INVESTIGATION NO. 2 1948

STATE OF ILLINOIS
DWIGHT H. GREEN, Governor

GROUNDWATER RESOURCES IN WINNEBAGO COUNTY with Specific Reference to Conditions at Rockford

H. F. SMITH AND T. E. LARSON

DEPARTMENT OF REGISTRATION AND EDUCATION
FRANK G. THOMPSON, Director

STATE WATER SURVEY DIVISION
A. M. BUSWELL, Chief

URBANA, ILLINOIS
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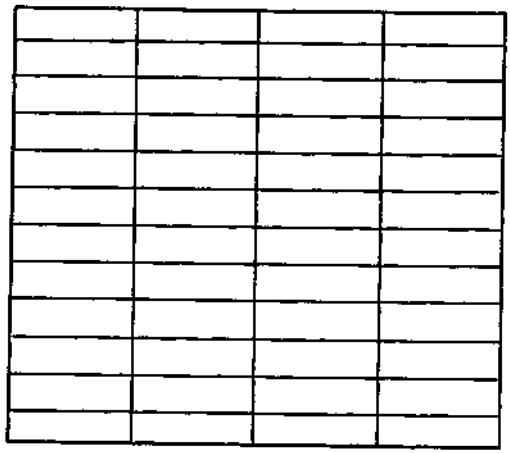

Smith, Harmon F.
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SUMMARY

This Investigation is part of a state-wide investigation of groundwater resources being conducted by the State Water Survey Division.

Most of the groundwater withdrawal in Winnebago County is at Rockford. Since 1885 all the water pumped by the municipality has been from wells penetrating sandstone. The average daily municipal pumpage has increased from 7,180,000 gallons in 1940 to 12,950,000 gallons in 1947 or an increase of 80% in 7 years. There has been about a 9% decrease in non-municipal pumpage in the past four years. The average daily non-municipal pumpage for 1947 was 12,480,000 gallons of which 11,410,000 gallons were from wells penetrating sandstone and 1,070,000 gallons were from wells finished in the glacial drift.

Water pressure contours of the sandstone at Rockford and vicinity show the direction of movement of the groundwater is toward the Rock River from northwest to southeast and from northeast to southwest.

Two small water pressure cones of depression are noted at Rockford, one in the industrial area in the southeastern part of the city that includes the city Unit Well No. 7, and the other includes the 6 city group wells at the main pumping station and Unit Well No. 1. A much larger cone of depression is indicated to the south that extends from the southern limits of Rockford to Oregon which includes the Rock River.

Waters from 34 wells were sampled for chemical analysis in order to characterize the waters from the various sources. The chemical data have been interpreted to classify the waters as originating from 3 primary sources, namely, sandstone, pre-Wisconsin drift and local recharge. These classifications have been used to assist in interpreting the hydrologic data by indicating the sources of water obtained at the various wells.

The decline of the water levels in wells at Rockford has been very slight in the past 10 years. No decline has been noted in the non-pumping water level of the city's Unit Well No. 1 since 1933.

The original flowing deep wells at Rockford yielded water of 60° F. temperature, which is comparable to temperatures of water from 1200 to 1400-foot depths in Northern Illinois, indicating that the Mt. Simon sandstone yielded water at one time. However, the fact that few of the present wells of similar depth yield water of temperature approaching 60° F. indicates that (1) the Mt. Simon was of low permeability, and (2) it has suffered an appreciable recession. Little if any difference is now noted between the water levels of the different sandstones.

From pumping test data the average coefficient of transml88ibllity of the bedrock aquifers was calculated to be 90,000 and the average coefficient of storage was calculated to be 0.00005.

The flow through the sandstone, across the 710-foot contour, into Rockford was computed to be 25.000,000 gallons a day. The flow across the 700-foot contour exclusive of Rockford was calculated to be 28,000,000 gallons a day.

Since the pumpage within the 680-foot contour is not more than 1,000,000 gallons a day, it was assumed that approximately 30,000,000 gallons a day is being discharged from the sandstone in the region. Stream flow records suggest that as much as 75 to 100 million gallons a day of groundwater could be discharging into the streams of this area. A substantial increase in pumpage in the neighborhood of Rockford would lower the hydrostatic pressure of the sandstones so that much of the groundwater now being discharged into the streams would become available.

ACKNOWLEDGMENTS

The writers are indebted to the many owners of wells for valuable Information regarding their wells, and especially to Quaker Oats Co., Geo. D. Roper Corporation and Woodward Governor Company for allowing measurements to be made of flow and water level fluctuations of their wells. The well drillers, especially Chas. W. Varner and I. B. Null, furnished data on wells drilled by them. Credit is due in particular to H. S. Merz, Superintendent of the City Water Department who made available records of the department and furnished certain labor and material during the investigation; and to the various employees of the State Water Survey Division who from time to time secured certain information used in this report. The conscientious, careful work of J. B. Millls, Field Engineer is deeply appreciated by both writers.

ENGINEERING

by H. F. Smith,
Associate Engineer

INTRODUCTION

This report covers an investigation of the groundwater resources of Winnebago County with specific reference to the supply of groundwater available for the Rockford district. This investigation began in September 1947 and ended in January 1948. The field operations included routine inventories of pumpage, measurements of water levels in wells and collection of other hydrologic data. Pumping tests on one city-owned well and three industry-owned wells were conducted to determine coefficients of permeability and storage. Thirty-four wells were sampled for chemical analysis in order to characterize the waters from the various sources. Six quality-source tests were made to determine the source of water from the wells tested.

Location of the Area

Winnebago County is situated along the northern border of Illinois, about midway of its width; Boone County adjoins it on the east, Ogle County on the south, and Stephenson County on the west. The area comprises about 15 townships and has an area of 529 square miles.

Rockford, the largest city in the county, began in 183k by the building of a sawmill on Kent Creek. In 1839 Rockford became the county seat and in the middle forties the utilization of the water power of the river began. In 1850 the population of Rockford exceeded 2000. Two years later Rockford was reached by the pioneer railroad from Chicago and was incorporated as a city. By 1860 its population had more than tripled. The 1940 census shows its population as 84,637. At the present time the 1948 population is estimated to be about 93,000.

History of Investigation and Previous Reports

This investigation is part of a state-wide investigation of groundwater resources being conducted by the State Water Survey Division.

The work was done under the general administration of Dr. A. M. Buswell, Chief, State Water Survey Division and under' the supervision of Mr. H. E. Hudson, Jr., Head of the Engineering Sub-Division. The field work was done by Mr. J. B. Millis, Field Engineer.

The investigation in Winnebago County was made to determine quality, quantity, movement and availability of groundwater and the feasibility of further development.

Attention has been focused on the lowering of groundwater levels at a number of centers in the State in recent years and some have feared that our groundwater supplies are nearing exhaustion. A large part of this concern has resulted from the persistent decline of the water levels in pumped wells in locally over-developed area. Where local over-development has occurred investigations are being made to find practical measures to alleviate the condition.

A report on the city of Rockford water supply was made in 1891 by a commission comprised of J. T. Fanning, D. C. Dunlap and D. W. Mead. A second report was made in 1910 by a commission comprised of J. W. Alvord, D. H. Maury and D. W. Mead. Since then, the State Water Survey Division has from time to time secured information on water levels, new well installations and municipal pumpage. In February 1944 the writer made a preliminary investigation at Rockford.

The present investigation included an inventory of the larger producing wells in the Rockford area which included data on pumpage and water levels. This inventory included wells that had facilities capable of producing more than 50 gallons per minute.

PHYSIOGRAPHY - GEOLOGY

The following paragraphs on the geology of Winnebago County are excerpts from the publications cited.

The glacial drift deposit covering Winnebago County is not heavy except in a few places.[1] The original topography has therefore not been greatly modified. The land as a whole is gently rolling, although the numerous streams have cut it up considerably.

The drainage of the county is affected by Rock River and its tributaries. This stream enters Winnebago County in the Northeastern township and flows southward across the eastern part. It differs from most Illinois rivers in that the waters are relatively clear and swift flowing.

The Rock River enters a preglaclal' valley near Janesville, Wisconsin and follows southward a distance of 50 miles to the mouth of Kishwaukee River a few miles below Rockford, Illinois.[2] At this point the river turns southwestward toward the Mississippi, the preglaclal valley continuing southward and apparently connecting with the Illinois at Hennepin. The breadth of the valley averages 3 miles, though in places it reaches about 5 miles.

Glacial drift of four different ages exists within the quadrangle.[3] Named in order of superposition, the drift deposits are:

Late Wisconsin valley trains of Rock and Klshwaukee rivers.

Early Wisconsin till and gravel.

Illinoian till and gravel.

Pre-Illinoian gravel.

---

1. Anderson, Carl B., Artesian Waters of Northern Illinois, State Geological Survey Bulletin No. 34, 1919.

2. Leverett, F., The Illinois Glacial Lobe, U. S. Geological Survey Monograph 38, 1899.

3. Bretz, J. Harlen, Geology and Mineral Resources of Kings Quadrangle, State Geological Survey Bulletin 43C, 1923.

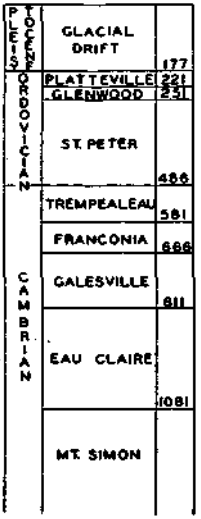

Figure 1

The bedrock of the region is stratified. The geological succession in the city is shown by the log of Unit Well No. 6. The sample study was made by M. H. Smith of the State Geological Survey in 1941. See Figure 1.

Within the preglaclal valley the glacial drift immediately overlies the St. Peter sandstone.[3] This is also true of a good part of the narrow valley from the mouth of the Kishwaukee River, where the Rock River leaves the preglaclal valley, to below Oregon.

HISTORY OF THE ROCKFORD WATER SUPPLY

A public water supply was installed by the city of Rockford about 1875. The original pumping station was located on the west bank of the river north of Peach Street which has since been renamed West Jefferson Street. Water was secured from an infiltration well near the river bank. This well was 24 1/2 feet in diameter and 20 1/2 feet deep. The demand soon exceeded the supply.

Early Sandstone Wells

In 1885 the first deep (penetrating the Mt. Simon sandstone) sandstone well was drilled near the pumping station to a depth of 1530 feet. Between 1885 and 1888 four additional deep sandstone wells were drilled. A sixth deep sandstone well was drilled in 1897.

Shaft and Tunnel System

To augment the supply five 8-inch St. Peter sandstone wells having depths of approximately 400 feet were drilled in 1891. These five wells together with three of the deep sandstone wells (No. 1, 4 and 6) were connected to a shaft-and-tunnel system installed in 1896-98.

This shaft-and-tunnel system was designed by Mr. D. W. Mead. The shaft was seven feet in diameter and extended to a depth of 95 feet. The tunnels were constructed in a clay bed in the glacial drift below the surface. The wells were connected with iron pipe to the main suction pipe at the shaft. Each pipe was provided with a valve so that the well could be used or cut off, as desired. It was reported that the capacity of the plant was increased from three to seven million gallons per twenty-four hours. This shaft-and-tunnel system was operated until 1926 when it was abandoned. The wells of the Tay Street group (described below) were put into operation at this time. See Figure 2.

Tay Street Group Wells

Construction

The Tay Street group wells were drilled between 1921 and 1926.

Group Wells No. 1 and 2 have depths of 1600 feet. They are cased with 12-inch pipe to depths of 100 feet and are 12-inch holes below. Group Well No. 3 is 1601 feet deep, otherwise similar to Wells No. 1 and 2; Group Well No. 4 is 1631 feet deep, otherwise the same as 1, 2 and 3. Group Well No. 5 has a depth of 1615 feet. It is cased with 16-inch pipe to a depth of 97 feet, 16-inch open hole from 97 feet to 300 feet, 12-inch open hole from 300 feet to the bottom. Group Well No. 6 was drilled to a depth of 1608 feet, otherwise similar to Group Well No. 5.

A test was made on Wells Nos. 1, 2, 3 and 4 by Mr. Mead on January 9, 1923 shortly after completion. These wells were

equipped with air lift pumps operated from a central compressor. The four wells produced 2,089,300 gallons in a 10-hour period or a yield of 3487 gpm.

Rehabilitation

Group Wells No. 3 and 4 were shot and rehabilitated in 1934. Before shooting, Well No. 3 produced 625 gpm. with a drawdown of approximately 95 feet. After shooting, the well produced 972 gpm. with a drawdown of 65 feet. Prior to shooting, Well No. 4 produced 278 gpm. with a drawdown of 84 feet. After shooting, the well produced 972 gpm. with a drawdown of 65 feet. Each well was shot with a total of 300 pounds of dynamite in four shots placed in metal cans and set at 1325, 1400, 1475 and 1550 feet, respectively.

Group Wells No. 2, 5 and 6 were shot and cleaned in 1943. Group Well No. 2 was shot at depths of 900, 1000, 1125 and 1175 feet, respectively with 150 pounds of explosives at each depth location. After the rehabilitation work was completed the well produced 1160 gpm. with a drawdown of 58 feet from a non-pumping level of 70 feet below the ground surface.

Group Well No. 5 was shot at depths of 650, 850, 900 and 1100 feet, respectively with 150 pounds of explosives at each depth location. After rehabilitation the well produced 1360 gpm. with a drawdown of 58 feet from a non-pumping level of 73 feet below the surface. Before rehabilitation the well produced 840 gpm. with comparable water levels.

Group Well No. 6 was shot at depths of 900, 1000, 1125 and 1175 feet, respectively with 150 pounds of explosive at each depth location. After rehabilitation the well produced 1425 gpm. with a drawdown of 62 feet from a non-pumping level of 32 feet below the surface. Upon completion the rates of pumpage for the three wells were adjusted as follows: Well No. 2, 840 gpm.; Well No. 5, 705 gpm.; Well No. 6, 1220 gpm.

Unit Wells

No. 7

During the period between the construction of the tunnel system and the establishment of the Tay Street group, Unit Wells No. 7 and 8 were drilled to augment the summer demand. A numbering system was devised whereby the Tay Street wells were called Group Wells and the outlying wells were to be called Unit Wells. Drilling was not in numerical sequence.

Unit Well No. 7 was drilled in the southeast part of the city in 1913. The well had a total depth of 1503 feet, was 18 inches in diameter at the top and 12 inches in diameter at the bottom. This well was used primarily in the summer time, in 1923 it operated 689 hours at an average rate of 1410 gpm. In 1925 the non-pumping level was reported to be 16 feet and the drawdown 90 feet when pumping at pump capacity.

The well was rehabilitated in the Spring of 1947. This work comprised shooting with explosives and cleaning out caved material. The first shot was placed at a depth of 1125 feet and consisted of 330 pounds of explosive. The second shot was placed at 730 feet and consisted of 275 pounds of explosive. Before rehabilitation, the well produced 910 gpm. with a pumping level of approximately 150 feet below the ground surface. After rehabilitation the well produced 1500 gpm. with the same pumping water level. The non-pumping water level, after several weeks re6t period, at the end of the rehabilitation work was 55 feet below the ground surface.

No. 8

Unit Well No. 8 was drilled in the northeastern part of the city in 1917 to a total depth of 1500 feet. The upper 210 feet is cased and is 22 inches in diameter; below 210 feet is open hole 12 inches in diameter. In 1921 the non-pumping level was 16.5 feet and the pumping level was 100 feet when pumping at a rate of 1560 gpm. In 1923 the pump operated 424 hours at a rate of 1338 gpm.

No. 1

The original deep sandstone well now known as Unit Well No. 1 was reconditioned in 1937-38. The casing was removed and the well was reamed to a depth of 1530 feet. An 18-inch casing was set in bedrock at 129 1/2 feet, 18-inch hole reamed to 200 feet, and 15-inch hole reamed to 1530 feet. The non-pumping level after repairs was 18 feet. The drawdowns were 36, 47, 56 1/2 and 92 feet when pumping at rates of 680, 910, 1200 and 2100 gpm., respectively.

A pumping test made on January 17, 1948 showed a production of 1570 gpm. with a drawdown of 116.5 feet from a non-pumping level of 18 feet.

No. 9

Unit Well No. 9 was drilled at the east edge of the city in 1928 to a depth of 1600 feet. The well is cased with 18-lnch pipe to 243 feet, and 12-inch pipe between depths of 224 feet and 350 feet. Below 350 feet is 12 l/2-inch open hole. This well was rehabilitated in 1936-37. A bridge was placed at the base of the St. Peter sandstone at 530 feet. The non-pumping level was 105 feet and the drawdown was 17 feet when pumping at a rate of 400 gpm. The bridge was removed and the well was shot with five 100 pound shots. Two shots were placed between depths of 1220 and 1370 feet, two between 750 and 830 feet, and one between 680 and 750 feet. After rehabilitation was completed the non-pumping level was 104 feet and the drawdown was 37 1/2 feet when pumping at a rate of 1300 gpm.

No. 6

Unit Well No. 6 was drilled in the southeast part of the city in 1941 to a depth of 1372 feet. The well was cased to 194 feet with 20-lnch casing cemented in a 30-inch hole, and has 20-inch open hole from 194 feet to the bottom. A production test was made by the contractor on February 2, 1941. This test showed a

production of 1550 gpm. with a drawdown of 55 feet from a non-pumping level of 98 feet.

No. 5

Unit Well No. 5 was drilled in the northeast part of the city in 1945 to a depth of 1312 feet. The well was cased with 321 feet of 20-inch casing extending below a 12-foot pump pit, cemented in a 30-inch hole. A production test was made by the contractor on June 5. 1945. This test showed a production of 1500 gpm. with a drawdown of 75 feet. The non-pumping level was 104 feet from the top of the casing.

To augment the supply from the deep sandstones, and to evaluate the productivity of the drift, a drift well known as Well 7A was drilled in 1947 Just north of Well No. 7. The well has a total depth of 200 feet. From the surface to 120 feet there is a 20-lnch casing set inside a 30-lnch casing. From 120 feet to 200 feet there was installed a 15-inch Johnson well screen. A production test was made July 26, 1947 by the contractor. The test showed a production of 1606 gpm. with a drawdown of 23 feet from a non-pumping level of 36 feet below the surface.

Nos. 10. 4 and 3

Unit Wells Nos. 10, 4 and 3 are under construction at the present time. They will be finished at depths of approximately 1400 feet.

Well Reconditioning

Sandstone wells need to be reconditioned from time to time to give continuous service otherwise they lose specific capacity to such an extent that their operation costs are greatly increased. This history of the city wells at Rockford gives some indication as to the reconditioning needed to keep such wells in a satisfactory operating condition.

PUMPAGE

Municipal

The pumpage for the public supply has been from the sandstones since about 1395. There has been a relatively steady increase in pumpage since the water system was installed in 1875. There has, however, been a much more rapid increase since 1940. The average daily pumpage for 1940 was about 7,180,000 gallons and in 1947 had increased to about 12,950,000 gallons a day, or an increase of 80% in 7 years.

Yearly municipal pumpage in million gallons pumped

1890	866	1922	1757	1935	2094
1900	948	1923	1983	1936	2408
1910	1347	1924	1944	1937	2518
1912	1234	1925	2173	1938	2350
1913	1046	1926	2339	1939	2700
1914	1000	1927	2481	1940	2627
1915	967	1928	2565	1941	3042
1916	1065	1929	2615	1942	3302
1917	1208	1930	2600	1943	3419
1918	1347	1931	2515	1944	3689
1919	1506	1932	2283	1945	3728
1920	1771	1933	2239	1946	4167
1921	1616	1934	2244	1947	4732

Non-Municipal

The first pumpage data available for the non-municipal wells were those collected during the investigation of February 1944 which showed the average daily industrial pumpage to be about 13,760,000 gallons. In 1947 the average daily non-municipal pumpage was 12,480,000 gallons of which 11,410,000 gallons were from wells penetrating sandstone and 1,070,000 gallons were from wells finished in the glacial drift. These data represent both metered pumpage and estimated pumpage. It is estimated that these data represent more than 95% of pumpage at Rockford.

No information is available on the pumpage at Camp Grant during the war years, however, the average daily pumpage for 1947 was 90,000 gallons.

ARTESIAN CONDITIONS OF THE SANDSTONES

general

Maps showing the water pressure contours of the St. Peter and Cambrian sandstones at Rockford and vicinity have been prepared (Figures 2 and 3). The contours were baaed on measurements of the altitudes of water levels in the wells shown on the maps.

With the exception of those for the city wells (furnished by the city), the altitudes of the measuring points of the wells where water level observations were made at Rockford were determined by a Paulin surveying barometer. The altitudes of the measuring points of the outlying wells were taken from topographic maps. In most instances the depths to water in the observed wells were furnished by the owners. In a few instances where the well was recently completed, water level measurements were furnished by the driller.

Using these altitudes and the water levels obtained for the various wells interpolated from depth to water level measurements, maps showing water pressure contours of the sandstones were drawn. Within the city a water pressure contour map with a 10-foot interval was constructed (Figure 2). Beyond the city a water pressure contour map with a 20-foot interval was constructed (Figure 3).

Little if any difference is now noted in the water levels of the different sandstones, so no separation of the water levels was made. Many of the observed wells penetrate both the St. Peter and Cambrian sandstones, and any original difference in the artesian pressure of the various sandstones has apparently been equalized.

Movement of Groundwater. Hydraulic Gradient. Cones of Depression

The movement of groundwater depends on two conditions: First, the saturated material must be permeable in order that water can percolate through it and second, there must be a force.

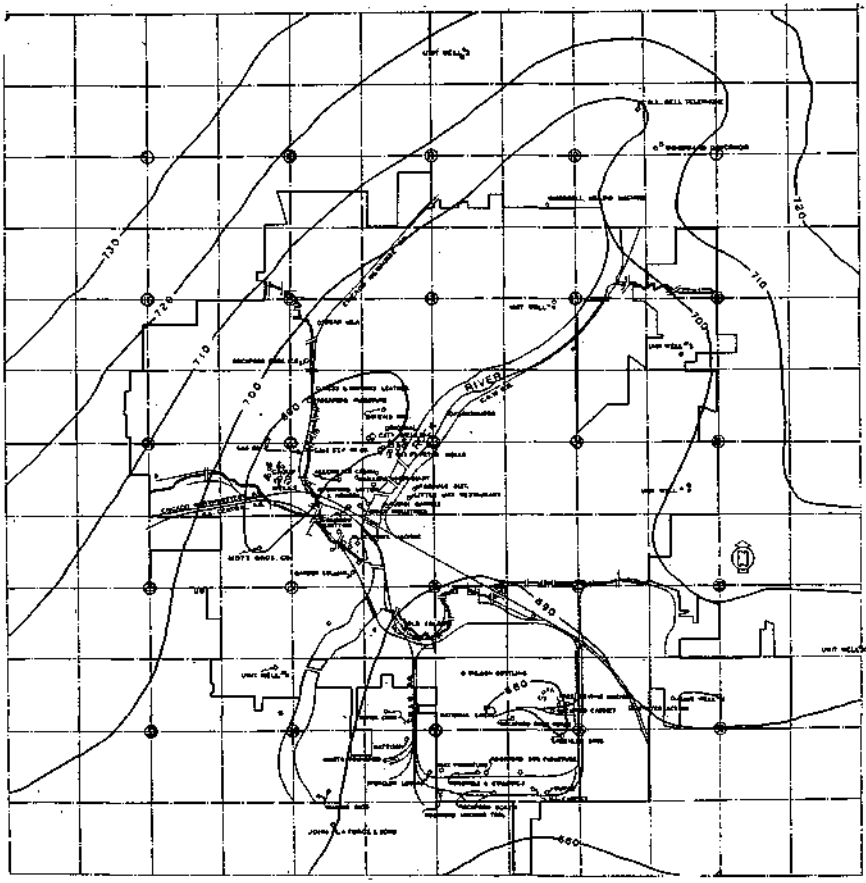

FIGURE 2. MAP OF ROCKFORD SHOWING WELL LOCATIONS AND CONTOURS OF WATER PRESSURE SURFACES.

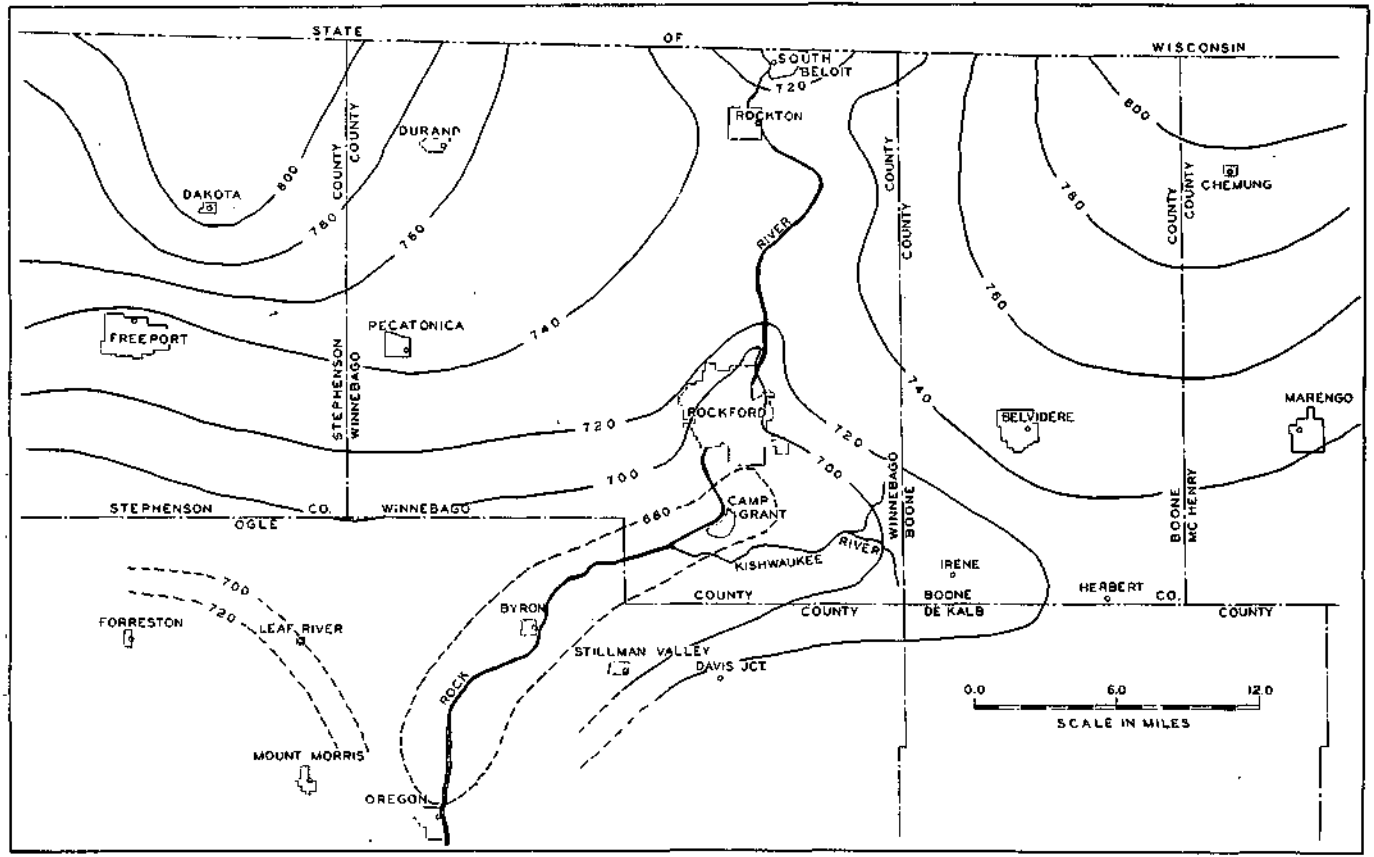

FIGURE 3. MAP OF WINNEBAGO COUNTY SHOWING CONTOURS OF WATER PRESSURE SURFACES.

(hydraulic gradient) to cause the water to move. The flow of the groundwater is directly proportional to the permeability of the water-bearing material, the hydraulic gradient, and the cross-sectional area of the material through which the water moves.

The direction of movement of the groundwater is at right angles to the contour lines. Thus the groundwater movement at Rockford and vicinity is toward the Rock River from northwest to southeast and from northeast to southwest. The hydraulic gradient is determined from the contour interval divided by the distance between contour lines.

Two cones of depression are noted on the contour map of Rockford, one in the industrial area in the southeastern part of the city that includes the city Unit Well No. 7. The other includes the six city group wells and Unit Well No. 1. On the contour map of the area a much larger cone of depression is indicated that extends from the southern limits of Rockford to Oregon which includes the Rock River.

Decline of Water Levels in Wells

The decline of the water levels in wells at Rockford has been very slight in the past ten years. The decline of the water level of Unit Well No. 1 Was 24 feet between 1891 and 1938. Since 1938 no decline has been noted in the non-pumping water level of this well. A recession graph for Unit Well No. 1 was constructed having the decline in water level as the ordinate and the log of time as the abscissa (Figure 4). With no local recharge a continued recession as shown by the extrapolation would be expected.

Other wells within the city have shown little if any decline since the survey of February 1944. Because of these very small changes, no quantitative comparison of the water levels in 1944 and 1947 was made.

In a few cases non-pumping water levels were measured before full recovery had occurred after the pump had stopped.

TRANSMISSIBILITY AND STORAGE COEFFICIENTS

Transmissibility

The rate at which water is transmitted depends on the thickness and permeability of the sandstone and the hydraulic gradient.

The coefficient of permeability used by the State Water Survey is called the field coefficient of permeability and is defined by the U. S. Geological Survey as the number of gallons of water a day that percolates under prevailing conditions through each mile of water-bearing bed under investigation (measured at right angles to the direction of flow) for each foot of thickness of the bed and for each foot per mile of hydraulic gradient. For convenience the term "coefficient of transmissibility" which is the product of the field coefficient of permeability and the thickness of the saturated aquifer is used in the report.

During this investigation four pumping tests were made. In each well it was possible to observe the interference in a nearby well. Three pumping tests were made of industrial wells; in each of these tests one well was available for interference measurements. These wells were owned by Quaker Oats Co., Roper Corporation and Woodward Governor Co. One test was made of a city well with automatic water level recorders installed in two nearby wells to measure interference. Hydrographs of these two observation wells are shown in Figure 5. Well No. 4 is 160 feet from the pumped well, the Jefferson Street well (original No. 3) is 630 feet from the pumped well. The results of these tests were analyzed by means of a formula developed by Theis[4] and further developed by Wenzel.

---

4. Theis, C. V., The relation between the lowering of the piezometric surface and the rate and duration of discharge of a well using groundwater storage: Am. Geophys. Union Trans., pp. 519-524, 1935.

5. Wenzel, L. K., Methods for determining permeability of water-bearing materials: U. S. G. S. Water Supply Paper 887, Washington, 1942.

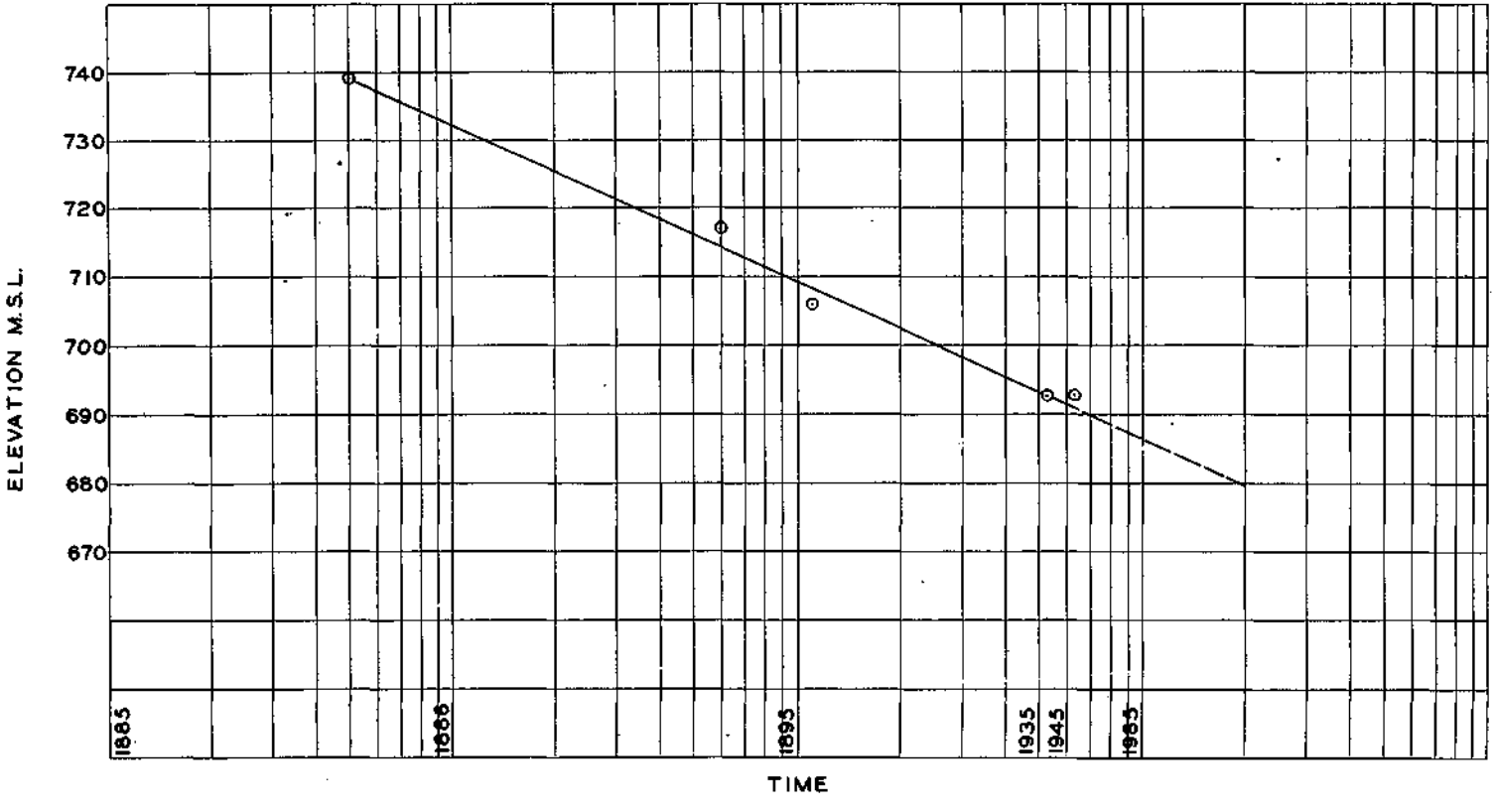

FIGURE 4. GRAPH SHOWING WATER LEVEL RECESSION IN UNIT WELL NO.I.

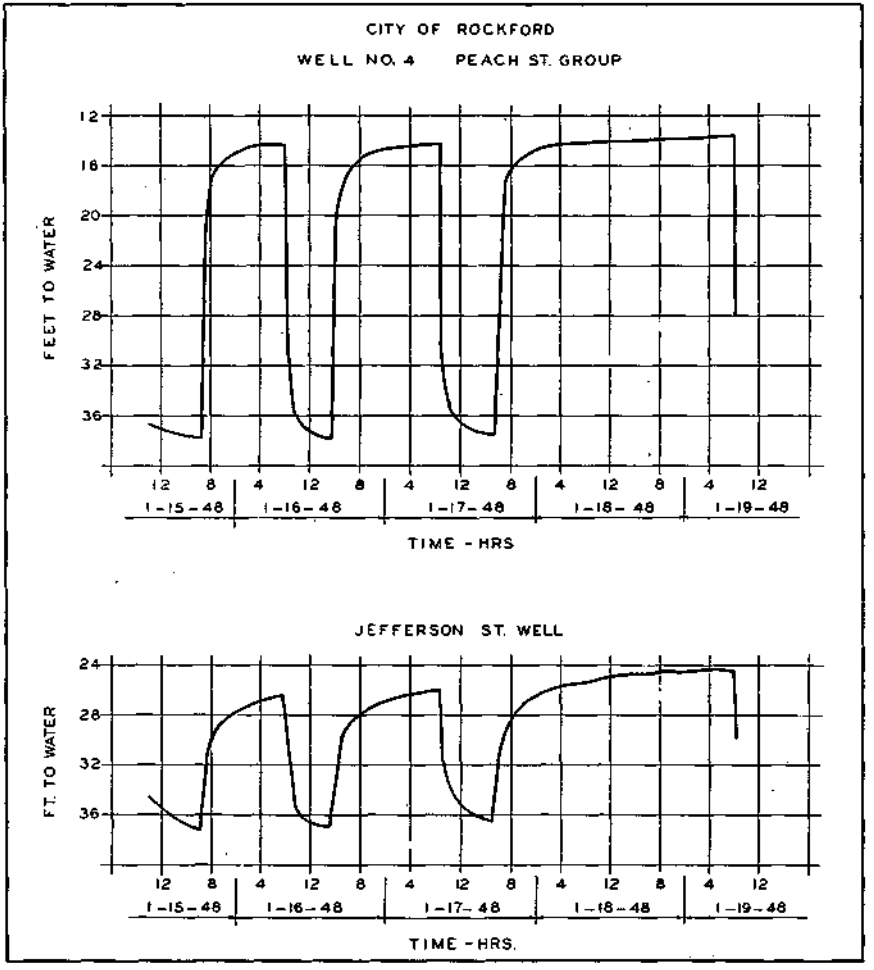

FIGURE 5. HYDROGRAPHS OF OBSERVATION WELLS FOR UNIT WELL NO. 1 TEST.

Value of the coefficient of transmissibility of the bedrock aquifers at the Woodward Governor Co. and the city wells at the main pumping plant ranged from 55,500 to 118,300 and averaged about 90,000.

At the Roper Corporation the transmissibility was calculated to be about 350,000 for the bedrock aquifers. This value appears to be too high since no additional aquifers were penetrated by the Roper wells. This high value might possibly have been caused by the influence of a crevice in the Trempeleau dolomite that was reported encountered by the driller in the pumped well at the time the well was rehabilitated. There are records of crevices in the Trempeleau at one or two other locations in this area.

The data secured from the Quaker Oats Co. test were not used because no interference occurred. Chemical analyses of the waters from these two wells were dissimilar.

Storage Capacity

The amount of water that is released from storage when the head of an artesian aquifer declines has been called the coefficient of storage. It has been defined by Theis as the amount of water, in cubic feet, that will be released from storage in each vertical column of the aquifer having a base 1 foot square when the artesian head is lowered 1 foot.

Using the Thels formula, values were obtained for the coefficient of storage in the three interference pumping tests. These values ranged from 0.00001 to 0.00006, with most values at about 0.00005. A value of 0.00005 was chosen as the average coefficient of storage.

These values are considerably lower than those found at Chicago indicating that considerably less water is being taken from storage at Rockford. The average values in the Chicago region were about 0.0004. The lower values at Rockford could possibly be explained by the almost stationary artesian pressure

head at Rockford. The calculations were made from data obtained from teats made where the head had fluctuated many times through the range recorded in the tests.

Use of Coefficients

If the extent of the water-producing formations and the coefficients of transmissibility and storage are known, estimates can be made of the future decline of the water level and the influence between wells. Although the available data are insufficient to permit a comprehensive analysis, the curves shown in Figure 6 afford a simple approach to the problem in the areas where there is no local recharge. The curves show theoretical drawdowns which have been computed according to the Theis formula, due to pumping a well at a constant rate of 1,000,000 gallons a day, the aquifer having a coefficient of transmissibility of 90,000 gallons a day and a coefficient of storage of 0.00005.

DISCUSSION

The amount of water that can be withdrawn from the water-bearing formations depends upon the amount of rainfall that percolates into them in their outcrop areas, the capacity of the formations to transmit the water to the pumped areas, and the amount of water that is withdrawn from storage in the formations when the head declines. In the Rockford area the water levels in the sandstone wells are higher than those of the overlying gravel and of the Rock River water surface with the exception of the wells within two local cones of depression at Rockford. Here the sandstone hydrostatic pressure is somewhat less than that of waters in the overlying gravel. Some local recharge of the sandstone is apparently taking place in these two areas. Otherwise the sandstone receives recharge at the outcrop areas, the major portion of which are in southern Wisconsin. Numerous

Pumping test data, City Unit Well No. 1

Pumping rate 1570 gpm.

Date	Time	Feet to Water	Date	Time	Feet to Water
1-17-48	7:54 AM.	20	1-17-48	4:00 PM.	134.5
	8:22	Started		4:35	134.5
	8:23	89		5:05	134.5
	8:24	100		5:06	Stopped
	8:25	105		5:07	87
	8:27	111		5:08	90
	8:28	114		5:09	87
	8:29	117		5:10	84
	8:31	119		5:12	78
	8:34	122		5:13	76
	8:36	125		5:14	72
	8:39	127		5:16	68
	8:44	130		5:19	63
	8:55	133		5:21	58
	9:20	134		5:24	53
	9:36	134		5:29	46
	10:30	134		5:40	39
	11:05	134		6:25	26
	11:30	134		7:05	23
	12:17 PM.	134	1-18-48	9:10 AM.	20
	1:01	134		12:48 PM.	19
	2:25	134		5:15	18.5
	3:30	134.5	1-19-48	7:23 AM.	18

Pumping test data, Woodward Governor Co.

	Pumped Well			Observation Well
Date	Time	GPM.	Feet to Water	165 ft. distant
10-16-47	12:05 AM.	700	164	
	12:15	Stopped pump - 18 hrs. operation		
	12:20		31.5	
	12:40		29.5	
	12:45		29.0	15.5
	1:15		28.8	
	1:35			13.5
	2:55		28.4	13.4
	4:00		28.2	13.2
	5:00		28.1	13.0
	5:30		28.0	started pump
	5:40	565		16.7
	5:50		127	
	5:55			17.5
	6:30		130	17.7
	6:35	750		
	6:41			19.1
	6:45			19.7
	6:57			
	7:15		162	19.9
	7:30			20.0
	8:00			20.5
	9:00		162.5	20.5
	10:55		165.5	21.0
	12:30 PM.		166.5	21.0

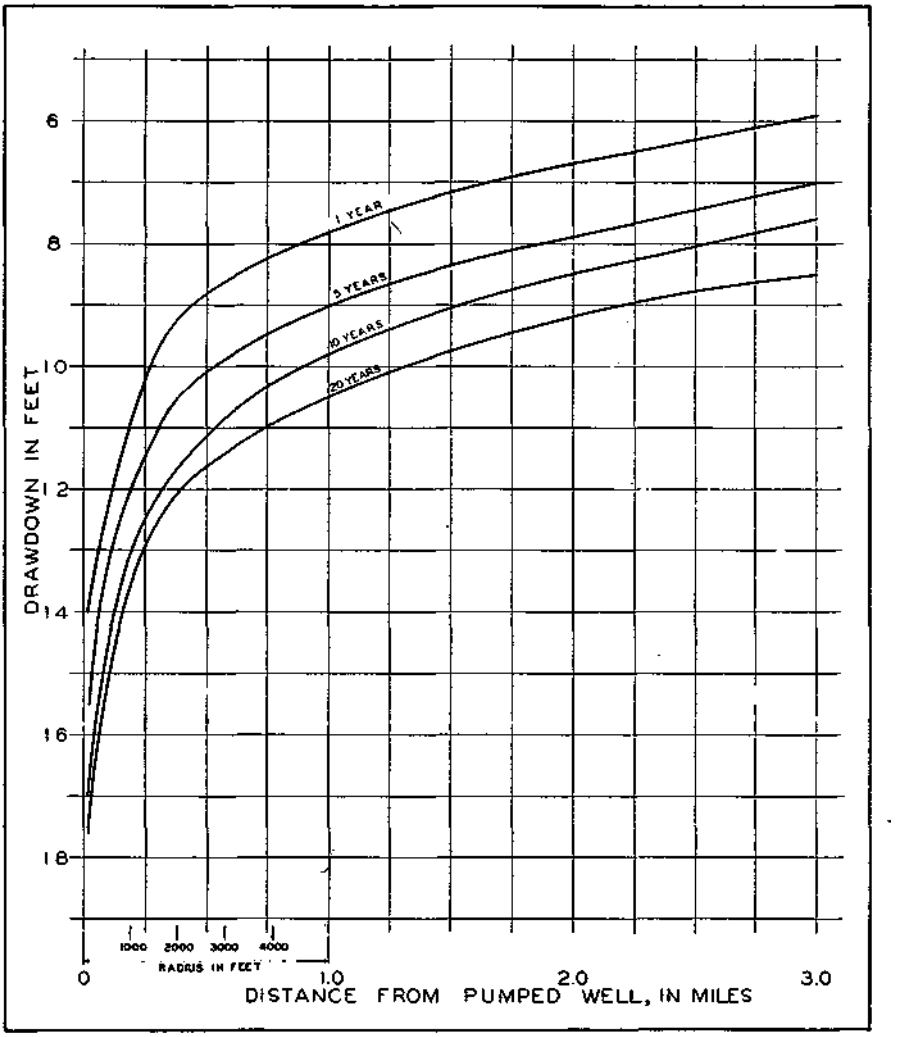

FIGURE 6. GRAPH SHOWING THEORETICAL DRAWDOWN.

springs are reported in and adjacent to these outcrop areas.[6] It therefore appears that the rainfall recharges the sandstone aquifers at a rate greater than the water is transmitted down the slope.

Sandstone Flow into City of Rockford

The rate at which water is transmitted depends on the transmissibility of the formation and the hydraulic gradient. At Rockford the contour having an altitude of 710 feet above sea level as shown on the water pressure contour map was chosen as the line along which the rate of inflow could be most readily and accurately determined (Figure 2). The length of this line between east and west city limits was estimated as 11 miles, the average hydraulic gradient across this contour as 25 feet to the mile, and the average coefficient of transmlssibllity as 90,000 gallons a day. On the basis of these estimates the inflow at this time across the 710 foot contour into Rockford was computed to be 25,000,000 gallons a day.

Sandstone Flow into General Rockford Region

South and southwest of the city area the 700 foot contour was chosen (Figure 3). The length of this line from the west boundary of Winnebago County to Davie Junction exclusive of Rockford was estimated as 45 miles, the average hydraulic gradient across the contour as 7 feet to the mile, and the average coefficient of transmissibility was assumed to be 90,000 gallons a day. The inflow across the 700-foot contour exclusive of Rockford was then calculated to be 28,000,000 gallons a day. There is also some flow through a part of the city as the hydraulic gradient

6. Samuel Weidman and Alfred R. Schultz, The Underground and Surface Water Supplies of Wisconsin. Wisconsin Geological and Natural History Survey, Bulletin No. 35, 1915.

continues downgrade. Since the pumpage within the 680-foot contour is not more than 1,000,000 gallons a day, it can reasonably be assumed that approximately 30,000,000 gallons a day is being discharged from the sandstones in the region.

Weidman and Schultz (see p. 19) state that at Beloit, Wisconsin (joins South Belolt, Illinois) the depth of the drift is very irregular, but it seems very probable that a considerable portion of this water is fed directly to the gravel and porous beds of the drift by the underlying St. Peter sandstone in which the pre-glacial valleys were eroded.

An examination of flow records [7] for the Rock River between Rockton and Oregon for the minimum recorded flow period at Oregon between August 21 and August 31, 1941, show a flow-drainage area ratio of 0.525 for that part of the river between Rockton and Oregon compared with a ratio of 0.1685 at Oregon and 0.1442 at Rockton. The flow rates are in sec. ft. days and the drainage areas are in sq. miles. Table 1 gives these data.

7. Surface Water Supply of Hudson Bay and Upper Mississippi River Basins, 1941: U.S.G.S. Water Supply Paper 925, 1943.

TABLE 1

Showing Flow Rates of Rock River Between Aug. 21 and Aug. 31, 1941

	Rock River at Rockton	Rock River at Oregon	Leaf River at Leaf River	Kish-waukee at Perry-ville	Kilbuck Creek at Monroe Center	Oregon[8]	Oregon[8] minus Rockton 1-day Interval
Drainage Area in Sq.Miles	6290	8120	102	1090	114	6814	524
Date 1941 Aug.							
21	914	1460	13	164	4	1279	
22	947	1460	11	156	4	1289	375
23	919	1360	11	142	4	1203	256
24	706	1360	11	137	4	1208	289
25	1080	1190	15	156	6	1014	308
26	890	1570	15	179	5	1371	291
27	905	1460	13	156	4	1287	397
28	1020	1460	12	137	4	1307	402
29	956	1270	12	124	4	1130	110
30	906	1270	11	119	3	1138	172
31	720	1190	9	121	3	1057	151
Average	906	1369	12	148	4	1208	275
Flow Dr.Area	.1442	.1685	.12	.136	.037	.1772	.525

Inspection of these data reveals that a secor of the Rock River watershed at and below Rockford contributed several times as much to the river flow (per unit watershed area) than other nearby sectors. Other low flow periods showed similar effects. Based on these measurements it is estimated that as much as 75 to 100 million gallons a day of groundwater was discharging into the streams of this area. It is assumed that during a period of minimum flow, following a period of little or no precipitation, practically all of the flow is of groundwater origin.

If the rate of pumping in the neighborhood of Rockford is increased substantially, the hydrostatic pressure of the sandstones will lower and much of, this water now being discharged into the streams will become available.

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8. Rock River flow at Oregon minus, Leaf River flow at Leaf River, Kishwaukee flow at Perryvlle, Kilbuck Creek flow at Monroe Center.

Drift Deposits

No attempt has been made to analyze the availability of water from the overlying sands and gravels as sufficient data are not available. There are, however, indications that the sand and gravel-filled pre-glacial valley has a very large potential safe yield. This valley has a width of from 3 to 5 miles and is more than 300 feet deep in the deeper portion.

The water surface in these deposits has an altitude at Rockton of 722 feet above mean sea level and at center 6f Rockford the water surface altitude is 695. This gives a hydraulic gradient of 2.3 feet to the mile. The specific capacity of Well No. 7A was 72 gallons per foot of drawdown when tested on July 26, 1947; this is from 3 to 5 times greater than that of the sandstone wells. Values of transmissibility and specific yield of the sand and gravel deposits have not been determined but appear to be sufficiently large to warrant development of these deposits. These waters, together with a portion of that of the Rock River, are available for recharge of the underlying sandstone should the hydrostatic pressure of the sandstone be lowered sufficiently to permit such recharge. The Rock River flows over sand and gravel or sandstone through practically all of Winnebago County.

CHEMISTRY

by T. E. Larson
Head, Chemistry Sub-Division

CLASSIFICATION OF WATERS

Waters from thirty-four wells were sampled for chemical analysis in 1947 in order to characterize the waters from the various sources.

Three distinct characterizations were possible on the basis of similarity in quality and hydrologic conditions.

Sandstone

TABLE I

Name	Depth	Fe	NO_3	Cl	SO_4	Alk.	Hd.	Res.	Temp. °F	Notes
Ingersoll Milling Machine Co.	1204	0.1	3.4	1	4.7	272	282	289	54	
Rockford Malleable Iron Co.	720	0.1	0.5	1	3.9	312	300	311		(1919)
W.F. and John Barnes	1150	4.0	7.9	4	5.3	256	274	288	53.5	short pump period.
Atwood Vacuum Machine Co.	700	Tr.	3.9	1	6.0	264	275	285	53.5	
Ingersoll Milling Machine Co.	729	0.2	2.6	1	6.2	272	282	291		
Gunite Foundries Corp.	1140	0.2	0.4	1	7.0	272	275	294	56	
Ingersoll Golf Course	846	0.4	3.0	3	11.1	252	260	282	53	
No. Town Heights	427	0.2	1.2	2	13.2	246	272	278		
Barber Coleman	450	0.0	0.0	2	6.1	282	258	287		(1917)
Chicago, Milwaukee, St.Paul & Pacific	438				13.9	261	275			(1913)
Dean Milk Co.	1000	0.2	0.7	9	14.8	240	253	289	52	
Rockford City Wells No. 1, 2 & 3	1300-2000	0.2	nil	3	9.5	290	290	295	60	(1886)
Rockford City No.3	1601	0.4	2.1	3	9.0	246	245	298		(1924)
Rockford City No.3	1601	Tr.	2.3	7	18.9	292	310	338		(1930)
Rockford City No.3	1601	0.2	1.9	4	14.0	260	271	278		(1936)(Mt. Simon shot and cleaned in 1934)
Rockford City No.1		0.6	1.4	4	12.3	272	295	306	54.5	(1948)

The analyses tabulated in Table I are attributed to characteristic sandstone waters. These waters are characterized by (1) a hardness less than 300 ppm.; (2) iron less than 0.3 ppm.; (3) nitrate less than 4 ppm.; and (4) sulfate less than 15 ppm. No distinction was possible between the waters of the St. Peter, Galesville and Mt. Simon sandstone since there was no evidence to indicate that any well in the vicinity yielded water solely or to an appreciable proportion from either the Mt. Simon or Galesvllle sandstone.

Comparison with analysis made in 1886 on 60° F. water from the flowing Wells No. 1, 3 and 4 indicates no distinctive mineral ingredients.

Pre-Wisconsin Drift

The analyses in Table II are attributed to be from pre-Wisconsin drift deposits. All waters from pre-Wisconsin drift deposits in Illinois have been characterized by an appreciable iron content and the virtual absence of sulfates and nitrates. Such waters usually contain an appreciable ammonia content and hardness. Since the Wisconsin outwash and pre-Wisconsin deposits are not distinctly separated in this vicinity some sulfate is evident in these waters. This class of waters is characterized by (1) an iron content greater than 0.3 ppm.; (2) hardness greater than 300 ppm.; (3) sulfates less than 20 ppm.; and (4) chlorides and nitrates less than 3 ppm.

TABLE II

Name	Depth	Fe	NO_3	Cl	SO_4	Alk.	Hd.	Res.	Temp. °F.	Notes
Woodward Governor Co.	200	1.2		1		334	321	339	52.5	(1942)
Greenlee Bros. Co.	746	31.4	1.1	1	4.7	304	303	321	54	
Sandy Hollow Golf Course	853	0.2	0.4	2	6.4	300	310	318	56	Collected from pressure tank.
Rockford Bureau for Transients	304	0.8	8.3	2	22.2	248	222	388	52	(1935)part-ally softened
Rockford Malleable Iron Co.	356	0.6	1.1	3	10.8	318	317	328		(1919)
St. Antony Hospital	810	0.9	1.1	3	11.3	316	325	335	55	(1934)
Rock Drop Forge	752	0.5	2.3	1	9.9	328	338	350	54	
Woodward Governor Co.	728	2.2	0.5	3	10.9	312	328	333	53.5	
Woodward Governor Co.	688	0.6	1.6	2	11.1	340	354	347	53.4	(1942)
Rockford Screw Products Co.	398	2.4	0.4	2	20.2	304	336	347	53.8	
Camp Grant No. 4	160	2.1	2.2	1	9.3	334	342	349	52.0	(1941)
Camp Grant No. 6	189	1.1	3.1	2	16.9	320	342	338	52.5	(1941)
Camp Grant No. 3	158	1.5	2.7	3	13.0	338	335	351	52	(1941)
Camp Grant No. 2*	168	1.4	0.4	3	29.8	318	353	388		(1941)
Camp Grant No. 1*	154	Tr.	1.3	2	28.8	310	347	360	52	(1941)

* possibly some recharge water present

In many cases these waters appear to be entering the veils from the St. Peter sandstone, the normal sandstone water having been virtually all replaced by the pre-Wisconsin water.

Local Recharge

The analyses in Table III are interpreted to be local recent recharge waters from rainfall or river infiltration and passing through loess and loam deposits. These waters are characterized by exceptional nitrate, sulfate and hardness and by a low iron content. Specifically, (1) the nitrates are generally greater than 10 ppm.; (2) the hardness is greater than 400 ppm.; (3) the sulfate content greater than 50 ppm.; (4) the chlorides greater than 20 ppm.; and (5) the iron content is less than 0.4 ppm.

TABLE III

Name	Depth	Fe	NO_3	Cl	SO	Alk.	Hd.	Res.	Temp. °F.	Notes
Consumers Co.	44	2.0	7.3	31	60.9	320	393	465	54.5	dipped sample.
Mattison Machine Co.	90	0.1	29.6	61	104.3	288	450	568	55	
Quaker Oats Co. No.2	308	0.1	18.1	40	108.1	296	408	520	55.2	
Produce Distributors Co.	480	0.1	12.9	50	134.7	360	521	637	55	
Spengler Loomis Manufacturing Co.	100	1.3	1.3	24	147.7	340	507	590	55	
Spengler Loomis Manufacturing Co.	100	0.3	26.6	24	154.7	336	500	596	55	
Allens Ice Cream Co.	450	0.3	29.6	45	167.4	312	500	638	56	
Nelson Hotel	400±	0.0	2.2	26	71.6	318	414±	528		(1914)
Trust Bldg.	400±	0.0	14.1	34	47.0	330	392	468		(1914)

Mixtures

The analyses in Table IV appear to be blends of sandstone and recharge waters, the recharge waters entering these wells (2) directly past a faulty casing, (b) through creviced Galena-Platteville dolomite, or (c) as recharged St. Peter sandstone water.

TABLE IV

Name	Depth	Fe	NO_3	Cl	SO_4	Alk.	Hd.	Res.	Temp. °F.	Notes
Rockford Mitten and Hosiery Co.	250	Tr.	0.4	3	15.0	316	321	338	56	
Burson Knitting Co.	355	0.3	4.1	11	21.0	304	321	355	55.5	
Hess & Hopkins Leather Co.	450	0.2	0.2	9		276	357			(pumps sand)
Log Cabin Arbor Association	338	0.1	16.2	7	25.3	324	373	386	53	
Rockford Screw Products Co.	555	0.3	7.6	4	38.5	288	336	348	54	
National Lock Co.	1140	0.3	5.9	6	45.3	288	354	364	53.7	(1946)
W. F. and John Barnes Bros.	300	0.1	22.8	4	37.4	240	310	327	54.5	
Quaker Oats Co. No. 3	450	0.3	6.8	19	46.3	296	330	380	53.8-54.5	

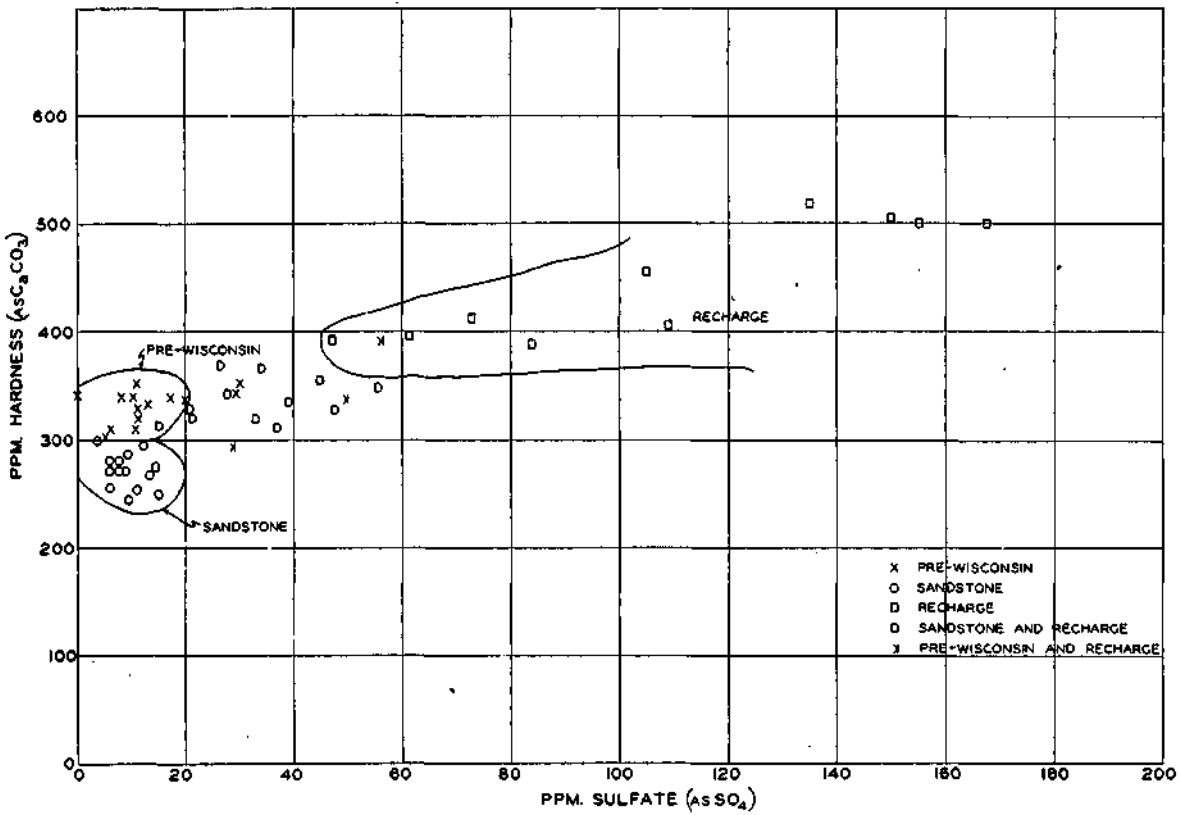

FIGURE 7. GRAPH PATTERN SHOWING CLASSIFICATIONS OF WATERS.

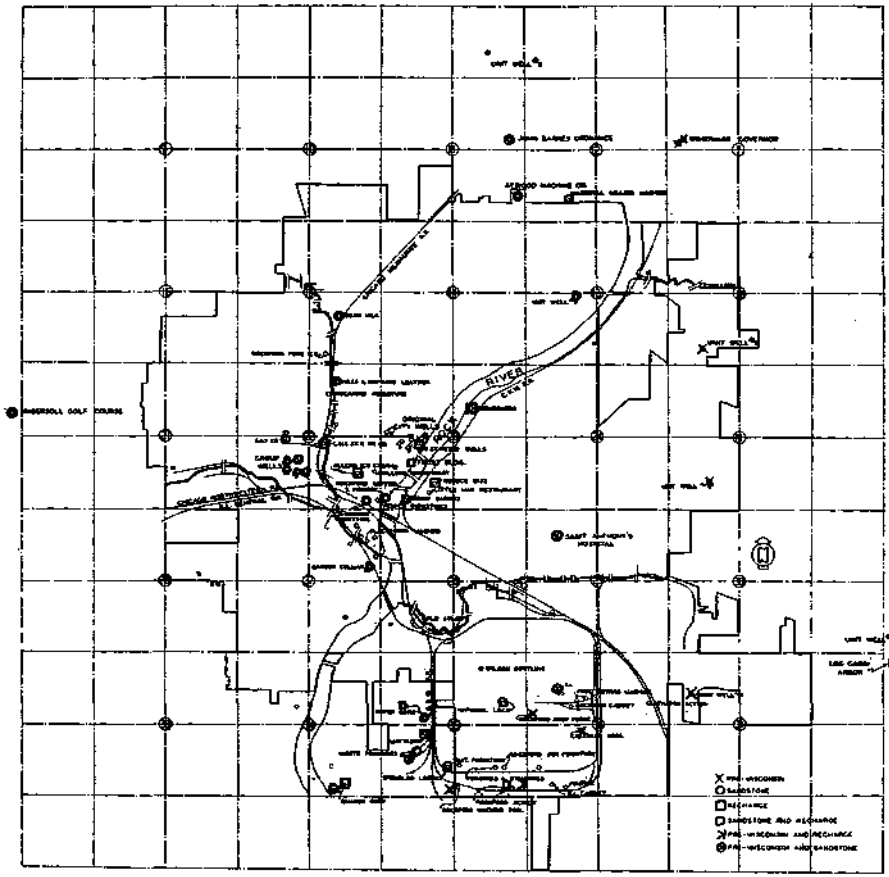

FIGURE 8. MAP SHOWING DISTRIBUTION OF THE CLASSIFIED WATERS.

TABLE IV (Con't)

Name	Depth	Fe	NO_3	Cl	SO_4	Alk.	Hd.	Res.	Temp. °F.	Notes
Rockford Sanitary District	210	Tr.	12.6	7	54.9	272	350	360	53	
Geo. D. Roper Corp. No. 3	1089	0.2	Tr.	5	20.0	308	328	350	53	
Geo. D. Roper Corp. No. 1	1100	0.8	Tr.	6	33.9	324	371	372	52.4	
Barber Colman	450	Tr.	0.7	11	28.4	316	346	366		(1948)
Rockford City Gr.2		0.4	6.3	12	33.1	276	317	346	54	(1948)
Rockford City Gr.6		0.6	13.9	17	83.9	300	389	446	53	(1948)

The three analyses In this table appear to be blends of pre-Wisconsin and recharge water.

TABLE V

Name	Depth	Fe	NO_3	Cl	SO_4	Alk.	Hd.	Res.	Temp. °F.	Notes
National Lock Co.	1000	1.2		6	28.0	320	296	378		(1928)
City 7A	200	0.8	12.4	8	57.0	320	394	459	52.5	
Rockford Screw Products Co.	454	2.0	9.3	5	47.7	276	336	344	53.9	

These classifications are spotted according to the sulfate content and hardness in Figure 7 and geographically in Figure 8.

QUALITY-SOURCE STUDIES

Quality-source tests were conducted on 6 city wells.

Unit Well No. 5

The data are indicated in Table VI. Very little variation in character is noted. The water quality would indicate this water to be of pre- Wisconsin drift origin and presumably entering the well as St. Peter sandstone water. The temperatures may be somewhat unreliable due to the sampling point. Four samples collected June 5, 1945 were of similar mineral character and the temperature was reported to be 52.5° F.

TABLE VI

33 1/2 hrs. idle period
1300 gpm.

Date & Time	Temp. °F.	Fe ppm.	Cl ppm.	SO_4 ppm.	NO_3 ppm.	Alk. (as $CaCO_3$) ppm.	Hd. (as $CaCO_3$) ppm.	Res. ppm.
7-24-47								
6:19 PM.	pump started							
6:20	55	8.2	1	10.5	1.9	324	344	353
6:23	55.4	2.2	4	13.2	2.3	328	351	346
6:28	55.4	1.7	2	12.3	1.7	332	351	356
6:38	56.5	1.8	3	14.2	1.1	332	351	356
6:58	57	1.8	2	13.6	1.4	332	358	356
7:18	57	1.7	2	12.1	1.4	332	358	356
7:48	57	1.9	2	12.3	1.4	332	358	356
7:20	57	1.9	2	11.5	1.0	332	358	356

Unit Well No. 6

The data are recorded in Table VII. Very little change in character is noted. No previous analyses are available for comparison. The quality would indicate the presence of (1) some recharge water by virtue of the nitrate and sulfate content, (2) some pre-Wisconsin water by virtue of the 0.5 ppm. iron and some normal sandstone water.

TABLE VII

5 hrs. idle period

Date & Time	Temp. °F.	Fe ppm.	Cl ppm.	SO_4 ppm.	NO_3 ppm.	Alk. (as $CaCO_3$) ppm.	Hd. (as $CaCO_3$) ppm.	Res. ppm.
8-10-47								
9:10 AM.	55	0.4	8	33.5	9.8	292	338	353
9:15	55.5	0.4	7	30.0	8.5	296	345	352
9:19	56	0.6	7	24.3	7.1	300	338	350
9:29	55.8	0.6	6	26.5	7.6	304	338	352
9:49	56.5	0.5	4	24.7	7.0	300	338	351
10:09	57	0.5	6	23.2	6.7	304	338	350
10:39	58	0.5	5	23.7	6.4	304	338	347
11:10	56.9	0.3	6	21.8	7.3	304	338	350

Unit Well No. 7

The data are recorded in Table VIII. A distinct change in quality occurred after 20 minutes of pumping. It appears that during the idle period as well as during the pumping period, a blend of largely pre-Wisconsin with some recharge water enters the well at a rate of about 100-150 gpm.

Subsequent samples appear to be of character indicating some 80 to 90 per cent normal sandstone water.

TABLE VIII

6 hrs. idle period
1500 gpm.

Date & Time	Temp. °F.	Fe ppm.	Cl ppm.	SO_4 ppm.	NO_3 ppm.	Alk. (as $CaCO_3$) ppm.	Hd. (as $CaCO_3$) ppm.	Res. ppm.
7-26-47								
3:40 PM.	54	3.3	5	33.3	2.0	324	365	376
3:43	54	1.7	5	31.5	2.1	328	365	370
3:48	55.5	1.1	5	30.2	2.2	324	365	370
3:58	57	1.4	4	28.8	1.8	324	365	369
4:18	58	0.5	5	16.7	1.8	288	315	326
4:58	58	0.4	3	14.2	1.1	292	315	325
5:38	58	0.3	3	15.0	1.2	292	308	313
9:30 AM.	57.4	1.1	8	14.6	2.1	272	301	314

Unit Well No. 8

The data are recorded in Table IX. A change in water quality 18 noted after a 10-20 minute pumping period. The water first obtained appears to be a blend of pre-Wisconsin and recharge waters and after 1 hr. pumping appears to contain approximately 80 per cent water of normal sandstone character.

TABLE IX

8 hrs. idle period
1600 gpm.

Date & Time	Temp. °F.	Fe ppm.	Cl ppm.	SO_4 ppm.	NO_3 ppm.	Alk. (as $CaCO_3$) ppm.	Hd. (as $CaCO_3$) ppm.	Res. ppm.
8-10-47								
6:54 AM.	55	1.4	7	30.8	1.8	272	310	331
6:58	55.5	1.3	8	51.6	1.8	284	345	373
7:03	55	1.2	8	55.5	2.1	272	345	359
7:13	57	0.8	6	33.3	2.1	276	331	351
7:27	pump stopped							
7:35	pump started							
7:36	58	2.4	6	31.7	0.9	272	310	329
7:53	58	0.6	5	25.9	0.7	280	317	370
8:23	58.5	0.6	5	24.9	1.0	276	310	322
8:51	58.5	0.6	4	31.1	1.1	272	310	322

Unit Well No. 9

The data are recorded in Table X. Very little change in character is noted and the water appears to be largely of pre-Wl8coneln origin presumably entering the well as St. Peter sandstone water.

TABLE X

8 hrs. idle period
1680 gpm.

Date & Time	Rate of Production GPM.	Temp. °F.	Fe ppm.	Cl ppm.	SO_4 ppm.	NO_3 ppm.	Alk. ppm.	Hd. ppm.	Res. ppm.
9-21-47									
7:04 AM.	pump started								
7:05	pumping water								
7:06	1680	54	4.7	4	22.8	1.3	308	338	345
7:09	1680	53.5	3.4	5	22.2	1.0	308	338	345
7:14	1680	54	1.4	6	23.0	1.1	308	338	347
7:24	1680	54.5	1.3	5	25.1	1.1	304	338	346
7:44	1660	53.5	1.1	5	22.2	1.1	308	338	345
8:04	1670	54.5	1.0	6	23.4	1.3	308	331	346
8:34	1680	55	1.0	6	23.0	1.8	308	338	344
9:04	1680	54	1.0	6	24.3	1.0	304	331	344

Unit Well No. 1

The data are recorded in Table XI. The water obtained during the first hour of pumping appears to be largely of recharge origin and approaches in character the quality of normal sandstone water.

TABLE XI

10 hrs. idle period
1570 gpm.

Date & Time	Rate of Production GPM.	Temp. °F.	Fe ppm.	Cl ppm.	SO_4 ppm.	NO_3 ppm.	Alk. ppm.	Hd. ppm.	Res. ppm.
6-25-39			0.1	11	33.8	3.7	316	367	404
12-2-46									
7:18 AM.	1750	55	0.3	11	72.4	13.1	288	379	426
7:21	1750	54.5	0.2	11	62.7	8.3	288	354	402
7:26	1750	55	0.5	11	58.6	10.3	288	354	397
7:36	1750	55	0.2	11	55.1	10.3	292	341	392
7:56	1750	54.8	0.2	11	54.5	8.7	288	348	390
8:16	1750	54.6	0.1	11	46.7	9.0	288	348	376
8:46	1750	54.6	0.1	10	43.2	0.6	292	329	370
9:16	1750	54.7	0.1	9	40.3	0.5	296	322	365
2:25 PM.	1570	54.6	0.2	11	35.6	3.3	300	353	364

CONCLUSIONS

The chemical data have been interpreted to classify the waters as originating from three primary sources.

No attempt was made to distinguish between the various sandstone waters. More detailed classification of these waters must conform with the characters established for sandstone waters and be distinguished by temperature.

In Northern Illinois, temperatures of water from 1200 to 1400-foot depths approach 60° F. The fact that the original flowing deep wells yielded water of 60° F. temperature indicates that the Mt. Simon sandstone yielded water at one time. However, the fact that few of the present wells of similar depth yield water of temperature approaching 60° F. indicates that (1) the Mt. Simon was of low permeability and (2) it has suffered an appreciable recession.

The construction of many of the present sandstone wells is such that drift water should not enter these wells directly. However, since such water does appear in several of these wells in appreciable proportions, it appears that the St. Peter sandstone and in some cases the intermediate creviced dolomite is locally replenished directly through or from the overlying drift deposits. This replenishment did not and does not take place unless the water pressure in the St. Peter sandstone becomes or is less than that of the overlying drift. Such replenishment is noted where analyses show a change in quality from that recorded previously to that observed at the present time.

The high iron content of the Unit Wells on the East side of the river originates in the pre-Wisconsin drift. It appears that the iron enters the wells principally through the underlying St. Peter sandstone.

ROCKFORD INDUSTRIAL WELLS

Name	Date Drilled	Diam. Depth	Ref. Elev.	Static Water Level	Rate of Production GPM.	Ave. Daily Pumpage GPD.	Remarks
Charles V. Weise Co.	1936	8"- 480'				115,000	Air conditioning
St. Anthony's Hospital	1933	8"- 810'	795'	703'	100	40,000	
John LaForge & Sons	1945	8"- 465'	726	691	208	192,000	
Mattison Machine Works	1918	90'	725	695	175	105,000	55° pumped 10 hrs/day
Spengler Loomis Mfg.Co. (1)		5"- 100'	718	678	5	6,000	55° pumped 10 hrs/day
(2)		5"- 100'		678	5		
Rockford Mitten & Hosiery (1)		250'	707	697	100	144,000	Pumped 24 hrs/day
(2)		95'			500	360,000	56° pumped 12 hrs/day
Burson Knitting Co. (1)	1908	355'				400,000	55.5°
(2)	1909	352'					
Ziock Industries Inc.	1938	300'	707			50,000	
Produce Distributors	1905	6"- 480'	736	696	90	105,000 S. 16,000 W.	
Consumers Company		44'	719	712	250	360,000	Pumped 24 hrs/day
Barber Coleman (1)	1911	300'				280,000	Not in use
(2)	1913	450'					
Gunite Foundries Corp. (1)	1906	6"- 365'					Abandoned
(2)	1919-19	8"- 720'	722	677	400	576,000	Sat. & Sun. each week
(3)	1928	10"-1005'			600	864,000	56° - 5 days each week
National Lock Co. (1)	1914	8"- 700'					Abandoned 1926
(2)	1925	12"-1140'	731	679	350	832,000	53.7°

ROCKFORD INDUSTRIAL WELLS (Con't)

Name	Date Drilled	Diam. Depth	Ref. Elev.	Static Water Level	Rate of Production GPM.	Ave. Daily Pumpage GPD.	Remarks
Atwood Vacuum Machine Co.	1943	700'	734	689	600	432,000	54°
Quaker Oats Co. (2)	1907	8"- 308'	702	690	400	768,000	55.2°
(3)	1929	10"- 450'	738	698	600		54.5°, 53.8°, 54.1°
Geo. D. Roper Corps. (1)	1919	1100'	725	656	400	115,000	Operated 9.6 hrs/day
(2)	1929	1089'	728	643	400	230,000	53° powerhouse well
Woodward Governor Co. (1)	1941	200'					Discontinued
(2)	1941	688'	723		549	1,000,000	W. 53.5°
(3)		732'	732	704	909(B) 632	1,500,000	S. 53.0°
Ingersoll Milling Mach. Co. E.	1918	8"- 729'	746	712	200	24,000	Pumped 2 hrs/day
W.		20"-1204'	746	698	385	554,400	Pumped 24 hrs/day
W. F. & John Barnes	1890	300'			500	720,000	
Tom Swords		8"- 380'				2,000	S.
						1,000	W.
Bradley Heights		8"- 490'±				20,000	S.
						10,000	W.
Midway Theater		8"- 403'				210,000	Pumped May-Oct.
Wilson Bottling Co.	1910					8,000	Well points below 25' pit.
Thayer Action	1905	65'				20,000	Well points below pit.
Rockford Sup. Furniture Co.	1920	55'				30,000	Dug pit-well points below.
Forgings & Stampings Inc.						15,000	Well points below 30' pit.

Name	Date Drilled	Diam. Depth	Ref. Elev.	Static Water Level	Rate of Production GPM.	Ave. Daily Pumpage GPD.	Remarks
Free Sewing Machine Co. (1) (3)	1900	50' 50'				 5,000	Discontinued about 1940 Well points
Wolf Subdivision		8"- 350'				7,500 5,000	S. W.
Burr Heights	1914	6"- 400'±				3,000 1,500	S. W.
Central Ill. Electric & Gas Co.	1928	1200'	719'	685'	750	200,000	Average pumpage listed Not in use at present
Rockford Trust Bldg.	1915	5"- 180'				12,000	
Rockford Pure Ice		705'			250	240,000	16 hpd. in summer
Muller's Union Dairy	1915	132'			80	115,200 48,000	56° - summer 24 hpd. 54° - winter 10 hpd.
Little Max Restaurant		300'				16,000	Summer only
Blackhawk Machine Co.	1900	10"- 650'	712'	695	500	720,000	55° - pumpage 24 hpd. summer only
Mott. Bros. Co.	1946	6"- 324'	719	689	35	25,200	Pumped 12 hrs/day (S)
Nelson Knitting Co.	1925	400'±					Discontinued 1931
Ill. Bell Telephone Co.	1947	283'	729	699	25	7,500	Pumped 5 hpd.
Dean Milk Co.		1000'	710	695	200	200,000	52° - well in 16' pit
Sandy Hollow Gold Course		853'	812	706	300	216,000	56° - pumped 12 hrs/day summer

ROCKFORD INDUSTRIAL WELLS (Con't)

Name	Date Drilled	Diam. Depth	Ref. Elev.	Static Water Level	Rate of Production GPM.	Ave. Daily Pumpage GPD.	Remarks
Rockford Drop Forge Co.	1912	8"- 752'	734	684	400	144,000	Pumped 6 hrs/day; 6 days/wk.
Greenlee Bros. Co.	1913	8"- 743'	730	682	350	252,000 420,000	W. 54°-well in 8' pit S. Pumped 20 hrs/day in summer
Owens Inc.	1944	8"- 465'	715	682		90,000	Pumped May-Oct.
Ingersoll Golf Course	1921	846'	822	732	210	201,600	53° - pumped 16 hrs/day summer only
Allens Ice Cream Co.	1918	400'			60	36,000	56° pumped 10 hrs/day
W. F. & John Barnes (Ord.)	1941	1150'				50,000	57.5° - 53.5°
Rockford Industries Co.		283'					
Hess & Hopkins Leather	1909	450'			150	15,000	Pumped 5.5 days/wk.
Rockford Screw Prod.Co. (1)		8"- 555'	717		200	120,000	
(2)	1942	8"- 398'	716	686	100-200	212,000	
(3)	1943	8"- 454'	717	684	100	120,000	
Palace Amusement Co.	1941	8"- 335'			200	102,000	Pumped May-Oct.
Auburn Theatre	1941	8"- 350'	731	711	250	75,000	Pumped May-Oct
Brown Bldg.	1942	6"- 250'	715	696.5		50,000	Air conditioning
J. I. Case Co.	1943	6"- 450'	726	708			