	5	2	1	11
401- 500	6	0	1	6
501- 700	9	5	1	2
701-1,000	1	5	3	1
1,001-1,500	0	4	2	0
1,500-2,000	0	0	1	0
IRON				
0.1- 1.0	0	1	0	2
1.1- 2.0	0	0	0	0
2.1- 5.0	0	3	1	3
5.1-10.0	9	3	3	4
10.1-15.0	6	4	1	7
15.1-20.0	6	4	1	3
20.1-25.0	1	1	2	2
25.1-50.0	0	2	1	0
More than 50	0	0	1 (*a*)	2
CHLORIDE				
Less than 10	0	0	0	1
11- 20	13	0	0	14
21- 30	5	0	1	2
31- 50	2	0	2	5
51- 100	4	3	1	1
101- 200	0	4	4	0
201- 500	0	3	1	0
501-1,000	0	3	1	0
1,001-2,000	0	3	0	0
2,001-5,000	0	2	0	0

a. 416 parts per million.

the consumption of soap, and its removal by a softening process is profitable for laundries or other industries using large quantities of soap. Waters in the upper part of this range of hardness will cause considerable scale in steam boilers. Hardness above 150 parts per million can be noticed by anyone, and if the hardness is above 200 or 300 parts per million it is common practice to soften water for household use or to install cisterns to collect soft rain water.

Water samples collected in the Kansas and Missouri Valleys ranged in hardness from 227 to 1,548 parts per million. Only 6 of

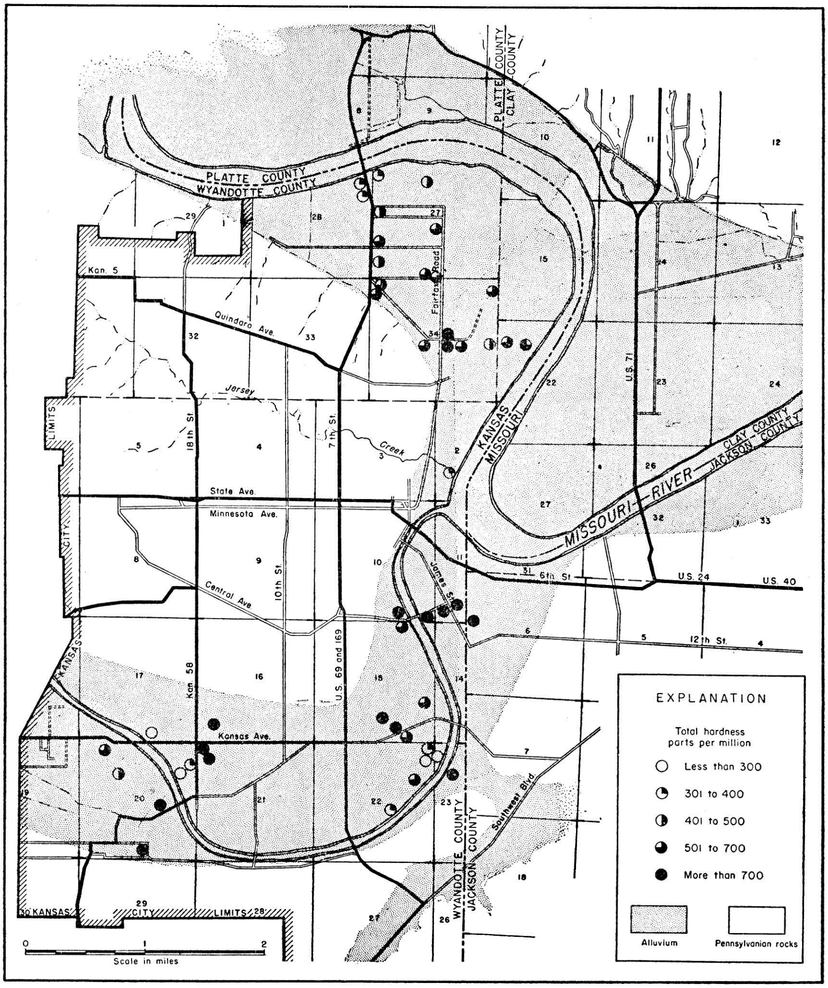

FIG. 10. Total hardness in the waters in the alluvium of the Kansas and Missouri River Valleys.

the 72 samples had less than 300 parts per million of hardness and only 38 samples contained less than 500 parts of hardness. As shown on Figure 10 and summarized in Table 6 the ground water in the Kansas River Valley west of Kansas City is not as hard as that in the Missouri River Valley.

Iron.—Next to hardness, iron is the constituent of natural waters that in general receives the most attention. The quantity of iron in ground waters may differ greatly from place to place, even though the waters are derived from the same formation. If a

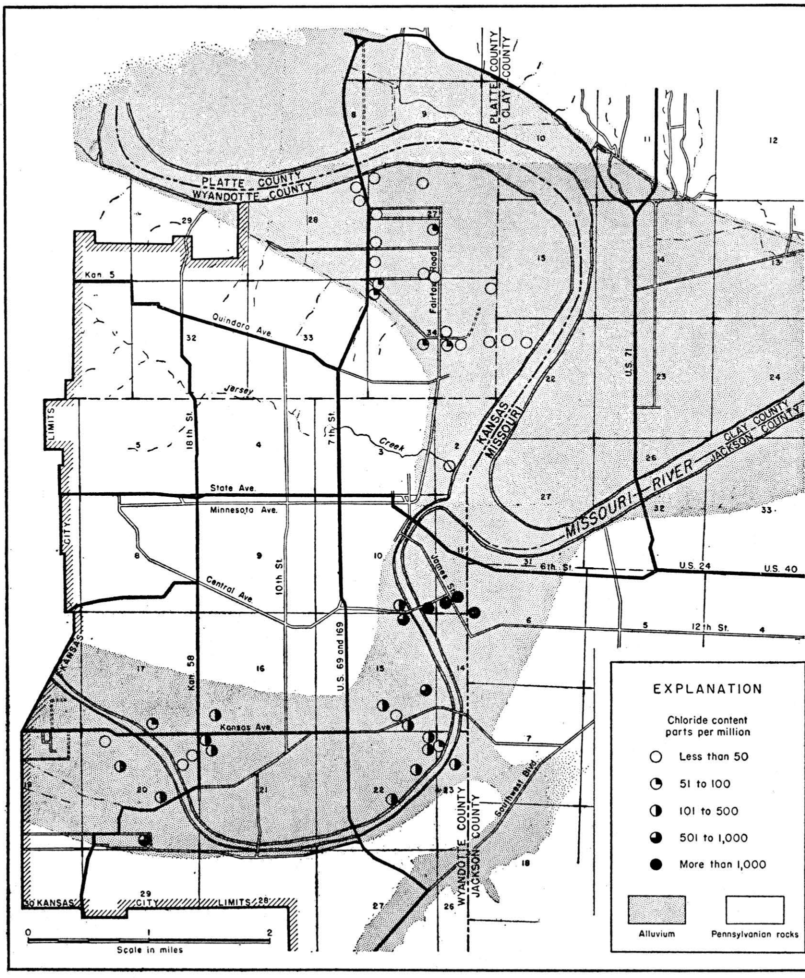

FIG. 11. Chloride content of waters in the alluvium in the Kansas and Missouri River Valleys.

water contains much more than 0.1 part per million of iron, the excess may precipitate and settle as a reddish sediment. Iron may be removed from most waters by simple aeration and filtration, but a few waters require the addition of lime or some other substance.

All but 3 of the samples of water collected in the Missouri and Kansas River Valleys contained more than 2.0 parts per million of iron (Tables 5 and 6). Most of the samples of water contained more than 5.0 parts per million of iron and 12 samples contained more than 20 parts. One sample collected at the Sinclair Refining Company in the Argentine District contained 416 parts per million of iron.

Chloride.—Water containing less than 150 parts per million of chloride is not objectionable for most uses but that containing more than 350 parts per million is objectionable for irrigation or industrial use. Water containing more than about 500 parts per million becomes objectionable to the taste.

The quantities of chloride in the samples of water collected in the Kansas and Missouri Valleys are summarized in Table 6 and are shown graphically in Figure 11. The samples of water from the Missouri River Valley and from the Kansas River Valley west of Kansas City contained less than 100 parts per million of chloride. The samples of water collected in the Argentine, Armourdale, and Central Districts contained much greater amounts of chloride; 13 samples contained more than 200 parts per million of chloride and 5 samples contained more than 1,000 parts.

Hydrogen-Ion Concentration.—The hydrogen-ion concentration is of importance with reference to the corrosiveness of waters. The pH value of a water is the logarithm of the reciprocal of the gram ionic hydrogen equivalents per liter. Thus a low value of pH means a high concentration of hydrogen-ions, or acidity, and a high value of pH indicates a low concentration of hydrogen-ions. A neutral water has a pH of 7.0. The pH values of the waters were determined by Mr. Stoltenberg using portable apparatus at the time of collection of the samples.

The pH of 14 water samples collected in the Kansas and Missouri River Valleys ranged from 6.1 to 7.5. Four samples of water collected in the Argentine and west Armourdale Districts had pH values of 6.1, 6.8, 6.8, and 7.0, respectively. The pH values of the five samples of water collected in the East Armourdale and Central Districts were 7.0 or higher.

Temperature of Ground Water

The great advantage of ground water in this area for cooling is not only its relatively low temperature, but its uniform temperature throughout the year, which approximates the mean annual temperature of the air. The temperature of water in wells located near the river may be affected considerably by the infiltration of river water but the temperature of water in any one well that is not affected by the river probably does not vary more than 2° or 3° F. during the year. The temperatures of the waters in 62 wells and test holes were determined during 1943 and 1944 and are given in Table 7. The temperatures ranged from 52° to 66° F. but most of the waters had temperatures between 56° and 62° F. The range in temperature of the water in the 62 wells and test holes is summarized in Table 7.

Table 7. *Range of temperature of water in wells and test holes in the Kansas City, Kansas, area*

Temperature range °F.	Number of wells and test holes
52–54	4
55–56	2
57–58	11
59–60	20
61–62	17
63–64	4
65–66	4

The temperature of the water in the wells of the Federal Cold Storage Company, which are located near Missouri River in the Fairfax District, varies with the season. The minimum annual water temperature is about 55° F. and the maximum about 64° F. The maximum temperature in 1942 was 62° F.

The temperature measurements given in Table 5 and summarized in Table 8 indicate that the normal temperature of the ground water that is not affected by recharge from the river ranges from about 57° to 61° F. In wells near the river, the water may have a temperature considerably lower or higher than the normal water temperature, depending on the season. Temperatures as high as 66° F. and as low as 52° F. were observed but they were caused by seasonal recharging of the ground-water reservoir with river water.

UTILIZATION OF GROUND-WATER

During the course of the investigation information on 81 wells in the Kansas City, Kansas, area, was obtained. All known industrial wells were visited and all available data concerning them were obtained. No attempt was made to obtain data on all the wells in Kansas River Valley between Bonner Springs and Kansas City, most of which are domestic or stock wells.

Industrial Supplies

In the Kansas City, Kansas, area ground water is used for many industrial purposes. The chief industrial use of ground water is for cooling and condensing, which is largely seasonal. It is used at the Standard Rendering Company for scrubbing and cleaning the plant. It was formerly used in large quantities by the packing plants for washing meat but its use for this purpose has been discontinued because of the possibility of pollution of the ground water and also because the iron in the water discolored the meat. Many years ago ground water was used at the stock yards in Kansas City, Kansas, for watering stock, but as the stock tanks soon became iron-stained the stock that were unaccustomed to the iron-stained tanks refused to drink the water.

With few exceptions, the users of ground water in Kansas City, Kansas, do not keep records of the quantities of water pumped from their wells. It is this factor more than any other that makes it difficult to carry on a quantitative investigation of the ground-water resources of the area. Because it is essential to have quantitative data before drawing conclusions concerning the ground-water resources, it is necessary to estimate as closely as possible the quantities of water pumped from wells in different parts of the area. This is generally done by obtaining statements from the well operators as to the capacities of the wells and pumps and the average number of hours of pumping each day.

The industrial utilization of ground water in the Kansas City, Kansas, area is considered under four subareas: (1) the Kansas River Valley west of Kansas City, Kansas; (2) the Argentine and West Armourdale Districts; (3) the East Armourdale and Central Districts; and (4) the Fairfax District. Pumpage figures given are for the year 1943.

The first area located west of Kansas City includes only two industrial users of ground water—the Lone Star Cement Company, near Bonner Springs, and the Atchison, Topeka and Santa Fe Railway Company at Morris. The Lone Star Cement Company obtains its water supply from one well located across the road from and a little west of the plant. The company uses about 350,000 gallons a day for maintaining a moisture chamber at 70° F. Some water is also used for drinking purposes. The Santa Fe Railway Company at Morris obtains its water supply from two gravel-packed wells. The water is used for drinking and for watering stock that are kept temporarily at the Morris stockyards. The wells are pumped at irregular intervals; hence it was difficult to estimate the pumpage, but it is believed to be about 300,000 gallons a day.

There are only three industrial users of ground water in the Argentine and West Armourdale Districts but each uses large amounts, all of which is for cooling and condensing. These three users are the Sinclair Refining Company, which uses about 2,600,000 gallons a day, the Proctor and Gamble Manufacturing Company, which uses about 3,000,000 gallons a day, and the Colgate-Palmolive-Peet Company, which uses about 1,000,000 gallons a day.

The East Armourdale and Central Districts include the packing houses, which are the large users of ground water in these districts, and also a few smaller users of ground water. Some water is used for washing floors as at the Peters Serum Company and the Standard Rendering Company, but most of the ground water is used for cooling and condensing. Swift and Company uses about 4,000,000 gallons of water a day, Wilson and Company uses about 2,600,000 gallons a day, Midwest Cold Storage and Ice Corporation uses about 1,800,000 gallons a day, and the Kansas City Dressed Beef Company, the Meyer Kornblum Company, and the Standard Rendering Company each use about 500,000 gallons per day.

The Fairfax District has nine companies that are using ground water. The largest users of ground water in this area are the Bomber Assembly Plant and the Modification Center of the North American Aviation Company, Incorporated, which use a total of about 8,000,000 gallons a day; the Phillips Petroleum Company, which uses about 7,000,000 gallons a day; and the Federal Cold Storage Company, which uses about 1,300,000 gallons a day. Ground water in the Fairfax District is used almost entirely for cooling and condensing but at the Modification Center it is also used for fire protection.

The industrial use of ground water in the four subareas is summarized in Table 8 and is shown graphically for the three subareas in Kansas City, Kansas, in Figure 12.

TABLE 8. *Summary of the industrial use of ground water in and west of Kansas City, Kansas*

SUBAREA	Number of wells	Pumpage in gallons a day
Kansas River Valley west of Kansas City	3	700,000
Argentine and West Armourdale districts	15	6,600,000
East Armourdale and Central districts	21	10,300,000
Fairfax district	28	17,400,000
Total	....	35,000,000

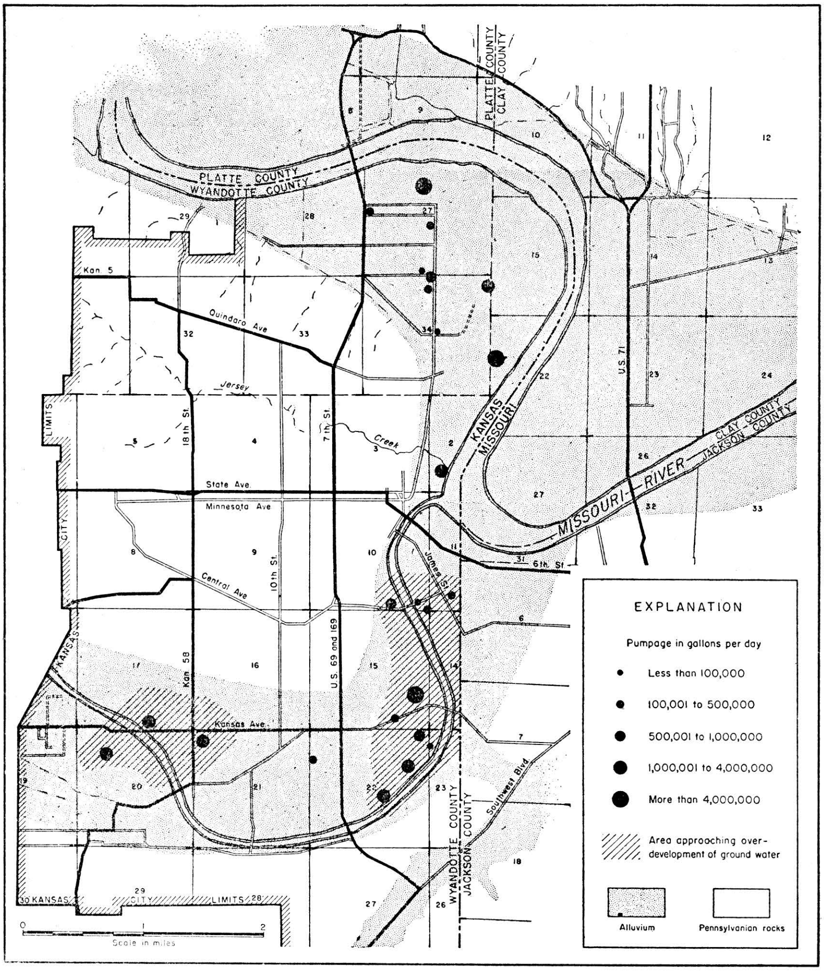

FIG. 12. Distribution of pumpage by industries in the Kansas City, Kansas, area.

4—7167

Public Supplies

Bonner Springs is the only city in the area that has a public water system supplied by wells. Kansas City, Kansas, and a large area in the eastern part of Wyandotte County are supplied from the Missouri River.

Bonner Springs is supplied by eight wells (164, 165, and 166), all of which are in the Kansas River Valley, on the south side of the river, and all of which derive water from the alluvium. Two wells (164 and 165) are gravel-packed and are equipped with electrically driven turbine pumps. They are about 60 feet deep and yield from 250 to 300 gallons a minute each. The other six wells (166) are each about 60 feet deep and are connected by suction lines to a common cylinder pump located in a pump house. These wells are seldom used as their yields are low and the required amount of water can generally be obtained from the two gravel-packed wells.

The water is aerated and chlorinated and is then pumped into the mains. A standpipe, which holds 50,000 gallons, is connected with the mains and is located in the north part of town. The average consumption of water is about 2,500,000 gallons a month. The maximum monthly consumption on record was in August 1936 and amounted to 4,365,000 gallons. An analysis of the water (Table 5) indicates a total hardness of 348 parts per million.

Domestic and Stock Supplies

Most of the rural residents in the Kansas River Valley between Bonner Springs and Kansas City derive their domestic and stock supplies from driven wells equipped with lift or suction pumps operated by windmills or by hand. The water is moderately hard, but generally is satisfactory for domestic and stock use.

RECORDS OF WELLS AND TEST HOLES

Descriptions of the wells and test holes in the Kansas City, Kansas, area are given in Table 9. The wells and test holes are listed in order beginning at the farthest upstream area in the Missouri River Valley and then following the Kansas River Valley upstream to Bonner Springs. All information classed as "reported" was obtained from the owner or driller. Depths of wells not classed as "reported" are measured and given to the nearest tenth of a foot below the land surface and depths to water level not classed as "reported" are measured and given to the nearest hundredth of a foot.

Table 9. *Records of wells and test holes in the Kansas City, Kansas, area*

No. on Plate 1[1]	Description[2]	Location	Owner	Driller	Year completed	Depth of well or test hole (feet)[3]	Diameter of well (in.)	Use of water[4]	Depth to water level below land surface (feet)[5]	Date of measurement	Altitude of land surface (feet)	REMARKS (Yield given in gallons a minute, drawdown in feet)
		T. 10 S., R. 25 E.										
1	(W)	SE NE sec. 28	Corps of Engineers	Layne-Western Co.	1944	111.5	16	N	15	.....	745.9	Test well for determining permeability of alluvium
2	(W)	SE NE sec. 28	do.	do.	1944	111	16	N	11	.....	745.6	do.
3	(W)	SE NE sec. 28	do.	do.	1944	111	16	N	12	.....	746.0	do.
		T. 50 N., R. 33 W.										
4	(T)	SE NE SE sec. 5	.....	State and Federal Geological Surveys	1944	67.7	.....	.....	6.0	Aug. 16, 1944	742.2	——
5	(T)	NW cor. sec. 9	.....	do.	1944	91	.....	.....	7.2	Aug. 17, 1944	741.6	——
6	(T)	SE cor. NE sec. 8	.....	do.	1944	93	.....	.....	7.7	Aug. 18, 1944	740.6	——
7	(T)	NW cor. SW sec. 9	.....	do.	1944	100	.....	.....	10.5	Aug. 18, 1944	741.6	——
		T. 10 S., R. 25 E.										
(8)	(T)	SE cor. NE NE sec. 28	.....	do.	1944	106	.....	.....	13.8	Aug. 15, 1944	747.6	——
(9)	(T)	NE SE NE sec. 28	.....	do.	1944	129	.....	.....	12.7	Aug. 14, 1944	746.3	——
(10)	(T)	SW cor. NW sec. 27	.....	do.	1944	118	.....	.....	14.9	Aug. 11, 1944	745.7	——
(11)	(T)	SW cor. NW SW sec. 27	.....	do.	1944	105	.....	.....	12.0	Aug. 10, 1944	746.3	——
(12)	(T)	NW cor. SW SW SW sec. 27	.....	do.	1944	107	.....	.....	11.2	Aug. 3, 1944	745.3	——
(13)	(T)	NW NW NW sec. 34	.....	do.	1944	90	.....	.....	11.15	Aug. 9, 1944	745.9	[6] Converted into observation well, depth 89.2 feet; measuring point, 1.6 feet above land surface.
(14)	(T)	NW NW NW sec. 34	.....	do.	1944	84	.....	.....	9.8	July 29, 1944	744.2	——
15	W	SW SW sec. 27	Kansas Service Grocers, Inc.	.....	.....	85	.....	C	1.5	Aug. 15, 1943	.....	——
(16)	(W)	NW NW sec. 27	Corps of Engineers	Layne-Western Co.	1943	106	12	N	17	.....	744.8	Test well for determining permeability of alluvium
(17)	(W)	NE NW sec. 27	North American Aviation Co.	do.	1941	105	18	C	11.5	July 18, 1941	745.2	Bomber Assembly Plant, reported yield 1,000.
18	(W)	NE NW sec. 27	do.	do.	1941	106.5	18	C	15.1	Aug. 22, 1941	745.3	Bomber Assembly Plant, reported yield 1,100.
19	(W)	NE NW sec. 27	do.	do.	1941	105	18	C	17.0	Nov. 2, 1943	745.5	Bomber Assembly Plant, reported yield 1,075.
20	(W)	NE NW sec. 27	do.	do.	1941	105	18	C	17.0	Nov. 2, 1943	745.2	Bomber Assembly Plant, reported yield 1,100.
21	(W)	NW NE sec. 27	do.	do.	1943	104	18	C	21	Jan. 22, 1943	744.5	Bomber Assembly Plant, reported yield 1,500, drawdown 4.
22	(W)	NW NE sec. 27	do.	do.	1942	101	18	C	21	Dec. 18, 1942	744.5	Bomber Assembly Plant, reported yield 1,500, drawdown 5.5.
23	(W)	NW NE sec. 27	do.	do.	1943	101	18	C	21	Jan. 11, 1943	744.2	Bomber Assembly Plant, reported yield 1,500. drawdown 5.0.
24	(T)	NW NE sec. 27	.....	Corps of Engineers	1944	97	.....	.....	.....	.....	745.0	——
(25)	W	NW SE sec. 27	Milk Producers Marketing Co.	Air-Made Well Co.	1943	84	16	C	11.50	July 15, 1943	746.2	Reported yield 400, drawdown 1.5.
(26)	(W)	SW SE sec. 27	Fruehauf Trailer Co.	Layne-Western Co.	1937	73.2	7	C	19	Mar. 20, 1937	.....	Reported yield 80, drawdown 1.0.

27	W	SW SE sec. 27	Minneapolis Moline Power Impl.Co.					C				——
(28)	W	NW NE sec. 34	Aircraft Accessories Corp.					C				——
29	W	NW NE sec. 34	do.	Layne-Western Co.	1942	77.5	8	C				——
		T. 50 N., R. 33 W.										
30	(T)	SE SW sec. 10	Corps of Engineers	Corps of Engineers	1940	112					738.7	——
		T. 10 S., R. 25 E.										
31	(W)	NW NW sec. 35	North American Aviation Co.	Layne-Western Co.	1942	88.3	18	C, F	18.5	Dec. 20, 1942	741.5	Modification center, reported yield 1,540, Draw-down 9.5.
(32)	(W)	NW NW sec. 35	do.	do.	1943	85.3	18	C, F	16.5	Jan. 11, 1943	741.8	Modification center, reported yield 1,070, draw-down 8.0.
33	(W)	NW NW sec. 35	do.	do.	1942	86.7	18	C, F	17	Dec. 29, 1942	740.6	Modification center, reported yield 1,580, draw-down 14.0.
(34)	W	SW NE sec. 34	Sealright Co. Inc.	Air-Made Well Co.		60		C			742.6	——
(35)	(T)	NE NE SW sec. 34		State and Federal Geological Surveys.	1944	35.5			15.0	Aug. 19, 1944	739.2	——
(36)	(T)	NW NW SE sec. 34		do.	1944	73			8.7	Aug. 19, 1944	740.0	——
(37)	(T)	NW NE SE sec. 34		do.	1944	90			8.5	Aug. 22, 1944	738.9	——
38	(T)	NE NE SE sec. 34		do.	1944	86.5					741.8	——
(39)	(T)	SW NW NW sec. 34		do.	1944	94			11.1	Aug. 7, 1944	740.5	——
		T. 50 N., R. 33 W.										
(40)	(T)	SE NW NW sec. 22		do.	1944	94			10.9	Aug. 8, 1944	740.7	——
(41)	(T)	SE NE NW sec. 22		do.	1944	94			11.2	Aug. 4, 1944	741.2	——
42	(T)	NW NW sec. 14		Corps of Engineers		127			12		749.8	——
43	T	NW NE sec. 14		do.								——
44	(T)	NW SW sec. 14		do.		134			21		746.0	——
45	T	NW cor. SE sec. 14		do.								——
46	(T)	SE NE sec. 22		do.		114			21		743.6	——
47	W	NW NW sec. 22	Phillips Petroleum Co.	Layne-Western Co.	1944	94	26	C	10.9	Sept. —, 1944	740.7	Plant well 8: Reported yield 1,000, drawdown 8.0
48	(W)	NE NW sec. 22	Phillips Petroleum Co.	Layne-Western Co.	1942	79	26	C	7	Sept. —, 1942	741.4	Plant well 7; reported yield 1,000; drawdown 7.0.
49	(W)	SW NW sec. 22	do.	do.	1941	85.8	26	C	17	July —, 1943	745.2	Plant well 6; reported yield 1,000; drawdown 18.0.
50	(W)	NW SW sec. 22	do.	do.	1939	73.5	26	C	18	June —, 1939	741.6	Plant well 5; reported yield, 850; drawdown 6.0.
51	(W)	NW SW sec. 22	do.	do.	1933	86.5	18	C	15	June —, 1933	743.1	Plant well 4; reported yield, 1,000; drawdown 5.0.
52	(W)	NW SW sec. 22	do.	do.	1937	78.5	26	C	20	Mar. —, 1937	742.4	Reported yield, 1,000; drawdown 9.9.
53	W	NW SW sec. 22	do.	Austin and Sons	1930	86.5		N				Plant well 2.
54	(W)	NW SW sec. 22	do.	Layne-Western Co.	1936	84.3	26	C	22.8	Apr. —, 1936	742.0	Plant well 1; reported yield, 850; drawdown 6.8.
55	T	NW NE sec. 23		Corps of Engineers								——
56	T	SW SE sec. 23		do.								——
57	T	SW SE sec. 23		do.								——
58	T	NW SE sec. 23		do.								——
59	T	NW SE sec. 23		do.								——
60	(T)	NW SE sec. 22		do.		99.2			31		750.5	——
61	(T)	NE SW sec. 24		do.		144					744.9	——

TABLE 9. *Records of wells and test holes in the Kansas City, Kansas, area—Continued*

No. on Plate 1[1]	Description[2]	Location	Owner	Driller	Year completed	Depth of well or test hole (feet)[3]	Diameter of well (in.)	Use of water[4]	Depth to water level below land surface (feet)[5]	Date of measurement	Altitude of land surface (feet)	REMARKS (Yield given in gallons a minute, drawdown in feet)
62	T	SE SE sec. 23		Corps of Engineers								——
63	T	SW SE sec. 23		do.								——
64	(T)	NE NE sec. 32		do.		91			17		740.5	——
65	(T)	SE cor. SW sec. 28		do.		101.5			10.0		743.5	——
66	(T)	SE NE sec. 32		do.		95.5			15.5		751.5	——
67	(T)	SE NW sec. 26		do.		81.8			27		744.8	——
		T. 11 S., R. 25 E.										
68	(T)	SW SW sec. 2		do.		106			11		750.7	——
(69)	W	SW SW sec. 2	Federal Cold Storage Co.			100	26	C	30		750.4	Reported yield 600, drawdown 2.0.
70	W	SW SW sec. 2	do.			100	26	C	30		750.4	Reported yield 400, drawdown 2.0.
71	W	SW SW sec. 2	do.			100	26	C	30		749.9	Reported yield 400, drawdown 2.0.
		T. 50 N., R. 33 W.										
72	(T)	NW SE sec. 32		Corps of Engineers		87.5			14.5		753.8	——
73	T	NE SW sec. 32		do.								——
74	(T)	NW SE sec. 27		do.		80			17		740.7	——
		T. 11 S., R. 25 E.										
75	W	NW SW sec. 11	Armour Packing Co.	Layne-Western Co.	1919	77.3	24	O	37	Apr. —, 1919		Plant well No. 1. Reported yield 1,260, drawdown 13.5.
76	W	NW SW sec. 11	do.	do.	1919	84	24	O	42	Aug. —, 1919		Plant well No. 5. Reported yield 950, drawdown 20.0.
77	W	SE SE sec. 10, 77 S. James St.	Kansas City Dressed Beef Co.			85		C				Plant well No. 1. Reported yield 125.
(78)	(W)	SE SE sec. 10, 77 S. James St.	do.	Layne-Western Co.	1942	77.5	10	C	20	Nov. 11, 1942		Plant well No. 2. Reported yield 400, drawdown 30.
(79)	W	SE SE sec. 10, 210 Central Ave.	National Laboratories Corp.									——
(80)	W	SW SW sec. 11, 100 Myers Ave.	Maurer Packing Co.									——
(81)	(W)	SE SE sec. 10, 300 Central Ave.	Meyer Kornblum Packing Co.	Layne-Western Co.	1941	64.7	12	C	29.9	Mar. 28, 1944		Plant well No. 2. Reported yield 200, drawdown 12.5.
82	(W)	SE SE sec. 10, 300 Central Ave.	do.	do.	1937	67	12	C	23.7	July 7, 1937		Plant well No. 1. Reported yield 250, drawdown 10.3.
83	(T)	SW cor. SE sec. 10		State and Federal Geological Surveys.	1944	33					766.3	——
84	(T)	SE SW SE sec. 10		do.	1944	118					746.0	——
(85)	(T)	SE SW SE sec. 10		do.	1944	72			23.5	July 24, 1944	747.2	——

(86)	(T)	SE SE SE sec. 10		do.	1944	78			26.08	Oct. 1, 1944	748.9	Converted into observation well. Depth 789 feet; measuring point 1.5 feet above land surface.
(87)	(T)	SW SW SW sec. 11		do.	1944	77			20.07	July 28, 1944	746.2	Converted into observation well. Depth 69.6 feet; measuring point 1.7 feet above land surface.
		T. 49 N., R. 33 W.										
(88)	(T)	SW NW sec. 6		do.	1944	79.5			21.7	July 26, 1944	749.5	———
89	(T)	SW SW NE sec. 6		do.	1944	67			24.2	July 28, 1944	750.4	———
		T. 11 S., R. 25 E.										
90	W	SW SE sec. 15, 10 Berger Ave.	Swift and Co.	Swift and Co.	1925	77	120	C			745.5	Plant well No. 2. Reported yield 1,000.
91	W	SW SE sec. 15	do.	Swift and Co.	1925	78	144	C			747.0	Plant well No. 1. Reported yield 1,000.
(92)	(W)	SW SE sec. 15	do.	do.	1925	80	192	C			740.5	Plant well No. 3. Reported yield 1,400.
93	W	SW SE sec. 15	do.	Layne-Western Co.	1944	79	19	C	43	Aug. —, 1944	747.9	Plant well No. 4. Reported yield 600.
94	W	SW SE sec. 15, 20 Kansas Ave.	Williams Meat Co.		1940	72	10	C	28	1940		———
(95)	W	NE NE sec. 22, 631 S. Adams	Standard Rendering Co.	Air-Made Well Co.	1941	80		W, C				———
(96)	W	NE NE sec. 22, Shawnee and Belt Line.	Sambol Packing Co.		1912	76	10	W, C				———
(97)	(T)	NW SW SE sec. 15		State and Federal Geological Surveys.	1944	70			22.10	Oct. 1, 1944	745.3	Converted into observation well; depth 68.9 feet; measuring point 1.7 feet above land surface.
(98)	(T)	SE SW SE sec. 15		do.	1944	74			26.40	Oct. 1, 1944	749.4	Converted into observation well; depth 67.8 feet; measuring point 1.4 feet above land surface.
(99)	(T)	NE cor. NW NE sec. 22		do.	1944	78			19.5	July 20, 1944	741.3	———
(100)	(T)	SE NE NE sec. 22		do.	1944	78			24	July 20, 1944	746.8	Converted into observation well; depth 79.5 feet; measuring point 1.4 feet above land surface.
(101)	(T)	NW SW NW sec. 23		do.	1944	106			34.49	July 21, 1944	758.9	Converted into observation well; depth 97.9 feet; measuring point, 1.6 feet above land surface.
102	W	SW NE sec. 22; Osage and Adams	Wilson and Co.	Wilson and Co.	1919	81.3	60	C			750.9	Plant well No. 1. Reported yield 400.
103	W	SW NE sec. 22	do.	do.		90	60	C			752.0	Plant well No. 7. Reported yield 200.
104	(W)	SW NE sec. 22	do.	Kelly Well Co.	1944	83	18	C	27.33	Nov. 20, 1944	750.2	Plant well No. 10. Reported yield 1,800, drawdown 29. Measuring point, 1.4 feet above land surface
(105)	W	SW NE sec. 22	do.	Wilson and Co.	1924		60	C			751.3	Plant well No. 8. Reported yield 600.
106	(W)	SW NE sec. 22	do.	Austin and Sons.	1934	87.5	24	C	49.7	Sept. —, 1934	751.6	Plant well No. 9. Reported yield 600.
107	(N)	NE SW sec. 22, 5th and Kaw	Midwest Cold Storage and Ice Corp.	Layne-Western Co.	1938	84	26	C	44	July —, 1938	752.7	Plant well No. 2. Reported yield 870, drawdown 7.3.
(108)	(W)	NE SW sec. 22	do.	do.	1932	93.5	26	C	37	June —, 1932	760.6	Plant well No. 1. Reported yield 500, drawdown 17.
109	W	NE SW sec. 22	do.	do.		87	16	C	33.97	Nov. 20, 1944	757.8	Plant well No. 3. Measuring point, 1.0 feet above land surface.
110	W	NW cor. SW NW sec. 22	Osage Theater			74		C				———
(111)	W	NW NW sec. 21, 17th and Kansas Ave.	Colgate-Palmolive-Peet Co.	Layne-Western Co.				C			757.1	Plant well No. 5.
112	W	NW NW sec. 21	do.	do.				C			756.0	Plant well No. 6.
113	W	NW NW sec. 21	do.	do.				C			760.8	Plant well No. 7.
114	(W)	NW NW sec. 21	do.	do.	1937	73	26	C	27.5	July 12, 1944	757.4	Plant well No. 9. Reported yield 765.
115	(W)	NW NW sec. 21	do.	do.	1940	68.5	26	C	47	June 6, 1940	756.3	Plant well No. 10. Reported yield 500, drawdown 7.7.

TABLE 9. *Records of wells and test holes in the Kansas City, Kansas, area—Concluded*

No. on Plate 1[1]	Description[2]	LOCATION	Owner	Driller	Year completed	Depth of well or test hole (feet)[3]	Diameter of well (in.)	Use of water[4]	Depth to water level below land surface (feet)[5]	Date of measurement	Altitude of land surface (feet)	REMARKS (Yield given in gallons a minute, drawdown in feet)
116	(T)	NW SE SW sec. 16		State and Federal Geological Surveys.	1944	63			23.9	July 18, 1944	752.7	———
(117)	(T)	SE SW SW sec. 16		do.	1944	70			24.5	July 18, 1944	754.3	———
(118)	(T)	NW cor. sec. 21		do.	1944	73			28.74	Oct. 1, 1944	755.7	Converted into observation well; depth 68.6 feet; measuring point 1.5 feet above land surface.
(119)	(T)	SE NE NE sec. 20		do.	1944	88			25.30	July 15, 1944	759.2	Converted into observation well; depth 79.1 feet; measuring point 1.3 feet above land surface.
(120)	(T)	NW SE NE sec. 20		do.	1944	83			20.34	July 10, 1944	742.8	Converted into observation well; depth 77.8 feet; measuring point 1.3 feet above land surface.
		T. 11 S., R. 25 W.										
(121)	(T)	NE NW SE sec. 20		do.	1944	73			19.4	Nov. 17, 1944	746.2	Converted into observation well. Depth 70.0.
122	(T)	NE SW SE sec. 20		do.	1944	80			17.4	July 17, 1944	751.9	———
(123)	(T)	SW SW SE sec. 20		do.	1944	73			12.2	July 7, 1944	749.7	———
124	(W)	SE SE sec. 17; 19th and Kansas Ave.	Procter and Gamble Mfg. Co.	Layne-Western Co.	1938	75	26	C	48	Dec. 22, 1938	762.3	Plant well No. 5. Reported yield 900, drawdown 10.
125	W	SE SE sec. 17	do.	Austin and Sons	1926	89		C	46	1942	762.3	Plant well No. 2. Reported yield 800.
126	W	SE SE sec. 17	do.	do.				C	46	1942	763.2	Plant well No. 1. Reported yield 100.
127	W	SE SE sec. 17	do.	do.		85		N	45	1942	762.1	Plant well No. 3. Reported yield 200.
128	W	SE SE sec. 17	do.	do.		72		N	32	1942	759.5	Plant well No. 4. Reported yield 200.
(129)	(W)	SE SE sec. 17	do.	Layne-Western Co.	1940	82	18	C	45.7	Apr. —, 1940	758.9	Plant well No. 6. Reported yield 730, drawdown 7.5.
130	(W)	SE SE sec. 17	do.	do.	1941	82	18	C	50	May —, 1941	759.4	Plant well No. 7. Reported yield 900, drawdown 8.5.
(131)	(W)	NW NW sec. 20, 34th and Kansas Ave.	Sinclair Refining Co.	Austin and Sons	1919	69-72	24	C	38	June —, 1943	750.0	Plant well No. 5. Reported yield 800, drawdown 24.
132	W	NW NW sec. 20	do.	do.	1921	69.7	24	C	38	June —, 1943	748.4	Plant well No. 6. Reported yield 460.
(133)	(W)	NE NW sec. 20	do.	do.	1921	65	24	C	38	June —, 1943	749.2	Plant well No. 7. Reported yield 550, drawdown 24.
134	(T)	SE NW sec. 20	do.	do.	1921	60			26	June —, 1943		Test hole 4.
135	(T)	SW NW sec. 20	do.	do.	1921	60						Test hole 1.
136	(T)	NW NW sec. 20	do.	do.	1921	60			25.5	1921		Test hole 2.
137	(W)	NW cor. SW sec. 20	do.	do.	1919	71		O				Well No. 3.
		T. 11 S., R. 24 E.										
138	W	SE SE sec. 13	P. S. Judy	Air-Made Well Co.	1942	43.2	18	I (8)	23.75	Sept. 3, 1943	758.3	Used as observation well; measuring point 1.8 feet above land surface.
(139)	(T)	NW cor. NE SE sec. 21		State and Federal Geological Surveys.	1944	70			28.4	June 20, 1944	766.3	———
(140)	(T)	SE cor. NW NE SE sec. 21		do.	1944	77			31.1	June 15, 1944	768.2	———

(141)	(T)	NE SE SE sec. 21		do.	1944	60			13.9	June 16, 1944	756.6	———
(142)	(T)	NE cor. SW SW SW sec. 22		do.	1944	56			16.1	July 5, 1944	756.1	———
(143)	(T)	SE cor. SW SW sec. 22		do.	1944	70			18.7	June 16, 1944	759.8	———
(144)	(T)	SE cor. NW NE NW sec. 27		do.	1944	78			14.0	June 17, 1944	756.3	———
(145)	(T)	SE NE NW sec. 27		do.	1944	65			17.3	June 19, 1944	760.1	———
146	W	NE SW sec. 28, Morris, Kans.	Atchison, Topeka and Santa Fe Railway Co.	Air-Made Well Co.	1938	64	18	S, R			765.1	Railroad well No. 2.
(147)	W	NE SW sec. 28, Morris, Kans	do.	do.		69.9	18	S, R	27.53	Nov. 22, 1943	765.1	Railroad well No. 1. Used as observation well; measuring point 3.2 feet above land surface.
		T. 11 S., R. 23 E.										
148	W	SW NE sec. 27	Lake of the Forest Club	Layne-Western Co.	1936	57	8	N	26	June —, 1936	772.0	Reported yield 120.
(149)	W	SW NW sec. 27	Camp Theodore Naish				8	D			773.1	Supplies Boy Scout camp.
(150)	(T)	NW NE SE sec. 28		State and Federal Geological Surveys.	1944	69			22.2	June 23, 1944	776.6	———
(151)	(T)	NE NW SE sec. 28		do.	1944	69			23.8	June 22, 1944	772.2	———
(152)	(T)	SE NW SE sec. 28		do.	1944	72			26.0	June 21, 1944	779.1	———
(153)	(T)	NW cor. SW SW SE sec. 28		do.	1944	56			15.0	June 27, 1944	767.7	———
(154)	(T)	NW NW NE sec. 33		do.	1944	55			14.2	June 28, 1944	766.4	———
(155)	(T)	SW NW NE sec. 33		do.	1944	55			13.8	June 29, 1944	769.9	———
(156)	(T)	NW SW NE sec. 33		do.	1944	58			19.3	July 1, 1944	774.9	———
(157)	(T)	SW SW NE sec. 33		do.	1944	52			15.1	July 1, 1944	770.6	———
(158)	(T)	NW NW SE sec. 33		do.	1944	42			16.5	July 3, 1944	768.8	———
(159)	(T)			do.	1944	18			9.7	July 3, 1944	769.9	———
(160)	(W)	NE SW sec. 28	Lone Star Cement Co.		1924	84.0	25	C, D	36.83	Nov. 16, 1944	785.9	Measuring point, 1.5 feet above land surface.
(161)	(T)	SE cor. NW SW sec. 28		State and Federal Geological Surveys.	1944	86.5			36.2	June 24, 1944	789.2	———
(162)	(T)	NE SE SE sec. 29		do.	1944	64			39.7	June 24, 1944	794.8	———
(163)	(T)	NE SE SE sec. 29		do.	1944	73			35.9	June 26, 1944	780.8	———
164	W	SW NE sec. 32	City of Bonner Springs	Layne-Western Co.	1927	60		P			779.4	———
(165)	W	SW NE sec. 32	do.	Austin and Sons	1935	60	14	P	25.79	Sept. 1, 1943	775.9	Used as observation well. Measuring point, 3.5 feet above land surface.
166	W	SW NE sec. 32	do.		1908	60	6	P				Six wells pumped by suction with one centrally located pump.
(167)	(T)	SE SW SW sec. 32		State and Federal Geological Surveys.	1944	45			17.7	June 27, 1944	764.9	———

1. Well or test hole number in parentheses indicates that analysis of water is given in table 6.
2. T, test hole; W, well. W or T in parentheses indicates that log of well or test hole is given at back of this report.
3. Reported depths below the land surface are given in feet; measured depths are given in feet and tenths of feet below the land surface.
4. C, condensing, air conditioning; D, domestic; N, none; F, fire protection; O, obsolete, may be filled in; P, public supply; R, railroad; S, stock; W, washing and scrubbing purposes.
5. Measured depths to water level are given in feet and in tenths and hundredths of feet, reported depths to water level are given in feet.
6. During 1944, 59 test holes were drilled by State and Federal Geological Surveys. Eleven of these test holes were cased with 1¼ inch pipe and made into permanent observation wells.
7. Well was dug by employees of company under supervision of master mechanic.
8. Well was drilled for use as drainage well; is used occasionally as irrigation well.

LOGS OF TEST HOLES AND WELLS

On the following pages are listed the logs of 126 wells and test holes in the Kansas City, Kansas, area. Fifty-nine of the test holes were drilled by the State Geological Survey, 18 test holes were drilled by the Corps of Engineers, and the other test holes and wells were drilled by private contractors. Many of the logs of the wells were supplied by the Layne-Western Co. The logs include 5 test holes drilled in Missouri, 7 in Johnson County, Kansas, and 114 test holes and wells in Wyandotte County, Kansas.

1. *Log of test hole at site of well 1 in the SE¼ NE¼ sec. 28, T. 10 S., R. 25 E., Kansas City, Kansas, drilled by Corps of Engineers, 1944. Surface altitude, 745.9 feet.*

	Thickness, feet	*Depth, feet*
QUATERNARY—Pleistocene and Recent		
Alluvium		
Silt and sand (water level, 15 feet below land surface.),	18	18
Sand; contains some silt and gravel	22	40
Sand and gravel	20	60
Sand	10	70
Sand and gravel	4	74
Sand	2	76
Sand; contains some gravel	12	88
Sand	2	90
Sand and gravel	4	94
Gravel and sand	15	109
Sand and silt	2	111
PENNSYLVANIAN—Missourian		
Shale, blue	0.5	111.5

2. *Log of test hole at site of well 2 in the SE¼ NE¼ sec. 28, T. 10 S., R. 25 E., Kansas City, Kansas, drilled by Corps of Engineers, 1944. Surface altitude, 745.6 feet.*

	Thickness, feet	*Depth, feet*
QUATERNARY—Pleistocene and Recent		
Alluvium		
Silt and sand (water level, 11 feet below land surface.),	20	20
Sand; contains some silt and gravel	22	42
Sand and gravel	20	62
Sand; contains some gravel and silt	4	66
Sand; contains some silt	2	68
Sand; contains some silt and gravel	2	70
Gravel and sand	6	76
Sand; contains some silt	2	78
Sand and gravel; contains some silt	2	80
Gravel and sand; contains some silt	30	110
PENNSYLVANIAN—Missourian		
Shale, blue	1	111

3. *Log of test hole at site of well 3 in the SE¼ NE¼ sec. 28, T. 10 S., R. 25 E., Kansas City, Kansas, drilled by Corps of Engineers, 1944. Surface altitude, 746.0 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene and Recent		
Alluvium		
Sand, silty	1	1
Sand and silt	2	3
Sand; contains some silt	2	5
Sand	2	7
Silt and clay; contains some sand	2	9
Sand (water level, 12 feet below land surface.)	4	13
Sand and silt	1	14
Sand	6	20
Sand; contains some silt	12	32
Sand; contains some silt and gravel	2	34
Sand; contains some silt	4	38
Sand; contains some gravel and silt	2	40
Sand; contains some silt	2	42
Sand and gravel	2	44
Sand	4	48
Sand and gravel	12	60
Sand; contains some silt	2	62
Sand and gravel; contains some silt	4	66
Sand; contains some gravel	4	70
Sand and gravel; contains some silt	4	74
Gravel and sand; contains some silt	12	86
Sand; contains some silt and gravel	4	90
Gravel and sand	20	110
PENNSYLVANIAN—Missourian		
Sandstone	1	111

4. *Log of test hole 4 in the SE¼ NE¼ sec. 5, T. 50 N., R. 33 W., 30 feet west and 9 feet north of second telephone pole south of highway, Platte County, Missouri, drilled by Kansas Geological Survey, 1944. Surface altitude, 742.2 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene and Recent		
Alluvium		
Silt, clayey, brown gray (water level, 6.0 feet below land surface.)	12	12
Sand, medium to fine	18	30
Gravel, fine, and sand, fine to medium	8	38
Gravel, fine to coarse, and sand, medium	22	60
PENNSYLVANIAN—Missourian		
Limestone, hard, gray	2	62
Shale, dark blue gray, grading downward to light blue gray	5.5	67.5
Limestone, hard, light gray	0.2	67.7

5. *Log of test hole 5 at NW cor. sec. 9, T. 50 N., R. 33 W., 12 feet north and 3 feet east of telephone pole southeast of road intersection, Platte County, Missouri, drilled by Kansas Geological Survey, 1944. Surface altitude, 741.6 feet.*

	Thickness, feet	Depth, feet
Road fill	1	1
QUATERNARY—Pleistocene and Recent		
Alluvium		
Silt, gray brown	3	4
Clay, silty, yellow gray (water level, 7.2 feet below land surface.)	6	10
Silt, yellow gray; contains much fine sand	4	14
Silt, clayey, blue gray	2	16
Sand, coarse to fine, and some gravel, medium to fine	4	20
Sand, coarse to fine, and gravel, fine to coarse	40	60
Gravel, fine to coarse, and sand, medium	10	70
Gravel, fine to medium, and sand, medium	10	80
Gravel, fine to coarse, and sand, medium	11	91

6. *Log of test hole 6 at SE cor. NE¼ sec. 8, T. 50 N., R. 33 W., 30 feet east and 84 feet south of base of north tree in grove west of road, Platte County, Missouri, drilled by Kansas Geological Survey, 1944. Surface altitude, 740.6.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene and Recent		
Alluvium		
Silt, clayey, dark gray and yellow gray	9	9
Silt, clayey, blue gray (water level, 7.7 feet below land surface.)	6	15
Sand, coarse to fine, and some gravel, fine	5	20
Gravel, fine, and sand, medium	30	50
Gravel, fine to medium, sand, medium, and silt, blue gray	10	60
Gravel, fine, and sand, fine to medium	6	66
Gravel, coarse to fine, and sand, medium	24	90
PENNSYLVANIAN—Missourian		
Shale, light gray; contains much sand, fine	3	93

7. *Log of test hole 7 at NW cor. SW¼ sec. 9, T. 50 N., R. 33 W., 36 feet south and 15 feet west of base of cottonwood tree east of road and south of levee, Platte County, Missouri, drilled by Kansas Geological Survey, 1944. Surface altitude, 741.6 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene and Recent		
Alluvium		
Silt, yellow gray and gray; contains much very fine sand	10	10
Sand, medium to fine; interbedded with blue-gray silt, (Water level 10.5 feet below land surface.)	10	20
Sand, coarse to fine, and some gravel, medium to fine	10	30
Gravel, fine to coarse, and sand, medium	38	68
Gravel, coarse to fine, and sand, medium	22	90
Gravel, coarse to fine, and some sand, coarse	7	97

	Thickness, feet	Depth, feet
PENNSYLVANIAN—Missourian		
Shale, gray and light gray; contains some very fine greenish-gray sandstone	3	100

8. *Log of test hole 8 in the SE cor. NE¼ NE¼ sec. 28, T. 10 S., R. 25 E., 42 feet east and 45 feet south of first power pole west of south end of toll bridge on Seventh Street Trafficway, 40 feet south of levee, Kansas City, Kansas, drilled by Kansas Geological Survey, 1944. Surface altitude, 747.6 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene and Recent		
Alluvium		
Silt, partly clayey, yellow gray; contains some fine sand	10	10
Sand, medium to fine; containing very little fine gravel, (Water level, 13.8 feet below land surface.)	10	20
Sand, coarse to fine, and some gravel, coarse to fine,	10	30
Gravel, fine to coarse, and sand, medium	20	50
Gravel, medium to fine, medium sand, and gray-green silt	10	60
Gravel, fine to medium, and sand, medium	10	70
Gravel, coarse to fine, and sand, medium	34	104
PENNSYLVANIAN—Missourian		
Shale, light gray green, and sandstone, gray green	2	106

9. *Log of test hole 9 in the NE¼ SE¼ NE¼ sec. 28; T. 10 S., R. 25 E., on west side of Seventh Street Trafficway, 800 feet north of test hole 10 and 600 feet south of levee, 15 feet west and 3 feet south of second power pole west of corrugated-iron building, Kansas City, Kansas, drilled by Kansas Geological Survey, 1944. Surface altitude, 746.3 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene and Recent		
Alluvium		
Silt, soft, gray buff; contains much medium to fine sand,	5	5
Silt, clayey, gray	2	7
Sand, coarse to fine, and some gravel, fine (Water level, 12.7 feet below land surface.)	13	20
Gravel, fine, and sand, medium	10	30
Sand, coarse to fine, some medium gravel, and gray-green silt	10	40
Gravel, fine to medium, and sand, medium	10	50
Gravel, fine to medium, and sand, fine	10	60
Gravel, fine to coarse, and sand, medium	10	70
Gravel, coarse to fine, and sand, coarse	20	90
Gravel, very coarse to fine, and sand, coarse	10	100
Gravel, very coarse to fine	26	126
PENNSYLVANIAN—Missourian		
Shale, sandy, light gray green, and some sandstone, hard, fine, gray green	3	129

10. *Log of test hole 10 at SW cor. NW¼ sec. 27, T. 10 S., R. 25 E., 54 feet east and 21 feet south of first power pole north of Kindleberger Road and east of Seventh Street Trafficway, Kansas City, Kansas, drilled by Kansas Geological Survey, 1944. Surface altitude, 745.7 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene and Recent		
Alluvium		
Silt, yellow gray, and some clay	9	9
Sand, coarse to fine, and some gravel, fine	11	20
Sand, coarse to fine, and some gravel, medium to fine	10	30
Gravel, medium to fine, and sand, medium	20	50
Gravel, coarse to fine, and sand, coarse	30	80
Gravel, medium to fine, and sand, medium	10	90
Gravel, very coarse to fine, and sand, coarse	10	100
Gravel, very coarse to fine	16	116
PENNSYLVANIAN—Missourian		
Sandstone, carbonaceous, very hard, gray	2	118

11. *Log of test hole 11 at SW cor. NW¼ SW¼ sec. 27, T. 10 S., R. 25 E., 48 feet east and 15 feet north of power pole northeast of intersection of Eagle Road with Seventh Street Trafficway, Kansas City, Kansas, drilled by Kansas Geological Survey, 1944. Surface altitude, 746.3 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene and Recent		
Alluvium		
Silt, yellow buff and gray	5	5
Silt, clayey, yellow buff and gray	3	8
Silt, yellow buff and gray	2	10
Sand, medium to fine, some buff silt, and some fine gravel (Water level, 12.0 feet below land surface.)	10	20
Sand, medium to fine, buff and blue-gray silt, and some medium to fine gravel	20	40
Gravel, coarse to fine, medium sand, and blue-gray silt,	10	50
Gravel, coarse, to fine, and sand, medium	52	102
PENNSYLVANIAN—Missourian		
Shale, very light blue gray, and much sandstone, very fine, light gray	3	105

12. *Log of test hole 12 at NW cor. SW¼ SW¼ SW¼ sec. 27, T. 10 S., R. 25 E., on east side of Seventh Street Trafficway between Funston and Eagle Roads, 54 feet north and 12 feet east of northwest corner of Bright Bisquit Co., Kansas City, Kansas, drilled by Kansas Geological Survey, 1944. Surface altitude, 745.3 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene and Recent		
Alluvium		
Silt, gray and yellow gray	10	10
Sand, medium to fine, and some silt, buff (Water level, 11.2 feet below land surface.)	34	44
Gravel, medium to fine, and sand, medium	6	50
Sand, coarse to fine, and much gravel, coarse to fine	27	77
Gravel, very coarse to fine, and sand, coarse	3	80

Gravel, coarse to fine, and sand, coarse	10	90
Gravel, very coarse to medium, and sand, coarse	15	105
PENNSYLVANIAN—Missourian		
Limestone, very hard, light gray	2	107

13. *Log of test hole 13 in the NW¼ NW¼ NW¼ sec. 34, T. 10 S., R. 25 E., between Funston and Rickel Roads at their intersection with Seventh Street Trafficway, Kansas City, Kansas, drilled by Kansas Geological Survey, 1944. Surface altitude, 745.9 feet.*

QUATERNARY—Pleistocene and Recent	*Thickness, feet*	*Depth, feet*
Alluvium		
Silt, yellow buff	6	6
Sand, medium to fine, and some silt, blue gray (Water level, 11.2 feet below land surface.)	7	13
Silt, blue gray, interbedded with some sand, medium to fine	7	20
Sand, medium to fine	27	47
Gravel, medium to fine, and sand, medium	5	52
Sand, coarse to fine, and some gravel, fine	16	68
Gravel, medium to fine, and sand medium	13	81
Boulder, limestone	1	82
Gravel, very coarse to fine, and sand, coarse	0.5	82.5
Boulder, limestone, and some clay, white	0.5	83
Gravel, coarse to fine	2	85
Boulder, limestone	0.5	85.5
Gravel, coarse to fine	1.5	87
PENNSYLVANIAN—Missourian		
Shale, partly carbon-flecked, gray	3	90

14. *Log of test hole 14 in the NW¼ NW¼ NW¼ sec. 34, T. 10 S., R. 25 E., 9 feet east and 6 feet south of second pillar south of north end of Seventh Street viaduct on the east side, Kansas City, Kansas, drilled by Kansas Geological Survey, 1944. Surface altitude, 744.2 feet.*

QUATERNARY—Pleistocene and Recent	*Thickness, feet*	*Depth, feet*
Alluvium		
Silt, clayey, yellow gray	12	12
Sand, medium to fine, and some silt, soft blue gray (Water level, 9.8 feet below land surface.)	8	20
Sand, medium to fine	25	45
Sand, medium to fine; contains some blue-gray silt	1	46
Sand, medium to fine	4	50
Sand, coarse to fine, and some gravel, fine	10	60
Gravel, coarse to fine, and sand	13	73
Gravel, very coarse to fine, and some sand, coarse	9	82
PENNSYLVANIAN—Missourian		
Shale, carbon-flecked, gray	2	84

15. *Log of test hole 16 in the NW¼ NW¼ sec. 27, T. 10 S., R. 25 E., Kansas City, Kansas, drilled by Corps of Engineers, 1944. Surface altitude, 744.8 feet.*

	Thickness, feet	*Depth, feet*
QUATERNARY—Pleistocene and Recent		
Alluvium		
Silt, clay, and sand	8	8
Sand	10	18
Sand; contains some silt (Water level, 17 feet below land surface.)	12	30
Sand and gravel; contains some silt	10	40
Sand and gravel	12	52
Sand	4	56
Sand and gravel; contains some silt	18	74
Gravel and sand; contains some silt	30.3	104.3
PENNSYLVANIAN—Missourian		
Shale, blue	1.7	106

16. *Log of well 17 at the Bomber Assembly Plant of the North American Aviation Co. in the NE¼ NW¼ sec. 27, T. 10 S., R. 25 E., Kansas City, Kansas, drilled by Layne-Western Co., 1941. Surface altitude, 745.2 feet.*

	Thickness, feet	*Depth, feet*
QUATERNARY—Pleistocene and Recent		
Alluvium		
Clay, fine sandy	18	18
Sand, blue, fine	3	21
Sand, fine	19	40
Sand, fine, and driftwood	5	45
Sand, fine to coarse, and some gravel	4	49
Sand and gravel	20	69
Sand, gravel, and boulders; contains some balls of clay,	21	90
Sand, gravel, and boulders	15	105

17. *Log of well 18 at the Bomber Assembly Plant of the North American Aviation Co. in the NE¼ NW¼ sec. 27, T. 10 S., R. 25 E., Kansas City, Kansas, drilled by Layne-Western Co., 1941. Surface altitude, 745.3 feet.*

	Thickness, feet	*Depth, feet*
QUATERNARY—Pleistocene and Recent		
Alluvium		
Soil, sandy	13	13
Clay	2	15
Sand, medium coarse	25	40
Sand, medium coarse, and clay	10	50
Sand and gravel	2	52
Sand, medium coarse	8	60
Sand, gravel, and balls of clay	3	63
Sand and gravel	7	70
Gravel and rocks	36	106

18. *Log of well 19 at the Bomber Assembly Plant of the North American Aviation Co. in the NE¼ NW¼ sec. 27, T. 10 S., R. 25 E., Kansas City, Kansas, drilled by Layne-Western Co., 1941. Surface altitude, 745.5 feet.*

QUATERNARY—Pleistocene and Recent

Alluvium	*Thickness, feet*	*Depth, feet*
Soil, sandy	14	14
Sand, medium coarse	24	38
Sand, medium coarse; contains balls of clay	15	53
Sand, medium coarse	15	68
Gravel, rice-sized	9	77
Gravel	28	105

19. *Log of well 20 at the Bomber Assembly Plant of the North American Aviation Co. in the NE¼ NW¼ sec. 27, T. 10 S., R. 25 E., Kansas City, Kansas, drilled by Layne-Western Co., 1941. Surface altitude, 745.2 feet.*

QUATERNARY—Pleistocene and Recent

Alluvium	*Thickness, feet*	*Depth, feet*
Clay, sandy	15	15
Clay, sandy, mucky; contains some driftwood	12	27
Sand, fine, blue	4	31
Sand, fine, blue; contains some driftwood	2	33
Sand, fine, blue	2	35
Sand, fine, blue; contains some driftwood and balls of clay	14	49
Clay, sand, and gravel	9	58
Sand, fine to medium, and some gravel and balls of clay,	11	69
Sand, fine to medium	2	71
Sand, gravel, and boulders	36.5	107.5

20. *Log of well 21 at the Bomber Assembly Plant of the North American Aviation Co. in the NW¼ NE¼ sec. 27, T. 10 S., R. 25 E., Kansas City, Kansas, drilled by Layne-Western Co., 1943. Surface altitude, 744.5 feet.*

QUATERNARY—Pleistocene and Recent

Alluvium	*Thickness, feet*	*Depth, feet*
Sand, fine	2	2
Clay	5	7
Sand, fine, blue	13	20
Sand, medium fine	11	31
Sand, coarse, and gravel	11	42
Sand, fine	5	47
Sand, medium coarse	18	65
Sand, coarse, and gravel	40	105

21. *Log of well 22 at the Bomber Assembly Plant of the North American Aviation Co. in the NW¼ NE¼ sec. 27, T. 10 S., R. 25 E., Kansas City, Kansas, drilled by Layne-Western Co., 1942. Surface altitude, 744.5 feet.*

	Thickness, feet	*Depth, feet*
QUATERNARY—Pleistocene and Recent		
Alluvium		
Clay, sandy	5	5
Sand, fine	15	20
Sand, medium coarse	15	35
Sand, fine	15	50
Clay balls and gravel	11	61
Sand and gravel	19	80
Clay	9	89
Sand and gravel	13	102

22. *Log of well 23 at the Bomber Assembly Plant of the North American Aviation Co. in the NW¼ NE¼ sec. 27, T. 10 S., R. 25 E., Kansas City, Kansas, drilled by Layne-Western Co., 1943. Surface altitude, 744.2 feet.*

	Thickness, feet	*Depth, feet*
QUATERNARY—Pleistocene and Recent		
Alluvium		
Clay, sandy	6	6
Sand	14	20
Sand, medium fine	5	25
Sand, medium coarse	15	40
Sand, medium coarse; contains some clay	9	49
Sand and gravel	35	84
Clay	1	85
Sand and gravel	17	102

23. *Log of test hole 24 in the NW¼ NE¼ sec. 27, T. 10 S., R. 25 E., Kansas City, Kansas, drilled by Corps of Engineers, 1944. Surface altitude, 745.0 feet.*

	Thickness, feet	*Depth, feet*
QUATERNARY—Pleistocene and Recent		
Alluvium		
Sand, silt, and gravel	2	2
Sand and gravel	4	6
Sand, silt, and gravel	2	8
Silt, clay, and sand	14	22
Sand and silt	2	24
Sand, contains silt and gravel	8	32
Sand and gravel	12	44
Sand, contains gravel and silt	10	54
Sand and gravel; contains some silt	14	68
Sand; contains some gravel and silt	6	74
Gravel and sand	22	96
PENNSYLVANIAN—Missourian		
Shale	1	97

24. *Log of test hole 26 at the Fruehauf Trailer Co. in the SW¼ SE¼ sec. 27, T. 10 S., R. 25 E., northeast of the intersection of Funston Road with Chrysler Road, Kansas City, Kansas, drilled by Layne-Western Co., 1937.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene and Recent		
Alluvium		
Soil and clay	10	10
Clay, yellow (Water level, 19 feet below land surface.)	10	20
Sand, fine	10	30
Gravel, coarse	43.3	73.3

25. *Log of test hole 30 in the SE¼ SW¼ sec. 10, T. 50 N., R. 33 W., Kansas City, Kansas, drilled by Corps of Engineers, 1940. Surface altitude, 738.7 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene and Recent		
Alluvium		
Sand, contains silt and clay	4	4
Sand	12	16
Sand; contains some silt	12	28
Sand and gravel	26	54
Sand	6	60
Gravel and sand	26	86
Gravel	3	89
Gravel and sand	9	98
Sand; contains some silt	3	101
Gravel and sand	7	108
Sand	3	111
PENNSYLVANIAN—Missourian	1	112

26. *Log of test hole 31 at the Modification Center of the North American Aviation Co. in the NW¼ NW¼ sec. 35, T. 10 S., R. 25 E., Kansas City, Kansas, drilled by Layne-Western Co., 1942. Surface altitude, 741.5 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene and Recent		
Alluvium		
Clay	5	5
Sand, fine	15	20
Sand, medium coarse	24	44
Sand, fine	11	55
Sand, coarse	4	59
Sand, gravel, and boulders	29	88

27. *Log of test hole 32 at the Modification Center of the North American Aviation Co. in the NW¼ NW¼ sec. 35, T. 10 S., R. 25 E., Kansas City, Kansas, drilled by Layne-Western Co., 1943. Surface altitude, 741.8 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene and Recent		
Alluvium		
Clay	5	5
Sand, fine	16	21
Sand, medium coarse	32	53
Sand, medium to coarse, and some gravel	8	61
Sand, coarse	26	87
Gravel; contains a few boulders	0.5	87.5
Boulders	....	87.5

28. *Log of test hole 33 at the Modification Center of the North American Aviation Co. in the NW¼ NW¼ sec. 35, T. 10 S., R. 25 E., Kansas City, Kansas, drilled by Layne-Western Co., 1942. Surface altitude, 740.6 feet.*

	Thickness, feet	*Depth, feet*
Fill	1	1
QUATERNARY—Pleistocene and Recent		
Alluvium		
Sand, coarse	7	8
Clay, sandy	7	15
Sand, very fine	30	45
Sand, fine	10	55
Sand, coarse, and gravel	2	57

29. *Log of test hole 35 in the NE¼ NE¼ SW¼ sec. 34, T. 10 S., R. 25 E., 36 feet east and 27 feet south of second pole in line southwest of intersection of Rickel Road with Chrysler Road, Wyandotte County, drilled by Kansas Geological Survey, 1944. Surface altitude, 739.2 feet.*

	Thickness, feet	*Depth, feet*
QUATERNARY—Pleistocene and Recent		
Alluvium		
Silt, clayey, buff and gray	8	8
Sand, medium to fine, and some blue-gray clay near top (Water level, 15.0 feet below land surface.)	12	20
Sand, medium to fine	8	26
Sand, medium to fine, and clay, blue gray	2	30
Sand, medium to fine	4	34
PENNSYLVANIAN—Missourian		
Limestone, hard, brittle, brown	1	35
Limestone, hard, brittle, blue gray; contains thin shale break at top. Shale is fossiliferous, blue gray	0.5	35.5

30. *Log of test hole 36 in the NW¼ NW¼ SE¼ sec. 34, T. 10 S., R. 25 E., on Rickel Road and 275 feet east of Fairfax Road, at coördinates 52 + 00 N., and 16 + 40 E. of Phillips Petroleum Co. coördinate system, 30 feet east and 75 feet south of center of railroad crossing, Kansas City, Kansas, drilled by Kansas Survey, 1944. Surface altitude, 740.0 feet.*

	Thickness, feet	*Depth, feet*
QUATERNARY—Pleistocene and Recent		
Alluvium		
Silt, buff	7	7
Sand, medium to fine (Water level, 8.7 feet below land surface.)	13	20
Sand, coarse to fine, and some gravel, medium	20	40
Sand, coarse to fine, some fine gravel, and blue-gray silt,	18	58
Gravel, very coarse to fine, and sand, coarse	13	71
PENNSYLVANIAN—Missourian		
Shale, light gray green, interbedded with sandstone, fine, gray green	2	73

31. *Log of test hole 37 in the NE¼ NW¼ SE¼ sec. 34, T. 10 S., R. 25 E., 660 feet east of test hole 36, at coördinates 52 + 00 N. and 25 + 00 E. of Phillips Petroleum Co. coördinate system, Kansas City, Kansas, drilled by Kansas Geological Survey, 1944. Surface altitude, 738.9 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene and Recent		
Alluvium		
Silt, gray and yellow gray	6	6
Sand, medium to fine (Water level, 8.5 feet below land surface.)	34	40
Sand, coarse to fine	8	48
Gravel, fine to medium, and some gravel, medium	18	66
Gravel, coarse to fine, and sand, coarse	19	85
PENNSYLVANIAN—Missourian		
Shale, blue gray, and some sandstone, fine, yellowish gray	5	90

32. *Log of test hole 38 in the NW¼ NE¼ SE¼ sec. 34, T. 10 S., R. 25 E., 700 feet west of test hole 39, at coördinates 52 + 40 N. and 30 + 00 E. of Phillips Petroleum Co. coördinate system, 250 feet east of guard gate, 45 feet east and 30 feet south of third power pole east of guard gate, Kansas City, Kansas, drilled by Kansas Geological Survey, 1944. Surface altitude, 741.8 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene and Recent		
Alluvium		
Silt, soft, light brown	7	7
Sand, medium to fine	13	20
Sand, coarse to fine, and some gravel, fine	30	50
Gravel, coarse to fine, and sand, coarse	10	60
Gravel, very coarse to fine, and sand coarse	26	86
PENNSYLVANIAN—Missourian		
Limestone, hard, light gray	0.5	86.5

33. *Log of test hole 39 at NE cor. SE¼ sec. 34, T. 10 S., R. 25 E., 650 feet west of test hole 40 at coördinates 52 + 25 N. and 37 + 00 E. of Phillips Petroleum Co. coördinate system, 12 feet south of center line between two concrete sewer boxes, Kansas City, Kansas, drilled by Kansas Geological Survey, 1944. Surface altitude, 740.5 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene and Recent		
Alluvium		
Silt, clayey, gray and buff	7	7
Sand, medium to fine (Water level, 11.1 feet below land surface.)	13	20
Sand, coarse to fine, some fine gravel, and gray and buff silt	8	28
Silt, gray buff	2	30
Sand, coarse to fine, and some gravel, medium to fine,	10	40
Gravel, coarse to fine, and sand, coarse	30	70
Gravel, medium to fine, and sand, coarse	5	75
Gravel, coarse to fine, and sand, coarse	5	80

	Thickness, feet	Depth, feet
Boulder, limestone	2.5	82.5
Gravel, very coarse to fine, and sand, coarse	5.5	88
PENNSYLVANIAN—Missourian		
Shale, partly sandy, light blue gray	6	94

34. *Log of test hole 40 in the SW¼ NW¼ NW¼ sec. 22, T. 50 N., R. 33 W., 950 feet west of test hole 41, at coördinates 52 + 40 N. and 43 + 60 E. of Phillips Petroleum Co. coördinate system, 45 feet west of power-line brace pole, Kansas City, Kansas, drilled by Kansas Geological Survey, 1944. Surface altitude, 740.7 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene and Recent		
Alluvium		
Silt, gray and buff, interbedded with some sand	10	10
Sand, medium to fine, and some silt, blue gray and buff (Water level, 10.9 feet below land surface.)	10	20
Sand, coarse to fine, some silt, gray, and some gravel	10	30
Gravel, fine to coarse, and sand, medium	14	44
Gravel, coarse to fine, coarse sand, and blue-gray silt	11	55
Gravel, coarse to fine, and sand, medium	25	80
Gravel, very coarse to fine, and sand, coarse	7	87
Boulder, limestone	1	88
Gravel, very coarse to fine, and sand, coarse	1	89
PENNSYLVANIAN—Missourian		
Shale, very light blue gray, and some sandstone, fine, light blue gray	5	94

35. *Log of test hole 41 in the SE¼ NE¼ NW¼ sec. 22, T. 50 N., R. 33 W., 48 feet west and 30 feet south of NE corner fence post of Phillips Petroleum Company property at coördinates 52 + 40 N. and 53 + 00 E. of Phillips Petroleum Co. coördinate system, Kansas City, Kansas, drilled by Kansas Geological Survey, 1944. Surface altitude, 741.2 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene and Recent		
Alluvium		
Silt, gray and dark yellow gray	6	6
Sand, medium to fine, and much silt, blue gray	4	10
Sand, coarse to fine, some blue-gray silt, and some medium to fine gravel (Water level, 11.2 feet below land surface.)	10	20
Gravel, medium to fine, and sand, coarse	13	33
Sand, coarse to fine, some blue gray silt, and some medium to fine gravel	7	40
Sand, coarse to fine, and some gravel, medium	16	56
Gravel, coarse to fine, and sand, coarse; contains some pebbles	20	76
Boulder, limestone	2	78
Gravel, very coarse to fine, and some sand, coarse	11	89
PENNSYLVANIAN—Missourian		
Limestone, hard, light gray	1	90
Shale, alternating soft and hard, gray	2	92
Limestone, brittle, light gray	2	94

36. *Log of test hole 42 in the NW¼ NW¼ sec. 14, T. 50 N., R. 33 W., North Kansas City, Missouri, drilled by Corps of Engineers. Surface altitude, 749.8 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene and Recent		
Alluvium		
Sand, fine to coarse (Water level, 12 feet below land surface.)	14	14
Silt and sand	4	18
Sand; contains some silt	8	26
Sand and gravel	2	28
Sand; contains some silt	2	30
Sand; contains some gravel	2	32
Sand and gravel	4	36
Sand; contains some gravel	4	40
Sand	5	45
Sand and gravel	12	57
Sand	3	60
Clay; contains some sand	6	66
Sand; contains some gravel	4	70
Sand; contains some silt	10	80
Sand	2	82
Gravel and sand	43.5	125.5
PENNSYLVANIAN—Missourian		
Shale	1.5	127

37. *Log of test hole 44 in the NW¼ SW¼ sec. 14, T. 50 N., R. 33 W., North Kansas City, Missouri, drilled by Corps of Engineers. Surface altitude, 746.0 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene and Recent		
Alluvium		
Silt, sandy	14	14
Sand (Water level, 21 feet below land surface.)	12	26
Sand and gravel	18	44
Sand	4	48
Sand; contains some gravel and silt	4	52
Gravel and sand	10	62
Sand and gravel	16	78
Gravel and sand	55	133
PENNSYLVANIAN—Missourian		
Shale	1	134

38. *Log of test hole 46 in the SE¼ NE¼ sec. 22, T. 50 N., R. 33 W., North Kansas City, Missouri, drilled by Corps of Engineers. Surface altitude, 743.6 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene and Recent		
Alluvium		
Silt and clay	2	2
Silt and sand	3.7	5.7
Silt and clay, sandy (Water level, 21 feet below land surface.)	16.3	22
Sand; contains some gravel	14	36
Sand and gravel	7	43
Sand	10	53
Sand; contains some gravel	19	72
Gravel and sand	41	113
PENNSYLVANIAN—Missourian		
Shale	1	114

39. *Log of well 48 (plant well 7) at the Phillips Petroleum Co. in the NE¼ NW¼ sec. 22, T. 50 N., R. 33 W., at coördinates 50 + 00 N. and 51 + 20 E. of the Phillips Petroleum Co. coördinate system, Kansas City, Kansas, drilled by Layne-Western Co., 1942. Surface altitude, 741.4 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene and Recent		
Alluvium		
Soil	2	2
Sand, fine	4	6
Sand, fine, and streaks of clay (Water level, 7 feet below land surface.)	6	12
Sand, fine	10	22
Sand, medium fine	8	30
Sand, gravel, and balls of clay	19	49
Sand and gravel	31	80

40. *Log of well 49 (plant well 6) at the Phillips Petroleum Co. in the SW¼ NW¼ sec. 22, T. 50 N., R. 33 W., at coördinates 41 + 55 N. and 45 + 10 E. of the Phillips Petroleum Co. coördinate system, Kansas City, Kansas, drilled by Layne-Western Co., 1941. Surface altitude, 745.2 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene and Recent		
Alluvium		
Sand, fine silty (Water level, 17 feet below land surface.)	18	18
Sand, fine	5	23
Sand, fine; contains some driftwood	10	33
Sand, fine, and lignite	8	41
Sand, fine to coarse, balls of clay and flat rocks	9	50
Sand, fine, blue	10	60
Sand, gravel, and boulders	5	65
Gravel and boulders	21.6	86.6

41. *Log of test hole 49 A (test hole 1) at the Phillips Petroleum Co. in the SE¼ NW¼ sec. 22, T. 50 N., R. 33 W., at coördinates 43 + 70 N. and 46 + 50 E. of the Phillips Petroleum Co. coördinate system, 100 feet south and 100 feet east of tank 184, Kansas City, Kansas, drilled by Layne-Western Co., 1941.*

QUATERNARY—Pleistocene and Recent Alluvium	*Thickness, feet*	*Depth, feet*
Soil, sandy	3	3
Sand, fine	12	15
Sand, fine, packed; contains streaks of clay (Water level, 16.8 feet below land surfaces.)	23	38
Sand, fine	7	45
Sand, medium fine, and some balls of clay	10	55
Sand and boulders	10	65

42. *Log of test hole 49B (test hole 2) at the Phillips Petroleum Co. in the SW¼ NW¼ sec. 22, T. 50 N., R. 33 W., at coördinates 39 + 60 N. and 43 + 60 E. of the Phillips Petroleum Co. coördinate system, 240 feet southwest of well 49, Kansas City, Kansas, drilled by Layne-Western Co., 1941.*

QUATERNARY—Pleistocene and Recent Alluvium	*Thickness, feet*	*Depth, feet*
Clay, sandy	11	11
Sand, fine (Water level, 12.1 feet below land surface.),	17	28
Sand, medium fine	13	41
Sand, coarse, and gravel	5	46
Clay, blue	1	47
Sand, coarse, and gravel	4	51
Sand and gravel; contains numerous streaks of clay	4	55
Sand, coarse, gravel, and boulders	13	68
Sand, coarse, and some gravel	10	78
Boulder	..	78

43. *Log of test hole 49C (test hole 3) at the Phillips Petroleum Co. in the SW¼ NW¼ sec. 22, T. 50 N., R. 33 W., at coördinates 37 + 70 N. and 42 + 30 E. of the Phillips Petroleum Co. coördinate system 60 feet east of the center of tank 173, 230 feet southwest of test hole 49B, Kansas City, Kansas, drilled by Layne-Western Co., 1941.*

QUATERNARY—Pleistocene and Recent Alluvium	*Thickness, feet*	*Depth, feet*
Sand, silty	11	11
Sand, very fine (Water level, 12.8 feet felow land surface.)	12	23
Sand, fine	4	27
Sand, coarse to medium	6	33
Sand, coarse, and some gravel	14	47
Sand, fine	4	51
Sand, coarse, gravel, and boulders	2	53
Clay	1	54
Sand, gravel, and boulders	5	59
Sand, coarse, uniform-grained	7	66
Sand, gravel, and boulders	13	79
Boulder	..	79

44. *Log of test hole 49D (test hole 4) in the NW¼ SW¼ sec. 22, T. 50 N., R. 33 W., at coördinates 35 + 90 N. and 41 + 00 E. of the Phillips Petroleum Co. coördinate system, 350 feet north of well 51, 90 feet east of center of tank 171, 220 feet southwest of test hole 49C, Kansas City, Kansas, drilled by Layne-Western Co., 1941.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene and Recent		
Alluvium		
Clay fill	4	4
Sand, silty	7	11
Sand, fine, dirty (Water level, 17.8 feet below land surface.)	17	28
Sand, coarse, and some lignitic gravel	8	36
Sand, fine, blue	11	47
Sand, coarse, gravel, and balls of clay	5	52
Sand, coarse, and gravel	8	60
Gravel and boulders	3	63
Boulder	....	63

45. *Log of test hole 49E (test hole 5) in the NW¼ SW¼ sec. 22, T. 50 N., R. 33 W., at coördinates 33 + 20 N. and 39 + 30 E. of the Phillips Petroleum Co. coördinate system, 84 feet north and 35 feet west of well 51, 245 feet southwest of test hole 49D, Kansas City, Kansas, drilled by Layne-Western Co., 1941.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene and Recent		
Alluvium		
Sand, fine, dirty	8	8
Sand, fine	10	18
Clay, blue	2	20
Sand, fine	6	26
Sand, coarse, brown	5	31
Sand, coarse, gravel, and lignite	5	36
Sand, fine, and balls of clay	4	40
Sand, fine	7	47
Clay	2	49
Sand, coarse, and gravel	4	53
Sand, gravel, and boulders	6	59
Boulder	....	59

46. *Log of well 50 (plant well 5) at the Phillips Petroleum Co. in the NW¼ SW¼ sec. 22, T. 50 N., R. 33 W., at coördinates 32 + 95 N. and 35 + 60 E. of the Phillips Petroleum Co. coördinate system, Kansas City, Kansas, drilled by Layne-Western Co., 1931. Surface altitude, 741.6 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene and Recent		
Alluvium		
Clay	5	5
Sand, fine (Water level, 18 feet below land surface.),	18	23
Sand, medium	11	34
Clay, gray	3	37
Sand, fine	6	43
Sand, gravel, and boulders	30.5	73.5

47. *Log of test hole 50A (test hole 3) at the Phillips Petroleum Co. in the NW¼ SW¼ sec. 22, T. 50 N., R. 33 W., at coördinates 32 + 50 N. and 35 + 60 E. of the Phillips Petroleum Co. coördinate system, 150 feet west of center of tank 5803, Kansas City, Kansas, drilled by Layne-Western Co., 1939.*

QUATERNARY—Pleistocene and Recent

Alluvium	*Thickness, feet*	*Depth, feet*
Clay	5	5
Sand, very fine (Water level, 21 feet below land surface.)	18	23
Sand, medium fine	11	34
Clay	3	37
Sand, fine	6	43
Clay	2	45
Sand, coarse, and gravel; contains some boulders	25	70

48. *Log of well 51 (plant well 3) at the Phillips Petroleum Co. in the NW¼ SW¼ sec. 22, T. 50 N., R. 33 W., at coördinates 32 + 60 N. and 39 + 70 E. of the Phillips Petroleum Co. coördinate system, Kansas City, Kansas, drilled by Layne-Western Co., 1933. Surface altitude, 743.1 feet.*

QUATERNARY—Pleistocene and Recent

Alluvium	*Thickness, feet*	*Depth, feet*
Soil	3	3
Sand and clay	17	20
Sand, fine, silty	13	33
Sand, medium fine, clean	7	40
Quick sand, fine, blue	12	52
Sand, coarse, gravel, and boulders	18	70
Clay, sand, and boulders	6	76
Sand, gravel, and boulders	10.5	86.5

49. *Log of well 52 (plant well 4) at the Phillips Petroleum Co. in the NW¼ SW¼ sec. 22, T. 50 N., R. 33 W., at coördinates 29 + 15 N. and 35 + 60 E. of Phillips Petroleum Co. coördinate system, Kansas City, Kansas, drilled by Layne-Western Co., 1937. Surface altitude, 742.4 feet.*

QUATERNARY—Pleistocene and Recent

Alluvium	*Thickness, feet*	*Depth, feet*
Soil	2	2
Clay, sandy	16	18
Sand, fine (Water level, 20 feet below land surface.)	31	49
Sand, gravel, and balls of clay	5	54
Sand, gravel, and boulders	22.5	76.5
Clay	2	78.5

50. *Log of test hole 52A (test hole 2) at the Phillips Petroleum Co. in the NW¼ SW¼ sec. 22, T. 50 N., R. 33 W., at coördinates 29 + 50 N. and 32 + 30 E. of the Phillips Petroleum Co. coördinate system, 25 feet northwest of intersection of fire dikes between tanks 5202, 5203, 256, and 257, Kansas City, Kansas, drilled by Layne-Western Co., 1939.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene and Recent		
Alluvium		
Clay, silty	8	8
Sand, very fine (Water level, 20 feet below land surface.)	17	25
Sand, medium coarse	13	38
Sand, fine	2	40
Sand, coarse	8	48
Sand, fine	2	50
Sand, coarse, and some gravel	6	56
Clay	5	61
Sand, gravel, and boulders	11	72

51. *Log of test hole 52B (test hole 1) at the Phillips Petroleum Co. in the NW¼ SW¼ sec. 22, T. 50 N., R. 33 W., at coördinates 27 + 70 N. and 29 + 80 E. of the Phillips Petroleum Co. coördinate system, 125 feet west of center of tank 256 and 25 feet north of line extending through centers of tanks 256 and 257, Kansas City, Kansas, drilled by Layne-Western Co., 1939.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene and Recent		
Alluvium		
Clay, blue	5	5
Sand, fine	9	14
Clay, blue	1	15
Sand, very fine (Water level, 18 feet below land surface.)	13	28
Sand, fine	13	41
Sand, coarse, mixed with some clay	17	58
Sand, coarse, to gravel, fine	2	60
Limestone	.5	60.5

52. *Log of test hole 52C (test hole 2) at the Phillips Petroleum Co. in the NW¼ SW¼ sec. 22, T. 50 N., R. 33 W., at coördinates 27 + 50 N. and 27 + 40 E. of the Phillips Petroleum Co. coördinate system, 135 feet south and 200 feet east of center of tank 73, Kansas City, Kansas, drilled by Layne-Western Co., 1937.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene and Recent		
Alluvium		
Clay, brown	8	8
Clay, sandy	5	13
Sand, fine, dirty	7	20
Sand, medium fine (Water level, 22 feet below land surface.)	7	27
Clay	1	28

	Thickness, feet	Depth, feet
Sand, fine, and balls of clay	10	38
Sand, coarse	4	42
Sand, gravel, and boulders	6	48
Clay, blue	2	50
Sand, gravel, and few boulders	5	55
Rock	....	55

53. *Log of well 54 (plant well 1) at the Phillips Petroleum Co. in the NW¼ SW¼ sec. 22, T. 50 N., R. 33 W., at coördinates 24 + 90 N. and 34 + 40 E. of the Phillips Petroleum Co. coördinate system, Kansas City, Kansas, drilled by Layne-Western Co., 1936. Surface altitude, 742.0 feet.*

Quaternary—Pleistocene and Recent	Thickness, feet	Depth, feet
Alluvium		
Soil, and sand, fine	13	13
Sand, fine (Water level, 2.8 feet below land surface.),	31	44
Sand, medium coarse	4	48
Clay, sand, and gravel	4	52
Sand, coarse, gravel, and boulders	24	76
Clay	10	86
Shale	....	86

54. *Log of test hole 54A (test hole 2) at the Phillips Petroleum Co. in the NE¼ NE¼ sec. 2, T. 10 S., R. 25 E., at coördinates 19 + 80 N. and 31 + 20 E. of the Phillips Petroleum Co. coördinate system, 95 feet north and 175 feet east of tank 132, Kansas City, Kansas, drilled by Layne-Western Co., 1933.*

Quaternary—Pleistocene and Recent	Thickness, feet	Depth, feet
Alluvium		
Sand	20	20
Silt and clay, sandy	8	28
Clay, sandy, blue	2	30
Sand, coarse, clean	2	32
Clay; contains some sand	2	34
Sand, coarse, and gravel	1	35
Sand, fine, clean	3	38
Quick sand	6	44
Quick sand, dark-blue	3	47
Sand, medium coarse, clean, blue, and some gravel	6	53
Sand and gravel	2	55
Clay	1.5	56.5
Sand and gravel; contains some clay	4.5	61
Sand and gravel; mixed with clay	6	67
Clay, sandy	13	80

55. *Log of test hole 54B (test hole 1) at the Phillips Petroleum Co. in the NE¼ NE¼ sec. 2, T. 10 S., R. 25 E., at coördinates 17 + 50 N. and 30 + 00 E. of the Phillips Petroleum Co. coördinate system, 160 feet south and 50 feet east of tank 132, Kansas City, Kansas, drilled by Layne-Western Co., 1933.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene and Recent		
Alluvium		
Silt, sandy	1	1
Clay	5	6
Sand, fine	8	14
Silt, clayey	1	15
Sand, fine	9	24
Silt, clayey	1	25
Sand, fine	4	29
Silt, clayey	1	30
Sand, coarse	3	33
Clay, sandy	5	38
Sand, fine	7	45
Sand, coarse, and gravel, fine	10	55
Gravel, fine	6	61
Sand, fine; contains streaks of clay	4	65
Boulders	2	67
Sand, gravel, and balls of clay	16	83
Sand, fine	2	85
Boulders	1	86
Shale	4	90

56. *Log of test hole 60 in the NW¼ SE¼ sec. 22, T. 50 N., R. 33 W., North Kansas City, Missouri, drilled by Corps of Engineers. Surface altitude, 750.5 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene and Recent		
Alluvium		
Silt and clay, sandy	26	26
Sand; contains some silt	4	30
Sand and silt (Water level, 31 feet below land surface.),	10	40
Sand; contains some gravel	14	54
Sand and gravel	4	58
Gravel and sand	6	64
Sand and gravel	4	68
Silt and sand	4	72
Sand; contains some silt	2	74
Gravel and sand	24.2	98.2
PENNSYLVANIAN—Missourian		
Shale, blue	1	99.2

57. *Log of test hole 61 in the NE¼ SW¼ sec. 24, T. 50 N., R. 33 W., North Kansas City, Missouri, drilled by Corps of Engineers. Surface altitude 744.9 feet.*

	Thickness, feet	*Depth feet*
QUATERNARY—Pleistocene and Recent		
Alluvium		
Sand	10	10
Sand; contains some silt	2	12
Silt and sand	2	14
Sand	2	16
Clay and silt; contains some sand	2	18
Silt and sand	14	32
Sand; contains some silt	6	38
Sand and gravel	6	44
Sand; contains some gravel	6	50
Sand	8	58
Sand and gravel	4	62
Gravel and sand	16	78
Sand and gravel	8	86
Gravel and sand	26	112
Sand; contains some silt	15	127
Gravel and sand	16.5	143.5
PENNSYLVANIAN—Missourian		
Shale, blue	.5	144

58. *Log of test hole 64 in the NE¼ NE¼ sec. 32, T. 50 N., R. 33 W., North Kansas City, Missouri, drilled by Corps of Engineers. Surface altitude, 740.5 feet.*

	Thickness, feet	*Depth feet*
QUATERNARY—Pleistocene and Recent		
Alluvium		
Sand	4	4
Sand; contains some silt	4	8
Sand	3.7	11.7
Sand; contains some silt	2.3	14
Silt and sand (Water level, 17 feet below land surface.),	4	18
Sand; contains some silt	4	22
Sand and gravel	2	24
Sand and silt	2	26
Sand and gravel; contains some silt	10	36
Sand and gravel	28	64
Gravel and sand	26	90
PENNSYLVANIAN—Missourian		
Shale, blue	1	91

59. *Log of test hole 65 in the SE cor. SW¼ sec. 28, T. 50 N., R. 33 W., Kansas City, Missouri, drilled by Corps of Engineers. Surface altitude, 743.5 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene and Recent		
Alluvium		
Sand and silt, contains gravel	4	4
Sand; contains gravel and silt (Water level, 10.0 feet below land surface.)	6	10
Sand and silt	20	30
Sand; contains silt and gravel	2	32
Silt and sand	2	34
Sand; contains gravel and silt	5	39
Sand	1	40
Sand and silt	2	42
Sand; contains gravel	10	52
Sand and gravel	6	58
Sand; contains some gravel and silt	2	60
Sand and gravel	4	64
Sand, contains gravel and silt	16	80
Gravel and sand	8	88
Sand and gravel	4	92
Gravel and sand	7.4	99.4
PENNSYLVANIAN—Missourian		
Shale	2.1	101.5

60. *Log of test hole 66 in the SE¼ NE¼ sec. 32, T. 50 N., R. 33 W., Kansas City, Missouri, drilled by Corps of Engineers. Surface altitude, 751.5 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene and Recent		
Alluvium		
Sand, contains some silt (Water level, 15.5 feet below land surface.)	21	21
Silt and sand	2	23
Sand; contains silt	2	25
Silt, clay, and sand	8	33
Sand and silt	16	49
Sand; contains silt	2	51
Sand; contains gravel and silt	4	55
Gravel and sand	11	66
Sand; contains gravel and silt	7	73
Gravel and sand	2	75
Sand; contains some gravel and silt	3	78
Gravel and sand	6	84
Sand and gravel	9	93
PENNSYLVANIAN—Missourian		
Limestone	2.5	95.5

61. *Log of test hole 67 in the SE¼ NW¼ sec. 26, T. 50 N., R. 33 W., North Kansas City, Missouri, drilled by Corps of Engineers. Surface altitude 744.8 feet.*

	Thickness, feet	*Depth, feet*
QUATERNARY—Pleistocene and Recent		
Alluvium		
Sand	2	2
Sand and silt	10	12
Silt and sand	4	16
Sand and silt (Water level, 27 feet below land surface.),	16	32
Sand; contains some silt and gravel	16	48
Sand and gravel	6	54
Silt and sand; contains some gravel	2	56
Gravel and sand	24.8	80.8
PENNSYLVANIAN—Missourian		
Shale, blue	1	81.8

62. *Log of test hole 68 in the SW¼ SW¼ sec. 2, T. 11 S., R. 25 E., Kansas City, Kansas, drilled by Corps of Engineers, 1944. Surface altitude, 750.7 feet.*

	Thickness, feet	*Depth, feet*
QUATERNARY—Pleistocene and Recent		
Alluvium		
Silt and clay, sandy	1.5	1.5
Sand and gravel; contains some silt	3.5	5
Sand; contains some gravel and silt (Water level, 11 feet below land surface.)	20	25
Silt and clay	2.5	27.5
Sand, silt, and clay	16.5	44
Sand; contains silt and clay	14	58
Sand; contains some silt	12	70
Sand and gravel	2	72
Sand; contains gravel and silt	10	82
Gravel and sand	6	88
Sand; contains some gravel and silt	4	92
Gravel and sand; contains silt	4	96
Sand	2	98
Gravel and sand	7.5	105.5
PENNSYLVANIAN—Missourian		
Shale	.5	106

63. *Log of test hole 72 in the NW¼ SE¼ sec. 32, T. 50 N., R. 33 W., Kansas City, Missouri, drilled by Corps of Engineers. Surface altitude, 753.8 feet.*

	Thickness, feet	*Depth, feet*
QUATERNARY—Pleistocene and Recent		
Alluvium		
Silt, clay, and sand	1.7	1.7
Sand; contains gravel and silt	5.8	7.5
Sand and gravel (Water level, 14.5 feet below land surface.)	10.5	18
Silt and clay	12	30

	Thickness, feet	Depth, feet
Sand and silt	10	40
Sand and gravel; contains some silt	13	53
Sand	3	56
Sand and gravel	8	64
Sand	1	65
Sand and gravel; contains some silt	4	69
Sand; contains silt	2	71
Sand and gravel	13.7	84.7
PENNSYLVANIAN—Missourian		
Shale	2.8	87.5

64. *Log of test hole 74 in the NW¼ SE¼ sec. 27, T. 50 N., R. 33 W., North Kansas City, Missouri, drilled by Corps of Engineers. Surface altitude, 740.7 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene and Recent		
Alluvium		
Silt and clay; contains some sand	6	6
Sand and silt	2	8
Sand; contains some silt and gravel (Water level, 17 feet below land surface.)	22	30
Sand and gravel	8	38
Gravel and sand	28	66
Silt and sand	4	70
Sand and gravel; contains some silt	6	76
Gravel and sand	3	79
PENNSYLVANIAN—Missourian		
Limestone, weathered	1	80

65. *Log of well 78 (plant well 2) at the Kansas City Dressed Beef Co. in the SE¼ SE¼ sec. 10, T. 11 S., R. 25 E., 77 South James Street, Kansas City, Kansas, drilled by Layne-Western Co., 1942.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene and Recent		
Alluvium		
Cinders	3	3
Sand, fine	15	18
Clay, soft, blue (Water level, 20 feet below land surface.)	5	23
Sand, fine	3	26
Sand, coarse	3	29
Sand, medium coarse	11	40
Sand, coarse, and gravel	14	54
Clay, blue	8	62
Sand, coarse, and gravel	10	72
Gravel and rocks	5.5	77.5

66. *Log of well 81 (plant well 2) at the Meyer-Kornblum Packing Co. in the SE¼ SE¼ sec. 10, T. 11 S., R. 25 E., 300 Central Avenue, Kansas City, Kansas, drilled by Layne-Western Co., 1941.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene and Recent		
Alluvium		
Fill, black	1	1
Gumbo, black	6	7
Clay, dark blue	7	14
Clay, gray (Water level, 29.9 feet below land surface.),	35	49
Sand, coarse, and gravel	10	59
Clay, brown	2	61
Sand, coarse	2	63
Gravel	2	65
Rock	..	65

67. *Log of well 82 (plant well 1) at the Meyer-Kornblum Packing Co. in the SE¼ SE¼ sec. 10, T. 11 S., R. 25 E., 300 Central Avenue, Kansas City, Kansas, drilled by Layne-Western Co., 1937.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene and Recent		
Alluvium		
Fill	2	2
Clay	14	16
Sand (Water level, 23.7 feet below land surface.)	12	28
Clay, blue	22	50
Sand and gravel	12	62
Clay, yellow	2	64
Sand, coarse, and gravel	4	68

68. *Log of test hole 83 at SW cor. SE¼ sec. 10, T. 11 S., R. 25 E., southeast of intersection of Fifth Street with Central Avenue, 20 feet south of second brace pole south of viaduct, Kansas City, Kansas, drilled by Kansas Geological Survey, 1944. Surface altitude, 766.3 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene and Recent		
Alluvium		
Silt, buff and gray	10	10
Silt, light brown and light gray, interbedded with some sand, medium to fine	15	25
Silt, blue gray	7	32
PENNSYLVANIAN—Missourian		
Limestone, hard, light gray and white	1	33

69. *Log of test hole 84 in the SE¼ SW¼ SE¼ sec. 10, T. 11 S., R. 25 E., 54 feet north and 30 feet east of power pole northwest of intersection of Fourth Street with Central Avenue, Kansas City, Kansas, drilled by Kansas Geological Survey, 1944. Surface altitude, 746.0 feet.*

	Thickness, feet	Depth, feet
Fill	9	9
QUATERNARY—Pleistocene and Recent		
Alluvium		
Silt, dark gray; contains some medium to fine sand	19	28
Sand, coarse to fine	2	30
Gravel, medium to fine, and sand, medium	4	34
Silt, green gray	11	45
Gravel, fine to coarse, and sand, medium	15	60
Gravel, coarse to fine	5	65
Silt, buff and yellow	3	68
Gravel, very coarse to fine	6	74
Clay, silty, dark gray	4	78
Sand, medium to fine, interbedded with clay, dark gray,	9	87
Sand, medium to fine	19	106
PENNSYLVANIAN—Missourian		
Shale, gray	12	118

70. *Log of test hole 85 in the SE¼ SW¼ SE¼ sec. 10, T. 11 S., R. 25 E., southeast of intersection of Third Street with Central Avenue, 5 feet south of fire plug, Kansas City, Kansas, drilled by Kansas Geological Survey, 1944. Surface altitude, 747.2 feet.*

	Thickness, feet	Depth, feet
Fill	8.5	8.5
QUATERNARY—Pleistocene and Recent		
Alluvium		
Silt, dark blue gray	11.5	20
Silt, blue gray, interbedded with sand, coarse to fine (Water level, 23.5 feet below land surface.)	10	30
Gravel, fine to medium, and sand, medium	10	40
Silt, light blue gray	10	50
Gravel, fine to coarse, and sand, medium	10	60
Gravel, very coarse to fine, sand, medium and some silt; blue gray and gray green	9	69
PENNSYLVANIAN—Missourian		
Limestone, fairly hard, light gray	1	70
Shale, light bluish gray; contains some light-gray limestone	2	72

71. *Log of test hole 86 in the SE¼ SE¼ SE¼ sec. 10, T. 11 S., R. 25 E., southeast of intersection of Central Avenue with Kansas River at south end of truck lot at Farmer's Coöperative Association, Kansas City, Kansas, drilled by Kansas Geological Survey, 1944. Surface altitude, 748.9 feet.*

	Thickness, feet	Depth, feet
Fill	12	12
QUATERNARY—Pleistocene and Recent		
Alluvium		
Silt, dark gray	8	20
Sand, coarse to fine, and some gravel, fine	5	25
Silt, light blue gray	5	30
Gravel, fine to medium, and sand, medium	20	50
Gravel, medium to fine, and sand, medium	10	60
Gravel, fine to medium, sand, medium, and silt, light blue gray	10	70
Gravel, coarse to fine, and sand, medium	7	77
PENNSYLVANIAN—Missourian		
Limestone, buff, and shale, gray	1	78

72. *Log of test hole 87 in the SW¼ SW¼ SW¼ sec. 11, T. 11 S., R. 25 E., southwest of the intersection of James Street with Meyers Avenue, 33 feet west and 15 feet north of power pole at curve on Central Avenue viaduct, Kansas City, Kansas, drilled by Kansas Geological Survey, 1944. Surface altitude, 746.2 feet.*

	Thickness, feet	Depth, feet
Fill	7	7
QUATERNARY—Pleistocene and Recent		
Alluvium		
Silt, gray buff, interbedded with some sand, medium	9	16
Sand, coarse to fine, and gravel, medium (Water level, 21.8 feet below land surface.)	14	30
Sand, coarse to fine	20	50
Silt, clayey, greenish gray	3	53
Gravel, fine to medium and sand, medium	7	60
Gravel, medium to fine, and sand, medium	10	70
Gravel, coarse to fine	6	76
PENNSYLVANIAN—Missourian		
Limestone, hard, white	1	77

73. *Log of test hole 88 in the SW¼ NW¼ sec. 6, T. 49 N., R. 33 W., 15 feet east of State Line Street and 15 feet south of alley located north of intersection of Ewing Avenue with State Line Street, Kansas City, Missouri, drilled by Kansas Geological Survey, 1944. Surface altitude, 749.5 feet.*

	Thickness, feet	Depth, feet
Fill	2	2
QUATERNARY—Pleistocene and Recent		
Alluvium		
Silt, clayey buff gray	8	10
Silt, clayey	10	20

	Thickness, feet	Depth, feet
Sand, coarse, gravel, fine, and silt, gray (Water level, 21.7 feet below land surface.)	20	40
Gravel, coarse to fine, and sand, coarse	17	57
Gravel, coarse to fine, sand, coarse, and silt, blue gray,	3	60
Gravel; contains some pebbles, and sand, coarse	19	79
PENNSYLVANIAN—Missourian		
Limestone, very hard, gray	0.5	79.5

74. *Log of test hole 89 in the SW¼ SW¼ NE¼ sec. 6, T. 49 N., R. 33 W., northeast of intersection of Twelfth Street with Santa Fe Street, 15 feet west and 33 feet south of first power pole east of gate in board fence, Kansas City, Missouri, drilled by Kansas Geological Survey, 1944. Surface altitude, 750.4 feet.*

	Thickness, feet	Depth, feet
Fill	4	4
QUATERNARY—Pleistocene and Recent		
Alluvium		
Silt, clayey, dark gray	6	10
Silt, clayey, some sand, fine, and some charcoal	10	20
Sand, fine, charcoal, and silt (Water level, 24.2 feet beland surface.)	30	50
Gravel, medium to fine, and sand, fine to medium	16	66
PENNSYLVANIAN—Missourian		
Limestone, hard, gray white	1	67

75. *Log of well 92 (plant well 3) at Swift and Co. in the SW¼ SE¼ sec. 15, T. 11 S., R. 25 E., 10 Berger Avenue, Kansas City, Kansas, dug by employees of Swift and Co. under supervision of master mechanic, 1925. Surface altitude, 740.5 feet.*

	Thickness, feet	Depth, feet
Cinders	2.5	2.5
QUATERNARY—Pleistocene and Recent		
Alluvium		
Sand, fine, white	9.5	12
Sand, fine, gray, and clay	5	17
Sand, fine, gray	3	20
Sand, medium, gray	3	23
Sand, coarse	5	28
Gravel, fine, and clay, blue	4	32
Sand, coarse, gray	7	39
Sand, medium coarse	11	50
Sand, fine, gray	9	59
Sand, coarse, and gravel fine	4	63
Sand, coarse, and gravel	15	78
Shale	..	78

76. *Log of test hole 97 in the NW¼ SW¼ SE¼ sec. 15, T. 11 S., R. 25 E., 30 feet south and 21 feet east of center of intersection of Fourth Street with Berger Avenue, Wyandotte County, drilled by Kansas Geological Survey, 1944. Surface altitude, 745.3 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene and Recent		
Alluvium		
Silt, yellow gray and light gray	10	10
Silt, clayey, bluish gray	7	17
Sand, coarse to fine, some gravel, medium to fine, and some silt, blue gray (Water level, 23.8 feet below land surface.)	13	30
Gravel, fine, sand, green, and silt, blue gray	20	50
Gravel, fine, sand, medium, and some silt, blue gray	14	64
Gravel, coarse to fine, and sand, coarse	5	69
PENNSYLVANIAN—Missourian		
Limestone, very hard, buff and white	1	70

77 *Log of test hole 98 in the SE¼ SW¼ SE¼ sec. 15, T. 11 S., R. 25 E., at the rear of the port of entry, north of Kansas Avenue and 125 feet west of Second Street, Wyandotte County, drilled by Kansas Geological Survey, 1944. Surface altitude, 749.4 feet.*

	Thickness, feet	Depth, feet
Fill	2	2
QUATERNARY—Pleistocene and Recent		
Alluvium		
Silt, soft, light yellow gray	12	14
Silt, light blue gray	9	23
Gravel, fine to medium, and sand, medium, brown (Water level, 27.8 feet below land surface.)	37	60
Gravel, coarse to fine, greenish	10	70
PENNSYLVANIAN—Missourian		
Limestone, hard, brown gray	0.5	70.5
Shale, yellow green downward to gray blue	3.5	74

78. *Log of test hole 99 in the NE cor. NW¼ NE¼ sec. 22, T. 11 S., R. 25 E., 120 feet east and 48 feet south of center of railroad crossing at the intersection of First Street with Custer Avenue, Wyandotte County, drilled by Kansas Geological Survey, 1944. Surface altitude, 741.3 feet.*

	Thickness, feet	Depth, feet
Fill	6	6
QUATERNARY—Pleistocene and Recent		
Alluvium		
Silt, gray	4	10
Silt, gray, and sand, medium to fine (Water level, 19.5 feet below land surface.)	10	20
Gravel, medium to fine, and sand, medium	10	30
Gravel, medium to fine, sand, medium, and some silt, gray	10	40

	Thickness, feet	Depth, feet
Gravel, fine to coarse, and sand, medium	20	60
Gravel, coarse to fine, and sand, coarse	12	72
PENNSYLVANIAN—Missourian		
Shale, laminated, gray	6	78

79. *Log of test hole 100 in the SE¼ NE¼ NE¼ sec. 22, T. 11 S., R. 25 E., 30 feet south and 102 feet east of center of intersection of Shawnee Avenue with Adams Street, Wyandotte County, drilled by Kansas Geological Survey, 1944. Surface altitude, 746.8 feet.*

	Thickness, feet	Depth, feet
Fill	8	8
QUATERNARY—Pleistocene and Recent		
Alluvium		
Silt, dark gray	1	9
Silt, blue gray, interbedded with some sand, fine	13	22
Gravel, fine to medium, sand, medium, and silt, blue gray (Water level, 25.4 feet below land surface.),	41	63
Gravel, coarse to fine, and some sand, coarse	14	77
PENNSYLVANIAN—Missourian		
Limestone, hard, gray white	1	78

80. *Log of test hole 101 in the NW¼ SW¼ NW¼ sec. 23, T. 11 S., R. 25 E., about 150 feet southeast of river, 30 feet southwest of Kansas City Terminal Railway high-line viaduct, 15 feet west and 15 feet south of first manhole cover south of railroad bridge, Wyandotte County, drilled by Kansas Geological Survey, 1944. Surface altitude, 758.9 feet.*

	Thickness, feet	Depth, feet
Fill	10	10
QUATERNARY—Pleistocene and Recent		
Alluvium		
Silt, dark gray and buff gray	13	23
Sand, medium to fine, and silt, soft, gray	9	32
Sand, coarse to fine, some silt, blue gray, and some gravel, medium (Water level, 36.1 feet below land surface.)	8	40
Gravel, medium to fine, sand, medium and silt, blue gray	10	50
Gravel, coarse to fine, and sand, coarse	10	60
Gravel, coarse to fine, sand, coarse, and some silt, blue gray	10	70
Gravel, medium to fine, and sand, medium	10	80
Gravel, coarse to fine, and sand, medium	25.5	105.5
PENNSYLVANIAN—Missourian		
Limestone, hard, buff to white	0.5	106

81. *Log of well 104 (plant well 10) at Wilson and Co. in the SW¼ NE¼ sec. 22, T. 11 S., R. 25 E., Osage and Adams Streets, Kansas City, Kansas, drilled by Kelly Well Co., 1944. Surface altitude, 750.2 feet.*

	Thickness, feet	Depth, feet
Fill	4	4
QUATERNARY—Pleistocene and Recent		
Alluvium		
Clay, sandy	14	18
Clay	2	20
Clay, sandy	4	24
Sand, medium to fine (Water level, 29 feet below land surface.)	7	31
Sand and balls of clay	15	46
Clay, sandy	2	48
Sand, medium to coarse	4	52
Sand, coarse, and gravel	2	54
Clay, blue	2	56
Sand, coarse, gravel, and balls of clay	5	61
Clay	1	62
Sand, and gravel, very coarse, and some stones	21	83
Shale	....	83

82. *Log of well 106 (plant well 9) at Wilson and Co. in the SW¼ NE¼ sec. 22, T. 11 S., R. 25 E., Osage and Adams Streets, Kansas City, Kansas, drilled by Austin and Sons, 1934. Surface altitude, 751.6 feet.*

	Thickness, feet	Depth, feet
Fill	6	6
QUATERNARY—Pleistocene and Recent		
Alluvium		
Sand, fine, dirty	12	18
Clay, sandy	2	20
Clay, blue	2	22
Sand, fine	1.5	23.5
Clay	1	24.5
Sand, fine	1.5	26
Sand, medium coarse	7.5	33.5
Sand and balls of clay	14.5	48
Clay, sandy (Water level, 49.7 feet below land surface.)	2	50
Sand, medium coarse, and balls of clay	4	54
Sand, medium coarse, and gravel	2.5	56.5
Clay, blue	2	58.5
Sand, coarse, gravel, and balls of clay	5	63.5
Clay	1	64.5
Sand, coarse, gravel, and few balls of clay	6.5	71
Sand, coarse, gravel, large boulders and flat rocks	5	76
Sand, coarse, clean, and gravel, fine	3	79
Sand, very coarse, and gravel	8.2	87.2

83. *Log of well 107 (plant well 2) at the Midwest Cold Storage and Ice Corp. in the NE¼ SW¼ sec. 22, T. 11 S., R. 25 E., northeast of intersection of Fifth Street with Kansas River, Kansas City, Kansas, drilled by Layne-Western Co., 1938. Surface altitude, 752.7 feet.*

	Thickness, feet	*Depth, feet*
Cinders	4	4
QUATERNARY—Pleistocene and Recent		
Alluvium		
Sand, fine, silty	21	25
Sand, coarse	17	42
Clay, sandy, blue (Water level, 44 feet below land surface.)	3	45
Sand, coarse; contains a few balls of clay	9	54
Sand, fine	1	55
Sand, coarse, and balls of clay	3	58
Clay, sandy	2	60
Sand, coarse, and gravel	9	69
Sand, coarse, gravel, and boulders	5	74
Sand, coarse and gravel	10	84
Rock	..	84

84. *Log of well 108 (plant well 1) at the Midwest Cold Storage and Ice Corp. in the NE¼ SW¼ sec. 22, T. 11 S., R. 25 E., northeast of intersection of Fifth Street with Kansas River, Kansas City, Kansas, drilled by Layne-Western Co., 1932. Surface altitude, 760.6 feet.*

	Thickness, feet	*Depth, feet*
Fill	1	1
QUATERNARY—Pleistocene and Recent		
Alluvium		
Sand and balls of clay	11	12
Clay	2	14
Sand, blue, fine	3	17
Clay	2	19
Sand, fine, blue, and clay	12	31
Clay	2	33
Sand and balls of clay	4	37
Clay	1	38
Sand and gravel	15	53
Sand, coarse, and gravel	13	66
Clay	2	68
Sand, coarse, and gravel	25.5	93.5
Rock	..	93.5

85. *Log of well 114 (plant well 9) in the NW¼ NW¼ sec. 21, T. 11 S., R. 25 E., Seventeenth and Kansas Avenue, Kansas City, Kansas, drilled by Layne-Western Co., 1937. Surface altitude, 757.4 feet.*

	Thickness, feet	Depth, feet
Fill	2	2
QUATERNARY—Pleistocene and Recent		
Alluvium		
Clay, sandy	16	18
Sand	17	35
Clay	2	37
Sand (Water level, 38.8 feet below land surface.)	18	55
Sand and balls of clay	3	58
Clay, sand, and gravel	15	73

86. *Log of well 115 (plant well 10) in the NW¼ NW¼ sec. 21, T. 11 S., R. 25 E., Seventeenth and Kansas Avenue, Kansas City, Kansas, drilled by Layne-Western Co., 1940. Surface altitude, 756.3 feet.*

	Thickness, feet	Depth, feet
Fill	3	3
QUATERNARY—Pleistocene and Recent		
Alluvium		
Clay, sandy	4	7
Sand	3.5	10.5
Clay	1.5	12
Sand (Water level, 47 feet below land surface.)	35	47
Sand and balls of clay	7	54
Sand, coarse, gravel, and some balls of clay	15	69

87. *Log of test hole 116 in the NW¼ SE¼ SW¼ sec. 16, T. 11 S., R. 25 E., about 1,200 feet north of Kansas Avenue at east edge of Fourteenth Street, 25 feet south and 5 feet west of power pole at north end of Fourteenth Street, Wyandotte County, drilled by Kansas Geological Survey, 1944. Surface altitude, 752.7 feet.*

	Thickness, feet	Depth, feet
Fill	1	1
QUATERNARY—Pleistocene and Recent		
Alluvium		
Silt, gray buff	7	8
Sand, coarse to fine	6	14
Silt, gray and buff, interbedded with some sand and gravel (Water level, 23.9 feet below land surface.),	12	26
Silt, dark blue gray	4	30
Gravel, medium to fine, sand, medium, and some silt,	10	40
Gravel, medium to fine, sand, medium, and silt, light gray	2	42
Gravel, medium to fine, and sand, medium	19	61
PENNSYLVANIAN—Missourian		
Shale, partly laminated, light blue gray	2	63

88. *Log of test hole 117 in the SE¼ SW¼ SW¼ sec. 16, T. 11 S., R. 25 E., 36 feet north and 18 feet west of first power pole southwest of office of Philadelphia Quartz Co., about 700 feet north and 800 feet east of intersection of Eighteenth Street with Kansas Avenue, Wyandotte County, drilled by Kansas Geological Survey, 1944. Surface altitude, 754.3 feet.*

	Thickness, feet	*Depth, feet*
QUATERNARY—Pleistocene and Recent		
Alluvium		
Silt, soft, light brown	8	8
Silt, soft, and some sand, medium	12	20
Sand, medium to fine, some silt, blue gray, and some gravel, medium (Water level, 24.5 feet below land surface.)	10	30
Gravel, fine to medium, sand, medium, and some silt, blue gray	20	50
Gravel, medium to fine, and sand, medium	15	65
PENNSYLVANIAN—Missourian		
Shale, light blue gray, partly laminated and micaceous,	5	70

89. *Log of test hole 118 in the NW cor. sec. 21, T. 11 S., R. 25 E., 72 feet south and 15 feet west of center of intersection of Kansas Avenue with Seventeenth Street, Wyandotte County, drilled by Kansas Geological Survey, 1944. Surface altitude, 755.7.*

	Thickness, feet	*Depth, feet*
Fill	1	1
QUATERNARY—Pleistocene and Recent		
Alluvium		
Silt, light gray buff	5	6
Sand, coarse to fine, and some gravel, medium to fine	7	13
Silt, gray and buff	7	20
Sand, coarse to fine, and some gravel, medium	10	30
Sand, coarse to fine, and gravel, medium. (Water level, 30.2 feet below land surface.)	10	40
Gravel, fine to medium, sand, medium, and silt, green gray	10	50
Gravel, medium to fine, and sand, medium	10	60
Gravel, coarse to fine, sand, medium, and some silt, gray green	11	71
PENNSYLVANIAN—Missourian		
Shale, green and light blue gray, and some limestone	2	73

90. *Log of test hole 119 in the SE¼ NE¼ NE¼ sec. 20, T. 11 S., R. 25 E., southeast of intersection of Osage Avenue with Nineteenth Street, 36 feet south of center of Osage Avenue and between two sets of double railroad tracks, Wyandotte County, drilled by Kansas Geological Survey, 1944. Surface altitude, 758.9 feet.*

	Thickness, feet	*Depth, feet*
Fill	2	2
QUATERNARY—Pleistocene and Recent		
Alluvium		
Silt, gray buff and gray	7	9
Sand, coarse to fine, and some gravel, fine	7	16
Silt, gray and buff, interbedded with some sand, coarse to fine. (Water level, 26.6 feet below land surface.)	14	30
Gravel, fine to medium, and sand, medium	10	40
Gravel, fine, and sand, medium	7	47
Silt, light gray	0.5	47.5
Gravel, coarse to fine, and sand, medium	2.5	50
Gravel, fine, sand, medium, and silt, light gray	10	60
Gravel, medium to fine, and sand, medium	25	85
PENNSYLVANIAN—Missourian		
Shale, micaceous, laminated, light blue gray	3	88

91. *Log of test hole 120 in the NW¼ SE¼ NE¼ sec. 20, T. 11 S., R. 25 E., just northeast of intersection of Miami Avenue extended with levee, Wyandotte County, drilled by Kansas Geological Survey, 1944. Surface altitude, 752.8 feet.*

	Thickness, feet	*Depth, feet*
QUATERNARY—Pleistocene and Recent		
Alluvium		
Gravel, medium to fine, sand, medium, and silt	8	8
Silt, gray and buff	9	17
Sand, coarse to fine, and some gravel, medium	3	20
Sand, coarse to fine, some gravel, coarse to fine, and silt, buff and blue gray (Water level, 21.5 feet below land surface.)	20	40
Sand, coarse to fine, and some gravel, medium to fine,	20	60
Gravel, fine to medium, and sand, medium	8	68
Gravel, coarse to fine, and sand, coarse	13	81
PENNSYLVANIAN—Missourian		
Shale, laminated, light gray	2	83

92. *Log of test hole 121 in NE¼ NW¼ SE¼ sec. 20, T. 11 S., R. 25 E., northeast of intersection of Twenty-second Street with Argentine Boulevard, 24 feet north and 12 feet east of second power pole north of Boulevard, Wyandotte County, drilled by Kansas Geological Survey, 1944. Surface altitude, 746.2 feet.*

	Thickness, feet	Depth, feet
Fill	2	2
QUATERNARY—Pleistocene and Recent		
Alluvium		
Silt, buff, and sand, medium to fine	8	10
Sand, coarse to fine, and some gravel, medium (Water level, 13.1 feet below land surface.)	7	17
Silt, blue gray	3	20
Gravel, fine to medium, and sand, medium	28	48
Silt, greenish gray	2	50
Gravel, medium to fine, and sand, medium	10	60
Gravel, coarse to fine, and sand, medium	10	70
Gravel, very coarse to fine	1	71
PENNSYLVANIAN—Missourian		
Shale, laminated, partly carbonaceous, gray green and light gray	2	73

93. *Log of test hole 122 in the NE¼ SW¼ SE¼ sec. 20, T. 11 S., R. 25 E., between Twenty-third and Twenty-fourth Streets extended, 900 feet southeast of Argentine railroad station, north of two railroad tracks but south of main lines, 120 feet west and 9 feet south of railroad sign post marked 5545, Wyandotte County, drilled by Kansas Geological Survey, 1944. Surface altitude, 751.9 feet.*

	Thickness, feet	Depth, feet
Fill	2	2
QUATERNARY—Pleistocene and Recent		
Alluvium		
Silt, gray buff (Water level, 17.4 feet below land surface.)	26	28
Sand, coarse to fine, and some gravel, medium	22	50
Silt, clayey, light green gray, and some sand, medium,	9	59
Gravel, medium to fine, and sand, medium	11	70
Gravel, coarse to fine, sand, medium, and some clay, gray green	8	78
PENNSYLVANIAN—Missourian		
Shale, light purple gray, micaceous, partly carbonaceous,	2	80

94. *Log of test hole 123 in the SW¼ SW¼ SE¼ sec. 20, T. 11 S., R. 25 E., 36 feet north and 20 feet west of third power pole south of intersection of Strong Avenue with Twenty-fourth Street, Wyandotte County, drilled by Kansas Geological Survey, 1944. Surface altitude, 749.7 feet.*

	Thickness, feet	*Depth, feet*
Fill, consisting of large blocks of limestone	2	2
QUATERNARY—Pleistocene and Recent		
Alluvium		
Silt, clayey, buff and gray (Water level, 12.2 feet below land surface.)	15	17
Silt, soft, blue gray; contains some sand in lower part,	13	30
Gravel, fine to medium, and sand, medium	10	40
Gravel, fine to coarse, and sand, medium	20	60
Gravel, coarse to fine, and sand, coarse	12	72
PENNSYLVANIAN—Missourian		
Limestone, hard, buff	1	73

95. *Log of well 124 (plant well 5) at the Proctor and Gamble Mfg. Co. in the SE¼ SE¼ sec. 17, T. 11 S., R. 25 E., Nineteenth and Kansas Avenue, Kansas City, Kansas, drilled by Layne-Western Co., 1938. Surface altitude, 762.3 feet.*

	Thickness, feet	*Depth, feet*
Cinders	8	8
QUATERNARY—Pleistocene and Recent		
Alluvium		
Clay, sandy	8	16
Sand	8	24
Clay	7	31
Sand (Water level, 48 feet below land surface.)	17	48
Sand, medium coarse	13	61
Sand, medium coarse, and some balls of clay	2	63
Sand, medium coarse	7	70
Sand, coarse, and gravel	6	76

96. *Log of well 129 (plant well 6) at the Proctor and Gamble Mfg. Co. in the SE¼ SE¼ sec. 17, T. 11 S., R. 25 E., Nineteenth and Kansas Avenue, Kansas City, Kansas, drilled by Layne-Western Co., 1940. Surface altitude, 758.9 feet.*

	Thickness, feet	*Depth, feet*
QUATERNARY—Pleistocene and Recent		
Alluvium		
Clay, sandy	23	23
Sand, fine	9	32
Sand and gravel	6	38
Clay, blue	1	39
Sand, coarse, gravel and balls of clay	3	42
Clay, blue	3	45
Sand, coarse (Water level, 45.7 feet below land surface.),	4	49
Sand, coarse, and gravel	33	82
Shale	....	82

97. *Log of well 130 (plant well 7) at the Proctor and Gamble Mfg. Co. in the SE¼ SE¼ sec. 17, T. 11 S., R. 25 E., Nineteenth and Kansas Avenue, Kansas City, Kansas, drilled by Layne-Western Co., 1941. Surface altitude, 759.4 feet.*

	Thickness, feet	*Depth, feet*
QUATERNARY—Pleistocene and Recent		
Alluvium		
Top soil	2	2
Clay, sandy	21	23
Sand, fine	11	34
Sand, coarse, and balls of clay	6	40
Sand and gravel	5	45
Sand, coarse (Water level, 50 feet below land surface.),	5	50
Sand and gravel	4	54
Clay	2	56
Sand, coarse, and gravel	9	65
Sand and gravel	3	68
Sand, coarse, and gravel	12	80
Boulders	2	82
Limestone	....	82

98. *Log of test hole at site of well 131 (test hole 8 and well 5 of Sinclair Refining Co.) in the NW¼ NW¼ sec. 20, T. 11 S., R. 25 E., Kansas City, Kansas, drilled by Austin and Sons, 1919.*

	Thickness, feet	*Depth, feet*
QUATERNARY—Pleistocene and Recent		
Alluvium		
Sand and loam	13	13
Sand, fine	13	26
Sand, coarse, and gravel, fine (Water level, 27 feet below land surface.)	4	30
Gravel, pea-sized	2	32
Sand, white, fine, and gravel, fine	3	35
Clay	6	41
Gravel, pea-sized	4	45
Sand, coarse, and gravel, fine	6	51
Gravel, coarse	12	63

99. *Log of test hole at site of well 133 (test hole 9 and well 7 of Sinclair Refining Co.,) at the NE¼ NW¼ sec. 20, T. 11 S., R. 25 E., at coördinates 1265 S. and 2277 E. of Sinclair Refining Co. coördinate system, Kansas City, Kansas, drilled by Austin and Sons, 1919.*

	Thickness, feet	*Depth, feet*
QUATERNARY—Pleistocene and Recent		
Alluvium		
Sand, loam, and silt	19	19
Sand, coarse, and gravel, coarse, flat	4	23
Clay, blue	2	25
Clay, yellow	1	26
Sand, coarse, blue white. (Water level, 28 feet below land surface.)	4	30

	Thickness, feet	Depth, feet
Sand, fine, white	3	33
Sand, very fine, white	1	34
Sand, coarse, white, and some gravel, pea-sized	4	38
Sand, coarse, white, and gravel, pea-sized	12	50
Gravel, pea-sized	10	60

100. *Log of test hole 134 (test hole 4 of Sinclair Refining Co.) in the SE¼ NW¼ sec. 20, T. 11 S., R. 25 E., at coördinates 1211 S. and 1900 E. of Sinclair Refining Co. coördinate system, Kansas City, Kansas, drilled by Austin and Sons, 1919.*

QUATERNARY—Pleistocene and Recent

Alluvium	Thickness, feet	Depth feet
Loam	7	7
Clay, sandy	9	16
Sand, fine, white	6	22
Sand and silt	3	25
Clay, blue. (Water level, 26 feet below land surface.)	1	26
Sand, coarse	4	30
Sand, coarse	..	..
Gravel, fine	4	44
Sand, fine, and some gravel, fine	4	48
Gravel, pea-sized	2	50
Gravel, very coarse	4	54
Rock	..	54

101. *Log of test hole 135 (test hole 1 of Sinclair Refining Co.) in the SW¼ NW¼ sec 20, T. 11 S., R. 25 E., at coördinates 1036 S. and 1197 E. of the Sinclair Refining Co. coördinate system, Kansas City, Kansas, drilled by Austin and Sons, 1919.*

QUATERNARY—Pleistocene and Recent

Alluvium	Thickness, feet	Depth, feet
Loam and sand, fine	21	21
Sand, medium, white	12	33
Sand, coarse, white	1	34
Sand, fine	4	38
Sand, coarse, white	2	40
Sand, coarse, white, and gravel, pea-sized	10	50
Gravel and sand, fine, reddish	6	56
Sand, fine to coarse	4	60
Rock	..	60

102. *Log of test hole 136 (test hole 2 of Sinclair Refining Co.) in the NW¼ NW¼ sec. 20, T. 11 S., R. 25 E., at coördinates 817 S. and 1088 E. of Sinclair Refining Co. coördinate system, Kansas City, Kansas, drilled by Austin and Sons, 1919.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene and Recent		
Alluvium		
Loam and sand	20	20
Sand, coarse (Water level, 25.5 feet below land surface.)	7	27
Walnut log	1	28
Gravel, fine	2	30
Sand, fine, and gravel, fine	12	42
Sand, fine; contains some gravel	6	48
Gravel, coarse	2	50
Gravel, fine to coarse	10	60
Rock	..	60

103. *Log of well 137 (obsolete well 3 of Sinclair Refining Co.) in the NW cor. SW¼ sec. 20, T. 11 S., R. 25 E., at coördinates 2475 S. and 650 E. of Sinclair Refining Co. coördinate system, Kansas City, Kansas.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene and Recent		
Alluvium		
Loam and clay	5	5
Sand, loamy, very fine	14	19
Sand, fine	10	29
Sand and gravel, fine	1	30
Gravel, pea-sized	8	38
Sand, coarse; contains few balls of clay	14	52
Sand and gravel	15	67
Gravel	4	71
Rock	..	71

104. *Log of test hole 139 in the NW cor. NE¼ SE¼ sec. 21, T. 11 S., R. 24 E., 36 feet north and 48 feet east of northeast corner of office building of Peck-Wolff Sand Co., Wyandotte County, drilled by Kansas Geological Survey, 1944. Surface altitude, 766.3 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene and Recent		
Alluvium		
Silt, alternating dark gray and light brown gray	8	8
Silt, soft, dull gray	12	20
Silt, clayey, gray (Water level, 28.4 feet below land surface.)	9	29
Clay, silty, soft, blue gray	5	34
Gravel, medium to fine, and sand, medium	6	40
Gravel, medium to fine, sand, medium, and silt, soft, light gray and very dark gray	6	46
Gravel, coarse to fine, and sand, medium	13	59
PENNSYLVANIAN—Missourian		
Shale, yellowish green, and sandstone, very fine, dull yellow green	7	66
Shale, gray blue, and sandstone, very fine, gray blue	4	70

105. *Log of test hole 140 in the SE cor. NW¼ NE¼ SE¼ sec. 21, T. 11 S., R. 24 E., near bank of river at edge of cinder fill at end of road running east by south from office of Peck-Wolff Sand Co. to railroad tracks on fill, Wyandotte County, drilled by Kansas Geological Survey, 1944. Surface altitude, 768.2 feet.*

	Thickness, feet	*Depth, feet*
Cinder fill	2	2
QUATERNARY—Pleistocene and Recent		
Alluvium		
Silt, gray	21	23
Sand, coarse to fine, and gravel, fine	7	30
Gravel, fine to medium, and sand, medium (Water level, 31.1 feet below land surface.)	10	40
Gravel, fine to medium, and sand, medium	10	50
Gravel, medium, and sand, medium	18	68
Gravel, coarse to fine, and sand, medium	4	72
PENNSYLVANIAN—Missourian		
Shale, light blue gray, interbedded with sandstone, silty, micaceous, very fine, blue gray	5	77

106. *Log of test hole 141 in the NE¼ SE¼ SE¼ sec. 21, T. 11 S., R. 24 E., 190 feet north and 60 feet east of northeast corner of gas-line valve pit, Wyandotte County, drilled by Kansas Geological Survey, 1944. Surface altitude, 756.6 feet.*

	Thickness, feet	*Depth, feet*
QUATERNARY—Pleistocene and Recent		
Alluvium		
Silt, gray; contains much fine sand	3	3
Sand, coarse to fine, and some gravel, medium (Water level, 13.9 feet below land surface.)	21	24
Gravel, medium to fine, sand, medium, and silt, gray,	6	30
Gravel, coarse to fine, and sand, medium	24	54
PENNSYLVANIAN—Missourian		
Sandstone, fine, micaceous, yellow gray, interbedded with some shale, sandy, yellow gray	3	57
Sandstone, fine, micaceous, light blue gray, interbedded with some shale, carbon-flecked, sandy, blue gray,	3	60

107. *Log of test hole 142 in the NE cor. SW¼ SW¼ SW¼ sec. 22, T. 11 S., R. 24 E., 126 feet north and 15 feet west of northwest corner fence post of barn lot, Wyandotte County, drilled by Kansas Geological Survey, 1944. Surface altitude, 756.1 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene and Recent		
Alluvium		
Silt, soft, brown gray	15	15
Gravel, fine to medium, and sand, medium (Water level, 16.1 feet below land surface.)	5	20
Gravel, fine to medium, sand, medium, and some silt, blue gray	10	30
Gravel, fine to medium, and sand, medium	20	50
Gravel, coarse to fine	5	55
PENNSYLVANIAN—Missourian		
Limestone, hard, buff, and gray white	1	56

108. *Log of test hole 143 in the SE cor. SW¼ SW¼ sec. 22, T. 11 S., R. 24 E., in farmyard, south of house, Wyandotte County, drilled by Kansas Geological Survey, 1944. Surface altitude, 759.8 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene and Recent		
Alluvium		
Silt, dark gray; contains much fine sand	2	2
Silt, soft, yellow gray; contains much very fine sand,	8	10
Silt, gray; contains much very fine sand and some nodular caliche	5	15
Sand, coarse to fine, and some gravel, fine (Water level, 18.7 feet below land surface.)	10	25
Gravel, fine to medium, and sand, fine to medium	23.5	48.5
Gravel, coarse to fine, and sand, medium	17.5	66
PENNSYLVANIAN—Missourian		
Shale, partly carbonaceous, thin-bedded, blue gray	4	70

109. *Log of test hole 144 in the SE cor. NW¼ NE¼ NW¼ sec. 27, T. 11 S., R. 24 E., about 100 feet from railroad tracks, Wyandotte County, drilled by Kansas Geological Survey, 1944. Surface altitude, 756.3 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene and Recent		
Alluvium		
Silt, clayey, dark gray downward to light yellow gray; contains some fine sand	13	13
Sand, coarse to fine, and some gravel, coarse to fine (Water level, 14.0 feet below land surface.)	7	20
Gravel, fine to medium, and sand, medium	10	30
Gravel, medium to fine, and sand, medium	16	46
Gravel, coarse to fine, and sand, medium	27	73
PENNSYLVANIAN—Missourian		
Shale, fairly soft, greenish yellow	2	75
Shale, light blue gray, some sandstone, very fine, blue gray	3	78

110. *Log of test hole 145 in the SE¼ NE¼ NW¼ sec. 27, T. 11 S., R. 24 E., 200 feet from highway on west side of lane leading to site of house destroyed by fire, Wyandotte County, drilled by Kansas Geological Survey, 1944. Surface altitude, 760.1 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene and Recent		
Alluvium		
Silt, soft, gray buff; contains much fine sand	10	10
Silt, clayey, soft, gray, contains many nodules of sand-iron. (Water level, 17.3 feet below land surface.)	10	20
Sand, medium to fine, and silt, soft, gray and blue gray,	10	30
Sand, coarse to fine, and some gravel, medium to fine	10	40
Gravel, fine to coarse, and sand, medium to fine	8	48
PENNSLVANIAN—Missourian		
Limestone, very hard, brittle, light brownish gray	3	51
Sandstone, fine, gray green	14	65

111. *Log of test hole 146A at Morris, Kansas, owned by the Santa Fe Railroad in the NE¼ SW¼ sec. 28, T. 11 S., R. 24 E., about 50 feet southeast of well 146, drilled by Layne-Western Co., 1933. Surface altitude 765.1 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene and Recent		
Alluvium		
Top soil	1	1
Sand, fine	5	6
Clay, sandy	2	8
Sand, coarse	9	17
Sand, fine	2	19
Sand, coarse	4	23
Sand and gravel. (Water level, 27.8 feet below land surface.)	5	28
Sand, coarse, and gravel	26	54
Gravel, coarse, and boulders	11	65
Rock	..	65

112. *Log of test hole 150 in the NW¼ NE¼ SE¼ sec. 28, T. 11 S., R. 23 E., 78 feet south and 3 feet east of center of intersection of lane with highway, Wyandotte County, drilled by Kansas Geological Survey, 1944. Surface altitude, 776.6 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene and Recent		
Alluvium		
Silt, clayey, dark gray	8	8
Silt, soft, yellow gray. (Water level, 22.2 feet below land surface)	17	25
Sand, coarse to fine, and silt, gray to yellow gray	5	30
Silt, clayey, blue gray, sand, medium, and gravel, medium	10	40
Sand, coarse to fine, some gravel, medium, and silt, clayey, blue gray	10	50
Gravel, medium to fine, and sand, medium, greenish to brown	18	68
PENNSYLVANIAN—Missourian		
Limestone, very hard, gray white	1	69

113. *Log of test hole 151 in the NE¼ SW¼ SE¼ sec. 28, T. 11 S., R. 23 E., on west side of lane running south from highway, 63 feet south and 15 feet west of center of railroad crossing, Wyandotte County, drilled by Kansas Geological Survey, 1944. Surface altitude, 777.2 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene and Recent		
Alluvium		
Silt, partly clayey, yellow gray downward to gray	12	12
Silt, soft, buff (Water level, 23.8 feet below land surface.)	14	26
Sand, coarse to fine, and some gravel, fine	5	31
Silt, clayey, blue gray	13	44
Silt, clayey, blue gray; contains some sand, medium to fine	4	48
Gravel, coarse to fine, and sand, brown	20	68
PENNSYLVANIAN—Missourian		
Limestone, hard, gray white	1	69

114. *Log of test hole 152 in the SE¼ NW¼ SE¼ sec. 28, T. 11 S., R. 23 E., on west side of lane running south from highway, 12 feet north of river and 6 feet west of center of lane, Wyandotte County, drilled by Kansas Geological Survey, 1944. Surface altitude, 779.1 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene and Recent		
Alluvium		
Silt, dark yellow gray; contains much fine sand	22	22
Sand, coarse to fine, and some gravel, fine (Water level, 26.0 feet below land surface.)	9	31
Sand, coarse to fine, silt, clayey, blue gray, and some gravel, medium	7	38
Gravel, medium to fine, sand, medium, and some clay, greenish gray	17	55
Gravel, coarse to fine, and sand, coarse	5	60
Gravel, coarse to fine, and some sand, coarse	11	71
PENNSYLVANIAN—Missourian		
Limestone, very hard, white	1	72

115. *Log of test hole 153 in the NW cor. SW¼ SW¼ SE¼ sec. 28, T. 11 S., R. 23 E., on south bank of river and just northwest of curve of lane, Johnson County, drilled by Kansas Geological Survey, 1944. Surface altitude, 767.7 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene and Recent		
Alluvium		
Silt, light buff; contains much medium to fine sand (Water level, 15.0 feet below land surface.)	17	17
Silt, blue gray, gravel, fine, and sand, medium	3	20
Gravel, fine to medium, and sand, medium; contains some blue-gray silt at depth of 34 feet	20	40
Gravel, medium to fine, and sand, medium	10	50
Gravel, coarse to fine, and sand, medium	5	55
PENNSYLVANIAN—Missourian		
Limestone, hard, white and light brown	1	56

116. *Log of test hole 154 in the NW¼ NW¼ NE¼ sec. 33, T. 11 S., R. 23 E., 10 feet east of center of lane, 0.15 mile south of river, and 0.45 mile north of highway, Johnson County, drilled by Kansas Geological Survey, 1944. Surface altitude, 766.4 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene and Recent		
Alluvium		
Silt, gray brown and gray buff	6	6
Sand, medium to fine, brown, and some silt, light gray buff	4	10
Sand, coarse to fine, brown (Water level, 14.2 feet below land surface.)	9	19
Gravel, fine to medium, and sand, medium	11	30
Gravel, medium to fine, sand, medium, and some silt, gray green	10	40
Gravel, coarse to fine, and sand, medium	10	50
Gravel, coarse to fine	3	53
PENNSYLVANIAN—Missourian		
Limestone, hard, buff and pink	0.5	53.5
Shale, hard, calcareous, fossilferous, yellow to buff	1.5	55

117. *Log of test hole 155 in the SW¼ NW¼ NE¼ sec. 33, T. 11 S., R. 23 E., on east side of lane, 3 feet west and 6 feet south of corner fence post, 0.25 mile south of river and 0.35 mile north of highway, Johnson County, drilled by Kansas Geological Survey, 1944. Surface altitude, 769.9 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene and Recent		
Alluvium		
Silt, dark gray	2	2
Silt, gray buff to light gray	8	10
Silt, soft, light gray (Water level, 13.8 feet below land surface.)	5	15
Sand, medium to fine, and some gravel, fine	5	20
Gravel, medium, sand, medium, and silt, gray	10	30
Gravel, medium to fine, sand, medium, and much silt, gray	10	40
Gravel, medium to fine	8.5	48.5
Boulders, consisting of limestone, pink quartzite, and coarse gravel	1.5	50
Clay, blue gray, yellow, and buff; contains some gravel and sand	3	53
PENNSYLVANIAN—Missourian		
Limestone, fairly hard, light buff and brown	2	55

118. *Log of test hole 156 in the NW¼ SW¼ NE¼ sec. 33, T. 11 S., R. 23 E., 15 feet east of center of lane, 0.45 mile south of river, and 0.15 mile north of highway, Johnson County, drilled by Kansas Geological Survey, 1944. Surface altitude, 774.9 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene and Recent		
Alluvium		
Silt, gray buff; contains much medium sand	8	8
Sand, medium to fine, interbedded with silt, blue gray,	11	19

	Thickness, feet	Depth, feet
Sand, coarse to fine, some gravel, medium to fine, and some silt (Water level, 19.3 feet below land surface.)	11	30
Gravel, medium to fine, and sand, medium	2	32
Gravel, medium to fine, sand, medium, and silt, blue gray	4	36
Gravel, medium to fine, and sand, medium	14	50
Gravel, coarse to fine, and sand, medium	6	56
PENNSYLVANIAN—Missourian		
Limestone, hard, light buff and brown, and some shale, blue gray	2	58

119. *Log of test hole 157 in the SW¼ SW¼ NE¼ sec. 33, T. 11 S., R. 23 E., 8 feet east of center of road, 0.55 mile south of river, and 0.05 mile north of highway, Johnson County, drilled by Kansas Geological Survey, 1944. Surface altitude, 770.6 feet.*

QUATERNARY—Pleistocene and Recent Alluvium	*Thickness, feet*	*Depth, feet*
Silt, gray buff; contains much sand	7	7
Sand, coarse to fine, and some gravel, medium (Water level, 15.1 feet below land surface.)	18	25
Gravel, coarse to fine; sand, medium, and some silt, blue gray	5	30
Gravel, medium to fine, sand, medium, and some pebbles	10	40
Gravel, coarse to fine, and sand, coarse	11	51
PENNSYLVANIAN—Missourian		
Limestone, hard, light gray	1	52

120. *Log of test hole 158 in the NW¼ NW¼ SE¼ sec. 33, T. 11 S., R. 23 E., on west side of highway, 0.65 mile south of river and 0.05 mile south of turn in highway, 66 feet north and 6 feet west of telephone pole, Johnson County, drilled by Kansas Geological Survey, 1944. Surface altitude, 768.8 feet.*

QUATERNARY—Pleistocene and Recent Alluvium	*Thickness, feet*	*Depth, feet*
Silt, gray and light buff	6	6
Sand, coarse to fine	7	13
Sand, coarse to fine, and some gravel, fine (Water level, 16.5 feet below land surface.)	7	20
Gravel, fine, and sand, medium	10	30
Gravel, medium to fine, and sand, medium	11.5	41.5
PENNSYLVANIAN—Missourian		
Limestone, hard, gray white	0.5	42

121. *Log of test hole 159 in the SW¼ NW¼ SE¼ sec. 33, T. 11 S., R. 23 E., 0.15 mile south of turn in highway, 75 feet west and 30 feet north of center of south railroad crossing, Johnson County, drilled by Kansas Geological Survey, 1944. Surface altitude, 769.9 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene and Recent		
Alluvium		
Silt, gray and buff	8	8
Sand, medium to fine. (Water level, 9.7 feet below land surface.)	2	10
Sand, coarse to fine, some gravel, medium, and many concretions of sand-limonite	5	15
Limestone block	0.5	15.5
Gravel, coarse to medium	1	16.5
PENNSYLVANIAN—Missourian		
Limestone, very hard, light gray	0.5	17
Shale, yellow buff	1	18

122. *Log of well 160 at the Lone Star Cement Co. in the NE¼ SW¼ sec. 28, T. 11 S., R. 23 E., near Bonner Springs, drilled, 1924.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene and Recent		
Alluvium		
Soil	1	1
Gumbo, black	5	6
Clay, red	2	8
Clay, yellow	26.5	34.5
Sand, fine. (Water level, 35.8 feet below land surface.)	3	37.5
Clay, sandy	7	44.5
Sand, medium	9	53.5
Sand, coarse	6	59.5
Sand, coarse, and gravel	20	79.5
Gravel, coarse, and boulders of limestone	2.5	82

123. *Log of test hole 161 at the southeast cor. NW¼ SW¼ sec. 28, T. 11 S., R. 23 E., 400 feet south of highway, 80 feet west and 60 feet south of southwest corner of house, Wyandotte County, drilled by Kansas Geological Survey, 1944. Surface altitude, 789.2 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene and Recent		
Alluvium		
Silt, gray black to gray brown	6	6
Silt, clayey, gray to yellow gray	24	30
Silt, clayey, soft, light yellow to brown. (Water level, 36.2 feet below land surface.)	8	38
Silt, clayey, buff and light gray	5	43
Sand, coarse to fine, some gravel, medium, and clay, blue gray	7	50
Sand, medium, gravel, medium to fine, and some clay, blue gray	10	60
Gravel, medium to fine, and sand, medium	23	83
Gravel, coarse to fine, and some silt, yellow brown	2.5	85.5
PENNSYLVANIAN—Missourian		
Limestone, hard, gray white	1	86.5

124. *Log of test hole 162 in the NE¼ SE¼ SE¼ sec. 29, T. 11 S., R. 23 E., 27 feet south and 9 feet west of gate post in fence south of railroad, Wyandotte County, drilled by Kansas Geological Survey, 1944. Surface altitude, 794.8 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene and Recent		
Alluvium		
Silt, clayey, yellow brown (Water level, 39.7 feet below land surface.)	40	40
Silt, clayey, light gray and brown; contains some gravel and sand	8	48
Sand, coarse to fine, and gravel, fine	15	63
PENNSYLVANIAN—Missourian		
Limestone, fossiliferous, hard, buff and gray white	1	64

125. *Log of test hole 163 in the NE¼ SE¼ SE¼ sec. 29, T. 11 S., R. 23 E., near bank of river and 350 feet south of test hole 12, Wyandotte County, drilled by Kansas Geological Survey, 1944. Surface altitude, 780.8 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene and Recent		
Alluvium		
Silt, clayey, light brown (Water level, 35.9 feet below land surface.)	36	36
Silt, clayey, light greenish gray and brown; contains some medium to fine sand	6	42
Sand, coarse to fine, some clay, light gray, and some gravel, medium to fine	18	60
Gravel, fine to medium, and sand, medium	10	70
Gravel, medium to fine, gray	2.5	72.5
PENNSYLVANIAN—Missourian		
Limestone, fossiliferous, hard, brittle, gray and brown,	0.5	73

126. *Log of test hole 167 in the SE¼ SW¼ SW¼ sec. 32, T. 11 S., R. 23 E., about 0.1 mile southwest of mouth of Little Kaw Creek, about 1,000 feet southeast of railroad overpass, 57 feet east and 78 feet south of southwest gate post, Wyandotte County, drilled by Kansas Geological Survey, 1944. Surface altitude, 764.9 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene and Recent		
Alluvium		
Silt, gray and gray brown (Water level, 17.7 feet below land surface.)	20	20
Silt, mottled light gray and yellow brown	4	24
Silt, gray blue; contains some medium sand	6	30
Silt, blue gray and gray brown, partly carbonaceous,	7	37
Silt, blue gray and gray brown; contains much gravel,	3	40
Gravel, coarse to fine, and some silt, gray	4	44
PENNSYLVANIAN—Missourian		
Limestone, fossiliferous, hard, light gray	1	45

REFERENCES

BAILEY, E. H. S., *1902,* Special report on mineral waters: University Geol. Survey of Kansas, Vol. 7, pp. 1-330, pls. 1-38.

DARTON, N. H., and others *1915,* Guidebook of the Western United States: U. S. Geol. Survey, Bull. 613, pp. 1-178, pls. 1-42, figs. 1-40.

JEWETT, J. M., and NEWELL, N. D., *1935,* Geology of Wyandotte County: Kansas Geol. Survey, Bull. 21, pt. 2, pp. 151-205, fig. 2, pls. 13-23.

LOHMAN, S. W., and others, *1942,* Ground-water supplies in Kansas available for national defense industries: Kansas Geol. Survey, Bull. 41, pt. 2, pp. 21-68, figs. 1-3, pls. 1-4.

McCOURT, W. E., ALBERTSON, M., and BENNETT, J. W., *1917,* The geology of Jackson County: Missouri Bur. Geology and Mines, pp. 1-152, pls. 1-19.

MEINZER, O. E., and WENZEL, L. K., *1946,* Water levels and artesian pressure in observation wells in the United States in 1943: U. S. Geol. Survey, Water-Supply Paper 988, pp. 1-352.

MOORE, R. C., *1935,* Stratigraphic classification of the Pennsylvanian rocks of Kansas: Kansas Geol. Survey, Bull. 22, pp. 1-248, figs. 1-12.

MOORE, R. C., and others, *1940,* Ground-water resources of Kansas: Kansas Geol. Survey, Bull. 27, pp. 1-112, figs. 1-28, pls. 1-34.

NEWELL, N. D., *1935,* The geology of Johnson and Miami Counties, Kansas: Kansas Geol. Survey, Bull. 21, pt. 1, pp. 7-150, fig. 1, pls. 1-12.

STEARNS, N. D., *1927,* Laboratory tests on physical properties of water-bearing materials: U. S. Geol. Survey, Water-Supply Paper 596F, pp. 121-176, figs. 18-26, pls. 11-13.

WENZEL, L. K., *1942,* Methods for determining permeability of water-bearing materials: U. S. Geol. Survey, Water-Supply Paper 887, pp. 1-192, figs. 1-17, pls. 1-6.

INDEX

21-7167