Geohydrology of JEFFERSON COUNTY Northeastern Kansas

John D. Winslow

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By

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ABSTRACT

Jefferson County is an area of about 552 square miles in northeastern Kansas. Rocks of Late Pennsylvanian age, which constitute the bedrock in the county, generally dip gently west-northwestward and crop out in sharp ridges and along valley walls. Deposits of Quaternary age underlie the flood plains and terraces along the larger streams and mantle much of the upland area.

Moderate to large supplies of ground water are available to wells in alluvium in the Delaware and Kansas River valleys. Small to moderate supplies of water are available from thick glacial deposits in the northeastern part of the county; marginally adequate supplies for domestic and stock purposes may be found in upland areas elsewhere in the county. The bedrock formations generally are not a source of water.

Ground water in Jefferson County generally is very hard and locally contains excessive concentrations of nitrate.

INTRODUCTION

This study is part of a continuing cooperative program of ground-water-resources investigations that have been conducted in Kansas since 1937. The objectives of the study were to determine the occurrence, availability, and chemical quality of ground water, and the character and extent of the water-bearing geologic units. The report was prepared by the State Geological Survey of Kansas and the U.S. Geological Survey, in cooperation with the Division of Environmental Health of the Kansas State Department of Health and the Division of Water Resources of the Kansas State Board of Agriculture.

Jefferson County is an area of about 552 square miles in northeastern Kansas. It is bounded on the north by Atchison County, on the east by Leavenworth County, on the south by Douglas County, and on the west by Jackson and Shawnee Counties. Figure 1 shows the area of this study and other areas in the State for which ground-water reports have been published or are in preparation.

The report is based on geologic mapping, geologic interpretation of aerial photographs, test-hole logs and water-well drillers' logs, inventory of selected wells, and analyses of water samples from selected wells. The basic data are on file in the offices of the U.S. Geological Survey and the State Geological Survey of Kansas, Lawrence, Kans.

Well and test-hole numbers used in this report give the location of wells according to General Land Office surveys. The well number is composed of township, range, and section numbers, followed by letters that indicate the subdivision of the section in which the well is located. The first letter denotes the quarter section; the second letter denotes the quarter-quarter section, or 40-acre tract; the third letter denotes the quarter-quarter-quarter section, or 10-acre tract. The 160-acre, 40-acre, and 10-acre tracts are designated *a*, *b*, *c*, and *d* in a counter-clockwise direction, beginning in the northeast quarter (fig. 2). When two or more wells are located within a 10-acre tract, the wells are numbered serially according to the order in which they were inventoried. For example, well 8-17E-33bad is in the SE¼NE¼NW¼ sec. 33, T. 8 S., R. 17 E., and is the first well inventoried in that tract.

Reports describing the ground-water resources in and near Jefferson County are included in the Selected References.

GEOLOGY[1]

Unconsolidated deposits of Pleistocene age form the surficial material in most of Jefferson County (pl. 1). In the upland areas, the unconsolidated material is glacial drift mantled almost everywhere by eolian deposits. Alluvial deposits underlie the flood plains in the valleys and colluvium generally mantles the valley slopes. Bedrock of Pennsylvanian age crops out in sharp ridges and along bluffs and steep valley walls, especially in the western part of the county bordering the Delaware River valley and in the

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

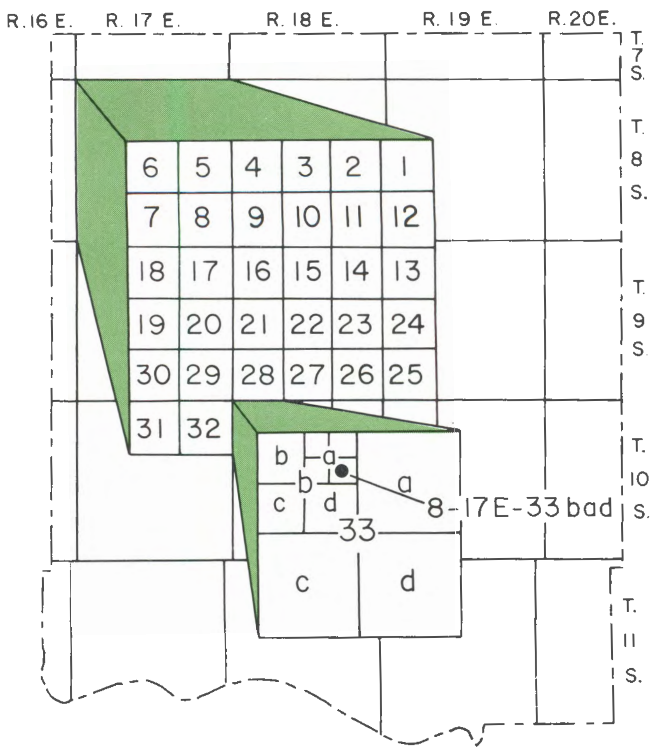

FIGURE 2.—Well-numbering system.

Wabaunsee Group is the youngest formation of Pennsylvanian age that crops out in the county; it underlies glacial drift in the uplands in the northwestern part of the area. The stratigraphic relationship of the bedrock units is shown on the geologic section (pl. 1).

Bedrock Surface

The present configuration of the bedrock surface has resulted from subaerial erosion before Pleistocene time, erosion caused by the advance of continental glaciers into northeastern Kansas during Nebraskan and Kansan time, and development of Pleistocene interstadial and present drainage systems. The present drainage system generally has developed along courses coincident with those of a previous drainage system or systems. Present streams generally flow on the bedrock or on unconsolidated deposits just above the bedrock. Except in the upland area in the northeastern part of the county, the unconsolidated deposits generally are less than 50 feet thick.

Pleistocene Series

Continental ice sheets advanced into northeastern Kansas during the Nebraskan and Kansan Stages of the Pleistocene Epoch. Nebraskan till has not been recognized in surface exposures in the county. However, a dense pebble-bearing clay overlying the bedrock that was penetrated by deep test holes in the vicinity of Nortonville may be Nebraskan till. The clay was either directly on the bedrock or above thin intervening glaciofluvial deposits of sand and gravel.

Kansan till overlies bedrock, or the till of possible Nebraskan age, everywhere in the upland part of the county. The Kansan till contains glacial erratics composed of principally pink quartzite, but pebbles and cobbles of igneous rock are common. Two or more zones of pebble-bearing clay interbedded with fine to medium glaciofluvial material were penetrated by test holes in the vicinity of Nortonville; these clays are also believed to be Kansan till. In areas where the till is thin and the topography reflects the bedrock surface, the bedrock formations are shown on the geologic map (pl. 1).

In the upland area in the north-central part of the county, the Kansan till is overlain by the "Nortonville clay." Frye and Leonard (1952, p. 81) suggest that this silty clay may have been ". . . deposited in slight initial depressions on the surface of the newly formed Kansan till plain as the Kansan ice front retreated. . . ."

Loess underlies most of the upland areas in Jefferson County. It is principally of Wisconsinan age, but studies by James Thorp and others (unpublished material in the files of the State Geological Survey of Kansas) indicate that some of the loess is of Illinoisan age. The loess may be as much as 20 feet thick in the northern part of the county, but thins and becomes discontinuous southward. Where soils have developed on loess, the surface is virtually free of pebbles.

Terrace deposits are found principally in the Kansas and Delaware River valleys. The Newman terrace of late Wisconsinan age (Davis and Carlson, 1952) is a major topographic feature in the Kansas River valley. The material beneath the Newman terrace generally grades from clay and silt at the surface to coarse sand and gravel overlying the bedrock. These deposits generally increase in grain size and thickness with increasing distance from the valley wall. Dissected and weathered remnants of terrace deposits of Kansan, Illinoisan, and Wisconsinan age locally border the bluffs along the Kansas and Delaware River valleys.

Alluvium of Recent age is found in all the valleys. In the Kansas and Delaware River valleys, the material grades from clay and silt at the surface to coarse sand and gravel overlying the bedrock. In some areas, the material in abandoned meanders is clay. Alluvium in the smaller valleys generally is finer grained than in the two principal valleys.

Pennsylvanian	Upper Pennsylvanian	Virgilian	Wabaunsee	Scranton Shale	Silver Lake Shale	75-120	Upper shale is bluish gray to yellowish brown and sandy to clayey; contains thin platy limestone beds. Upper limestone is bluish gray weathering to gray or brown. Middle shale is bluish gray to yellowish brown and sandy to clayey; contains the Elmo coal bed near top. Lower limestone is pinkish brown weathering to light brown. Lower shale is bluish gray to yellowish brown and sandy to clayey; locally contains sandstone.	Small quantities of water are available locally to wells.
					Rulo Limestone			
					Cedar Vale Shale			
					Happy Hollow Limestone			
					White Cloud Shale			
				Howard Limestone	Utopia Limestone	10-20	Upper limestone is thin to medium bedded and brownish gray to gray weathering to light brown. Shale is clayey and gray to reddish brown. Lower limestone is bluish gray weathering to light gray or yellow brown.	Small quantities of water are available locally to wells.
					Winzeler Shale			
					Church Limestone			
				Severy Shale		30-70	Brown to gray fissile sandy to clayey shale. Nodaway coal bed and carbonaceous shale in upper part. Locally contains a silty fine-grained sandstone.	Small quantities of water are available locally to wells.
			Shawnee	Topeka Limestone	Coal Creek Limestone	20-30	Limestone members generally are medium to thick bedded and gray to grayish brown weathering to yellowish brown. Upper shale is a platy dark-gray carbonaceous shale. Two middle shales are silty to clayey and calcareous. Lower shale is sandy to clayey and brownish gray to gray.	Small quantities of water are available locally to wells in the upper part of the limestones, where weathered.
					Holt Shale			
					Du Bois Limestone			
					Turner Creek Shale			
					Sheldon Limestone			
					Jones Point Shale			
					Curzon Limestone			
					Iowa Point Shale			
					Hartford Limestone			

				Oread Limestone	Kereford Limestone	35-60	Upper limestone is very fossiliferous, even to wavy bedded, and light gray weathering to yellowish brown. Upper shale is silty to clayey and light gray to reddish gray. Second limestone is wavy bedded and gray weathering to light grayish brown; contains chert horizons in upper part. Middle shale grades upward from fissile carbonaceous shale to brownish-gray to gray shale. Third limestone is hard, dense, massive, and dark bluish gray weathering to light yellowish brown. Lower shale is clayey and greenish gray. Lower limestone is thick bedded and brownish gray weathering to brown.	Small quantities of water are available locally to wells in the upper part of the thicker limestones, where weathered.
					Heumader Shale			
					Plattsmouth Limestone			
					Heebner Shale			
					Leavenworth Limestone			
					Snyderville Shale			
					Toronto Limestone			
			Douglas	Lawrence Formation		60	Reddish-gray and bluish-gray to olive-gray sandy to clayey shale and locally silty fine-grained sandstone.	Small quantities of water are available locally to wells.

[1] Outcrop thickness given for rocks of Pennsylvanian age.
[2] In this report, small supplies refers to yields generally less than 10 gpm, moderate supplies to 10 to 100 gpm, and large supplies to greater than 100 gpm.

wells penetrate as much as 165 feet of saturated material. Locally, however, the yield of a well may be much less, because the glaciofluvial deposits are discontinuous and have a considerable range in thickness and water-bearing characteristics.

In the upland areas of Jefferson County, other than in the vicinity of Nortonville, glacial drift and thin loess overlie bedrock. In northeastern Jefferson County, where the drift is more than 30 feet thick, one or more of the thin sand or gravel lenses incorporated in the drift generally will be penetrated by a well and may yield small to moderate amounts of water. Where the drift is less than 30 feet thick, the chances of penetrating a sand or gravel lens are remote, and wells may obtain small quantities of water only from the weathered zone at the bedrock surface. Because the glacial drift yields water slowly, a large-diameter dug well provides the advantage of storage within the well. It is for this reason, and because water can enter the permeable well wall at all levels, that about half of the wells inventoried in Jefferson County are large-diameter dug wells.

In many places in the upland areas where glacial drift is thin, domestic and stock wells are in draws or small valleys, and water is piped to points of use. Here, the yield from wells in combined colluvium and alluvium may provide an adequate supply of water. In localities where the ground-water supply is inadequate to meet needs, a supplementary supply may be obtained by collecting precipitation from roofs of buildings and storing it in cisterns, or by purchasing water delivered by tank truck.

The rocks of Pennsylvanian age generally yield only small quantities of water to wells—a few gallons per hour or less. Wells drilled or dug into the bedrock derive most of their yield from weathered material in the upper few feet of the bedrock. The part of the well beneath the bedrock surface serves to store water for intermittent periods of pumping at rates higher than the average yield of the well. Wells cased tightly into the bedrock generally are reported to be dry or to yield only small quantities of water that usually has an objectionable flavor or odor.

CHEMICAL QUALITY OF WATER

Chemical analyses of water from selected wells in Jefferson County (table 2) indicate that most of the water is of the calcium bicarbonate type. The concentration of dissolved solids in water samples from wells provides a general means of evaluating the quality of water in various aquifers. The concentration of dissolved solids ranges from 125 to 1,190 mg/l (milligrams per liter), with most values ranging from 300 to 600 mg/l. Water is considered to be of good quality for public supply if the dissolved-solids concentration is less than 500 mg/l, and of acceptable quality if the concentration is less than 1,000 mg/l. (The limits of the various constituents cited are those recommended by the U.S. Public Health Service, 1962.) Sulfate concentrations were generally low for most of the samples analyzed; however, two of the samples contained concentrations of sulfate in excess of the 250 mg/l limit recommended for public water supplies. The water generally is very hard, but it can be softened if found objectionably so.

About a third of the water samples analyzed contained concentrations of nitrate (NO_3) in excess of the 45 mg/l limit recommended for public water supply. Ingestion by infants (less than 6 months old) of water containing nitrate in concentrations in excess of 45 mg/l may cause infantile methemoglobinemia (also called cyanosis or blue-baby disease). It may also affect young stock animals adversely. Boiling or softening of water does not remove or decrease the nitrate content. A brief investigation of a number of wells that yield water having a high nitrate content indicated that surface pollution was the probable source of the nitrate. Legumes, plant debris, fertilizers, animal wastes, and sewage probably are the sources of nitrate in most surface and ground waters. Protection of wells against the entrance of surface water may not be sufficient to prevent nitrate pollution. Nitrate can be leached from surface sources and can be carried to the water table where the nitrate will remain in solution.

Iron and manganese, when present in concentrations of more than 0.3 mg/l, may cause turbidity in the water and staining of plumbing fixtures and laundered fabrics. In Jefferson County the majority of samples contained iron concentrations of less than 1.0 mg/l.

SUMMARY OF GROUND-WATER CONDITIONS

Moderate to large supplies of water are available from wells in alluvium of the Delaware and Kansas River valleys. The potential for development of large ground-water supplies is greatest from wells drilled in alluvium near the Kansas River, where infiltration can be induced from the stream.

Small to moderate supplies of ground water are available from properly constructed wells in areas of thick glacial deposits in the northeastern part of Jefferson County. In upland areas elsewhere in the county where glacial drift is relatively thin, ground-water supplies for domestic and stock use may be

11-17E-18ccc	93	do	4-28-66	....	383	31	.00	.00	100	11	17	320	38	11	.1	16	300	35	600	7.5
20cac	70	do	4- 8-66	14	576	26	2.3	.87	150	20	22	376	140	30	.2	.9	470	160	880	7.6
21ada	48	do	6- 1-66	14	267	25	--	--	67	6.1	14	198	33	5.0	.2	19	190	30	400	7.9
25bbc	52	do	5-27-66	15	360	27	.13	.00	110	4.1	14	256	40	7.0	.1	8.8	280	30	540	8.4
11-18E-16bbb	75	do	6-20-66	14	509	20	21	.62	140	9.7	19	356	64	21	.1	59	390	100	820	7.6
20acb	44	do	7-15-66	14	362	28	.22	.35	100	11	16	344	28	6.0	.2	2.2	300	15	580	7.6
24ccd	84	do	4-20-67	14	433	23	20	1.2	110	20	11	307	84	14	.2	21	350	100	690	7.6
26bab	81	do	5-18-66	15	405	30	.09	.06	110	18	15	376	35	10	.1	5.3	340	33	660	7.4
26ccd	57	Alluvium	5-26-66	14	389	32	8.0	1.0	110	15	11	376	28	6.0	.2	2.7	330	26	600	7.9
11-19E-21dab	13	do	4-10-67	12	396	12	.07	.00	110	11	22	303	41	26	.2	29	310	62	640	7.5
24acc	35	do	6-29-67	19	302	12	15	.17	85	11	13	278	26	15	.1	2.2	260	29	510	7.4
27bcc	58	Terrace deposits	12- 2-50	14	230	12	.35	---	61	5.4	11	181	12	9.0	.1	30	170	26		
11-20E-19daa	16	Glacial drift, Kanwaka Shale	4- 3-67	13	349	7.2	2.4	.18	91	18	15	312	36	24	.4	3.8	300	45	580	7.2

[1] Analyses by Kansas State Department of Health.

[2] In areas where the nitrate content of water is known to exceed 45 mg/l, the public should be warned of the potential dangers of using the water for infant feeding (U.S. Public Health Service, 1962, p. 7).

only marginally adequate or may require supplementary supply.

The bedrock formations generally are not a source of water, but wells may yield small amounts of water from the weathered zone at the bedrock surface, with the part of the well below the bedrock surface serving principally as a storage reservoir. A relatively common practice in upland areas is to locate wells in draws or small valleys where water-bearing zones in combined colluvium and alluvium may provide an adequate supply of water for domestic and stock use.

Ground water in Jefferson County generally is very hard and locally contains excessive concentrations of nitrate and iron.

RECORDS OF WELLS AND TEST HOLES

Information pertaining to 231 water wells and test holes in Jefferson County is given in table 3. Much of the data was obtained from well owners and well users. The depth to water and the depth of the well were measured by the author when possible. The locations of the wells and test holes are shown on plate 1.

5aaa	do	68	4	N	do	N	T	21.0	9-69	1,090	
5ccd	P. Corpstien	140 R	10	S	do	S, E	D, S	18 R		1,165	18gpm R
6aab	State Geological Survey	107	4	N	do	N	T	25 R	5-69	1,125	
8bba	P. Corpstien	160 R	10	S	do	S, E	S	130 R	4-67	1,165	
8ddb	State Geological Survey	48	4	N	do	N	T	9.5	9-69	1,090	
9abb	do	62	4	N	do	N	T	--	--	1,105	
9cbc*	A. Stockwell	66	14	T	do	J, E	D, S	56.0	4-67	1,120	
18aaa	State Geological Survey	107	4	N	do	N	T	28.5	5-69	1,140	
18ada	S. Leu	49	36	R	do	S, E	D, S	22.1	7-67	1,147	
19caa*	K. Martin	43	12	T	do	J, E	D	12.3	6-67	1,162	
20ddd	E. Houston	38	30	R	Alluvium	Cy, H	D	16.9	7-67	1,083	
26cda*	City of Winchester	132 R	6	S	Tecumseh Shale, Queen Hill Shale Member of Lecompton Limestone	S, E	P	65 R	4-67	1,179	10gpm R
31aaa	W. H. McBride	38	36	R	Glacial drift	Cy, E	S	28.9	7-67	1,122	
32dad	State Highway Commission	62	8	S	do	N	N	23.6	7-67	1,125	
33bcb	W. H. McBride	52 R		--	do	Cy, W	D, S	46 R	--	1,140	
8-20E-18dbc	State Geological Survey	72	4	N	do	N	T	28.3	10-48	1,173	
29caa	C. Hollandsworth	50 R		--	do	--	D	1 R	--	1,085	1gpm R
29dbb	R. Allen	42 R	6	G	Calhoun Shale, Deer Creek Limestone	Cy, H	D	19.7	4-67	1,112	
32dcc*	Jefferson County	24	12	R	Alluvium	Cy, H	P	9.8	4-67	967	
33ccc*	Eldon Farris	42	36	R	Glacial drift	J, E	D, S	25.2	4-67	1,070	
9-16E-12bbc	O. Meredith	25	48	C	Alluvium	J, E	D, S	7.4	7-67	1,060	
24cbb	Jefferson County	29	144	R	do	J, E	D, S	10.7	7-67	1,010	
36bcb	J. McClurg	22 R	78	R	Glacial drift	J, E	D, S	5 R	7-67	1,020	
36ccd	H. Klein	50 R	6	G	do	S, E	D		--	1,000	
9-17E-11abd*	Elmer Wood	26	48	R	do	J, E	S	22.8	4-67	990	
11adc	P. H. Grange	27	48	R	do	Cy, H	N	13.2	4-67	971	
16acb	I. Pratt	17	48	C	Alluvium	J, E	D, S	8.0	7-67	980	
18cbb*	W. D. Martin	11	96	C	Glacial drift	S, E	D	4.0	4-67	1,055	
20cdd	Jefferson County	12	36	R	Alluvium	Cy, W	N	1.8	7-67	1,028	
25dab*	City of Ozawkie	54 R	8	I	do	S, E	P	34 R	2-67	900	
25dac	do	55 R	8	I	do	S, E	P	34 R	2-67	900	
31ccc	F. Kresie	20 R	6	S	do	T, E	D, S	7.0	7-67	980	
32ddd*	Roy Cunning	32	48	R	Glacial drift	Cy, H	D	--	--	1,049	
34bcb	A. W. McPeek	113 R	8	--	Scranton Shale, Howard Limestone	N	T		--	1,000	
35aab	Jefferson County Rural Water District 3	40 R	6	S	Glacial drift	S, E	P	20 R	66	946	25gpm R
35aac	do	40 R	6	S	do	S, E	P	20 R	66	938	25gpm R
9-18E- 1dba	J. Bates	45	30	R	do	Cy, W	D, S	29.0	7-67	1,135	
2aab	W. P. Cummings	55 R	36	R	do	T, E	D, S	19.4	7-67	1,143	
5aad	U.S. Corps of Engineers	34	36	R	do	N	N	19.2	7-67	916	
14cbb*	J. Turner	12	36	R	do	Cy, H	D	7.3	4-67	1,065	
16aac	L. W. McNary	30 R	48	R	do	J, E	D	24 R	4-67	1,080	
27cda*	Jefferson County	20	12	R	Alluvium	C, E	P	7.8	4-67	931	
32bcc	U.S. Corps of Engineers	27	48	R	do	N	N	15.5	4-67	900	
9-19E- 1cbc*	D. L. Wallace	49	36	R	Glacial drift	J, E	D	3.5	7-67	1,120	
4ccb	R. Rush	156 R	6	S	do	S, E	D	55 R	7-62	1,175	
5aab	N. Curry	50	36	R	do	J, E	D, S	29.8	7-67	1,140	
9add*	E. Ashworth	24	48	R	Alluvium	Cy, H	D	7.4	4-67	1,070	
9ccd	R. McClough	80 R	6	S	Glacial drift	Cy, E	S	50 R	7-57	1,120	5gpm R
15ddd	L. Stephens	24 R	36	R	do	J, E	D	11.6	7-67	1,095	
16cbc*	A. McCullough	70 R	6	G	Calhoun Shale, Deer Creek Limestone	J, E	D, S	36.4	5-67	1,115	3gpm R
23bcd	J. May	34	6	S	Glacial drift	N	N	14.4	5-67	1,115	
24cbc*	M. Ehlers	92	6	S	Calhoun Shale, Deer Creek Limestone	Cy, W	S	16.5	7-67	1,100	
26adc	do	10	36	B	Glacial drift	Cy, W	D	2.7	7-67	1,105	
26dab	do	34	36	R	do	Cy, H	N	5.0	7-67	1,111	
34ccc*	M. Farmer	40	48		do	J, E	D	8.9	6-67	1,124	
9-20E- 6bdd	State Geological Survey	76	4	N	do	N	T	8.4	10-48	1,115	
21dad	C. Decker	95 R	6	S	Kanwaka Shale, Oread Limestone	T, E	D, S	40.6	5-67	1,050	
31bda	State Geological Survey	92	4	N	do	N	T	--	--	1,129	
32cdd	City of McLouth	28	6	S	Glacial drift	--	P	18.1	4-67	1,120	

24bbc	Sam Cohen	72	12	S	do	T, T	I, O	24.7	11-57	874	
25cba	State Geological Survey	40	2	A	Alluvium	N	T, O	26.1	6-66	873	
11-17E-10add	P. A. Segal	14	48	R	Glacial drift	S, E	D, S	2.3	4-67	940	
16cbb	R. Dewelde	48	6	S	Newman terrace deposits, Tecumseh Shale, Lecompton Limestone	Cy, E	D, S	27.6	4-67	876	
17bbb	J. Johnson	50	6	S	Glacial drift, Calhoun Shale, Deer Creek Limestone	J, E	D	15.1	4-67	889	
17cbd	J. W. Johnson	66 R	18	C	Newman terrace deposits	T, LPG	I, O	21.9	9-67	870	1,000gpm R
17ccd	Keith Stanwix	72 R	18	C	do	T, E	I	22.9	9-67	871	1,350gpm R
18ccc*	Jefferson County Rural Water District 1	93 R	12	S	do	T, E	P	42 R	57	875	200gpm R
19cdd	State Geological Survey	38	2	A	Alluvium	N	T, O	17.4	7-68	866	
19dac	C. H. Tucker, Jr.	56 R	18	S	Newman terrace deposits	T, E	I	27.4	11-66	873	1,200gpm
20bbb	A. J. Shirley	78 R	18	G	do	T, E	I, O	25.7	5-66	871	1,320gpm
20cac*	E. E. Shell	70 R	18	C	do	T, E	I	26.9	3-67	870	225gpm
20dbc	A. J. Shirley	72 R	18	G	do	T, T	I	26.0	5-66	870	1,340gpm
21ada*	State Geological Survey	48	2	A	do	N	T, O	20.7	6-66	865	
22bad	A. Shirley	58	18	C	do	T, LPG	I	25.0	9-67	870	750gpm R
22dda	J. T. Quinlan	62 R	18	G	do	T, LPG	I, O	24.4	12-66	864	940gpm
23dcb	Homer Price	58 R	18	S	do	T, D	I	--	--	860	
25bbc*	State Geological Survey	52	2	A	do	N	T, O	24.0	6-66	862	
26dac	do	56	2	A	Alluvium	N	T, O	19.8	6-66	857	
27bbc	do	42	2	A	do	N	T, O	17.7	6-66	860	
28bbd	W. E. Worthington	57 R	19	C	do	T, LPG	I, O	15.9	3-67	854	1,140gpm
29bab	George Shirley	38	18	G	do	T, D	N	14.8	5-66	859	
11-18E- 1ccb	K. Rodgers	135 R	6	G	Kanwaka Shale, Oread Limestone	N	N	--	--		
8dac	State Geological Survey	49	2	A	Alluvium	N	T, O	15.1	7-66	852	
9bdb	do	34	3	N	Newman terrace deposits	N	T				
16bab	do	80	4	N	Alluvium	N	T	--	--	848	
16bbb*	do	75	5	G	Newman terrace deposits	N	T, O	9.6	6-66	849	
16bcc	do	87	4	N	do	N	T		--	851	
17bbd	Dale Hupe	79 R	--	--	do	T, E	I	30 R	6-67	855	
17ccb	D. C. Hupe	51 R	18	C	do	T, LPG	I, O	19.0	3-67	854	1,080gpm
18cdc	State Geological Survey	76	4	N	do	N	T	--	--	856	
19bcc	do	62	2	A	do	N	T, O	18.1	6-66	858	
20acb*	B. C. Slough	44	18	G	do	T, LPG	I, O	21.8	10-57	857	600gpm
20acc	State Geological Survey	49	2	A	do	N	T, O	22.0	6-66	857	
21acd	do	36	2	A	Alluvium	N	T, O	15.3	6-66	848	
21baa	do	50	4	N	Newman terrace deposits	N	T	--	--	853	
21cbd	State Board of Agriculture	21	1	I	Alluvium	N	N	7.8	6-59	842	
22aab	Jefferson County Rural Water District 2	52 R	6	I	Newman terrace deposits	T, E	P	29 R	6-62	855	25gpm R
22dab	City of Perry	60 R	12	S	do	S, E	P	25 R	--	850	600gpm R
23dbc	Mrs. F. Isaacs	60	18	I	do	S, E	D, S	9.6	5-67	850	
24ccd*	State Geological Survey	84	2	A	do	N	T, O	27.6	10-66	854	
25abd	Jefferson County Rural Water District 2	60 R	--	--	do	--	P	19 R	4-68	850	50gpm R
26bab*	W. A. Grindol	81	6	S	do	T, E	I, O	20.7	10-57	849	50gpm
26ccd*	State Geological Survey	57	2	A	Alluvium	N	T,O	20.0	11-66	845	
28bad	do	43	4	N	do	N	T	--	--	847	
28bbd	do	34	4	N	do	N	T	--	--	835	
29aba	do	43	4	N	do	N	T	--	--	845	
29bab	do	53	4	N	do	N	T	--	--	851	
30aac	do	50	4	N	do	N	T	--	--	851	
35cbb	State Highway Commission	56	--	N	do	N	T	--	--	840	
11-19E-11bdc	T. Holladay	19	48	R	Glacial drift, Tecumseh Shale, Lecompton Limestone	B, H	D, S	2.0	6-67	1,042	
14cba		32	48	R	Glacial drift, Kanwaka Shale, Oread Limestone	N	N	21.4	5-67	1,060	
16aac	E. Otremble	40 R	48	R	Glacial drift, Tecumseh Shale, Lecompton Limestone	J, E	D, S	12 R	--	1,025	

LOGS OF WELLS AND TEST HOLES

Given on the following pages are sample logs of 16 test holes and drillers' logs of 4 wells. Additional logs of wells and test holes are retained in the files of the U.S. and State Geological Survey offices, Lawrence, Kans., and may be examined there. The drillers' logs were obtained from drillers' records and are essentially unchanged. The locations of the wells and test holes are shown on plate 1.

7-18E-25ddd

	Thickness, feet	*Depth, feet*
Soil, sandy, brown	4	4
Clay, dark-gray	3	7
Clay, sandy, slightly calcareous, light-brown to gray	3	10
Clay, slightly calcareous, tan to light-gray; contains embedded sand and gravel, abundant iron nodules	7	17
Clay, calcareous, tan to gray; contains embedded sand and gravel and thin layers of sand; iron nodules and stain present	22	39
Clay, calcareous, brownish-gray, and interbedded tan fine sand	8	47
Clay, calcareous, dark-gray with tan streaks; contains embedded sand and gravel	21	68
Sand, very fine, clayey, calcareous, dark-gray	13	81
Sand, fine to medium, silty, calcareous, dark-gray	20	101
Gravel, fine to medium, sandy	2	103
Limestone	1	104

8-17E-13cab

	Thickness, feet	*Depth, feet*
Soil	6	6
Clay	24	30
Clay, sandy	2	32
Sand and fine to coarse gravel	13	45

8-18E-1dda

	Thickness, feet	*Depth, feet*
Roadfill and brown soil, calcareous	3	3
Clay, light-gray, slightly sandy, iron stained and carbonaceous	5	8
Clay, slightly calcareous, light-gray to tan, embedded sand and gravel, slightly carbonaceous	3	11
Clay, very sandy, light-gray to tan	1	12
Sand, quartz, medium to coarse, rounded, brown; contains igneous material	12	24
Sand, quartz, fine to medium, rounded to angular, gray to tan; contains igneous material	4	28
Sand, quartz, medium to coarse, rounded to angular, gray to tan; contains igneous and metamorphic material and fine to medium pebbles	11	39
Clay, calcareous, dark-gray; contains embedded sand and gravel	4	43

8-19E-4bab

	Thickness, feet	*Depth, feet*
Silt, clayey, black	7	7
Clay, silty, brown	5	12
Clay, tan, gray	10	22
Sand, silty, gray	10	32
Sand, silty, olive-gray	5	37
Sand, silty; contains some gravel	10	47
Sand and gravel	2	49
Shale, black	..	49

8-19E-26cda

	Thickness, feet	*Depth, feet*
Topsoil	6	6
Clay	14	20
Clay, yellow	20	40
Gravel and sand	10	50
Clay	23	73
Clay, blue	12	85
Limestone	2	87
Shale, blue	28	115
Sandstone	5	120
Limestone, blue	10	130
Shale, blue	4	134
Limestone	1	135
Shale	1	136
Limestone, white	10	146
Shale, blue	14	160

8-20E-18dbc

	Thickness, feet	*Depth, feet*
Silt and clay, black	3	3
Clay, buff-tan	6	9
Clay, grayish-tan	8	17
Clay, pale-gray	15	32
Clay, calcareous, tan and buff	20	52
Clay, sandy, calcareous, tan and buff	11	63
Sand, fine to medium, rounded, and clay	5	68
Limestone, tan, and thin tan shale	4.5	72.5

9-17E-25dab

	Thickness, feet	*Depth, feet*
Clay, brown	10	10
Clay, grayish-brown	25	35
Clay, sandy, grayish-brown	5	40
Sand, fine to coarse, gray, brown; contains abundant clay	5	45
Gravel and sand, medium to coarse, grayish-brown	8	53
Shale, gray	1+	54+

9-20E-21dad

	Thickness, feet	*Depth, feet*
Clay	30	30
Clay, blue	20	50
Sand	10	60
Sand and shale	7	67
Sand, fine	28	95

10-18E-7bdb

	Thickness, feet	*Depth, feet*
Topsoil	1	1
Clay, silty, medium, brown	17	18
Clay, sandy, gray	20	38
Clay, silty, brownish-gray	4	42
Sand, medium to coarse, brown	3	45
Sand, medium to coarse, gray and brown	5	50
Sandstone, medium to coarse, gray and brown; contains very fine gravel	1	51
Sandstone	1.75	52.75
Clay and limestone, brown	4.25	57
Shale, hard, gray	1	58
Shale, hard, black	2	60

10-20E-19bdd

	Thickness, feet	*Depth, feet*
Clay, dark-gray mottled with tan	3	3
Clay, sandy, tan to buff; contains some fine to medium gravel	7	10
Clay, calcareous, tan; contains some fine gravel and chalk pebbles	27	37
Clay, slightly sandy, calcareous, greenish-black	9.5	46.5
Gravel, fine; contains clay	1.5	48
Clay, greenish-black; contains rounded fine gravel	9	57
Clay, calcareous, greenish-black	19	76
Gravel, fine to medium; contains clay	3	79
Clay, calcareous, greenish-black	3	82
Clay, greenish-black	8	90

	Thickness, feet	Depth, feet
Sand, coarse, brownish-tan; contains some silt	2	29
Sand, coarse, brown	9	38
Sand, very coarse, grayish-brown	5	43
Sand, very coarse, and some gravel, gray	4	47
Sand and gravel, gray	5	52
Gravel, gray	12	64
Gravel, grayish-brown	4	68
Gravel, brown; contains flat pieces of gray limestone	9	77
Shale	1+	78+

SELECTED REFERENCES

DAVIS, D. E., 1959, Geology of southeastern and south-central Jefferson County, Kansas: Unpub. master's thesis, Dept. Geology, Univ. Kansas, 81 p.

DAVIS, S. N., and CARLSON, W. A., 1952, Geology and ground-water resources of the Kansas River valley between Lawrence and Topeka, Kansas: Kansas Geol. Survey Bull. 96, pt. 5, p. 201-276.

DUFFORD, A. E., 1958, Quaternary geology and ground-water resources of Kansas River valley between Bonner Springs and Lawrence, Kansas: Kansas Geol. Survey Bull. 130, pt. 1, p. 1-96.

FRYE, J. C., 1941, Reconnaissance of ground-water resources in Atchison County, Kansas: Kansas Geol. Survey Bull. 38, pt. 9, p. 237-260.

FRYE, J. C., and LEONARD, A. B., 1952, Pleistocene geology of Kansas: Kansas Geol. Survey Bull. 99, 230 p.

FRYE, J. C., and WALTERS, K. L., 1950, Subsurface reconnaissance of glacial deposits in northeastern Kansas: Kansas Geol. Survey Bull. 86, pt. 6, p. 141-158.

GOGEL, A. J., 1969, Ground-water resources of northwestern Jefferson County, Kansas: Unpub. master's thesis, Dept. Geology, Univ. Kansas, 142 p.

HEM, J. D., 1970, Study and interpretation of the chemical characteristics of natural water: U.S. Geol. Survey Water-Supply Paper 1473, 2nd ed., 363 p.

JOHNSON, W. D., ADKISON, W. L., and WAGNER, H. C., 1967, Geology of Shawnee County, Kansas: U.S. Geol. Survey Bull. 1215, 254 p.

MOORE, R. C., 1949, Divisions of the Pennsylvanian System in Kansas: Kansas Geol. Survey Bull. 83, 203 p.

O'CONNOR, H. G., 1960, Geology and ground-water resources of Douglas County, Kansas: Kansas Geol. Survey Bull. 148, 200 p.

STONE, W. A., 1965, Relation of the stratigraphy and geomorphology to the occurrence of ground water in northeastern Jefferson County, Kansas: Unpub. master's thesis, Dept. Geology, Univ. Kansas, 84 p.

U.S. PUBLIC HEALTH SERVICE, 1962, Drinking water standards: U.S. Public Health Service Pub. 956, 61 p.

WALTERS, K. L., 1953, Geology and ground-water resources of Jackson County, Kansas: Kansas Geol. Survey Bull. 101, 91 p.

ZELLER, D. E., ed., 1968, The stratigraphic succession in Kansas: Kansas Geol. Survey Bull. 189, 81 p.