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PRELIMINARY REPORT
ON
GROUND WATER FOR IRRIGATION IN THE VICINITY OF WICHITA, KANSAS

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By O. E. Meinzer.

INTRODUCTION.

Wichita, the county seat of Sedgwick County, Kans., is situated on Arkansas River less than 50 miles north of the Oklahoma line. In 1910 it contained 52,450 inhabitants and ranked second only to Kansas City, Kans., among the municipalities of the State. It has excellent railroad facilities, is an important distributing point, and has acquired prominence as a milling and meat-packing center. It is surrounded by a prosperous agricultural region that produces a diversity of crops, among which winter wheat, Indian corn, alfalfa, and Kafir corn are important. Fruit and vegetables are also grown, but not in sufficient quantities to supply the local market.

The average annual precipitation in this region is about 31 inches, most of which falls during the crop-growing season. Nevertheless, the rainfall is irregular, evaporation in the summer and early autumn is great, and in some seasons long droughts cause serious damage to crops. These dry seasons and especially the unusual drought of 1913 have impressed upon the people the fact that the average yield per acre of most crops could be increased if an irrigation supply were available at the times when the crops are suffering for lack of moisture, and moreover that irrigation is necessary for the most successful truck farming. As ground water is known to occur in large quantities under a part of the region this supply appeared to be the most accessible, and hence appeal was made to the United States Geological Survey for advice as to the feasibility of developing this supply for irrigation. No detailed investigation has been made of the ground water of this vicinity, but the area was included in several general investigations that have been made by the Federal and State geological surveys, the work of Prof. Erasmus Haworth, State geologist, being especially valuable. The following brief report is based on data obtained from these earlier investigations (see list of publications consulted, p. 9) and from a reconnaissance of the vicinity of Wichita made by the writer in November, 1913. Except as otherwise indicated the statements in this paper refer only to Sedgwick County.

OUTLINE OF GEOLOGY OF THE WICHITA REGION.

The region surrounding Wichita is underlain by Carboniferous formations that dip gently westward and consist chiefly of shale but partly of limestone and sandstone. Into these formations a valley about 5 to 10 miles wide was cut by Arkansas River, and apparently a valley 15 to 25 miles wide was cut by a stream that connected Smoky Hill River with Arkansas River, the junction between the two valleys being between Hutchinson and Wichita. Later both valleys were filled with stream deposits.

According to maps issued by the Kansas Geological Survey and the United States Bureau of Soils and other data, the eastern margin of these valley deposits passes a few miles west of Lehigh and Newton and a short distance east of Valley Center, thence through the eastern part of Wichita and southward near the river; their western margin north of Arkansas River passes near Conway and Aiken and thence southward to the Little Arkansas, up which stream deposits extend a long distance. In the vicinity of Hutchinson a belt of sand dunes, several miles wide, intervenes between the Little Arkansas and Arkansas valleys. The valley deposits extend indefinitely both up and down stream along the Arkansas. In the vicinity of Wichita their western margin is about 3 miles west of the river; farther south it is 3 to 5 miles west of the river.

The valley deposits consist chiefly of clean sand and gravel at the bottom and finer sediments at the top. The following section of a test well sunk in 1912 by the city of Wichita under the direction of Commissioner R. B. Campbell shows the general character of these deposits and the large amount of porous sand and gravel that they contain.

Log of test well sunk by city of Wichita in SW. ¼ sec. 33, Park Township.

	Thickness.	Depth.
	Feet.	*Feet.*
Dark sandy loam	2	2
Dark-red loamy sand	9	11
Reddish medium sand	14	25
Black gumbo	3½	28½
Gray clay	1	29½
Fine sand	2	31½
Brown gumbo	1	32½
Coarse sand and fine gravel	2½	35
Fine sand	3	38
Coarse sand and fine gravel, chiefly quartz but some feldspar, etc.; waterworn and partly rounded	23	61
Fine sand	3	64
Coarse sand and fine gravel, chiefly quartz but some feldspar, etc.; waterworn and partly rounded	4	68
Medium sand	2	70
Medium gravel, chiefly granite pebbles; partly rounded	2	72
Coarse sand	1	73
Drab clay	2	75
Fine sand	1	76
Hard and tenacious gray clay	1	77
Fine sand	2	79
Medium sand	4	83
Sand and clay	1	84
Coarse sand and fine gravel, chiefly quartz but some feldspar, etc.; waterworn and partly rounded; well ended.		

The thickness of the valley deposits is not the same in different localities. Near McPherson and near Halstead it is about 150 feet, but in Sedgwick County it is less. For example, dense blue clay, which is believed to be Carboniferous shale, was struck at 63 feet in the SW. ¼ sec. 24, Valley Center Township, at 45 feet in the NW. ¼ sec. 29, Valley Center Township, at 44 feet in the NW. ¼ sec. 23, Delano Township, and at 40 to 45 feet at the Wichita city waterworks. In the SW. ¼ sec. 33, Park Township, however, drilling was carried to a depth of 84 feet without reaching the shale.

Over parts of the uplands the Carboniferous formations are covered only by a mantle of rock waste, but on the west side of the river they are in some places covered by stream deposits that belong chiefly to the Tertiary period and were laid down before the valleys were cut.

GROUND WATER.

OCCURRENCE AND QUANTITY.

The deep wells that have been drilled in this region show that the Carboniferous formations are unpromising as a source of water supply. The shales are too dense to yield much water and the limestones and sandstones generally yield water of poor quality. Further deep drilling should therefore be discouraged.

On the other hand, the wells that have been finished in the sands and gravels of the valley deposits show that these sands and gravels contain a large supply of water that is yielded freely when the wells are pumped. The valley deposits in Sedgwick County are saturated approximately to the river level, or generally within 20 feet of the surface. Over a large part of the valley area the depth to water is between 10 and 15 feet.

The city test well, from which sample drillings were carefully preserved, passed through a total thickness of 35 to 40 feet of clean, coarse sand and gravel—excellent water-bearing material. Other wells that were examined pass through varying thicknesses of similar water-bearing beds. Since the valley deposits have the irregular character typical of deposits made by streams, the wells in different localities will not be equally good, and in exceptional places they may be unsatisfactory, but as a rule wells that are sunk to the bottom of the valley deposits and properly constructed will yield freely.

In a detailed investigation of Arkansas Valley in the vicinity of Garden City C. S. Slichter, of the United States Geological Survey, determined (1) that the ground water in the valley is derived chiefly from the rain that falls on the porous soil of the valley and the adjacent uplands, and only to a small extent from the floods in the river, (2) that on the sandy bottom lands 60 per cent of an ordinary rain reaches the ground water, and (3) that the ground water in the valley is moving downstream at an average rate of 8 feet per day. The conditions at Wichita are similar to those at Garden City. Although the soil is on the whole probably less porous and the percentage of percolation is therefore not so great, nevertheless it is believed that the porosity is sufficient to allow rapid renewal of the ground-water supply from local rainfall. If the ground water is for any reason drawn down below the level of the water in the river, it will be replenished in rainy seasons with relative rapidity; but after this level has been restored additional contributions to the ground water will be rapidly lost by seepage into the river.

WELLS.

The domestic and industrial water supplies of Wichita and adjacent areas are obtained almost exclusively from wells sunk into the saturated valley sands and gravels. Large supplies are drawn at the Dold and Cudahy packing houses, at the Atchison, Topeka & Santa Fe Railway shops, and at other points in and near the city. The largest pumping plant is, however, at the city waterworks, situated between Arkansas and Little Arkansas rivers not far above their junction. At this plant there are 43 wells and the pumpage in 1912 amounted to about 4,280 acre-feet, or a daily average of about 3,825,000 gallons.

The common domestic wells are sand points, which are generally driven with a sort of hand pile driver for $2 per well, exclusive of material. They rapidly become clogged with silt and incrusted with precipitated mineral matter and must generally be renewed after a few years of service. The wells used for larger supplies are provided either with fine strainers or with perforated casings of various types. They are most conveniently sunk by removing the incoherent sediments with a sand pump or by other means and allowing the casing to descend as rapidly as room is made for it. The fine strainers are very poorly adapted to the conditions in this vicinity. Much larger and more permanent supplies of water can be developed by using casings that are perforated where they pass through the coarser sand and gravel beds with slits at least one-fourth inch wide or with circular holes at least one-fourth inch in diameter. The bottom of the casing should be either plugged or set firmly on the Carboniferous shale. The well should then be thoroughly cleaned out by first using a bailer or sand pump and later applying an air-lift or pumping to the limit of capacity with a centrifugal pump. The fine sediments intermingled with the coarser sand and gravel should not be shut out and allowed to clog the well but should be washed freely into the well and then removed, in order to give the water in the formation free access to the well.

An excellent method for inserting gravel around the casing has been used in a few wells. It consists of making the hole considerably larger than the casing and allowing gravel composed of pebbles at least one-fourth inch in diameter to fill the space around the casing as the casing sinks. With proper methods of construction, yields of a few hundred gallons per minute from a single well may be generally expected.

Three principal types of casing are in use—heavy standard well casing, lighter galvanized sheet-iron casing, and cement casing. The relative merit of these casings was not investigated, but it is believed that where water contains as much chlorine as is found in the water of this vicinity there is some risk from corrosion if thin metal casings are used. The large cement casings are generally reinforced, as they should be, in order to increase their tensile strength. They should have as large perforations as the metal casings.

QUALITY OF WATER.

Analyses of about 60 samples of ground water in Sedgwick County are at hand, 45 of which are incomplete analyses made in duplicate by State Chemist C. C. Young and Prof. S. E. Swartz in connection with an investigation conducted by Commissioner R. B. Campbell for the city of Wichita and generously made available for this paper by the city authorities. Most of the rest are published in Water-Supply Paper 273 of the United States Geological Survey (p. 181). These analyses show that although the ground waters are generally somewhat hard and otherwise mineralized they differ widely in the quantities of mineral matter that they contain. The total solids range from 180 parts per million in the purest sample to more than 2,000 parts in the most highly mineralized sample. Likewise chlorine, which indicates common salt, ranges from less than 10 parts per million to more than 300 parts, and the sulphate radicle ranges from less than 10 parts to more than 600 parts. The cause of these local differences has not been discovered, but they are so important, especially for those wishing to develop industrial supplies, that the analyses made for the city and a few others not already published in Water-Supply Paper 273 are given in the following table. With a few exceptions the determinations made by Young and Swartz agree closely.

Partial analyses of ground waters in the vicinity of Wichita, Kans.

[Parts per million.]

Owner.	Location. Sec.	Location. Position in section.	Depth (feet).	Total solids.	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Chlorine (Cl).
Valley Center Township.							
H. W. Reynolds [1]	36	About ⅛ mile west of southeast corner of NW. ¼.	30	306	267	28	7
Park Township.							
J. A. Adamson [1]	12	About 15 rods east of northwest corner.	20	412	292	35	60
C. F. Wright [1]	12	SE. ¼	15	545	259	44	139
N. R. Bishop [1]	13	Northeast corner	16	385	186	33	81
John Torkleson [2]	19	Southeast corner of SW. ¼		228	140	14	43
J. Stilley [2]	24	Northeast corner of SE. ¼		1,061			
W. H. Linzo [2]	29	East margin of SW. ¼	18	240	158	5.3	40
T. Hudson [2]	30	¼ mile north of SW. corner	35	325	295	14	45
H. M. Kinwell [2]	30	Northwest corner	18	390	332	19	39
L. Crater [2]	31	do		332	244	13	36
John Torkleson [2]	31	do	35	280	200	21	54
W. M. Tuell [2]	33	¼ mile north of SW. ¼	54	220	156	9.1	26
C. C. Chance [2]	36	Lot 1 or 2	25	1,616			
Kechi Township.							
J. P. Creeson [1]	6	SW. ¼ SW. ¼	14	328	298	28	9
A. F. Rothfuss [1]	7	White House poultry farm	25	335	317	35	10
T. Goodrich [1]	8	NW. ¼; at barn	28	334	311	36	10
Do. [2]	8	NW. ¼; at house 200 feet west and 200 feet north of barn.	28	263	232	33	6
J. R. Conine [1]	17	Opposite Fairfield station, Arkansas Valley Electric Ry.		488	399	54	23
F. E. Dunmire [2]	19	About 60 rods south of northwest corner.	25	1,112			
B. C. Bethel [1]	20	Lot 10; west of Urbandale station.	26	392	298	67	7
T. B. Young [2]	25	Lot 9; well at house	35	1,305			
Do. [2]	25	Lot 9; well at barn	25	1,346			
William Blair [1]	29	SE. ¼ SW. ¼; 1628 Market St.	35	403	290	46	49
E. L. Gaitskill [1]	29	NE. ¼		325	258	44	10
Carrie H. Young [2]	30	N. ½ SW. ¼		1,237			
J. R. Russell [2]	31	Near center of E. ½ SW. ¼		1,470			
Atchison, Topeka & Santa Fe Ry. [3]		Railway shops	30	592		219	20
Attica Township.							
William Morgan [2]	1	Southeast corner		346	329	10	29
S. Eberly [2]	12	About ⅛ mile west of southeast corner.		345	329	8.6	18
Delano Township.							
J. M. Bullinger [2]	1	NE. ¼; opposite end of road		1,376			
William Greeson [2]	1	Near center of SW. ¼ NE. ¼		1,337			
B. F. McLean [2]	1	SW. ¼		858			
L. L. Kessler [1]	4	do	38	261	165	Trace.	41
A. G. Kessler [2]	5	Near center of NE. ¼	32	180	97	12	15
Ed. Jaax [2]	7	Southeast corner of SW. ¼	35	390	365	13	20
L. L. Kessler [1]	8	NE. ¼	35	290	194	Trace.	55
T. V. Hankinson [1]	9	SE. ¼	38	248	160	Trace.	42
T. F. Pickens [1]	9	SW. ¼	55	389	251	27	71
S. A. Sprankle [1]	11	SE. ¼	25	404	249	41	72
F. Rickers [1]	12	do		466	296	46	91
L. D. Dow [1]	15	NW. ¼	40	304	179	Trace.	65
G. Wilbur [1]	16	SE. ¼	35	363	278	19	51
T. F. Pickens [1]	17	NW. ¼	35	359	306	Trace.	36
O. Craig [2]	20	NE. ¼	36	356	312	35	59
E. Benson [1]	21	SW. ¼	35	158	132	Trace.	16

[1] Analyses by C. C. Young, State chemist.
[2] Analyses by S. E. Swartz.
[3] Recalculated from analysis furnished by the railway company.

Partial analyses of ground waters in the vicinity of Wichita, Kans.—Continued.

Wichita Township.

Owner.	Location.		Depth. (feet).	Total solids.	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Chlorine (Cl).
	Sec.	Position in section.					
Wichita Water Co.[1]	18	Near southeast corner	40–45	1,015	228	172	326
J. W. Protherow[2]		Minnie Street, opposite 18th Street.		2,031			

Waco Township.

Owner.	Sec.	Position in section.	Depth. (feet).	Total solids.	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Chlorine (Cl).
J. Furley[1]	11	NW. ¼		274	153	19	53

[1] Analyses by C. C. Young, State chemist.
[2] Analyses by S. E. Swartz.

IRRIGATION.

The feasibility of irrigation with ground water depends on the answers to three questions. Is the supply adequate in quantity? Is the water satisfactory in quality? Will the cost be small enough and the additional income large enough to make irrigation developments profitable?

The supply of ground water in the valley areas is of course not unlimited, but it is large and will be rather rapidly replenished if locally depleted. If the climate were arid, serious depletion from heavy drafts for irrigation might reasonably be feared, but with the large average annual precipitation that is assured to this region anything like continuous irrigation will not be necessary nor desirable, and, on the other hand, frequent rains will make contributions to the underground supply. The danger of exhausting the supply is believed to be so remote that it need not prevent anyone from making developments that will otherwise be profitable.

A large proportion of the samples analyzed represent waters that are satisfactory for irrigation use, but a few of the most highly mineralized samples approach the danger line, especially in their content of common salt. However, with the relatively humid conditions that prevail in this region and the consequent dilution and leaching that will result from the rain water, injury from the salt in even the more highly mineralized waters need not be feared except where the soil is clayey or already impregnated with alkali.

As a result of the prolonged drought in 1913 several pumping plants have been installed for irrigation. These furnish some data as to first cost but few as to operating expenses and none as to depreciation. A single example will be cited: The plant of Schuyler Jones, SW. ¼ sec. 24, Valley Center Township, consists of an electrically driven 8-inch horizontal centrifugal pump drawing from four 15-inch wells with perforated 16-gage casing, 63 feet deep, and spaced 40 feet apart. According to a test of several hours reported by the owner, the wells together yielded approximately 1,600 to 1,800 gallons per minute, with a lowering of the water, during pumping, from its normal level 21 feet below the surface to a level 42 to 45 feet below the surface. The cost of the completed plant, including the wells, is estimated at $3,300, or about $825 to $950 per second-foot of water developed. If a duty of 60 acres per second-foot is assumed, the initial cost is therefore about $15 per acre, exclusive of grading and ditching. The cost per second-foot will vary considerably with the depth and yield of the water-bearing beds, the depth to the water level, the construction of wells and plant, and the kind of machinery installed. If standard casing or cement casing had been used in the Jones wells the cost would have been several hundred dollars greater. The cost per acre will of course depend largely on the number of acres irrigated with 1 second-foot of water.

Because of the low lift and the cheapness of fuel the cost for power will not be great, whether the individual plants are provided with electric motors or with internal-combustion engines. At the power plant of the Kansas Gas & Electric Co. electric current is at present generated by steam produced through combustion of natural gas. Engines using crude oil or distillate have been installed at a few pumping plants.

In estimating the annual cost of irrigation the following items must be included:

1. Interest on investment (including ditches and grading).
2. Taxes.
3. Depreciation and repairs.
4. Power and lubricating oil.
5. Labor in operating the pumping plant and distributing and applying the water.

The probable sum total of all these items should be frankly and fully considered before any developments are made. The first two items are fixed charges which will be the same in wet as in dry years. The third item is only partly a fixed charge. In this area, where operating expenses will be relatively light and where the pumping plants will stand idle during long periods of adequate rainfall, depreciation will be a very important item. Success will not be possible unless the most scrupulous care is taken of all parts of the plant during the periods of idleness.

The subject of increase in crop production is not within the scope of the investigations of the Geological Survey. Enough is known, however, to warrant the statement that with good management, both in regard to pumping and in regard to agricultural or horticultural practice, irrigation can be made profitable for raising vegetables and certain fruits and probably also alfalfa and some other field crops. On the other hand, as a result of the dry season of 1913 and the general interest that has been aroused in irrigation, there will be a tendency for farmers to make expenditures for irrigation supplies without taking full account of the costs, without considering the years of abundant rainfall, and without having adequate knowledge of the methods of irrigation that are required. The result of such ill-considered expenditures will be financial loss. The movement for irrigation with ground water in the vicinity of Wichita is rational and commendable, but, because of the lack of quantitative knowledge as to the increase in crop values that will in the long run result from irrigation, this movement should be prosecuted with conservatism and developments should be made only after deliberate consideration of all the factors involved.

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