OKLAHOMA GEOLOGICAL SURVEY

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GROUND-WATER SUPPLIES IN THE OKLAHOMA CITY AREA, OKLAHOMA

by

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Prepared in cooperation between
the U. S. Geological Survey and
The Oklahoma Geological Survey.

INTRODUCTION

This report is based on a memorandum* prepared and placed in the open file in typewritten form in 1944. It has been rewritten and is now published in view of the continuing interest in the ground-water resources of the area.

The report summarizes information that was available on the ground-water resources of the Oklahoma City area, Oklahoma County, Oklahoma, to the end of 1943. It was prepared largely from material already in the files, supplemented by records of pumpage and ground-water levels then being obtained currently, and by a few days of field work and study of aerial photographs to outline the terrace deposits near Bethany. The predicament then faced by Oklahoma City was made more acute by the urgent need for adequate water supplies for war industries, and a general picture of ground-water possibilities and probabilities was desirable, not only to indicate where sufficient water might be obtained, but also as a guide to obtaining that water without excessive consumption of materials in short supply. Although the urgency of the situation passed with the arrival of rains that filled the municipal reservoirs, the ground water of the area is still of much interest to suburban areas, industries, and individuals providing their own water supplies.

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* Jacobsen, C. L., and Reed, E. W., Memorandum on ground-water supplies in Oklahoma City area, U.S. Geol. Survey typewritten report, Januray, 1944.

STATEMENT OF PROBLEM

Oklahoma City, capitol of the State of Oklahoma, is almost at the geographical center of the State. The population in 1943 was estimated as about 263,000, an increase of 59,000 (29 percent) since the regular census of 1940.

The war effort was the major cause for the large gain in population. After 1940 the Army took over Will Rogers Field (the municipal airport), and stationed several thousand men there. The Army also built the Oklahoma City Air Depot and the Oklahoma City Aircraft Assembly Plant, employing 20,000 or more people who, with their families, lived in or near Oklahoma City. In addition, the established industries, particularly the oil industry, received increases in business. As a result, even though the Air Depot, the Assembly Plant, and most oil companies had independent well supplies, the consumption of water from the municipal supply was greater in 1943 than in any previous year.

The Oklahoma City water supply is derived from the North Canadian River and stored in Lake Overholser, about 6 miles west of the city. (fig. 1) Lake Overholser, when full, holds 17,000 acre-feet of water. In 1943 the City completed Lake Hefner, on the headwaters of Bluff Creek, about 4 miles northwest of the city. Although this reservoir is in the drainage basin of the Cimarron River, it is filled by water diverted from the North Canadian through a canal leading from the sedimentation basin of Lake Overholser. The combined capacity of the two reservoirs is 93,000 acre-feet, which is about a 4-year supply at the rate of consumption contemplated when the plans were made, and is adequate to meet drought periods for years to come.

In addition, the city has fifteen wells in the alluvium of the North Canadian River Valley, at the west edge of the city, downstream from Lake Overholser. These wells were put down during the drought of 1939-40, when Lake Overholser was low, and they helped to carry the city over that critical period. The experience

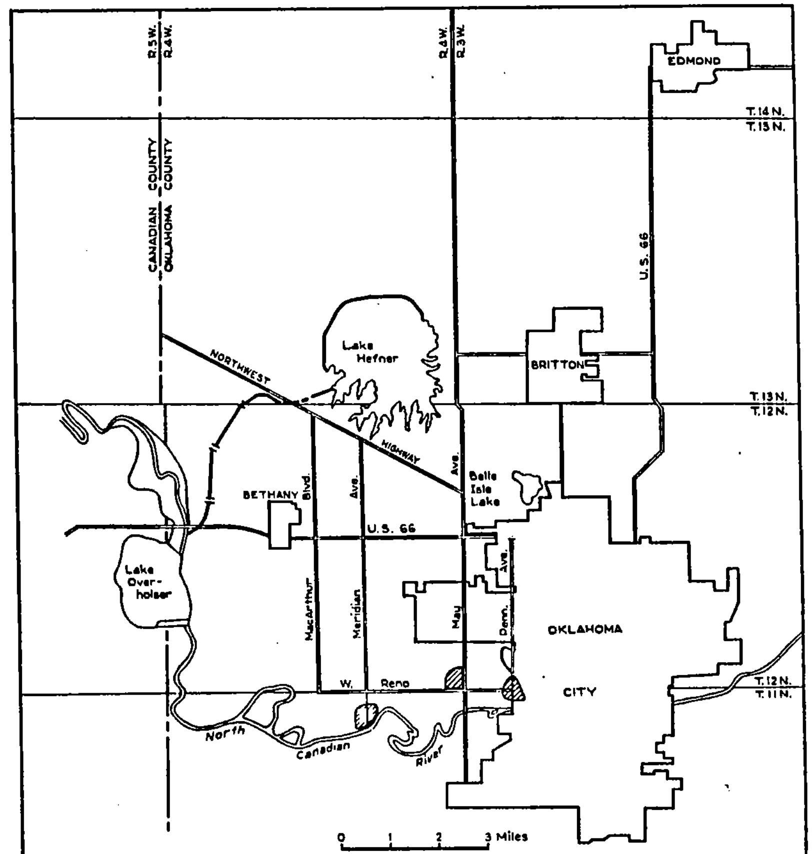

Fig. 1

OKLAHOMA CITY AREA

Municipal Well Fields

Proposed Well Field

spurred the city to plan and construct additional surface-water storage, but shortages of labor and material caused delays and the new reservoir was not available during May 1943, the last month of excessive runoff in the North Canadian River before the summer dry period of that year began. Figure 1 shows the location of the reservoirs and well fields.

In May 1943, Lake Overholser was full as a result of heavy precipitation. It had been the wettest May in 52 years of record, Oklahoma City receiving 9.76 inches of rain, or 4.88 inches above normal. Major floods occurred in the rivers of eastern Oklahoma, but the North Canadian River above Lake Overholser had only minor flooding, damage being confined to bottom farmland in Blaine County.

Precipitation for June at Oklahoma City was 1.60 inches below normal and the average temperature was 4.4° F. above normal. During the first week the level of Lake Overholser receded only 0.1 foot but by the end of the month it had fallen an additional foot.

During July the precipitation was 2.55 inches below normal, the average temperature was 4.4° F. above normal, municipal consumption of water was over 700 million gallons, and the water level in Lake Overholser fell 2 feet.

In August the precipitation was only 0.77 inch, or 2.11 inches below normal, the average temperature was 7.5° F. above normal, consumption of water again exceeded 700 million gallons, and the water level fell 4 feet.

The September precipitation was only 0.18 inch below normal, but the drought of July and August had lowered the water table in the alluvium and the water falling on the bottom lands seeped into the ground without reaching the lake. The unprecedented municipal consumption of water in July and August, followed by consumption of 530 million gallons in September, did not create a serious shortage at the time, but it caused the Oklahoma City Water Department to take steps to provide additional water supplies. On September 14, pumping was begun in the wells in the alluvium, which supplies from 3.6 to 4.0 million gallons a day.

The usual fall rains failed to arrive. October and November rainfall was 1.58 inches and 1.50 inches, respectively, below normal, completing six consecutive months of subnormal precipitation. Only October had an average temperature below normal and then the departure was only 0.1° F.

At the beginning of November, after a rain had fallen in the drainage basin of the North Canadian River from the Oklahoma Panhandle to Oklahoma City, more than 6,400 acre-feet of water was released from Fort Supply Reservoir, about 180 miles upstream from Lake Overholser. Of this amount, only 20 acre-feet reached the lake. This was less than a day's supply. The remainder had percolated into the alluvium or was lost through evaporation.

By this time the situation was becoming acute and plans were rushed to get supplementary supplies. Water leaking through the dam at Lake Overholser was pumped back into the lake, dewatering operations during the paving of sections of the canal to Bluff Creek Reservoir produced some water that was diverted to the lake, and an intense conservation program was started.

Plans were made for salvaging 1.4 million gallons a day from the filter wash water, 2.0 million gallons a day from surface flow in the river below Lake Overholser by constructing a sump across the channel at May Avenue, 0.6 million gallons a day from the drains beneath the paved section of the canal, and 4.0 million gallons a day from well points in the unpaved section of the canal.

It also was proposed that well points be installed along the drainage ditch just north of Lake Overholser and west of the river, and that another well field be established in the alluvium along Meridian Avenue. The Meridian Avenue area was test drilled in 1940 and sites were selected for eight wells. Little information was available on the depth or type of alluvium beneath the drainage ditch, but, as the cost of installing well points in a favorable location is much less than the cost of drilling wells, the well-point method was to be tried first in the hope that the wells would prove unnecessary. These projects are discussed separately under their respective ground-water provinces.

SOURCES OF GROUND WATER

Two sources of ground water are readily available in the Oklahoma City area - the sandstones of Permian age, and the alluvial deposits of the North Canadian River. The alluvial deposits can be subdivided into those underlying the Bethany terrace, of Pleistocene age, and the lower terrace and flood-plain deposits of Recent origin. All sources have been used to some extent, but the water in Permian sandstones has been over-pumped in some localities. All produce water of fair quality in moderate amounts.

PERMIAN BEDROCKS

Except where covered by alluvium or terrace deposits, red-beds of Permian age are at the surface in the entire Oklahoma City area. The Hennessey shale crops out within Oklahoma City and to the west; the Garber sandstone is at the surface in the central third of the county; and the Wellington formation crops out over the eastern most third of the county.

The regional structure of these beds is that of a homocline dipping westward into the Anadarko basin at approximately 40 feet to the mile. Superimposed upon this is the Oklahoma City anticline, a fold of large proportions along the axis of which the Garber sandstone crops out as an inlier surrounded by Hennessey shale.

Wellington formation. The Wellington formation is lower Permian, or perhaps even basal Permian 1/ in age and is the oldest formation in this area from which supplies of fresh ground water can be obtained. It is 600 to 650 feet thick and consists of complexly inter-bedded red shale, and red, poorly cemented, fine-grained sandstone. The amount of sandstone in the formation varies locally but in general is between one-fourth and one-third of the total thickness. Well logs indicate that the individual beds of sandstone range considerably in thickness and are not continuous for more than short distances. However, the continuous replenishment of ground water, and the evidence of very wide spread interference of wells suggest that there is some interconnection over large areas.

The Wellington formation is the most important bedrock aquifer in the area, and it has been extensively used by industries. About 10 million gallons a day are withdrawn from approximately 150 wells in the area, with reported yields up to 400 gallons per minute. Except for the basal beds, which may contain water high in chloride, the Wellington in the Oklahoma City area yields water of good quality, especially noted for softness. As the formation is followed down dip, the water becomes more highly mineralized, and along the western border of Oklahoma County and in Canadian County the few wells that have been drilled to the Wellington formation have encountered water unfit for most uses.

Garber sandstone. The Garber sandstone rests conformably upon the Wellington formation, apparently with no great break in sedimentation. Approximately 350 feet thick, it is characterized by cross-bedded red and red-brown sandstone lenses interbedded with red shales. Except for a somewhat greater proportion of sandstone it is similar in most respects to the Wellington formation. Both formations have been eroded to yield rough, hilly topography.

1/ Green, Darsie A., "Permian Pennsylvanian Sediments Exposed in Central and West Central Oklahoma." A.A.P.G. Bulletin, Vol. 20, Pt. 2, p. 1463

In this area the Garber sandstone is not nearly as important an aquifer as the Wellington formation, principally because the water in it is more highly mineralized. In most of the deep wells in Oklahoma City the upper two-thirds of the Garber is cased off.

Hennessey shale. The Hennessey shale overlies the Garber sandstone and in turn is overlain by the Duncan sandstone. The Hennessey crops out in the western third of the county, and consists almost entirely of red shales underlying a relatively smooth prairie topography. The lithologic change from the Garber to the Hennessey is a well defined break in the Oklahoma City area. Because the Hennessey lacks thick sandstone beds, no large water supplies can be developed from it.

Hydrology. The water in the Permian sandstones is under artesian head, and in wells it rises above the aquifer penetrated. Only a few scattered wells flow at the surface, these being close to the outcrop and at relatively low elevations. There is no evidence that the artesian wells in Oklahoma City area ever flowed at the surface, and the original static head was probably about 100 feet below the surface. At first, only the upper sandstones of the Garber sandstone were tapped. In a tabulation of deep wells 2/ made in 1912, only 28 wells are mentioned, the deepest being 256 feet. Later, wells were drilled deeper, and some of the present wells are more than 800 feet deep. Some wells have been drilled even deeper, but encountered salt water and had to be plugged back. Therefore, at the present time, all available water sands in bedrocks of the area have been tapped by wells.

As the water is under artesian pressure and the permeability of the sands is relatively low, the zone of influence, or cone of depression, caused by pumping a well is relatively large. Most of the wells in the area are close enough together to interfere with each

2/ Phillips, H., Alvord, J. W., Billingsley, J. W. "Report to the Mayor and Board of Commissioners of Oklahoma City on an Improved Water Supply for the City," February 15, 1913, p. 182.

other, increasing drawdowns or decreasing discharges, or both, and a general lowering of water levels has occurred. It is reported that the static water level declined 35 feet when operations in the Oklahoma City oil field were at their height, and that no recovery was observed when slackening of activity in the field reduced the pumpage. Probably the oil-field pumpage is only part of the story. It is likely that as the pumping of ground water in the oil fields was reduced, the pumping for other uses was increased, so that the total pumpage and the drawdown remained about the same. At the end of 1943 the oil industry in the area was still using 1.5 million gallons of water per day, and other industries were steadily increasing their consumption of water.

Because most of the industries using water from the Permian are in the southeastern part of the city, the greatest drop in water level occurred there, and the aquifers undoubtedly have been overpumped. The wells in the northern part of the city have static levels of 150 to 200 feet below the surface, but here, also, the wells interfere with each other, and there has been a lowering of water levels, although not as much as farther south.

Probably several million gallons a day could be drawn from the red beds in the northern part of the area, but at the expense of lowering the water table and considerably reducing the discharge of the present wells. The public water supplies of Nichols Hills, West Nichols Hills, and probably Britton would be affected, and for this reason further large-scale development of the ground-water resources in that locality is believed to be undesirable.

QUATERNARY ALLUVIAL DEPOSITS

Pleistocene Terrace Deposits

Character. Terrace deposits consist of materials laid down by ancient streams, which since the time of deposition have cut their valleys to their present lower levels. In many instances, the streams that made the deposits were the ancestors of the streams flowing across Oklahoma today. The deposits consist of sand, gravel, and clay in differing proportions. They generally yield better water than that in the bedrocks of the same locality, and, on the whole, better water than that in the alluvium, although the quality is not uniform from place to place. Replenishment of the ground water in the terrace deposits comes mainly from rain falling on their surface.

Such a deposit underlies most of T. 12 N., R. 4 W. Its surface is the Bethany terrace, which is more than 55 feet above the present flood plain of the North Canadian River. The thickest part of the deposit, as revealed by test drilling and by depths of existing water wells, is south of U.S. Highway 66 in a strip about 1 mile wide west of Bethany. There, as much as 60 feet of stream-laid material was found. Farther from the river, the deposit thins abruptly, and along the outer margin it is only a thin veneer overlying the redbeds.

Wind-blown sand has accumulated at several places on the terrace deposit. The largest area of sand, totaling several hundred acres, is in the S½ sec. 29 and N½ sec. 32, T. 12 N., R. 4 W. Sand areas are especially favorable to downward percolation of water from rains, and, hence, to recharge of the ground-water reservoir.

Hydrology. The ground water under the Bethany terrace (fig. 2) occurs under water-table (unconfined) conditions. It is replenished mainly from precipitation on the area, which either percolates directly to the water table or runs off at the surface, some of it later percolating to the water table from the stream channels when the streams are high. At such times the streams are said to be influent.

The possibilities of recharge to the terrace deposits from the red beds are negligible because they are higher than the terrace in only a few places, their permeability is very low, and the area between the divide and the terrace is small.

The ground water may discharge in several ways, the greatest discharge probably occurring by seepage into the streams (which are then said to be effluent) during the periods of high ground-water levels, and by underflow into the alluvium of the North Canadian River Valley. Underground flow from the terrace into the red beds is probably small because of the low permeability of the red beds. Discharge from the terrace deposits by evaporation and transpiration may be large, especially during periods of high water levels and high temperatures. Discharge into Bluff Creek Canal, which cuts across the terrace below the water table, and the pumpage from wells account for the artificial discharge.

The largest user of ground water from the terrace is the City of Bethany, which pumps about 250,000 gallons per day. Plants mining building sand in the area wash the sand with ground water from the pits, supplemented by water from deep wells, their total being about 50,000 gallons per day. In addition, several housing developments in the area have private wells for each home. The estimated daily pumpage from about 150 such wells is 50,000 gallons. The total pumpage of ground water in the Bethany area, therefore, is about 350,000 gallons per day, or less than 130,000,000 gallons per year, which appears to be safely below the annual replenishment. As reported by the U.S. Weather Bureau, the normal annual precipitation at Oklahoma City is 31.15 inches. If only 5 percent of this reaches the water table, the annual recharge is about 250,000,000 gallons per square mile. Although this is only a rough estimate of the recharge, it is apparent that the water in the terrace deposits has been utilized to only a limited extent, and that considerable additional water may be obtained from them.

The canal connecting the North Canadian River with Bluff Creek Reservoir is cut through the terrace deposit for about 3 miles of its 5-mile length, and as it extends below the water table for most of this distance it acts as a drainage ditch and lowers the water level when the canal is not being used to transport surface water. As the water table is higher than the canal, the gradient is toward the canal and water flows into

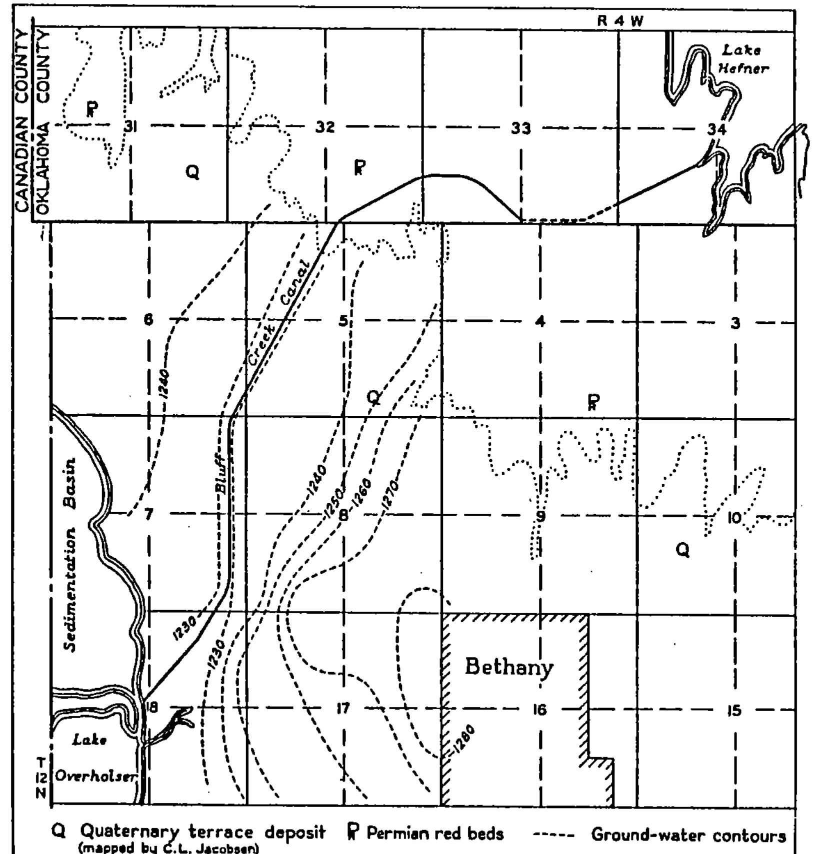

FIG. 2
CONTOURS OF WATER TABLE UNDER BETHANY TERRACE
DECEMBER 7, 1943

and along it toward Bluff Creek. In addition, tile drains have been installed under the paved section of the canal to drain off the ground water, so that the hydrostatic pressure of the ground water will not cause the paved section to rise or "float". It is estimated that 0.6 million gallons a day will be drained from the paved portion of the canal.

The Oklahoma City Water Department has maintained observations in a series of wells along the canal in order to record the recession of the water table due to the drainage. These observations plainly show the effect of the canal, and a contour map drawn from observations in them shows the gradient toward the canal. (fig. 2) Equilibrium apparently had not been reached late in 1943, but dewatering operations along the canal during paving complicated the picture by making gradients steeper than normal at some points. Furthermore, the surface of the red beds rises sharply about 2 miles southeast of the canal and seems to act as a dam preventing the drainage effect of the canal from extending far in that direction.

When the canal carries flood flow from the North Canadian River, the ground-water gradient toward the canal will be lessened and the ground-water discharge will decrease. However, as the canal will be used for only a few weeks during the year, this will have little effect on the average ground-water conditions. In the paved section, the ground water and surface water will be separated and the same amount of ground water will be drained away whether or not surface water is in the canal.

Well points and suction pumps were installed in the bottom of the unpaved section of the canal with the expectation of recovering about 40 million gallons of water per day during a period of 2 or 3 months. The pumping would have increased the discharge of ground water along this part of the canal materially, and the resulting cone of depression — in this case, more accurately, a trough of depression — would have spread out considerably, causing a lowering of water levels in wells in the vicinity. It was thought that the southeastward rise of the red bed basement would act as a deterrent to the extension of the cone or trough in that direction. Some of the anticipated results were not obtained, however, because it proved unnecessary to continue pumping long enough for them to appear.

RECENT LOW TERRACES AND ALLUVIUM

Character. The materials deposited by a stream are called alluvium, and consist of unconsolidated gravel, sand, and clay in any proportion and any degree of sorting, generally thickest near the middle of the valley. Alluvium is distinguished from the terrace deposits not by the way it was deposited, but by the fact that it underlies the flood plain or "bottoms" of the present valley. In the North Canadian Valley, two or three "bottoms" or terraces are evident, but these terraces were made in relatively recent time, and, although the higher ones were formed first and hence must be somewhat older than the lower ones, the deposits underlying them belong to the same generation. The deposits under the different terrace levels connect with one another and they therefore constitute a single aquifer.

The depth to the bedrock under the flood plain and low terraces is less and the alluvium under them is thinner than under the Bethany terrace. The maximum thickness of alluvium encountered by test wells sunk by the Oklahoma City Water Department is about 45 feet. Presumably this thickness was found over the deepest part of a channel cut into the bedrock, for in general the flood plain is only 25 to 35 feet above the bedrock floor.

Most of the alluvium is probably derived from the Tertiary formations of the northwestern part of the State, with only relatively minor amounts from the red beds. The texture of the material is far from uniform, but in general grades from coarser at the bottom to finer at the top. Throughout most of the North Canadian River bottoms near Oklahoma City, several feet of coarse sand occurs just above the bed rock, and it is to this bed that most of the water wells are sunk.

Municipal wells in alluvium. At the end of 1943, the Oklahoma City Water Department was using 15 wells ranging from 36.75 to 43 feet deep in the alluvium of the North Canadian River, all of them gravel-packed. The gravel used in them ranged in size from 0.25 inch to 1 inch, the 0.25 inch size predominating. Well 1 has a 45-inch outer casing, an 18-inch steel inner casing, and an 18-inch perforated steel screen. Wells 3, 4, 5, and 6 have a 48-inch outer casing, an 18-inch steel inner casing, and a concrete screen with an 18-inch inner diameter and a 24-inch outer diameter. The screen openings are 0.25 inch wide and 4 inches long. The other wells have a 48-inch outer casing, a 12 inch steel inner casing, and a concrete screen with an 18-inch inner diameter and a 23-inch outer diameter. The screen openings are 0.25 inch wide and 6 inches long. All the wells are equipped with turbine pumps of various types and sizes. The rated capacities range from 150 gallons per minute against a 140-foot head to 300 gallons per minute against a 200-foot head. The pumps are electrically driven by motors which range from 7.5 to 30 horsepower.

Hydrology. The North Canadian River itself is the main source of recharge and avenue of discharge for the ground water in the alluvium, for the river is influent during high stages and effluent at low stages. Leakage from the dam for Lake Overholser probably extends the influent period of the river by maintaining the flow beyond the normal period, but this favorable factor is probably offset by the diversion of a large fraction of the flood flows into Lake Overholser. Rainfall directly on the alluvium, and the runoff from surrounding areas that becomes influent upon crossing the alluvium, are other sources of recharge. Ground-water underflow down the valley has been estimated as about 150,000 gallons per day. As the contours on the water table show the flow to be directed at an angle of about 45° to the general trend of the valley, even at high stages of the water table, it is apparent that the water pumped from the alluvium comes mainly from storage.

In addition to the discharge into the river, a part of the ground water in the alluvium is discharged by evaporation and transpiration. Although little of the flood plain in the immediate vicinity of Oklahoma City is cultivated, most of it bears heavy vegetation, some drawing on ground water. Several abandoned channels on the flood plain normally contain water that is replenished from the underground supply, and the evaporation from their water surfaces is high, especially in hot weather.

The importance of the losses by transpiration and evaporation was made evident by a study of ground-water levels in the alluvium from Yukon to Geary, above Lake Overholser. When contour maps of the water table for dry seasons were compared with those for wet seasons, no significant change in slope of the water table was found. The contour lines were simply shifted back somewhat from the channel, which meant that the ground water was still moving in the same direction and at about the same rate as in wet seasons, to be discharged somewhere. As the river channel was dry for miles, it is plain that the discharge was not into the stream and, hence, that it must have taken place through plant use (transpiration), evaporation, and pumping from wells. Conditions are similar below Lake Overholser.

Except for a few small private wells for stock and domestic water supplies, the 15 city wells account for all the pumping from the Recent alluvium near Oklahoma City. On the basis of records of pumpage during the early part of 1940, the Oklahoma City Water Department estimated that 4 million gallons per day could be withdrawn from the alluvium initially, but that the yield would decline to about 2 million gallons per day after about 3 months of pumping. The wells were pumped from September 14 to the end of December 1943, and, although the initial yield was less than expected--only about 3.54 million gallons per day in October, the first full month of pumping--it increased to 3.77 million gallons per day in November, and was 3.67 in December. At the end of December, individual wells were yielding from 60 to 260 gallons per minute and averaging about 175 gallons per minute. The average drawdown was about 20 feet, increasing about 0.75 foot during December. This rate of increase is not very indicative of the decline of the water table however, because as the drawdown increased the city reduced the rate of discharge. The continued high yield in the face of the predicted 50% reduction can be explained as due partly to local recharge from rain that fell on the immediate area, without affecting the flow in the river upstream, especially during December when precipitation was above and temperature below normal; and partly to induced recharge from the river, which continued to flow as a result of seepage through the dam at Lake Overholser despite attempts to salvage the losses by pumping back into the Lake.

The proposal to drill more wells along Meridian Avenue, which is 2 miles west of May Avenue and about 4 miles downstream from Lake Overholser, appears to be essentially feasible. Test drilling in that area has shown enough water-bearing material in the alluvium, and the history of the pumping at May and Pennsylvania Avenues suggests that considerable ground water could be withdrawn without creating a shortage in the present well fields.

Heavy pumping from the alluvium, if continued through a long period with little or no recharge, will tend to deplete the aquifer surrounding the wells, but the emergency pumping in 1943 had no permanent effect. After the shortage of surface water passed and the pumping was stopped, the aquifer again became fully saturated and the normal natural ebb and flow of recharge and discharge prevailed. Even the immediate effects of the heavy pumping could not be considered serious, for there were no other wells of importance in the area to be affected by the drawdown. The proposed wells on Meridian Avenue were not drilled and their effect on the older well fields therefore, was never ascertained.

Likewise, the proposal to sink well points in the drainage ditch north of Lake Overholser and west of the river was not carried out. At that place the water table is near the surface, premitting pumping by centrifugal pumps, but precise information on the thickness and character of the water-bearing materials is lacking. It is believed that the thickest alluvium is on the opposite (east) side of the river, although a well 0.5 mile

Well 8.

	Thickness (feet)	Depth (feet)
Fine sand and clay	5	5
Fine sand	7	12
Medium-coarse sand and clay balls	5	17
Blue clay	3	20
Coarse sand, some clay	9	29
Very coarse sand	10½	39½
Red beds	.....	.....

Well 21.

Fine sand and clay	6	6
Fine sand	9	15
Blue clay	5	20
Medium-fine sand	12	32
Very coarse clean sand	4 3/4	36 3/4
Red beds	......	......

Well 22.

Fine sand	13	13
Medium-fine sand, some clay	7	20
Clean coarse sand	4	24
Clay, clay balls, fine sand	4	28
Clean coarse sand, some gravel	15	43
Red beds	....	....

Well 23.

Fine sand	18	18
Medium-fine sand	2	20
Coarse sand	4	24
Coarse sand and clay balls	3	27
Coarse sand, some gravel	10½	37½
Red beds	.....	.....

Well 25.

Fine sand	17	17
Medium-fine sand, some clay	12	29
Coarse sand	7	36
Coarse sand and gravel	5¼	41¼
Red beds	.....	.....

Well 24.

	Thickness (feet)	Depth (feet)
Black loam topsoil	1	1
Fine sand	16	17
Fine gray sand	3	20
Clean coarse sand	3	23
Coarse sand and clay	2	25
Clean coarse sand	13	38
Red beds	....	....

Well 26.

Fine sand	18	18
Medium-coarse sand and clay balls	7	25
Coarse sand	14¼	39¼
Red beds	.....	.....

Well 27.

Topsoil	1	1
Fine sand	19	20
Fine white sand	3	23
Fine quicksand	1	24
Clean coarse sand	17	41
Red beds	....	....

Well 28.

Topsoil and clay	8	8
Fine sand	9	17
Medium-coarse sand	9	26
Coarse sand	12	38
Red beds	....	....

TOTAL PUMPAGE - OKLAHOMA CITY

(Gallons)

1942 Month	Total	Av. daily	Max.	Min.
January	374,989,000	12,096,000	13,550,000	9,815,000
February	308,706,000	11,025,000	12,120,000	9,155,000
March	345,570,000	11,147,000	11,910,000	8,905,000
April	345,068,000	11,502,000	13,510,000	9,105,000
May	423,205,000	13,652,000	18,866,000	10,055,000
June	427,240,000	14,241,000	19,614,000	10,160,000
July	564,978,000	18,225,000	22,963,000	12,385,000
August	503,771,000	16,251,000	22,693,000	11,420,000
September	423,277,000	14,109,000	16,152,000	11,150,000
October	407,969,000	13,160,000	14,780,000	10,939,000
November	390,445,000	13,015,000	14,690,000	10,874,000
December	404,160,000	13,037,000	14,360,000	10,171,000

Total pumpage, 1942 - 4,919,378,000 gallons
Av. daily pumpage, 1942 - 13,478,000 gallons

TOTAL PUMPAGE - OKLAHOMA CITY

(Gallons)

1943 Month	Total	Av. daily	Max.	Min.
January	411,834,000	13,285,000	16,930,000	10,505,000
February	350,706,000	12,525,000	15,583,000	10,630,000
March	385,903,000	12,448,000	13,955,000	10,636,000
April	396,596,000	13,219,000	16,053,000	10,674,000
May	417,403,000	13,465,000	17,115,000	10,792,000
June	512,131,000	17,071,000		
July	715,376,000	23,077,000	28,216,000	18,122,000
August	734,402,000	23,690,000	28,219,000	16,960,000
September	530,133,000	17,671,000	20,817,000	13,474,000
October	473,168,000	15,263,000	17,049,000	13,171,000
November	442,900,000	14,763,000	16,486,000	12,153,000
December	417,660,000	13,472,000	15,724,000	11,302,000

Total pumpage, 1943 - 5,788,212,000 gallons
Av. daily pumpage, 1943 - 15,858,000 gallons