DEPARTMENT OF THE INTERIOR

UNITED STATES GEOLOGICAL SURVEY

GEORGE OTIS SMITH, DIRECTOR

WATER-SUPPLY PAPER 345—D

GROUND WATER FOR IRRIGATION

IN THE

VALLEY OF NORTH FORK OF CANADIAN RIVER NEAR OKLAHOMA CITY, OKLAHOMA

BY

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Contributions to the Hydrology of the United States, 1914—D

WASHINGTON

GOVERNMENT PRINTING OFFICE

1914

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GROUND WATER FOR IRRIGATION IN THE VALLEY OF NORTH FORK OF CANADIAN RIVER NEAR OKLAHOMA CITY, OKLAHOMA.

By A. T. Schwennesen.

INTRODUCTION.

The North Fork of Canadian River is formed by the union of Wolf and Beaver creeks in Woodward County, in the northwestern part of Oklahoma. It flows diagonally across the State in a southeasterly direction for 300 miles and joins Canadian River near Eufaula, in the southern part of McIntosh County. The river follows a meandering course through a narrow alluvium-filled valley. The area discussed in this paper is the 80-mile stretch of river valley which extends from Elreno, in Canadian County, through Oklahoma and Lincoln counties to Shawnee, in Pottawatomie County. This part of the valley has an average width of about $1\frac{3}{4}$ miles and an area of about 140 square miles, and on account of its level surface and fertile soil it contains some of the most prosperous farms in the State. Oklahoma City, the capital and largest city of the State, with a population in 1910 of 64,205, is situated on the North Fork of Canadian River in the southwestern part of Oklahoma County, near the geographic center of the State. It is a typical inland city supported chiefly by meat packing, milling, and other industries dependent on the cattle and agricultural business of the country.

Two other important cities on the North Fork of Canadian River are Elreno and Shawnee, the former 30 miles above and the latter 50 miles below Oklahoma City, measured along the axis of the valley. The census for 1910 credits Shawnee with a population of 12,474 and Elreno with 7,872. Communication between these cities and with outside points is furnished by several railroads. An electric railroad affords excellent interurban service between Oklahoma City and Elreno.

In the excitement incident to the phenomenal growth of Oklahoma City during the years following the opening to settlement of the Indian lands the full development of the fertile bottom lands along the river was neglected, but now that the city has settled down to a normal rate of growth attention has been directed toward the higher development of these lands by subdivision into small tracts and more intensive and diversified farming. In regions adjacent to large cities market gardening is usually a profitable business. In this kind of farming success depends largely on getting the products to market when there is the most demand for them, and to do this the farmer must be able to control the growth of his crops through the timely application of water.

In Oklahoma the rainfall is not evenly distributed throughout the year. Records for the last 23 years show an average annual rainfall of 31.07 inches, nearly 50 per cent of which falls during April, May, June, and July. For ordinary field crops, of which as a rule only one crop a year is raised, the planting and harvest seasons can to some extent be arranged to conform to such a distribution of rainfall, but for mixed farming, in which planting and harvesting are more or less continuous throughout the year, artificial watering becomes necessary. At several farms in the valley water for irrigation is pumped from the river, but for the lands not adjacent to the river the most practicable source of supply is the ground water, and it was for the purpose of obtaining some data on the occurrence and quantity of the available ground water that a short investigation was made in January, 1914. The writer was able to spend only a few days in the field, and the information contained in this paper is the result of a hurried reconnaissance of the region with the addition of information obtained from a perusal of such literature concerning this region as was available.

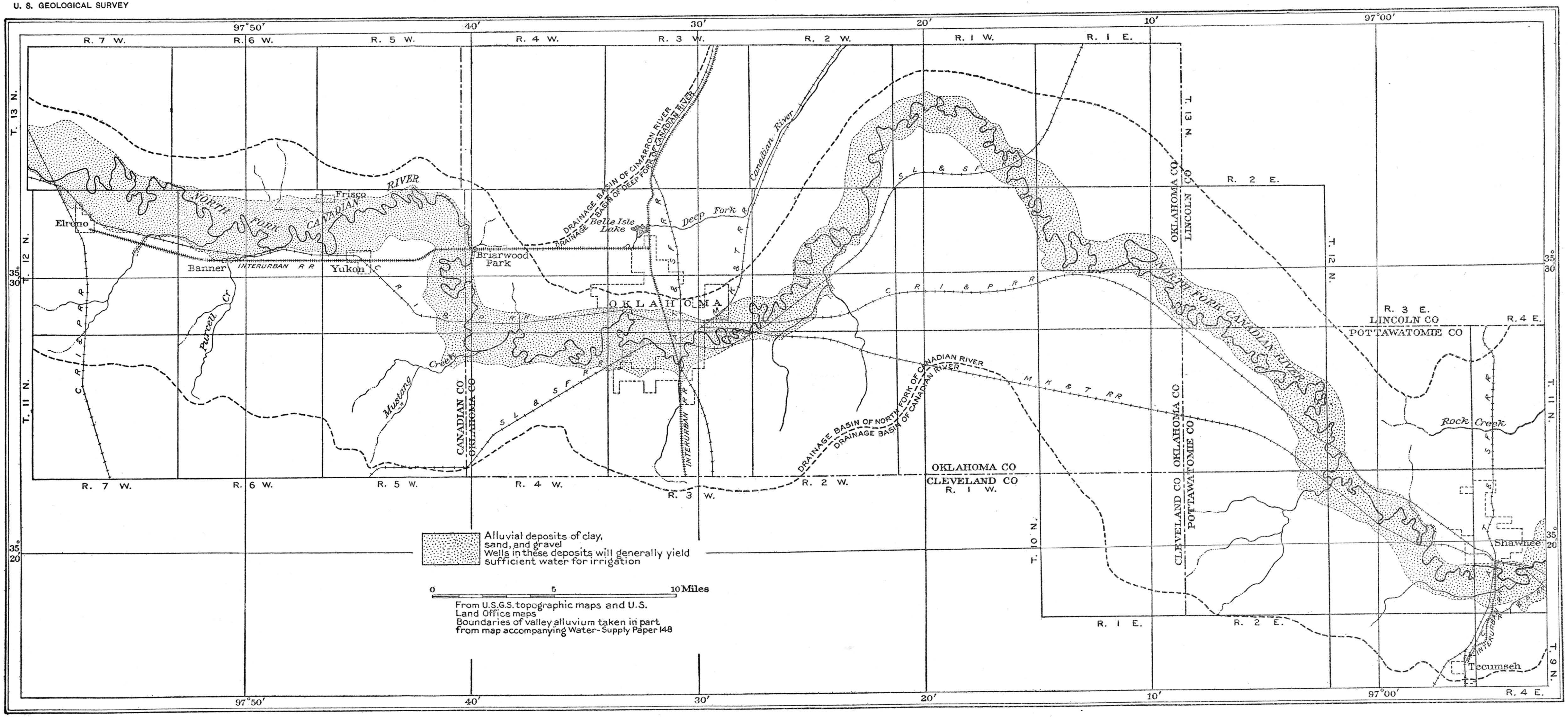
GEOLOGIC OUTLINE.

The valley of the North Fork of Canadian River is an alluvium-filled trench channeled out of the Carboniferous red shales and sandstones known as the "Red Beds." The present valley floor, which is considerably lower than the general land surface, is bordered on both sides by low bluffs. (See Pl. III.)

The valley fill is from 30 to 60 feet deep and consists of water-sorted clays, sands, and gravels. The different materials occur in lenticular beds arranged in the irregular fashion of deposits laid down by meandering streams with frequently shifting channels. Test holes and wells put down in different parts of the valley show the character and general arrangement of the materials. Several lines of test holes across the valley in the vicinity of Oklahoma City [1] show in a general way the following succession of the beds:

1. Clayey or sandy soil, 2 to 3 feet thick.
2. Very fine sand, 15 to 20 feet thick. Thickest near the center of the valley and giving place to clay near the outer edges of the valley.
3. Lenticular beds of sandy and gravelly black clay and some beds of quicksand.
4. Coarse sand with some fine gravel, 5 to 10 feet thick, overlying shale.

[1] Phillips, Hiram, Alvord, J. W., and Billingsley, J. W., A report to the mayor and board of commissioners of Oklahoma City on an improved water supply for the city, pp. 101–103, 212–215, 1913.



MAP SHOWING DISTRIBUTION OF PRINCIPAL WATER-BEARING DEPOSITS IN THE VICINITY OF OKLAHOMA CITY, OKLA.

The following logs of wells in other parts of the valley show conditions similar to those at Oklahoma City:

Generalized log of a group of three wells at the city waterworks of Elreno, Okla., 30 miles above Oklahoma City.

[Furnished by M. P. Latimer, city engineer.]

	Thickness.	Depth.
	Feet.	*Feet.*
"Gumbo" soil	6	6
Quicksand, water bearing	20	26
Stiff blue clay	½	26½
Medium-coarse sand	7½	34
Coarse sand	8-17	42-51
Shale.		

Log of well at Banner, Okla., 20 miles above Oklahoma City, in the SE. ¼ sec. 17, T. 12 N., R. 6 W.

[Furnished by the owner, John W. Shartel.]

	Thickness.	Depth.
	Feet.	*Feet.*
Soil	17	17
Fine dark sand, water bearing	10	27
Fine white sand	8	35
Medium-coarse sand with some gravel	5	40
Fine sand	1	41
Gravel and very coarse sand	9	50
Shale.		

At Shawnee, 50 miles below Oklahoma City, at the Atchison, Topeka & Santa Fe Railway shops, a 50-foot well ends in clean, coarse water-bearing sand very similar to material found near the bottom of the wells farther up the river.

OCCURRENCE AND QUANTITY OF WATER.

Water may be reached almost anywhere in the valley at depths of 15 to 30 feet. The water-bearing material is clean, coarse sand consisting of well-rounded quartz grains with some small rounded pebbles, but usually not enough for the material to be termed gravel. The well sections given above show the coarsest material to occur at the bottom, nearest the bedrock.

Many wells have been sunk in the valley alluvium, both for domestic and for industrial supplies. Bored wells are in most general use, but dug and driven wells are also used to some extent. The material is not self-sustaining, and therefore all wells must be curbed or cased to prevent caving. The best wells are usually sunk to bedrock to get the benefit of the full thickness of the water-bearing material. Where only small amounts of water are used, as for domestic supplies, a single well is usually adequate, but where large amounts are required, as for industrial purposes, it has generally been found necessary to have several wells, usually grouped so that they can be connected together and pumped by means of a single pumping plant. On account of the irregular distribution of the coarse sands some wells will not yield as freely as others, and occasionally a well may be a failure by missing the water-bearing sand entirely, but in general the chances for getting a supply in almost any part of the valley are thought to be good. The yield and other data in regard to some of the largest well systems in the valley alluvium are given in Table 1.

TABLE 1.—*Records of representative wells in the alluvium of the valley of North Fork of Canadian River.*

No.	Location.	Owner.	Number of wells used.	Diameter of wells.	Spacing of wells.	Depth.	Depth to water.	Drawdown.	Yield.	Length of time during which given yield was maintained.
				Ft. in.	*Feet.*	*Feet.*	*Feet.*	*Feet.*		
1	Elreno, Okla.	City waterworks	3	12 0	200	50–51	....	....	613,000 gallons a day	Continuously during July, 1913.
2[a]	SE. ¼ sec. 17, T. 12 N., R. 6 W.	John W. Shartel	4	1 6	25	50	14½	17	800 gallons a minute from 4 wells.	18 hours a day for 6 weeks during summer of 1913.
3[b]	.....do	.....do	1	1 6	....	50	14½	14	200 gallons a minute	Short test.
4	Yukon, Okla.	City waterworks	6	....	(c)	....	....	....	11,000 gallons an hour	4½ hours, to fill 50,000-gallon tank.
5	NE. ¼ sec. 17, T. 12 N., R. 4 W.	Oklahoma Ry. Co.	1	....	....	212	16	12 17½	25 gallons a minute 32 gallons a minute	Short test.
6[d]	Oklahoma City, Okla.	Morris & Co.	14	8	150	27–36	....	....	Average 1,250,000 gallons a day.	Continuously.
7[d]	.....do	Atchison, Topeka & Santa Fe Ry. Co.	4	8	50–75	35	....	....	Average 150,000 gallons a day	Intermittently.
8[d]	.....do	Oklahoma Gas & Electric Co.	2	8	250	42	....	....	Average 330,000 gallons a day.	Continuously.
9	1 mile south of Shawnee, Okla.	Atchison, Topeka & Santa Fe Ry. Co.	1	25 0	....	50±	35 or 36	10±	8,700 to 11,500 gallons an hour.	14 hours a day.

[a] This test was made on four of a group of nine wells at this place.
[b] This test was made on one of a group of nine wells at this place.
[c] Distributed on 1 acre of ground.
[d] Information obtained from Phillips, Alvord, and Billingsley, op. cit., p. 209, 1913.

Water withdrawn from the underground supply is replaced by the downward percolation of rain water that falls on the valley surface, by seepage from the North Fork of Canadian River, and by seepage from tributary streams in their course across the valley. The amount of water contributed to the underground supply from these several sources depends upon the permeability of the soil. Much of the soil in the valley is sandy and porous and in the rainy seasons absorbs water in considerable quantities.

In considering the feasibility of developing a water supply for Oklahoma City from shallow wells in the valley alluvium the engineers[1] employed by the city made some estimates on the yearly accretions to the ground-water supply. On the basis of experiments made to determine the porosity of the valley fill and with various assumptions, ranging from 15 to 40 per cent, as to the proportion of the rainfall which percolates to the ground-water level, they estimated that the additions to the ground-water supply would be equal to a layer of water 8 to 16 inches deep over the whole valley area in average years and 4 to 8 inches in the driest years.

QUALITY OF WATER.

Table 2 shows the composition of the water from some wells in the alluvium of the valley of the North Fork of Canadian River.

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[1] Phillips, Alvord, and Billingsley, op. cit., pp. 98–118.

TABLE 2.—*Analyses of water from wells in the valley alluvium along North Fork of Canadian River.*[a]

[Parts per million.]

No.	Owner.	Silica (SiO_2).	Oxides of iron and aluminum ($Al_2O_3+Fe_2O_3$).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Chlorine (Cl).	Alkali coefficient.[b]	Suitability for irrigation.
										Inches.	
1	Kings Laundry, Oklahoma City	23	1.0	74	73	67	537	56	45	23	Good.
2	Palace Laundry, Oklahoma City	13	.9	142	104	133	639	283	150	13	Fair.
3	Morris Packing Co., Oklahoma City	27	.0	94	34	86	342	91	118	17	Do.
4	Gas Co., Oklahoma City	23	.0	160	113	223	537	169	183	7.2	Do.
5	New State Laundry, Oklahoma City	24	.2	144	28	80	478	107	64	27	Good.
6	Santa Fe Ry. Co., Oklahoma City	21	.4	104	52	45	366	132	139	15	Fair.
7	John W. Shartel, SE. ¼ sec. 17, T. 12 N., R. 6 W	....	....	93	7.3	234	376	251	92	6.8	Do.

[a] Analyses Nos. 1, 2, 3, 4, 5, and 6 were taken from Phillips, H. W., Alvord, J. W., and Billingsley, J. W., A report to the mayor and board of commissioners of Oklahoma City on an improved water supply for the city, p. 221, 1913. Analysis No. 7 was furnished by the owner of the well. The results, reported in hypothetical combinations in grains per United States gallon, have been recalculated to parts per million and the ionic form.

[b] Alkali coefficient is defined as the depth in inches of water which, on evaporation, would yield sufficient alkali to render a 4-foot depth of soil injurious to the most sensitive crops.

All these waters are satisfactory for irrigation. According to a classification based on the relative harmfulness of the most common substances detrimental to plant growth, given by Stabler,[1] the waters represented by Nos. 1 and 5 may be classed as "good," and in using them no special care needs to be taken to prevent alkali accumulation in the soil. The remaining five waters may be classed as "fair," and experience in different parts of the United States has shown that in the use of such waters special care has generally been found necessary to prevent gradual alkali accumulation except on loose soil with free drainage. Where the valley soil is sandy, waters whose analyses approximate those of Nos. 2, 3, 4, 6, and 7 could safely be used without special precautions, but on heavy soil some drainage facilities would probably be necessary. As none of the valley lands are located far from the river and as the level of the water in the river is considerably lower than the valley surface, the river will serve as a convenient outlet of such drainage ditches as are found to be necessary

IRRIGATION.

As to the feasibility of irrigating considerable areas of the valley land there can be no question. The commission houses of Oklahoma City import large quantities of vegetables and small fruits the year round. Much of this produce could well be raised at home with profit to both consumer and producer. The excellent service offered by the interurban electric railway which parallels the valley between Oklahoma City and Elreno affords a means of getting perishable products to market with frequency and dispatch. Alfalfa and some other field crops which are now raised in the valley without irrigation would probably produce enough more if irrigated to warrant the outlay for pumping plants.

Very little irrigation has been done in the valley of the North Fork of Canadian River up to the present time. At the Blake farm, near Elreno, and at the La Grange farm, near Yukon, water for irrigation is pumped from the river, and on the farm of John W. Shartel, near Banner, in the SE. ¼ sec. 17, T. 12 N., R. 6 W., water for irrigation is pumped from wells in the valley alluvium. On the Shartel farm there are three pumping plants, the combined output of which in 1913 was about 1,300 gallons a minute, with which 80 acres of land was irrigated during part of the summer. The largest of these plants is equipped with a 15-horsepower direct-current electric motor belted to a 7-inch American centrifugal pump set in a pit at the water level, 15 feet below the surface. The water supply is drawn from a group of nine wells, spaced 25 feet apart and connected to a common suction main

[1] Stabler, Herman, Some stream waters of the western United States, with chapters on sediment carried by the Rio Grande and the industrial application of water analyses: U. S. Geol. Survey Water-Supply Paper 274, pp. 177-181, 1911.

laid in a drift, or "tunnel," driven out from the pump pit at water level. Weir measurements of the discharge from four of these wells, made by the chief engineer of the Oklahoma Railway Co., showed an output of 800 gallons a minute. On account of a smaller drawdown, the output is probably considerably more when all the wells are in use. The wells are 18 inches in diameter and 50 feet deep and extend to bedrock. They are of a modified type of the so-called gravel-wall well. The ordinary gravel-wall well, used where the water occurs in sand, consists essentially of a perforated casing surrounded by a cylinder of gravel or crushed rock that keeps the sand from crowding against the casing and entering the perforations. The casing used in the Shartel well is 10 inches in diameter and is perforated with ¾-inch round holes and covered with 6-inch wire screen to keep out the crushed rock, which is of ½-inch size. An 18-inch cylinder of 4-mesh wire screen surrounds the zone of crushed rock and holds it against the casing. The two smaller plants discharge into a reservoir. Each is equipped with a 5-horsepower direct-current electric motor, direct-connected to a 2½-inch centrifugal pump having a capacity of 250 gallons a minute and supplied from two wells connected together.

The cost of each of the smaller plants, including the wells, pump, and motor, is given by the owner as approximately $500. The large plant cost $3,000, making a total cost of $4,000 for the three plants. The electric current is taken from the trolley line of the Oklahoma Railway Co. At 5 cents a kilowatt-hour the cost for power in pumping from a depth of 30 feet is $2.35 an acre-foot of water lifted. When more development creates a greater demand for electric power the cost can probably be materially reduced. The Oklahoma City Gas & Electric Co. is tentatively considering a plan whereby consumers will be furnished with current for 3 cents a kilowatt-hour or less, delivered at the city limits, the consumers to build their own transmission line. Some such plan for reducing the cost of electric power can probably be worked out provided the necessary cooperation of the farmers is obtained. Those who prefer to use internal-combustion engines can obtain cheap fuel in the form of crude oil from the oil fields near by at $1.05 a barrel.

The engineers engaged to plan a water-supply system for Oklahoma City advised against the development of a supply from shallow wells in the valley alluvium, but the utilization of the ground water for irrigation involves an entirely different problem for the following reasons: For a city supply it is desirable to have the wells concentrated within a comparatively small area in order to minimize the expense for pipe lines, rights of way, etc. To obtain the amount of water needed to supply the city they found that it would be necessary to spread the system over a large area. In irrigation from small individual plants, each situated near the land which it is to supply, the plants become widely distributed, and pumping is not concentrated at any particular point, so that it is possible to utilize more nearly the entire supply. Also, for city use the drain on the ground-water supply is continuous the year round, while for irrigation any depletion of the supply in the dry season would be replenished in the rainy months, when the demand for water is small. Moreover, in irrigation a part of the pumped water percolates to water level, where it is available for future use.

According to the lowest estimate made by the engineers at Oklahoma City, the annual accretion to the ground-water supply, part of which is contributed by the downward percolation of rain water that falls on the surface and part by seepage from the river, is equal to a depth of about 8 inches of water on the valley surface in average years and about 4 inches in the dryest years on record. The calculations of the part added by direct rainfall are based on the theoretic assumption that 15 per cent of the rain that falls on the surface reaches the ground-water level, and the calculations of the amount that seeps from the river are based on the determination of the porosity of the sands in the portion of the valley considered in the engineers' report.

The conditions are nearly uniform throughout the valley, from Elreno to Shawnee, and it is believed that any estimate made for the vicinity of Oklahoma City can be applied in general to the larger area covered by the present paper. The data at hand, therefore, indicate that the annual supply of ground water is sufficient for the irrigation of a large acreage between Elreno and Shawnee if the irrigated tracts are widely distributed, but that exhaustion or depletion of the supply is likely to occur locally if the irrigated tracts are too closely grouped. As the investigation of the accretions to the ground water has not been exhaustive, and as estimates of these accretions are at best liable to be considerably in error, it would obviously be unwise to make initial irrigation developments on as large a scale as the estimates would seem to warrant. It is therefore recommended that at first not over 10,000 acres of land in the valley be put under irrigation and in no locality much more than 80 acres to the square mile. After irrigation on this scale has been carried on successfully for a period of years and the ground-water level has not been greatly lowered thereby, further developments may be justified.

Prospective irrigators should be cautioned against making large outlays for pumping installations without duly considering all the factors of cost that are involved. The costs of installing and operating an irrigation system where the water is pumped from wells are numerous and complex. The initial outlay, which includes the cost of wells, pumps, and engines, in addition to the cost of grading the land and constructing ditches, flumes, or pipe lines, may be a large fraction of the original value of the land and in some places may even exceed it. The pumping costs are made up of the running expenses, such as the cost of power, lubricating oil, repairs, and attendance, which are incurred only when the plant is in operation, and of certain fixed charges, such as interest on the investment, taxes, and depreciation. Where irrigation is used merely to supplement the rainfall in the raising of ordinary field crops, these fixed charges may constitute a large part of the cost of water and often determine the financial success or failure of the project.