ILLINOIS

STATE WATER SURVEY

No. 21

ERRATA.

Page 189, fourteenth line: read "is a steel shoe" instead of "in a steel shoe".

Page 212, line 5 of table: read "$(NH_4)_2CO_3$" instead of "$(NH_4)_4CO_3$".

Page 251, line 6 of table: read "5.9" instead of "5.6".

Page 464, line 5 of table: read "Na_2SO_4" instead of "Na_2SO_2".

Page 487, fifth line from bottom: omit whole line.

Page 654, line 6 of table : omit

"Magnesium Sulfate $MgSO_4$. . . . . 137.2 7.99"

STATE OF ILLINOIS
DEPARTMENT OF REGISTRATION AND EDUCATION

DIVISION OF THE
STATE WATER SURVEY
A. M. BUSWELL, Chief

BULLETIN NO. 21

PUBLIC GROUND-WATER SUPPLIES

IN ILLINOIS

By G. C. HABERMEYER

[Printed by authority of the State of Illinois.]

URBANA, ILLINOIS

CONTENTS.

MAPS AND ILLUSTRATIONS.

STATE OF ILLINOIS
DEPARTMENT OF REGISTRATION AND EDUCATION
A. M. SHELTON, Director.

BOARD OF NATURAL RESOURCES AND CONSERVATION ADVISORS.

A. M. SHELTON, *Chairman.*

WILLIAM A. NOYES, Chemistry, *Secretary.*
JOHN W. ALVORD, Engineering.
EDSON S. BASTON, Geology.
JOHN M. COULTER, Forestry.
WILLIAM TRELEASE, Biology.
KENDRICK C. BABCOCK, Representing the President of the University of Illinois.

MEMBERS OF WATER SURVEY DIVISION SUB-COMMITTEES.

A. M. SHELTON,
KENDRICK C. BABCOCK.
WILLIAM A. NOYES.
JOHN W. ALVORD.

WATER SURVEY DIVISION.

A. M. BUSWELL, *Chief.*

LETTER OF TRANSMITTAL.

STATE OF ILLINOIS,
DEPARTMENT OF REGISTRATION AND EDUCATION.
STATE WATER SURVEY DIVISION.

URBANA, ILLINOIS, June 5, 1925.

A. M. Shelton, Chairman, and Members of the Board of Natural Resources and Conservation Advisors:

GENTLEMEN: Herewith I submit a report on the ground water resources of the State of Illinois and recommend that it be published as Bulletin No. 21.

Since the Directors' report includes a statement of the general activities of all divisions, it has seemed advisable to discontinue the publication of an annual report of this division and to prepare instead summaries of our various investigations as they are completed. This policy was adopted with the publication of Bulletin No. 18 in May of 1922, and has been followed since that date.

A portion of this material has appeared in abstract form in annual reports published prior to 1920. That material was too meager and scattered to be of practical value. In the present collected form we believe this data will be of very considerable value to the State of Illinois.

Respectfully submitted,

A. M. BUSWELL, *Chief.*

PUBLIC WATER SUPPLIES OF ILLINOIS
(Except in Cook and DuPage Counties)

PUBLIC GROUND-WATER SUPPLIES IN ILLINOIS.

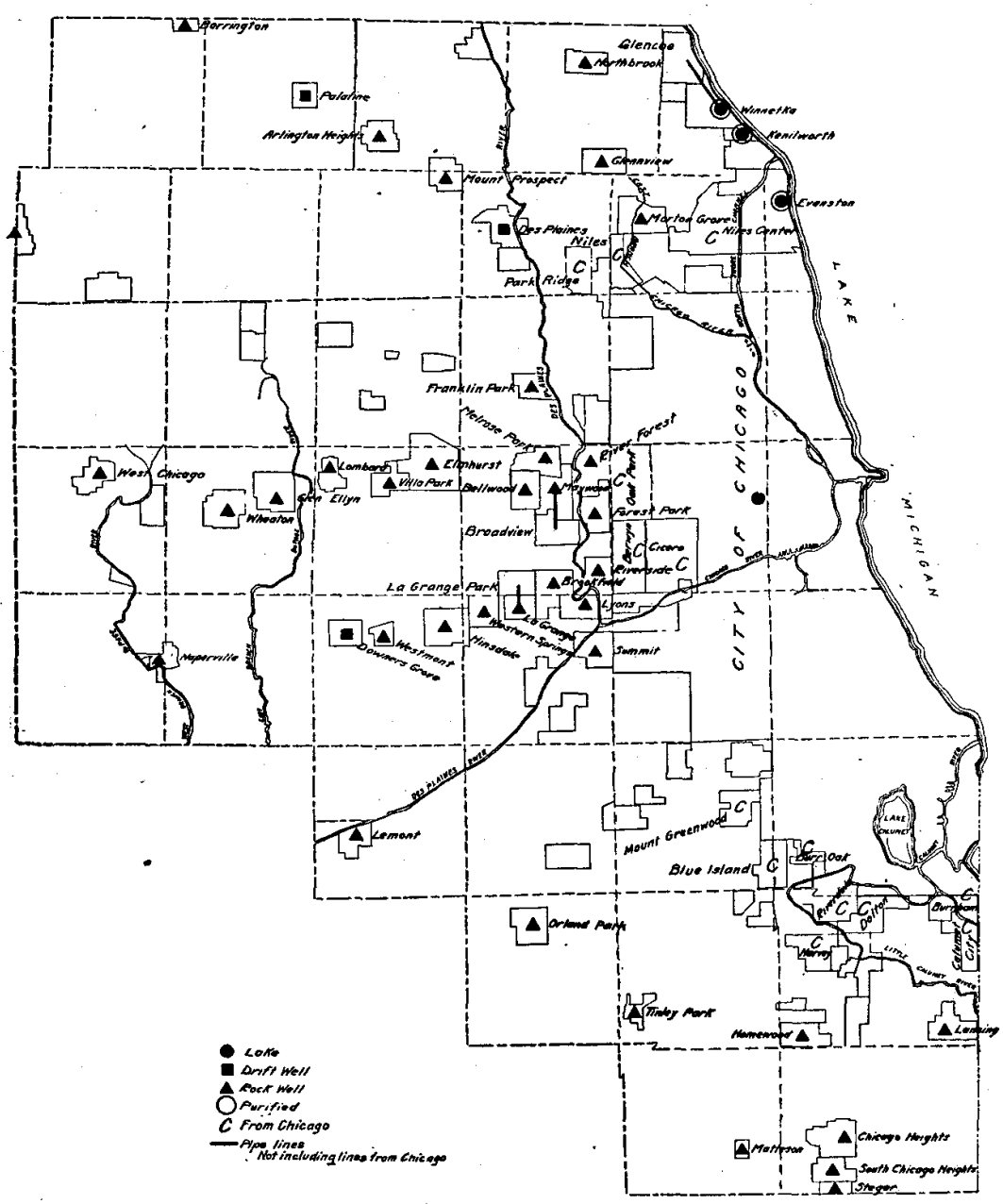
This bulletin was prepared to present in convenient form for reference information which has been collected in regard to the quantity and quality of ground waters available throughout the state. Investigations which have been made to secure information have been principally of supplies of incorporated municipalities. These investigations are often made on request and it is in order to be of assistance to as great a number as possible that the work is confined to the municipal supplies.

Municipal officials, employees of municipalities, well drillers, and engineers who have made investigation of water supplies have kindly given us much valuable information. There have been so many changes in personnel of officials and persons employed by them that it is impossible to give credit here to each one excepting in the case of well drillers. When data are given in regard to a well the name of the driller is given when known.

Records of material penetrated by wells are given when possible. Many of these records were secured from the drillers and from city officials and others were secured from the State Geological Survey Division. The material penetrated by the wells was classified by the State Geological Survey Division. Much of this work was done by G. E. Ekblaw. No attempt has been made to give the complete classifications in this bulletin but a few of the more common terms have been given. Some of these are names of formations and others are names of series consisting of two or more formations. Where names of systems have been used they are designated as systems. Certain sandstones in this state have, in the past, been referred to as "Potsdam" sandstones. These are in the Cambrian system and the words Cambrian system are used in this bulletin and, in some places, a few of the more common formations and series in this system have been given.

Some statements in regard to water supplies have been conflicting and data which appeared to be unreliable have been omitted.

A map showing incorporated municipalities with public water supplies is inserted on the following sheet. On account of the great number of municipalities with public supplies in Cook and Du Page Counties, these are shown on a separate map on page 8. The municipalities which secure water from surface supplies have been shown for convenience and such municipalities are listed on pages 708 to 710 of this bulletin.



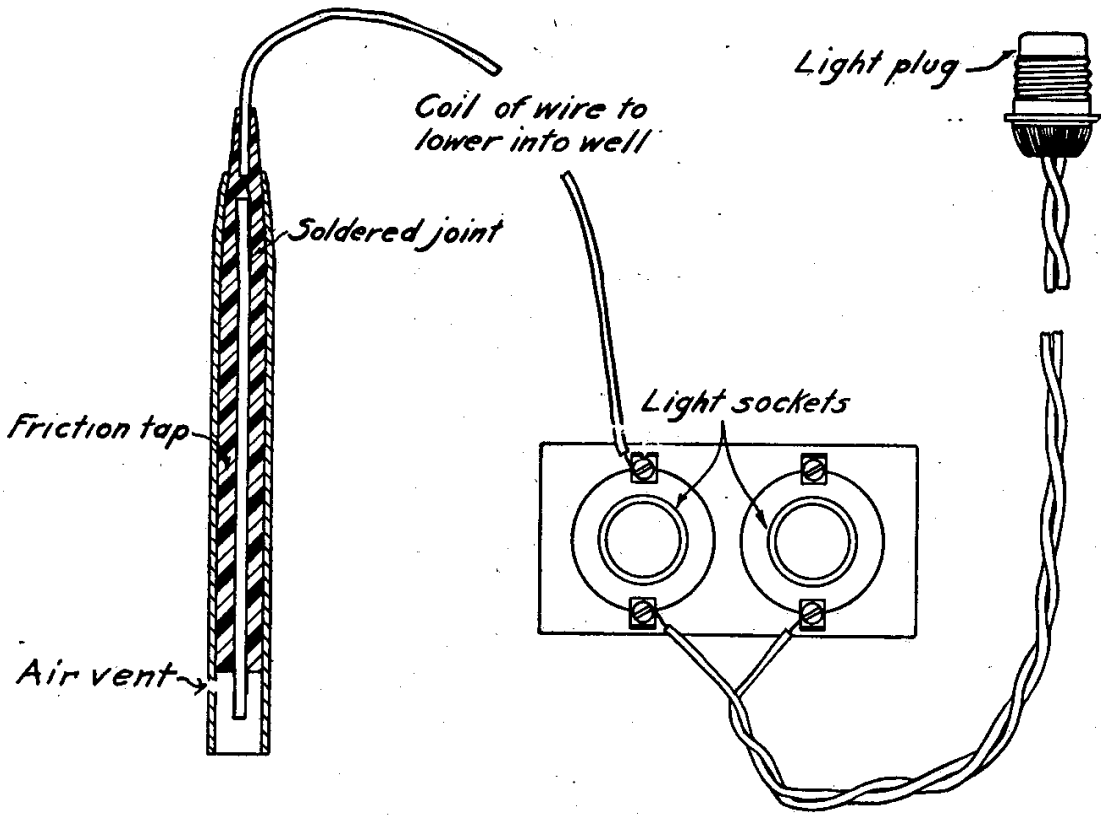
PUBLIC WATER SUPPLIES IN COOK AND DUPAGE COUNTIES

A study of the text or of the maps will show that a large portion of the ground-water supplies are in the northern and central parts of the state. Water of good quality is available from wells in nearly all places in the northern part of the state. In the central part, waters from wells into rock are generally highly mineralized but as little other ground water is available west of Illinois River, waters from wells into rock are in use in many places in that part of the state. In the central eastern part of the state many supplies

are from wells into sand and gravel. In large areas in the southern part of the state little water of good quality for public supplies is available from wells and many of the larger cities have developed supplies using surface water.

The amount of water available from wells is dependent in part upon the depth to which the water level is drawn down in the wells so as to create a flow toward them in the water bearing strata. During the past few years the rate of pumping from wells and water levels in wells have been measured when possible. At some places the amount of water pumped is recorded by meter. Meters on service connections usually measure accurately or slightly low. Meters at pumping stations are in many places incrusted to such an extent that they soon record appreciably higher than the actual quantity of water pumped. Measurements of discharge are made in reservoirs when possible.

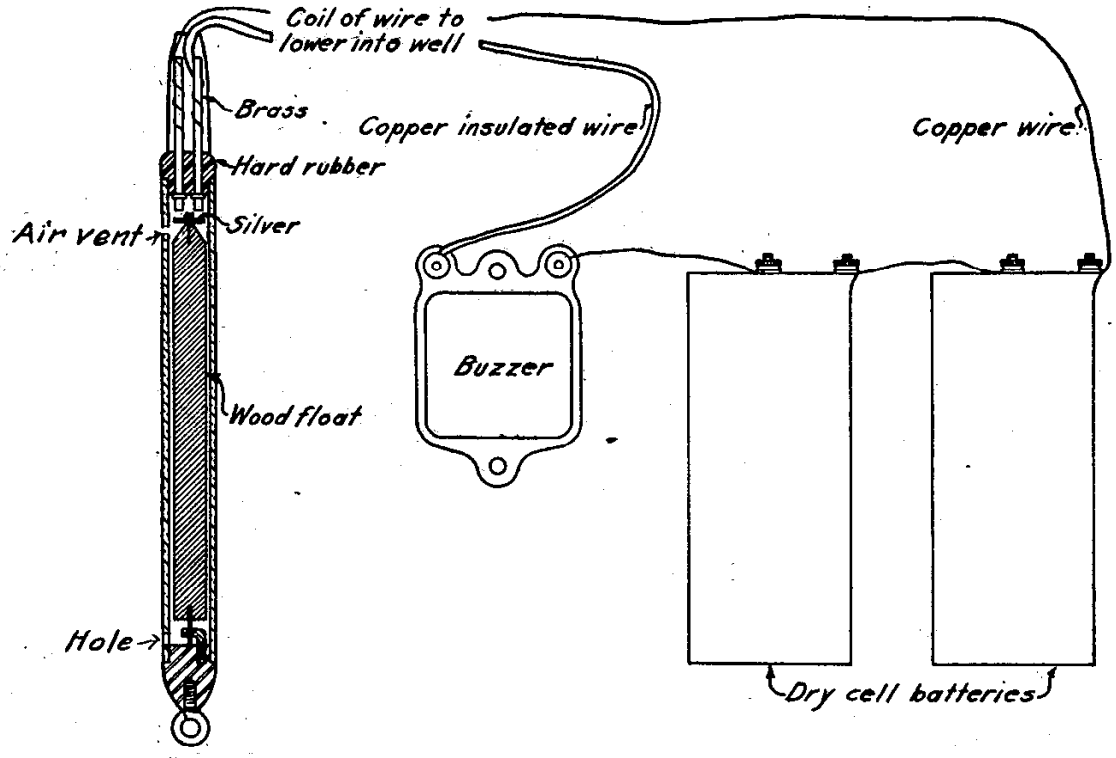
Equipment available to measure depths to water is limited to what can be carried conveniently when carrying personal baggage and, at times, bottles for the collection of samples. In some places depths to water are measured by lowering a weight attached to a wire and noting when the weight strikes water or by lowering a float attached to cord or wire. Where very little space is available a thin sheet of lead attached to a cord or insulated wire is used. The lead and cord are chalked with blue chalk which readily shows a water line. Where an electric lighting circuit is available it is often used in making measurements. One end of an insulated wire, protected so that it can not touch the well casing or other metal, is lowered into the well. The other end of the wire is connected to one terminal of an electric lamp and the other terminal of the lamp is connected to the lighting circuit. When the end of the wire lowered into the well touches water the circuit is completed and the lamp is lighted. A drawing of such apparatus is shown on the following page. As two wires are used in the lighting circuit and it is not usually possible to tell in advance which is carrying the current to the lamp we use two lamp sockets and each is connected to one of the wires of the connecting cord. This is merely to save time. If the apparatus does not work with the lamp in one socket the lamp is changed to the other socket. In some places a light circuit is not available and at times the insulation on the wire lowered into the well may be found to be badly worn. In such cases an apparatus is used such as shown on page 11. Two common electric dry cells and a buzzer or an electric bell are connected in series. The electric circuit is completed by current



APPARATUS USED IN MEASURING WATER LEVELS IN WELLS WHERE LIGHTING CIRCUITS ARE AVAILABLE

flowing through an insulated copper wire to a metal cap on a wooden float and from the metal cap through a copper wire back to the dry cells. The float is protected by a metal cylinder. The terminals of the wires with which the cap on the float come in contact are separated by hard rubber. In the apparatus used the bottom of the float is held away from the walls of the cylinder to reduce friction. When the float is lowered in a well and reaches water the rise of the float closes the electric circuit. The principal trouble experienced with apparatus of this kind, especially small apparatus made to go in small openings, is that the terminals corrode easily. In some places, where other apparatus is not satisfactory, use is made of a magneto, such as is used in testing electric circuits that have high resistance. One terminal of the magneto is connected to an insulated wire with a protected point which is lowered into the well and the other terminal is connected to the ground or the well casing. The handle of the magneto is turned and when the wire touches water the circuit is completed and the bell of the magneto rings.

When measurements to water cannot be made, information is secured in regard to the depth to which pumps are placed and



APPARATUS USED IN MEASURING WATER LEVELS IN WELLS

lengths of suction pipes on the pumps, as the water level in a well cannot be drawn down below the bottom of the suction pipe.

The mineral content of each water supply is shown by chemical analysis of samples of water. Most of these analyses, as will be seen by reference to the tables, have been made according to the standard methods for complete mineral analysis. During the War period, however, sodium and potassium were not separated, due to the shortage of platinum. In a few cases where complete mineral analyses have not been available, results obtained by rapid methods have been included. Up until 1920 a slightly modified "soda reagent" method was used. Subsequent to 1920 the only abbreviation in methods was the elimination of the sodium potassium determination.

Samples collected from wells which are equipped with pumps have been collected, excepting as noted, after the pumps had operated for several hours or, in villages where pumps are operated continuously for only a short time, during the latter part of the pumping.

The form of recording and reporting analysis has varied slightly during the past thirty years. Some revisions have been made to make the reports more uniform. Slight differences in form which may be detected in a few places are of no significance.

Special note is made of mineral content, the total hardness, and the content of iron of each supply. The hardness given is equivalent hardness in parts of calcium carbonate per million parts of the sample. The iron content of a supply may vary. This is especially true in places where pumps in wells are operated for a short time and are then idle for a few hours. In such cases the content of iron of water pumped may be more than 100 parts per million when starting to pump and decrease to a small quantity before pumping ceases.

The population in 1920, of each municipality, is given in parenthesis following the name of the municipality.

Every engineer employed by the State Water Survey since it was organized has had a part in the collection of data which appears in this bulletin, and every chemist of the Survey has had a part in the collection of data or in the analyses of waters.

ABINGDON (2721). Abingdon is located in the southwestern part of Knox County on the drainage area of Spoon River. Water sufficient for residences may be secured from drift above rock, which is encountered at depths of from 15 to 35 feet.

A public water supply was installed by the city in 1902. The installation included a deep well equipped with a deep-well pump, a brick reservoir 40 feet in diameter and 10 feet deep, a brick pumping station, a Smith-Vaile 14 by 8 by 12-inch duplex steam pump, a distribution system, and an elevated steel tank of 36,000 gallons capacity supported on a brick tower. Steam to operate the plant was furnished from an electric light plant located across the street until about 1912 when two 60-horsepower Frost fire-tube boilers were installed. An air lift replaced the deep-well pump about 1912. No other important changes have been made. Air is supplied by an Ingersoll-Rand Imperial, type 10, compressor. Water is discharged from the well into the reservoir from which it is pumped into the distribution system.

Four hundred twenty-five services, nearly all of which were metered, were supplied with water in 1923. The consumption was estimated at about 55,000 gallons a day. The rates are 75 cents for the first 1000 gallons per month and 50 cents per 1000 gallons for all over 1000 gallons with a minimum charge of $1.50 for three months.

Water is obtained from a well. S. T. Mosser, Alderman, wrote in 1901 that the well was 1355 feet deep and was cased to St. Peter sandstone at a depth of 1232 feet. A. T. Bowton states that a flow of water was encountered at a depth of 400 feet, that this flow was cased off, and that no other water was encountered above the St. Peter sandstone. The diameter of the well is said to be 6 inches at the bottom. The well is equipped with an air lift. In 1913 the equipment included a 4-inch discharge pipe and a 1¾-inch air pipe extending to a depth of 275 feet. The discharge was given as 153 gallons a minute and the depth to water when not pumping was 130 feet. The equipment has been changed. The air line in 1920 was 479 feet in length and 2 inches in diameter excepting the lower 16 feet which was 1-inch and which connected to a Harris jet. A test of the well was made in January, 1920. After standing idle all night, the water level was 170 feet below the ground surface, the

discharge was 130 gallons a minute, and after long continued pumping the water level was lowered to a depth of 216 feet. At the time of visit in 1921 the air compressor was operating 150 revolutions a minute, a displacement of 150 cubic feet a minute, for about 12 hours a day and the yield of the well was estimated at 90 gallons a minute, the decrease since the previous year being accounted for by a leak in the air line.

A sample of water number 45193, collected on August 5, 1921, had a mineral content of 1312, a total hardness of 340, and a content of iron of 0.2 parts per million as shown by the analysis.

Analysis of Sample Number 45193 from the City Supply.

Determinations Made.	Parts Per Million
Iron Fe	0.2
Manganese Mn	0.0
Silica SiO_2	11.6
Nonvolatile	1.2
Alumina Al_2O_3	1.8
Calcium Ca	80.0
Magnesium Mg	33.9
Potassium K	19.6
Ammonium NH_4	0.9
Sodium Na	308.2
Sulfate SO_4	556.1
Nitrate NO_3	2.3
Chloride Cl	155.6
Alkalinity	
Phenolphthalein	12.0
Methyl Orange	236.0
Residue	1292.0

Hypothetical Combinations.	Parts Per Million.	Grains Per Gallon.
Potassium Nitrate KNO_3	3.7	.22
Potassium Chloride KCl	34.5	2.02
Sodium Chloride NaCl	228.4	13.35
Sodium Sulfate Na_2SO_4	674.5	39.44
Ammonium Sulfate $(NH_4)_2SO_4$	3.4	2 0
Magnesium Sulfate $MgSO_4$	121.8	7.12
Magnesium Carbonate $MgCO_3$	31.9	1.87
Calcium Carbonate $CaCO_3$	199.7	11.68
Silica SiO_2	11.6	.68
Nonvolatile	1.2	.07
Iron oxide Fe_2O_3	0.3	.02
Alumina Al_2O_3	1.8	.11
Total	1312.8	76.78

A sample collected in 1914 contained slightly less sodium and more calcium and magnesium. No serious damage to service pipe or meters due to action of water is reported. The water is treated with boiler compound before using in the boilers at. the pumping station.

ALEDO (2231). Aledo is located in the central part of Mercer County on the drainage areas of Pope Creek and Edwards River, tribuarties of Mississippi River. A public water supply was installed by the city about 1894. The installation included a well 3165 feet deep equipped with air lift; two brick reservoirs, one 15 feet in diameter and 10 feet deep and the other 54 feet by 17 feet 8 inches in plan and 10 feet 6 inches deep; a brick pumping station; an air compressor; a steam pump; a distribution system; and a 35,000 gallon steel tank on a brick tower 60 feet high. Changes in equipment have been made. Air is usually supplied by an Ingersoll-Rand

10 and 6½ by 10-inch compound compressor driven by a 38-horsepower electric motor. A steam-driven compressor with 12 and 7½-inch air cylinders and 14-inch stroke, formerly in regular service is also available. Water is usually pumped from the reservoir by a Goulds 7 by 8-inch triplex pump which is driven by a 15-horsepower electric motor. A Cameron two-stage centrifugal pump of 500 gallons a minute capacity driven by a 40-horsepower electric motor is used at times of fire. An 8 and 12 by 8¼ by 12-inch compound duplex steam pump is available in case of emergency. The original elevated tank has been replaced by a tank of 150,000 gallons capacity.

Water is pumped for the city by a Utility Company at a rate of 6 cents per 1000 gallons. The quantity is measured by meter at the station. Seven hundred and fifty service connections were in use in 1924. The meter rate for three months is 30 cents per 100 cubic feet for the first 5000 cubic feet, 20 cents per 100 cubic feet for the next 5000 cubic feet, and 15 cents per 100 cubic feet for additional quantities with a minimum charge of $1.00.

Water is obtained from a well which was originally 3165 feet deep and which has been filled to within 1450 feet of the ground surface to exclude salt water. The ground surface at the well is about 780 feet above sea level. A detailed record on file with the State Geological Survey Division shows Silurian limestone between depths of 440 and 595 feet; Maquoketa shale between depths of 595 and 790 feet; St. Peter sandstone between depths of 790 and 1240 feet; and Cambrian sandstone, shales, and limestones below a depth of 1960 feet. The well is cased with 8-inch pipe to rock. In 1913 the water level when not pumping was about 100 feet below the ground surface.

The well is equipped with air lift with a 1½-inch aid line to a depth of 400 feet. During the year to February, 1924, the amount of water pumped averaged 148,000 gallons a day. On the afternoon of April 3, 1924, during regular operation when the air lift had operated for more than an hour the discharge was the same as the amount of water drawn from the reservoir, and that, measured by meter, was 200 gallons a minute. During the test the pressure shown on gauge was 117 pounds at start and 112 pounds during operation.

The water is highly mineralized. This may be due in part to water gaining entrance from below a depth of about 1450 feet to which depth the well has been filled. The water had a mineral

content of 1746, a total hardness of 350, and a content of iron of 0.2 parts per million as shown by the analysis of sample number 39700, collected on July 3, 1918.

Analysis of Sample Number 39700 from the City Supply.

Determinations Made.

	Parts per million.
Iron, Fe	0.2
Manganese, Mn	0.0
Silica, SiO_2	9.6
Nonvolatile	3.6
Alumina, Al_2O_3	2.5
Calcium, Ca	95.5
Magnesium, Mg	26.9
Ammonium, NH_4	1.4
Sodium, Na	463.5
Sulfate, SO_4	524.0
Nitrate, NO_3	0.9
Chloride, Cl	439.7
Carbon Dioxide, CO_2	4.0
Hydrogen Sulfide H_2S	0.4
Alkalinity, Methyl orange	237.0
Residue	175.0

Hypothetical Combinations.

	Parts Per Million.	Grains Per Gallon.
Sodium Nitrate $NaNO_3$	0.1	.01
Sodium Chloride NaCl	725.3	41.91
Sodium Sulfate Na_2SO_4	638.4	37.15
Ammonium Sulfate $(NH_4)_2SO_4$	5.2	.30
Magnesium Sulfate $MgSO_4$	110.5	6.42
Magnesium Carbonate $MgCO_3$	16.7	.97
Calcium Carbonate $CaCO_3$	238.5	13.85
Iron Carbonate $FeCO_3$	0.4	.02
Alumina Al_2O_3	2.5	.15
Silica SiO_2	9.6	.55
Nonvolatile	3.6	.21
Total	1750.8	101.54

A sample collected in 1914 was similar but more highly mineralized. The mineral content was 2070 and the total hardness 440 parts per million.

ALEXIS (830). Alexis is located in the northern part of Warren County on the drainage area of Middle Henderson River. Some private wells 25 to 30 feet deep are in use in which water stands at a depth of from 8 to 10 feet.

A public water supply was installed by the village in 1895. Water was pumped from a well into the distribution system to which an elevated wooden tank was connected. The well was 100 feet deep. The supply was insufficient and another well was drilled and equipped with a deep-well pump. The pump is now driven by a 5-horsepower electric motor. Electric current is supplied by the Northern Illinois Utilities Company.

About one hundred and twenty-five service connections are in use. The minimum charge is 75 cents a month and the rate 40 cents a 1000 gallons excepting for the stock yards and butcher shop which have rates of 35 and 25 cents respectively.

The water supply is from a well 1200 feet deep located near the center of the business district on ground approximately 700 feet above sea level. It was drilled by the J. P. Miller Artesian Well

Company of Chicago in 1898. The drillers noted shale at a depth of 570 feet and shale and limestone at a depth of 690 feet. Between depths of 730 and 1056 feet the well is in limestone and from a depth of 1056 feet to near the bottom of the well it is in St. Peter sandstone. The well was cased from the surface with 64 feet of 8-inch pipe and 348 feet of 6-inch pipe. The depth to water from the ground surface was 135 feet after placing the casing, 80 feet when the well was 900 feet deep, and 58 feet when the well was completed. When completed the well was pumped at a rate of 100 gallons a minute. The well is equipped with a McGowan double-acting deep-well pump with a 4¼-inch cylinder placed at a depth of about 140 feet, and 24-inch stroke. The water level was said to be 70 feet below the ground surface when not pumping in 1915 and it was 120 feet in March, 1924. In 1923 the pump was operating 27½ revolutions a minute. From April, 1922, to January, 1923, it operated an average of 5 hours a day. Estimating the yield at 2½ gallons per revolution the total yield was about 21,000 gallons a day.

A sample of water, number 48958, collected at the pumping station in January, 1923, after 2 hours continuous pumping, had a mineral content of 1022, a total hardness of 290, and a content of iron of 0.8 parts per million as shown by the analysis.

Analysis of Sample Number 48958 from Well 1200 Feet Deep.

Determinations Made.	Parts per million.
Iron, Fe	0.8
Manganese, Mn	0.2
Silica, SiO_2	14.2
Nonvolatile	1.8
Alumina, Al_2O_3	0.0
Calcium, Ca	67.7
Magnesium, Mg	29.8
Ammonia, NH_4	1.5
Sodium, Na	219.0
Potassium, K	31.5
Sulfate, SO_4	410.7
Nitrate, NO_3	2.5
Chloride, Cl	85.0
Alkalinity, Methyl orange	274.0
Residue	1077.0

Hypothetical Combinations.	Parts Per Million.	Grains Per Gallon.
Potassium Nitrate KNO_3	4.0	.23
Potassium Chloride KCl	57.2	3.34
Sodium Chloride NaCl	95.3	5.53
Sodium Sulfate Na_2SO_4	560.7	32.70
Ammonium Sulfate $(NH_4)_2SO_4$	5.7	.33
Magnesium Sulfate $MgSO_4$	34.2	2.00
Magnesium Carbonate $MgCO_3$	79.2	4.62
Calcium Carbonate $CaCO_3$	169.0	9.87
Silica SiO_2	14.2	.83
Nonvolatile	1.8	.11
Iron oxide Fe_2O_3	1.2	.07
Alumina Al_2O_3	0.0	.00
Total	1022.5	59.63

The water is said to have little effect on meters but to seriously affect galvanized service pipe. All services now installed are of lead pipe. Water fronts in ranges clog in about a year.

ALGONQUIN (693). Algonquin is located in the southeastern part of McHenry County on the banks of Fox River.

Gravel is encountered a few feet below the ground surface and furnishes an abundant supply of water.

A public water supply was installed by the village about 1895. Water collected from springs flows by gravity to the city. The collecting system has been extended and a reservoir of 100,000 gallons capacity has been built on a hillside 50 to 60 feet higher than the collecting system. Water for fire protection is pumped into this reservoir by a Goulds triplex pump driven by an electric motor. Power is purchased from the Public Service Company of Northern Illinois. All services were equipped with meters in 1921 and the water consumption was greatly reduced. One hundred and seventy-one consumers were supplied in 1922. The rate is twelve cents per 1000 gallons with a minimum charge of $1.20 every three months which allows the use of 10,000 gallons of water. Bills are not subject to cash discount.

Water is secured from gravel deposits about one mile northeast of the city by lines of tile laid from four to five feet below the ground surface. Water flows into a concrete reservoir 15 feet by 20 feet in plan and 14 feet deep, from which part flows to the city and part flows to waste. At 9:30 a. m. on November 14, 1922, the overflow was about 100 gallons a minute.

A sample of water, number 48655, collected at the springs on November 14, 1922, had a mineral content of 315, a total hardness of 300, and contained no iron, as shown by the analysis.

Analysis of Sample Number 48655 from the Village Supply.

Determinations Made.

	Parts per million.
Turbidity	0.0
Residue	332.0
Iron, Fe	0.0
Manganese, Mn	0.0
Nitrate, NO_3	12.4
Chloride, Cl	5.0
Sulfate, SO_4	52.2
Alkalinity,	
Phenolphthalein	0.0
Methyl Orange	238.0
Magnesium	32.4
Calcium	66.9

Hypothetical Combinations.

	Parts Per Million.	Grains Per Gallon.
Calcium Carbonate $CaCO_3$	167.0	9.76
Magnesium Carbonate $MgCO_3$	59.8	3.49
Magnesium Sulfate $MgSO_4$	65.2	3.82
Magnesium Chloride $MgCl_2$	6.7	0.39
Magnesium Nitrate $MgNO_3$	1.2	0.07
Sodium Nitrate $NaNO_3$	15.5	0.90
Total	315.4	18.43

ALPHA (281). Alpha is located in the southwestern part of Henry County. A public water supply was installed by the village about 1900. Water was first secured from a well 165 feet deep into sand and gravel located near the center of the business

district. Water was pumped from the well into the distribution system and an elevated tank connected to the system. Water was later taken from a similar well owned by a company operating a local electric light plant. The yield of one well was not sufficient and the village then drilled a 5-inch well to a depth of 580 feet. This was located on the lot on which the elevated tank is located. The supply was ample at first but decreased rapidly and the well was abandoned after six or eight months use. A well which had been drilled for the Chicago, Burlington and Quincy Railroad was then leased by the village for $100 a year and is used to furnish the public water supply.

Water is pumped from the well by an electrically driven deep-well pump, through more than 1000 feet of 2-inch pipe to a wood tank of 6000 gallons capacity supported on a 50-foot steel tower. The pump is automatically controlled. A Witte gasoline engine of 6-horsepower is used to furnish power in case of emergency. One hundred and twenty-two service connections were in use in 1924. The average consumption was estimated to be about 8000 gallons a day.

The public water supply is from a well 1364 feet deep which was drilled in 1904 by the J. P. Miller Artesian Well Company for the Chicago, Burlington and Quincy Railroad and was later leased to the village. It is located in the southwestern part of the village, on ground about 800 feet above sea level. A record of material penetrated furnished to the State Geological Survey by the drillers with part of classifications is as follows:

	Thickness in feet.	Depth in feet.
Slate and coal	92	92
Clay, gray	26	118
Limestone	12	130
"Soapstone", black probably shale	20	150
"Black material"	75	225
"Sticky formation"	40	265
Sandstone	10	275
"Soapstone"	75	350
Shale, white	15	365
Limestone, Silurian system all or chiefly Niagaran	325	690
Shale, Maquoketa	200	890
Limestone, Galena-Platteville	320	1210
Sandstone St. Peter	50	1260
Shale St. Peter	10	1270
Sandstone St. Peter	70	1340
Shale St. Peter	4	1344
Limestone, brown and red Prairie du Chien	20	1364

The well was cased with 12-inch pipe to a depth of 119 feet, with 170 feet of 105/8-inch pipe with the bottom at a depth of 284 feet, and 100 feet of 8¼-inch casing with the bottom at a depth

of 375 feet. The diameter is 8¼ inches at the bottom. When the well was completed it was pumped at a rate of 200 gallons a minute. The pump cylinder was at a depth of 237 feet. The well is equipped with a deep-well pump. The cylinder is placed about 10 feet below the water level at a depth of about 220 feet and has 18 or 20 feet of suction pipe attached. The discharge when the pump is in good condition is given as 28 gallons a minute. On April 8, 1924, the discharge of the pump through a connection opened at the top of the well, was 22 gallons a minute. During regular operation against pressure the discharge would be less.

A sample of water, number 36310, collected on January 18, 1917, had a mineral content of 1017, a total hardness of 215, and a content of iron of 0.2 parts per million as shown by the analysis.

Analysis of Sample Number 36310 from Well 1364 Feet Deep.

Determinations Made.	Parts per million.
Iron, Fe	0.2
Silica, SiO_2	4.8
Alumina, Al_2O_3	4.0
Calcium, Ca	52.3
Magnesium, Mg	20.5
Ammonia, NH_4	1.6
Sodium, Na	277.2
Potassium, K	18.3
Sulfate, SO_4	288.0
Nitrate, NO_3	1.7
Chloride, Cl	225.0
Alkalinity, Methyl Orange	240.0
Residue	1053.0

Hypothetical Combinations.	Parts Per Million.	Grains Per Gallon.
Potassium Nitrate KNO_3	2.8	.16
Potassium Chloride KCl	32.8	1.91
Sodium Chloride NaCl	345.5	20.15
Sodium Sulfate Na_2SO_4	419.7	24.47
Ammonium Sulfate $(NH)_2SO_4$	5.9	.37
Magnesium Carbonate $MgCO_3$	71.0	4.14
Calcium Carbonate CaCO	130.5	7.61
Iron Oxide Fe_2O_3	0.3	.02
Alumina Al_2O_3	4.0	.23
Silica SiO_2	4.8	.28
Total	1017.3	59.31

The water was not considered satisfactory for use in locomotives and was not used by the railroad company. A length of galvanized steel drop pipe above the pump cylinder in the well is replaced about every three years.

ALTAMONT (1352). Altamont is located in the western part of Effingham County on the watershed between tributaries of Little Wabash and Kaskaskia Rivers. Many dug wells about 20 feet deep and a few drilled wells about 150 feet deep are in use.

A public water supply was installed by the city in 1913. Water from wells located in the city was pumped into a collecting reservoir from which it was pumped into the distribution system by a steam pump. This supply is now used for boiler water at the municipa1 water and power plant. The public water supply is now secured from two wells located east of the city. A concrete

reservoir into which water from these wells is discharged has been built close to the pumping station in the city. Water is pumped from the reservoir into the distribution system and an elevated steel tank of 40,000 gallons capacity which is connected to the system, by a Dayton-Dowd singe-stage centrifugal pump of 300 gallons a minute capacity. The pump is driven by a 20-horsepower electric motor. The pumping station is operated in connection with an electric power plant. Fifty-five consumers were supplied with water in 1924 and the consumption during the summer was estimated at 20,000 gallons a day. The rate for water for three months is $1.00 per 1000 gallons for the first 3000 gallons and 75 cents per 1000 gallons for additional water, with a minimum charge of $2.00.

A well at the municipal electric plant was used to supply water for the boilers for several years before the water works was installed. It is 6 inches in diameter and 131 feet deep. The yield was small and the well has not been used for several years. When the pump was idle the depth to water was said to be 20 feet in 1913 and 50 feet in 1917.

In an attempt to secure an additional supply when the water works was installed in 1913 a well was drilled 200 feet south of the old well to a depth of about 328 feet. Very little water was found until salt water was encountered and the well was abandoned.

Another well was then drilled by R. H. Kersey. It is located 40 feet north and west of the old well. A record of the material penetrated, as given by Mr. Kersey, is as follows:

	Thickness in feet.	Depth to bottom- in feet.
Drift	55	55
Blue shale	85	140
Sand rock	50	190
Shale	35	225

The well is cased to a depth of 60 feet with 8-inch pipe and between depths of 60 and 110 feet with 6-inch pipe. After drilling, water stood at a depth of 100 feet. The well was then blasted and water raised to within 58 feet of the ground surface. The well is equipped with a steam-head deep-well pump with a 3½-inch water cylinder and 24-inch stroke. During a test at the time of visit in 1913 with the pump cylinder at a depth of 100 feet the well yielded 10 gallons a minute. In 1917 the pump was operating from 15 to 16 strokes a minute, a displacement of 15 gallons a minute, a total of about seven hours a day. The total yield as operated was probably less than 6000 gallons a day. It was

operated about 45 minutes at a time, as after that time the pump would draw air. When not pumping, water stood at a depth of 50 feet.

Well number 3, located 600 feet east and 100 feet south of the old well, back of the city hall, was drilled by C. C. Kavanaugh. The material penetrated is as follows:

	Thickness in feet.	Depth to bottom in feet.
Yellow clay and sand	40	40
Shale	55	95
Limestone	5	100
Sand	45	145

This well is cased with 7-inch pipe. It is equipped with an electrically driven Luitwieler deep-well pump with a 3½-inch cylinder and 18-inch stroke.

A sample of water, number 37749, collected from well number 3 in 1917, had a mineral content of 758, a total hardness of 149, and a content of iron of 0.2 parts per million as shown by the analysis.

Analysis of Sample Number 37749 from Well Number 3.

Determinations Made.	Parts per million.
Iron, Fe	0.2
Silica, SiO_2	16.4
Alumina, Al_2O_3	1.3
Calcium, Ca	29.3
Magnesium, Mg	18.3
Ammonia, NH_4	0.4
Potassium, K	6.0
Sodium, Na	242.1
Nitrate, NO_3	1.8
Chloride, Cl	210.0
Sulfate, SO_4	1.1
Nonvolatile	1.0
Alkalinity, Methyl Orange	414.
Residue	735.

Hypothetical Combinations.	Parts Per Million.	Grains Per Gallon.
Potassium Nitrate KNO_3	2.9	.17
Potassium Chloride KCl	9.3	.54
Sodium Chloride NaCl	339.3	19.79
Sodium Sulfate Na_2SO_4	1.6	.09
Sodium Carbonate Na_2CO_3	248.4	14.49
Ammonium Carbonate $(NH_4)_2CO_3$	1.1	.06
Magnesium Carbonate $MgCO_3$	63.4	3.69
Calcium Carbonate $CaCO_3$	73.1	4.27
Iron Oxide Fe_2O_3	0.3	.02
Alumina Al_2O_3	1.3	.08
Silica SiO_2	16.4	.96
Nonvolatile	1.0	.06
Total	758.1	44.22

A sample, number 37748, collected from well number 2 in 1917, had a. mineral content of 880, a total hardness of 188, and a content of iron of 0.4 parts per million. A sample collected from this well in 1913 was less highly mineralized and very similar to the water collected from well number 3 in 1917.

The public water supply is now secured from two wells into sand and gravel located about one mile west and about 400 feet south from the pumping station in the city. The ground surface is 14 feet higher at the wells than it is at the reservoir in the city.

One of the wells, number 1, was installed in 1922. At the top is a pit 8 feet in diameter and 6 feet deep lined with concrete. Below this is a shaft about 30 inches in diameter and 6 feet deep. From the bottom of the shaft an 8-inch well is drilled to a depth of 35 or 40 feet below the ground surface. In the bottom is a Cook screen 15 feet long. The well is equipped with an American centrifugal pump which is driven by an electric motor on a vertical shaft. The pump is placed at the bottom of the brick-lined shaft. When not pumping water rises to nine feet below the ground surface and flows through the pipe line to the city. The rate of discharge when pumping is said to be from 15,000 to 20,000 gallons a day. The well is within 20 feet of an old spring or dug well. Before the city well was installed water flowed from the spring into a pond. The water level in the spring on October 15, 1924, was 10 feet below the ground surface.

Well number 2 was installed in the fall of 1923. It was constructed similar to well number 1. Below 8 or 10 feet of soil and clay is 40 feet of sand and gravel. Below the gravel is blue shale. The bottom of the gravel here is about 10 feet lower than at well number 1. At the top of the well is a concrete pit 12 feet in diameter and 6 feet deep. This well was being enlarged in 1924 by sinking a 38-inch steel casing below the concrete pit. A concrete strainer 18 inches inside diameter with 116 square inches opening per foot, made by H. E. Will, is to be installed in the bottom and gravel placed- around the strainer. With temporary equipment. in place in 1924, with a pump in the bottom of the concrete pit, the rate of yield was estimated at 20,000 gallons a day. When not pumping, water raised to nine feet below the ground surface and flowed through the pipe line to the city.

The total amount of water pumped from the two wells in the summer of 1924 was said to be 25,000 gallons a day. Pumping had not affected the water level in farm wells in the vicinity.

The yield on January 9, 1925, when measured by noting the rise in water level in the reservoir in the city did not exceed five gallons a minute. It is probable that all or nearly all of this water was from well number one.

A sample of water, number 53151, collected on January 29, 1925, from a tap in the pumping station in the city, had a mineral content of 501 and a total hardness of 290 parts per million and contained no iron, as shown by the analysis.

Analysis of Sample Number 53151 from the City Supply.

Determinations Made.

	Parts per million.
Iron, Fe	0.0
Manganese, Mn	0.0
Silica, SiO_2	18.8
Nonvolatile	0.8
Alumina, Al_2O_3	0.9
Calcium, Ca	61.3
Magnesium, Mg	33.4
Ammonia, NH_4	0.0
Sodium, Na	65.1
Potassium, K	2.2
Sulfate, SO_4	148.2
Nitrate, NO_3	4.4
Chloride, Cl	3.0
Alkalinity,	
Phenolphthalein	0.
Methyl Orange	312.
Residue	472.

Hypothetical Combinations.

	Parts Per Million.	Grains Per Gallon.
Potassium Nitrate KNO_3	5.6	.33
Sodium Nitrate $NaNO_3$	1.3	.08
Sodium Chloride NaCl	4.9	.29
Sodium Sulfate Na_2SO_4	193.9	11.33
Magnesium Sulfate $MgSO_4$	21.2	1.24
Magnesium Carbonate $MgCO_3$	100.9	5.90
Calcium Carbonate $CaCO_3$	153.2	8.95
Alumina Al_2O_3	0.9	.05
Silica SiO_2	18.8	1.10
Nonvolatile	0.8	.04
Total	501.5	29.31

AMBOY (1944). Amboy is located in the central part of Lee County on the north bank of Green River.

A public water supply was installed by the city about 1893. Water from a deep well, equipped with a deep-well pump, was pumped into a reservoir 20 feet in diameter from which it was pumped into the distribution system. An elevated steel tank located back of the station was connected to the mains. The deep-well pump was replaced by an air lift and in 1915 the air lift was replaced by another deep-well pump. Water is pumped from the reservoir by a Goulds 8½ by 10-inch triplex pump, driven by a 35-horsepower electric motor. About 350 service connections were in use in 1923. The rates, not subject to discount, are:

0	to	5,000	gallons	35	cents	per 1000	gallons
5,000	to	10,000	gallons	30	cents	per 1000	gallons
10,000	to	15,000	gallons	25	cents	per 1000	gallons
15,000	to	20,000	gallons	20	cents	per 1000	gallons
20,000	to	25,000	gallons	15	cents	per 1000	gallons
	Over	25,000	gallons	12½	cents	per 1000	gallons

The Amboy Milk Products Company uses large quantities of water and is charged 8 cents for amounts over 25,000 gallons.

The Amboy Milk Products Company has drilled seven wells to depths of from 75 to 150 feet. They did not secure any water from the wells and are using river water for cooling purposes and city water for cleaning. The railroads have private surface water supplies.

Water for the public supply is from a well 2012 feet deep located near the center of the city. It was drilled by the J. P. Miller

Artesian Well Company. The top of the well is 750 feet above sea level. St. Peter sandstone with a small flow of water was entered at a depth of 180 feet. At a depth of 455 feet the flow was noted as 5 gallons a minute and at a depth of 1020 feet it was noted the flow was decreasing. Some notes on material were made by the drillers. At 515 feet was limestone, at 730 feet was red marl and sandy lime, at 750 and at 775 was hard red marl, at 920 and 970 was shale, at 1080 was sandstone (Cambrian), and at 1340 was limestone. In 1915 when measurements were made it was found that the well is cased. with 10-inch pipe to a depth of 57 feet and that for some distance below that depth the diameter is 6 inches.

The well is equipped with an American deep-well pump with 36-inch stroke. In their bid the company offered a figure 380 A, 7½-inch cylinder which apparently was installed. The bottom of the suction pipe attached to the cylinder is at a depth of 79 feet. The pump operates 19 revolutions a minute. At the time of visit in October, 1921, water discharged by the deep-well pump raised the water level in the reservoir 2 feet 10 inches in 30 minutes, a rate of discharge of 222 gallons a minute. When the well was drilled it flowed. The water level when not pumping was at a depth of 10 feet in 1915 and was said to be at a depth of 12 or 15 feet in 1921.

A sample of water, number 46414, collected at the pumping station in December, 1921, had a mineral content of 496, a total hardness of 419, and a content of iron of 1.3 parts per million as shown by the analysis.

Analysis of Sample Number 46414 from the City Supply.

Determinations Made.

	Parts per million.
Iron, Fe	1.3
Manganese, Mn	0.1
Silica, SiO_2	16.8
Nonvolatile	1.4
Alumina, Al_2O_3	3.6
Calcium, Ca	98.3
Magnesium, Mg	42.1
Ammonia, NH_4	0.3
Sodium, Na	21.8
Potassium, K	4.1
Sulfate, SO_4	53.0
Nitrate, NO_3	1.1
Chloride, Cl	22.0
Alkalinity, Phenolphthalein	0.
Alkalinity, Methyl Orange	356.
Residue	483.

Hypothetical Combinations.

	Parts Per Million.	Grains Per Gallon.
Potassium Nitrate KNO_3	1.7	.10
Potassium Chloride KCl	6.5	.48
Sodium Chloride NaCl	31.1	1.82
Sodium Sulfate Na_2SO_4	29.5	1.72
Ammonium Sulfate $(NH_4)_2SO_4$	0.9	.06
Magnesium Sulfate $MgSO_4$	40.5	2.37
Magnesium Carbonate $MgCO_3$	117.1	6.85
Calcium Carbonate $CaCO_3$	245.5	14.35
Silica SiO_2	16.8	.98
Nonvolatile	1.4	.08
Iron Oxide Fe_2O_3	1.8	.11
Alumina Al_2O_3	3.6	.21
Total	496.4	29.13

A sample collected in 1913 was similar but a little less highly mineralized. The mineral content was 415, the total hardness 373, and the content of iron 1.4 parts per million.

Since data for the above report were secured, another well has been drilled and it has been equipped with an American deep-well turbine pump. In April, 1923, it was estimated the wells yielded at a rate of 225 gallons a minute and a total of about 90,000 gallons a day.

ANNA (3019). Anna is located in the central part of Union County on the drainage area of Cache River about thirty miles north of Cairo. The Anna State Hospital is located near the eastern limits of the city.

Some private wells in use are from 20 to 60 feet deep and a few are as much as 200 feet deep. All draw water from limestone which is encountered a few feet below the ground surface. The hospital developed a supply from wells from 460 to 500 feet deep but this was inadequate and a supply is now obtained in part from an impounding reservoir of about 30,000,000 gallons capacity on Kohler Creek 3 miles west and north of the city, and in part from a creek close to the reservoir. The water is filtered.

A public water supply was installed in 1912. Mains were laid, an elevated steel tank of 100,000 gallons capacity was erected on a 70-foot tower, and water was purchased from the Central Illinois Public Service Company. Electrically driven machinery has been intalled by the company and a steam pump and a steam-driven compressor are held in reserve. Water is pumped from a well into a reservoir by air lift and from the reservoir to the mains by a Ro-Turbo centrifugal pump of 400 gallons a minute capacity which is direct connected to a 25-horsepower electric motor. A Ro-Turbo pump of 750 gallons a minute capacity direct connected to a 75-horsepower electric motor is used at times of fire. Air is supplied by an 11 by 12-inch compressor which is driven at 270 revolutions a minute by a 75-horsepower electric motor. This compressor was installed in 1923. The reservoir has two compartments, each 17 by 26 feet in plan and 11 feet deep.

Water for the public supply is obtained from a well 650 feet deep located in the southeastern part of the city. The diameter is 12 inches to a depth of 100 feet and 8 inches below that depth. The lower part of the well is in rock. Water probably comes from the lower 15 feet of the well. The well is equipped with an air lift. In

1913 the air line extended to a depth of 350 feet. The rate of yield, measured in the reservoir, was 300,000 gallons a day and the depth to water when not pumping was given as 90 feet.

The rate of yield during a test in June, 1924, after the air lift had operated for five hours with the compressor running 270 revolutions a minute was 440 gallons a minute. The water level, computed from gauge pressure, was at a depth of 77 feet when not pumping and at a depth of 94 feet when pumping.

The temperature of water when discharged from the well on July 22, 1924, was 60 degrees Fahrenheit. A sample of water, number 51935, collected at the well on September 8, 1924, had a mineral content of 434, a total hardness of 307, and a content of iron of 1.0 parts per million as shown by the analysis.

Analysis of Sample Number 51935 from the City Supply.

Determinations Made.	Parts per million.
Iron, Fe	1.0
Manganese, Mn	0.0
Silica. SiO_2	17.4
Nonvolatile	1.5
Alumina, Al_2O_3	1.6
Calcium, Ca	88.3
Magnesium, Mg	21.2
Ammonia, NH_4	0.0
Potasissum, K	3.2
Sodium, Na	26.3
Sulfate, SO_4	22.4
Nitrate, NO_3	74.4
Chloride, Cl	37.0
Alkalinity, Phenolphthalein	0.
Alkalinity, Methyl Orange	252.
Residue	424.

Hypothetical Combinations.	Parts Per Million.	Grains Per Gallon.
Potassium Nitrate KNO_3	8.4	0.49
Sodium Nitrate $NoNO_3$	94.9	5.54
Sodium Chloride NaCl	1.5	0.08
Magnesium Chloride MgCl	48.4	2.83
Magnesium Sulfate $MgSO_4$	28.0	1.63
Magnesium Carbonate $MgCO_3$	10.9	0.64
Calcium Carbonate $CaCO_3$	220.4	12.87
Iron Oxide Fe_2O_3	1.4	0.08
Alumina $A1_2O_3$	1.6	0.09
Silica SiO_2	17.4	1.02
Nonvolatile	1.5	0.08
Total	434.4	25.35

ANTIOCH (775). Antioch is located in the northern part of Lake County on the drainage area of Fox River. Many private wells dug or drilled to sand are in use. At some places the depth to sand is 14 feet and at other places it is more than 50 feet.

A public water supply was installed by the village in 1907. A well was drilled and equipped with a deep-well pump, an elevated steel tank 12 feet in diameter and 40 feet high was erected on a brick tower 60 feet high, and 6-inch mains were laid to practically all parts of the village. Later another well was drilled. Each well is equipped with an electrically driven deep-well pump which discharges directly into the mains. Either pump may be driven by belt from a gasoline engine. Electric current is purchased from the

Public Service Company of Northern Illinois. In June, 1921, two hundred and seven consumers were supplied with water and the total quantity of water used, as measured by service meters, was about 6,000,000 gallons a year. A meter is to be installed in the pumping station.

Water is secured from two wells located near the center of the village. The elevation of the tops of the wells is about 770 feet above sea level. Fine sand was encountered below a depth of 40 feet, and below a depth of 180 feet some of the sand was coarser. The first well was drilled by Charles Thorne in 1907. It is 6 inches in diameter, 216 feet deep, and in the bottom is a Johnson screen 4½ inches in diameter and 9 feet long. It is equipped with a Goulds deep-well pump with the pump cylinder, to which 12 feet of suction pipe is attached, at a depth of about 80 feet. The pump operates about 46 revolutions a minute and has discharged 40 gallons a minute. The average discharge is probably considerably less due to wear of leathers by fine sand.

Analysis of Sample Number 45491 from the Village Supply.

Determinations Made.

	Parts per million.
Iron, Fe	00.0
Manganese, Mn	0.0
Silica, SiO_2	18.1
Nonvolatile	0.4
Alumina, Al_2O_3	0.9
Calcium, Ca	22.9
Magnesium, Mg	18.5
Ammonium, NH_4	0.05
Potassium, K	2.8
Sodium, Na	62.0
Sulfate, SO_4	93.3
Nitrate, NO_3	1.4
Chloride, Cl	7.0
Alkalinity, Phenolphthalein negative	
Methyl Orange	170.0
Residue	311.

Hypothetical Combinations.

	Parts Per Million.	Grains Per Gallon.
Potassium Nitrate KNO_3	2.0	.12
Potassium. Chloride. KCl	3.9	.23
Sodium Chloride NaCl	8.7	.51
Sodium Sulfate Na_2SO_4	137.8	8.06
Sodium Carbonate Na_2CO_3	32.4	1.90
Ammonium Carbonate $(NH_4)_2CO_3$	0.1	.01
Calcium Carbonate $CaCO_3$	57.0	3.33
Magnesium Carbonate $MgCO_3$	64.1	3.75
Silica SiO_2	18.1	1.06
Nonvolatile	0.4	.02
Alumina Al_2O_3	0.9	.05
Total	325.4	19.04

The other well was drilled in 1919 about 20 feet distant from the first well. The depth is reported by various persons at from 220 to 237 feet. It is 10 inches in diameter and the lower length of casing was bored with holes and wrapped with fine screen. The well was tested for 48 hours. It is reported that the yield was 100 gallons a minute, that the water level was lowered 4 feet in 15 minutes, and that continued pumping gave no further lowering. The well is equipped with a Luitwieler deep-well pump, with 5¾-inch cylinder and 15-inch stroke, driven through gears by a 10-

horsepower electric motor. It was operating at 32 revolutions a minute at which speed it would discharge near 100 gallons a minute if the leathers were in good condition but the leathers are worn by fine sand.

The temperature of the water was 53 degrees Fahrenheit. The water had a mineral content of 325, a total hardness of 131, and contained no iron as shown by the analysis of sample number 45491, collected at the well on June 22, 1921.

The water causes comparatively little scale in boilers and hot water heaters and is used for washing by many residents in place of cistern water.

ARCOLA (1831). Arcola is located in the southwestern part of Douglas County on the watershed between Embarrass and Kaskaskia Rivers. A limited supply of water is secured from some private wells into sand above blue clay at a depth of about 20 feet and a greater supply is secured from wells which are drilled to a stratum of sand below the blue clay to a depth of from 90 to 100 feet.

A public water supply was installed by the city in 1890-1891. Water was pumped from a dug well. Later wells were drilled and equipped with steam-head deep-well pumps and the dug well was used as a collecting reservoir from which water was pumped into the mains. The dug well has been filled and a collecting reservoir built with two compartments, each 29½ feet by 30 feet at the top and 8 feet deep. Two automatically controlled Luitwieler pumps, each driven by an electric motor, have been installed to pump from the reservoir into the mains and a meter in the pumping station records the amount of water pumped. An elevated steel tank 12 feet in diameter and 40 feet high on a 60-foot steel tower, located on the same plot of ground as the station and reservoir, is connected to the mains. The charge for the first 5000 gallons of water used in three months is thirty cents per 1000 gallons with a minimum charge of $1.00. For larger quantities the charge is less and for quantities in excess of 35,000 gallons it is ten cents per 1000 gallons.

The original well, located at the northeast corner of Oak and Locust Streets, was 12 feet in diameter and 70 feet deep. It is said that the elevated tank was filled in 1 hour 28 minutes from this well. Fine sand entered the well and the yield decreased. This trouble was undoubtedly due in large part to the high rate of pumping. Wells were then drilled on the plot of ground

on which the dug well and pumping station were located. Some of these wells were not equipped with screens and considerable trouble was experienced with fine sand. In time the yield of a well would decrease and additional wells would be drilled. Steam pumps were first used, later some wells were equipped with air lift and these were abandoned in favor of electrically-driven deep-well pumps. The last wells drilled are located in Oak Street and all other wells have now been abandoned.

The public water supply is now secured from four wells, each 100 feet deep, located on Oak Street north of Jefferson Street. The elevation of the tops of the wells is about 680 feet above sea level. The two south wells, about 260 feet apart, were drilled more than ten years ago. They are 8 inches in diameter and penetrate about 4 feet of sand and gravel. The north one of these two wells has a number 16 screen and the south one has a number 20 screen. Each is equipped with a Luitwieler deep-well pump with a 4¾-inch cylinder and 10-inch stroke, which operates 33 revolutions a minute. A suction pipe extends to within 2 feet of the bottom of each well. In the spring of 1921 all water pumped was from these two wells and the total supply did not exceed 15,000 gallons a day. When visited in November, 1923, the south well was in use but no water could be secured from the north one.

The two north wells were drilled in 1921 and furnish the entire supply excepting at times of maximum demand. They are 200 feet apart and the average spacing of the four wells is slightly more than 200 feet. Each of these two wells is 12 inches in diameter. The north well penetrates 18 inches of good sand and gravel and is equipped with a number 25 Cook screen 8 feet long. The south one of these two wells penerated 9 feet of coarse sand and gravel and has a number 20 Cook screen 10 feet long. Each of these two wells is equipped with a Cook double-stroke deep-well pump with 4¾-inch cylinder and 18-inch stroke, which is operated at 19½ revolutions a minute. A suction pipe extends to within two feet of the bottom of each well.

In 1921, when equipment was installed in the two north wells, one well was tested for 24 hours and yielded 50 gallons a minute. On November 13, 1923, after 10 hours continuous operation the discharge from the two wells raised the water level in the reservoir 3 1/16 inches in 52 minutes, a yield of 65 gallons a minute. The south well of the four wells had operated 4 hours 20 minutes during the day and was shut down immediately preceding this test. On the morning of November 12, after 3 hours operation, the discharge

from the two north wells raised the water level in the reservoir 5⅝ inches in 90 minutes, a yield of 68 gallons a minute. New leathers had been put on the pumps in 1923.

The amount of water pumped, as shown by meter readings, is recorded by Mr. Caldwell. The consumption, which also gives the yield of the wells, was 17,000,000 gallons during 1922, an average of 47,000 gallons a day. The consumption during 1923 to November 12, averaged 51,000 gallons a day. In August, 1923, the consumption was 2,110,000 gallons, an average of 68,000 gallons a day, and during September it averaged 63,000 gallons a day. At times of maximum demand one well pump was operated during the night and all four were operated during the day time.

The depth of water in one of the north wells when equipment was installed in 1921 was 40 feet before pumping and 53 feet after pumping continuously for 24 hours at a rate of 54 gallons a minute. During regular operation the water level is drawn down nearly to the bottoms of the wells. The depth to water in the well next to the north, on September 25, 1923, after the pump had operated continuously for 10 hours, was 98.7 feet.

The temperature of water discharged from one of the wells in 1923 after pumping for one hour forty minutes was 55 degrees Fahrenheit. The water had a mineral content of 665, a total hardness of 195, and a content of iron of 6.0 parts per million as shown by the analysis of sample number 50198, collected from the well next to the north well after pumping for 90 minutes on September 25, 1923.

Analysis of Sample Number 50198 from City Supply.

Determinations Made.

	Parts per million.
Iron, Fe	6.0
Manganese, Mn	0.0
Silica, SiO_2	23.3
Nonvolatile	1.1
Alumina, Al_2O_3	4.7
Calcium, Ca	40.2
Magnesium, Mg	23.0
Ammonia, NH_4	16.7
Sodium, Na	139.6
Potassium, K	40.0
Sulfate, SO_4	1.7
Nitrate, NO_3	1.4
Chloride, Cl	58.0
Alkalinity,	
Phenolphthalein	0.
Methyl Orange	504.
Residue	640.

Hypothetical Combinations.

	Parts Per Million.	Grains Per Gallon.
Potassium Nitrate KNO_3	2.3	0.13
Potassium Chloride KCl	74.5	4.35
Sodium Chloride NaCl	37.2	2.17
Sodium Sulfate Na_2SO_4	2.6	0.15
Sodium Carbonate Na_2CO_3	286.1	16.71
Ammonium Carbonate $(NH_4)_2CO_3$	44.5	2.60
Magnesium Carbonate $MgCO_3$	79.5	4.64
Calcium Carbonate $CaCO_3$	100.7	5.88
Iron Oxide Fe_2O_3	8.6	0.50
Alumina Al_2O_4	4.7	0.27
Silica SiO_2	23.3	1.36
Nonvolatile	1.1	0.06
Total	665.1	38.82

A sample collected in 1912 from wells then in use was more highly mineralized. The mineral content was 847, the total hardness 400, and the content of iron 5 parts per million.

Rotary meters placed on discharge lines from the well pumps were removed as they clogged, due partly to the iron content of the water. Little trouble is experienced with meters on the distribution system.

ARLINGTON (284). Arlington is located in the northeastern part of Bureau County on the drainage area of Brush Creek, a stream tributary to Bureau Creek and Illinois River. A public water supply was installed by the village in 1893. Water was secured, from a well which became clogged with sand and was abandoned. Water is now secured from two wells equipped with deep-well pumps which discharge directly into the distribution system and an elevated wooden tank which is connected to the system. Both pumps are operated from one -crank shaft which is driven by belt from a 10-horsepower electric motor.

Analysis of Sample Number 52944 from the Village Supply.

Determinations Made.	Parts per million.
Iron, Fe	4.0
Manganese, Mn	0.0
Silica, SiO_2	15.5
Nonvolatile	1.2
Alumina, Al_2O_3	0.0
Calcium, Ca	73.4
Magnesium, Mg	36.1
Ammonia, NH_4	0.0
Sodium, Na	19.1
Potassium, K	6.2
Sulfate, SO_4	31.7
Nitrate, NO_3	0.7
Chloride, Cl	11.0
Alkalinity, Methyl Orange	320.
Residue	415.

Hypothetical Combinations.	Parts Per Million.	Grains Per Gallon.
Potassium Nitrate KNO_3	1.1	0.06
Potassium Chloride KCl	11.0	0.64
Sodium Chloride NaCl	9.5	0.55
Sodium Sulfate Na_2SO_4	46.9	2.74
Sodium Carbonate Na_2CO_3	0.5	0.03
Ammonium Carbonate $(NH_4)_2CO_3$	0.0	0.00
Magnesium Carbonate $MgCO_3$	124.9	7.29
Calcium Carbonate $CaCO_3$	183.2	10.70
Iron Oxide Fe_2O_3	5.7	0.33
Silica SiO_2	15.5	0.90
Nonvolatile	1.2	0.07
Total	399.5	23.31

Water is secured from two 6-inch wells, both 94 feet deep, located 3 feet apart. They penetrate a sand and gravel stratum to a depth of about 6 feet. The elevation of the tops of the wells is about 750 feet above sea level. The wells are equipped with deep-well pumps with 3¾-inch cylinders and 10-inch stroke. The cylinders are at a depth of about 40 feet. In 1923 and in 1924 the pumps were operated at 44 revolutions a minute for about 4 hours a day. The water level when not pumping was at a depth of about 20 feet. Both wells were first equipped with fine screens.

The fine screen from one well was replaced with a screen of 4½-inch pipe perforated with ¼-inch holes. The pump in the well with the large screen is thought to discharge at near capacity and the other pump is thought to discharge much less. About 45 service connections were in use in 1923.

The water had a mineral content of 399, a total hardness of 331, and a content of iron of 4.0 parts per million as shown by the analysis of sample number 52944, collected at the pumping station on December 5, 1924.

ARLINGTON HEIGHTS (2250). Arlington Heights is located in the northern part of Cook County on the drainage area of Des Plaines River.

A public water supply was installed by the village in 1900. Water from a well flowed into a reservoir from which it was pumped into the distribution system. An elevated steel tank of 68,000 gallons capacity on a steel tower 85 feet high was connected to the system. With increasing demands and lowering of the water level it was necessary to drill additional wells and they were equipped with deep-well pumps which discharge directly into the mains. A 48-horsepower boiler and two Fairbanks-Morse 8 and 12 by 8 and 12-inch compound duplex steam pumps, formerly in regular use to pump from the reservoir, are maintained for service at time of emergency.

About 600 consumers were supplied in 1923 and as nearly as could be estimated the average demands were near 125,000 gallons a day. There are no consumers using large quantities of water. The rates are 30 cents per 1000 gallons for the first 10,000 gallons and 25 cents per 1000 gallons for the next 10,000 gallons. The rate decreases to 12 cents per 1000 gallons for quantities in excess of 100,000 gallons. A penalty of ten per cent is added for late payment.

The pumping station and wells are located to the west of the intersection of Railroad and Wing Streets. The ground surface at the wells is about 700 feet above sea level. The original well was 5 inches in diameter and 127 feet deep. In 1900 the well flowed. Later air lift equipment was installed and in 1914 when the air lift was not operating water stood 12 feet below the ground surface. The equipment has been sold and a plug driven in the top of the well. The depth of the well in 1923 was 118 feet.

A 12-inch well was drilled 40 feet southeast of the 5-inch well in 1919. Rock, about 75 feet thick, was encountered at a depth of 120 feet. Above the rock was about 15 feet of quicksand and below

the rock the well was in shale to the bottom at a depth of 253 feet. The well was blasted with 25 pounds of dynamite. It filled below a depth of 108 feet and was then abandoned.

The public water supply is now secured from two wells. One well, drilled in 1909, is 10 inches in diameter and about 140 feet deep. It is equipped with a Keystone Driller Company double-stroke deep-well pump driven by belt from a 15-horsepower electric motor. The pump cylinder to which 18 feet of suction pipe is attached is 6¾ inches in diameter and is placed at a depth of 120 feet. It operates with 18-inch stroke about 30 strokes a minute.

The other well was drilled in 1920. It is 40 feet northeast of the well drilled in 1909 and 3 feet west of the abandoned 5-inch well. It is 10 inches in diameter and 143 feet deep and is cased to rock at a depth of 120 feet. It is equipped with a Cook double-stroke deep-well pump driven by belt from an oil engine. The cylinder, to which 18 feet of suction pipe is attached, is 7¾ inches in diameter and is placed at a depth of 120 feet. Both pumps cannot be operated at once for any considerable period without drawing air, and the pump driven by oil engine is usually used as the operating cost is less. On November 21, 1923, when this pump had operated for 8 hours or more the depth to water in the abandoned 5-inch well, 3 feet distant, was 67 feet. Mr. Kolling in charge of the station estimates that 225 gallons a minute could be pumped from the two wells. The total amount pumped in 1923 probably averaged near 125,000 gallons a day.

Analysis of Sample Number 50607 from Village Supply.

Determinations Made.

	Parts per million.
Iron, Fe	0.2
Manganese, Mn	0.0
Silica, SiO_2	17.0
Nonvolatile	1.6
Alumina, Al_2O_3	0.5
Calcium, Ca	61.4
Magnesium, Mg	42.9
Ammonia, NH_4	0.4
Sodium, Na	67.9
Potassium, K	18.1
Sulfate, SO_4	404.3
Nitrate, NO_3	1.4
Chloride, Cl	4.0
Alkalinity,	
Phenolphthalein	0.
Methyl Orange	88.
Residue	664.

Hypothetical Combinations.

	Parts Per Million.	Grains Per Gallon.
Potassium Nitrate KNO_3	2.3	0.13
Potassium Chloride KCl	8.4	0.49
Potassium Sulfate K_2SO_4	2.8	0.16
Sodium Sulfate Na_2SO_4	209.7	12.25
Ammonium Sulfate $(NH_4)_2SO_4$	1.7	0.10
Magnesium Sulfate $MgSO_4$	212.1	12.39
Calcium Sulfate $CoSO_4$	107.4	6.27
Calcium Carbonate $CaCO_3$	74.5	4.35
Iron Oxide Fe_2O_3	0.3	0.02
Alumina Al_2O_3	0.5	0.03
Silica SiO_2	17.0	0.99
Nonvolatile	1.6	0.09
Total	638.3	37.27

The water had a mineral content of 638, a total hardness of 339, and a content of iron of 0.2 parts per million as shown by the

analysis of sample number 50607, collected on November 21, 1923, after pumping from the well 143 feet deep for several hours.

Some meters and some galvanized service pipes have been in use since 1902. Iron in the water causes some staining of plumbing fixtures.

ARTHUR (998). Arthur is located in Moultrie and Douglas Counties on the drainage area of Kaskaskia River, a tributary of Mississippi River.

Many private wells are in use. Some are less than thirty feet deep. Others pass through hardpan, entered at depths of from 25 to 30 feet, into sand at depths of from 60 to 80 feet. Many of these deeper wells are not cased through the hardpan.

A public water supply was installed by the city in 1911-1914. Water flows from wells into a collecting reservoir from which it is pumped into the distribution system. Few important changes have been made in the system. The pump is an 8 by 10-inch single-acting triplex and it is driven by belt from a 15-horsepower electric motor at a speed of 47 revolutions a minute. The discharge is about 280 gallons a minute and during the year to May, 1923, the pump was operated an average of a little less than 3 hours a day. A 28horse-power gas engine formerly used can be used in case of emergency. An elevated steel tank of 50,000 gallons capacity, the top of which is 110 feet above the foundation, is located on the same lot as the wells and is connected to the distribution system. About 150 consumers were supplied with water in 1923. The total consumption averaged about 47,000 gallons a day. The domestic rate is 35 cents per 1000 gallons and the rate to the Pennsylvania Railroad, the largest consumer, is 12½ cents per 1000 gallons.

The public water supply is secured from three wells located east of Cleveland Street on the north side of South First Street. The ground surface at the tops of the wells is about 660 feet above sea level. The wells penetrate soil, yellow clay, blue clay, hardpan, and fine sand. The hardpan is encountered at a depth of about 30 feet and extends to near the bottoms of the wells. The wells were cleaned in.1922 and measured 67, 68, and 69 feet deep. The west well was then drilled to a depth of 89 feet. Quicksand was encoun tered at a depth of 72 feet and 2 feet of material in the bottom is said to be gravel. The wells are not equipped with screens. A reservoir 20 feet in diameter is excavated around the tops of the wells to a depth of more than 20 feet. The tops of the well casings are cut off 21 feet 5 inches below the top of the reservoir wall or

about 20 feet below the ground surface. The yields of the wells were measured on April 26 and on June 30, 1923, by noting the rise of water level in the reservoir. The yield was 57 gallons a minute when the water level was below the tops of the well casings and decreased to 26 gallons a minute when the water level raised to 14 feet below the top of the reservoir. When pumping from the city wells the depth to water in two private wells into the same stratum, 150 and 350 feet distant, was 51 inches and 43 inches respectively. The ground surface at these private wells is probably 2 feet lower than at the city wells and the difference of 8 inches to water is probably due principally to differences in elevation of well tops. Pumping from the city wells did not lower the water level in these wells, there being a rise of a fraction of an inch in water level in one due undoubtedly to the fact that no water was pumped from these private wells during the test.

The water had a mineral content of 554, a total hardness of 325, and a content of iron of 0.9 parts per million as shown by the analysis of sample number 49414, collected at the pumping station on April 27, 1923.

Analysis of Sample Number 49414 from the City Supply.

Determinations Made.

	Parts per million.
Iron, Fe	0.9
Manganese, Mn	0.0
Silica, SiO_2	44.2
Nonvolatile	1.6
Alumina, Al_2O_3	1.9
Calcium, Ca	79.0
Magnesium, Mg	31.7
Ammonia, NH_4	3.1
Sodium, Na	73.7
Potassium, K	10.5
Sulfate, SO_4	1.9
Nitrate, NO_3	2.6
Chloride, Cl	0.0
Alkalinity, Phenolphthalein	0.
Alkalinity, Methyl Orange	508.
Residue	544.

Hypothetical Combinations.

	Parts. Per Million.	Grains Per Gallon.
Potassium Nitrate KNO_3	4.3	0.25
Potassium Sulfate K_2SO_4	3.5	0.20
Potassium Carbonate K_2CO_4	12.8	0.75
Sodium Carbonate Na_2SO_4	169.8	9.92
Ammonium Carbonate $(NH_4)_2CO_3$	8.2	0.48
Magnesium Carbonate $MgCO_3$	109.8	6.41
Calcium Carbonate $CaCO_3$	197.3	11.52
Iron Oxide Fe_2O_3	1.3	0.07
Alumina Al_2O_3	1.9	0.11
Silica SiO_2	44.2	2.58
Nonvolatile	1.6	0.09
Total	554.7	32.38

ASHTON (882). Ashton is located in the northern part of Lee County on the drainage area of a tributary of Rock River. The Chicago and Northwestern Railway has a private well in the village, 248 feet deep into limestone which is entered at a depth of 29 feet. The well is cased with 12-inch pipe at the top and is 10¼ inches in diameter at the bottom. Crevices were struck at depths of 150 feet

and 248 feet. With a pump at a depth of 154 feet the drillers, the J. P. Miller Artesian Well Company, pumped at a rate of 350 gallons a minute.

A public water supply was installed by the village in 1914-1915. Water from a well is pumped directly into the distribution system to which an elevated steel tank of 50,000 gallons capacity on a tower 80 feet high is connected. The ground surface at the tower is 70 feet above the ground surface at the pumping station. The pump is now driven by an electric motor and an oil engine formerly used is also available. More than two hundred consumers were supplied with water in 1921. The rates for three months use are $1.50 for the first 5000 gallons, 25 cents per 1000 gallons for the next 10,000 gallons, 15 cents per 1000 gallons for the next 10,000 gallons, and 10 cents per 1000 gallons for quantities above 35,000 gallons. Bills are not subject to cash discount.

The public water supply is from a well located near the business district about 500 feet east of the Chicago and Northwestern Railway well. It was drilled by the W. L. Thorne Company of Des Plaines. Information secured at the village is that rock was encountered at a depth of 180 feet, that no large flow of water was obtained above St. Peter sandstone which was entered at a depth of 415 feet, and that the well was drilled through the sandstone to a depth of 545 feet. The drillers state that the well is cased with 12-inch pipe to a depth of 138 feet and with 10-inch pipe to a depth of 199 feet, that the well is 10 inches in diameter and 544 feet 6 inches deep, and that the bottom is in sandstone. Water stood at a depth of 16 feet. The well was equipped with a Keystone Driller Company double-stroke deep-well pump with a 7¾-inch cylinder placed at a depth of 85 feet. It was operated with 24-inch stroke at a rate of about 30 strokes a minute but water was rapidly drawn down to the cylinder. The speed of the pump was then reduced to 25 strokes a minute and at the time of a visit in 1915 the pump was apparently drawing air. In 1921 the pump was operating with 18-inch stroke at a rate of 26 strokes a minute, an average of probably 5 hours a day. The cylinder was thought to be at a depth of 240 feet but this may be in error or it may be the original cylinder is not in use. The depth to water when not pumping was 20 feet in the spring of 1921 and about 36 feet in October, 1921.

The water had a mineral content of 377, a total hardness of 330, and a content of iron of 0.1 parts per million as shown by the analysis of sample number 46406, collected on October 20, 1921.

Analysis of Sample Number 46406 from the Village Supply.

Determinations Made.	Parts per million.
Iron, Fe	0.1
Manganese, Mn	0.0
Silica, SiO_2	13.4
Nonvolatile	0.8
Alumina, Al_2O_3	1. 6
Calcium, Ca	77.4
Magnesium, Mg	33.6
Ammonia, NH	00.0
Potassium, K	2.0
Sodium, Na	11.0
Sulfate, SO_4	25.7
Nitrate, NO_3	26.6
Chloride, Cl	12.0
Alkalinity, Methyl Orange	288.
Residue	385.

Hypothetical Combinations.	Parts Per Million.	Grains Per Gallon.
Potassium Nitrate KNO_3	5.0	.29
Sodium Nitrate $NaNO_3$	32.2	1.88
Sodium Chloride NaCl	5.9	.34
Magnesium Chloride $MgCl_2$	11.3	.66
Magnesium Sulfate $MgSO_4$	32.1	1.88
Magnesium Carbonate $MgCO_3$	84.0	4.91
Calcium Carbonate $CaCO_3$	191.0	11.31
Silica SiO_2	13.4	.78
Nonvolatile	0.8	0.04
Iron Oxide $Fe2O_3$	0.2	.01
Alumina Al_2O_3	1.6	.09
Total	377.5	22.19

Hot water coils clog rapidly when heating water from the village supply. One coil in which two-thirds the diameter of the pipe had been closed by hard scale had been in use in a bake shop for four months. Solder is destroyed rapidly and copper floats with pressed seams are usually used in toilets. These floats are said to last about a year. Gears of meters are destroyed and repairs are made with monel metal.

ASSUMPTION (1852). Assumption is located in the eastern part of Christian County on the drainage area of the south fork of Sangamon River.

A public water supply was installed by the city in 1914. Several wells were drilled in the city without securing a supply of water and wells were then drilled three miles southeast of the city. Water was pumped from the wells through a 6-inch pipe line to the city. The original equipment has been replaced and water is now pumped from wells located near the original wells by either a Goulds 5½ by 8-inch triplex pump or a Deming 7 by 8-inch triplex pump. Each pump is driven by a 15-horsepower electric motor. Electric power is furnished by the Central Illinois Public Service Company.

Two hundred and thirty consumers were supplied with water in 1923. A mine and the Illinois Central Railroad used large quantities, the latter using 1,500,000 gallons a month. The rates for three months are $1.50 for the first 6000 gallons, $1.00 for the next 5000 gallons, and 10 cents per 1000 gallons for quantities in excess of 11,000 gallons.

The public water supply is secured from wells located three miles southeast of the city close to the bank of Spring Creek. The water is from a stratum of sand and gravel about 10 feet thick which is entered at a depth of from 6 to 10 feet. About one-fourth mile south of, or up stream from the wells, the gravel outcrops into Spring Creek.

Six 4-inch wells were installed in 1913 in two rows 25 feet apart with the wells 25 feet apart in each row. The casings extended to a depth of 12 feet and each well was equipped with a screen formed by soldering a number 20 wire screen around a perforated pipe. The wells were connected to a pump by a 4-inch suction line and a test was run for 54 hours. At the time of visit on August 13, 1913, the rate of pumping was 100,000 gallons per day and this rate was said to have been maintained for 54 hours. The water level in a dug well 60 feet distant was lowered 12 inches during the first 24 hours of the test and remained stationary after that time until pumping ceased, when it raised 2 inches in 45 minutes. The flow at the outcrop continued and apparently all water pumped flowed down the stream. Three more 4-inch wells were bored in 1914. The nine wells were abandoned in 1917.

The water supply in 1923 was from nine wells located close to the original wells. Three of the wells were drilled by the city in 1917. Six others were drilled in 1918-1919. The railroad company drilled the wells and was paid by the city by water furnished. These wells are from 16 to 25 feet deep. Some are 8 inches, others are 10 inches, and one is 12 inches in diameter. The 12-inch well and four 10-inch wells were drilled by O. H. Steigman of Roberts. A screen was made for each well by drilling 4000 one-half-inch holes in the casing. A 4-inch suction line extends to near the bottom of each well. The Goulds pump is usually operated from nine to twelve hours a day, indicating a yield of the wells of approximately 75,000 gallons a day. The water level varies but a few inches during a day but during long continued dry periods it recedes to within 18 inches of the bottom of the sand stratum.

The water had a mineral content of 475, a total hardness of 369, and a content of iron of 1.0 parts per million as shown by the analysis of sample number 49736, collected on July 12, 1923, from a tap in the city.

The mineral content, the total hardness and content of iron are more than twice as great as in a sample collected in 1913. It is probable that the mineral content varies from time to time with the quantity of water available and rate of pumping. The water forms a hard scale in heaters.

Analysis of Sample Number 49736 from the City Supply.

Determinations Made.

	Parts per million.
Iron, Fe	1.0
Manganese, Mn	0.0
Silica, SiO_2	14.6
Nonvolatile	1.3
Alumina, Al_2O_3	1.3
Calcium, Ca	86.6
Magnesium, Mg	37.1
Ammonia, NH_4	0.1
Sodium, Na	18.6
Potassium, K	8.7
Sulphate, SO_4	139.8
Nitrate, NO_3	0.8
Chloride, Cl	9.0
Alkalinity, Phenolphthalein	0.
Methly Orange	250.0
Resdue	508.

Hypothetical Combinations.

	Parts Per	Grains Per
Potassium Nitrate KNO_3	1.4	0.08
Potassium Chloride KCl	15.6	0.91
Sodium Chloride NaCl	2.6	0.15
Sodium Sulphate Na_2SO_4	54.3	3.17
Ammonium Sulphate $(NH_4)_2SO_4$	0.3	2.02
Magnesium Sulfate $MgSO_4$	128.7	7.51
Magnesium Carbonate $MgCO_3$	38.1	2.22
Calcium Carbonate $CaCO_3$	216.3	12.63
Iron Oxide Fe_2O_3	1.4	0.08
Alumina Al_2O_3	1.3	0.07
Silica SiO_2	14.6	0.85
Nonvolatile	1.3	0.07
Total	475.9	27.76

ASTORIA (1340). Astoria is located in the southwestern part of Fulton County about 5 miles northwest of Illinois River.

A public water supply was installed by the town in 1897. Water from a deep well was pumped into a collecting reservoir 30 feet in diameter and 12 feet deep. From the reservoir it was pumped into the distribution system by a Deane 12 by 7 by 10-inch duplex steam pump. A stand pipe 12 feet in diameter and 100 feet high was connected to the system. In 1904 or 1905 the deep-well pump was replaced by air lift. Fifty-four consumers were supplied with water in 1921 and the consumption was estimated at 35,000 gallons a day. In 1924 a supply was developed from an impounding reservoir and the well was abandoned.

The public water supply, until 1924, was from a well 1660 feet deep located near the southern limits of the city. The upper 225 feet was cased with 9-inch pipe to which 975 feet of 6-inch casing was sealed with a rubber packer. The bottom of the well was 4 inches in diameter. The well was equipped with air lift with 600 feet of 4-inch discharge pipe and 1¼-inch air pipe. The engineer stated in 1921 that the air lift started at 250 pounds pressure and operated at 175 pounds and that, when not pumping, water stood at a depth of 125 feet. The discharge filled the reservoir at a rate of 8 inches an hour and the air lift operated from 8½ to 9 hours a day excepting on Sundays. This indicates a rate of yield of 59 gallons a minute and an average supply of 25,000 gallons a day. During a test of one hour by W. S. Shields in 1920 the yield was 66 gallons a minute.

The water was not satisfactory for a public supply as it was very highly mineralized. It had a mineral content of 3628, a total hardness of 630, and a content of iron of 0.36 parts per million as shown by the analysis of sample number 43156, collected on June 1, 1920. The seal between the casings was probably out of place before that time.

Analysis of Sample Number 43156 from Well 1660 Feet Deep.

Determinations Made.	Parts Per million.
Iron, Fe	0.36
Manganese, Mn	0.00
Silica, SiO_2	12.50
Alumina, Al_2O_3	3.48
Calcium, Ca	145.00
Magnesium, Mg	65.10
Ammonia, NH_4	3.09
Potassium, K } Sodium, Na }	1062.00
Nitrate. NO_3	2.66
Nitrite, NO_2	0.034
Choride, Cl	1125.60
Sulphate, SO_4	1087.00
Alkalinity Methyl Orange	240.0
Residue	3671.0

Hypothetical Combinations.	Parts Per Million.	Grains Per Gallon.
Sodium Nitrate KNO_3	3.66	0.21
Sodium Chloride KCl	1855.00	108.40
Sodium Sulphate Na_2SO_4	1018.00	59.34
Ammonium Sulphate $(NH_4)_2SO_4$	11.29	0.66
Magnesium Sulphate $MgSO_4$	321.60	18.75
Calcium Sulphate $CaSO_4$	153.70	8.96
Calcium Carbonate $CaCO_3$	249.10	14.55
Iron Oxide Fe_2O_3	0.52	0.93
Alumina Al_2O_3	3.48	0.20
Silica SiO_2	12.50	0.73
Total	3628.85	211.83

Investigations have been made of waters available for a more satisfactory supply. Considerable information was secured from W. S. Shields who reported on available supplies. The Astoria Creamery Association had a well drilled to a depth of 541 feet. The material penetrated was as follows:

	Thickness in feet.	Depth in feet.
Blue and yellow clay	52	52
Cap rock lime	1	53
Coal	6	59
Fire clay	25	84
Shale	80	164
Coal	3	167
Shale	60	227
Cap rock lime	2	229
Coal	2	231
Limestone	195	426
Shale	50	476
Limestone, Niagaran	65	541

W. E. Crouch, the driller, states that no test was made of the yield, that some water was obtained at 200 feet, some at 325 feet, and the last at 530 feet. A sample of water collected in 1920 had a mineral content of 1315, a total hardness of 630, and a content of iron of 0.1 parts per million.

The city drilled a well in 1913 about 10 feet distant from the well in use. Little water was encountered to a depth of 320 feet and the hole was then abandoned.

Shafts of two abandoned mines are located south of and near the southern limits of the city. One mine known as the Missouri mine was operated from 1870 to 1874. A pump was operated about 4 hours out of 24 and all water was discharged through a 2-inch pipe. The flow from the abandoned shaft on May 21, 1920, when tested by Mr. Shields, was 24 gallons a minute. A mine known as the Emerson-Skinner from which water flows into a railroad culvert southwest of the city was operated until 1878. Three-pumps were used, one with a 5½-inch discharge and each of the others with a 2½-inch discharge. Information is from Mr. Skinner who operated the mines. Samples of water collected from these two mines contained less dissolved mineral matter than the city supply but they were very much harder, the total hardness of samples from the Emerson-Skinner and Missouri mines being 1820 and 970 respectively. The quality of the water might vary considerably from time to time as the workings are near the ground surface.

ATKINSON (778). Atkinson is located in the central part of Henry County on the drainage area of Green River.

A public water supply was installed by the village in 1916. Water from a well is pumped directly into the distribution system by a deep-well pump driven by a 15-horsepower electric motor operated with automatic control. An elevated steel tank of 50,000 gallons capacity located on the same lot as the well is connected to the system. Power is purchased from the Spring Valley Utilities Company. One hundred and two service connections were in use in December 1924. The meter rate is 40 cents per 1000 gallons for the first 5000 gallons, 30 cents per 1000 gallons for the next 20,000 gallons, 25 cents per 1000 gallons for the next 75,000 gallons, and 15 cents per 1000 gallons for quantities in excess of 100,000 gallons in three months. The minimum charge is $1.50 per quarter.

The water supply is from a well 1123 feet deep located on the north side of East Exchange Street two blocks east of the business district. It was drilled by the Cambridge Driller Company in 1915. The ground surface at the well is 640 feet above sea level. The contract called for a size to admit a 12-inch pipe to rock, for bottom of 12-inch pipe to be driven firmly into rock, and 8-inch hole in rock until a good supply of water was secured, about 150 feet. Specifications had called for a 12-inch hole to rock, an 8-inch hole

through limestone, shale and limestone, and 6-inch in sand rock at least 100 feet making a total of 1050 feet. The material penetrated is said to be mostly limestone with about 100 feet of shale. The well is equipped with a Keystone Driller Company double-stroke pump with 7¾-inch brass cylinder attached to about 90 feet of drop pipe. The pump was to have a capacity of 200 gallons a minute and according to articles in the Atkinson News the well yielded 200 gallons on test. After the test, according to newspaper items, several lengths of casing perforated with ¾-inch holes were inserted through shale and the yield of the well decreased to 100 gallons a minute, due probably to closing of holes when the casing was lowered. The yield was reported to have come back to 230 gallons after several days testing. The pump is operated at 30 revolutions a minute and during twelve months to December, 1924, it is estimated that the pump was operated a little more than one hour a day and that the amount of water pumped averaged about 13,000 gallons a day. The water level when not pumping in 1922 was 38 feet below the top of the well.

The temperature of the water at a tap in the pumping station was 58 degrees Fahrenheit. A sample of water, number 44166, collected on November 8, 1920, had a mineral content of 1512, a total hardness of 240, and a content of iron of 1.2 parts per million as shown by the analysis.

Analysis of Sample Number 44166 from the Village Supply.

Determinations Made.	Parts Per million.
Iron, Fe	1.2
Manganese, Mn	0.0
Silica SiO_2	8.8
Nonvolatile	1.8
Alumina, Al_2O_3	3.0
Calcium, Ca	57.8
Magnesium, Mg	23.1
Ammonium, $N.H_4$	5.1
Potassium, K } Sodium, Na }	464.9
Sulfate, SO_4	312.4
Nitrate, NO_3	3.2
Chloride, Cl	470.2
Alkalinity	
Phenolphthalein	.0
Methyl Orange	236.

Hypothetical Combinations.	Parts Per Million.	Grains Per Gallon.
Sodium Nitrate	4.4	.26
Sodium Chloride	775.1	45.32
Sodium Sulfate	461.2	26.98
Sodium Carbonate	19.5	1.14
Ammonium Carbonate	13.7	.80
Magnesium Carbonate	80.1	4.68
Calcium Carbonate	144.2	8.43
Iron Oxide	1.7	.10
Alumina	3.0	.18
Silica	8.8	.51
Nonvolatile	1.8	11
Total	1512.5	88.51

A contract for a pump made in 1916 called for 90 feet of Byers genuine wrought iron drop pipe weighing 28.8 pounds per foot. According to prices and payments made this was evidently installed. The pipe was replaced in 1922. About twelve meters are said to be repaired annually.

The water causes little scale in a steam boiler operated at from 80 to 120 pounds.

The village had a well 180 feet deep at their light plant in 1915. A sample of water collected from this well had a mineral content of 525, a total hardness of 84, and a content of iron of 0.6 parts per million.

ATLANTA (1173). Atlanta is located in the northeastern part of Logan County on the drainage area of Sugar Creek, a tributary of Sangamon River. A public water supply was installed by the city in 1891. The installation included a well equipped with a steam-head deep-well pump, a pump house, a distribution system, and a standpipe 12 feet in diameter and 100 feet high. The original well has been abandoned. Two other wells have been drilled nearby. One of these has been abandoned and the other is used only in case of emergency. Water is obtained since 1922 from an abandoned mine shaft from which it is pumped directly into the distribution system by a deep-well pump driven by belt from a 20-horsepower electric motor.

Three hundred and fifty service connections were in use in 1924 and each was equipped with a meter. The meter rate is six cents per 100 gallons for quantities less than 300 gallons a day with decreasing rate to two and one quarter cents per 100 gallons for quantities of from 1000 to 2000 gallons a day. The minimum charge is $9.00 a year.

The public water supply was for many years obtained from two wells, each 151 feet deep, one 8 inches and the other 10 inches in diameter. The wells are located 30 feet apart in the same building as the original well. A record of material penetrated as given in the Monograph, Illinois Glacial Lobe, is as follows:

	Feet
Black soil	3
Yellow clay	15
Blue clay	10
Gray sand and gravel	10
Blue clay	2
Sand and gravel	9
White clay and sand	7
Blue clay and gas	3
White sand and gravel	10
Sand	6
Dry sand and gravel and gas	13
Blue clay	4
Clay, sand, gravel and gas	16
Hardpan	9
Black drift	6

	Feet
White clay	2
Green clay	4
Hardpan	10
Gravel and water.	12
	151

Each well was equipped with a Cook single-acting deep-well pump with 7¾-inch cylinder and 36-inch stroke. The amount of water pumped was recorded from April 20 to May 8, 1918, and averaged 48,000 gallons a day. The depth to water in 1913 was 50 feet when not pumping. In 1924 when water had not been pumped from either well for many days the depth to water in the 8-inch well was 105 feet. The 10-inch well can be used in emergency. Water from the wells had a mineral content of 471, a total hardness of 382, and a content of iron of 8.4 parts per million as shown by the analysis of sample number 27189, collected on March 9, 1914.

Analysis of Sample Number 27189 from Wells 151 Feet Deep.

Determinations Made.

	Parts Per million.
Iron, Fe	8.4
Silica, SiO_2	19.8
Alumina, Al_2O_3	1.4
Calcium, Ca	84.3
Magnesium, Mg	42.4
Sodium, Na	29.8
Potassium, K	3.8
Nitrate, NO_3	.5
Chloride, Cl	3.0
Sulphate, SO_4	0.0
Alkainity Methyl Orange.	452.
Residue	464.

Hypothetical Combinations.

	Parts Per Million.	Grains Per Gallon.
Potassium Nitrate KNO_3	0.8	.05
Potassium Carbonate K_2CO_3	0.3	.02
Potassium Chloride KCl	6.3	.37
Sodium Carbonate Na_2CO_3	68.6	4.00
Magnesium Carbonate $MgCO_3$	146.8	8.57
Calcium Carbonate $CaCO_3$	210.4	12.27
Iron Carbonate Fe_2CO_3	17.4	1.01
Alumina Al_2O_3	1.4	.08
Silica SiO_2	19.8	1.15
Total	471.8	27.52

Water is secured from a mine shaft which was abandoned at a depth of 160 feet in 1880. In 1922 it was curbed with 12 by 12-inch pine timbers and pumping equipment was installed. The shaft is 8 feet by 16 feet to a depth of 100 feet and 6 feet by 14 feet below that depth. The ground surface at the top of the shaft is about 720 feet above sea level. Water is pumped by a Keystone Driller Company double-stroke deep-well pump with 7¾-inch cylinder and 18-inch stroke. The cylinder is placed at a depth of 140 feet. At the time of visit in 1924 the pump was operating 28½ revolutions a minute. Estimating from the pump capacity and the amount of power consumed, the pump operated an average of 3 hours 30 minutes a day and discharged 40,000 gallons of water a day during the year 1923. The water level is about 100 feet below the ground surface.

The water had a mineral content of 526, a total hardness of 447, and a content of iron of 2.2 parts per million as shown by the analysis of sample number 51791, collected from a tap in the pumping station, on July 9, 1924.

Analysis of Sample Number 51791 from the City Supply.

Determinations Made

	Parts Per million.
Iron, Fe	2.2
Manganese, Mn	0.0
Silica, SiO_2	15.8
Nonvolatile	1.1
Alumina, Al_2O_3	2.3
Calcium, Ca	97.4
Magnesium, Mg	49.8
Ammonia, NH_4	5.9
Sodium, Na	19.6
Potassium, K	5.4
Sulfate, SO_4	41.9
Nitrate, NO_3	3.5
Chloride, Cl	7.0
Alkalinity	
Phenolphthalein	0.
Methyl Orange	472.
Residue	530.

Hypothetical Combinations.

	Parts Per Million.	Grains Per Gallon.
Potassium Nitrate KNO_3	5.6	.33
Potassium Chloride KCl	6.0	.35
Sodium Chloride NaCl	6.8	.40
Sodium Sulphate Na_2SO_4	52.3	3.05
Ammonium Sulphate $(NH_4)_2SO_4$	8.8	.51
Ammonium Carbonate $(NH_4)_2CO_3$	9.4	.55
Magnesium Carbonate $MgCO_3$	172.3	10.07
Calcium Carbonate $CaCO_3$	242.9	14.18
Iron Oxide Fe_2O_3	3.1	.18
Alumina Al_2O_3	2.3	.13
Silica SiO_2	15.8	.92
Nonvolatile	1.1	.06
Total	526.4	30.73

AURORA (36397). Aurora is located in the southeastern part of Kane County on the banks of Fox River. Some industries in the city secure water from Fox River, some from private wells, and many secure part or all of their water supply from the city.

A public water supply was installed by the city in 1886. Water was pumped from a well or filter gallery which was excavated into gravel on an island in Fox River about 1½ miles north of the center of the city. The pumping station was located on the east bank of the river. Four wells into Cambrian “Potsdam” sandstone were drilled during the years 1892 to 1895, on ground around the pumping station and the well into gravel was later abandoned. Another well has been drilled close to the main pumping station and five wells have been drilled in the city. The wells at the main station are equipped with air lifts. Water was at first discharged into an open reservoir of 1,350,000 gallons capacity. This has been abandoned and water is now discharged into a reinforced concrete reservoir of 1,500,000 gallons built above the water level in the river.

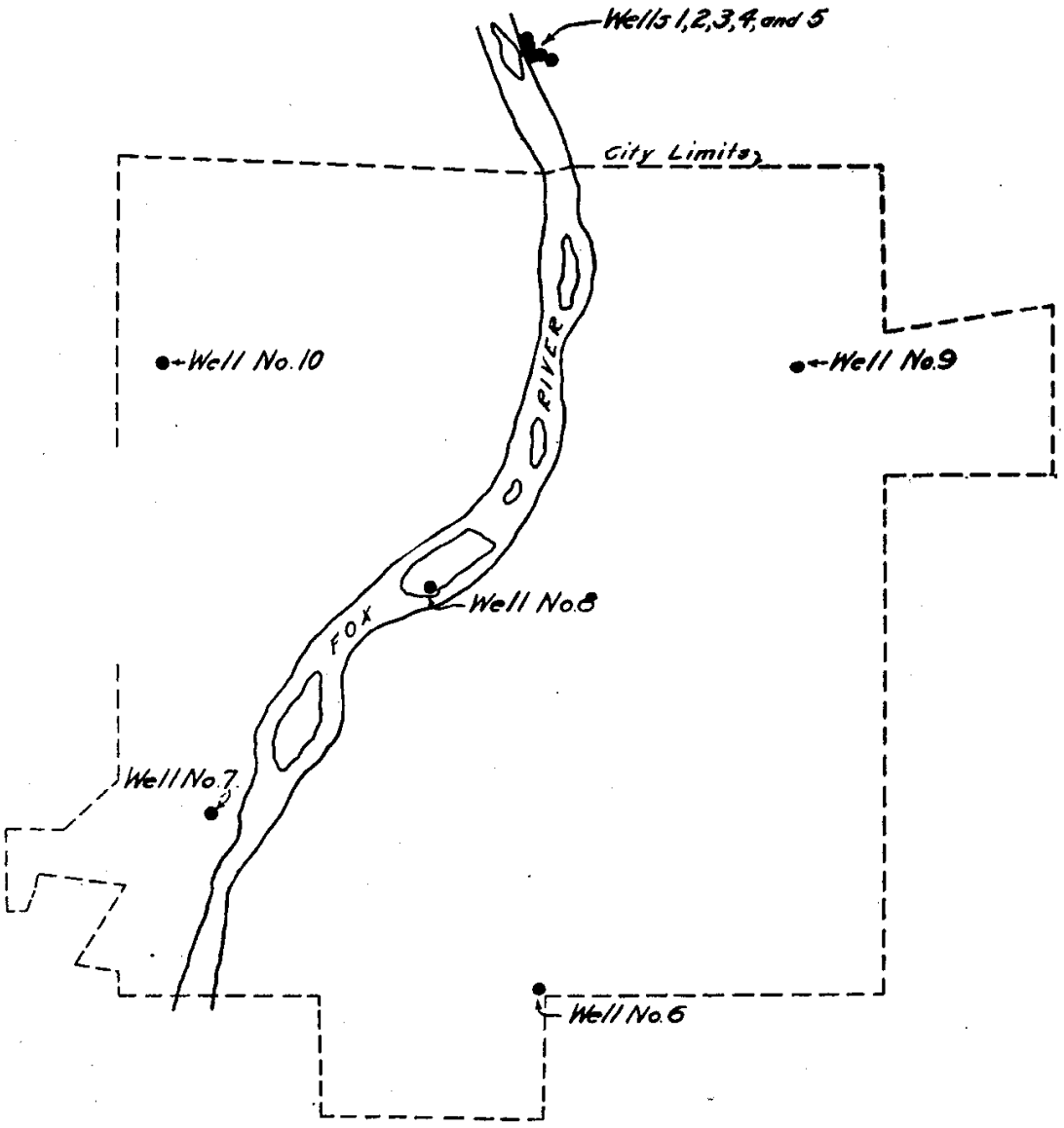
An American Well Works air compressor with 16-inch air cylinders and 36-inch stroke, direct connected to a cross-compound engine with 14 and 26-inch steam cylinders, formerly in regular

service, is available. The compressor usually used was manufactured by the American Well Works. It is compound and has 28 and 16¼-inch air cylinders and 36-inch stroke. It is direct connected to a cross-compound engine with 18 and 36-inch steam cylinders.

Water is pumped from the reservoir by a Nordberg triple-expansion steam pump of 3,500,000 gallons capacity. One of two horizontal duplex tandem-compound steam pumps of 1,500,000 gallons capacity, formerly in regular service, is also available.

The total water consumption in 1924 averaged near 2,700,000 gallons a day.

Wells drilled in the city are equipped with turbine pumps which discharge directly into the distribution system. The pumps are



LOCATION OF WELLS IN THE CITY OF AURORA

driven by electric motors. Power to run these pumps is purchased from the Western United Gas and Electric Company.

Water for the public supply is secured from wells into Cambrian sandstone. The location of the wells is shown on the following page. Five of these wells are located in an area 500 feet by 200 feet at the main pumping station north of the city limits, about 1½ mile north of the center of the city.

Two wells number 1 and number 2 were drilled by the American Well Works in 1892 and 1893. Records have been lost in a fire. In 1898 well number 1 was drilled from a depth of 1381 feet to a depth of 2235 feet by the J. P. Miller Artesian Well Company of Chicago. It was finished six inches in diameter at the bottom.

Two wells were drilled by the J. P. Miller Artesian Well Company. The first one was drilled in 1893. It was drilled 8 inches in diameter to a depth of 610 feet and 6 inches in diameter below that depth. The drillers noted that the well was reamed to a depth of 930 feet. The depth when measured in January 1894 was 2274 feet. A record of material penetrated by the well they drilled in 1895 with part of the classification given by the State Geological Survey Division is as follows:

	Thickness in feet.	Depth in feet.
Surface	10	10
Limestone, Silurian System all or chiefly Niagaran	95	105
Shale, Richmond	140	245
Limestone, Galena-Platteville	325	570
Sandstone, St. Peter	195	765
Shale, Prairie du Chien	135	900
Sandstone, Prairie du Chien	190	1090
Shale, Prairie du Chien	75	1165
Sandstone, Mazomanie-Dresbach Cambrian system	185	1350
Shale, Eau Claire, Cambrian System	190	1540
Limestone, Eau Claire, Cambrian system	25	1565
Shale, Eau Claire, Cambrian system	165	1730
Sandstone, Mt. Simon, Cambrian system	715	2445

This well was cased with 10-inch pipe to a depth of 76 feet, is 8 inches in diameter below the pipe to a depth of 1700 feet, and 6 inches in diameter below 1700 feet. The well was filled below a depth of 2250 feet.

Well number 5 was drilled by Timmes and Beckwith in 1910. The diameter is 16 inches at the top and 8 inches at the bottom.

Each of these five wells is equipped with an air lift. A. N. Talbot and M. L. Enger made a test in 1910, and wells 1, 2, 3, and 4 delivered 550, 350, 500, and 400 gallons a minute respectively with the air lift equipment then installed.

The total yield of the five wells during a test in 1916 was 1200 gallons a minute as given in the annual report of the city. The yield was increased by repairing equipment.

The yield in 1924 was about 1700 gallons a minute. Air lines extended in each well to a depth of 300 feet (within 10 feet). The larger compressor was operated at 54 revolutions a minute. About the same total yield was obtained pumping from four wells as could be obtained by pumping from all five wells.

The yield of wells discharging directly into the distribution system depends in part upon the water pressure in the system.

Well number 6 is located at the corner of Talma and Binder Streets in the southern part of the city about 2¾ miles south of the main station. The well was drilled by S. B. Geiger in 1915. It is 18 inches in diameter at the top, 15 inches at the bottom and 2200 feet deep. It is cased to a depth of about 400 feet and no casing is placed below that depth. The well is equipped with an American turbine deep-well pump placed at a depth of 325 feet with 40 feet of 9-inch suction pipe attached. The yield in 1916 was given at 750 gallons a minute but the well was seldom used as water could be secured more economically from the other wells. In 1923 the pump was at a depth of 304 feet. The yield was from 600 to 650 gallons a minute and the water level was lowered to a depth of 270 feet. When not pumping, water rises to 50 feet below the ground surface.

Well number 7 is located in the southwestern part of the city on River Street north of the Elgin, Joliet and Eastern Railroad about 2½ miles distant from the main pumping station and a mile to a mile and a quarter distant from number 6. It was drilled in 1916 by S. B. Geiger. It is 18 inches in diameter at the top, 15 inches in diameter at the bottom, and 2262 feet deep. It is near the river on lower ground than well number 6. The well is cased to a depth of 300 feet and no casing is placed below that depth. It is equipped with a turbine deep-well pump placed at a depth of 250 feet and the discharge is 900 to 1000 gallons a minute. When drilled the well flowed. The water level when not pumping is now at a depth of 50 feet.

Well number 8 is located on Stolps Island near the center of the city about.1¾ miles distant from the main station, 1¼ miles from well number 6 and one mile from well number 7. It was drilled by S. B. Geiger in 1916. It is 18 inches in diameter at the top, 15 inches in diameter at the bottom and about 2280 feet deep (2330?). It is cased to a depth of about 400 feet and no casing

is placed below that depth. The pump has been lowered to a depth of 200 feet and 30 feet of tail pipe is attached. The well flowed when drilled. The depth to water in 1924 was 60 feet when not pumping. The water level was lowered by pumping until the vacuum at the pump was 18 inches when the discharge was throttled to about 980 gallons a minute and the water level remained constant.

Well number 9 was drilled by S. B. Geiger in 1923. It is located west of Wood Street at Indian Avenue on low land. The well is 18 inches in diameter at the top, 15 inches in diameter at the bottom, and 2285 feet deep. The well is cased to a depth of 325 feet and about 70 feet of liner is placed at a depth of about 800 feet. The water level when not pumping in 1924 was at a depth of 50 feet. Lowering the water level 20 or 30 feet inside the casing did not lower the level outside the casing. The pump is placed at a depth of about 220 feet and about 40 feet of tail pipe is attached. The discharge at the ground surface was 1400 gallons a minute during an 8 hour test in 1923 and the water level was lowered to a depth of 167 feet. The actual discharge into the mains will be small until a larger connecting pipe is laid.

Well number 10 was drilled by S. B. Geiger in 1923. It is located at Russell and West Park Avenues. The well is 18 inches in diameter at the top, 15 inches in diameter at the bottom, and about 2280 feet deep. It is cased to a depth of about 400 feet and about 70 feet of liner is placed at a depth of about 800 feet. Pumping the water level down 20 or 30 feet inside the casing did not lower the water level outside the casing. This well was not equipped in 1924.

A sample of water, number 49624, collected from a tap at the city hall on June 11, 1923, had a mineral content of 441, a total hardness of 266, and a trace of iron as shown by the analysis.

Some variation is shown by analysis. This may be accounted for by the fact that the quality from different wells may vary and there may be variation with length of time wells are pumped. The iron content of several samples averaged 0.4 parts. A sample collected from well number 2 in 1915, many years after it had been drilled to a depth of 2440 feet and filled to a depth of 2250 feet, had a mineral content near three times that shown by the analysis above and contained 570 parts of chloride.

Water from a well 2759 feet deep at Phillips Park, the city park in the southwestern part of the city, had a mineral content of 2200,

a total hardness of 852, and a content of iron of 5.0 parts per million.

Analysis of Sample Number 49624 from the City Supply.

Determinations Made.	Parts Per million.
Iron, Fe	trace
Manganese, Mn	trace
Siica, SiO_2	8.6
Nonvolatile	1.1
Alumina, Al_2O_3	1.2
Calcium, Ca	66.0
Magnesium, Mg	25.0
Ammonium, NH_4	0.8
Potassium, K	18.7
Sodium, Na	52.1
Sulfate, SO_4	29.6
Nitrate, NO_3	2.5
Chloride, Cl	73.0
Alkalinity	
Phenophthalein	0.
Methyl Orange	266.
Residue	421.

Hypothetical Combinations.	Parts Per Million.	Grains Per Gallon.
Potassium Nitrate KNO_3	4.0	0.23
Potassium Chloride KCl	32.6	1.90
Sodium Chloride NaCl	94.7	5.53
Sodium Sulfate Na_2SO_4	43.7	2.55
Sodium Carbonate Na_2CO_3	1.5	0.08
Ammonium Carbonate $(NH_4)_2CO_3$	2.2	0.13
Magnesium Carbonate $MgCO_3$	86.6	5.06
Calcium Carbonate $CaCO_3$	164.8	9.62
Iron Oxide Fe_2O_3	trace	
Alumina Al_2O_3	1.2	0.07
Silica SiO_2	8.6	0.50
Nonvolatile	1.1	0.06
Total	441.0	25.78

Some trouble is experienced with clogging of meters and service pipes, especially near large mains leading from the main station.

AVERYVILLE (3815). Averyville is located in Peoria County on Illinois River. Water for a public supply is secured from the Peoria Water Works Company.

AVON (877). Avon is located in the northwestern part of Fulton County on the drainage area of Swan Creek, a tributary of Spoon River.

A public water supply was installed by the Avon Milling Company about 1890. The supply was installed for fire protection. About 30 service connections had been installed in 1924. Water was first secured from two wells. In 1916 or 1917 the wells were abandoned and water was used from a small impounding reservoir in the southern part of the village.

Water is now secured from an impounding reservoir located about three quarters of a mile east of the village and owned by the Chicago, Burlington and Quincy Railroad.

The two wells were located about 100 feet apart in the northwestern part of the village. One was 8 feet in diameter and 38 feet deep and the other 10 feet in diameter at the top, 8 feet in diameter

at the bottom, and 52 feet deep. The wells were curbed with brick with lime mortar joints. A sand stratum is reported at a depth of 22 feet. When the wells were not pumped for several days water raised to a depth of 10 or 15 feet below the ground surface. The supply was limited.

BARRINGTON (1743). Barrington is located in Cook and Lake Counties on the drainage area of Fox River.

A public water supply was installed by the village in 1898. The installation included a deep well with air-lift equipment, a storage reservoir 37 feet 4 inches in diameter and 7 feet deep, a distribution system and a steel standpipe 18 feet in diameter and 50 feet high located on ground 75 feet above the ground surface at the well. Water is pumped from the well into the reservoir by air lift. Air is supplied by a Stillwell-Bierce and Smith-Vaile 14 by 12-inch compressor driven by a 50-horsepower electric motor. Water is pumped from the reservoir into the distribution system by a Smith-Vaile 8 by 8-inch triplex pump. Power is purchased from the Public Service Company of Northern Illinois.

Four hundred and seventy-five service connections were in use in 1922. The average consumption from May 1 to October 1, 1922, as estimated from a pump test and record of pump revolutions, was 200,000 gallons a day. The Chicago and Northwestern Railway, the largest consumer, used about 2,500,000 gallons a month. The rate for three months is $1.50 for the first 5000 gallons with reductions for greater quantities to 12 cents per 1000 gallons for quantities in excess of 30,000 gallons.

The supply is from a well drilled in 1898. The top is about 815 feet above sea level. The well is cased with 12-inch pipe to rock at a depth of about 200 feet, is 10 inches in diameter in rock, and is 305 feet deep. A test of the yield was made on November 9, 1922. The well was equipped with an air lift with 114 feet of 1½-inch air pipe and 120 feet of 6-inch discharge pipe. The yield was 270 gallons a minute for 9 hours. The water level before the test, when the pump had been idle for 12 hours, was 52½ feet below the top of the casing, 56 feet below the floor level, and was lowered 5 feet by the 9 hours pumping. The air pressure as shown by gauge remained at 47 pounds and is said not to have changed during the past seven or eight years. The air lift, in 1922, was operated from 12 to 14 hours a day.

The temperature of water when discharged from the well was 52 degrees Fahrenheit. The water had a mineral content of 371, a

total hardness of 306, and a content of iron of 0.2 parts per million as shown by the analysis of sample number 48620, collected on November 9, 1922.

Analysis of Sample Number 48620 from the Public Supply.

Determinations Made.	Parts Per million.
Turbidity	0.0
Residue	380.0
Iron, Fe	0.2
Manganese, Mn	00.0
Nitrate, NO_3	0.9
Chloride, Cl	5.0
Sulfate, SO_4	89.0
Alkalinity	
Penolphthalein	10.0
Methyl Orange	260.0
Magnesium	42.4
Calcium	52.9

Hypothetical Combinations.	Parts Per Million.	Grains Per Gallon.
Calcium Carbonate $CaCO_3$	132.3	7.73
Magnesium Carbonate $MgCO_3$	107.6	6.29
Magnesium Sulphate $MgSO_4$	56.3	3.29
Sodium Sulphate Na_2SO_4	65.0	3.80
Sodium Chloride NaCl	8.2	0.48
Sodium Nitrate $NaNO_3$	1.9	0.01
Total	371.3	21.60

BARRY (1490). Barry is located in the western part of Pike County about ten miles distant from Mississippi River.

A public water supply was installed by the city about 1880. Information is principally from Mose Morey, Superintendent of Water Works. The installation included a well, a steel tank on a brick tower which served as a pump house, and a steam pump which pumped from the well into the tank and distribution system. Later a gasoline engine was used to drive the pump. In 1916 a water supply from a spring was developed, a reservoir 40 feet in diameter and a pumping station were built close to the spring, and a Deming 7 by 8-inch single-acting triplex pump driven by a 20-horsepower electric motor was installed. Water flows to the reservoir from which it is pumped into an 8-inch pipe line to the city.

About two hundred and fifty service connections were in use in 1924. Water used by stock feeders in the winter equalizes demands throughout the year, which are estimated at 20,000 to 25,000 gallons a day. The rates are $6.00 for the first 6000 gallons, 40 cents per 1000 gallons for the next 9000 gallons, with reduction to 20 cents per 1000 gallons for quantities in excess of 625,000 gallons. A cash discount of 25 cents is allowed for prompt payment.

The well drilled about 1880 was located in the City park, near the center of the city. It was drilled by the J. P. Miller Artesian Well Company. It was 2510 feet deep, was cased with 7-inch pipe to a depth of 300 feet, and was 2 inches in diameter at the bottom. A fair supply of water was secured at a depth of 65 feet and a good stream between depths of 700 and 800 feet from which water

raised to within 135 feet of the ground surface. A crevice was then struck and water could be heard flowing into the well. The water level lowered to a depth of 350 feet or 360 feet. Water was struck at depths of 1300 and 1700 feet and no water was found below 1700 feet. The depth to water when the well was completed was reported to be 135 feet. The pump cylinder was placed at a depth of 300 feet and was then raised to a depth of 160 feet. In 1914 it was reported that water stood at a depth of 130 feet, that the pump cylinder was at a depth of 200 feet and that during a test, made sometime before, extending over a period of 40 hours, the pump discharged about 35 gallons a minute.

The water was not satisfactory for a public supply. It had a mineral content of 5021, a total hardness of 1017, and a content of iron of 0.7 parts per million as shown by the analysis given below of a sample, number 22152, collected on July 10, 1911.

Analysis of Sample Number 22152 from Well 2510 Feet Deep.

Determinations Made.	Parts per million.
Iron, Fe	0.7
Silica, SiO_2	13.5
Nonvolatile	21.5
Alumina, Al_2O_3	12.0
Calcium, Ca	244.8
Magnesium, Mg	98.8
Ammonium, NH_4	3.1
Potassium, K	21.9
Sodium, Na	1452.7
Sulphate, SO_4	743.5
Nitrite, NO_2	2.6
Nitrate NO_3	4.9
Chloride, Cl	2254.8
Alkalinity Methyl Orange	246.
Residue	5047.

Hypothetical Combinations.	Parts Per Million.	Grains Per Gallon.
Potassium Nitrite KNO_2	4.8	.28
Potassium Nitrate KNO_3	8.0	.47
Potassium Chloride KCl	31.6	1.84
Sodium Chloride NaCl	3686.9	215.06
Ammonium Chloride NH_4Cl	8.5	.50
Ammonium Sulphate $(NH_4)_2SO_3$	0.7	.04
Magnesium Sulphate $MgSO_4$	488.4	28.49
Calcium Sulphate $CaSO_4$	500.9	29.22
Calcium Carbonate $CaCO_2$	242.9	14.17
Iron Carbonate $FeCO_3$	1.5	.09
Alumina Al_2O_3	12.0	.70
Silica SiO_2	13.5	.79
Nonvolatile	21.5	1.25
Total	5021.2	292.90

The spring from which the public water supply has been secured since 1916 is located in the northwest quarter of section 26 about one mile west of the city. It is at the foot of a hill in the valley of a small stream. The flow when measured in 1913 and 1914 was about 30 gallons a minute and the flow of two other springs in the same valley, which might be used to increase the supply, was 20 gallons a minute. Measurements of flow of the spring which furnishes the supply can now be made in the reservoir. On January 7, 1922, the flow was about 50 gallons a minute. It was said that in dry times the flow was 22 gallons a minute. On January 6, 1925, the flow was 22 gallons a minute.

A sample of water, number 53044, collected from the spring on January 6, 1925, had a mineral content of 267, a total hardness of 183, and a content of iron of 0.06 parts per million as shown by the analysis.

Analysis of Sample Number 53044 from the Spring.

Determinations Made.	Parts per million.
Iron, Fe	0.06
Manganese, Mn	0.0
Silica, SiO_2	18.2
Nonvolatile	1.4
Alumina, Al_2O_3	2.5
Calcium, Ca	57.8
Magnesium, Mg	9.5
Ammonia, NH_4	0.0
Sodium, Na	19.3
Potassium, K	4.0
Sulfate, SO_4	22.2
Nitrate, NO_3	13.3
Chloride, Cl	7.0
Alkalinity	
Phenolphthalein	0.
Methyl Orange	182.
Residue	273.

Hypothetical Combinations.	Parts Per Million.	Grains Per Gallon.
Potassium Nitrate KNO_3	10.1	0.59
Sodium Nitrate $NaNO_3$	9.3	0.55
Sodium Chloride NaCl	11.7	0.69
Sodium Sulfate Na_2SO_4	32.7	1.91
Sodium Carbonate Na_2CO_3	3.5	0.21
Magnesium Carbonate $MgCO_3$	32.9	1.92
Calcium Carbonate $CaCO_3$	144.6	8.46
Iron Oxide Fe_2O_3	.1	.01
Alumina Al_2O_3	2.5	.14
Silica SiO_2	18.2	1.07
Nonvolatile	1.4	.08
Total	267.0	15.63

BARTLETT (371). Bartlett is located in the northwestern part of Cook county near the watershed between tributaries of Du Page and Fox Rivers. The installation of the public water supply by the village was started in 1923. The installation was to include a well, a deep-well pump, a 10-horsepower electric motor, an oil engine for use in emergency, a distribution system, and a 40,000-gallon elevated steel tank.

The well was drilled by W. L. Thorne of Des Plaines. Information is from the driller. The well is 8 inches in diameter and 200 feet deep and is cased with 8-inch pipe into rock which was entered at a depth of 146 feet. Water stood 46 feet below the ground surface when the well was completed and was lowered 6 feet by pumping at a rate of 300 gallons a minute.

BARTONVILLE (1588). Bartonville is located in Peoria County southwest of the city of Peoria. Water for a public supply is secured from the Peoria Water Works Company.

BATAVIA (4395). Batavia is located in the southeastern part of Kane County on the banks of Fox River.

A public water supply was installed by the city in 1894. The supply was from one well until another well was drilled in 1915. Water from the wells is discharged into a collecting reservoir from which it is pumped into the distribution system. One well, seldom used since 1915, is equipped with air lift. Air is supplied by an Ingersoll-Rand compressor of 150 cubic feet a minute capacity. The other well is equipped with a centrifugal deep-well pump driven by a 35-horsepower electric motor. Two Worthington pumps are available to pump water from the reservoir, one of 1,500,000 gallons capacity and the other of 800,000 gallons capacity. The smaller pump was formerly in regular service and drew water from the reservoir or directly from the well then in use.

About 1200 service connections were in use in 1924. The meter rate is $2.50 for 400 cubic feet or less used in three months and 15 cents per 100 cubic feet for additional water.

Well Number 1 was drilled by the J. P. Miller Artesian Well Company in 1895. It is 10 inches in diameter at the top, 4 inches in diameter at the bottom, and 1279 feet deep. It is in sandstone between depths of 520 and 825 feet. Another stratum of sandstone was entered at or above a depth of 1110 feet and the bottom of this stratum was at a depth of 1270 feet. It is cased to a depth of 40 feet. The well flowed when drilled. Later the depth to water varied between 6 feet and 40 feet. At times when the water level was highest a considerable part of the supply was drawn from the well by suction. The well is equipped with an air lift with a 2-inch air line extending to a depth of 230 feet. The yield was given as 800 gallons a minute in 1911 and 600 gallons a minute in 1918. Since 1915 this well has seldom been used as the expense of operation is much greater than that for the other well.

Well Number 2 is 2,000 feet deep. It was drilled by the J. P. Miller Artesian Well Company of Chicago in 1915. The elevation of the top is about 660 feet above sea level. Rock was entered at a depth of 6 feet; St. Peter sandstone, which is 309 feet thick, was entered at a depth of 520 feet; and the principal water bearing formation, the Cambrian system, was entered at a depth of 1,100 feet. A detailed log for reference is on file with the State Geological Survey Division. The upper 70 feet (40 ?) of the well is cased and 77 feet of 8-inch galvanized pipe was placed in chert and shale immediately below the St. Peter sandstone. This liner is said to shut out sulphurous water encountered in that stratum. The well is 8 inches in diameter at the bottom. When completed, water stood at a depth of six feet.

The well is equipped with an American 8-stage centrifugal deep-well pump driven by a 35-horsepower electric motor. The yield in 1918 was 1,140 gallons a minute. The water level was 6 feet below the ground surface when not pumping and was said to be lowered 34 feet by pumping. The yield during a test in 1924 was the same. The depth to water in the well, computed from air pressures, was 40 feet before pumpingand 83 when pumping. The total amount of water pumped was estimated at an average of 350,000 gallons a day. In April, 1925, L. A. Parre, Superintendent of Water Works, reported the water level to be at a depth of 70 feet when not pumping and 108 feet when pumping, and the amount of water pumped to be 500,000 gallons a day.

Water from the well 2,000 feet deep had a mineral content of 311, a total hardness of 210, and a content of iron of 0.2 parts per million as shown by the analysis of sample number 43,359, collected on July 1, 1920.

Analysis of Sample Number 43359 from Well 2,000 Feet Deep.

Determinations Made.	Parts per million.
Potassium, K } Sodium, Na }	41.1
Ammonium, NH_4	1.3
Magnesium, Mg.	24.2
Calcium, Ca.	45.2
Iron, Fe.	0.2
Nitrite, NO_2	0.1
Nitrate, NO_3	2.1
Chloride, Cl.	12.0
Sulfate, SO_4	24.2
Alumina, Al_2O_3	1.3
Silica, SiO_2	4.0
Nonvolatile	3.0
Alkalinity Methyl Orange.	258.
Residue	330.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Sodium Nitrate, $NaNO_3$	2.9	.17
Sodium Chloride, NaCl.	19.8	1.16
Sodium Sulfate, Na_2SO_4	35.8	2.09
Sodium Carbonate, Na_2CO_3	48.0	2.80
Ammonium Carbonate $(NH_4)_2CO_3$	3.4	.20
Magnesium Carbonate $MgCO_3$	83.7	4.89
Calcium Carbonate, $CaCO_3$	112.8	6.60
Iron Oxide, Fe_2O_3	0.3	.02
Alumina, Al_2O_3	1.3	.08
Silica, SiO_2	2.0	.14
Nonvolatile	1.5	.09
Total	311.6	18.24

BEARDSTOWN (7111). Beardstown is located in the western part of Cass County on the east bank of Illinois River. A public water supply was installed by the Beardstown Water Company in 1892 and was purchased by the city during that year. Water is drawn from wells by suction and discharged directly into the distribution system by either of two 16 by 12 by 12-inch Gardner duplex steam pumps which are placed in a pit. Steam is supplied by two Erie 150-horsepower fire-tube boilers.

The wells are located in the eastern part of the city. The original wells were drilled in a pit 30 feet in diameter and 6 feet

deep. The wells were 6 inches in diameter and 100 feet deep. Below 8 feet of sand, 4 feet of clay, and 9 feet of quicksand the material penetrated was nearly all sand. Strainers on these wells clogged rapidly. In order to avoid trouble of cleaning and replacing screens on large wells seventy-two 2-inch wells were drilled to a depth of 40 feet. Each well was equipped with a screen 5 feet long. It was the practice to replace one-half of the wells each year using new casings and new strainers. The 2-inch wells have been abandoned and water is now secured from 6-inch wells. Wells have been drilled to various depths in an attempt to lessen clogging of the screens. In 1921 twelve 6-inch wells, located in a pit about 24 feet wide, 68 feet long, and 8 feet deep, were in use. Ten wells were 72 feet deep and two were a little deeper. It was said that one of the duplex pumps drawing water from the wells could be operated at a rate of 90 revolutions a minute, a displacement of 530 gallons a minute. In 1925 sixteen wells were reported in use.

The water had a mineral content of 560, a total hardness of 350, and a content of iron of 1.4 parts per million as shown by the analysis of sample number 43600, collected on August 4, 1920.

Analysis of Sample Number 43600 from the City Supply.

Determinations Made.	Parts per million.
Iron, Fe	1.4
Manganese, Mn	0.4
Silica, SiO_2	30.4
Nonvolatile	0.9
Alumina, Al_2O_3	1.9
Calcium, Ca	79.8
Magnesium, Mg	36.9
Ammonium, NH_4	0.7
Potassium, K / Sodium, Na	56.9
Sulfate, SO_4	125.8
Nitrate, NO_3	12.7
Chloride, Cl	83.0
Alkalinity	
Phenolphthalein	0.
Methyl Orange	240.0
Residue	655.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Sodium Nitrate, $NaNO_3$	17.4	1.02
Sodium Chloride, NaCl	132.3	7.76
Ammonium Chloride, NH_4Cl	0.5	.03
Magnesium Chloride, MgCl	3.0	.18
Magnesium Sulfate, $MgSO_4$	157.2	9.19
Magnesium Carbonate, $MgCO_3$	15.0	.88
Calcium Carbonate, $CaCO_3$	199.4	11.66
Silica	30.4	1.77
Nonvolatile	0.9	.05
Iron Oxide, Fe_2O_3	2.0	.12
Alumina, Al_2O_3	1.9	.11
Total	560.0	32.77

Considerable trouble has been experienced with a brown deposit in the mains and especially in the goose necks connecting mains and service pipe. The water has a distinct brown color and stains plumbing fixtures. This is due to the iron content of the water and a growth of crenothrix which thrives in it. At the pumping station water from the supply passes through a heater and is then treated with boiler compound before using in the boilers. The heater is

cleaned every two months and about six wheelbarrow loads of scale is removed, part of which is hard and part softer and much lighter.

Data in regard to a well drilled for the city in 1924 by the Kelly Well Company of Grand Island, Nebraska, was secured from the company. It is a 32-inch well. A record of material penetrated in as follows:

	Thickness in feet.	Depth in feet.
Top soil	14	14
Sand	1	15
Sand and clay	6	21
Blue clay and sand	5	26
Fine sand	30	56
Sand and gravel	9	65
Gravel	3	68
Coarse sand	12	80
Sand	4	84
Total		84

Fifty feet of concrete screen and thirty-three feet of plain concrete casing were used. The discharge during a test was 400 gallons a minute and the water level was lowered four feet. A yield of 1,500 gallons a minute was reported from the wells in use in 1925.

BEECHER (609). Beecher is located in the southeastern part of Will County on the drainage area of Kankakee River.

A public water supply was installed by the village in 1911. The installation included a well, a deep-well pump driven by gas engine, two steel pressure tanks 8 feet in diameter and 36 feet long, a building enclosing the pump and tanks, and a distribution system. The pump is now driven by an electric motor, and a 50-horsepower gas engine can be used in case of emergency. Electric current is purchased from the Public Service Company. One hundred and ten consumers were supplied in 1923 and the consumption was estimated at 27,000 gallons a day.

A local creamery has a private water supply from two wells the same depth as the city well.

Water for the public supply is secured from a well drilled in 1911 at the corner of Penfield and Woodward Streets near the center of the village. It is 10 inches in diameter, 164 feet deep, and cased to rock at a depth of 80 feet. The elevation at the top is about 705 feet above sea level. Water is pumped by a Goulds 7-inch by B-inch triplex pump which operates from 47 to 48 revolutions a minute. The rate of pumping is 180 gallons a minute when the pump is in good condition. It is estimated that during the year to June 1, 1923, the pump operated 2 hours 35 minutes a day. The

depth to water in 1917 was reported to be 15 feet. On June 19, 1923, it was 14 feet 8 inches from the top of the casing when the pump was idle. Pumping for 9 minutes lowered the water level 2 feet 3 inches and when the pump was stopped the water level came back to a depth of 14 feet 8 inches in one minute.

The water had a mineral content of 957, a total hardness of 619, and a content of iron of 0.5 parts per million as shown by the analysis of sample number 38536, collected on November 13, 1917.

Analysis of Sample Number 38536 from the Village Supply.

Determinations Made.	Parts per million.
Iron, Fe	0.5
Silica, SiO_2	18.0
Alumina, Al_2O_3	3.1
Calcium, Ca	156.8
Magnesium, Mg	55.4
Potassium, K	11.4
Sodium, Na	60.9
Ammonia, NH_4	0.5
Sulphate, SO	514.3
Nitrate, NO_3	1.2
Chloride, Cl	3.0
Alkalinity Methyl Orange	234.
Residue	995.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate, KNO_3	2.0	.11
Potassium Chloride, KCl	6.3	.37
Potassium Sulphate, K_2SO_4	16.3	.95
Sodium Sulphate, Na_2SO_4	187.8	10.95
Ammonium Sulphate, $(NH_4)_2SO_4$	1.8	.10
Magnesium Sulphate, $MgSO_4$	273.8	15.97
Calcium Sulphate, $CaSO_4$	210.6	12.27
Calcium Carbonate, $CaCO_3$	237.1	13.82
Iron Oxide, Fe_2O_3	0.7	.04
Alumina, Al_2O_3	3.1	.18
Silica, SiO_2	18.0	1.05
Total	957.5	55.81

BELLEVILLE (24823). Belleville is an industrial city located in the central part of Saint Clair County on the drainage area of Kankaskia River. Filtered Mississippi River water purchased from the American Water Works and Guarantee Company is now used for a public supply.

A public water supply was installed by a private company in 1894. Water was secured from impounding reservoirs northeast of the city but the quantity of water available was not sufficient to supply demands.

A water supply from deep wells in the valley of Richland creek in the southwestern part of the city was developed by a private company in 1896. The wells were in rock below a depth of about 30 feet. They penetrated several strata of sandstone. The main supply was from a stratum of sandstone entered at a depth of about 400 feet, a stratum which is close to the ground surface about 12 miles west of Belleville. A few records on file show some wells had a yield of three or four gallons a minute and many of the wells were not pumped. Well number 14, located 2,000 feet northwest of the pumping station, was 420 feet deep, was cased with $7^5/_8$-inch iron

pipe to a depth of 320 feet and yielded 30,000 gallons a day. The total supply from the wells was inadequate and it was necessary to use some water from the impounding reservoirs.

The water from well number 14 had a mineral content of 432 and a total hardness of 52 parts per million as shown by the analysis of sample number 17167, collected on March 6, 1908.

Analysis of Sample Number 17167 Collected from Well Number 14.

Determinations Made.	Parts per million.
Iron Oxide, Fe_2O_3 } Alumina, Al_2O_3 }	4.0
Calcium, Ca	7.6
Magnesium, Mg	8.1
Ammonia, NH_4	0.4
Sodium, Na	154.1
Sulfate, SO_4	18.1
Chloride, Cl	19.0
Silica, SiO_2	15.4
Alkalinity Methyl Orange	366.
Residue	443.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Sodium Chloride, NaCl	31.4	1.83
Sodium Sulphate, Na_2SO_4	26.8	1.56
Sodium Carbonate, Na_2CO_3	306.1	17.85
Ammonium Carbonate, $(NH4)_2CO_4$	1.1	.06
Magnesium Carbonate, $MgCO_3$	28.1	1.64
Calcium Carbonate, $CaCO_3$	19.0	1.11
Iron Oxide, Fe_2O_3 } Alumina, $Al2O_3$ }	4.0	.23
Silica, SiO_2	15.4	.90
Nonvolatile	0.7	.04
Total	432.6	25.23

A supply from wells in Mississippi River bottoms at Edgemont, about seven miles northwest of Belleville, was developed in 1907-1908. These wells were about 95 feet deep. They penetrated clay, silt, and fine sand and, at the bottom, about 20 feet of coarse sand. The station in the southwest part of the city was maintained to pump water from the reservoir at times of fire or other emergency. The water from this supply had a mineral content of 392 and a total hardness of 317 parts per million as shown by the analysis of sample number 17398, collected on May 4, 1908.

Analysis of Sample Number 17398 from the Wells in Edgemont.

Determinations Made.	Parts per million.
Iron Oxide, Fe_2O_3 } Alumina, Al_2O_3 }	7.4
Silica, SiO_2	33.1
Calcium, Ca	75.0
Magnesium, Mg	31.9
Ammonia, NH_4	0.5
Sodium, Na	15.8
Nitrate, NO_3	0.5
Sulfate, SO_4	40.2
Chloride, Cl	8.0
Alkalinity Methyl Orange	290.
Residue	378.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Sodium Nitrate, $NaNO_3$	0.7	.04
Sodium Chloride, NaCl	13.2	.77
Sodium Sulphate, Na_2SO_4	32.1	1.87
Ammonium Sulphate, $(NH_4)_2SO_4$	1.8	.10
Magnesium Sulphate, $MgSO_4$	21.6	1.26
Magnesium Carbonate, $MgCO_3$	95.2	5.56
Calcium Carbonate, $CaCO_3$	187.2	10.92
Iron Oxide, Fe_2O_3 } Alumina, Al_2O_3 }	7.4	.43
Silica, SiO_2	33.1	1.93
Nonvolatile	0.6	.03
Total	392.9	22.91

In 1912 the American Water Works and Guarantee Company, who had purchased the stock of the water company, built a pipe line from the station at Edgemont to East St. Louis and since that time have supplied filtered Mississippi River water from their plant located in East St. Louis.

BELLWOOD (1881). Bellwood is located in the western part of Cook County on the drainage area of Des Plaines River.

A public water supply was installed by the village in 1908. Water was purchased from Melrose Park until 1914 when a well supply developed in Bellwood was put into use. The well is equipped with a Luitwieler deep-well pump driven by a 20-horsepower electric motor. The pump discharges into the distribution system and a 60,000 gallon steel tank on a tower 120 feet high connected to the system. The tank is located on the same lot as the well.

The public water supply is from a well drilled in 1913. The elevation at the top is about 635 feet above sea level. The well is 12 inches in diameter at the top, 8 inches in diameter at the bottom, and 1,538 feet deep. It is cased with 12-inch pipe to rock at a depth of 87 feet, with 201 feet of 10-inch pipe in shale (above a depth of 510 feet), and with 8-inch pipe between depths of 910 feet and 971 feet 10 inches.

Analysis of Sample Number 47765 from the Public Supply.

Determinations Made.	Parts per million.
Iron, Fe	0.6
Manganese, Mn	0.0
Silica, SiO_2	16.2
Nonvolatile	0.7
Alumina, Al_2O_3	1.5
Calcium, Ca	90.4
Magnesium, Mg	50.5
Ammonia, NH_4	0.6
Sodium, Na	33.1
Potassium, K	6.8
Sulfate, SO_4	186.7
Nitrate, NO_3	0.2
Chloride, Cl	6.0
Alkalinity	
Methyl Orange	320.0
Residue	599.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate, KNO_3	0.3	.02
Potassium Chloride, KCl	12.6	.74
Potassium Sulphate, K_2SO_4	0.1	.01
Sodium Sulphate, Na_2SO_4	102.1	5.97
Ammonium Sulphate, $(NH_4)_2SO_4$	2.0	.12
Magnesium Sulphate, $MgSO_4$	145.4	8.50
Magnesium Carbonate, $MgCO_3$	72.7	4.26
Calcium Carbonate, $CaCO_3$	225.6	13.19
Silica, SiO_2	16.2	.94
Nonvolatile	0.7	.04
Iron Oxide, Fe_2O_3	0.8	.05
Alumina, Al_2O_3	1.5	.09
Total	580.0	33.93

The well was first equipped with a deep-well pump with the cylinder at a depth of 200 feet and was pumped at a rate of 200 gallons a minute. The water level when not pumping was at a depth of 75 feet. The pump in use in 1922 was thought to have a

capacity of 150 gallons a minute and the depth to water was said to have been 100 feet the last time the pump cylinder was removed. The pump was operated from 9 to 10 hours a day during the summer of 1922.

The temperature of water from the well after 6 hours pumping was 52 degrees Fahrenheit. The water had a mineral content of 580, a total hardness of 430, and a content of iron of 0.6 parts per million as shown by the analysis of sample number 47765, collected on June 21, 1922, after the pump had operated continuously for six hours.

A sample of water collected in 1913 from a well 226 feet deep was of similar quality. It had a mineral content of 565, a total hardness of 435, and a content of iron of 0.2 parts per million.

BELVIDERE (7804). Belvidere is located in the southern part of Boone County on the banks of Kishwaukee River, a tributary of Rock River.

A public water supply was installed by the city in 1891. The installation included a well, reservoir, pump, pumping station, distribution system, and elevated tank. Water flowed from the well to the reservoir from which it was pumped into the mains. Later three triplex pumps were installed, one to pump from each well. The wells are now equipped with air lifts. The equipment in 1924 included three 90-horsepower Sterling water tube boilers, a Sullivan 14 and 16 by 10 by 16-inch compressor, a Laidlaw-Dunn-Gordon 12 and 25 by 10¼ by 18-inch cross-compound pump to pump water from the reservoir, and two duplex pumps formerly in regular service maintained for use in emergency. Another air compressor was to be installed in 1924. Cooling water from the air compressor passes back to the pump suction and at times of low consumption a bypass on the pump is opened, so exact quantities of water pumped are difficult to estimate.

Two thousand service connections were in use in 1924. The minimum charge for a month is 75 cents which allows the use of 315 cubic feet of water. The lowest rate, for water in excess of 13,333 cubic feet, is 6¾ cents per 100 cubic feet.

Water is secured from three wells. A record of material penetrated by well number 3 is as follows:

	Thickness in feet.	Depth in feet.
Surface material, sand, gravel, etc	46	46
Limestone, Galena-Platteville	294	340
Sandstone, St. Peter	185	525
Limestone with some sandstone and shale, Prairie du Chien	200	725
Cambrian system "Potsdam"	1078	1803

A detailed log is on file with the State Geological Survey Division.

Well number 1, which is located in the pumping station, was drilled in 1891. The top is about 765 feet above sea level. The well was 8 inches in diameter to a depth of 1,000 feet, 6 inches in diameter at the bottom, and 1,950 feet deep. Part of the 6-inch was reamed to 8-inch and the material was left in the bottom of the well. The well flowed when drilled and supplied demands for about a year when a triplex pump was installed to pump water from the well. In 1918 the well was equipped with air lift. With 200 feet of air line the discharge was 600 gallons a minute. During a one hour test on December 7, 1921, after the pump had been idle for an hour the air lift discharged 540 gallons a minute, as computed from reservoir levels. The water level in this well was at a depth of six feet in 1896 and in 1921, while pumping from well number 2, was seventeen feet below the ground surface. In 1924 the air line in the well was replaced by an air line of 2-inch and 1½-inch pipe extending to a depth of 185 feet.

Well number 2, located two blocks east of the pumping station, was drilled in 1901. It is 8 inches in diameter and 1,861 feet deep. In May, 1924, this well had not been used for two years.

Well number 3 was drilled by the J. P. Miller Artesian Well Company in 1908. It was 1,803 feet deep. It was cased with 10-inch pipe to rock and was 8 inches in diameter at the bottom. When drilled, water stood 8 feet below the ground surface. In 1921 the well was equipped with air lift. In May, 1924, this well was operating continuosly and furnished the entire supply. The yield on May 26, when the compressor was running 72 revolutions a minute, was 490 gallons a minute. When the compressor was operating 56 revolutions a minute the discharge was 418 gallons a minute. The air line was 185 feet long.

Wells number 1 and 3 yielded 800 to 850 gallons a minute in 1921. When pumped continuously for 112 days in 1923 they yielded an average of 630 gallons a minute.

It was possible to supply all demands by drawing water from the wells by suction by pumps placed at the ground surface until 1916. Two of the pumps were then placed in a pit 8 feet deep. In 1918 the available supply with this arrangement was 600 gallons a minute and an air lift was then installed in well number 1.

The water had a mineral content of 537 and a total hardness of 440 parts per million as shown by the analysis of sample number 51525, collected at a tap in the pumping station on May 26, 1924.

Analysis of Sample Number 51525 from the Public Supply.

Determinations Made.	Parts per million.
Iron, Fe	0.0
Manganese, Mn	0.0
Silica, SiO_2	14.8
Nonvolatile	0.6
Alumina, Al_2O_3	1.1
Calcium, Ca	99.9
Magnesium, Mg	46.5
Ammonia, NH_4	0.1
Sodium, Na	20.1
Potassium, K	4.8
Sulfate, SO_4	125.1
Nitrate, NO_3	10.6
Chloride, Cl	23.0
Alkalinity	
Methyl Orange	330.
Residue	527.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate, KNO_3	12.3	0.72
Sodium Nitrate, $NaNO_3$	4.2	0.24
Sodium Chloride, NaCl	37.9	2.21
Sodium Sulphate, Na_2SO_4	12.6	0.74
Ammonium Sulphate, $(NH_4)_2SO_4$	0.4	0.02
Magnesium Sulphate, $MgSO_4$	145.6	8.50
Magnesium Carbonate, $MgCO_3$	59.1	3.45
Calcium Carbonate, $CaCO_3$	249.3	14.56
Alumina, Al_2O_3	1.1	0.06
Silica, SiO_2	14.8	0.86
Nonvolatile	0.6	0.03
Total	537.9	31.39

A sample collected in 1913 was similar. It had a mineral content of 508, a total hardness of 460, and a content of iron of 0.7 parts per million.

Water for use in boilers at the pumping station is heated and treated with compound. The heater is cleaned twice a month and hard scale is removed. The boiler feed pump is cleaned once a month and pipes to the boilers are cleaned about once a year. Meters last from one to twenty-five years.

BEMENT (1663). Bement is located in the southern part of Piatt County on the drainage area of Kaskaskia River, a tributary of Mississippi River.

A public water supply with wells as the source of supply was installed by the village in 1894. Some additions to the plant have been made. Water is now pumped from the wells into two reservoirs, one the original reservoir 21 feet, 11 inches in diameter and the other a reinforced concrete reservoir 41 feet in diameter and 10 feet deep which was built in 1914. The reservoirs are connected by pipe line. Water is pumped from the reservoirs into the mains by a 12-inch by 7-inch by 12-inch duplex steam pump. Steam is supplied by two boilers, one of 45-horsepower and the other, installed in 1916, a Kewanee boiler of 60-horsepower. An elevated tank located near the center of the city is connected to the mains. The original tank was replaced in 1917 by a fir tank 22 feet in diameter and 24 feet high which is placed on the original brick tower. The rate for water (per year?) is $12.00 for 20,000 gallons or less, 30 cents per 1,000 gallons for the next 20,000 gallons, 1.5 cents

per 1,000 gallons for the next 60,000 gallons, and 10 cents per 1,000 gallons for water in excess of 100,000 gallons.

The public water supply is secured from two wells drilled in 1894. They are located 6 feet apart near the eastern limits of the village. The elevation of the ground surface at the wells is about 680 feet above sea level. One well is 6 inches in diameter and 137 feet deep and the other is 6 inches in diameter and 140 feet deep. The material penetrated is soil, clay, hardpan, and sand. In 1917 with double-acting pumps with 24-inch strokes and 3¼-inch cylinders placed at a depth of 119 feet the water level in one well was drawn to a depth of 70 feet by operating the pump in the other well. Water was not drawn down to the bottom of the cylinder at the maximum rate of pumping which was probably about 50 gallons per minute from each well.

In March, 1924, a steam-head single-acting pump in the east well with 5½-inch cylinder and 36-inch stroke operating 24½ revolutions a minute, the highest speed at which it was run, was drawing some air. The cylinder was placed 11 feet above the bottom of the well. The west well had been equipped with a Cook double-stroke pump with 5½-inch cylinder and 18-inch stroke. It was operated at about 22 strokes a minute. In March one pump was operating for 12 or 13 hours a day. Some changes which have been made in pump equipment were to secure a greater quantity of water and other changes were necessary on account of drawing in fine sand when operating at comparatively high rate and drawing air into the pump cylinders.

Analysis of Sample Number 39683 from the Public Water Supply.

Determination Made.	Parts per million.
Iron, Fe.	1.5
Manganese, Mn.	0.0
Silica, SiO_2	18.4
Calcium, Ca.	57.9
Magnesium, Mg.	38.7
Ammonia, NH_4	2.1
Sodium, Na.	82.1
Nitrate, NO_3	0.4
Sulfate, SO_4	0.0
Chloride, Cl.	64.0
Carbon dioxide, CO_2	10.0
Hydrogen Sulphide	0.0
Alkalinity Methyl Orange	397.1
Residue	503.5

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Sodium Nitrate, $NaNO_3$	0.5	.03
Sodium Chloride, NaCl.	105.4	6.15
Sodium Carbonate, Na_2CO_3	92.7	5.40
Ammonium Carbonate, $(NH_4)_2CO_3$	5.5	.32
Magnesium Carbonate, $MgCO_3$	134.0	7.82
Calcium Carbonate, $CaCO_3$	144.5	8.43
Iron Carbonate, $FeCO_3$	3.1	.45
Manganese Carbonate, $MnCO_3$	0.1	0.01
Silica, SiO_2	18.4	1.07
Nonvolatile	0.9	.05
Total	505.1	29.73

The water had a mineral content of 505, a total hardness of 303, and a content of iron of 1.5 parts per million as shown by the analysis of sample number 39683, collected on June 27, 1918.

Many wells have been drilled into sand and gravel in an attempt to increase the supply. Several of the wells were drilled on the lot on which the old wells are located. One well was drilled near the center of the village and three or four wells were drilled on the north side of the Wabash Railroad about 900 feet west and north of the old wells at the pumping station. One of these wells drilled north of the railroad was pumped for a time. The casings of all of these wells have been pulled.

A well into rock was drilled on the pumping station grounds in 1917. The well is 12 inches in diameter to a depth of 139 feet, 6 inches in diameter below a depth of 139 feet, and 275 feet deep. The material penetrated below a depth of 133 feet, the depth at which a stratum of water bearing sand was encountered, is as follows :

	Thickness in feet.	Depth in feet.
Fine sand	7	140
Red Clay	10	150
	40	190
Quicksand	19	209
Flinty limestone	3	212
Rock	63	275

The well was first drilled to a depth of 140 feet and a screen was installed in the sand encountered at that depth. It is reported that sand flowed into the well and the yield was very small. The depth of the well was then increased to 275 feet. The depth to water when not pumping was 26 feet. During a test in 1917, with the bottom of the suction pipe of a deep-well pump at a depth of 68½ feet, 80 gallons a minute could be pumped without drawing air. Pumping 88 gallons a minute air was drawn into the cylinder. This well furnished part of the public water supply in 1923. It was equipped with a Luitwieler deep-well pump. The cylinder was placed at a depth of 90 feet. On June 14, 1923, the east well in the pumping station was operating 16 to 19 strokes a minute and the pump in this well was operating 24 revolutions a minute. The yield, measured in the reservoir, was 120 gallons a minute of which probably close to 70 gallons a minute was from this well. The water level was drawn down to a depth of 64 feet 9 inches. On account of the quality of water secured the well was not in use in 1924.

Water from the well 275 feet deep had a mineral content of 1545, a total hardness of 550, and a content of iron of 2.7 parts per

million as shown by the analysis of sample number 37776, collected from the well when it was pumped for several hours on August 11, 1917.

Analysis of Sample Number 37776 from City Well 275 Feet Deep.

Determinations Made.	Parts per million.
Turbidity	130.0
Iron, Fe	2.7
Magnesium, Mg	54.5
Nitrite, NO_2	0.1
Nitrate, NO_3	0.4
Sulfate, SO_4	10.3
Chloride, Cl	670.0
Alkalinity	
Phenolphthalein	0.0
Methyl Orange	354.0
Residue total	1740.0
Residue dissolved	1545.0

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Sodium Chloride, NaCl	860	50.16
Magnesium Chloride, $MgCl_2$	200	11.67
Magnesium Sulphate, $MgSO_4$	13	0.76
Magnesium Carbonate, $MgCO_3$	24	1.40
Calcium Carbonate, $CaCO_3$	326	19.02
Iron Carbonate, Fe_2CO_3	6	0.35
Undetermined	116	6.77
Total	1545	90.13

Following an attempt to secure water from a well into Niagaran limestone in 1924, another well was drilled into rock on the pumping station grounds close to the old wells and close to the well 275 feet deep. The well was drilled to a depth of 208 feet. A sample of water collected was of practically the same quality as the sample of water collected from the well 275 feet deep.

In 1924 a well was drilled to a depth of 1184 feet. An attempt was made to drill to Niagaran limestone but the hole was abandoned at a depth of 1,184 feet as the diameter was too small. Water from one sand stratum raised to the top of the well. The water was reported to be very salty. Water from the next sandstone stratum, between depths of 1,153 and 1,183 feet, raised probably 800 feet. The water was very salty, “too salty to swallow.”

BENSON (414). Benson is located in the northeastern part of Woodford County on the drainage area of Mackinaw River. Many residents secure their drinking water from wells, many of which are from 15 to 50 feet deep.

A public water supply was installed by the village in 1889. Then system included a dug well 50 feet deep, a steam pump and boiler, a wooden tank on a brick tower, and a system of mains. The original well and equipment have been abandoned on account of inadequate supply. Water is now pumped from a well into the mains by a pump driven by a 5-horsepower electric motor. A wooden tank on a brick tower is connected to the mains, the tank in use replacing the original tank in 1900.

The public water supply is from a well into sand and gravel located in the western part of the village. The elevation at the top is about 760 feet above sea level. The well is 20 feet in diameter to a depth of 20 feet and 14 feet in diameter between depths of 20 and 50 feet. Two holes extend from a depth of 50 feet to a depth of 80 feet and are cased with 2-inch pipe equipped with strainers at the bottom. Water is pumped from the well by a deep-well pump with 5¾-inch cylinder and 10-inch stroke.

The water had a mineral content of 397 and a total hardness of 323 parts per million, and contained only a trace of iron as shown by the analysis of sample number 31553, collected on September 16, 1915.

Analysis of Sample Number 31553 from the Public Supply.

Determinations Made.	Parts per million.
Iron, Fe	trace
Manganese, Mn	none
Silica, SiO_2	11.6
Calcium, Ca	80.3
Magnesium, Mg	30.0
Sodium, Na	5.3
Potassium, K	4.6
Ammonia, NH_4	0.0
Nitrate, NO_3	23.9
Sulphate, SO_4	101.0
Chloride, Cl	19.0
Alkalinity Methyl Orange	196.
Residue	490.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate, KNO_3	11.9	.69
Sodium Nitrate, $NaNO_3$	15.9	.93
Magnesium Nitrate, $Mg(NO_3)_2$	7.2	.04
Magnesium Chloride, $MgCl_2$	25.5	1.48
Magnesium Sulphate, $MgSO_4$	110.2	6.41
Calcium Sulphate, $CaSO_4$	18.6	1.08
Calcium Carbonate, $CaCO_3$	186.7	10.88
Iron Carbonate, $FeCO_3$	trace	trace
Alumina, Al_2O_3	trace	trace
Silica, SiO_2	11.6	6.77
Nonvolatile	9.8	.57
Total	397.4	28.85

BERWYN (14150). Berwyn is a suburban city located in the central part of Cook County close to the western limits of Chicago.

A public water supply serving what is now the southern part of Berwyn was installed by the village in 1893. Water was secured from one well into “Potsdam” sandstone until 1912 when another well was drilled. In 1915 a connection was made to the Chicago supply to secure water for the southern part of the city. The northern part of the city had been supplied with water from Chicago for several years. The wells have been filled in.

One well was drilled by the J. P. Miller Artesian Well Company in 1892-1893. It was 1571 feet deep. The other well was drilled about 100 feet distant from the older well and is said to be about 1600 feet deep. One well was 16 inches in diameter at the top and 5 inches in diameter at the bottom and the other 16 inches in diameter at the top and 8 inches in diameter at the bottom. The

depth to water when not pumping was reported to have been 113 feet early in 1912 and the water level is said to have dropped about 73 feet during the next year. In 1915 when the older well was equipped with an air lift with 6-inch discharge pipe and 237 feet of 2½-inch and 60 feet of 2-inch air pipe, it was said to yield 320 gallons a minute. The newer well, equipped with a steam-head deep-well pump with the cylinder at a depth of more than 200 feet, yielded about 100 gallons a minute.

Water from the wells had a mineral content of 727, a total hardness of 380, and a content of iron of 0.4 parts per million as shown by analysis of sample number 28751, collected on September 11, 1914.

Analysis of Sample Number 28751 from the Village Wells,

Determinations Made.	Parts per million.
Iron, Fe	0.4
Magnesium, Mg	35 .0
Nitrite, NO_2	0.7
Nitrate, NO_3	3.1
Sulphate, SO_4	210.1
Chloride, Cl	100.0
Alkalinity Methyl Orange	252.0
Residue	727.0

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Sodium Nitrate, $NaNO_3$	4.4	0.26
Sodium Chloride, NaCl	165.0	9.62
Sodium Sulphate, Na_2SO_4	126.7	7.39
Magnesium Sulphate, $MaSO_4$	156 .0	9.10
Magnesium Carbonate, $MgCO_3$	11.8	0.69
Calcium Carbonate, $CaCO_3$	238.0	13.88
Iron Carbonate, $FeCO_3$	0.8	0.05
Undetermined	24.3	1.42
Total	727.0	42.41

BIGGSVILLE (425). Biggsville is located in the central part of Henderson County about eight miles distant from Mississippi River. Many citizens use water from wells 25 or 30 feet deep, some use cistern water, and many carry part of their supply from deep wells. Water for the high school is secured from a well. Dr. W. D. Henderson states that it is 1200 feet deep, that little water was encountered until in a limestone stratum at the bottom of the well and that when this stratum was entered water raised to within 60 feet of the ground surface. The Chicago, Burlington and Quincy Railroad, which passes through the village, uses some water from South Henderson Creek and some water from a well 14 feet in diameter and 28 feet deep on the bank of the creek.

A public water supply was installed by the village about 1903. Water was pumped from a well into the distribution system to which an elevated tank was connected. Later a larger well was drilled on land on which the elevated tank is located. Water is pumped directly from this well into the mains and tank. Galvanized

iron pipe are laid in the business district and in two or three blocks of the residence district and about twenty-five connections had been made in 1921.

Water for the public supply is secured from a 4-inch well about 190 feet deep located one block east of the business district. The top is about 670 feet above sea level. Rock is entered at a depth of about 40 feet and the lower 3 feet is said to be in blue clay. The well is equipped with a deep-well pump with 4½-inch stroke and 2½-inch cylinder placed at a depth of 180 feet. When not pumping the water level is at a depth of 40 feet. Mr. Boyd states that it takes all day, pumping when water is available, to pump sufficient water to raise the level in the elevated tank one foot to one and one-half feet.

The original well, located near the center of the village, is 2 inches in diameter and 193 feet deep. It is equipped with a windmill and could be used in emergency.

Water from the city supply had a mineral content of 546, a total hardness of 360, and a content of iron of 0.7 parts per million as shown by the analysis of sample number 45200, collected on May 12, 1921.

Analysis of Sample Number 45200 from the Public Supply.

Determinations Made.	Parts per million.
Iron, Fe	0.7
Manganese, Mn	0.0
Silica, SiO_2	10.0
Nonvolatile	0.6
Alumina, Al_2O_3	0.9
Calcium, Ca	84.2
Magnesium, Mg	37.2
Ammonia, NH_4	0.4
Potassium, K	3.7
Sodium, Na	75.6
Sulfate, SO_4	23.2
Nitrate, NO_3	5.8
Chloride, Cl	8.0
Alkalinity	
Phenolphthalein	0.0
Methyl Orange	490.0
Residue	507.

Hypothetical Combinations.	Parts Per Million.	Grains Per Gallon.
Potassium Nitrate KNO_3	9.5	.56
Sodium Chloride NaCl	13.2	.77
Sodium Sulfate Na_2SO_4	34.2	2.00
Sodium Carbonate Na_2CO_3	136.8	8.00
Ammonium Carbonate $(NH_4)_2CO_3$	0.9	.05
Magnesium Carbonate $MgCO_3$	128.8	7.53
Calcium Carbonate $CaCO_3$	210.3	12.30
Silica SiO_2	10.0	.58
Nonvolatile	0.6	.04
Iron Oxide Fe_2O_3	1.0	.06
Alumina Al_2O_3	0.9	.05
Total	546.2	31.94

BLOOMINGTON (28725). Bloomington is located in the central part of McLean County on the drainage area of Sangamon River, a tributary of Illinois River.

A public water supply was installed by the city in 1875. The supply was from a well. Additional wells have been drilled and

extensions have been made to the system. Information has been secured principally from C. C. Williams, Superintendent of Water Works, and from reports prepared by J. G. Melluish and by Alvord and Burdick. All of the supply excepting at the time of maximum demand is pumped from wells located near Adelaide Street north of Division Street. Water is pumped from the wells into a reservoir of 10,000,000 gallons capacity. Three pumps are available to pump from the reservoir into the mains, a Canton-Hughes cross compound of 6,000,000 gallons capacity, a Canton-Hughes cross compound of 4,000,000 gallons capacity, and an American 12-inch single-stage centrifugal of 6,000,000 gallons capacity direct connected to a 350-horsepower electric motor. Steam to operate the pumps and to operate dynamos of the municipal light and power plant is furnished by four Heine boilers, two of 250-horsepower and two of 350-horsepower. Water for the boilers is taken from the public water supply of the city of Normal. At times of maximum demand some water is pumped from three wells on West Market Street. Water from the wells is pumped into a reservoir of 188,000 gallons capacity from which it is pumped into the mains.

The rates for water for three months are 40 cents per 1000 gallons for the first 20,000 gallons, 30 cents per 1000 gallons for the next 30,000 gallons, 25 cents per 1000 gallons for the next 150,000 gallons, 20 cents per 1000 gallons for the next 300,000 gallons, and 12 cents per 1000 gallons for water in excess of 500,000 gallons.

The well installed in 1874 is located in the valley of Sugar Creek about 400 feet north of Division Street and 140 feet east of Adelaide Street. This is the well at the north side of the pumping station. It was originally 48 feet in diameter and 28 feet deep. Water stood within 7 feet of the ground surface and the supply was ample until 1886. As the consumption of water increased and the water level lowered, tubular wells were installed, some to a depth of 174 feet. These were later equipped with air lifts. Pumps were placed in a pit 15 feet deep to pump from the main well, the depth of which was increased to 40 feet in 1894, the lower part being excavated 28 feet in diameter. Additional wells were drilled but the supply was not adequate to meet demands at all times. A well was drilled on South Lee Street in glacial drift outside the valley of Sugar Creek and used intermittently from 1910 to 1915, when it was abandoned.

In 1909-1910 George Cadogan Morgan investigated and reported on the water supply. After drilling many test holes he reported that the water bearing stratum from which water was obtained

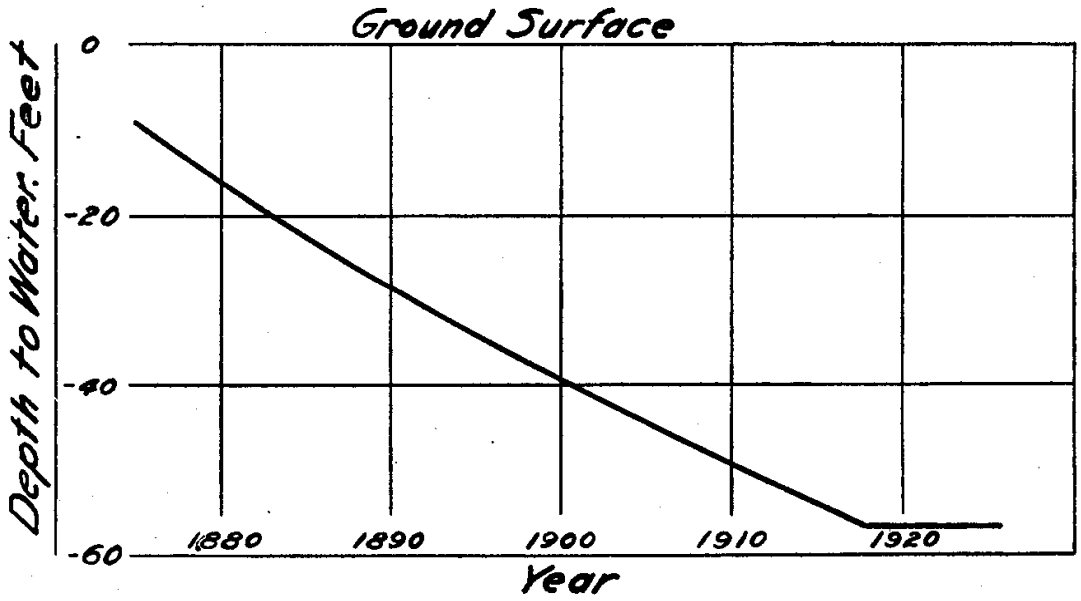
does not conform to the configuration of the ground surface; that it extends from the east and north to the southwest, far to the north and east of the watershed of Sugar Creek valley; that a uniform bed of gravel from 10 to 30 feet thick was found, and that there is a very high bottom from a point 600 feet north of Division Street northeasterly to a point about half a mile south of the Illinois Soldiers Orphans Home.

The public supply is now secured from wells in the valley of Sugar Creek north and west of the city. The principal supply is from five wells or groups of wells north of Division Street within 300 feet of Adelaide Street. Along this line the sand stratum extends south to within a few feet of Division Street. The bottom of the stratum along Adelaide Street from Division Street to one quarter mile north is from 60 to 80 feet lower than the step at the pumping station and between one quarter of a mile and half a mile north of Division Street it is about 80 feet lower than the step. The sand stratum extends to 7,500 feet north of Division Street but beyond half a mile north it is thinner and the bottom is at a higher elevation.

Tubular wells equipped with screens are drilled from the bottoms of pits to the bottom of the water bearing stratum. Water is pumped from each of these groups of tubular wells by an electrically driven centrifugal pump placed in the pit. Number 2, the south well, located 200 feet north of Division Street and about 250 feet west of Adelaide Street, has eight 12-inch number 60 Cook screens 10 feet long with bottoms at elevation 125. The pump capacity is 1400 gallons a minute. Number 4 is at the rear of the pumping station east of Adelaide Street. The pit at the top is the original well. It has four number 60 Cook screens 5 feet long and eight 10-inch pipes each 28 feet long with 3300 one-quarter-inch holes with the bottoms of the pipes at elevation of about 129. Number 1, on the east side of Adelaide Street 850 feet north of Division Street, has four 12-inch number 60 Cook screens 5 feet long and four 10-inch number 30 Cook screens 20 feet long with the bottoms at elevation of about 129. The pump capacity is 600 gallons a minute. Number 5 well, on the east side of Adelaide Street about 1700 feet north of Division Street, has four 12-inch number 60 Cook screens 10 feet long and eight 10-inch screens 20 feet long made by drilling 33,000 one-quarter inch holes in each. The bottoms of the screens are at elevation 117 feet. The pump capacity is 2000 gallons a minute. Number 3 well, the north well, is on the west side of Adelaide Street, 1900 feet north of Division

Street. It has four 10-inch number 30 Cook screens 20 feet long. The bottom of the water-bearing stratum is about at elevation 122. The pump capacity is 600 gallons a minute.

With continued pumping and increased rates of pumping the water level has been gradually lowered. The plat below gives approximate water levels for driest seasons. At times of high water it is not necessary to use all of these wells at the main station. In dry seasons water is drawn down so that some of the wells, where the gravel stratum is highest, cannot be used and valves on the other pumps are partly closed to decrease the discharge.



LOW WATER LEVELS IN WELLS IN THE CITY OF BLOOMINGTON

Three wells were drilled near West Market Street in 1920-1921. These are into the same stratum entered by the wells at the main station. The elevation of the ground surface is about 20 feet lower than the stone step at the main station. Wells 1 and 2 are 341 feet apart and number 3, to the south, is about 360 feet distant from both 1 and 2. The wells extend to the bottom of the water-bearing gravel at a depth of about 60 feet, at practically the same elevation as the bottom of the stratum at its lowest elevation at the main plant. Material penetrated in a test well close to number 1, the northwest well ,was as follows:

Black dirt	8 feet
White clay and gravel	7 feet
Water bearing sand and gravel	8 feet
Water raised to 8 feet from surface	
Blue clay	10 feet
Fine sand and gravel	12 feet
Coarse gravel	19 feet
Water raised to 12 feet, 11 inches from surface	
Blue clay	2 feet

The strata penetrated by number 2 well, the east well, are similar. The log of number 3 well is given below:

Black dirt	6 feet
Blue clay	26 feet
Water bearing gravel (no fine sand)	29 feet
Blue clay	3 feet

The wells are cased with 15-inch pipe and equipped with number 30 Cook strainers 20 feet long. Number 1 well is equipped with an American centrifugal deep-well pump of 680 gallons a minute capacity. Wells 2 and 3 are each equipped with an American centrifugal deep-well pump of 1000 gallons a minute capacity. Each pump is driven by an electric motor. During a test of number 1 well the yield was 45 gallons a minute for each foot of draw down. The greatest depth to water to February, 1922, measured in a test well 10 feet distant from number 1, from an elevation about 3 feet above the ground surface, was 22 feet 8 inches.

The water had a mineral content of 826, a total hardness of 690, and a content of iron of 0.8 parts per million as shown by the analysis of sample number 51782, collected at the main station on July 8, 1924.

Analysis of Sample Number 51782 from the Main Station.

Determinations Made.	Parts per million.
Iron, Fe	0.8
Manganese, Mn	0.0
Silica, SiO_2	8.9
Nonvolatile	3.6
Alumina, Al_2O_3	2.3
Calcium, Ca	174.2
Magnesium, Mg	62.1
Ammonia, NH_4	0.6
Sodium, Na	16.4
Potassium, K	4.9
Sulfate, SO_4	292.0
Nitrate, NO_3	1.8
Chloride, Cl	15.0
Alkalinity Methyl Orange	394.0
Residue	912.0

Hypothetical Combinations.	Parts Per Million.	Grains Per Gallon.
Potassium Nitrate KNO_3	2.8	.16
Potassium Chloride KCl	7.3	.43
Sodium Chloride NaCl	19.0	1.11
Sodium Sulfate Na_2SO_4	27.8	1.62
Ammonium Sulphate $(NH_4)_2SO_4$	2.2	.13
Magnesium Sulphate $MgSO_4$	306.8	17.90
Calcium Sulphate $CaSO_4$	37.4	2.18
Calcium Carbonate $CaCO_3$	407.2	23.79
Iron Oxide Fe_2O_3	1.1	.06
Alumina Al_2O_3	2.3	.13
Silica SiO_2	8.9	.52
Nonvolatile	3.6	.21
Total	826.4	48.24

A sample collected on April 30, 1912, was of similar quality. The mineral content was 904 and the total hardness 696 parts per million.

A sample of water, number 51883, collected from one of the west-side wells on July 19, 1924, had a mineral content of 750, a total hardness of 640, and a content of iron of 1.2 parts per million as shown by the analysis.

Analysis of Sample Number 51883 from the West Side Wells.

Determinations Made.	Parts per million.
Iron, Fe	1.2
Manganese, Mn	0.0
Silica, SiO_2	15.6
Nonvolatile	1.4
Alumina, Al_2O_3	3.3
Calcium, Ca	141.1
Magnesium, Mg	70.0
Ammonia, NH_4	0.1
Potassium, K	4.4
Sodium, Na	12.4
Sulfate, SO_4	254.0
Nitrate, NO_3	0.7
Chloride, Cl	11.0
Alkalinity Methyl Orange	370.
Residue	761.

Hypothetical Combinations.	Parts Per Million.	Grains Per Gallon.
Potassium Nitrate KNO_3	1.1	0.06
Potassium Chloride KCl	7.6	0.44
Sodium Chloride NaCl	12.1	0.71
Sodium Sulphate Na_2SO_4	23.6	1.38
Ammonium Sulphate $(NH_4)_2SO_4$	0.5	0.03
Magnesium Sulphate $MgSO_4$	297.6	17.38
Magnesium Carbonate $MgCO_3$	33.6	1.96
Calcium Carbonate $CaCO_3$	352.4	20.58
Iron Oxide FE_2O_3	1.7	0.10
Alumina Al_2O_3	3.3	0.19
Silica SiO_2	15.6	0.91
Nonvolatile	1.4	0.08
Total	750.5	43.82

BLUE ISLAND (11424). Blue Island is located in the southern part of Cook County, adjoining Chicago.

A public water supply was installed by the city in 1883. Water was secured from a well into sand on high land in the city about 50 feet above the surrounding country. When sewers were installed a few years later the supply decreased, the well was abandoned, and a well was dug on low land. In 1894 a well was drilled to a depth of 1100 feet. A few years later another well was drilled to the same depth and in 1910 a third well was drilled to a depth of 1659 feet. Wells number 1 and 2 were cased with 10-inch pipe to rock at a depth of 62 feet and were 6 inches in diameter at the bottom. A record of material penetrated by well number 3, secured from the city, with classification by the State Geological Survey Division, is given below:

	Thickness in feet.	Depth in feet.
Drift	62	62
Limestone, Silurian System all or chiefly Niagaran	408	470
Shale, Richmond	106	576
Limestone, Galena-Platteville	334	910
Sandstone, St. Peter	145	1055
Limestone, Prairie du Chien	285	1340
Sandstone imbedding layers of limestone and pebbles, Prairie du Chien	135	1475
Sandstone Mazomanie-Dresbach Cambrian System	184	1659

The well was cased with 20-inch pipe to rock. The diameter at the bottom was 6 inches. When the well was drilled, water raised to 172 feet below the ground surface, and in 1914 the depth to water was reported to be 230 feet.

The wells were equipped with air lift and the yield in 1914 was slightly less than 1,000,000 gallons in 24 hours. In that year an odor of gas developed and soon after a connection was made with the public supply of Chicago. The wells are not now in use. A sample of water collected in 1914 from the wells into St. Peter sandstone had a mineral content of 1248, a total hardness of 550, and a content of iron of 0.4 parts per million. A sample collected from the deeper well in 1914 had a mineral content of 1164 and a total hardness of 400 parts per million. It contained no iron.

BLUE MOUND (881). Blue Mound is located in the southwestern part of Macon County on the drainage area of Sangamon River, a tributary of Illinois River.

A limited public water supply was installed by the city about 1882. The installation included a dug well 50 feet deep, an elevated tank, and about seven blocks of wooden mains. The installation now includes two wells equipped with deep-well pumps driven by a 15-horsepower electric motor, cast iron mains, and a steel tank on a tower 80 feet high. Ninety-seven consumers were supplied with water in 1923. The rate for water was 40 cents per 1000 gallons with a minimum charge of $2.00 a quarter. There is no discount.

Analysis of Sample Number 39817 from the Public Supply.

Determinations Made.

	Parts per million.
Iron, Fe	.4
Manganese, Mn	0.0
Silica, SiO_2	20.6
Nonvolatile	0.2
Alumina, Al_2O_3	33.0
Calcium, Ca	72.9
Magnesium, Mg	34.9
Ammonia, NH_4	1.6
Sodium, Na	14.8
Sulfate, SO_4	91.6
Nitrate, NO_3	1.1
Chloride, Cl	17.0
Carbon dioxide, CO_2	1.0
Hydrogen Sulphide	0.0
Alkalinity Methyl Orange	220.
Residue	414.

Hypothetical Combinations.

	Parts Per Million.	Grains Per Gallon.
Sodium Nitrate $NaNO_3$	1.4	.08
Sodium Chloride NaCl	27.9	1.63
Sodium Sulphate Na_2SO_4	1.1	.06
Ammonium Sulphate $(NH_4)_2SO_4$	5.9	.34
Magnesium Sulphate $MgSO_4$	100.4	5.86
Magnesium Carbonate $MgCO_3$	50.6	2.95
Calcium Carbonate $CaCO_3$	182.1	10.62
Iron Carbonate Fe_2CO_3	0.9	.05
Alumina Al_2O_3	33.0	1.92
Silica SiO_2	20.6	1.20
Total	424.2	24.72

The public water supply is secured from two wells into gravel drilled by W. H. Long of Decatur in 1917. The wells are 6 inches in diameter and 55 feet deep. A screen 8 feet long is placed in the bottom of each well. When the wells were drilled they were

pumped for 24 hours at a rate of 50 gallons a minute. Each well is equipped with a Cook double-stroke deep-well pump with 18-inch stroke and 5¾-inch cylinder placed at a depth of 35 feet. The pumps are operated 23 strokes a minute, a displacement of 93 gallons a minute. The pump in the west well was operated an average of 4 hours a day in 1922 giving a total yield of probably 19,000 gallons a day. The pump in the east well was operated occasionally. They are now operated alternately.

The water had a mineral content of 424, a total hardness of 325, and a content of iron of 0.4 parts per million as shown by the analysis of sample number 39817, collected on July 24, 1918.

BOURBONNAIS (620). Bourbonnais is located in the central part of Kankakee County on the drainage area of Kankakee River, a tributary of Illinois River.

A public water supply was installed by the village in 1900. The installation included a well located on grounds of Saint Viateur's College, a pumping station which was part of the college power station, a distribution system, and an elevated tank of 50,000 gallons capacity on a steel tower 110 feet high. In 1924 a well completed in that year was place in service. Water is pumped from the well into the distribution system by a deep-well pump driven by 10-horsepower electric motor. It is operated with automatic electrical control. Two wells in use before 1924 were sold to Saint Viateur's College. About 150 service connections were in use in 1924.

Water was first secured from a well 10 inches in diameter and 181 feet deep. It was cased to rock. The pump in use in 1923 operated with 24-inch stroke and had a 4¾-inch cylinder placed at a depth of 100 feet. It was operated 20 revolutions a minute, a displacement of about 70 gallons a minute. The depth to water in a well of about the same depth, 14 feet distant, was 92 feet on June 20, 1923, while pumping from this well. The amount of water pumped in 1923 was estimated at near 20,000 gallons a day. When the pumps were removed in December, 1923, the depth to water was 80 feet.

The water had a mineral content of 548 and a total hardness of 470 parts per million and contained no iron as shown by the analysis of sample number 39,360, collected on April 22, 1918.

A well 185 feet deep was drilled 14 feet distant from the original well in 1918. The yield was small and little use was made of the well.

Analysis of Sample Number 39360 from the Well 181 Feet Deep.

Determinations Made.	Parts per million.
Iron, Fe	0.0
Manganese, Mn	0.0
Silica, SiO_2	9.2
Nonvolatile	3.9
Alumina, Al_2O_3	5.9
Calcium Ca	106.8
Magnesium, Mg	49.5
Sodium, Na	23.0
Ammonia, NH_4	0.0
Nitrate, NO_3	0.0
Sulfate, SO_4	90.1
Chloride, Cl	26.0
Carbon dioxide	4.4
Hydrogen sulphide	0.0
Alkalinity Methyl Orange	366.
Insoluble	3.9
Residue	570.

Hypothetical Combinations.	Parts Per Million.	Grains Per Gallon.
Sodium Chloride NaCl	42.8	2.49
Sodium Sulphate Na_2SO_4	18.9	1.09
Magnesium Sulphate $MgSO_4$	97.1	5.71
Magnesium Carbonate $MgCO_3$	103.5	6.25
Calcium Carbonate $CaCO_3$	267.1	15.50
Alumina Al_2O_3	5.9	.34
Silica SiO_2	9.2	.53
Nonvolatile	3.9	.23
Total	548.4	32.14

Water is now secured from a well drilled by Adam Heidenreich of Kankakee in 1923. It is located on Union Street east of Roy Street. The well is 10 inches in diameter and 230 feet deep. A record of material penetrated is given by the driller as follows:

	Thickness in feet.	Depth to bottom in feet.
Drift	17	17
Limestone	103	120
Flint	82	202
Soft rock	28	230

The well is cased with 10-inch pipe to a depth of 32 feet. Water raised to the ground surface when the well was completed. The well is equipped with a double-acting pump with a 4¾-inch cylinder attached to 140 feet of drop pipe. It operates with 24-inch stroke at from 20 to 21 revolutions a minute, a displacement of a little over 70 gallons a minute. It is estimated that the pump operated 15 hours a day in the spring of 1924.

BRACEVILLE (303). Braceville is located in the southeastern part of Grundy County on the drainage area of Mazon River, a tributary of Illinois River.

A public water supply was installed in 1889 when the population was more than 2000. Water was secured from a dug well 24 feet deep into sand and gravel. Coal mines which were operated in the vicinity were worked out and abandoned, the population decreased, and the water work was abandoned about 1918.

BRADFORD (915). Bradford is located in the northeastern part of Stark County on the drainage area of Spoon River, a tributary of Illinois River.

A public water supply is secured from a well equipped with a deep-well pump driven by a 10-horsepower electric motor. Water is discharged into a reservoir from which it is pumped into the distribution system by a centrifugal pump driven by an electric motor. An elevated steel tank is connected to the system.

The well was drilled in 1898. A record of material penetrated is as follows:

	Thickness in feet.	Depth to bottom in feet.
Clay	137	137
Soapstone	40	177
Coal shale	75	252
Shale	235	487
Limestone	40	527
Shale	320	847
Limestone	145	992
Shale	65	1057
Limestone	270	1327
Shale	60	1387
Limestone	238	1625
Sand stone, St. Peter	88	1713
Limestone, Prairie du Chien	266	1979
Sandstone, Prairie du Chien	100	2079

The well is cased to a depth of 1730 feet. This casing consists of 121 feet of 10-inch, 509 feet of 8-inch, 200 feet of 6-inch, and 903 feet of 5-inch pipe. Another record sent in 1898 gives slight differences in depths to strata, a total depth of 2052 feet, and gives the depth of casing as 1600 feet.

Analysis of Sample Number 37908 from the Public Supply.

Determinations Made.

	Parts per million.
Iron, Fe	0.4
Silica, SiO_2	10.4
Nonvolatile	1.0
Alumina, Al_2O_3	2.0
Calcium, Ca	85.1
Magnesium, Mg	33.4
Sodium, Na	376.3
Ammonia, NH_4	0.5
Nitrate, NO_3	5.3
Sulfate, SO_4	238.8
Chloride, Cl	490.0
Alkalinity Methyl Orange	232.
Residue	1390.

Hypothetical Combinations.

	Parts Per Million.	Grains Per Gallon.
Sodium Nitrate $NaNO_3$	7.3	.42
Sodium Chloride NaCl	808.6	47.16
Sodium Sulphate Na_2SO_4	171.8	10.02
Ammonium Sulphate $(NH_4)_2SO_4$	1.8	.10
Magnesium Sulphate $MgSO_4$	152.5	8.90
Magnesium Carbonate $MgCO_3$	8.7	.51
Calcium Carmonate $CaCO_3$	212.4	12.39
Iron Oxide Fe_2O_3	0.6	.03
Alumina Al_2O_3	2.0	.12
Silica SiO_2	10.4	.61
Nonvolatile	1.0	.06
Total	1377.1	80.32

The well is equipped with a deep-well pump with the cylinder attached to 360 feet of drop pipe. The pump was operated at 23 revolutions a minute in 1917 at which speed the yield was estimated at 130 gallons a minute. In 1898 the depth to water was said to be 150 feet and in 1917 it was reported to be 160 feet.

The water had a mineral content of 1377, a total hardness of 350, and a content of iron of 0.4 parts per million as shown by the analysis of sample number 37908, collected on August 27, 1917.

BRADLEY (2128). Bradley is located in the central part of Kankakee County on the drainage area of Kankakee River, a tributary of Illinois River.

A public water supply was installed by the village in 1905. Water was secured from a well and another well has since been drilled. Water is pumped from the wells into the distribution system by deep-well pumps driven by electric motors. An elevated tank located on the same lot as the wells is connected to the system. Electric current is purchased from the Kankakee Public Service Company. A gasoline engine is available for use in case of emergency. About 450 service connections were in use in May 1924.

A part of the village is supplied with water from Kankakee.

Water for the public supply is secured from two wells located south of Broadway and west of Michigan Street. One well was drilled in 1905. It is 337 feet deep. It is said to be cased with 12-inch pipe to a depth of 200 feet and to be 10 inches in diameter below that depth. The depth to water when not pumping in 1916 was given as 30 feet. The amount of water pumped was estimated at from 15,000 to 20,000 gallons a day. A few years later it was necessary to lower the pump cylinder below a depth of 100 feet to avoid drawing air. In April, 1924, a 4¾-inch double-acting cylinder was at a depth of 184 feet. The pump was operated with 24-inch stroke at 22 revolutions a minute for about 10 hours a day.

The other well was drilled by Adam Heidenreich in 1918. It is located 28 feet northwest of the older well. A record of material penetrated as given by the driller with classification by the State Geological Survey Division is as follows:

	Thickness in feet.	Depth to bottom in feet.
Drift	4	4
Limestone, Silurian system, all or chiefly Niagaran	316	320
Shale, Richmond	20	340

The well is 10 inches in diameter and is cased to a depth of 20 feet. It is equipped with an American double-acting deep-well pump with 5¾-inch cylinder and 24-inch stroke. The cylinder is attached to 180 feet of drop pipe and has 20 feet of suction pipe attached. The pump was operating 25 revolutions a minute about 13 hours a day in March, 1924.

The amount of water pumped from the two wells in March, 1924, is estimated at 100,000 gallons a day.

The water had a mineral content of 490, a total hardness of 365, and a content of iron of 0.1 parts per million as shown by the analysis of sample number 36,022, collected on November 27, 1916.

Analysis of Sample Number 36022 from the Public Supply.

Determinations Made.

	Parts per million.
Iron, Fe	0.1
Silica, SiO_2	8.4
Nonvolatile	2.0
Alumina, Al_2O_3	1.1
Calcium, Ca	96.9
Magnesium, Mg	30.3
Potassium, K	2.8
Sodium, Na	26.6
Ammonia, NH_4	0.0
Nitrate, NO_3	70.7
Sulfate, SO_4	82.9
Chloride, Cl	0.4
Alkalinity Methyl Orange	292.
Residue	611.

Hypothetical Combinations.

	Parts Per Million.	Grains Per Gallon.
Potassium Nitrate KNO_3	7.2	0.42
Sodium Nitrate $NaNO_3$	90.0	5.29
Sodium Chloride NaCl	0.7	0.04
Sodium Sulphate Na_2SO_4	5.2	0.30
Ammonium Sulphate $(NH_4)_2SO_4$	0.0	
Magnesium Sulphate $MgSO_4$	98.3	5.72
Magnesium Carbonate $MgCO_3$	34.8	2.03
Calcium Carbonate $CaCO_3$	241.8	14.09
Iron Oxide Fe_2O_3	0.1	.01
Alumina Al_2O_3	1.1	.06
Silica SiO_2	8.4	.49
Nonvolatile	2.0	.11
Total	490.5	28.60

BRAIDWOOD (1297). Braidwood is located in the southwestern part of Will County on the drainage area of Mazon River, a tributary of Illinois River.

A public water supply was installed by the village about 1883 when the population of the village was more than 5000. Many coal mines operating in the vicinity at that time have been exhausted and the population has decreased. Water is pumped from wells into the mains by a Fairbanks-Morse 5 by 6-inch duplex pump which is driven by a 10-horsepower electric motor. A 5¾-inch by 6-inch duplex pump formerly in regular service was to be repaired in 1924. Several wells have been dug and drilled since the original installation. One of these was 1800 (?) feet deep. The water level in this well lowered and in an attempt to drill the hole larger the well was plugged and was then abandoned.

The water supply is now secured from wells 12 to 20 feet deep into sand and gravel. They are located on ground about 580 feet

above sea level in the rear of the city hall. One well is 8 by 13 feet in plan and 20 feet deep and is curbed with wood. This was not in use in April, 1924. The wells in use in April, 1924, were nine 2-inch wells 16½ feet deep. Two were drilled in 1920 and seven were drilled deeper in that year. They are cased with 2-inch pipe and equipped with number 90 gauze screens. The amount of water pumped from July, 1913, to January, 1914, as registered by meter at the station, averaged 8000 gallons a day.

On April 17, 1924, one foot depth of water was pumped into the elevated tank in twenty-five minutes, a rate of pumping of 75 gallons a minute. The total amount pumped was estimated at 14,000 gallons a day. Water was sold at flat rates.

The water had a mineral content of 450, a total hardness of 330, and a content of iron of 0.0 parts per million as shown by analysis of sample number 51277, collected on April 17, 1924, at a tap near the pump after the pump had operated for fifty minutes.

Analysis of Sample Number 51277 from Public Supply.

Determinations Made.	Parts per million.
Iron, Fe	0.0
Manganese, Mn	0.0
Silica, SiO_2	9.7
Nonvolatile	1.7
Alumina, Al_2O_3	2.3
Calcium, Ca	87.4
Magnesium, Mg	27.3
Ammonia, NH_4	0.3
Sodium, Na	10.9
Potassium, K	6.6
Sulfate, SO_4	170.6
Nitrate, NO_3	40.7
Chloride, Cl	12.0
Alkalinity Methyl Orange	144.
Residue	457.

Hypothetical Combinations.	Parts Per Million.	Grains Per Gallon.
Potassium Nitrate KNO_3	17.1	1.00
Sodium Nitrate $NaNO_3$	40.4	2.36
Ammonium Nitrate NH_4NO_3	1.0	.06
Ammonium Chloride NH_4Cl	0.1	.01
Magnesium Chloride $MgCl_2$	15.9	.93
Magnesium Sulphate $MgSO_4$	114.4	6.68
Calcium Sulphate $CaSO_4$	111.8	6.53
Calcium Carbonate $CaCO_3$	135.9	7.94
Alumina Al_2O_3	2.3	.13
Silica SiO_2	9.7	.57
Nonvolatile	1.7	.10
Iron Oxide Fe_2O_3	0.0	.00
Total	450.3	26.31

Strainers in the wells are replaced frequently on account of corrosion.

BRIDGEPORT (2229). Bridgeport is located in the central part of Lawrence County on the drainage area of Embarrass River, west of the city of Lawrenceville. Water for a public supply is secured from Lawrenceville. See Lawrenceville.

BROADVIEW (430. Broadview is located in Cook County south of and adjoining the city of Maywood. A water distribution system was installed by the village in 1922. Water for a public supply is purchased from the city of Maywood.

BROOKFIELD (3589). Brookfield, a suburban community, is located in the western part of Cook County on the drainage area of Des Plaines River, a tributary of Illinois River.

Water for a public supply was obtained from La Grange until 1922 when a new system was installed by the village. The installation included a well with equipment; a concrete reservoir 40 feet by 60 feet in plan and 16 feet deep; an elevated steel tank of 150,000 gallons capacity with the overflow 140 feet above the foundations; two Fairbanks-Morse single-stage centrifugal pumps, each of 300 gallons a minute capacity at 140 feet pressure, each driven by a 25-horsepower Fairbanks-Morse oil engine; a Fairbanks-Morse 2-stage centrifugal pump of 500 gallons a minute capacity driven by a 100- horsepower Van Blerck gas engine; and a brick pumping station which houses the machinery. The well pump is in the basement of the station and the reservoir and elevated tank are located on the same plot of ground.

The minimum charge for water is $5.00 for three months and very few consumers pay more than the minimum charge. The distribution system is connected to that of Riverside which adjoins Brookfield and at times water is supplied to Riverside.

The well from which water is obtained was drilled by S. B. Geiger and was completed in 1922. It is 18 inches in diameter at the top and 7 inches in diameter at the bottom. A record of material penetrated, with classifications by the State Geological Survey Division, is as follows:

	Thickness in feet.	Depth in feet.
Clay and gravel	41	41
Limestone, Silurian System all or chiefly Niagaran	314	355
Blue shale, Richmond	165	520
Limestone, Galena-Platteville	320	840
Sand and cavey formation, St. Peter	120	960
Limestone with crevices, Prairie du Chien	140	1245
Shale, green, cavey, Prairie du Chien	20	1265
Limestone, Prairie du Chien	185	1450
Sandstone, Mazomanie-Dresbach Cambrian system	200	1650
Shale, green and blue, Eau Claire Cambrian system	200	1850
Sandstone, Mt. Simon Cambrian system	154	2004

The well is cased with 18-inch pipe to rock, with 12-inch pipe through the blue shale between depths of 348 and 520 feet, with 8-inch pipe between depths of 935 and 1,105 feet, and with 60 feet of 7-inch acetylene-welded pipe through the green cavey shale noted. The well is equipped with a Layne centrifugal pump with the bottom at a depth of 201 feet and the bottom of a suction pipe which is attached, at a depth of 225 feet.

After the well was completed the water level when not pumping was 15 feet below the ground surface and when pumping at a rate of 670 gallons a minute it was at a depth of 94 feet. On June 21, 1922, the yield for 1 hour, 15 minutes after starting the pump was 685 gallon a minute, as determined by measuring the rise of water level in the reservoir and adding the amount of water pumped from the reservoir as recorded by meter. The depth to water in the well was 22 feet before the test when the well pump had been idle for 8 or 9 hours and was 126.6 feet after pumping for 1 hour and 15 minutes. The yield on September 15, 1923, was 665 gallons a minute. The amount of water pumped between these two dates, June 21, 1922, and September 15, 1923, averaged 375,000 gallons a day. In April, 1925, the amount of water pumped averaged 463,000 gallons a day and the depth to water when not pumped for ten hours was 30 feet.

The temperature of the water in 1922 when the well pump had operated for 3 hours was 53 degrees Fahrenheit, indicating that a considerable part of the water was from the upper part of the well. The water had a mineral content of 509, a total hardness of 415, and a content of iron of 0.1 parts per million as shown by the analysis of sample number 47766, collected at the pumping station on April 21, 1922.

Analysis of Sample Number 47766 from the Public Supply.

Determinations Made.

	Parts per million.
Iron, Fe	0.1
Manganese, Mn	0.0
Silica, SiO_2	12.2
Nonvolatile	2.7
Alumina, Al_2O_3	1.3
Calcium, Ca	92.7
Magnesium, Mg	44.5
Ammonia, NH_4	0.4
Sodium, Na	25.4
Potassium, K	6.3
Sulfate, SO_4	95.8
Nitrate, NO_3	0.4
Chloride, Cl	6.0
Alkalinity Methyl Orange	366.
Residue	507.0

Hypothetical Combinations.

	Parts Per Million.	Grains Per Gallon.
Potassium Nitrate KNO_3	0.6	.04
Potassium Chloride KCl	11.5	.67
Sodium Chloride NaCl	0.8	.05
Sodium Sulphate Na_2SO_4	77.4	4.53
Ammonium Sulphate $(NH_4)_2SO_4$	1.3	.08
Magnesium Sulphate $MgSO_4$	53.2	3.11
Magnesium Carbonate $MgCO_3$	116.9	6.85
Calcium Carbonate $CaCO_3$	231.5	13.54
Silica SiO_2	12.2	.71
Nonvolatile	2.7	.15
Iron Oxide Fe_2O_3	0.1	.01
Alumina Al_2O_3	1.3	.08
Total	509.5	29.82

BROOKPORT (1098). Brookport is located in the southeastern part of Massac County on the north bank of Ohio River. Many residences have private wells about 30 feet deep into sand.

A public water supply was installed by the city in 1907. The installation included a well, a deep-well pump, a gas engine to drive the pump, a steel tank of 60,000 gallons capacity on a tower 90 feet high, a distribution system, and a pumping station. The original well has been abandoned and another well has been drilled. Water is pumped from the well into the distribution system by a 2-stage centrifugal pump placed in a pit 18 feet deep. The pump is direct connected to a 15-horsepower electric motor. About 350 service connections were in use in 1924.

The original well was located near the center of the city. It was 8 inches in diameter and 226 feet deep. The lower 60 feet was in fine white sand and the well was equipped with a Cook screen 18 feet long. Water raised to within 20 feet of the top of the well in 1915.

Water is now secured from a six-inch well 202 feet deep, drilled by Mr. Elwood of Bay City in 1922. A screen 10 feet long is placed in the bottom. The elevation of the top of the well is about 333 feet above sea level. The water level when not pumping was said to be at a depth of 30 feet in 1924.

The water had a mineral content of 216, a total hardness of 190, and a content of iron of 0.8 parts per million as shown by the analysis of sample number 51952, collected on July 24, 1924, from a tap outside the pumping station.

Analysis of Sample Number 51952 from the Public Supply.

Determinations Made.	Parts per million.
Iron, Fe	0.8
Manganese, Mn	0.0
Silica, SiO_2	9.4
Nonvolatile	0.9
Alumina, Al_2O_3	0.6
Calcium, Ca	56.8
Magnesium, Mg	11.9
Ammonia, NH_4	0.1
Sodium, Na	3.9
Potassium, K	3.9
Sulfate, SO_4	10.8
Nitrate, NO_3	1.2
Chloride, Cl	2.0
Alkalinity Methyl Orange	182.0
Residue	249.

Hypothetical Combinations.	Parts per Million.	Grains per Gallon.
Potassium Nitrate KNO_3	2.0	0.11
Potassium Chloride KCl	4.2	0.24
Potassium Sulfate K_2SO_4	2.0	0.11
Sodium Sulfate Na_2SO_4	12.1	0.71
Ammonium Sulfate $(NH_4)_2SO_4$	0.3	0.02
Magnesium Sulfate $MgSO_4$	1.6	0.09
Magnesium Carbonate $MgCO_3$	40.2	2.35
Calcium Carbonate $CaCO_3$	141.9	8.28
Iron Oxide Fe_2O_3	1.1	0.06
Alumina Al_2O_3	0.6	0.03
Silica SiO_2	9.4	0.55
Nonvolatile	0.9	0.05
Total	216	12.60

BUCKLEY (461). Buckley is located in the southwestern part of Iroquois County on the drainage area of Iroquois River, a tributary of Kankakee River.

A public water supply was installed by the village about 1889. The installation included a dug well, a pump operated by windmill, an elevated tank, and about 800 feet of galvanized iron pipe. Two wells have been drilled and equipped with deep-well pumps and the old well has been abandoned. Since 1913 the pumping station has been operated by the Central Illinois Public Service Company who have installed a 10-horsepower electric motor to drive the pumps. A 25-horsepower gasoline engine is available for emergency. Water is discharged directly into the elevated tank and distribution system.

Seventy-seven service connections were in use in 1922. The minimum charge for water is $5.00 a year which allows the use of 12,000 gallons. Water in excess of this amount is charged for at rates of from 35 to 15 cents per 1,000 gallons but no consumers use large quantities of water.

Harry Fritch, well driller, states that in this vicinity wells penetrate 40 or 50 feet of soft mud, hardpan, a little more soft mud and, at a depth of 140 or 150 feet, enter a stratum of sand and gravel which is about 50 feet thick. Wells are driven a few feet into this sand and gravel as the sand is fine at the top and coarser below.

Analysis of Sample Number 30593 from the Village Supply.

Determinations Made.	Parts per million.
Iron, Fe	1.4
Manganese, Mn	0.1
Silica, SiO_2	20.0
Alumina, Al_2O_3	2.6
Calcium, Ca	147.1
Magnesium, Mg	98.0
Ammonia, NH_4	1.6
Sodium, Na	73.3
Potassium, K	6.6
Sulfate, SO_4	503.4
Nitrate, NO_3	0.5
Chloride, Cl	4.0
Alkalinity	
Methyl Orange	350.
Residue	1105.

Hypothetical Combinations.	Parts per Million.	Grains per Gallon.
Potassium Nitrate, KNO_3	0.8	.05
Potassium Chloride, KCl	8.4	.49
Potassium Sulphate, K_2SO_4	4.2	.24
Sodium Sulphate, Na_2SO_4	226.0	13.18
Ammonium Sulphate, $(NH_4)_2SO_4$	5.9	.34
Magnesium Sulphate, $MgSO_4$	432.6	25.23
Magnesium Carbonate, $MgCO_3$	19.0	1.11
Calcium Carbonate, $CaCO_3$	367.2	21.42
Iron Carbonate, $FeCO_3$	2.9	.17
Alumina, Al_2O_3	2.6	.15
Silica, SiO_2	20.0	1.17
Nonvolatile	2.0	.12
Total	1091.6	63.67

Water is secured from two 4-inch wells, each 147 feet deep, located 12 feet apart near the center of the village. One well was drilled in 1893 and the other in 1912. Each well is equipped with a Deming deep-well pump with 24-inch stroke and 3¾-inch cylinder placed at a depth of 70 feet. In 1922 both pumps were operated at a time an average of from 2 to 2½ hours a day. The yield estimated from the time taken to fill the tank was about 40 gallons a minute. In 1893 water flowed from the well into the reservoir. The depth to water when not pumping was 10 feet in 1915 and 16 feet in 1922.

The water had a mineral content of 1,091, a total hardness of 750, and a content of iron of 1.4 parts per million as shown by the analysis of sample number 30593, collected on June 3, 1915.

BUDA (796). Buda is located in the southwestern part of Bureau County on the drainage area of Green River, a tributary of Rock River.

A public water supply was installed by the village in 1896. The installation included a well equipped with a deep-well pump, a gas engine, a pumping station, a distribution system, and a standpipe 10 feet in diameter and 100 feet high. A concrete reservoir 20 feet in diameter and 12 feet deep has been built, a 7 by 8-inch Goulds triplex pump has been installed to pump from the reservoir, and a 15-horse-power electric motor has been installed to drive the deep-well pump which now discharges into the reservoir. Approximately 220 service connections were in use in 1922. Meter rates are 40 cents per 100 cubic feet.

The public water supply is from a well located in the south-eastern part of the village. It was drilled in 1896. The top is about 770 feet above sea level. It is 8 inches in diameter at the top, 6 inches in diameter at the bottom, and 1,612 feet deep. The upper 483 feet is cased. The bottom 140 feet is said to be in St. Peter sandstone. The well is said to have yielded 120 gallons a minute for 27 consecutive hours in 1896. The well was cleaned out about 1909 and very little material was removed, probably a bushel. The well is equipped with a Downie double-stroke deep-well pump with a 5¾-inch cylinder. The cylinder was at a depth of 212 feet in 1920. With full electric voltage the pump operated 35 revolutions a minute. With new leathers the discharge in 1920 was said to be 28 inches depth of water in the reservoir in 1 hour, a rate of ninety gallons a minute. The depth of water when not pumping was given as 125 feet in 1898?, 160 feet in 1915, and 167 feet the last time measured before 1920.

A sample of water, number 44165, collected on November 9, 1920, had a mineral content of 1257, a total hardness of 237, and a content of iron of 0.2 parts per million as shown by the analysis.

Many service pipes installed in 1896 were in use in 1920. They were being replaced with lead pipe. The original standpipe was in use in 1920 and was apparently in good condition. The inside had been painted once. The water stains plumbing fixtures due to the iron content.

Analysis of Sample Number 44165 from the Village Supply.

Determinations Made.

	Parts per million.
Iron, Fe	0.2
Manganese, Mn	0.0
Silica, SiO_2	8.2
Nonvolatile	0.6
Alumina, Al_2O_3	2.9
Calcium, Ca	56.6
Magnesium, Mg	23.3
Ammonia, NH_4	4.1
Potassium, K / Sodium, Na	375.3
Sulfate, SO_4	221.4
Nitrate, NO_3	4.4
Chloride, Cl	412.0
Alkalinity	
Phenolphthalein	0.
Methyl Orange	248.
Residue	1194.

Hypothetical Combinations.

	Parts per Million.	Grains per Gallon.
Sodium Nitrate, $NaNO_3$	6.1	.36
Sodium Chloride, NaCl	679.3	39.73
Sodium Sulphate, Na_2SO_4	326.6	19.10
Ammonium Sulphate, $(NH_4)_2SO_4$	0.5	.03
Ammonium Carbonate $(NH_4)_2CO_3$	10.5	.62
Magnesium Carbonate, $MgSO_4$	80.7	4.72
Calcium Carbonate, $CaCO_3$	141.4	8.27
Iron Oxide, Fe_2O_3	0.3	.02
Alumina, Al_2O_3	2.9	.17
Silica, SiO_2	8.2	.48
Nonvolatile	0.6	.03
Total	1257.2	73.53

BUREAU (682). Bureau is located in the southern part of Bureau County about a mile distant from Illinois River.

A public water supply was installed by the village about 1899. The installation included a well and distribution system, water flowing directly from the well into the mains. Another deep well has been drilled and a Fairbanks-Morse 5-inch by 5-inch single-cylinder, double-acting pump has been installed to pump water taken from mains in the lower part of the village into a system serving the higher part. A pressure tank 42 inches in diameter and 14 feet long is connected to the mains in this higher district. The pump is driven by a 3-horsepower electric motor controlled automatically by the pressure in the tank. Machinery and tank are housed in a concrete pump house. Water is sold at flat rates.

Water for the public supply is from two wells each 305 feet deep. One is located on the Chicago, Rock Island and Pacific Railway depot grounds and is the joint property of the railway and the village and the other is on Kansas Street three and a half blocks distant from the railroad. The pressure at the ground surface in 1915 was said to be 30 pounds.

The temperature of water from the wells is 56 degrees Fahrenheit. The water had a mineral content of 1931 and a total hardness of 52 and contained no iron as shown by analysis of sample number 52930, collected from the well at the depot on December 2, 1924.

Analysis of Sample Number 52930 from the Well at the Depot.

Determinations Made.	Parts per million.
Iron, Fe	0.0
Manganese, Mn	0.0
Silica, SiO_2	7.0
Nonvolatile	4.4
Alumina, Al_2O_3	0.8
Calcium, Ca	8.8
Magnesium, Mg	7.3
Ammonia, NH_4	1.1
Sodium, Na	698.7
Potassium, K	48.6
Sulfate, SO_4	160.6
Nitrate, NO_3	5.3
Chloride, Cl	730.6
Alkalinity as $CaCO_3$	
Phenolphthalein	
Methyl Orange	514
Residue	2008.

Hypothetical Combinations.	Parts per Million.	Grains per Gallon.
Potassium Nitrate, KNO_3	0.9	0.05
Potassium Chloride, KCl	91.9	5.37
Sodium Chloride, NaCl	1132.0	66.11
Sodium Sulfate, Na_2SO_4	237.2	13.85
Sodium Carbonate, Na_2CO_3	406.6	23.74
Ammon'm Carbonate $(NH_4)_2CO_3$	3.0	0.17
Magnes'm Carbonate, $MgCO_3$	25.4	1.48
Calcium Carbonate, $CaCO_3$	22.1	1.29
Alumina, Al_2O_3	0.8	0.05
Silica, SiO_2	7.0	0.41
Nonvolatile	4.4	0.26
Total	1931.3	112.78

BUSHNELL (2716). Bushnell is located in the northeastern part of McDonough County on the watershed between Crooked Creek and Spoon River, two tributaries of Illinois River. Some private wells in use are from 20 to 40 feet deep and wells into sand and gravel at a depth of about 120 feet, which furnish a greater supply, are in use by the Bushnell Farm Products Company, the Bushnell Pump Company, the Toledo, Peoria, and Western Railway, and Swift and Company. The yield of two wells 128 feet deep at the Bushnell Farm Products Company is estimated at 25 gallons a minute. This company has one well into rock 725 feet deep. It is 8 inches in diameter at the top and 6 inches in diameter at the bottom. It is equipped with a deep-well pump with the cylinder placed at a depth of 180 feet and the yield is estimated to be at least 30 gallons a minute. The Chicago, Burlington and Quincy Railroad secures water from a creek.

A public water supply was installed by the city in 1889. Information is principally from C. F. Sturtevant and Willard Waltman, Superintendent of Waterworks. Water was first secured from wells into a sand and gravel stratum entered at a depth of about 120 feet. These wells, on account of small yield, were abandoned and a supply is now taken from two wells into rock, each equipped with a pump which discharges into either of two reservoirs. One reservoir is 24 feet in diameter, the other is 30 feet in diameter and each is 15 feet deep. Water is pumped from the reservoirs into the distribution system by either of two American 8-inch centrifugal

pumps. Each is driven by an electric motor. An elevated steel tank of 100,000 gallons capacity, erected in 1914, is connected to the mains. The amount of water pumped is measured by meter.

About five hundred consumers were supplied with water in 1923, and the water consumption from April 21, 1922, to May 21, 1923, averaged 105,000 gallons a day. The rate per 1000 gallons is 25 cents for the first 20,000, gallons, 20 cents for the next 30,000 gallons, and 15 cents for all in excess of 50,000 gallons. The rates are not subject to cash discount.

The public water supply is secured from two wells into St. Peter sandstone. One is 1352 and the other is 1355 feet deep. The tops of the wells are approximately, 650 feet above sea level. Records of material penetrated by each well are available. An abstract of a log prepared by the State Geological Survey Division is as follows:

	Thickness in feet.	Depth to bottom in feet.
Loam and clay	100	100
Sand	10	110
Shale, Pottsville	16	126
Limestone, Keokuk—Burlington	283	409
Shale, Kinderhook Shale, Devonian system	241	650
Limestone, Devonian and Silurian systems	75	725
Dolomite, Silurian system	7	732
Sand, Silurian system	8	740
Shale, Maquoketa	123	863
Shale and dolomite, Maquoketa	32	895
Dolomite, Galena-Platteville	320	1215
Sandstone, St. Peter	140	1355

Mr. Sturtevant, engineer in charge, stated that the first well drilled was cased 15 feet into “Trenton” rock (given Galena-Platteville above) and that no water was encountered below the casing until St. Peters sandstone was entered. Water was reported in the second well drilled at depths of 121 feet, 326 feet, 725 feet, and 1350 feet. The wells are cased with 12½-inch casing into rock, with 10-inch pipe to a depth of 400 feet and with 8-inch pipe from 400 feet to a depth of 900 feet. The wells are 8 inches? in diameter at the bottom. (One record gives 6 inches). In 1914 well number 1 was repaired. Material that had dropped into the well was removed and new casing was placed.

In 1898 the water level in well number 1 was at a depth of 25 feet when not pumping and the well furnished 276,000 gallons in 24 hours, lowering the water level 60 feet. The depth to water was given as 52 feet in 1914, 65 feet in 1923, and 83 feet in 1925 when neither pump had operated for several hours. Each well is equipped with an American double-acting deep-well pump with a

5¾-inch cylinder and 36-inch stroke. Each cylinder is placed at a depth of 100 feet and has 18 feet of suction pipe attached. On the morning of May 29, 1923, the well pumps were operated for three hours. The yield, determined from water levels in the reservoirs and meter readings of water withdrawn, was 344 gallons a minute and the water level in one of the wells was drawn down to a depth of 92.2 feet. After stopping the pumps the water level raised 13 feet in seven minutes. In April, 1925, the amount of water pumped was given as 105,000 gallons a day.

The water had a mineral content of 1906, a total hardness of 444, and a content of iron of 0.2 parts per million as shown by the analysis of sample number 49564, collected at the pumping station on May 29, 1923.

Analysis of Sample Number 49564 from the City Supply.

Determinations Made.	Parts per million.
Iron, Fe	0.2
Manganese, Mn	0.0
Silica, SiO_2	11.0
Nonvolatile	1.3
Alumina, Al_2O_3	2.3
Calcium, Ca	100.4
Magnesium, Mg	47.0
Ammonia, NH_4	1.4
Sodium, Na	455.9
Potassium, K	65.4
Sulfate, SO_4	649.8
Nitrate, NO_3	0.7
Chloride, Cl	416.0
Alkalinity Methyl Orange	144.0
Residue	1920.

Hypothetical Combinations.	Parts per Million.	Grains per Gallon.
Potassium Nitrate, KNO_3	1.1	0.06
Potassium Chloride, KCl	123.8	7.23
Sodium Chloride, NaCl	588.6	34.37
Sodium Sulphate, Na_2SO_4	693.3	40.49
Ammonium Sulphate, $(NH_4)_2SO_4$	5.3	0.31
Magnesium Carbonate, $MgCO_3$	7.6	0.44
Magnesium Sulphate, $MgSO_4$	221.4	12.93
Calcium Carbonate, $CaCO_3$	250.6	14.63
Iron Oxide, Fe_2O_3	0.3	0.01
Alumina, Al_2O_3	2.3	0.13
Silica, SiO_2	11.0	0.64
Nonvolatile	1.3	0.07
Total	1906.6	111.31

A sample collected in 1918 was similar. The iron content was 0.8 parts per million.

The elevated steel tank erected in 1889 rusted through and was taken down in 1913. One steel pipe to which a pump cylinder was attached was removed from one of the wells after ten months use and another line of pipe was removed after only two years use. The life of galvanized pipe now used for service connections is estimated at from 8 to 10 years.

BYRON (855). Byron is located in the northern part of Ogle County on the north bank of Rock River.

A public water supply was installed by the village in 1900. The installation included a well, a Deming 8½ by 8-inch triplex pump, a

small air compressor, a 30-horsepower gasoline engine, and a steel pressure tank 8 feet in diameter and 36 feet long. A 50-horsepower gas engine for use in emergency and another steel pressure tank, an exact duplicate of the first, have been installed.

Two hundred and ten service connections were in use in 1921. The minimum rate for three months was $1.50 and the lowest rate, for water in excess of 100,000 gallons, was 9 cents per 1000 gallons.

The water supply is from a well 2000 feet deep. The elevation at the top is about 720 feet above sea level. The diameter of the well is 12 inches to a depth of 213 feet, 10 inches between depths of 213 and 1000 feet, 8 inches between depths of 1000 and 1600 feet, and 5 inches below 1600 feet. It is cased to a depth of 213 feet. The well flowed when it was completed. The water level in 1921 was below the top but not at a great depth as water was drawn from the well by suction and the pump apparently operated without drawing air.

The temperature of the water is 58 degrees Fahrenheit. The water had a mineral content of 306, a total hardness of 360, and a content of iron of 0.2 parts per million as shown by the analysis of sample number 46387, collected on October 17, 1921.

Analysis of Sample Number 46387 from the Village Supply.

Determinations Made.

	Parts per million.
Iron, Fe	0.2
Manganese, Mn	0.1
Silica, SiO_2	9.9
Nonvolatile	0.9
Alumina, Al_2O_3	3.7
Calcium, Ca	63.6
Magnesium, Mg	24.8
Ammonia, NH_4	0.0
Potassium, K	4.3
Sodium, Na	11.0
Sulfate, SO_4	13.8
Nitrate, NO_3	0.5
Chloride, Cl	6.0
Alkalinity Methyl Orange	270.0
Residue	280.

Hypothetical Combinations.

	Parts per million.	Grains per gallon.
Potassium Nitrate, KNO_3	8.1	.47
Potassium Chloride, KCl	7.7	.45
Sodium Chloride, NaCl	3.8	.22
Sodium Sulphate, Na_2SO_4	20.3	1.19
Sodium Carbonate, Na_2CO_3	6.6	.39
Ammon'm Carbonate, $(NH_4)_2CO_3$	0.1	.006
Magnesium Carbonate, $MgCO_3$	85.9	5.02
Calcium Carbonate, $CaCO_3$	158.9	9.29
Silica, SiO_2	9.9	.58
Nonvolatile	0.9	.05
Iron Oxide, Fe_2O_3	0.3	.02
Alumina, Al_2O_3	3.7	.22
Total	306.2	17.90

The water stains plumbing fixtures. It is said that water from shallow dug wells clogs hot water coils more rapidly than does the water from the public supply. No trouble due to the action of this water on meters has been experienced.

CABERY (299). Cabery is located in the northern part of Ford County on the drainage area of Mazon River, a tributary of Illinois River. A public water supply was installed by the village in 1885. The installation included a well 8 inches in diameter and 200 feet deep located in the western part of the business district, a pump driven by a windmill, a distribution system, and an elevated wooden tank 20 feet in diameter and 20 feet high on a brick tower 40 feet high. A gas engine was installed in 1908. The original well was abandoned in 1920 and water has since been obtained from a well drilled in that year. It is equipped with a deep-well pump which is driven by belt from an 8-horsepower electric motor. Twenty-eight service connections were in use in April, 1925.

Analysis of Sample Number 51259 from the Village Supply.

Determinations Made.

	Parts per million.
Iron, Fe	0.4
Manganese, Mn	0.0
Silica, SiO_2	11.0
Nonvolatile	4.2
Alumina, Al_2O_3	5.4
Calcium, Ca	194.3
Magnesium, Mg	80.9
Ammonia, NH_4	6.4
Sodium, Na	294.9
Potassium, K	29.5
Sulfate, SO_4	1098.0
Nitrate, NO_3	2.5
Chloride, Cl	18.0
Alkalinity Methyl Orange	340 .0
Residue	1964.

Hypothetical Combinations.

	Parts per million.	Grains per gallon.
Potassium Nitrate, KNO_3	4.0	.23
Potassium Chloride, KCl	37.9	2.21
Potassium Sulphate, K_2SO_4	18.0	1.05
Ammonium Sulphate, $(NH_4)_2SO_4$	23.6	1.38
Sodium Sulphate, Na_2SO_4	910.2	53.15
Magnesium Sulphate, $MgSO_4$	399.6	23.31
Calcium Sulphate, $CaSO_4$	191.5	11.15
Calcium Carbonate, $CaCO_3$	344.2	20.08
Iron Oxide, Fe_2O_3	0.6	.04
Alumina, Al_2O_3	5.4	.32
Silica, SiO_2	11.0	.64
Nonvolatile	4.2	.26
Total	1950.2	113.81

Water is secured from a well located north of Chestnut Street and west of Ames Street. It was drilled by Chris Jensen of Clinton in 1920. The ground surface at the well is about 700 feet above sea level. The well is 6 inches in diameter and 233 feet deep. W. H. Essington states that soft limestone was struck at a depth of 192 feet and water was struck at a depth of 233 feet. The well is cased with 6-inch pipe to a depth of 200 feet. When the well was completed water stood 33 feet below the ground surface. It was tested by the driller with a pump cylinder placed 80 feet below the ground surface. Pumping at a rate of 60 gallons a minute air was not drawn into the cylinder but when pumping 70 gallons a minute for 10 minutes air was drawn into the cylinder. The well is equipped with a Meyer single-acting deep-well pump with 4-inch cylinder and 20-inch stroke. The cylinder is attached to 80 feet of 4-inch drop pipe. No suction pipe is below the cylinder. The amount of water used in

a day was given in 1924 as one foot depth in the elevated tank, or 2300 gallons. It required about one and one-half hours pumping a day from which the rate of pumping was computed to be near 25 gallons a minute. In April, 1925, it was reported that the amount of water used per day was about two feet depth in the tank and that the pump was operated about two hours a day.

The water had a mineral content of 1950, a total hardness of 817, and a content of iron of 0.4 parts per million as shown by the analysis of sample number 51259, collected from a tap on the distribution system on April 15, 1924.

CAMBRIDGE (1335). Cambridge is located in the central part of Henry County. Many wells from 25 to 30 feet deep were formerly in use but these have nearly all been abandoned.

A public water supply was installed by the city in 1896. The installation included a well, a deep-well pump, a collecting reservoir 40 feet in diameter and 10 feet deep, a Deane 8 by 10-inch duplex pump to pump from the reservoir, a gas engine, a distribution system, and an elevated steel tank 11 feet in diameter and 48 feet high on a brick tower 69 feet high. Another well has been drilled and a 40-horsepower electric motor has been installed to drive the pumps.

Four hundred and fifty service connections were in use in 1923. The rate for water is 40 cents a 1000 gallons with a charge for the meter of 75 cents each six months.

The water supply is secured from two wells located about 35 feet apart near the center of the village. The tops of the wells are about 810 feet above sea level. Well number 1 was drilled in 1896. It is 1380 feet (1345?) deep. The bottom is in St. Peter sandstone and the well was cased to the sandstone. The upper 250 feet of casing was 10 inches in diameter. Below this depth the casing was 6 inches and 4 inches in diameter. The well was recased in 1921. The well is equipped with a Deming double-stroke deep-well pump with 5¾-inch cylinder and 24-inch stroke, which operates 15 revolutions a minute. The cylinder has been lowered to a depth of 280 feet.

Well number 2 is 1377 feet deep. It was drilled by the J. P. Miller Artesian Well Company of Chicago in 1913. The well is in blue clay between depths of 30 and 120 feet and strata of shale, slate, coal and limestone below clay to a depth of more than 950 feet. Notes of materials at various depths show sandstone (St. Peter) at 1277 feet, shale at 1326 feet, sandstone between 1335 and 1375 feet, and red marl below 1375 feet. The well was

cased with 142 feet of 15-inch outside diameter pipe and with 288 feet of 10-inch pipe with the bottom at a depth of 422 feet. Possibly some 8-inch casing was placed as the well was 8 inches in diameter at the bottom. The well is equipped with a Keystone Driller Company double-stroke pump with 6¾-inch cylinder and 36-inch stroke. The cylinder is at a depth of 300 feet. The pump is operated 25 revolutions a minute.

The yield of the two wells on July 31, 1923, measured in the reservoir, was 112 gallons a minute. The total amount of water pumped was estimated at 85,000 gallons a day. The depth to water in well number 1 when not pumping was given as 145 feet in 1897, 150 feet in 1912, and 180 feet in 1921.

The temperature of water from the wells was 64 degrees Fahrenheit. The water had a mineral content of 1009, a total hardness of 188, and a content of iron of 0.6 parts per million as shown by the analysis of sample number 49833, collected on July 31, 1923, after forty minutes pumping.

Analysis of Sample Number 49833 from the City Supply.

Determinations Made.	Parts per million.
Iron, Fe	0.6
Manganese, Mn	0.0
Silica, SiO_2	10.4
Nonvolatile	2.6
Alumina, Al_2O_3	3.1
Calcium, Ca	44.0
Magnesium, Mg	19.2
Ammonia, NH_4	2.3
Potassium, K	34.7
Sodium, Na	265.5
Sulfate, SO_4	290.9
Nitrate, NO_3	1.2
Chloride, Cl	180.0
Alkalinity Methyl Orange	260.
Residue	1080.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate, KNO_3	2.0	0.11
Potassium Chloride, KCl	64.7	3.78
Sodium Chloride, NaCl	246.0	14.37
Sodium Sulfate, Na_2SO_4	429.9	25.10
Sodium Carbonate, Na_2CO_3	67.8	3.96
Ammonium Carbonate, $(NH_4)_2CO_3$	6.3	0.37
Magnesium Carbonate, $MgCO_3$	66.4	3.88
Calcium Carbonate, $CaCO_3$	109.8	6.41
Iron Oxide, Fe_2O_3	0.8	0.04
Alumina, Al_2O_3	3.1	0.18
Silica, SiO_2	10.4	0.61
Nonvolatile	2.6	0.15
Total	1009.8	58.96

Samples collected in 1897 and 1912 were similar. They had a mineral content of 1000 and a total hardness of 190 parts per million. The iron content of one was 0.5 and of the other 1.0 parts per million. Plumbing fixtures are discolored by iron in the water. When the casing was removed from well number 1 after 24 years service it was very thin.

CAMPUS (228). Campus is located in the northeastern part of Livingston County on Mazon River, a tributary of Illinois River. Private wells about 16 feet deep have been in use in the southern

part of the village where the ground surface is high. On low land in the northern part of the village little water is available. The Wabash Railway has drilled several wells without securing water.

A public water supply was installed by the village about 1896 Water was secured from a 2-inch well at the corner of Center and Elm Streets. The source of supply and equipment have been changed. Water is now pumped from a well 130 feet deep located near the center of the village. The bottom of the well is in sand and gravel. The well is equipped with a Goulds deep-well pump driven by a 25-horsepower gas engine. The pump has a 5¾-inch cylinder and 24-inch stroke. The pump discharges into the mains and an elevated tank located on the same lot as the well. This tank is 12 feet in diameter and 30 feet high and is supported on a brick tower 50 feet high. Forty-nine service connections were in use in 1916. The quantity of water pumped was estimated at 20,000 gallons a day.

The water had a mineral content of 685, a total hardness of 215, and a content of iron of 0.4 parts per million as shown by the analysis of sample number 35952, collected on November 15, 1916.

Analysis of Sample Number 35952 from the Village Supply.

Determinations Made.	Parts per million.
Iron, Fe	0.4
Silica, SiO_2	9.2
Alumina, Al_2O_3	1.8
Calcium, Ca	54.1
Magnesium, Mg	19.6
Ammonia, NH_4	3.3
Sodium, Na	159.8
Potassium, K	3.5
Nitrite, NO_2	0.0
Nitrate, NO_3	0.4
Sulfate, SO_4	184.9
Chloride, Cl	105.
Alkalinity Methyl Orange	254.
Residue	728.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	0.7	0.04
Potassium Chloride KCl	6.1	.36
Sodium Chloride NaCl	168.5	9.79
Sodium Sulphate Na_2SO_4	273.6	15.93
Sodium Carbonate Na_2CO_3	10.8	.63
Ammonium Carbonate $(NH_4)_2CO_3$	8.8	.51
Magnesium Carbonate $MgCO_3$	67.9	3.96
Calcium Carbonate $CaCO_3$	137.1	7.99
Iron Oxide Fe_2O_3	0.6	.03
Alumina Al_2O_3	1.8	.10
Silica SiO_2	9.2	.54
Nonvolatile	0.6	.03
Total	685.7	39.91

CANTON (10928). Canton is located in a coal mining district in the northeastern part of Fulton County on the drainage area of Illinois River.

Several industrial plants in the city requiring large quantities of water have private water supplies. The P and O plant of the International Harvester Company have a well 10 inches in diameter at the top and 1600 feet deep. It is equipped with air lift with a 1½-inch air line extending to a depth of 300 feet and a 6-inch dis-

charge line. The discharge line is wedged in the well at a depth of 500 feet and indicates that the well is not much more than 6 inches in diameter at that depth and may be smaller. During a test (sometime before 1922) an 8000-gallon elevated tank was filled in 40 minutes, a rate of 200 gallons a minute. The depth to water in the well when measured before 1922, when the air lift had not operated for a few hours, was 80 feet.

A number of coal mines are operated in this vicinity. The Drake mine about 5 miles north of the city has a well 935 feet deep. The amount of water pumped from some of the mines is very small.

The Canton Ice and Fuel Company secures water from an impounding reservoir near the southwestern limits of the city. They supply some water to the railroads and to the local power plant when it is operating.

The Central Illinois Public Service Company pumps water from Big Creek and furnishes part of the supply for the P and O plant.

A public water supply was installed by the city in 1880. Water was secured from a well 2500 feet deep in Jones Park near the center of the city. The well was drilled by the J. P. Miller Artesian Well Company. Water stood at a depth of 30 feet. Later one of the wells now in use was drilled on low land and the original well was abandoned. Two other wells have been drilled and air lift equipment has been installed. Water from the wells is discharged into a collecting reservoir from which it is pumped into the distribution system. The reservoir is 160 feet long and 80 feet wide and the corners are rounded on about 20-foot radius. All machinery is operated by steam. The air compressor generally used is a Laidlaw-Dunn-Gordon two-stage cross-compound with 13 and 22-inch steam cylinders, 20 and 12-inch air cylinders, and 18-inch stroke. The two pumps usually used are Laidlaw-Dunn-Gordon cross-compound fly wheel. One is 14 and 27 by 9 by 24-inch and the other 14 and 26 by 8½ by 18-inch. An old compressor and old pumps are available in case of emergency.

Water for the public supply is secured from three wells located in the southwestern part of the city on low land in the valley of Big Creek. Well number 1 is 1646 feet deep. The casing is given as 300 feet of 6⅝-inch, 373 feet of 10-inch, 431 feet of 6-inch and 40 feet of 14-inch. The 14-inch evidently is at the top of the well outside of the smaller casing. This well is equipped with an air lift, with a 1½-inch air line extending to a depth of 255 feet and a 5-inch discharge line.

Well number 2 is located 55 feet north and west of number 1. A record of material penetrated with classification of the lower strata by the State Geological Survey Division is as follows:

	Thickness in feet.	Depth in feet.
Clay	18	18
Blue shale	14	32
Grey shale	45	77
Blue shale	45	122
Grey shale	8	130
Coal and slate	1	131
Slate and shale	5	136
Blue shale	41	177
Grey Shale	13	190
Coal and slate	2	192
Slate	28	220
Black shale	45	285
? and shale	35	320
Shale	30	350
Lime, flint, sand and shale	100	450
Shale and marl	75	525
Shale	100	625
Brown shale	40	665
Lime and shale	40	705
Brown shale	55	760
Lime	160	920
Lime and shale, Maquoketa	200	1120
Limestone, Galena-Platteville	200	1320
Limestone and sand	90	1410
Sandstone, St. Peter	240	1650
Shale, cave, Prairie du Chien	4	1654
Rock and shale, cave, Prairie du Chien	62	1716
Brown rock and shale, Prairie du Chien	50	1766
Shale and sand, Prairie du Chien	46	1810
Shale, lime and sand, Prairie du Chien	134	1944
Sandstone, Prairie du Chien	98.75	2042.75

The casing of this well is given as 359 feet of 8-inch, 803 feet of 6-inch, and 34 feet of 12-inch, the 12-inch evidently being at the top around the smaller casing. This well is equipped with an air lift with 301 feet of 1½-inch air line and 5-inch discharge line.

Wells 1 and 2 were the only wells in use before 1924. The air compressor was usually operated at from 60 to 85 revolutions a minute. From readings of water levels in the reservoir on February 17 and February 18, 1924, and estimates of water pumped from the reservoir the yield of the two wells during the night was estimated at 310 gallons a minute. The total amount of water pumped during the summer of 1923 was estimated at an average of 350,000 gallons a day. At times of maximum demands the air lifts were operated 24 hours a day.

Well number 3 was drilled by the Sewell Well Company of St. Louis in 1923-1924. The well is located north and west of the two old wells, 145 feet distant from number 1 and 90 feet distant from number 2. The well is 1640 feet deep. It is cased with 15-inch

Analysis of

Sample number	3912
Date	Aug.3,1898
Depth of well	2500
Well	

	Parts per million.
Iron Fe	0.8
Manganese Mn	....
Silica SiO_2	11.4
Nonvolatile	....
Alumina Al_2O_3	3.2
Calcium Ca	95.9
Magnesium Mg	38.6
Ammonia NH_4	1.6
Potassium K	25.3
Sodium Na	338.9
Sulfate SO_4	649.6
Nitrate NO_3	0.6
Chloride Cl	245.0
Alkalinity Methyl Orange	.....
Residue	1581.6

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	0.9	.05
Potassium Chloride KCl	47.7	2.78
Sodium Chloride NaCl	366.3	21.36
Sodium Nitrate $NaNO_3$	.....	.....
Sodium Sulfate Na_2SO_4	601.1	35.06
Sodium Carbonate Na_2CO_3	.....	.....
Ammonium Sulfate $(NH_4)_2SO_4$	5.8	.33
Ammonium Carbonate $(NH_4)_2CO_3$	.....	.....
Magnesium Sulfate $MgSO_4$	192.0	11.19
Magnesium Carbonate $MgCO_3$	.....	.....
Calcium Sulfate $CaSO_4$	121.2	7.70
Calcium Carbonate $CaCO_3$	149.4	8.70
Iron Carbonate $FeCO_3$	1.6	.09
Iron Oxide Fe_2O_3	.....	.....
Nonvolatile	.....	.....
Alumina Al_2O_3	3.2	.18
Silica SiO_2	24.4	1.42
Total	1513.6	88.86

pipe to a depth of 300 feet and with 12-inch pipe to a depth of 1402 feet. The well is 12 inches in diameter at the bottom.

Temporary air equipment was placed in the well in February and the well was tested. An air line 2 inches in diameter was placed inside a 7-inch discharge line and was extended to a depth of 272 feet. The air lift was operated for six hours on February 15 and eight hours on February 16 before measurements were made during an 11 hour test on February 17. The discharge was wasted through a ditch and measured on a weir placed in the ditch. After

Samples From Canton.

14746		46144		50985	
Aug. 7, 1906		Sept. 22, 1921		Feb. 17, 1924	
1646		1646		1640	
No. 1		No. 1		No. 3	
Parts per million.		Parts per million.		Parts per million.	
0.6		0.0		1.2	
....		0.0		0.0	
5.0		12.0		38.0	
2.8		1.2		1.2	
0.7		4.0		5.8	
107.5		86.7		64.6	
42.3		35.9		33.0	
0.3		1.3		2.1	
.....		26.9		137.2	
437.2		551.2		725.2	
737.7		648.8		364.5	
1.1		0.2		1.1	
285.0		440.0		855.0	
.....		284		472	
.....		1929		2481	
Parts per million.	Grains per gallon.	Parts per million.	Grains per gallon.	Parts per million.	Grains per gallon.
.....	.....	0.3	.02	1.7	0.10
.....	.....	51.0	2.98	260.5	15.21
470.3	27.43	685.5	40.09	1205.0	70.37
1.5	.09	.....	.....	.....	.....
775.6	45.23	867.4	50.72	538.7	31.46
.....	.....	.....	.....	177.0	10.30
1.1	.06	4.7	.27	.....	.....
.....	.....	.....	.....	5.5	0.30
.....	.....	73.2	4.28	.....	.....
209.1	12.20	73.0	4.27	144.1	6.66
65.2	3.80	.....	.....	.....	.....
220.4	12.85	215.1	12.85	161.4	9.43
1.2	.07	.....	....	....	.....
.....	.....	.....	....	1.7	0.10
2.8	.16	1.2	.07	1.2	0.07
0.7	.04	4.0	.23	5.8	0.34
5.0	.29	12.0	.70	38.0	2.22
1752.9	102.22	1987.4	116.22	2510.6	146.60

pumping for five hours the rate of pumping during the next two hours was 220 gallons a minute and the water level in the well was 150 feet below the ground surface. During this seven hours water was pumped from well number 1 also and that well probably yielded near the same quantity as did the well tested. During the last four hours of the test the air lifts in wells 1 and 2 were not operated. The rate of pumping varied from 240 to 270 gallons a minute and the water level in the well was from 162 to 166 feet below the top. One hour after the air lift was closed down the

water level in the well had raised to 74 feet below the ground surface. The air lifts in wells 1 and 2 were then operated, discharging about 310 gallons a minute, and during the next ten hours the water level in this well raised to 72 feet below the ground surface.

The temperature of water discharged from well number 1 was 68 degrees and that of water discharged from well number 3 during the test was 64 degrees Fahrenheit.

Samples were collected from well number three during the drilling. The depth of the well when the samples were collected is known. The depth or depths from which waters of all samples flowed into the well is not known. The depth of the well when each sample was collected and the mineral content and total hardness in parts per million of each sample are given below:

Depth of well in feet.	Mineral Content.	Total Hardness.
300	1950	400
490	1470	30
1555	1350	620
1640	2500	300

Analyses of samples of water from the city well 2500 feet deep from city wells number 1 and 3 are given. Samples were collected from well number two at about the same time as collections were made from number 1. The waters were of the same quality and the analysis of samples from well number 2 are not given. The analysis of waters from the wells in use show an increase in the amount of sodium in the water, a decrease in the amount of sulphates, a decrease in hardness, and an increase in the total mineral content. The mineral content of water from well number three may be slightly less than given as the sample analyzed was collected before the well was in regular service but after pumping for several hours. The change in quality of the water may be due in part at least to an increase in the quantity of water pumped.

An analysis of a sample of water, number 48342, collected from a well of less depth than the city wells is given below for comparison. This sample was from the well 935 feet deep at the Drake mine about five miles north of the city.

A meter installed at the pumping station could not be maintained in good order on account of action of the water on meter parts. Leaks develope around the tubes in the boilers in use at the pumping station. Some service pipe, especially near the large main from the station, have been closed by the deposits from the water.

Analysis of Sample Number 48342 from Well 935 Feet Deep.

Determinations Made.	Parts per million.
Turbidity	10.0
Residue	2743.0
Iron, Fe	1.8
Manganese, Mn	0.0
Nitrate, NO_3	1.8
Chloride, Cl	1010.0
Sulphate, SO_4	3275.0
Alkalinity Methyl Orange	542.0
Magnesium	11.4
Calcium	24.6

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Calcium Carbonate $CaCO_3$	61.5	3.59
Magnesium Carbonate $MgCO_3$	39.4	2.30
Sodium Carbonate Na_2CO_3	459.5	26.88
Sodium Sulphate Na_2SO_4	483.5	28.28
Sodium Chloride NaCl	1663 .0	97.20
Sodium Nitrate $NaNO_3$	2.4	0.14
Total	2709.3	158.39

CAPRON (550). Capron is located in the northeastern part of Boone County on the drainage area of Kishwaukee River, a tributary of Rock River. Several private wells are in use. The American Milk Products Company have a well into gravel which is thought to be about 200 feet deep. It is equipped with an air lift and the yield is estimated at 100,000 gallons a day. Some wells at residences are about 60 feet deep and others about 100 feet deep.

A public water supply was installed by the village in 1900. Water is pumped from the well into the distribution system by a deep-well pump which is driven by belt from a 10-horsepower gas engine. A tank 16 feet in diameter and 20 feet high on a brick tower 80 feet high is connected to the system. Ninety-nine service connections were in use in 1917. About one-half of the services were metered.

The public water supply is from a well 680 feet deep which was drilled in 1900 in a park near the center of the village. It is cased to rock at a depth of 400 feet with about 200 feet of 8-inch pipe and about 200 feet of 6-inch pipe and is 5 inches in diameter in rock. The well is equipped with a Goulds single-acting deep-well pump with 4¾-inch cylinder and 24-inch stroke. The cylinder is placed at a depth of 50 feet and has 4 feet of suction pipe attached. In 1917 the pump was operated an average of about 3 hours a day at a rate of 38 revolutions a minute, a displacement of 70 gallons a minute. It has operated continuously for 24 hours without drawing air. The water level when not pumping was 10 feet below the top in 1900 and 15 feet below the top in 1917.

Water from the public supply had a mineral content of 362, a total hardness of 335, and a content of iron of 1.3 parts per million as shown by the analysis of sample number 35084, collected on September 8, 1916.

Analysis of Sample Number 35084 from the Village Supply.

Determinations Made.	Parts per million.
Iron, Fe.	1.3
Silica, SiO_2	13.5
Alumina, Al_2O_3	1.7
Calcium, Ca.	77.3
Magnesium, Mg.	34.4
Ammonia, NH_4	0.4
Sodium, Na.	11.5
Potassium, K	1.4
Nitrite, NO_2	0.0
Nitrate, NO_3	1.4
Sulfate, SO_4	2.8
Chloride, Cl.	4.0
Alkalinity Methyl Orange.	352.
Residue	362.

Hypothetical Combinations.	Parts per million	Grains per gallon.
Potassium Nitrate KNO_3	2.3	.13
Potassium Chloride KCl	0.9	.05
Sodium Chloride NaCl	5.9	.34
Sodium Sulfate Na_2SO_4	4.1	.24
Sodium Carbonate Na_2CO_3	18.2	1.06
Ammonium Carbonate $(NH_4)_2CO_3$	1.0	.05
Magnesium Carbonate $MgCO_3$	119.1	6.95
Calcium Carbonate $CaCO_3$	192.9	11.25
Iron Carbonate $FeCO_3$	2.7	.15
Alumina Al_2O_3	1.7	.10
Silica SiO_2	13.5	.79
Total	362.3	21.11

A sample of water collected from a private well 108 feet deep had a mineral content of 832, a total hardness of 640, and a content of iron of 0.2 parts per million.

CARBON HILL (281). Carbon Hill is located in the eastern part of Grundy County on the drainage area of Mazon River, a tributary of Illinois River. Coal mines were formerly operated in the vicinity and the population in 1900 was 1252.

A public water supply was installed by the village about 1893. The water works now includes a well equipped with a deep-well pump; a 4-horsepower oil engine which is belted to the pump; a distribution system; and a wooden standpipe 15 feet in diameter at the bottom, 12 feet in diameter at the top, and 30 feet high. The well and standpipe are on property owned by the Elgin, Joliet and Eastern Railway. The charge for water is $1.00 a month.

Water is obtained from a well 1900 feet deep, cased with 8-inch pipe to a depth of 150 feet. When the well was drilled about 1893 water flowed directly into the mains. In 1900 a rotary pump was installed to draw water from the well and this served until 1908 when, due to further lowering of the water level, a deep-well pump was installed. The pump is a Goulds with 5¾-inch cylinder and 24-inch stroke, with the cylinder placed at a depth of 60 feet. The amount of water pumped in 1919 was estimated at 3000 gallons a day. The water level lowered and in 1922 the pump cylinder was lowered 20 feet. In April, 1925, the pump was operated about four hours a day.

The water had a mineral content of 1242, a total hardness of 442, and a content of iron of 0.3 parts per million as shown by the

analysis of sample number 53081, collected at a tap in the pumping station on January 15, 1925.

Analysis of Sample Number 53081 from the Village Supply.

Determinations Made.	Parts per million.
Iron, Fe	0.3
Manganese, Mn	0.0
Silica, SiO_2	6.9
Nonvolatile	1.6
Alumina, Al_2O_3	11.0
Calcium, Ca	104.0
Magnesium, Mg	44.3
Ammonia, NH_4	2.4
Sodium, Na	245.4
Potassium, K	31.0
Sulfate, So_4	371.6
Nitrate, NO_3	0.5
Chloride, Cl	280.0
Alkalinity	
Phenolphthalein	0.
Methyl Orange	254.
Residue	1253.

Hypothetical Combinations.	Parts per million	Grains per gallon.
Potassium Nitrate KNO_3	0.9	.05
Potassium Chloride KCl	58.4	3.42
Sodium Chloride NaCl.	415.9	24.32
Sodium Sulfate Na_2SO_4	252.3	14.75
Ammonium Sulfate $(NH_4)_2SO_4$	8.7	.51
Magnesium Sulfate $MgSO_4$	219.4	12.82
Calcium Sulfate $CaSO_4$	27.5	1.61
Calcium Carbonate $CaCO_3$	239.3	14.00
Iron Oxide Fe_2O_3	0.4	.02
Alumina Al_2O_3	11.0	.65
Silica SiO_2	6.9	.41
Nonvolatile	1.6	.09
Total	1242.3	72.65

A sample collected in 1914 was of the same quality.

CARBONDALE (6267). Carbondale is located in the eastern part of Jackson County on the drainage area of Big Muddy River, a tributary of Mississippi River. Many private wells from 15 to 25 feet deep have been in use. The Southern Illinois State Normal University, located in the city, had a well 400 feet deep. A record of material penetrated by a well at the University, secured from Albert Butler of Carbondale, is as follows:

Clay	19 feet
Sand, white	11 feet
Soapstone	9 feet
Sandstone, red	6 feet
Soapstone	5 feet
Limestone, blue	3 feet
Shale	10 feet
Limestone, blue	3 feet
Shale, black	1 feet
Limestone, blue	3 feet
Shale, blue	10 feet
Sand, white	52 feet
Shale	118 feet
Sandstone, White	15 feet
Soap shale	10 feet
Sandstone, white	25 feet
Shale, soft	32 feet
Sandstone, white	58 feet
Shale	5 feet
sand	150 feet
	545 feet

Water from the well in use, said to be 400 feet deep, had a mineral content of 669, a total hardness of 76, and a content of iron of 0.1 parts per million as shown by the analysis of sample number 39420, collected at the well on May 6, 1918.

Analysis of Sample Number 39420 from the Well at the University.

Determinations Made.

	Parts per million.
Iron, Fe	0.1
Manganese, Mn	0.0
Silica, SiO_2	15.8
Alumina, Al_2O_3	0.7
Calcium, Ca	18.7
Magnesium, Mg	7.3
Ammonia, NH_4	0.4
Sodium, Na	234.4
Potassium, K	4.1
Nitrate, NO_3	5.3
Sulfate, SO_4	12.2
Chloride, Cl	180.0
Alkalinity Methyl Orange	322.
Residue	690.

Hypothetical Combinations.

	Parts per million	Grains per gallon.
Potassium Nitrate KNO_3	8.6	.50
Potassium Chloride KCl	1.5	.09
Sodium Chloride NaCl	295.5	17.24
Sodium Sulphate Na_2SO_4	18.0	1.05
Sodium Carbonate Na_2CO_3	259.2	15.12
Ammonium Carbonate $(NH_4)_2CO_3$	1.1	.06
Magnesium Carbonate $MgCO_3$	25.3	1.48
Calcium Carbonate $CaCO_3$	38.9	2.27
Iron Carbonate $FeCO_3$	0.1	.01
Alumina Al_2O_3	0.7	.04
Silica SiO_2	15.8	.92
Nonvolatile	4.3	.25
Total	669.0	39.03

The Ayer and Lord Tie Company have a tie-treating plant located north of the city. They have two wells drilled by Albert Butler in 1922. A record of material penetrated is as follows:

Clay	42 feet
Clay, blue	48 feet
Sand, white	19 feet
Sand, green	6 feet
Sand, brown	6 feet
Soapstone	5 feet
Slate	4 feet
Limestone, blue	3 feet
Shale	8 feet
	141 feet

The diameter of one well is 8 or 10 inches and the other is 6 inches. Both are cased to the bottom and two lengths of casing in the sandstone are perforated and covered with fine screen. The larger well is equipped with an Indiana air pump placed 2 feet above the bottom of the well. The yield is not definitely known but is estimated at 40,000 gallons a day.

The Illinois Central Railroad filter water pumped from Big Muddy River for use in locomotives. They furnish water for use in boilers at the Central Illinois Public Service Company pumping station.

A public water supply was installed by a private company about 1897. Water was secured from two wells in the northwestern part of the city. A reservoir of 28,000 gallons capacity, a pumping sta-

tion, and a standpipe of 60,000 gallons capacity were installed on the same plot of ground as the wells. The water works is now owned by the Central Illinois Public Service Company. They have installed additional wells, a reservoir 43 feet square at the top and pumping machinery, on their property on which an electric light plant is also located. Water from the two original wells is pumped into a collecting reservoir 42 feet in diameter and 13 feet deep located on the same plot of ground. From this reservoir it flows by gravity to the reservoir at the main station. A Deane 8 by 8-inch triplex pump is usually used to pump water into the mains. A centrifugal pump of 400 gallons a minute capacity and a steam pump are also available for this service. Two Manistee Iron Works centrifugal pumps, each of 500 gallons a minute capacity, have been installed for fire service. The pumping machinery except one well pump is electrically operated. Current used can be generated at the local plant or furnished from the company plant at Harrisburg.

Water for the municipal supply is secured from five wells. Two of the wells, known as number 1 and number 2, are located about 100 feet apart on a plot of ground at the southeast corner of Springer and Sycamore Streets in the northwestern part of the city. These wells were drilled about 1897. The elevation at the tops is about 470 feet above sea level. Number 1 well is 412 feet deep and number 2 is 416 feet deep. Both are cased to rock at a depth of 60 feet and are 8 inches in diameter in rock. Well number one is equipped with a Hill single-acting pump with 3¾-inch cylinder placed at a depth of 400 feet. Well number two is equipped with a Cook single-acting deep-well pump with a 5-inch cylinder and 24-inch stroke. The cylinder is at a depth of 412 feet.

The other three wells are located in the northern part of the city at the northeast corner of Hickory and West Streets on the east side of the Illinois Central Railroad. The elevation of the tops of the wells is 440 feet above sea level. All are cased to rock. Number 3 well located inside the pumping station is 610 feet deep. It is equipped with a Cook single-acting deep-well pump with 4¾-inch cylinder and 24-inch stroke. Well number 4 is eight inches in diameter and 410 feet deep. It is equipped with a single-acting steam-head deep-well pump with 3¼-inch cylinder and 36-inch stoke. The cylinder is placed at a depth of 450 feet. Well number 5, located 75 feet distant from well number 3, was finished in June 1914. A record of material penetrated is as follows:

	Thickness in feet.	Depth to bottom in feet.
Clay, sandy, yellow	20	20
Sandstone, white	40	60
Shale, dark	30	90
Limestone and sand.	30	120
Slate and sand shells	20	140
Sandstone, gray	60	200
Slate and shells	15	215
Sandstone	10	225
Sand, shale and slate	75	300
Slate, dark	35	335
Slate, blue	35	370
Sandstone, white	35	405
Slate	85	490
Sandstone	35	525
Slate	25	550
Sandstone, dark hard	46	596
Sandstone, white open	30	626
Slate dark	15	660

A small quantity of water was found in sandstone between depths of 120 and 200 feet and a large quantity in sandstone between depths of 596 and 626 feet. A bailer test was made and 30 to 40 gallons a minute was pumped for three hours. The well is equipped with a Cook single-acting deep-well pump with 4¾-inch cylinder and 24-inch stroke.

During a test made by J. A. Rue of the Central Illinois Public Service Company on January 15 and 16, 1921, the five wells furnished 120 gallons a minute, a rate of 172,000 gallons a day. There was little interference between the two groups of wells. Wells 1 and 2 located about 100 feet apart yielded 51½ gallons and when number 1 was not operating number 2 yielded 44½ gallons a minute. Wells 3, 4, and 5, the group at the main station, yielded 58½ gallons a minute. Well number 3 yielded 27 gallons a minute when the other two wells were operating and 33 gallons a minute when they were not operating. Well number 5 yielded 29½ gallons a minute when the other two well pumps were operating and 33 gallons a minute when number 3 well was not operating. Well number 4 yielded 12 gallons a minute with the other two operating and 15 gallons a minute when number 3 was not operating.

The well pumps as described above were operating continuously in July, 1924. The amount of water supplied during 1923 was 54,000,000 gallons, an average of 148,000 gallons a day, which, allowing for ordinary repairs, is evidently near the capacity of the wells.

A sample of water, number 51901, collected from one of the deeper wells, well number 3 on July 21, 1924 had a mineral content

of 2777, total hardness of 138, and a content of iron of 1.0 parts per million as shown by the analysis.

Analysis of Sample Number 51901 from Well Number 3.

Determinations Made.	Parts per million.
Iron, Fe	1.0
Manganese, Mn	0.0
Silica, SiO_2	15.2
Nonvolatile	0.5
Alumina, Al_2O_3	1.8
Calcium, Ca	29.3
Magnesium, Mg	15.8
Ammonia, NH_4	0.0
Potassium, K	86.0
Sodium, Na	967.2
Sulfate, SO_4	81.0
Nitrate, NO_3	30.1
Chloride, Cl	1325.0
Alkalinity Methyl Orange	362.
Residue	2792.

Hypothetical Combinations.	Parts per million	Grains per gallon.
Potassium Nitrate KNO_3	49.0	2.86
Potassium Chloride KCl	127.9	7.47
Sodium Chloride NaCl	2083.8	121.69
Sodium Sulphate Na_2SO_4	119.7	6.99
Sodium Carbonate Na_2CO_3	250.7	14.64
Magnesium Carbonate $MgCO_3$	54.8	3.20
Calcium Carbonate $CaCO_3$	73.1	4.27
Iron Oxide Fe_2O_3	1.4	0.08
Alumina Al_2O_3	1.8	0.10
Silica SiO_2	15.2	0.89
Nonvolatile	0.5	0.03
Total	2777.9	162.22

The temperature of water from this well on July 21, 1924, was 60 degrees Fahrenheit.

A sample of water, number 51902, collected from one of the shallower wells, number 2, on July 21, 1924, had a mineral content of 1922, a total hardness of 50, and a content of iron of 2.4 parts per million as shown by the analysis.

Analysis of Sample Number 51902 from Well Number 2.

Determinations Made.	Parts per million.
Iron, Fe	2.4
Manganese, Mn	0.0
Silica, SiO_2	15.0
Nonvolatile	2.6
Alumina, Al_2O_3	0.6
Calcium, Ca	12.3
Magnesium, Mg	4.6
Ammonia, NH_4	0.3
Potassium, K	65.7
Sodium, Na	690.2
Sulfate, SO_4	31.4
Nitrate, NO_3	3.5
Chloride, Cl	865.0
Alkalinity Methyl Orange	364.
Residue	1976.

Hypothetical Combinations.	Parts per million	Grains per gallon.
Potassium Nitrate KNO_3	5.8	0.34
Potassium Chloride KCl	120.9	7.06
Sodium Chloride NaCl	1331.0	77.73
Sodium Sulphate Na_2SO_4	46.4	2.71
Sodium Carbonate Na_2CO_3	349.2	20.39
Ammonium Carbonate $(NH_4)_2CO_3$	0.7	0.04
Magnesium Carbonate $MgCO_3$	16.0	0.93
Calcium Carbonate $CaCO_3$	30.7	1.79
Iron Oxide Fe_2O_3	3.4	0.20
Alumina Al_2O_3	0.6	0.03
Silica SiO_2	15.0	0.88
Nonvolatile	2.6	0.15
Total	1922.3	112.25

The temperature of water from this well on July 21, 1924, was 58 degrees Fahrenheit.

Analyses of many samples have shown considerable variation in the supply. Samples of water from wells one and two, wells on

high ground and a little over 400 feet deep, have had mineral contents of from 1390 to 2550 and chloride contents of from 950 to 1500. Samples from the deeper wells number 3 and number 5 and from well number 4 located close by have had mineral contents of from 2580 to 3400 and chloride contents of from 1140 to 2000.

Considerable trouble has been experienced with various makes of meters due to action of the water on the meter parts. The use of monel metal greatly decreased this action.

CARPENTERVILLE (1036). Carpenterville is located in the northeastern part of Kane County on Fox River.

A public water supply was installed by the village in 1914. The installation includes a well, a brick pumping station, a pump which draws water from the well and discharges into the distribution system, a 25-horsepower electric motor, a 30-horsepower gas engine, and a 60,000-gallon steel tank on a steel tower 75 feet high. This tank is located on a hill in the western part of the village. The electric motor is operated with automatic control and is used to drive the pump at night. The gas engine is generally used at other times. Two hundred and ten consumers were supplied with water in 1923 and the total consumption was estimated at. an average of 100,000 gallons a day. The rate is 15 cents per 1000 gallons for the first 2000 gallons and the lowest rate is 4½ cents, which is for water in excess of 70,000 gallons. Bills are not subject to cash discount.

Water is obtained from a well 20 feet in diameter and 17 feet deep, located in the southern part of the village on the east side of the river. The top of the well is about 10 feet above the river or about 728 feet above sea level. The material penetrated is said to be about 5 feet of black soil and clay below which is gravel and stone. Water is pumped from the well by a Platt Iron Works 8½ by 10-inch single-acting triplex pump operating 51, revolutions a minute. One June 28, 1923, the water level was drawn down to a depth of 9.4 feet below the top of the well by pumping for 33 minutes and the pump was then stopped. The rate of inflow was 141 gallons a minute when the water level was 9.1 feet below the top and gradually reduced to 43 gallons a minute when the water level was 7 feet below the top. The inflow was computed from the rate of rise of water level in the well. Water can be drawn to a depth of 13 feet below the top of the well and rises to a level about

6 feet below the top, to a 6-inch overflow pipe. The amount of water pumped in June, 1923, probably averaged near 100,000 gallons a day, as the pump was operated about 5 hours a day.

The water had a mineral content of 494, a total hardness of 455, and a content of iron of 2.8 parts per million as shown by the analysis of sample number 37359, collected on June 19, 1917.

Analysis of Sample Number 37359 from the Village Supply.

Determinations Made.	Parts per million.
Iron, Fe	2.8
Silica, SiO_2	17.8
Alumina, Al_2O_3	3.7
Calcium, Ca	100.0
Magnesium, Mg	49.7
Sodium, Na	7.9
Potassium, K	2.2
Nitrate, NO_3	1.4
Sulphate, SO_4	64.3
Chloride, Cl	0.0
Alkalinity Methyl Orange	392.
Residue	500.

Hypothetical Combinations.	Parts per million	Grains per gallon.
Potassium Nitrate KNO_3	2.3	.13
Potassium Sulphate K_2SO_4	2.9	.17
Sodium Sulphate Na_2SO_4	24.4	1.42
Magnesium Sulphate $MgSO_4$	58.0	3.38
Magnesium Carbonate $MgCO_3$	131.2	7.65
Calcium Carbonate $CaCO_3$	249.6	14.55
Iron Oxide Fe_2O_3	4.1	.24
Alumina Al_2O_3	3.7	.22
Silica SiO_2	17.8	1.04
Total	494.0	28.80

CARROLLTON (2020). Carrollton is located in the central part of Green County about 10 miles distant from Illinois River.

A public water supply was installed by the city about 1891. A well was drilled in the central part of the city to a depth of 1330 feet. Water stood 50 feet below the ground surface in 1890.

The water was so highly mineralized that the well was abandoned in 1900 when a supply was developed from springs near the city. Water is pumped from the springs through a 6-inch pipe line to the city by either of two pumps which are placed in a pit four or five feet above the water level in the springs. Boilers and a steam pump formerly in use have been abandoned and water is now pumped by either of two triplex pumps, one a Deane 7½ by 10 inch and the other an Aldrich 7 by 10-inch. Each pump is driven by a gas engine. A steel tank of 100,000 gallons capacity on a steel tower, located near the center of the city, is connected to the mains. The rate for the first 20,000 gallons used in three months is 40 cents per 1000 gallons with a minimum charge of $1.50. The lowest rate, for water in excess of 250,000 gallons, is 17 cents per 1000 gallons.

Water is secured from springs located four miles northwest of the city near the bank of a small stream at the northern end of a long narrow ridge. Rock out crops along this ridge from the bot-

tom to within 10 feet of the top. This rock consists of thin alternate strata of limestone and chert. The springs have been enclosed by concrete walls which extend above the surface of the ground. The enclosure is of irregular shape but approximately 70 feet long by 30 feet wide. Two 10-inch overflow pipes equipped with check valves are placed in the west wall of the enclosure a few inches above ordinary water level in the stream. The stream formerly flowed along the north wall of the enclosure but has been diverted about 90 feet northward and the old channel has been filled. Water from the overflow which formerly discharged directly into the stream now discharges into a manhole from which it flows to the stream through a tile line.

The flow of the springs varies with weather conditions. At the time of visit on November 2, 1921, water was pumped from the springs at a rate estimated at 240 gallons a minute and about 50 gallons a minute was flowing to waste, so the yield was near 300 gallons a minute. The total amount of water pumped to the city was probably near 200,000 gallons a day as the 7 by 10-inch triplex pump was operated at 50 revolutions a minute for from 10 to 12 hours a day.

Microspora algae; a water moss, Fontanelis? ; and many medium sized crustaceans were growing in the spring enclosure at the time of visit in November 1921. The quality of water probably varies somewhat with the rainfall. A sample, number 38721, collected on December 12, 1917, had a mineral content of 331, a total hardness of 280, and a content of iron of 0.2 parts per million as shown by the analysis.

Analysis of Sample Number 38721 from the City Supply.

Determinations Made.

	Parts per million.
Iron, Fe	0.2
Manganese, Mn	0.3
Silica, SiO_2	30.9
Alumina, Al_2O_3	0.3
Calcium, Ca	74.8
Magnesium, Mg	23.1
Sodium, Na	8.1
Potassium, K	2.5
Nitrite, NO_2	0.0
Nitrate, NO_3	10.6
Sulfate, SO_4	8.8
Chloride, Cl	5.0
Alkalinity Methyl Orange	292.
Residue	357.

Hypothetical Combinations.

	Parts per million	Grains per gallon.
Potassium Nitrate KNO_3	6.5	.38
Sodium Nitrate $NaNO_3$	9.1	.53
Sodium Chloride NaCl	8.3	.48
Sodium Sulphate Na_2SO_4	7.1	.41
Magnesium Sulphate $MgSO_4$	5.0	.29
Magnesium Carbonate $MgCO_3$	76.9	4.46
Calcium Carbonate $CaCO_3$	186.7	10.89
Iron Carbonate $FeCO_3$	0.4	.02
Manganese Carbonate $MnCO_3$	0.5	.03
Alumina Al_2O_3	0.3	.02
Silica SiO_2	30.9	1.80
Total	331.1	19.31

The spring has now been covered and no trouble with growths is experienced.

CARTHAGE (2129). Carthage is located in the central part of Hancock County on the drainage area of Crooked Creek, a tributary of Illinois River. Many private wells from 18 to 30 feet deep are in use at residences. Wells from 200 to 350 feet deep into a stratum of limestone are in use at the Court House, Carthage College, Carthage Ice Company plant, and Fair Grounds.

The wells at the ice plant furnish a greater supply than any of the other private wells. The company has two 6-inch wells located 28 feet apart, one 340 feet and the other 349 feet deep. Water was encountered at a depth of 185 feet and casing was placed, but when the second well was drilled and reached a depth of 185 feet turbid water was pumped from the other well showing that the water had not been excluded by the casing. When the wells were drilled in 1922 the water level was 75 feet below the ground surface. The east well is equipped with an air lift which is operated about twelve hours a day when the plant is in full operation. On May 31, 1922, at a time when the plant was not operating at capacity, the yield, measured in a reservoir, was 36 gallons a minute. The water level in the well 28 feet distant was drawn down 7 feet to a depth of 89 feet 6 inches. The water had a mineral content of 776, a total hardness of 505, and a content of iron of 0.7 parts per million as shown by the analysis of sample number 49576, collected on May 31, 1923.

Analysis of Sample Number 49576 from Well at the Ice Plant.

Determinations Made.	Parts per million.
Iron, Fe	0.7
Manganese, Mn	0.0
Silica, SiO_2	10.1
Nonvolatile	1.5
Alumina, Al_2O_3	4.2
Calcium, Ca	123.0
Magnesium, Mg	48.0
Ammonia, NH_4	4.9
Sodium, Na	68.7
Potassium, K	20.1
Sulfate, SO_4	137.2
Nitrite, NO_2	11.5
Nitrate, NO_3	3.7
Chloride, Cl	143.0
Alkalinity Methyl Orange	346.0
Residue	807.

Hypothetical Combinations.	Parts per million	Grains per gallon.
Potassium Nitrite KNO_2	21.3	1.24
Potassium Nitrate KNO_3	5.9	0.34
Potassium Chloride KCl	15.3	0.89
Sodium Chloride NaCl	174.6	10.19
Ammonium Chloride NH_4Cl	14.5	0.84
Magnesium Chloride $MgCl_2$	27.1	1.58
Magnesium Sulphate $MgSO_4$	171.7	10.03
Magnesium Carbonate $MgCO_3$	21.9	1.28
Calcium Carbonate $CaCO_3$	307.1	17.93
Iron Oxide Fe_2O_3	1.0	0.06
Alumina Al_2O_3	4.2	0.24
Silica SiO_2	10.1	0.59
Nonvolatile	1.5	0.08
Total	776.2	45.29

A public water supply was installed by the city about 1890. Water was secured from a well about 1700 feet deep which has since been abandoned. The U. S. Geological Survey Seventeenth Annual Report reported the depth 1800 feet and the water surface 16 feet below the ground surface in 1896. Two other wells have been drilled. Each is equipped with a deep-well pump which discharges into the distribution system and an elevated wooden tank of 65,000 gallons capacity on a tower 80 feet high located at the side of the pumping station. The pumps are driven by belts from a shaft which is turned by a 10-horsepower electric motor. A 22-horsepower gas engine is available for use in emergency and at times when both pumps are operated.

The older well, drilled in 1898, is 1000 feet deep. A record of material penetrated as given in the "Illinois Glacial Lobe" by Leverett, with classification by the State Geological Survey Division, is as follows:

	Thickness in feet.	Depth in feet.
Drift, clay sand and gravel	214	214
Limestone, white, Silurian System, all or chiefly Niagaran	70	284
Shale, Maquoketa	355	639
Limestone, Galena-Platteville	336	975
Sandstone, St. Peter	25	1000

The depth to water was given as about 16 feet.

The well is equipped with a single-acting deep-well pump with 5¾-inch cylinder and 24-inch stroke. The cylinder is placed at a depth of about 115 feet. This pump is not often operated.

The other well has been drilled since 1912. It is located about 25 feet north of the older well. This well is 847 feet deep. A record of material penetrated, given from memory by Oliver Rohrbough, is as follows:

	Thickness in feet.	Depth in feet.
Drift	216	216
Limestone	130	346
Shale	300	646
Limestone	201	847

This well is equipped with a Goulds deep-well pump with a 6¾-inch cylinder and 24-inch stroke. The cylinder is placed at a depth of about 115 feet. In August 1919 the pump was operated 28 revolutions a minute, a displacement of 100 gallons a minute. In 1923 the pump was operated at the same speed and was said to operate about 15 hours a day, indicating a water consumption of about 80,000 gallons a day.

Water from the well 847 feet deep, the well usually used, has a mineral content of 2682, a total hardness of 632, and a content of iron of 0.0 parts per million as shown by the analysis of sample number 49575, collected at the well after the pump had operated for several hours on May 31, 1923.

Analysis of Sample Number 49575 from Well 847 Feet Deep.

Determinations Made.	Parts per million.
Iron, Fe	0.0
Manganese, Mn	0.0
Sliica, SiO_2	9.4
Nonvolatile	1.3
Alumina, Al_2O_3	2.9
Calcium, Ca	143.3
Magnesium, Mg	66.3
Ammonia, NH_4	3.1
Sodium, Na	614.1
Potassium, K	119.1
Sulfate, SO_4	927.6
Nitrate, NO_3	1.6
Chloride, Cl	643.0
Alkalinity	
Methyl Orange	260.0
Residue	2698.

Hypothetical Combinations.	Parts per million	Grains per gallon.
Potassium Nitrate KNO_3	2.5	.15
Potassium Chloride KCl	225.2	13.15
Sodium Chloride NaCl	883.3	51.58
Sodium Sulphate Na_2SO_4	823.2	48.07
Ammonium Sulphate $(NH_4)_2SO_4$	11.3	.66
Magnesium Sulphate $MgSO_4$	327.7	19.14
Calcium Sulphate $CaSO_4$	142.5	8.32
Calcium Carbonate $CaCO_3$	252.9	14.77
Alumina Al_2O_3	2.9	.17
Silica SiO_2	9.4	.53
Nonvolatile	1.3	.07
Total	2682.2	156.61

CARY (463). Cary is located in the southeastern part of McHenry County about one mile west from Fox River. Water for some private supplies is secured from sand and gravel which is overlaid with a thin covering of soil. The Bowman Dairy Company has a private water supply. Springs known as the Minerva Mineral Springs are located near the east edge of the village.

A public water supply was installed by the village in 1913. The installation included a well; a deep-well pump driven by a 5-horsepower electric motor; a collecting reservoir 30 feet in diameter of 100,000 gallons capacity; two American centrifugal pumps of 320 gallons a minute capacity, each direct connected to a 15-horsepower electric motor equipped with automatic control; a distribution system; and a reinforced concrete standpipe of 70,000 gallons capacity. The centrifugal pumps are located in a room in the village hall. They pump from the reservoir into the main and may be operated in parallel or in series. The well pump is in a frame building back of the hall and the standpipe is on a hill near the southern village limits. The elevated tank and reservoir were built without forms by the use of a cement gun. The top of the collecting reservoir is 11 feet above the ground surface.

Power is purchased from the Public Service Company of Northern Illinois.

Ninety service connections, all of which were metered, were in use in November 1922. The consumption, as nearly as could be estimated, averaged about 42,000 gallons during the summer and 27,000 gallons at the time of visit in November, 1922. The minimum charge is $2.10 for three months, which allows the use of 6000 gallons of water. The rate for the next 6000 gallons is 24 cents per 1000 gallons and the lowest rate is 12 cents, which is for quantities in excess of 1,500,000 gallons a month. A discount of from 10 to 15 per cent is allowed depending upon the size of the bill.

Water is secured from a well 10 inches in diameter and 300 feet deep located near the center of the village back of the village hall. The ground surface at the well is about 800 feet above sea level. The well is cased to limestone at a depth of 154 feet. When the well was completed it was pumped for 30 hours at a rate of 110 gallons a minute. During the test air was drawn into the pump cylinder which was placed at a depth of 80 feet. In 1916 water stood at a depth of about 12 feet. At the time of visit on November 8, 1922, the well pump was operated for three hours and the yield, measured in the reservoir, was 118 gallons a minute. The depth to water in the well was 68 feet after pumping for one hour and forty minutes, 74 feet after pumping for three hours, 28 feet two and one half hours after the pump was stopped, and 22 feet when the pump had been idle for 12 hours before the test. All measurements were from the pump base.

The temperature of water direct from the well is 54 degrees Fahrenheit. The water had a mineral content of 307, a total hardness of 260, and a content of iron of 0.2 parts per million as shown by the analysis of sample number 48666, collected in November, 1922.

Aanlysis of Sample Number 48666 from the Village Supply.

Determinations Made.	Parts. per million.
Turbidity,	5.0
Residue	334.0
Iron, Fe	0.2
Manganese, Mn	0.0
Nitrate, NO_3	1.2
Chloride, Cl	0.0
Sulfate, SO_4	0.0
Alkalinity	
Phenolphthalein	0.0
Methyl Orange	326.0
Magnesium	37.7
Calcium	41.9

Hypothetical Combinations.	Parts per million	Grains per gallon.
Calcium Carbonate $CaCO_3$	104.5	6.08
Magnesium Carbonate $MgCO_3$	131.1	7.66
Sodium Carbonate Na_2CO_3	70.5	4.09
Sodium Nitrate $NaNO_3$	1.7	0.10
Total	307.8	17.93

A sample collected in 1916 was similar. The greatest difference was in iron content which in that analysis was 0.8 parts per million.

CASEY (2189). Casey is located in the western part of Clark County on the drainage area of Embarrass River, a tributary of Wabash River.

A public water supply was installed by the city about 1908. Water was taken from a reservoir which had been formed by building a dam across a small ravine in the southeastern part of the city. The area of the reservoir was four acres and the tributary drainage area about one square mile. In the summer of 1916 there were about 270 service connections but no water was supplied at that time except for fire purposes on account of scarcity of water. In that year wells were drilled in the bottom lands of the North Fork of Embarrass River and have since furnished the entire supply, excepting on a few occasions when water from the reservoir has been used. A pumping station has been built close to the wells and earth has been filled around the station to above high water level. Water is pumped from the wells through a pipe line to the city by a horizontal duplex plunger pump, driven by belt from an oil engine. The pump is placed in a pit about 5 feet below the general ground surface and draws water from the wells by suction. The pipe line is part 8 inches and part 10 inches in diameter. About 360 service connections were in use in 1923 and all services were metered.

Before drilling the wells now in use other sources of supply were investigated. In 1914 a 6-inch test well was drilled to a depth of 52 feet in the bottom lands of Embarrass River about ten miles southwest of the city. The well penetrated clay, sand, blue spongy muck, six feet of limestone, and, at the bottom, 5 feet of coarse gravel. During a test water was pumped with a 3-inch centrifugal pump for 5½ hours at a rate of 50 gallons a minute. The city voted in favor of a bond issue to install two 15-inch wells with necessary pumping equipment and a pipe line to the city. The bonds were not sold and the project was dropped.

A well was drilled close to the bank of the impounding reservoir in the city in about 1900, to secure water for an electric light plant. The well was 20 feet in diameter and 60 or 70 feet deep but very little water was secured until a direct connection was made with the reservoir.

Two wells at the plant of the Ohio Oil Company entered water bearing sand and gravel at a depth of 72 feet. Two wells, the deepest 135 feet deep, furnish about 16,000 gallons of water a day. Records of several other wells are available but no definite record is available of any wells with yield sufficient to furnish water for a public supply, excepting wells yielding salty water and the wells referred to in stream valleys.

The public water supply is secured from three wells located in the valley of the North Fork of Embarrass River in section 19, five miles east of Casey. The ground surface at the wells is about 580 feet above sea level. The wells are in a row 15 feet apart and are 70 feet north of the creek. The two end wells are 80 feet deep and the center well is 131 feet deep. A record of material penetrated by the west well, number 1, was given by Everett Christler, alderman, as follows:

River silt and top soil	15 feet
Gravel	13 feet
Gravel, some mud	4 feet
Coarse sand	15 feet
Coarse sand and gravel	29 feet
Coarse gravel	4 feet

The well is 8 inches in diameter and is provided with a number 40 Cook screen 12 feet long. A strong flow of water was reported in the gravel between depths of 47 and 80 feet. The well was tested in 1916 by pumping continuously for 68 hours with a deep-well pump with the cylinder placed at a depth of 69 feet. The pump displacement at the speed run was from 147 to 227 gallons a minute and was 214 gallons a minute during the last hour. The yield as determined by filling a barrel was about four percent less than the displacement. The static water level was about 18 inches below the ground surface. It was said that the water level was not drawn down to the pump cylinder and that the water level in well number 2 was not affected.

The center well, number 2, is 131 feet deep. Below a depth of 80 feet, the well penetrated sand with no water at 80 feet, sand and mud 27 feet, sand with gas 2 feet, mud 3 feet, sand and buried wood 2 feet, mud 3 feet, sand and gravel 14 feet. The bottom 14 feet is fine sand above and coarse gravel near the bottom and yields considerable water and also considerable gas. This well was tested by pumping continuously for 53 hours with the equipment that was used to test well number 1. The pump displacement at the speed operated averaged near 133 gallons a minute. No mention is made of testing the actual yield of the pump during this test, and as the water contained considerable gas the yield may have been con-

siderable less than the displacement. The water level was not drawn down to the pump cylinder and the water level in well number 1 was not affected during the test. On the day following the test the water level in this well was at a depth of 11 feet.

The east well, number 3, similar to well number 1, was installed after these tests were made.

The water had a mineral content of 525, a total hardness of 290, and a content of iron of 3.0 parts per million as shown by the analysis of sample number 41499, collected on August 5, 1919.

Analysis of Sample Number 41499 from the City Supply.

Determinations Made.	Parts per million.
Iron, Fe	3.0
Silica, SiO_2	16.8
Nonvolatile	3.8
Alumina, Al_2O_3	0.8
Calcium, Ca	65.7
Magnesium, Mg	30.8
Sodium, Na	86.7
Ammonia, NH_4	9.3
Nitrate, NO_3	0.9
Sulfate, SO_4	0.0
Chloride, Cl	31.0
Alkalinity	
Phenolphthalein	0.0
Methyl Orange	460.0
Residue	535.0

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Sodium Nitrate $NaNO_3$	1.2	0.07
Sodium Chloride NaCl	51.1	2.99
Sodium Carbonate Na_2CO_3	152.3	8.91
Ammonium Carbonate $(NH_4)_2CO_3$	24.7	1.44
Magnesium Carbonate $MgCO_3$	106.5	6.23
Calcium Carbonate $CaCO_3$	163.9	9.59
Iron Oxide Fe_2O_3	4.3	0.25
Alumina Al_2O_3	0.8	0.05
Silica SiO_2	16.8	0.98
Nonvolatile	3.8	0.22
Total	525.4	30.73

The water stains plumbing fixtures and has some odor, especially when drawn from dead ends on the system. A partial analysis of a sample collected in 1916 from well number 1, eighty feet deep, indicates a water very similar in quality to the sample for which analysis is given above.

A sample, number 35355, collected from the well 131 feet deep on October 2, 1916, had a mineral content of 1020, a total hardness of 206, and a content of iron of 4.0 parts per million as shown by the analysis.

Analysis of Sample Number 35355 from Well 131 Feet Deep.

Determinations Made.	Parts per million.
Iron, Fe	4.0
Magnesium, Mg	19.5
Nitrite, NO_2	0.0
Sulfate, SO_4	0.0
Chloride, Cl	275.0
Alaklinity	
Methyl Orange	514.0
Residue	1020.0

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Sodium Chloride NaCl	454	26.48
Sodium Carbonate Na_2CO_3	326	19.02
Magnesium Carbonate $MgCO_3$	67	3.91
Calcium Carbonate $CaCO_3$	126	7.35
Iron Carbonate $FeCO_3$	8	0.47
Undetermined	39	2.27
Total	1020	59.50

CEDAR POINT (686). Cedar Point is located in the southwestern part of LaSalle County about four miles south of Illinois River.

A public water supply was installed in 1912 by the Cedar Point Light and Water Company, a company controlled by the LaSalle County Carbon Coal Company. Water is pumped from a well. Many changes have been made in the equipment which now includes on air lift; a Sullivan air compressor with 7-inch cylinder and 6-inch stroke driven by belt from a 10-horsepower electric motor; a tank of 15,000 gallons capacity into which the air lift discharges; and an American two-stage centrifugal pump direct connected to a 20-horsepower electric motor, which pumps water from the tank and discharges into the distribution system. An elevated steel tank of 35,000 gallons capacity located in the northern part of the village is connected to the distribution system.

In 1922 about one hundred service connections were in use. Water is sold at a rate of 50 cents a month and meters are not read. Water for use at a mine operated by the coal company is taken from the tank into which the air lift discharges.

Water for the public supply is secured from a well 1750 feet deep, drilled in 1912. It is located near the shaft of the coal mine northeast of the city. The top of the well is about 660 feet above sea level. A record of material penetrated as furnished by the coal company with part of classification given by the State Geological Survey Division is as follows:

	Thickness in feet.	Depth in feet.
Coal measures	580	580
Shale, gray	110	690
Fine grain sandstone, white	40	730
Shale, light gray	35	765
Fine sand, gray	10	775
Shale, light blue to greenish gray	25	800
Sandy shale, gray	25	825
Limestone, mostly Niagaran	245	1070
Shale, Richmond	145	1215
Limestone, Galena-Platteville	395	1610
Sandstone, St. Peter	140	1750
Limestone, Prairie du Chien		

When the well had been drilled to a depth of 1500 feet water stood 102 feet below the ground surface. A test of yield was made with a pump cylinder at a depth of 140 feet. The discharge was at a rate of 150 gallons a minute for 24 hours and 183 gallons a minute for one hour. On account of the unsatisfactory quality of water secured the well was then drilled through the St. Peter sandstone and water from the Galena-Platteville limestone was

cased off. Water from the sandstone raised to 101 feet below the ground surface. The well was pumped for two hours at a rate of 183 gallons a minute. The quality of water secured was about the same as was secured above the St. Peter sandstone and casing was withdrawn from the Galena-Platteville limestone to increase the yield of the well. Sixteen-inch and twelve-inch casings extend from the ground surface to depths of 124 feet and 275 feet respectively; 10-inch and 8-inch casings from 222 feet to depth of 405 feet and 667 feet respectively. A 10-inch casing extends from the ground surface to a depth of about 200 feet and a 6-inch casing, attached to the bottom of this 10-inch casing, extends to a depth of 1104 feet.

The well is equipped with an air lift with 150 feet of 2½-inch and 185 feet of 2-inch discharge pipe and a 1-inch air line connected to the bottom of the discharge line.

A test was run on October 17, 1922. The air compressor operated 320 revolutions a minute at which speed it had a displacement of 85 cubic feet a minute. The pressure at the start was 100 pounds and during operation it was 97 pounds. The amount of water pumped during the first 2½ hours, measured in the tank into which the water is discharged, was 57 gallons a minute. The water level in the well was lowered to 119 feet 4 inches below the top after 4½ hours operation. The air lift was then shut down and in 14 minutes the water level raised to a depth of 112 feet 8 inches, the depth at which it stood before the start of the test when the air had not operated for more than 3 hours.

Analysis of Sample Number 48478 from the Public Supply.

Determinations Made.	Parts per million.
Iron, Fe	0.2
Manganese, Mn	0.0
Silica, SiO_2	9.8
Nonvolatile	0.8
Alumina, Al_2O_3	0.0
Calcium, Ca	52.5
Magnesium, Mg	22.2
Ammonia, NH_4	0.7
Sodium, Na	280.0
Sulfate, SO_4	171.3
Potassium, K	1.1
Nitrate, NO_3	1.8
Chloride, Cl	295.0
Alkalinity Methyl Orange	150.0
Residue	1009.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	2.9	0.17
Potassium Chloride KCl	17.8	1.04
Sodium Chloride NaCl	473.8	27.70
Sodium Sulphate Na_2O_4	253.2	14.78
Sodium Carbonate Na_2CO_3	25.9	1.51
Ammonium Carbonate $(NH_4)_2CO_3$	1.9	0.11
Magnesium Carbonate $MgCO_3$	76.9	4.45
Calcium Carbonate $CaCO_3$	131.0	7.65
Silica SiO_2	9.8	0.57
Nonvolatile	0.8	.05
Iron Oxide Fe_2O_3	0.2	.01
Alumina Al_2O_3	0.6	.04
Total	994.8	58.08

The amount of water pumped, computed from a record of the number of hours the air lift operated, and using 57 gallons a minute as the discharge, averaged 28,000 gallons during the summer of 1922 and 60,000 gallons a day after the mine started operation in the fall.

The water had a mineral content of 994, a total hardness of 222, and a content of iron of 0.2 parts per million as shown by the analysis of sample number 48478, collected near the station on October 17, 1922.

CERRO GORDO (1003). Cerro Gordo is located in the south western part of Piatt County on the water shed between Sangamon and Kaskaskia Rivers.

A public water supply was installed by the village in 1909. The installation included two wells, one of which had been drilled several years before, deep-well pumps, a gas engine, a distribution system, and a steel tank 12 feet in diameter and 40 feet high of 34,000 gallons capacity on a brick tower 70 feet high. Additional wells have been drilled and equipped and changes have been made in the equipment. The original well has been abandoned. The installation now includes three wells equipped with deep-well pumps which discharge directly into the distribution system to which the elevated tank is connected. Two pumps are driven by electric motors. Electric power is purchased from the Illinois Power and Light Corporation. One pump is driven by an oil engine. Water is sold at a rate of two cents per 100 gallons with a minimum charge of $2.00 every three months, which allows the use of 10,000 gallons of water.

Water is secured from three wells, number 2, 3, and 4. Well number 1, which has been abandoned, was about 150 feet deep. Well number 2 located 8 feet east of number 1 was drilled in 1909. This well was drilled considerably deeper than well number 1 and as no lower water-bearing stratum was found the well casing was pulled back to a depth of about 150 feet. The well is equipped with a Goulds single-acting deep-well pump with 5¾-inch cylinder and 24-inch stroke. The pump was driven by belt from a 25-horse-power oil engine in 1924 and was operated from 18½ to 19 strokes a minute. It has been operated three or four hours at a time, a total of about 10 hours a day. The discharge is said to be irregular after about two hours of pumping. In May, 1924, when the pump in well number three was operating satisfactorily this pump would not deliver water.

Well number three was drilled by Omer Kersey in 1918. It is 32 feet north and west of well number two. The well is 10 inches in diameter. It was drilled to limestone which was struck at a depth of 228 feet. The casing was then pulled back to the same stratum of gravel penetrated by wells number 1 and 2. The gravel at this depth was 8 feet thick. A screen was formed by drilling 3/16-inch holes in an 8-inch pipe. These holes clogged and a screen was formed by drilling ½-inch holes in the lower part of an 8-inch pipe and 7/16-inch holes in the upper part. In 1922 the well was drilled 20 feet deeper and two screens were placed, one at the bottom and one in the stratum encountered at the depth of 151 feet. In 1924 the lower screen was removed and the well is now 151 feet deep. Considerable trouble has been experienced with fine sand and gas and at times the yield is small.

Well number 4 was drilled by G. M. Patton in 1922. It is located a quarter of a mile south of wells 2 and 3 on ground about 18 feet lower. A record of material penetrated is as follows:

	Thickness in feet.	Depth in feet.
Sail and blue clay mixed with gravel.	85	85
Trace of water.	1	86
Second soil.	3	86
Clay, yellow.	9	98
Sand, hardpan.	11	109
Sandy clay and gravel (a strong flow of gas).	3	112
Sand and gravel water bearing.	20	132
Quick sand and clay.	4	136
Clay and gravel, hardpan.	64	200
Clay, shale.	5½	205½

Six inches of water-bearing sand and gravel was encountered at a depth of 182 feet and ten or twelve inches of water bearing sand from which water raised 100 feet was encountered at a depth of 189 feet. The well is cased with 8-inch wrought iron pipe. After drilling to a depth of 205 feet the casing was drawn back to a depth of 172 feet and the well was pumped until it was decided to install a screen. On driving the 8-inch casing loose sand and gravel was apparently found between depths of 180 and 190 feet and a number 40 Cook screen was sealed to the casing with a lead packer at a depth of 176 feet. The well is equipped with a Goulds single-acting deep-well pump with 3¾-inch cylinder and 24-inch stroke. The pump is operated 27 strokes a minute for about 12 hours a day. When tested on January 8, 1924, by measuring the discharge in a pail the yield was about 17 gallons a minute after the pump had operated for 1½ hours. Water from this well contains more gas than does water from the other wells. At one time when an

electric switch was pulled the gas was ignited and windows were blown out. The water level when not pumping was at a depth of 85 feet in 1924.

A sample of water, number 50804, was collected from well number 2, which is 150 feet deep ,on January 8, 1924. The water had a mineral content of 567, a total hardness of 386, and a content of iron of 2.2 parts per million as shown by the analysis.

Analysis of Sample Number 50804 from Well Number 2.

Determinations Made.	Parts per million.
Iron, Fe	2.2
Manganese, Mn	0.0
Silica, SiO_2	24.0
Nonvolatile	2.6
Alumina, Al_2O_3	1.3
Calcium, Ca	84.7
Magnesium, Mg	42.8
Ammonia, NH_4	3.4
Sodium, Na	59.9
Potassium, K	12.3
Sulphate, SO_4	1.2
Nitrate, NO_3	3.4
Chloride, Cl	38.0
Alkalinity Methyl Orange	482.
Residue	643.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate, KNO_3	5.4	0.32
Potassium Chloride, KCl	19.4	1.13
Sodium Chloride, NaCl	47.5	2.77
Sodium Sulphate, Na_2SO_4	1.8	0.11
Sodium Carbonate, Na_2CO_3	93.5	5.46
Ammonium Carbonate $(NH_4)_2\ CO_3$	9.0	0.50
Magnesium Carbonate, $MgCO_3$	148.0	8.65
Calcium Carbonate, $CaCO_3$	211.5	12.36
Iron Oxide, Fe_2O_3	3.1	0.18
Alumina, Al_2O_3	1.3	0.07
Silica, SiO_2	24.0	1.40
Nonvolatile	2.6	0.15
Total	567.1	33.10

A sample of water, number 50805, collected on January 8, 1924, from well number 4, which is 190 feet deep, was more highly mineralized. The mineral content was 738, the total hardness 440, and the content of iron 4.0 parts per million as shown by the analysis.

Analysis of Sample Number 50805 from Well Number 4.

Determinations Made.	Parts per million.
Iron, Fe	4.0
Manganese, Mn	0.0
Silica, SiO_2	28.1
Nonvolatile	1.6
Alumina, Al_2O_3	3.4
Calcium, Ca	91.7
Magnesium, Mg	51.6
Ammonia, NH_4	5.3
Sodium, Na	100.3
Potassium, K	19.6
Sulphate, SO_4	2.8
Nitrate, NO_3	1.6
Chloride, Cl	64.0
Alkalinity Methyl Orange	588.
Residue	787.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate, KNO_3	2.6	0.15
Potassium Chloride, KCl	35.5	2.07
Sodium Chloride, NaCl	77.7	4.54
Sodium Sulphate, Na_2SO_4	4.1	0.24
Sodium Carbonate, Na_2CO_3	157.7	9.21
Ammonium Carbonate, $(NH_4)_2CO_3$	14.3	0.83
Magnesium Carbonate, $MgCO_3$	178.6	10.43
Calcium Carbonate, $CaCO_3$	229.1	13.38
Iron Oxide, Fe_2O_3	5.7	0.33
Alumina, Al_2O_3	3.4	0.20
Silica, SiO_2	28.1	1.64
Nonvolatile	1.6	0.09
Total	738.4	43.11

CHADWICK (582). Chadwick is located in the central part of Carroll County on the drainage area of Rock Creek, a tributary of Rock River. Many private wells formerly in use extend into limestone which is entered at a depth of about 60 feet.

A limited public water supply was installed by the village in 1895 and additions have since been made. The original well, which was 215 feet deep, has been abandoned. The installation now includes a well equipped with a deep-well pump driven by belt from a 20-horsepower electric motor, a distribution system, and an elevated wooden tank of 68,000 gallons capacity supported on a brick tower. The well pump discharges directly into the distribution system and elevated tank. Nearly all residents use water from the public supply.

The public water supply is from a well 8 inches in diameter and 600 feet deep. The elevation at the top is about 805 feet above sea level. Limestone was encountered at a depth of 60 or 70 feet. The well is equipped with a Hill Machine Co. deep-well pump with a 4¾-inch cylinder and 24-inch stroke. The cylinder is placed at a depth of 250 feet. The pump is operated at a speed of 26 strokes a minutes, a displacement of 80 gallons a minute. During two years, to April, 1924, it is estimated that the pump was operated an average of five hours thirty minutes a day and discharged near 26,000 gallons a day. The depth to water when not pumping in 1924 was given as 40 feet.

Analysis of Sample Number 52214 from Village Supply.

Determinations Made.	Parts per million.
Iron, Fe	0.2
Manganese, Mn	0.0
Silica, SiO_2	11.3
Nonvolatile	2.0
Alumina, Al_2O_3	1.5
Calcium, Ca	88.2
Magnesium, Mg	45.0
Ammonia, NH_4	3.6
Sodium, Na	12.1
Potassium, K	1.4
Sulfate, SO_4	2.4
Nitrate, NO_2	2.6
Chloride, Cl	3.0
Alkalinity	
Phenolphthalein	0
Methyl Orange	432.
Residue	428.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate, KNO_3	3.6	0.21
Sodium Nitrate, $NaNO_3$	0.6	0.03
Sodium Chloride, NaCl	5.0	0.29
Sodium Sulfate, Na_2SO_4	3.5	0.20
Sodium Carbonate, Na_2CO_3	20.2	1.18
Ammonium Carbonate, $(NH_4)_2CO_3$	9.6	0.57
Magnesium Carbonate, $MgCO_3$	155.8	9.10
Calcium Carbonate, $CaCO_2$	221.3	12.92
Iron Oxide, Fe_2O_3	0.3	0.02
Alumina. Al_2O_3	1.5	0.09
Silica, SiO_2	11.3	0.66
Nonvolatile	2.0	0.11
Total	434.7	25.37

A sample of water, number 52214, collected from the well on August 20, 1924, after the pump had been operated for thirty min-

utes, had a mineral content of 434, a total hardness of 405, and a content of iron of 0.2 parts per million as shown by the analysis.

Samples collected in the past have been of the same quality. The first one collected, collected in 1906, had a mineral content of 429, a total hardness of 390, and a content of iron of 0.6 parts per million.

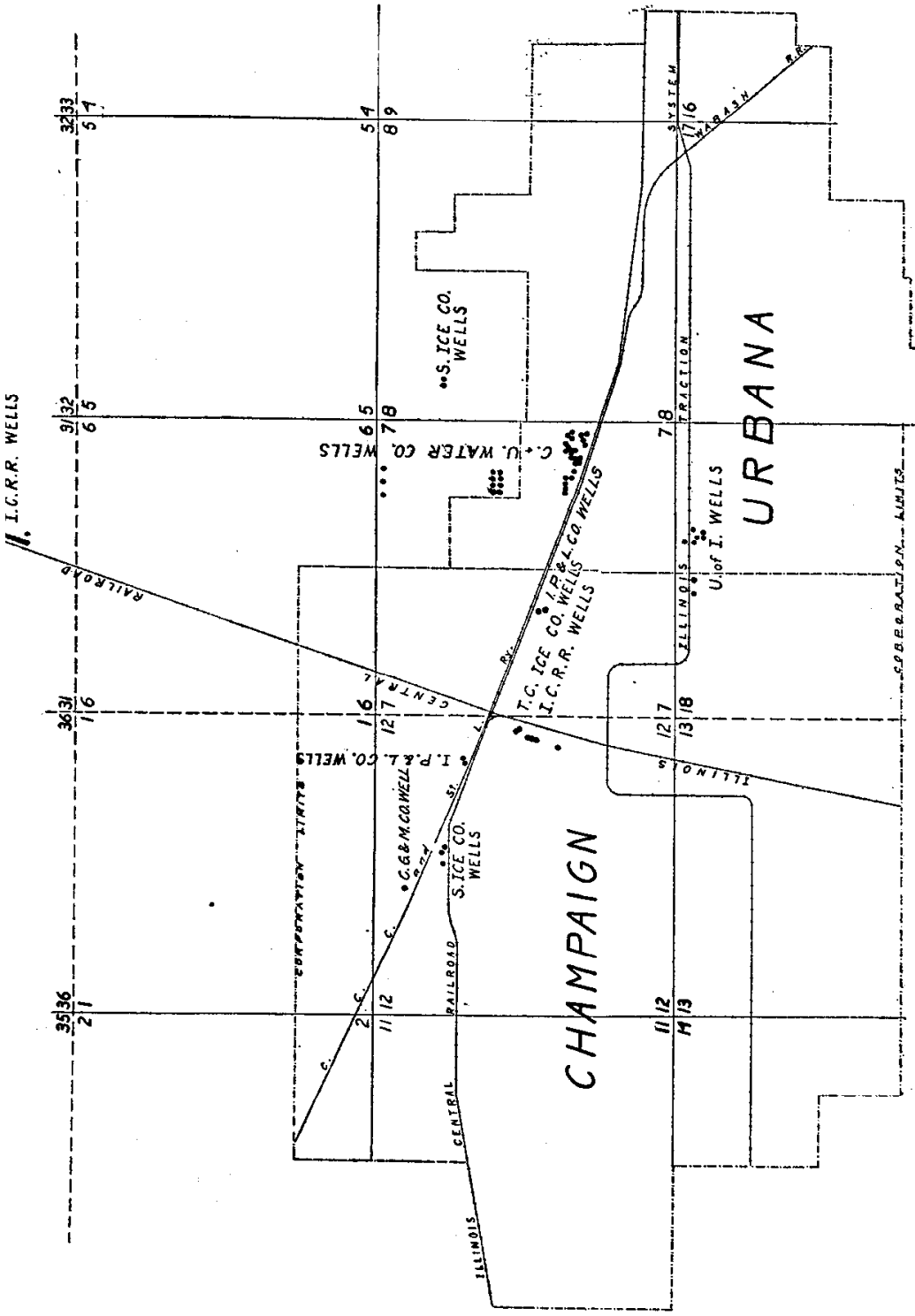
The temperature of the water when discharged from the well was 52 degrees Fahrenheit.

CHAMPAIGN and URBANA (26117). Champaign and Urbana, two adjoining cities, are located in the central part of Champaign County on the drainage area of Vermilion River, a tributary of Wabash River. Several industries using large quantities of water have private water supplies. The Peoria and Eastern Railroad secures a considerable part of their supply from Salt Fork, a tributary of Vermilion River. At their location, in the eastern part of Urbana, little water is available from wells. The Champaign and Urbana Water Company, the University of Illinois, the Illinois Central Railroad, ice plants, and a few other industrial plants in the cities secure water from wells into a stratum of sand and gravel which is encountered at a depth of 140 feet or more. The location of wells furnishing large quantities of water is shown on the plat on the following page. The greatest depth to the bottom of the gravel at any of these wells is at the north wells of the water company.

A public water supply was installed by a private company in 1885. The company had dug a shaft prospecting for coal and when an abundant supply of water was encountered it was used to furnish a public water supply. The water works passed into the hands of the Champaign and Urbana Water Company in 1899. The original well has been abandoned and many wells have been drilled. Each well in use is equipped with a deep-well pump. With increasing demands requiring additional wells and placing of wells at greater distances from the pumping station motor driven pumps were installed on the more distant wells and at the present time all well pumps are driven by electric motors.

A filter plant to remove iron from the water was installed in 1913. Water from the wells is pumped into a collecting reservoir of 250,000 gallons capacity, from which it is pumped to the filters by single-stage centrifugal pumps driven by electric motors.

Seven filters, each 12 by 18 feet in plan have been built. The filtering material is coarse sand from Wabash River. Water is difs-



LOCATION OF DEEP WELLS INTO GRAVEL IN CHAMPAIGN, URBANA AND VICINITY

charged into each filter through a vertical orifice and is practically saturated with oxygen. The rate of flow is determined by means of the orifice. With increasing low pressure in the filters the water level rises and maintains a rate of filtration practically uniform. Filtered water flows to two filtered water reservoirs which have a total capacity of 1,050,000 gallons.

Water used to wash the filters is treated with alum and flows to a settling reservoir from which, after settling, the clearer water is pumped back to the collecting reservoir and the sludge, which settles to the bottom, flows to a sewer.

Seven pumps are available to pump water from the clear water reservoir into the mains. One or more of four DeLaval single-stage centrifugal pumps are generally used. Two of these pumps are of 3,000,000 gallons daily capacity. Each is driven directly by a 100-horsepower electric motor or a 145-horsepower gas engine. The gas engines are for use in emergency. The other two De Laval pumps are each of 1,500,000 gallons daily capacity and each is driven by a 50-horsepower electric motor. Other pumps available for use at times of fires or emergency are an Aurora two-stage centrifugal of 3,000,000 gallons daily capacity driven by a 180-horsepower gas engine, an American single-stage centrifugal of 1,500,000 gallons daily capacity driven by a 100-horsepower electric motor, and a 15 and 24 by 10¼ by 18-inch Laidlaw Dunn Gordon cross-compound crank and fly wheel steam pump of 2,500,000 gallons daily capacity.

Power is purchased from the Illinois Power and Light Corporation. Steam boilers, the steam pump, a steam engine, and a dynamo are maintained at the pumping station for use in emergency.

Eight thousand and sixty-eight consumers were supplied with water on January 1, 1925. Meter rates are $.33 per 1000 gallons for the first 500 gallons per day, 26.4 cents per 1000 gallons for the next 500 gallons per day, 19.8 cents per 1000 gallons for the next 500 gallons per day, 13.2 cents per 1000 gallons for the next 500 gallons per day, 10.56 cents per 1000 gallons for the next 500 gallons per day, and 7.92 cents per 1000 gallons for all over 2500 gallons per day. Ten per cent is added if bills are not paid within ten days. The minimum charge is $1.65 every three months.

Water for the public supply is secured from wells from 150 to 216 feet deep into sand and gravel. The distribution system of the company and that of the University of Illinois are connected and either can furnish the other with water. The University secures water from the same stratum of sand. The company wells are located in the northwestern part of Urbana and to the north. Thirty-five wells were in use in 1925. Nearly all wells are equipped with Cook screens. The tendency during the past few years has been to use coarser screens of shorter length in the coarsest part of the sand stratum.

The older wells, the wells farthest south, shown near the railroads on the map, are close to the pumping station. Nearly all of

these are 8-inch wells. One or two yield as little as 40 gallons a minute and the greatest yield, from the well farthest west, was 192 gallons a minute when last measured.

The water level has been lowered with long continued pumping at increasing rates. Charles David Beebe and William Daniel States in a thesis prepared in 1897 state that seven wells were in use, the yield of a well was from 100,000 to 150,000 gallons a day, and, "The height the water is lifted by the deep-well pumps varies from 40 to 140 feet depending on the amount of water pumped." The top of the reservoir into which water was discharged was about 10 feet above the tops of the wells. The wells were all located in the pumping station. Three wells they tested yielded 58, 117, and 140 gallons a minute. In 1903 the depth to water, measured in a well when the pump in that well was not operating, was 70 feet. In May, 1925, the depth to water in an abandoned well in the filter plant, measured from the floor level, was 143 feet.

The largest yields are from the three north wells located about two-thirds of a mile north of the pumping station. These wells are numbered 35, 36, and 37. Sand is entered at a depth of about 140 feet and the bottoms of the wells are in sand. Each well is equipped with a number 60 Cook screen from 9 to 10 feet long. The yields can be measured by discharging water through vertical jets. Well number 35 is 18 inches in diameter and 204 feet deep. When it was drilled in 1922 the depth to water was 106 feet. The discharge when the pump is over-hauled is 460 gallons a minute. With wear of pump leathers the discharge gradually decreases. Well number 36 is located 125 feet east of well number 35. It is 12 inches in diameter and 201 feet deep. The yield when equipment is over-hauled is 180 gallons a minute. Well number 37 is located 112 feet east of well number 36. It is 14 inches in diameter and 209 feet deep. When equipment is over-hauled the yield is 375 gallons a minute. The water level in well number 36 when last measured, when pumps in wells number 35 and 37 were operating, was 119 feet. If the three pumps were idle for a short time it is estimated that the water level would be four or five feet higher. The ground surface at these three wells is five or ten feet above the ground surface at the wells near the pumping station.

All wells are operated almost continuously. In the year 1924 the amount of water pumped was 923,795,000 gallons. In April, 1925, it varied from 2,400,000 to 3,100,000 gallons a day.

The water before filtering had a mineral content of 396, a total

hardness of 296, and a content of iron of 1.2 parts per million as shown by the analysis of sample number 51728, collected on June 28, 1924.

Analysis of Sample Number 51728 from the Public Supply Before Filtering.

Determinations Made.	Parts per million.
Iron, Fe	1.2
Manganese, Mn	0.0
Silica, SiO_2	14.1
Nonvolatile	1.8
Alumina, Al_2O_3	0.0
Calcium, Ca	66.9
Magnesium, Mg.	31.4
Ammonia, NH_4	5.3
Sodium, Na	34.8
Potassium, K.	4.1
Sulfate, SO_4	1.2
Nitrate, NO_3	1.4
Chloride, Cl	4.0
Alkalinity	
Phenolphthalein	0.
Methyl Orange.	376.
Residue	380.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate, KNO_3	2.3	.13
Potassium Chloride, KCl.	6.1	.36
Sodium Chloride, NaCl.	1.8	.11
Sodium Sulfate, Na_2SO_4	1.7	.10
Sodium Carbonate, Na_2CO_3	77.3	4.52
Ammonium Carbonate, $(NH_4)_2CO_3$	14.3	.83
Magnesium Carbonate, $MgCO_3$.	108.7	6.34
Calcium Carbonate, $CaCO_3$	167.0	9.75
Iron Oxide, Fe_2O_3	1.7	.10
Silica, SiO_2	14.1	.82
Nonvolatile	1.8	.11
Total	396.8	23.17

The iron content of many samples analyzed has been near two parts per million.

CHATSWORTH (1087). Chatsworth is located in the southeastern part of Livingston County on the drainage area of Vermilion River, a tributary of Illinois River. Mr. Taylor of Chatsworth, well driller, states that considerable water may be secured at a depth of 212 feet. Many wells in the vicinity secure water as a less depth in strata of limited extent. In the limits of the town an upper water bearing stratum is generally encountered at a depth of from 135 to 140 feet.

A public water supply was installed by the town in 1909. The installation included a well, a deep-well pump, a concrete reservoir 29 feet in diameter into which water from the well is discharged, an 8 by 10-inch National triplex pump which pumps from the reservoir, a distribution system, a steel pressure tank 9 feet in diameter and 36 feet long, a small air compressor, and two 25-horsepower gas engines. The pumps and compressor were belted to a shaft which was turned by belt from either engine. Another steel tank similar to the one first installed has been added. In 1920 the deep-well pump was replaced by an air lift. Air is supplied by an Ingersoll-Rand 8 by 8-inch, class E R I compressor which is driven by one of the two gas engines.

One hundred and ninety-six consumers were supplied with water in 1922 and the total consumption was estimated at from 20,000 to 30,000 gallons a day. Meter rates per 100 gallons were 5 cents for from 25 to 100 gallons a day, 3 cents for 100 to 400 gallons a day, and 2 cents for over 400 gallons a day. The minimum charge was $5.00 a year.

Water is secured from a well located near the center of the town, drilled in 1909. From interpretation of information available the State Geological Survey Division gives the following log of the well.

	Estimated Thickness in feet.	
	Minimum	Maximum
Drift, boulder clay, etc.	200	270
Shale, Pennsylvania system.	0	21
Limestone, Silurian system.	348	355
Shale and limestone, Richmond.	127	205
Limestone, Galena-Platteville	390	500
Sandstone, St. Peter.	61	?
Total depth of well.	1,285	

Before installing the air lift some measurements of the well were made. A proposal from the Harris Air pump Company was for a number 8 Harris standard air lift pump for well 12 inches at the top and 8 inches in diameter below a depth of 500 feet. The well is said to be 6 inches in diameter at the bottom. On May 25, 1922, during a test, the air lift was operated for 47 minutes. This was about the usual length of time of continuous operation in daily service. The yield, computed from operating data and measurements of water level in the reservoir, was 120 gallons a minute. The air pressure as shown by gauge was 100 pounds at the start and 63 pounds during operation. The pump is thought to operate about 4 hours a day. In 1920 before installing the air lift the old pump was removed and a very small quantity of water was pumped with a small size pump. The depth to water then, when not pumping, was 65 feet.

The water had a mineral content of 597, a total hardness of 337, and a content of iron of 0.7 parts per million as shown by the analysis of sample number 43076, collected on May 19, 1920.

At the time this sample was collected the rate of pumping was low, the regular pump being out of service. The sample, however, did not differ greatly from other samples collected. A sample collected in 1908 had a mineral content of 701 and a total hardness of 335. The greater mineral content of this sample was principally sodium and sulphates (131 and 148 parts respectively).

Analysis of Sample Number 43076 From the Town Supply.

Determinations Made.	Parts per million.
Iron, Fe	0.7
Manganese, Mn	trace
Silica, SiO_2	14.7
Alumina, Al_2O_3	4.0
Nonvolatile	2.8
Calcium, Ca	77.1
Magnesium, Mg	35.3
Ammonia, NH_4	10.8
Potassium K, Sodium Na	92.9
Nitrate, NO_3	2.5
Nitrite, NO_2	0.1
Sulfate, SO_4	43.1
Chloride, Cl	3.0
Alkalinity Methyl Orange	498.
Residue	621.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Sodium Nitrate, $NaNO_3$	3.4	0.20
Sodium Chloride, NaCl	4.9	0.29
Sodium Sulfate, Na_2SO_4	63.8	3.72
Sodium Carbonate, Na_2CO_3	159.7	9.35
Ammonium Carbonate, $(NH_4)_2CO_3$	28.8	1.68
Magnesium Carbonate, $MgCO_3$	122.0	7.14
Calcium Carbonate, $CaCO_3$	192.6	11.26
Iron Oxide, Fe_2O_3	1.0	0.06
Alumina, Al_2O_3	4.0	0.23
Silica SiO_2	14.7	0.86
Nonvolatile	2.8	0.16
Total	597.8	34.95

Water may gain entrance to this well from a gravel stratum at a depth of 212 feet accounting for a lower mineral content in this water than in water from other deep wells in this part of the state and also accounting for excessive wear on pumps.

CHEBANSE (541). Chebanse is located in Iroquois and Kankakee Counties on the drainage area of Iroquois River, a tributary of Kankakee River. A public water supply was installed by a private company about 1874. Water was pumped from a well by a pump driven by a windmill. Later a gas engine was used and this was replaced by another windmill. The plant was abandoned after being in service for probably 25 years. Water is obtained from private wells from 80 to 125 feet deep which enter rock a few feet.

CHENOA (1311). Chenoa is located in the northeastern part of McLean County on the drainage area of Vermilion River, a tributary of Illinois River. Wells from 40 to 50 feet deep in drift are in use at some residences. Wells 185 feet deep are in use at a canning plant located in the northern part of the city and are used in emergency to furnish water to the city. Wells from 135 feet to 185 feet deep are in use at some residences.

A public water supply was installed by the city in 1895. Water was for a time secured from a well 180 feet deep. An abandoned coal mine was then used as a source of supply until 1897 when it caved in and another well was drilled. From about 1900 to 1911 water was supplied by the canning company and in 1911 the well

now in use was drilled. The well is equipped with an air lift. Water is discharged into a collecting reservoir 30 feet in diameter and 20 feet deep and is pumped from the reservoir into the distribution system by a Goulds 8 by 8-inch single-acting triplex pump which is driven by a 7½-horsepower electric motor. A steel tank 12 feet in diameter and 60 feet high of 50,000 gallons capacity; on a brick tower 70 feet high located near the center of the city, is connected to the distribution system. Air is supplied by an Ingersoll-Rand 7 by 6-inch compressor which is driven by belt from a 15-horsepower electric motor. Electric current is supplied by the Illinois Power and Light Corporation.

One hundred and ninety service connections were in use in 1924. The meter rate is 30 cents per 1000 gallons with a minimum charge of $1.50 every three months.

The public water supply is obtained from a well drilled by the J. P. Miller Artesian Well Company in 1911, located in the northwestern part of the city south of Scott Street and east of Fletcher Street. The top of the well is about 720 feet above sea level. A record of material penetrated as given by the drillers with part of the classifications given by the State Geological Survey Division is as follows:

	Thickness in feet.	Depth in feet.
Clay	197	197
Shale	281	478
Limestone, Silurian system		
Sandy limestone, Silurian system		563
Limestone, some shale, Silurian system	255	810
Shale, Richmond	5	815
Caving lime, Richmond	15	830
Limestone some shale, Richmond	145	975
Shale, blue, Richmond	81	1056
Limestone, Galena-Platteville	374	1430
Sandstone, St. Peter	270	1700
Cave, Prairie du Chien	5	1705
Limestone, some shale, Prairie du Chien	195	1900
Sandy shale, Prairie du Chien	32	1932
Sandstone, Prairie du Chien	64	1996
Limestone, Prairie du Chien	39	2035

The well is cased with 12-inch pipe to a depth of 203 feet, with 8-inch pipe from the surface to a depth of 478 feet, with 48 feet of 5-inch pipe with the bottom at a depth of 844 feet, with 100 feet of 5-inch pipe with the bottom at a depth of 1780 feet, with 76 feet of 4¼-inch pipe with the bottom at a depth of 1925 feet, and with 78 feet of 4-inch pipe placed on the 4¼-inch. The well is 4 inches in diameter at the bottom.

Below a depth of 500 feet gas was encountered and at a depth of 540 feet it was noted that the water was black. The water level

was at a depth of 125 feet when the well was 905 feet deep, at 70 feet when it was 1450 feet deep, at 59 feet when it was 1764 feet deep and dropped to 138 feet when a depth of 2013 feet was reached.

The yield when tested at a depth of 1865 feet was 25 gallons a minute and when completed and with a pump at a depth of 280 feet it was 130 gallons a minute. Pumping 130 gallons a minute brought in dirty water.

The well is equipped with air lift with an air line of 1¼ and 1-inch pipe to a depth of 320 feet. The yield of the well on March 25, 1924, measured in the reservoir, was 40 gallons a minute. The air compressor was running 340 revolutions a minute and the air pressure shown by the gauge was 125 pounds at the start and 113 pounds during operation. The total amount of water pumped was estimated at 35,000 gallons a day. The depth to water when not pumping was reported to be 40 feet in 1914,147 feet in 1918, and 155 feet in 1923.

The water had a mineral content of 1271, a total hardness of 240, and a content of iron of 0.0 parts per million as shown by the analysis of sample number 51170, collected at a tap in the pumping station on March 25, 1924.

Analysis of Sample Number 51170 from the City Supply.

Determinations Made.	Parts per million.
Iron, Fe	0.0
Manganese, Mn	0.0
Silica, SiO_2	14.4
Nonvolatile	1.9
Alumina, Al_2O_3	1.1
Calcium, Ca	54.7
Magnesium, Mg	25.4
Ammonia, NH_4	2.6
Sodium, Na	366.3
Potassium, K	36.7
Sulfate, SO_4	71.6
Nitrate, NO_3	3.5
Chloride, Cl	550.0
Alkalinity	
Methyl Orange	304.
Residue	1276.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate, KNO_3	5.8	.34
Potassium Chloride, KCl	65.8	3.84
Sodium Chloride, NaCl	855.3	49.93
Sodium Sulfate, Na_2SO_4	92.3	5.39
Ammonium Sulfate, $(NH_4)_2SO_4$	9.4	.55
Magnesium Sulfate, $MgSO_4$	2.6	.15
Magnesium Carbonate, $MgCO_3$	86.0	5.02
Calcium Carbonate, $CaCO_3$	136.5	7.97
Alumina, Al_2O_3	1.1	.06
Silica, SiO_2	14.4	.84
Nonvolatile	1.9	.11
Total	1271.1	74.20

A sample collected in 1914 was similar. It had a content of iron of 1.1 parts per million and there is sufficient iron to cause stain of plumbing fixtures. The water has an odor of hydrogen sulphide. About fifteen meters are repaired annually.

CHERRY (1265). Cherry is located in the eastern part of Bureau County on the drainage area of Negro Creek, a tributary

of Illinois River. The Chicago, Milwaukee and St. Paul Railroad has a well in the village. It is 8 by 10 feet in plan and extends to sand and gravel above rock at a depth of near 100 feet. The yield of this well is said to be 20 gallons a minute. The company operates a mine in the village. Some water flows into the mine shaft at a depth of 295 feet and considerable water is obtained from white sand at a depth of 500 feet. About 200 gallons of water a minute is pumped from the mine.

A public water supply was installed by the village in about 1911. Water is pumped from a well into an elevated tank of 100,000 gallons capacity by a single-acting deep-well pump driven by an electric motor. The well and tank are located near the business district. The tank is connected to the distribution system. Expenses of operation increased due to leakage resulting from freezing of services to vacant residences, settlement of the ground, and possibly to some settlement at the well, and since 1919 or 1920 no water has been supplied excepting at times of fires. The elevated tank is kept full of water.

The supply of water is secured from a 6-inch well 98 feet deep into sand and gravel which is underlaid by rock. The water level is said to be at a depth of 40 feet when not pumping and the pump cylinder is at a depth of 80 feet. The yield is not known but it is small.

A sample of water was collected from the village well on October 4, 1915, when the supply was in use. The water had a mineral content of 698, a total hardness of 395, and a content of iron of 2.0 parts per million as shown by the analysis of sample number 31776.

Analysis of Sample Number 31776 from the Village Well.

Determinations Made.

	Parts per million.
Iron, Fe	2.0
Manganese, Mn	0.0
Silica, SiO_2	18.0
Nonvolatile	0.6
Alumina, Al_2O_3	0.0
Calcium, Ca	71.4
Magnesium, Mg	52.9
Ammonia, NH_4	2.0
Sodium, Na	124.5
Potassium, K	6.9
Sulfate, SO_4	1.6
Nitrate, NO_3	1.6
Chloride, Cl	2.0
Alkalinity Methyl Orange	636.
Residue	706.

Hypothetical Combinations.

	Parts per million.	Grains per gallon.
Potassium Nitrate, KNO_3	2.6	.15
Potassium Chloride, KCl	4.2	.24
Potassium Sulfate, K_2SO_4	2.9	.17
Potassium Carbonate, K_2CO_3	4.2	.24
Sodium Carbonate, Na_2CO_3	286.5	16.71
Ammonium Carbonate, $(NH_4)_2CO_3$	5.3	.31
Magnesium Carbonate, $MgCO_3$	183.3	10.69
Calcium Carbonate, $CaCO_3$	178.2	10.39
Iron Carbonate, $FeCO_3$	4.0	.23
Alumina, Al_2O_3	0.0	.00
Silica, SiO_2	18.0	1.04
Nonvolatile	0.6	.03
Total	698.8	40.20

CHICAGO HEIGHTS (19,653). Chicago Heights is located in the southern part of Cook County on the drainage area of Calumet River. Wells into Niagara limestone are in use at several industrial plants in the city and the Victor Chemical Company has a well into Cambrian sandstone.

A public water supply was installed by the city in 1894. Wells were drilled in the bottom of pits and water was pumped directly from the wells into the distribution. system by pumps placed in the pits. With increasing demands and the lowering of the water level the original wells were abandoned and additional wells have been drilled close by and equipped with deep-well pumps. These pumps discharge into a line connected to a reservoir of 180,000 gallons capacity and to the suction line of high service pumps in the pits. They may be operated to discharge directly into the distribution system. Water is pumped into the distribution system by either of two pumps, one a Holly of 5,000,000 gallons capacity and the other a DeLaval single-stage centrifugal of 7,000,000 gallons capacity. Each pump is placed in a pit 30 feet deep.

The public water supply is secured from six wells. Four wells, numbers 11, 12, 13, and 14, drilled in 1910, are located in an area 11 feet by 22 feet in the north end of the pumping station at the corner of Fourteenth Street and East End Avenue. The elevation of the pumping station floor is 657 feet above sea level. The wells are 13 inches in diameter at the top and 12 inches in diameter at the bottom and with the exception of a few feet at the surface are in limestone. Large fissures are encountered in the limestone. Well number 15, drilled in 1917, is located about 60 feet southwest of the wells in the station and is 24 inches in diameter. Well number 16, drilled in 1921, is located north and east about 50 feet distant from the nearest of the four wells in the station and is 24 inches in diameter. These six wells are each from 200 to 475 feet deep but practically no water is secured below. a depth of about 200 feet. All six wells are equipped with Layne electrically-driven centrifugal pumps. The average discharge of a pump when discharging into the reservoir is 1000 gallons a minute.

Information in regard to yields and water levels was secured from C. E. Conklin, Superintendent. The yields are computed from pump revolutions and at times there has been considerable slip past the plungers whcih were badly worn so some yields given are probably high. The depth to water is measured in one of the old wells in the north pit in the station, about 20 feet distant from the nearest well in use. The water level a few feet distant from a

well in which a pump is operating is not more than one to two feet lower than it is in the test well from 20 to 80 feet distant, as has been determined by measurements made at times when a pump was out of a well. Considerable changes in rates of pumping lasting a few hours have little effect on the water level. On September 29, 1924, after two pumps had been operating one was shut down and the water level raised 6 inches inside of one minute and then remained constant.

Considerable variation in water level occurs at times when there is little change in the amount of water pumped at the station. Possibly some variation may be accounted for by changes in quantities of water pumped from other wells in the vicinity. Cave-ins into fissures in the rock from which water is withdrawn may account for rapid fluctuations of water levels.

Considerable of the variation in water levels during the years since water works were installed is due to changes in rates of pumping. In 1894 when the works were installed the water level was 22 inches below the pit floor or 32 feet below the pumping station floor from which all other measurements are given. In 1910 the water level was at a depth of 48 feet and in April 1915 when pumping 2,500,000 gallons a day the water level was at a depth of 69 feet. In January, 1918, the water consumption had increased to 5,000,000 gallons a day and the water level was at a depth of 115 feet. In May 1919 when the consumption had decreased to 2,600,000 gallons a day the water level had raised to a depth of 64 feet. During a large part of the year 1920 the water consumption was more than 4,000,000 gallons a day and when, for a short time, it increased to near 6,000,000 gallons a day the water level lowered to a depth of 129 feet. The water consumption again decreased to 3,000,000 gallons a day in the summer of 1921 and the water level raised to a depth of 68 feet. During the latter part of 1922 and in January 1923 the consumption was from 4,500,000 to 5,000,000 gallons a day and the water level lowered to a depth of 138 feet. With temporary relief from a well half a mile distant and with decreasing demands the water level raised. In the fall of 1924 when pumping near 2,800,000 gallons a day the water level was at a depth of 62 feet. At this time, on week days, three well pumps were operated at times and two pumps at other times. On Sundays two well pumps were operated part time and one pump at other times.

The water had a mineral content of 757, a total hardness of 610, and a content of iron of 0.4 parts per million as shown by the analysis of sample number 43,325, collected on June 23, 1920.

Analysis of Sample Number 43325 from the City Wells 200 Feet Deep.

Determinations Made.	Parts per million.
Sodium, Na	29.7
Ammonia, NH_4	0.7
Magnesium, Mg	66.4
Calcium, Ca	135.7
Iron, Fe	0.4
Nitrite, NO_2	0.0
Nitrate, NO_3	1.4
Chloride, Cl	7.0
Sulfate, SO_4	254.8
Alumina, Al_2O_3	1.6
Silica, SiO_2	17.9
Nonvolatile	0.9
Alkalinity Methyl Orange	388.
Residue	818.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Sodium Nitrate, $NaNO_3$	1.9	.11
Sodium Chloride, NaCl	11.5	.67
Sodium Sulfate, Na_2SO_4	76.1	4.45
Ammonium Sulfate, $(NH_4)_2SO_4$	2.8	.17
Magnesium Sulfate, $MgSO_4$	252.5	14.76
Magnesium Carbonate, $MgCO_3$	53.0	3.10
Calcium Carbonate, $CaCO_3$	338.9	19.82
Iron Oxide, Fe_2O_3	0.5	.03
Alumina, Al_2O_3	1.6	.09
Silica, SiO_2	17.9	1.04
Nonvolatile	0.9	.05
Total	757.8	44.29

Samples collected in the past were of similar quality. Sample number 19908, collected in 1909, contained a little less mineral. The mineral content was 645, the total hardness 520, and the content of iron 0.7 parts per million. The water has a strong taste and odor of petroleum or gas waste which is much stronger at some times than at other times and stronger at some wells than at others. This may be due at least in part to bitumen which is contained in the Niagaran limestone in this vicinity.

A well 1832 feet deep into Cambrian sandstone was completed by S. B. Geiger in 1924. It is located half a mile south of the main pumping station on ground about 20 feet above the floor of the main pumping station. Shale was encountered between depths of 451. and 692 feet with a few feet of limestone at a depth of 515 feet and the well was cased to a depth of 695 feet. The upper 205 feet of casing is 22 inches in outside diameter and the lower part of the casing is 18 inches in outside diameter. The bottom of the well is 15 inches in diameter. The depth to water when drilling was 101 feet until sandstone was encountered, when it dropped to a depth of 115 feet.

In 1923 when the well was 1500 feet deep, on account of shortage of water, it was equipped with a Layne pump driven by an electric motor and was in use for a month or more. Water was pumped during a test at a rate of 890 gallons a minute. At the time of visit in February, 1923, the pump was operating 24 hours a day and the yield was estimated at 700 gallons a minute. The attendant measured the depth to water at frequent intervals and the depth was given at 150 feet below the ground surface. After the well

was completed to a depth of 1832 feet it had not been equipped in November, 1924. Data in regard to a well 1796 feet deep at the plant of the Victor Chemical Company gives some information in regard to this city well. The company well was in St. Peter sandstone between depths of 1010 and 1125 feet and entered Cambrian sandstone at a depth of 1480 feet. The well was cased to a depth of 1200 feet with 400 feet of 12-inch pipe and 800 feet of 8-inch pipe. The casing was sealed to the well. The water level before casing was at a depth of near 40 feet and after casing and pumping for a short time it was at a depth, when not pumping, of 124 feet. Pumping at a rate of 120 gallons a minute lowered the water level to a depth of 202 feet and pumping 190 gallons a minute lowered it to a depth of 221 feet. Due to a high chloride content of 120 parts per million the lower 25 feet of the well was filled with concrete. Another analysis then showed a higher chloride content. Measurements then showed a depth to water when not pumping of 146 feet and a discharge of 150 gallons a minute with the air lift equipment which had furnished 190 gallons a minute before the bottom of the well was filled.

The temperature of water from the city well when it was 1500 feet deep and was pumped continuously for several days at a rate near 700 gallons a minute, was 52 degrees Fahrenheit, the same as the temperature of water from the wells 200 feet deep. A sample of water, number 49182, was collected at the well on February 27, 1923, when the pump had been operated for several days.

Analysis of Sample Number 49182 from the City Well When 1500 Feet Deep.

Determinations Made.

	Parts per million.
Iron, Fe	1.6
Manganese, Mn	0.0
Silica, SiO_2	15.0
Nonvolatile	1.2
Alumina, Al_2O_3	.1
Calcium, Ca	112.7
Magnesium, Mg	73.5
Ammonia, NH_4	0.5
Sodium, Na	24.8
Potassium, K	7.9
Sulfate, SO_4	177.2
Nitrate, NO_3	2.3
Chloride, Cl	11.0
Alkalinity Methyl Orange	434.0
Residue	679.

Hypothetical Combinations.

	Parts per million.	Grains per gallon.
Potassium Nitrate, KNO_3	3.7	.22
Potassium Chloride, KCl	12.4	.72
Sodium Chloride, NaCl	8.4	.49
Sodium Sulfate, Na_2SO_4	66.5	3.88
Ammonium Sulfate, $(NH_4)_2SO_4$	1.8	.12
Magnesium Sulfate, $MgSO_4$	164.0	9.58
Magnesium Carbonate, $MgCO_3$	139.4	8.15
Calcium Carbonate, $CaCO_3$	281.3	16.42
Silica, SiO_2	15.0	.88
Nonvolatile	1.2	.07
Iron Oxide, Fe_2O_3	2.3	.13
Alumina, Al_2O_3	1.1	.06
Total	697.1	40.72

This analysis with information in regard to temperature and yields and water levels in this well compared to yields and water

levels in the well of the Victor Chemical Company indidates that a considerable part of the water from this well was from the Niagaran limestone.

CHILLICOTHE and NORTH CHILLICOTHE (2988). The city of Chillicothe and the adjoining village of North Chillicothe are located in the northeastern part of Peoria County on the west bank of Illinois River. In the city and vicinity water may be obtained from sand which is entered a few feet below the ground surface. The Atchison, Topeka and Santa Fe Railway has a private water supply taken from a gravel pit.

A public water supply was installed in 1891 by a private company which sold the property to the Public Service Company of Northern Illinois in 1910. Water was pumped from wells near the bank of Illinois River directly into the mains to which an elevated steel tank of 100,000 gallons capacity was connected. Additional wells have been drilled and two pumps driven by electric motors have been installed, one a 7½ by 8-inch Smith Vaile triplex driven by a 30-horsepower electric motor and the other an 8 by 10-inch Platt triplex driven by a 40-horsepower electric motor. A Smedley tamden compound steam pump is also available for use.

Six hundred and fifty-two service connections were in use in 1921 and the water consumption averaged about 150,000 gallons a day. The rate for three months was 37½ cents per 1000 gallons for the first 18,750 gallons, 30 cents per 1000 gallons for the next 18,750 gallons, and 20 cents per 1000 gallons for all water over 37,500 gallons, with a minimum charge of $7.00 a year.

The original wells were 42 feet deep and were equipped with strainers 8 feet long. Ten wells, each 60 feet deep are now in use. They are in sand and gravel. Six are 6 inches in diameter and the other four are 4 inches in diameter. All are in an area 10 feet wide by 45 feet long. The wells have yielded more than 400,000 gallons a day. The depth to water fluctuates with the water level in the river.

The water had a mineral content of 507, a total hardness of 407, and a content of iron of 0.1 parts per million as shown by the analysis of sample number 46,216, collected on September 30, 1921.

This water is similar in quality to water collected from the original wells though the chloride content has increased. It is probable that the quality of water changes somewhat depending upon water levels or water available and the amount of water pumped.

Analysis of Sample Number 46216 from the Public Supply.

Determinations Made.	Parts per million.
Iron, Fe	0.1
Manganese, Mn	0.0
Silica, SiO_2	11.7
Nonvolatile	0.4
Alumina, Al_2O_3	1.7
Calcium, Ca	88.0
Magnesium, Mg	45.6
Ammonia, NH_4	0.1
Potassium, K	4.0
Sodium, Na	20.0
Sulfate, SO_4	113.1
Nitrate, NO_3	31.9
Chloride, Cl	29.0
Alkalinity	
Methyl Orange	274.
Residue	557.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate, KNO_3	10.1	.61
Sodium Nitrate, $NaNO_3$	34.8	2.04
Sodium Chloride, NaCl	26.7	1.56
Ammonium Chloride, NH_4Cl	0.2	.01
Magnesium Chloride, $MgCl_2$	16.9	.99
Magnesium Sulfate, $MgSO_4$	141.6	8.27
Magnesium Carbonate; $MgCO_3$	43.7	2.55
Calcium Carbonate, $CaCO_3$	219.7	12.84
Silica, SiO_2	11.7	.68
Nonvolatile	0.4	.02
Iron Oxide, Fe_2O_3	0.2	.01
Alumina, Al_2O_3	1.7	.09
Total	507.7	29.70

CHRISMAN (1101). Chrisman is located in the northern part of Edgar County on the drainage area of Bruilletts Creek, a tributary of Wabash River. Many private wells about 20 feet deep are in use. The Chrisman Ice and Fuel Company is reported to have drilled a well to a depth of 200 feet without securing water. Apparently there is little water near an east and west line through the center of the city. The ice company now secures a supply from two leased wells in the northern part of the city near the intersection of Washington Avenue and Illinois Street. One well 107 feet deep extends to rock and is not equipped with a screen.

A public water supply was installed by the city in 1905. Several changes have been made in pumping equipment. Water is now pumped from the well into four reservoirs by air lift. The smallest reservoir is 4 feet square and the largest is 6 feet square. Water is pumped from these reservoirs into the distribution system by a centrifugal pump which is throttled to give the same discharge as the air lift. Air is supplied by an Ingersoll-Rand 10 by 8-inch compressor operating at 240 revolutions a minute. Power is supplied by a 20-horsepower electric motor, and a gas engine is available in case of emergency. The discharge of the centrifugal pump is throttled and a valve on the air line is throttled and the motor is over-loaded.

Water is supplied from a well located on Ohio Street on the north side of Cincinnati, Indianapolis and Western Railroad. The well is generally said to be 132 feet deep, the depth to the bottom of the water-bearing stratum. A record of material penetrated is as follows:

	Thickness in feet.	Depth in feet.
Dirt and clay	18	18
Sand-water	2	20
Clay	66	86
Sand-water	6	92
Clay	28	120
Sand-water	12	132
Limestone	15	147
Shale	3	150

The well is cased with 10-inch pipe. It is equipped with an air lift with a 1¼-inch air line extending to the bottom of the well. The yield on July 30, 1923, was 63 gallons a minute. When the well was drilled it was equipped with a pump of 120 gallons a minute capacity but the maximum yield was 60 to 65 gallons a minute, the same as in 1923. During the summer of 1922 the amount of water pumped, estimated from records of the time the air lift was operated, averaged 40,000 gallons a day for two months. During a considerable part of the year it averages near 20,000 gallons a day.

A well was drilled to a depth of 98 feet at a distance of 15 feet from the well in use but this second well was never equipped.

The water had a mineral content of 666, a total hardness of 300, and a content of iron of 2.6 parts per million as shown by the analysis of sample number 31331, collected August 24, 1915.

Analysis of Sample Number 31331 from the City Supply.

Determinations Made.	Parts per million.
Iron, Fe	2.6
Silica, SiO_2	24.8
Alumina, Al_2O_3	4.3
Calcium, Ca	73.9
Magnesium, Mg	27.9
Ammonia, NH_4	20.6
Sodium, Na	120.0
Potassium, K	2.2
Sulfate, SO_4	2.4
Chloride, Cl	73.0
Nonvolatile	3.8
Alkalinity Methyl Orange	540.
Residue	664.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Chloride, KCl	4.2	.24
Sodium Chloride, NaCl	117.1	6.82
Sodium Sulfate, Na_2SO_4	3.6	.21
Sodium Carbonate, Na_2CO_3	167.3	9.76
Ammonium Carbonate, $(NH_4)_2CO_3$	54.8	3.20
Magnesium Carbonate, $MgCO_3$	96.6	5.62
Calcium Carbonate, $CaCO_3$	184.4	10.75
Iron Carbonate, $FeCO_3$	5.4	.32
Alumina, Al_2O_3	4.3	.25
Silica, SiO_2	24.8	1.45
Nonvolatile	3.8	.22
Total	666.3	38.84

The water contains considerable inflammable gas, carbon dioxide, and hydrogen sulphide. Good samples for analysis for gas cannot be obtained on account of aeration by the air lift. An approximate analysis showed 15 parts of carbon dioxide and 1½ part of hydrogen sulphide. Iron in the water interfered with the operation of a deep-well pump formerly in use and affects the taste of the water, especially near dead ends on the distribution system.

CISSNA PARK (670). Cissna Park is located in the southern part of Iroquois County on the drainage area of Iroquois River.

A public water supply was installed by the village in 1894 using water from a well as the source of supply. Additional wells have been drilled and additional equipment has been added. Water from wells flows into two collecting reservoirs which are connected by pipe line. One reservoir is 28 feet 3 inches in diameter and the other is 15 feet in diameter. From these reservoirs water is pumped into the mains by a Goulds 7 by 8-inch triplex pump driven by belt from a 15-horsepower gas engine. (An electric motor had been installed in 1925.) A wooden tank 20 feet in diameter and 20 feet high on a brick tower 80 feet high is connected to the mains.

Water was supplied to 142 consumers in 1922. The charge is 30 cents per 1000 gallons for the first 100,000 gallons, 20 cents per 1000 gallons for the next 400,000 gallons, and 15 cents per 1000 gallons for all over 500,000 gallons with a minimum charge of $7.50 a year payable in advance.

The public water supply is secured from two flowing wells. The surface of the ground at the wells is about 682 feet above sea level. One well, drilled in 1894, is 5 inches in diameter and 150 feet deep. It passes through a thin stratum of sand at a depth of 42 feet and the bottom is in sand and gravel which is entered at a depth of about 145 feet. The top of this well is in the smaller collecting reservoir.

The other well was drilled in 1921. It is 4 inches in diameter and 239 feet deep. It is cased to the bottom and the lower length of casing has holes drilled in the lower part and the bottom is left open. The well, with casing, cost about $540.00. This well passes through the two water-bearing strata at depths of about 40 and 145 feet and enters a sand and gravel stratum at the bottom from which water is secured. Mr. Whittaker, a well driller, states that the middle vein of sand and gravel is 50 feet thick and that the lower vein, encountered at a depth of from 200 to 225 feet, is probably from 15 to 20 feet thick. A stratum of hardpan from 20 to 40 feet thick is entered at a depth of 80 or 90 feet and a stratum of blue mud and rotten wood overlies the middle vein of sand.

A well drilled in 1906 to a depth of 237 feet furnished part of the supply for a few years. The yield in 1922 was one gallon a minute or less.

On May 11, 1922, when the water level in the reservoirs stood from 1.4 to 0.7 feet below the overflows, the flow from the wells was from 63 to 50 gallons a minute.

The water had a mineral content of 442, a total hardness of 365, and a content of iron of 0.5 parts per million as shown by the analysis of sample number 30633, collected on June 7, 1915.

Analysis of Sample Number 30633 from the Village Supply.

Determinations Made.	Parts per million.
Iron, Fe	0.5
Silica, SiO_2	9.8
Nonvolatile	2.2
Manganese, Mn	0.0
Alumina, Al_2O_3	0.7
Calcium, Ca	85.9
Magnesium, Mg	36.6
Ammonia, NH_4	2.8
Sodium, Na	23.8
Potassium, K	6.8
Nitrite, NO_2	0.1
Nitrate, NO_3	1.1
Sulfate, SO_4	32.2
Chloride, Cl	4.0
Alkalinity Methyl Orange	400.
Residue	427.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrite, KNO_2	0.2	.01
Potassium Nitrate, KNO_3	1.8	.10
Potassium Chloride, KCl	8.4	.49
Potassium Sulfate, K_2SO_4	3.6	.21
Sodium Sulfate, Na_2SO_4	44.7	2.61
Sodium Carbonate, Na_2CO_3	21.4	1.25
Ammonium Carbonate, $(NH_4)_2$ CO3	7.4	.43
Magnesium Carbonate, $MgCO_3$	126.7	7.39
Calcium Carbonate, $CaCO_3$	214.4	12.51
Iron Carbonate, $FeCO_3$	1.0	.06
Alumina, Al_2O_3	0.7	.04
Silica, SiO_2	9.8	.57
Nonvolatile	2.2	.13
Total	442.3	25.80

CLIFTON (638). Clifton is located in the northwestern part of Iroquois County on the drainage area of Iroquois river, a tributary of Kankakee River. In the village and vicinity rock is encountered at a depth of 80 to 100 feet. Many wells in use are from 117 to 120 feet deep.

A public water supply was installed many years ago. Water was secured from a well 117 feet deep. The pumping station was partly destroyed by fire and was later torn down. There has been no public water supply for 25 years or more.

CLINTON (5898). Clinton is located in the central part of DeWitt County on the drainage area of Salt Creek, a tributary of Sangamon River. Several industrial plants in the city using large quantities of water have private supplies from wells into sand and gravel.

A public water supply was installed by the city about 1888. Water was secured from wells about 100 feet deep into sand and gravel near Salt Creek about three miles south of the city. A supply was developed in about 1906 from wells located near the southern limits of the city on land now occupied by the water works. Additional wells have been drilled and the wells installed in 1906 have been abandoned. Water from wells is pumped

by air lift into a concrete collecting reservoir. Air is usually supplied by an air compressor with 14 and 22-inch steam cylinders, 19 and 12-inch air cylinders, and 16-inch stroke, which operates about 100 revolutions a minute. A compressor of smaller size is available. Water is pumped from the reservoir into the mains by either of two pumps, one a Worthington duplex pump used at times of small demands and the other a Worthington cross-compound pump with 11 and 21-inch steam cylinders, 10½-inch water cylinders and 12-inch stroke. Steam is supplied by two 150-horsepower McMasters boilers which were installed in 1911.

The average water consumption was estimated in the spring of 1922 at 450,000 gallons a day. Demands varied greatly depending upon whether water for railroad purposes was taken from the city supply or a private surface water then in use by the Illinois Central Railroad. The rate for 3 months for quantities not exceeding 3000 gallons is 50 cents per 1000 gallons and the lowest rate, for water in excess of 500,000 gallons, is 10 cents a 1000 gallons. The minimum rate is $1.50.

Water is secured from two wells located 180 feet apart near the southern limits of the city (A third well was to be drilled in 1923). The elevation of the tops of the wells is estimated to be 730 feet above sea level. One well, drilled in 1913, is 10 inches in diameter, and the other, to the west, drilled in 1914, is 12 inches in diameter. One was 314 feet deep and the other 327 feet deep when measured about 1922. Records of material penetrated are not available. The Clinton Ice Company gives the following log of their wells.

Material	Depth.			
Yellow clay	2	feet to	8	feet
Blue or gray clay	8	feet to	16	feet
Sandy clay	16	feet to	24	feet
Clay, some sand	24	feet to	55	feet
Drift, (afew inches)	55	feet to		
Brown or gray clay	56	feet to	60	feet
Gray Clay	60	feet to	73	feet
Sand and gravel	73	feet to	74	feet
Gray clay and gravel	74	feet to	95	feet
Sand	95	feet to	97	feet
Gray clay	97	feet to	111	feet
Sand and gravel	111	feet to	116	feet
Hardpan, gray clay, some gravel	116	feet to	167	feet
Drift	167	feet to	167½	feet
Gray clay	167½	feet to	173	feet
Green or blue clay	173	feet to	177	feet
Green clay	177	feet to	182	feet
Brown gray, hardpan	182½	feet to	261	feet
Fine sand (filled casing 45 feet)	261	feet to	273	feet
Very fine, called liver sand (6 to 8 inches)				
Good sand and gravel	273	feet to	317	feet

Material.	Depth.		
Coarse sand and gravel	323	feet to 330	feet
Very fine sand	330	feet to 353	feet
Coarse sand	353	feet to 364	feet
Layers of finer and coarser sand but about the same		374	feet

The city wells are equipped with air lifts with air nozzles placed a few feet above the bottoms of the wells. The 10-inch well has a 6-inch discharge line and the 12-inch well a discharge line of 6-inch and 65/8-inch pipe.

When tested about 1920 one well was said to have yielded 445 gallons a minute and the other 386 gallons a minute. The yield was estimated on May 24, 1923 by computing the amount of water drawn from the reservoir by the service pump and then estimating the amount discharged into the reservoir from the well pumps. During one hour of operation the amount of water discharged from the two wells averaged 750 gallons a minute. In the spring of 1923 the well pumps were operated an average of 10 hours a day, but at times were operated as much as 21 hours a day.

The water had a mineral content of 516, a total hardness of 306, and a content of iron of 0.8 parts per million as shown by the analysis of sample number 49556, collected from the west well on May 25, 1923.

Analysis of Sample Number 49556 from the West City Well.

Determinations Made.	Parts per million.
Iron, Fe	0.8
Manganese, Mn	0.0
Silica, SiO_2	14.2
Nonvolatile	1.2
Alumina, Al_2O_3	3.9
Calcium, Ca	70.4
Magnesium, Mg	31.8
Ammonia, NH_4	5.4
Sodium, Na	76.5
Potassium, K	6.2
Sulfate, SO_4	0.5
Nitrate, NO_3	1.1
Chloride, Cl	54.0
Alkalinity Methyl Orange	436.
Residue	532.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate, KNO_3	1.7	0.10
Potassium Chloride, KCl	10.5	0.61
Sodium Chloride, NaCl	80.8	4.72
Sodium Sulfate, Na_2SO_4	0.7	0.04
Sodium Carbonate, Na_2CO_3	102.5	5.98
Ammonium Carbonate, $(NH_4)_2CO_3$	14.4	0.84
Magnesium Carbonate, $MgCO_3$	110.2	6.43
Calcium Carbonate, $CaCO_3$	175.6	10.25
Iron Oxide, Fe_2O_3	1.1	0.06
Alumina, Al_2O_3	3.9	0.23
Silica, SiO_2	14.2	0.83
Nonvolatile	1.2	0.07
Total	516.8	30.16

A sample of water collected in 1917 was of the same quality.

COAL CITY (1744). Coal City is located in a coal mining district in the eastern part of Crundy County on the drainage area of Mazon River, a tributary of Illinois River. The Elgin, Joliet and

Eastern Railway has a private supply in this village from a well 1360 feet deep.

A public water supply was installed by the village about 1892. Water is pumped from a well by an American single-stage centrifugal pump which is placed in a pit thirty feet deep. The pump is driven by an electric motor with automatic control. A Goulds 8¼ by 10-inch triplex pump is also available. The pumps discharge into the distribution system to which is connected a stand pipe 18 feet in diameter and 60 feet high. A well located eight feet distant from the old well was being drilled for the city in 1925 by C. S. Cummings of Gardner.

Four hundred service connections were in use in 1924. The charge is $.50 a month for residences and $1.20 a month for business houses. The amount of water pumped was formerly recorded by a meter at the pumping station and averaged 96,000 gallons a day during the first eleven months of 1919. In January 1925 the meter was out of order. The amount of water used was probably close to 90,000 gallons a day as the power consumption was the same as when that amount was recorded by the meter.

Analysis of Sample Number 53080 from the Village Supply.

Determinations Made.

	Parts per million.
Iron, Fe	0.4
Manganese, Mn	0.0
Silica, SiO_2	5.5
Nonvolatile	5.1
Alumina, Al_2O_3	2.4
Calcium, Ca	112.0
Magnesium, Mg	51.8
Ammonia, NH_4	3.6
Sodium, Na	297.2
Potassium, K	28.3
Sulfate, SO_4	488.4
Nitrate, NO_3	0.3
Chloride, Cl	247.
Alkalinity	
Phenolphthalein	0.
Methyl Orange	322.
Residue	1414.

Hypothetical Combinations.

	Parts per million.	Grains per gallon.
Potassium Nitrate, KNO_3	0.6	.03
Potassium Chloride, KCl	53.5	3.13
Sodium Chloride, NaCl	365.3	21.36
Sodium Sulfate, Na_2SO_4	474.5	27.75
Ammonium Sulfate, $(NH_4)_2SO_4$	13.2	.78
Magnesium Sulfate, $MgSO_4$	197.9	11.57
Magnesium Carbonate, $MgCO_3$	41.0	2.40
Calcium Carbonate, $CaCO_3$	279.7	16.36
Iron Oxide, Fe_2O_3	0.6	.04
Alumina, Al_2O_3	2.4	.14
Silica, SiO_2	5.5	.32
Nonvolatile	5.1	.30
Total	1439.3	84.18

Water is secured from a well 350 feet deep located near the center of the city. It was drilled by Gray Brothers in 1892. The ground surface at the well is about 565 feet above sea level. The well is cased with 7-inch pipe into limestone which is said to be at a depth of 270 feet. A record of the railroad well on file with the State Geological Survey Division shows limestone entered below shale at a depth of 200 feet. When the well was drilled it flowed. In

1914 the water level when not pumping was 32 feet below the ground surface and in 1919 it was said to have been 33 feet below the ground surface when last measured. In 1925 it was reported that the pump did not draw air after long continued operation.

A sample of the water, number 53080, collected at the fountain close to the pumping station on January 15, 1925, after the pump had operated for several hours, had a mineral content of 1439, a total hardness of 492, and a content of iron of 0.4 parts per million as shown by the analysis.

A sample collected in 1914 had a mineral content of 1191, a total hardness of 422, and a content of iron of 2.8 parts per million.

The water stains plumbing fixtures and laundry fabrics. A hard scale is formed when it is used in boilers.

COLFAX (976). Colfax is located in the northeastern part of McLean County on the drainage area of Mackinaw River, a tributary of Illinois River.

A public water supply was installed by the village in 1910. Water was secured from a well dug to a depth of 28 feet and drilled to a total depth of 54 feet. This well was abandoned two years later when the first of two wells now in use were drilled. Each well is equipped with a deep-well pump which discharges directly into the distribution system. An elevated tank is connected to the system. The pumps are driven from a shaft which is turned by belt from a 15-horsepower electric motor. One hundred and seventy service connections were in use in 1924. Rates for three months are $2.00 for 6000 gallons or less, 25 cents per 1000 gallons for additional water when less than 1000 gallons per day is used, and 15 cents per 1000 gallons when more than 1000 gallons per day is used.

The supply is secured from two wells located in the northern part of the village. One was drilled in 1912 and the other in 1913. The ground surface at the wells is about 750 feet above sea level. One well is 10 inches in diameter and the other is 6 inches in diameter. Both are 103 feet deep and a screen 15 feet long is placed in the bottom of each well. The wells are in sand and gravel below a depth of 83 feet. Clay overlies the sand and in places it may contain considerable sand as “liver sand” was said to have been encountered. The sand stratum is apparently thin in places. At a well drilled at a school, 2 feet of sand and gravel was recorded with the bottom at a depth of 63 feet and 1 foot of sand at a depth of 94 feet. Other material below 10 feet of soil and clay was classed as blue clay to two feet of soapstone. Below the soapstone between depths of 151 and 163 feet was limestone.

The smaller well is equipped with a Goulds deep-well pump of 75 gallons a minute capacity. This well is seldom used. The 10-inch well is equipped with a Deming double-stroke pump with 6¾-inch cylinder and 24-inch stroke. The cylinder is attached to 70 feet of drop pipe. The pump is operated 25 revolutions a minute and in 1923 it operated an average of about 5 hours a day. The average amount of water pumped in 1923 is estimated at from 40,000 to 50,000 gallons a day. The depth to water when not pumping was given as 10 feet in 1917 and 20 feet in 1924.

The water had a mineral content of 749, a total hardness of 323, and a content of iron of 2.7 parts per million as shown by the analysis of sample number 39699, collected on July 6, 1918.

Analysis of Sample Number 39699 from the Village Supply.

Determinations Made.	Parts per million.
Iron, Fe.	2.7
Manganese, Mn.	0.0
Silica, SiO_2	21.0
Nonvolatile	1.5
Alumina, Al_2O_3	1.6
Calcium, Ca.	70.7
Magnesium, Mg	35.6
Ammonia, NH_4	20.1
Sodium, Na.	153.7
Sulfate, SO_4	0.4
Nitrate, NO_3	0.3
Chloride, Cl.	76.5
Carbon dioxide.	14.0
Hydrogen sulfide.	1.0
Alkalinity Methyl Orange.	577.
Residue	739.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Sodium Nitrate, $NaNO_3$	0.5	.03
Sodium Chloride, NaCl.	126.1	7.35
Sodium Sulfate, Na_2SO_4	0.6	.03
Sodium Carbonate, Na_2CO_3	238.3	13.89
Ammonium Carbonate, $(NH_4)_2CO_3$	54.8	3.19
Magnesium Carbonate, $MgCO_3$	124.5	7.26
Calcium Carbonate, $CaCO_3$	176.6	10.30
Iron Oxide, Fe_2O_3	3.9	.23
Silica, SiO_2	21.0	1.22
Alumina, Al_2O_3	1.6	.09
Nonvolatile	1.5	.09
Total	749.4	43.68

The water stains plumbing fixtures. About ten meters are repaired each year.

Water from the well 54 feet deep which was first used was said to be saturated with combustible gas.

COLLINSVILLE (9753). Collinsville is located in the southern part of Madison County on high land near bottom lands of Mississippi River.

A public water supply was installed by the city in 1892. The original supply was abandoned after a few years use and water is now secured from wells in bottom lands of Mississippi River. Water is pumped directly from the wells into a pipe line to the city. Three pumps are available, one 3-stage centrifugal, one Worthington 8 by 10-inch triplex, and one Worthington 8 by 10-

inch duplex. Each pump is driven by an electric motor. A steel tank of 250,000 gallons capacity on a tower 103 feet high, replacing a standpipe, was connected to the distribution system in 1922.

Fifteen hundred service connections were in use in 1923 and twelve hundred were metered. The meter rate for the first 15,000 gallons used in three months is 50 cents per 1000 gallons and the lowest rate, for all over 1,000,000 gallons a month, is 10 cents per 1000 gallons. The minimum charge is $1.00 a month.

The first well used as a source of supply was drilled in 1892 and a second well, similar to the first, was drilled later at a distance of 60 feet from the first. A record of material penetrated by the wells is as follows:

	Thickness in feet.	Depth in feet.
Upper drift	88½	88½
Shale, dark	74½	163
Limestone	20	183
Slate, dark	12	195
Limestone	18	213
Coal	7	220
Slate, dark	17	237
Limestone	3	240
Slate, brown	20	260
Slate, black	61	321
Slate, yellow	15	336
Slate, red	15	351
Sandstone	1½	352½
Limestone	30	382½
Slate, dark	28½	411
Sandstone	18	429
Slate, red and black	70	499
Limestone	10	509
Sandstone	64	573
Slate, blue	28	601

The wells were equipped with deep-well pumps with the cylinder in number 1 well at a depth of 300 feet and that in number 2 well at a depth of 400 feet. The capacity of the two wells was reported to be 40,000 gallons a day. The water was said to come within from 120 to 165 feet of the ground surface, the 120 feet apparently referring to the depth in 1892 and the 165 feet to the depth in 1898, when information was secured from J. L. R. Wadsworth. Mr. Wadsworth states that water from the first sand rock could not be more objectionable as it was quite corrosive, water from the second sand rock was not so bad, and water from the lower sand rock was heavily saturated with sodium sulfate. The water had a mineral content of 2489, a total hardness of 170, and a content of iron of 2.5 parts per million as shown by the analysis of sample number 4271, collected on October 26, 1898.

Analysis of Sample Number 4271 from City Wells 601 Feet Deep.

Determinations Made.	Parts per million.
Iron, Fe	2.5
Silica, SiO_2	51.4
Alumina, Al_2O_3	8.2
Calcium, Ca	38.8
Magnesium, Mg	17.9
Sodium, Na	830.4
Potassium, K	27.9
Nitrate, NO_3	1.7
Sulfate, SO_4	450.4
Chloride, Cl	865.0
Residue	2608.8

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrite, KNO_2	1 .1	.06
Potassium Nitrate, KNO_3	3 .8	.22
Potassium Chloride, KCl	48.6	2.83
Sodium Chloride, NaCl	1387.3	80.92
Sodium Sulfate, Na_2SO_4	666.3	38.87
Sodium Carbonate, Na_2CO_3	158.2	9.23
Magnesium Carbonate, $MgCO_3$	62.2	3.62
Calcium Carbonate, $CaCO_3$	97.1	5.65
Iron Carbonate, $FeCO_3$	5.1	.30
Alumina, Al_2O_3	8.2	.48
Silica, SiO_2	51.4	3.00
Total	2489.3	145.18

Mr. Wadsworth states that casing was placed to exclude all water encountered above a depth of 499 feet but that water from the upper sandstone may have entered at the time the sample was collected due to deterioration of the casing.

Water is now secured from eight wells located in bottom lands of Mississippi River about one mile west of the western limits of the city. Sand is entered at a depth of 45 feet. Four wells were drilled in 1902 to a depth of from 70 to 90 feet. Later wells were drilled to a depth of 100 feet and as the sand at that depth was coarser the depth of the old wells was increased. One well, drilled in 1919, is 26 inches in diameter and the others are 10 inches in diameter. In 1923 it was reported that the strainers on the 10-inch wells were badly clogged and that practically all water was secured from the 26-inch well. This well, installed by the Well Casing and Strainer Manufacturing Company, is cased with concrete 5 inches thick. The lower 45 feet is porous and acts as a strainer. The suction pipe from the pumps extends in this well to a depth of 40 feet, or 54 feet below the ground surface. The total amount of water pumped is estimated at 1,000,000 gallons a day. The water level when not pumping was 14 feet below the ground surface when measured once in 1923 and 17½ feet below the ground surface at another time in 1923. When pumping 1000 gallons a minute the water level was said to drop to 35 feet below the ground surface.

The water had a mineral content of 422, a total hardness of 380, and a content of iron of 1.0 parts per million, as shown by the analysis of sample number 39786, collected on July 19, 1918.

Analysis of Sample Number 39786 from the City Supply.

Determinations Made.	Parts per million.
Iron, Fe	1.0
Manganese, Mn	0.6
Silica, SiO_2	28.6
Alumina, Al_2O_3	1.0
Calcium, Ca	87.9
Magnesium, Mg	39.6
Sodium, Na	11.9
Sulfate, SO_4	60.2
Nitrate, NO_3	2.7
Chloride, Cl	5.0
Carbon dioxide	6.0
Hydrogen sulphide	0.0
Alkalinity Methyl Orange	317.
Residue	462.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Sodium Nitrate, $NaNO_3$	3.6	.22
Sodium Chloride, NaCl	8.2	.48
Sodium Sulfate, Na_2SO_4	2.3	.14
Magnesium Sulfate, $MgSO_4$	55.5	3.24
Magnesium Carbonate, $MgCO_4$	98.1	5.72
Calcium Carbonate, $CaCO_3$	219.5	12.80
Iron Carbonate, $FeCO_3$	1.6	.09
Manganese Carbonate, $MnCO_3$	1.1	.06
Alumina, Al_2O_3	1.0	.06
Silica, SiO_2	28.6	1.67
Nonvolatile	1.9	.11
Total	421.4	24.59

A standpipe installed in 1893 was removed in 1922. It was badly corroded near the top.

COMPTON (283). Compton is located in the southeastern part of Lee County on the drainage area of Big Bureau Creek, a tributary of Illinois River.

A public water supply has been installed by the village. Water is pumped from two wells directly into the distribution system by deep-well pumps which are driven by belt from a 15-horsepower electric motor. An elevated steel tank of 75,000 gallons capacity, 125 feet high to the top, is connected to the distribution system. Practically all water used in the village is from the public supply and the average consumption was estimated in 1917 at from 15,000 to 18,000 gallons a day. The meter rate is 30 cents per 1000 gallons with a minimum charge of 50 cents a month. Water is pumped by the Northern Utilities Company for 10 cents per 1000 gallons.

Water for the public supply is secured from two wells each 335 feet deep. One is 6 inches in diameter and the other is 3 inches in diameter. Each well is equipped with a deep-well pump with the cylinder placed at a depth of 272 feet. The cylinder in the larger well is attached to a drop pipe and that in the smaller well is wedged in the casing. Water is probably drawn down to the pump cylinders.

The water had a mineral content of 320, a total hardness of 207, and a content of iron of 1.1 parts per million as shown by the analysis of sample number 37764, collected on August 7, 1917.

Analysis of Sample Number 37764 from the Village Supply.

Determinations Made.	Parts per million.
Iron, Fe	1.7
Silica, SiO_2	15.3
Alumina, Al_2O_3	4.3
Calcium, Ca	48.7
Magnesium, Mg	20.9
Sodium, Na	43.5
Potassium, K	2.2
Nitrate, NO_3	1.3
Chloride, Cl	2.0
Alkalinity Methyl Orange	300.
Residue	300.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate, KNO_3	2.1	.12
Potassium Chloride, KCl	2.7	.16
Sodium Chloride, NaCl	1.5	.09
Sodium Sulfate, Na_2SO_4	98.7	5.76
Magnesium Carbonate, $MgCO_3$	72.4	4.21
Calcium Carbonate, $CaCO_3$	121.5	7.09
Iron Oxide, Fe_2O_3	2.4	.14
Alumina, $A1_2O_3$	4.3	.25
Silica, SiO_2	15.3	.89
Total	320.9	18.61

CRESCENT CITY (310). Crescent City is located in the central part of Iroquois County on the drainage area of Iroquois River, a tributary of Kankakee River. Many residents have private wells from 90 to 150 feet deep. Water flows from many of the wells.

A public water supply was installed by the village in 1892. Water was pumped from two wells, each 1¼ inches in diameter, by pumps operated by a windmill. Extensive improvements were made. A 4-inch well was drilled which was used until another well was drilled in 1908. Water flows from the well into a wooden tank 15 feet in diameter and 8 feet deep which is placed in excavation close to the well. Water is pumped from the tank into the distribution system and an elevated steel tank of 50,000 gallons capacity which is connected to the system. Forty-three consumers were supplied with water in 1922 and the charges for the majority of the services was $5.00 a year.

The public water supply is secured from a well 4 inches in diameter and 120 feet deep, located near the center of the village. It was drilled in 1908. No log of the well is available. (B. J. Gibson stated that a well at his residence is in hardpan to a depth of 98 feet below which is a “vein” of 3 inches and underneath is artesian sand which becomes coarser below.) In the spring of 1922 when a pump of about 110 gallons a minute capacity was used to pump water from the tank and was operated 1½ to 2 hours at a time twice a week, water would not flow over the reservoir until 36 hours after the pump was stopped.

The water had a mineral content of 490, a total hardness of 368, and a content of iron of 1.5 parts per million; as shown by the analysis of sample number 30611 ,collected on June 3, 1915.

Analysis of Sample Number 30611 from the Village Supply.

Determinations Made.	Parts per million.
Iron, Fe	1.5
Manganese, Mn	0.0
Silica, SiO_2	15.8
Nonvolatile	1.6
Alumina, Al_2O_3	2.7
Calcium, Ca	90.4
Magnesium, Mg	34.6
Ammonia, NH_4	2.4
Sodium, Na	24.5
Potassium, K	11.4
Sulfate, SO_4	97.8
Nitrate, NO_3	2.8
Chloride, Cl	5.0
Alkalinity Methyl Orange	340.
Residue	479.

Hypothetical Combinations..	Parts per million.	Grains per gallon.
Potassium Nitrate, KNO_3	4.5	.26
Potassium Chloride, KCl	10.5	.61
Potassium Sulfate, K_2SO_4	9.3	.54
Sodium Sulfate, Na_2SO_4	75.5	4.40
Ammonium Sulfate, $(NH_4)_2SO_4$	8.7	.51
Magnesium Sulfate, $MgSO_4$	44.3	2.58
Magnesium Carbonate, $MgCO_3$	89.0	5.19
Calcium Carbonate, $CaCO_3$	225.6	13.16
Manganese Carbonate, $MnCO_3$	0.1	.01
Iron Carbonate, $FeCO_3$	3.1	.18
Alumina, Al_2O_3	2.7	.16
Silica, SiO_2	15.8	.92
Nonvolatile	1.6	.09
Total	490.7	28.61

CRESTON (327). Creston is located in the southeastern part of Ogle County on the drainage area of Rock River. Private wells are generally from 20 to 100 feet deep but very few are now in use.

A public water supply was installed by the village in 1906. Water is pumped from a well directly into the mains and a steel pressure tank 9 feet in diameter and 36 feet long located in the pumping station and connected to the mains. The village light plant is combined with the pumping station. Power is furnished by two semi-Diesel engines of 25-horsepower each.

Sixty service connections were in use in 1919, of which few were metered. The meter rate was $.75 per 1000 gallons with a minimum charge of $.75 a month.

The public water supply is secured from a well 585 feet deep located near the center of the business district. The well is cased to a depth of 180 feet with 8-inch pipe, between depths of 150 and 403 feet with 6-inch pipe, and between depths of 339 and 417 feet with 4½-inch pipe. The diameter at the bottom is 4 inches. The drift encountered was mostly clay with occasional veins of sand containing some water. It was stated by village officials that rock was encountered at a depth of 416 feet. (A well 256 feet deep in the village is said to be in rock below a depth of 250 feet). Village officials thought the supply was from St. Peter sandstone entered at a depth of 465 feet. The well is equipped with a single-acting deep-well pump with 4¼-inch cylinder attached to a drop pipe and placed at a depth of 300 feet. The well was tested at the time of installation by pumping for 22 hours at a rate of 130 gallons a

minute and the water level was not drawn down to the cylinder. The pump was operated in 1919 with 24-inch stroke at a rate of 25 revolutions a minute for about 3 hours a day. This is a displacement rate of 36 gallons a minute and a total of about 6000 gallons a day. The water level when not pumping was 140 feet below the ground surface.

The water had a mineral content of 294, a total hardness of 217, and a content of iron of 1.8 parts per million, as shown by the analysis of sample number 41156, collected on June 5, 1919, at the pumping station.

Analysis of Sample Number 41156 from the Village Supply.

Determinations Made.	Parts per million.	Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium, K } Sodium, Na }	30.42	Sodium Nitrate, $NaNO_2$	3.42	.20
Ammonium, NH_4	0.82	Sodium Chloride, NaCl	6.43	.38
Magnesium, Mg	27.23	Sodium Carbonate, Na_2CO_3	62.01	3.63
Calcium, Ca	42.18	Ammonium Carbonate, $(NH_4)_2CO_3$	2.40	.14
Iron oxide, Fe_2O_3	2.57	Magnesium Carbonate, $MgCO_3$	94.44	5.52
Alumina, Al_2O_3	1.58	Calcium Carbonate, $CaCO_3$	105.00	6.14
Nitrate, NO_3	2.48	Iron Carbonate, $FeCO_3$	3.49	.23
Chloride, Cl	4.00	Alumina, Al_2O_3	1.58	.08
Sulfate, SO_4	Trace	Silica, SiO_2	14.80	.86
Silica, SiO_2	14.80	Nonvolatile	1.15	.07
Nonvolatile	1.15	Sulfates	trace	
Alkalinity Methyl Orange	288.	Total	294.72	17.25
Residue	292.			

Water from the public supply is used in boilers at a creamery where 70 pounds pressure is carried and no trouble is had with scale.

CRETE (945). Crete is located in the eastern part of Will County on the drainage area of Little Calumet River. Many private wells are in use. The Chicago and Eastern Illinois Railway has two wells, one a shallow dug well near the bank of a small stream and the other a drilled well into limestone, 220 feet deep. A softening plant has been installed but was not in use in 1921.

A public water supply was installed by the village in 1903. No important changes other than extensions to the system were made until 1924. A well 264 feet deep was drilled for the village in 1924 by the W. L. Thorne Company of Des Plaines. The well was cased with 12-inch pipe to a depth of 99 feet and with 10-inch pipe in shale between depths of 166 and 215 feet. It was drilled 12 inches in diameter to a depth of 215 feet and 10 inches in di-

ameter below that depth. The bottom is in, limestone. The well was tested by pumping 300 gallons a minute and water stood at a depth of 60 feet during the test.

The following data were secured before the well described above was drilled.

Water is pumped from a well directly into the distribution system to which an elevated steel tank of 60,000 gallons capacity is connected. The pump is driven by a 15-horsepower electric motor. Power is purchased from the Public Service Company of Northern Illinois. Seventy service connections were in use in 1924. The rate for water is 30 cents per 1000 gallons.

The public water supply is from a well located near the center of the village. The elevation at the top is about 695 feet above sea level. The well is 10 inches in diameter and 192 feet deep. Limestone is encountered at a depth of about 100 feet and the well is cased to a depth of about 150 feet. In 1915 the depth to water when not pumping was said to be 30 feet. The well was equipped with a deep-well pump with the cylinder placed at a depth of 80 feet. The capacity of the pump at the speed operated was said to be near 90 gallons a minute. In the summer of 1921 when water was used for the construction of a concrete pavement a tank full of water (60,000 gallons?) was used daily and some trouble was had with the pump, which may indicate that water was drawn down to the pump cylinder.

In 1924 a Goulds double-acting deep-well pump with 6¾-inch cylinder and 24-inch stroke was installed. The cylinder was placed at a depth of about 100 feet.

Analysis of Sample Number 30855 from Village Well 192 Feet Deep.

Determinations Made.	Parts per million.
Iron, Fe	0.9
Silica, SiO_2	11.6
Nonvolatile	0.8
Alumina, Al_2O_3	1.3
Calcium, Ca	102.6
Magnesium, Mg	35.1
Ammonia, NH_4	0.4
Sodium, Na	10.1
Potassium, K	4.2
Sulfate, SO_4	21.6
Nitrite, NO_2	0.0
Nitrate, NO_3	0.7
Chloride, Cl	2.0
Alkalinity Methyl Orange	414.
Residue	432.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate, KNO_3	1.1	.06
Potassium Chloride, KCl	4.2	.24
Potassium Sulfate, K_2SO_4	3.6	.21
Sodium Sulfate, Na_2SO_4	29.0	1.69
Sodium Carbonate, Na_2CO_3	1.6	.09
Ammonium Carbonate, $(NH_4)_2CO_3$	1.1	.06
Magnesium Carbonate, $MgCO_3$	121.6	7.09
Calcium Carbonate, $CaCO_3$	256.1	14.94
Iron Carbonate, $FeCO_3$	1.9	.11
Alumina, Al_2O_3	1.3	.08
Silica, SiO_2	11.6	.68
Nonvolatile	0.8	.05
Total	433.9	25.30

The water had a mineral content of 433, a total hardness of 400, and a content of iron of 0.9 parts per million as shown by the analysis of sample number 30855, collected on June 29, 1915.

CRYSTAL LAKE (2249). Crystal Lake is located in the southeastern part of McHenry County on the drainage area of Fox River, a tributary of Illinois River. A few private shallow dug wells into sand and gravel are in use. The only private supply furnishing a large quantity of water is that of the Bowman Dairy Company which has three wells, each 60 feet or more deep. The villages of North Crystal Lake and Crystal Lake were consolidated as the city of Crystal Lake in 1914.

The village of North Crystal Lake installed a public water supply in 1898 and the village of Crystal Lake installed a supply in 1913. Both pumping stations are maintained by the city. At either station water is pumped from a well directly into the distribution system. A wooden tank 20 feet in diameter and 24 feet high on a brick tower 75 feet high, located on the same lot as the well formerly used by North Crystal Lake, is connected to the distribution system. An elevated steel tank of 50,000 gallons capacity installed by the village of Crystal Lake is also connected to the system. Power is purchased from the Public Service Company of Northern Illinois.

About 500 service connections were in use in 1922 and the consumption was estimated at 60,000 gallons a day. The rate for water for three months is $2.00 for the first 5000 gallons, 30 cents per 1000 gallons for the next 20,000 gallons, 24 cents per 1000 gallons for the next 50,000 gallons, and 18 cents per 1000 gallons for quantities in excess of 75,000 gallons.

The public water supply is secured from two wells located 1¼ miles apart, one a drilled well in the northeastern part of the city formerly used by the Village of North Crystal Lake and the other a dug well in the southwestern part of the village formerly used by the Village of Crystal Lake.

A considerable part of the supply is from the dug well. This was installed in 1913 and is located in the city park near Virginia and King Streets. This well is 8 feet in diameter and 32 feet deep from the ground surface. The bottom is in sand and gravel. The well is cased with concrete blocks and the top is in the basement of the city hall, 15 feet below the ground surface. Water from this basement or pit drains into the sand and gravel through a sump dug in one corner of the pit. Two pumps are available to draw

water from the well. The one used when sufficient water is available is a Deming 6 by 8-inch triplex pump. It is driven by a 15-horsepower motor and operates at a speed of 67 revolutions a minutes. On November 13, 1922, when the pump was operating at a speed of 76 revolutions a minute and, when the water level was drawn down to a depth of 12½ feet below the bottom of the pit, the inflow was at a rate of 200 gallons a minute. In dry weather the inflow is much less and at such times the centrifugal pump is operated as the capacity is less and by operating at a lower rate and holding the water level at a low elevation a greater quantity of water can be secured. The average daily yield was estimated in 1922 at 60,000 gallons a day.

Water from this well had a mineral content of 449, a total hardness of 395, and a content of iron of 0.6 parts per million as shown by the analysis of sample number 48648, collected on November 13, 1922.

Analysis of Sample Number 48648 from City Well 32 Feet Deep.

Determinations Made.	Parts per million.
Iron, Fe	0.6
Manganese, Mn	0.0
Silica, SiO_2	20.0
Nonvolatile	1.5
Alumina, Al_2O_3	1.5
Calcium, Ca	89.6
Magnesium, Mg	41.9
Ammonia, NH_4	0.1
Sodium, Na	9.9
Potassium, K	1.9
Sulfate, SO_4	66.0
Nitrate, NO_3	4.3
Chloride, Cl	11.0
Alkalinity Methyl Orange	320.
Residue	452.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate, KNO_3	6.9	.04
Potassium Chloride, KCl	1.0	.06
Sodium Chloride, NaCl	17.3	1.01
Sodium Sulfate, Na_2SO_4	9.2	.54
Ammonium Sulfate, $(NH_4)_2SO_4$	0.2	.01
Magnesium Sulfate, $MgSO_4$	74.7	4.36
Magnesium Carbonate, $MgCO_3$	92.7	5.41
Calcium Carbonate, $CaCO_3$	223.7	13.07
Iron Oxide, Fe_2O_3	0.9	.05
Alumina, Al_2O_3	1.5	.09
Silica, SiO_2	20.0	1.17
Nonvolatile	1.5	.09
Total	449.6	25.90

The northeast well is located on the south side of Beardsley Street east of Main Street. It is 280 feet in depth and is cased with 10-inch pipe to limestone at 260 feet. The well is equipped with a Keystone Driller Company double-stroke deep-well pump driven at a speed of 27 revolutions a minute by a 20-horsepower electric motor. The cylinder is 7¾ inches in diameter and is placed at a depth of 170 feet. The pump is operated with 18-inch stroke. It is operated only at times of maximum demand. Estimated from power consumption the time operated during 1923 averaged less than two hours a day throughout the year.

A dug well installed in 1898, the original source of supply for North Crystal Lake, is located 12 feet north of the deep well. It has not been used for several years. The well is about 3 feet in diameter and is 63 feet deep. It is curbed with brick. In November, 1923, water stood 55 feet below the ground surface.

Water from the well 280 feet deep had a mineral content of 356, a total hardness of 295, and a content of iron of 2.4 parts per million as shown by the analysis of sample number 48649, collected on November 13, 1922.

Analysis of Sample Number 48649 from City Well 280 Feet Deep.

Determinations Made.	Parts per million.
Iron, Fe	2.4
Manganese, Mn	0.0
Silica, SiO_2	10.3
Nonvolatile	1.2
Alumina, Al_2O_3	0.0
Calcium, Ca	58.2
Magnesium, Mg	36.3
Ammonia, NH_4	0.6
Sodium, Na	25.1
Potassium, K	0.4
Sulfate, SO_4	1.7
Nitrate, NO_3	1.7
Chloride, Cl	19.0
Alkalinity Methyl Orange	322.
Residue	362.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate, KNO_3	2.9	0.17
Potassium Chloride, KCl	5.5	0.32
Sodium Chloride, NaCl	27.0	1.58
Sodium Sulfate, Na_2SO_4	2.6	0.15
Sodium Carbonate, Na_2CO_3	31.2	1.82
Ammonium Carbonate, $(NH_4)_2CO_3$	1.6	0.09
Calcium Carbonate, $CaCO_3$	145.0	8.47
Magnesium Carbonate, $MgCO_3$	125.7	7.35
Iron Oxide, Fe_2O_3	3.4	0.20
Silica, SiO_2	10.3	0.60
Nonvolatile	1.2	.07
Total	356.4	20.82

The high content of iron may be due to the short time this well pump is operated. A sample collected in 1913 when the pump in this well was operated daily contained 0.3 parts of iron. Otherwise the sample was similar to the one collected in 1922.

CUBA (1484). Cuba is located in the central part of Fulton County on the drainage area of Spoon River, a tributary of Illinois River.

A public water supply was installed by the city in 1915. Water is pumped from a well directly into an elevated tank and the distribution system by a deep-well pump which is driven by a 15-horsepower electric motor. The tank is of 60,000 gallons capacity and is located over the pumping station and well. Power is purchased from the Central Illinois Light Company.

The water consumption in 1923 was estimated at 15,000 gallons a day. The rate for the first 10,000 gallons is 33 cents per 1000 gallons, the lowest rate is 17 cents per 1000 gallons, and the minimum rate is $1.25 for three months.

Water is secured from a well 1768 feet deep, drilled by Gray Brothers of Chicago in 1914. It is located in the northern part of the village on Avenue A on the south side of the railroad. The elevation of the top of the well is 677 feet above sea level. A record of material penetrated, prepared by the drillers, is as follows:

	Thickness in feet.	Depth in feet.
Soil and clay	34	34
Shales, sandstone, coal, and limestone	396	430
Limestone	197	627
Shale,	243	870
Limestone	120	990
Shale	180	1170
Limestone	207	1377
Shale and sandstone	93	1470
Sandstone, St. Peter	298	1768

A log with complete classification, on file with the State Geological Survey Division, differs in places from the above. The top of St. Peter sandstone is shown at a depth of 1570 feet.

The well is cased with 12-inch pipe to a depth of 317 feet. It is 12 inches in diameter to a depth of 1000 feet and is 10 inches in diameter below that depth. The well was tested when completed but the rate of pumping was changed frequently. Pumping for one hour at a rate of 113 gallons a minute lowered the water level in the well to a depth of 125 feet. Before pumping water stood at a depth of 103 feet.

The well is equipped with a Luitwieler pump which is operated at a speed of 33 revolutions a minute. J. W. Turell gives the size of the cylinder as 6¾ inches, the depth at which the cylinder is placed as 172 feet 6 inches, and the discharge of the pump as 117 gallons a minute. On May 28, 1923, after pumping for 40 minutes the depth to water was 136½ feet. After pumping for 40 minutes and then standing idle for 35 minutes the depth to water was 122 feet. The amount of water pumped was estimated at 15,000 gallons a day. In 1920 when the pump was idle for three days water stood at a depth of 112 feet.

Water from the well had a temperature of 73 degrees Fahrenheit indicating that a considerable part of the water is from the lower part of the well. The water had a mineral content of 2558, a total hardness of 735, and a content of iron of 0.8 parts per million as shown by the analysis of sample number 49558, collected at the well on May 28, 1923, after the pump had been operated for two hours.

A sample collected in 1914 had a mineral content of 2400, a total hardness of 745, and a content of iron of 0.4 parts per million.

Few repairs to service connections or meters are necessary. A white powdery substance is said to form in places and more trouble is experienced with meters at dead ends than at other places.

Analysis of Sample Number 49558 from the City Supply.

Determinations Made.	Parts per million.
Iron, Fe	0.8
Manganese, Mn	0.0
Silica, SiO_2	18.4
Nonvolatile	2.2
Alumina, Al_2O_3	7.1
Calcium, Ca	137.3
Magnesium, Mg	95.7
Ammonia, NH_4	36.1
Sodium, Na	474.2
Potassium, K	106.1
Sulfate, SO_4	1116.0
Nitrate, NO_3	1.4
Chloride, Cl	392.0
Alkalinity Methyl Orange	226.0
Residue	2560.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate, KNO_3	2.3	.13
Potassium Chloride, KCl	200.6	11.71
Sodium Chloride, NaCl	488.6	28.53
Sodium Sulfate, Na_2SO_4	870.9	50.86
Ammonium Sulfate, $(NH_4)_2SO_4$	132.0	7.71
Magnesium Sulfate, $MgSO_4$	472.8	27.61
Calcium Sulfate, $CaSO_4$	74.4	4.34
Calcium Carbonate, $CaCO_2$	287.9	16.81
Iron Oxide, Fe_2O_3	1.1	.06
Alumina, Al_2O_3	7.1	.41
Silica, SiO_2	18.4	1.07
Nonvolatile	2.2	.13
Total	2558.3	149.37

CULLOM (631). Cullom is located in the eastern part of Livingston County on the drainage area of Vermilion River, a tributary of Illinois River.

A public water supply was installed by the village in 1907. Information was secured from E. J. Kingdon. Water is pumped from the well directly into the distribution system and an elevated steel tank by a deep-well pump which is driven by a 16-horsepower gas engine. About sixty service connections were in use in 1916 and the consumption was estimated at 5000 gallons a day.

The well drilled in 1907 was said to be 280 feet deep and the yield was given as 25 gallons a minute. Later it was reported that the water came from sand, gravel, and quicksand at a depth of 140 feet.

Water is now secured from a well 1700 (1470?) feet deep, drilled in 1914. An abstract of a record prepared by the State Geological Survey Division is as follows:

	Thickness in feet.	Depth in feet.
Drift	165	165
Shale and coal	155	310
Limestone, Silurian system, all or chiefly Niagaran	390	700
Shale, Richmond	165	865
Limestone, Galena-Platteville	415	1280
Sandstone, St. Peter	190	1470

The well is 10 inches in diameter at the top and 400 or 500 feet is cased with 10-inch pipe. A small flow of salt water was struck at a depth of 490 feet. The well is equipped with an American Well Works deep-well pump with 2¼-inch cylinder and 24-inch stroke. The cylinder is placed at a depth of 200 feet. The amount of water pumped is estimated at 5000 gallons a day.

The water had a mineral content of 1011, a total hardness of 76, and a content of iron of 0.5 parts per million as shown by the analysis of sample number 35953, collected close to the well after the pump was stopped on November 16, 1916.

Analysis of Sample Number 35953 from the Village Supply.

Determinations Made.	Parts per million.
Iron, Fe	0.5
Silica, SiO_2	10.4
Alumina, Al_2O_3	1.9
Calcium, Ca	28.3
Magnesium, Mg	1.4
Ammonia, NH_4	1.9
Sodium, Na	350.6
Potassium, K	13.2
Sulfate, SO_4	12.2
Nitrate, NO_3	0.9
Chloride, Cl	360.0
Nonvolatile	0.6
Alkalinity Methyl Orange	328.
Residue	1072.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate, KNO_3	1.5	0.09
Potassium Chloride, KCl	24.0	1.40
Sodium Chloride, NaCl	575.3	33.38
Sodium Sulfate, Na_2SO_4	106.9	6.21
Sodium Carbonate, Na_2CO_3	209.4	12.19
Ammonium Carbonate, $(NH_4)_2CO_3$	5.1	.30
Magnesium Carbonate, $MgCO_3$	4.8	.28
Calcium Carbonate, $CaCO_3$	70.6	4.11
Iron Oxide, Fe_2O_3	0.7	0.04
Alumina, Al_2O_3	1.9	.11
Silica, SiO_2	10.4	.61
Nonvolatile	0.6	.03
Total	1011.2	58.75

Salt water from a vein at a depth of 600 or 700 feet flows into the well when the pump is idle and is discharged when starting to pump.

The supply formerly secured from sand at a depth of 140 feet was very much more highly mineralized and much harder. The mineral content was 1970 and the total hardness was 1040 parts per million.

DANFORTH (398). Danforth is located in the western part of Iroquois County on the drainage area of Iroquois River, a tributary of Kankakee River. Many private wells in use are drilled into a stratum of sand encountered at a depth of little more than 100 feet.

A public water supply was installed by the village about 1891. Water was secured from a well 108 feet deep into a vein of sand. The well now in use was drilled in 1896 and the original well, located across the street, is now equipped with a hand pump. Water is pumped from the well by a deep-well pump which discharges into a

reservoir 30 feet in diameter and 13 feet deep. From the reservoir it is pumped into a steel pressure tank and the distribution system by an 8 by 8-inch triplex pump. The tank is 9 feet in diameter and 38 feet long. It replaced an elevated tank when the tower supporting the elevated tank was burned in 1905. The pumps are driven by belt from a shaft which is generally driven by belt from an electric motor. Either of two 20-horsepower gas engines can be used to furnish power.

About seventy-five consumers were supplied with water in 1922 and the total consumption was estimated at from 7000 to 8000 gallons a day. The minimum charge is $3.00 for three months and few pay more than the minimum.

The public water supply is secured from a well drilled near the center of the village in 1896. It is 6 inches in diameter and 1250 feet deep. The elevation of the top of the well is about 658 feet above sea level. The well is cased to rock and is thought to have some casing at a depth of about 500 feet. The well is equipped with a deep-well pump with the cylinder at a depth of 350 feet. Pumping for 20 minutes is thought to lower the water level to near the cylinder. On May 10, 1922, the yield after two hours operation was measured approximately by discharging into a pail and the yield was from 13 to 14 gallons a minute. The pump was operated an average of about 9 hours a day. The water level when not pumping was at a depth of 80 feet.

Analysis of Sample Number 47515 from Village Well 1250 Feet Deep.

Determinations Made.	Parts per million.
Iron, Fe	0.2
Manganese, Mn	0.0
Silica, SiO_2	26.8
Nonvolatile	3.6
Alumina, Al_2O_3	4.3
Calcium, Ca	33.4
Magnesium, Mg	17.8
Ammonia, NH_4	1.0
Sodium, Na	420.2
Potassium, K	20.3
Sulfate, SO_4	98.2
Nitrate, NO_3	0.3
Chloride, Cl	530.0
Alkalinity Methyl Orange	290.0
Residue	1374.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	0.4	0.02
Potassium Chloride KCl	39.0	2.27
Sodium Chloride NaCl	843.7	49.18
Sodium Sulfate Na_2SO_4	145.1	8.49
Sodium Carbonate Na_2CO_3	95.3	5.65
Ammonium Carbonate $(NH_4)_2CO_3$	2.7	0.16
Magnesium Carbonate $MgCO_3$	62.3	3.63
Calcium Carbonate $CaCO_3$	83.9	4.90
Silica SiO_2	26.8	1.52
Nonvolatile	3.6	.21
Iron Oxide Fe_2O_3	0.3	0.02
Alumina Al_2O_3	4.3	0.25
Total	1307.4	76.30

A well 4 feet in diameter was dug at the side of the pumping station to a depth of 108 feet, about 1918. A considerable supply of

water was secured from a vein of sand about 3 feet deep but the well caved in at a depth of 80 feet and was abandoned.

Water from the well 1250 feet deep has a temperature of 63 degrees Fahrenheit. It had a mineral content of 1307, a total hardness of 156, and a content of iron of 0.2 parts per million as shown by the analysis of sample number 47515, collected on May 10, 1922.

The water corrodes meters and meters with dials designed to turn only at long intervals are said to go out of commission at the time the dial should move.

DANVERS (616). Danvers is located in the western part of McLean County on the drainage area of Sangamon River, a tributary of Illinois River. Many private wells from 12 to 40 feet deep are in use.

A public water supply was installed by the village in 1892. Water was secured from a well which has been abandoned since other wells of about the same depth have been drilled. Water is pumped directly from the wells into the distribution system to which an elevated steel tank is connected. The tank is of 40,000 gallons capacity and is supported on a steel tower 75 feet high. The pumps are belted to a shaft which is driven by a 20-horsepower gas engine.

Sixty-nine service connections were in use in 1922 and the consumption was estimated at less than 15,000 gallons a day. All services are metered and the rate is 65 cents per 1000 gallons with a minimum charge of $1.30 for three months.

The public water supply is secured from two wells located 15 feet apart. Water is obtained from a stratum of fine sand and each well is equipped with a Cook screen 10 feet long. One well, to the north, is 8 inches in diameter and 218 feet deep and the other well is 6 inches in diameter and 205 feet deep.. Each well is equipped with a Fairbanks-Morse deep-well pump which is operated at a speed of 21 revolutions a minute. Gas is discharged with the water and the actual rate of pumping is not known. The quantity pumped was estimated in 1922 at 15,000 gallons a day.

A well drilled to a depth of 218 feet in 1905, twenty-five feet east of the original well on the lot on which the wells in use are located, was reported to be a dry hole.

The temperature of water when discharged from the north well was 54 degrees Fahrenheit. The water has a mineral content of 526, a total hardness of 345, and a content of iron of 2.4 parts per million, as shown by the analysis of sample number 48825, collected on December 18, 1922.

Analysis of Sample Number 48825 from the Village Supply.

Determinations Made.	Parts per million.
Iron, Fe	2.4
Manganese, Mn	0.0
Silica, SiO_2	19.1
Nonvolatile	1.4
Alumina, Al_2O_3	0.0
Calcium, Ca	76.3
Magnesium, Mg	37.8
Ammonia, NH_4	7.0
Sodium, Na	64.5
Potassium, K	7.3
Sulfate, SO_4	0.0
Nitrate, NO_3	2.1
Chloride, Cl	0.0
Alkalinity Methyl Orange	512.
Residue	525.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	3.4	.20
Potassium Carbonate K_2CO_3	10.6	.62
Sodium Carbonate Na_2CO_3	148.6	8.68
Ammonium Carbonate $(NH_4)_2CO_3$	18.5	1.08
Magnesium Carbonate $MgCO_3$	130.8	7.65
Calcium Carbonate $CaCO_3$	190.4	11.12
Silica SiO_2	19.1	1.12
Nonvolatile	1.4	.08
Iron Oxide Fe_2O_3	3.4	.20
Total	526.2	30.75

DE KALB (7871). De Kalb is located in the central part of De Kalb County on the drainage area of Kishwaukee River, a tributary of Rock River. The Chicago and Northwestern Railway has two wells in the city, one 1003 feet deep and the other of nearly the same depth. The American Steel and Wire Company have a large plant located in De Kalb and have a private water supply from deep wells. They can supply water to the city.

A public water supply was installed by the city many years ago, probably about 1875. Water was secured from two wells each about 2400 feet deep. These wells were abandoned about 1895 when a well was drilled in the western part of the city. Other wells were drilled later. One 107 feet deep into sand was abandoned as the yield was small. At the present time water is secured from three wells into rock. Water is discharged from the wells into a reservoir 65 feet in diameter and 22 feet deep and is pumped from the reservoir into the mains by two Goulds 10 by 12-inch triplex pumps. A Lee three-stage centrifugal pump of 1500 gallons a minute capacity is used at times of fire. Each pump is driven by an electric motor. A steel standpipe 22 feet in diameter and 85 feet high is connected to the distribution system. All water pumped is measured by a Venturi meter. The Illinois Power Company supplies electric current and cares for the equipment, charging for water pumped.

In 1922 about 1870 service connections were in use. The charge for the first 700 cubic feet is 30 cents per 100 cubic feet and the lowest rate, for water in excess of 16100 cubic feet, is 7½ cents per 100 cubic feet. The rates are higher if bills are not paid promptly

and the minimum charge for three months is $1.25 with an additional charge of 25 cents where the city owns the meter.

Nearly all water used for the public supply is secured from two or three wells available. One, called number 1, was drilled to a depth of 841 feet in 1898, and to a total depth of 1331 feet in 1903 by the J. P. Miller Artesian Well Company of Chicago. The well was 15 inches in diameter to a depth of 200 feet and 6 inches in diameter at the bottom which was in St. Peter sandstone. When drilled, 15-inch outside diameter casing was placed to a depth of 161 feet. Eighty feet of 6-inch pipe was placed when a depth of 913 feet was reached. The normal water level when the well was completed was 75 feet below the ground surface. The well is equipped with a Keystone Driller Company double-stroke deep-well pump with a 11½-inch cylinder placed at a depth of 161 feet. It is operated with 18-inch stroke. At the time of visit on April 19, 1922, this pump was operating slightly more than 26 revolutions a minute and the discharge, computed from water levels in the reservoir and meter readings of water pumped from the reservoir, was 370 gallons a minute. From the condition of pump rods when they were removed it was thought that water was drawn down to a depth of 140 feet when pumping.

Well number 2, is located at the main pumping station in the western part of the city from 350 to 400 feet north of well number 1. This well was drilled by the J. P. Miller Artesian Well Company of Chicago in 1912. The elevation at the top is about 865 feet above sea level. Following is an abstract of a log prepared by the State Geological Survey Division.

	Thickness in feet.	Depth in feet.
Clay, sand and gravel	150	150
Limestone, Galena-Platteville	374	524
Sandstone, St. Peter	311	835
Chert and shale, Prairie du Chien	45	880
Dolomite, Prairie du Chien	190	1070
Sandstone, Prairie du Chien	20	1090
Shale, Prairie du Chien	5	1095
Sandstone, Prairie du Chien	85	1180
Sandstone, Cambrian System	126	1306

The well is cased with 160 feet of 16-inch outside diameter casing, with 114 feet of 10-inch pipe with the bottom at a depth of 625 feet, and with 101 feet of 8-inch pipe with the bottom at a depth of 896 feet. When completed the well was pumped at a rate of about 306 gallons a minute with a pump cylinder attached to about 175 feet of drop pipe. It is equipped with a Keystone Driller Company double-stroke deep-well pump with 11½-inch cylinder and 18-inch stroke. The pump operates at a speed of 24½ revolutions a

minute. The yield of this well and well number 1 operating at the same time on April 19, 1922, was from 700 to 710 gallons a minute. The depth to water in this well was reported as 104 feet in 1912. In 1921 the depth to water was 125 feet when the pump was not used for several days but during which time the air lift in a well nearby had operated. In 1922 it was thought that the water was drawn down nearly to the pump cylinder which was at a depth of 195 feet.

Another well, drilled about 1895, is available and is used occasionally. This is located in the main pumping station near well number 2. It is reported to be 890 feet deep and is cased to a depth of 161 feet. The well is crooked and is equipped with an air lift.

A well 1321 feet deep was drilled by the W. L. Thorne Company of Des Plaines in 1924. It is 16 inches in diameter to a depth of 620 feet, 12 inches in diameter between depths of 620 and 1125 feet, and 10 inches in diameter at the bottom. Data on yields were not available when this was written.

In 1898 samples of water were collected by M. L. Merriman from well number 1 which at that time was completed to a depth of 841 feet and ended in St. Peter sandstone. One sample was collected when pumping from a pipe extending to a depth of 650 feet and packed at a depth of 648 feet to prevent the entrance of water from the upper part of the well. Before collecting the sample the pump in the well had been idle for two days and 5000 gallons of water had then been pumped. Another sample was collected with the pump at a depth of 200 feet drawing water from the entire depth of the well. Partial analysis showed no difference in the quality of the two samples. A mineral analysis is given of the combined samples, numbers 3463 and 3464.

Analysis of Sample Number 3463 and 3464 from City Well when 841 Feet Deep.

Determinations Made.	Parts per million.
Iron, Fe	0.5
Silica, SiO_2	6.7
Alumina, Al	0.8
Calcium, Ca	56.5
Magnesium, Mg	23.3
Ammonium, NH_4	1.0
Potassium, K	3.0
Sodium, Na	29.7
Sulfate, SO_4	2.9
Nitrate, NO_3	0.7
Chloride, Cl	0.9
Residue	334.4

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	1.1	.06
Potassium Chloride KCl	1.9	.11
Potassium Sulfate K_2SO_4	3.6	.21
Sodium Sulfate Na_2SO_3	1.3	.08
Sodium Carbonate Na_2CO_3	67.3	3.93
Ammonium Carbonate NH_4CO_3	1.9	.11
Magnesium Carbonate $MgCO_3$	81.0	4.72
Calcium Carbonate $CaCO_3$	141.2	8.23
Iron Carbonate Fe_2O_3	1.0	.06
Alumina Al_2O_3	0.2	.01
Silica SiO_2	6.7	.40
Total	307.2	17.92

Water from the wells now in use into Cambrian sandstone does not differ greatly from the former supply. It has a mineral content of 333, a total hardness of 267 parts per million, and contained no iron as shown by the analysis of sample number 47398, collected on April 19, 1922.

Analysis of Sample Number 47398 from the City Supply.

Determinations Made.	Parts per million.
Iron, Fe	0.0
Manganese, Mn	0.0
Silica, SiO_2	11.0
Nonvolatile	1.3
Alumina, Al_2O_3	1.3
Calcium, Ca	64.3
Magnesium, Mg	26.1
Ammonia, NH_4	0.3
Potassium, K	8.9
Sodium, Na	22.1
Sulfates, SO_4	8.9
Nitrate, NO_3	0.8
Chloride, Cl	4.0
Alkalinity Methyl Orange	302.0
Residue	344.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	1.4	.08
Potassium Chloride KCl	8.4	.49
Potassium Sulfate K_2SO_4	5.9	.34
Sodium Sulfate Na_2SO_4	5.9	.34
Sodium Carbonate Na_2CO_3	46.6	2.73
Ammonium Carbonate $(NH_4)_2SO_4$	0.7	.04
Magnesium Carbonate $MgCO_3$	90.3	5.28
Calcium Carbonate $CaCO_3$	160.4	9.38
Silica SiO_2	11.0	.64
Nonvolatile	1.3	.07
Alumina Al_2O_3	1.3	.07
Total	333.2	19.46

DE PUE (2525). De Pue is located in the southeastern part of Bureau County on Lake De Pue, which is connected with Illinois River.

A public water supply was installed by the village in 1899. The supply was secured from a well owned by a railroad company and about 500 feet of spiral riveted pipe was laid. This pipe was soon replaced by cast iron. Later the village drilled a well and has made many other improvements in the water supply. About 380 service connections were in use in 1920 and the consumption averaged near 35,000 gallons a day. (These figures may be a little high). The number of connections in use in 1924 was about 400. The charge for water is $2.50 every three months when less than 10,000 gallons is used and 10 cents per 1000 gallons for additional water. The rates are not subject to discount.

Water to supply all but a limited area in the village is secured from a flowing well 1278 feet deep which was drilled by W. F. Townsell of Streator in 1910-1911. A print furnished by the Mineral Point Zinc Company shows 6-inch casing to a depth of 900 feet. Water encountered above this depth was said to be salt water and water from below the casing was classed as fresh water. The flow (when the well was completed?) was estimated at 200 gallons a min-

ute and the pressure when the well was capped was given as 27 pounds. Tests were made by L. A. Buffinger in 1919. The pressure with no flow was 30 pounds. The flow was 79 gallons a minute with a pressure of 20 pounds, 148 gallons a minute with zero pressure, and 175 gallons a minute with a vacuum of 18 inches. With increasing demands the pressure lowered and in 1919 an American 1½-inch single-stage centrifugal pump driven by a 2-horsepower electric motor was installed. This was operated as a booster from about 5:00 A. M. to 8:00 P. M. Two larger centrifugal pumps were installed for use at times of fires. These were replaced in 1923 by two Deming 6 by 8-inch triplex pumps, each driven by a 15-horsepower electric motor. An elevated steel tank of 150,000 gallons capacity was erected and connected to the mains. In 1924 one of the triplex pumps was operated about four hours a day and the small centrifugal pump was used at times of small demand. Use of this small pump has been discontinued. When not pumping the line from the well is closed by a check valve and the pressure at the well, in 1924, was 30 pounds. After pumping for 30 minutes with one pump there was a vacuum of 10 pounds. The pumps are operated at 55 revolutions a minute.

Water is supplied to some residences on high ground in the eastern part of the village from a well into sand and gravel. The well is 10 feet in diameter and 32 feet deep. This was installed in 1916. It is equipped with a Goulds 4 by 6-inch triplex pump geared to a 5-horsepower electric motor. Water is stored in a tank 16 feet in diameter and 14 feet high. About eighty-five consumers were supplied in 1920. When tested by Mr. Buffinger in August, 1920, the pump was operated drawing the water in the well down from a depth of 12 feet to a depth of 10 feet 9 inches and with measurements of water pumped into the reservoir the flow into the well was computed to be 40 gallons a minute.

The Mineral Point Zinc Company has wells of about the same depth as the deep city well. Information was obtained from the company. Well number 1 was drilled by Gray Brothers in 1904-1905. It is 1359 feet deep and the smallest casing, 6-inch, extends from the ground surface to a depth of 839 feet 10 inches. The strata penetrated are similar to strata penetrated by the other two wells. When capped the pressure was 65 pounds. In 1909 it was 40 pounds. The well has since been abandoned.

Well number 2 was drilled by Miller and Company in 1909. It is 1278 feet deep. Between depths of 78 and 371 feet the well passes through shale and two layers of coal. It is in limestone be-

tween depths of 371 feet and 850 feet, in shale between depths of 850 and 1020 feet, and in Galena-Platteville formations below a depth of 1020 feet. When a depth of 580 feet was reached salt water flowed at a rate of 5 gallons a minute. The flow increased to 20 or 25 gallons a minute at a depth of 680 feet and below that depth it remained constant until fresh water was struck between depths of 1126 and 1131 feet. The approximate flow was 50 gallons a minute at a depth of 1131 feet, 175 gallons a minute at a depth of 1175 feet, and 250 gallons a minute at a depth of 1205 feet and the actual flow at a depth of 1245 feet was 782 gallons a minute. At this depth pieces of limestone were carried to the surface. The smallest casing, 8-inch, extends from the ground surface to a depth of 842 feet and a Marlin packer is placed at the lower end. When the well was capped the pressure was 40 pounds.

Well number 3 was drilled by S. B. Gieger in 1912. The smallest casing, 8-inch, extends to a depth of 845 feet. When completed and capped the pressure was 26 pounds.

A sample of water, number 31419, collected from the city well 1278 feet deep on September 1, 1915, when water was flowing from the well into the distribution system, had a mineral content of 520, a total hardness of 236, and a content of iron of 2.0 parts per million as shown by the analysis.

Analysis of Sample Number 31419 Flow from Well 1278 Feet Deep.

Determinations Made.	Parts per million.
Iron, Fe	2.0
Manganese, Mn	None
Silica, SiO_2	3.2
Nonvolatile	5.8
Calcium, Ca	55.5
Magnesium, Mg	23.8
Ammonia, NH_4	2.6
Sodium, Na	100.0
Potassium, K	8.7
Sulfate, SO_4	52.8
Nitrate, NO_3	3.5
Chloride, Cl	79.0
Alkalinity Methyl Orange	306.
Residue	545.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	5.7	.33
Potassium Chloride KCl	12.4	.72
Sodium Chloride NaCl	120.6	7.03
Sodium Sulfate Na_2SO_4	78.1	4.55
Sodium Carbonate Na_2CO_3	62.6	3.64
Ammonium Carbonate $(NH_4)_2CO_3$	6.9	.40
Magnesium Carbonate $MgCO_3$	82.4	4.80
Calcium Carbonate $CaCO_3$	138.5	8.08
Iron Carbonate $FeCO_3$	4.1	.23
Alumina Al_2O_3	trace	trace
Silica SiO_2	3.2	.18
Nonvolatile	5.8	.34
Total	520.3	30.00

When pumping, the water secured has a much higher content of sodium and chloride as shown by the analysis of sample number 52934, collected at the pumping station on December 2, 1924, when the triplex pump was operating.

Analysis of Sample Number 52934 Pumped from Well 1278 Feet Deep.

Determinations Made.	Parts per million.
Iron, Fe	1.2
Silica, SiO_2	9.1
Nonvolatile	3.2
Alumina, Al_2O_3	0.4
Calcium Ca	44.6
Magnesium, Mg	25.0
Ammonia, NH_4	2.3
Sodium, Na	352.4
Potassium, K	56.2
Sulfate, SO_4	70.6
Nitrate, NO_3	0.5
Chloride, Cl	490.0
Alkalinity	
Phenolphthalein	0.
Methyl Orange	332.
Residue	1236.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	0.9	0.05
Potassium Chloride KCl	106.4	6.21
Sodium Chloride NaCl	723.8	42.27
Sodium Sulfate Na_2SO_4	104.3	6.09
Sodium Carbonate Na_2CO_3	77.9	4.55
Ammonium Carbonate $(NH_4)_2CO_3$	6.0	0.35
Magnesium Carbonate $MgCO_3$	86.3	5.04
Calcium Carbonate $CaCO_3$	11.3	6.50
Iron Oxide Fe_2O_3	1.7	0.10
Alumina Al_2O_3	0.4	0.02
Silica SiO_2	9.1	0.53
Nonvolatile	3.2	0.19
Total	1231.3	71.90

When water was pumped with the large centrifugal pumps "black" water was secured. It is probable that the water was more highly mineralized than the sample analyzed which was collected when pumping at a lower rate.

Well casings are corroded by water from the deep wells. When a fire pump was run at the city pumping station in 1920, under the direction of Mr. Buffinger, considerable sediment was secured which contained 14 per cent sand, 62 per cent iron, and 2 per cent lime etc., and the loss on ignition was 20 per cent. It was concluded that the casing was rusted through. At the Zinc Company plant a flow outside the casing of well number 2 has ceased, indicating that the casing may be corroded.

Analysis of Sample Number 52935 from City Well 32 Feet Deep.

Determinations Made.	Parts per million.
Iron, Fe	4.8
Silica, SiO_2	16.7
Nonvolatile	1.0
Alumina, Al_2O_3	0.0
Calcium, Ca	88.9
Magnesium, Mg	42.5
Ammonia, NH_4	0.3
Sodium, Na	25.0
Potassium, K	6.8
Sulfate, SO_4	60.3
Nitrate, NO_3	1.4
Chloride, Cl.	13.0
Alkalinity	
Phenolphthalein	0.
Methyl Orange	368.
Residue	500.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	2.3	0.13
Potassium Chloride KCl	11.3	.66
Sodium Chloride NaCl	12.6	0.73
Sodium Sulfate Na_2SO_4	61.9	3.61
Ammonium Sulfate $(NH_4)_2SO_4$	0.9	0.05
Magnesium Sulfate $MgSO_4$	22.2	1.30
Magnesium Carbonate $MgCO_3$	131.5	7.68
Calcium Carbonate $CaCO_3$	221.8	12.95
Iron Oxide Fe_2O_3	6.8	0.40
Alumina Al_2O_3	0.0	0.00
Silica SiO_3	16.7	0.97
Nonvolatile	1.0	0.06
Total	489.0	28.54

A sample of water, number 52935, collected from the well 32 feet on December 2, 1924, had a mineral content of 489, a total hardness of 396, and a content of iron of 4.8 parts per million as shown by the analysis.

DEER CREEK (344). Deer Creek is located in the northeastern part of Tazewell County on the drainage area of Mackinaw River. Sufficient water for private supplies at residences is found in a vein of sand at a depth of about 12 feet or in a second vein at a depth of 35 or 40 feet.

A well was drilled by the village in 1907 near the center of the business district. A distribution system and other necessary equipment for a public water supply were installed in 1913 using this well as a source of supply. The well is equipped with a deep-well pump which discharges into a steel pressure tank and the distribution system. The tank is 8 feet in diameter and 36 feet long. The pump and a small air compressor are driven by a 10-horsepower electric motor. Power is secured from the Central Illinois Light Company. Fifty-five service connections were in use in 1924 and the water consumption was estimated at 6,700 gallons a day.

Water is secured from a well 6 inches in diameter and 267 feet deep. The well is equipped with an American deep-well pump with 3½-cylinder and 24-inch stroke. The pump is operated 31½ revolutions a minute. The cylinder is attached to 260 feet of drop pipe. During a test on June 19, 1924, the pump discharged about 35 gallons a minute. The pump was operated about 3 hours a day.

The water had a mineral content of 361, a total hardness of 350, and a content of iron of 0.3 parts per million as shown by the analysis of sample number 36135, collected on December 14, 1916.

Analysis of Sample Number 36135 from the Village Supply.

Determinations Made.	Parts per million.
Iron, Fe	0.3
Silica, SiO_2	15.9
Calcium, Ca	70.0
Magnesium, Mg	43.0
Ammonia, NH_4	0.0
Sodium, Na	5.7
Potassium, K	3.3
Sulfate, SO_4	0.8
Nitrate, NO_3	5.6
Chloride, Cl	3.0
Alkalinity Methyl Orange	296.
Residue	327.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	8.5	.49
Potassium Chloride KCl	4.9	.29
Sodium Carbonate Na_2CO_3	8.7	.51
Magnesium Carbonate $MgCO_3$	149.0	8.69
Calcium Carbonate $CaCO_3$	174.0	10.15
Iron Oxide Fe_2O_3	0.4	.02
Silica SiO_2	15.9	.92
Total	361.4	21.07

DE LAND (542). De Land is located in the northwestern part of Piatt County on the drainage area of Sangamon River. The village drilled three wells near the village hall in 1914 and 1915. Each well was about 80 feet deep into a vein of sand. One well was equipped with a number 20 Johnson screen and another with a number 30 Cook screen. The maximum yield of a well during a short test was 15 gallons a minute. Another well drilled to a depth of 225 feet was in blue clay and shale below the sand stratum at a depth of 80 feet.

In 1915 a well was drilled to a depth of 1085 feet. Some salt water was encountered at depths of 510 and 725 feet. The well was abandoned and the village has no public water supply.

DELAVAN (1191). Delavan is located in the southern part of Tazwell County on the drainage area of Quiver Creek, a tributary of Illinois River.

A public water supply was installed by the village about 1887. The installation included a well and wooden mains. The original well has been abandoned, the wooden mains have been replaced, and many other improvements have been made. Water from the public supply is now secured from two wells equipped with Cook steam-head deep-well pumps and is discharged directly into the distribution system to which a 55,000-gallon steel tank is connected. The water consumption in 1919 was estimated at 50,000 gallons a day. The rate for quantities to 500 cubic feet is 25 cents per 100 cubic feet; the lowest rate; for quantities in excess of 6500 cubic feet, is 10 cents per 100 cubic feet; and the minimum charge is $1.00 for three months. In 1919 the pumping station was being operated by the Royal Electric Company and steam was supplied from their plant which was located on a lot adjoining the pumping station.

Water is obtained from two drilled wells located about 20 feet apart in the rear of the city hall. The elevation of the tops of the wells is about 605 feet above sea level. One well, drilled by Mount and Dunseth of Delavan in 1917, is 10 inches in diameter and 158 feet deep. It penetrates 25 to 30 feet of soil and yellow clay, 90 feet of blue clay, and 2 or 3 feet of hardpan and is in sand and gravel below a depth of 121 feet. The well was drilled to a depth of 242 feet and the lower part of the hole was abandoned. A Cook screen 14 feet long is placed with the bottom at a depth of 158 feet. The well is equipped with a single-acting deep-well pump with a 7¾-inch cylinder and 36-inch stroke. The cylinder is at a depth of 140 feet. The pump speed depends upon steam pressure and the displacement

varies from 95 gallons to 190 gallons a minute. Water is not drawn down to the pump cylinder. The pump is generally operated about 8 hours a day.

The other well is used occasionally. It is 8 inches in diameter and 160 feet deep. It is equipped with a Cook single-acting pump with a 5¾-inch cylinder wedged in the casing and 36-inch stroke.

The water has a mineral content of 365, a total hardness of 310, and a content of iron of 1.6 parts per million as shown by the analysis of sample number 42044, collected on November 4, 1919, from the well 158 feet deep, after the pump had operated for thirty minutes.

Analysis of Sample Number 42044 from the Village Supply.

Determinations Made.	Parts per million.
Iron, Fe	1.6
Silica, SiO_2	21.1
Alumina, Al_2O_3	1.3
Calcium, Ca	73.7
Magnesium, Mg	31.0
Ammonia, NH_4	1.7
Sodium, Na } Potassium, K }	18.1
Sulfate, SO_4	2.5
Nitrate, NO_3	0.7
Chloride, Cl	4.0
Nonvolatile	1.2
Alkalinity Methyl Orange	340.
Residue	374.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Sodium Nitrate $NaNO_3$	0.9	.06
Sodium Chloride NaCl	6.6	.39
Sodium Sulfate Na_2SO_4	3.6	.21
Sodium Carbonate Na_2CO_3	32.5	1.90
Ammonium Carbonate $(NH_4)_2CO_3$	4.6	.27
Magnesium Carbonate $MgCO_3$	107.3	6.27
Calcium Carbonate $CaCO_3$	184.0	10.67
Iron Oxide Fe_2O_3	2.3	.13
Alumina Al_2O_3	1.3	.08
Silica SiO_2	21.1	1.23
Nonvolatile	1.2	.07
Total	365.6	21.35

A sample analyzed in 1914 was of practically the same quality. The iron content was 0.5 parts per million.

DES PLAINES (3451). Des Plaines is located in the northern part of Cook County on the Des Plaines River, a tributary of Illinois River. A well 1800 feet deep was drilled on ground back of the village hall in 1893-1894 by F. M. Gray. Mr. Gray stated that below a depth of 120 feet the well was in shale and that no water was secured.

A public water supply was installed by the village in 1895. Water was obtained from wells into sand and gravel located near the east bank of Des Plaines River and this has since been the principal source of supply. Some water was obtained in 1924 from a well into rock. The wells are equipped with air lifts which discharge into a reservoir at the pumping station on the west bank of the river. Water is pumped from the reservoir into the mains by a

Lea Courtenay centrifugal pump of 500 gallons a minute capacity. An Ingersoll-Rand 8 and 13 by 13-inch compound air compressor driven by an electric motor was installed in 1924.

The supply from the village wells is insufficient and since 1922 some water has been secured for the village from a well 1385 feet deep at the plant of the Benjamin Electric Company west of the village. The amount purchased increased to 150,000 gallons a day in 1924. About 1200 service connections were in use in 1924. The rate was 30 cents per 100 cubic feet with a minimum charge of $1.50 for three months. Consumers outside the village were charged $1.00 per 100 cubic feet.

All water for the public supply was secured, until about 1922, from walls about 130 feet deep into sand and gravel near the east bank of Des Plaines River. The wells were equipped with air lifts with an air line extending nearly to the bottom of each well. In 1912 the capacity of three 8-inch wells then in use was said to be 300 gallons a minute. The amount of water pumped when computed from pump revolutions in 1911 was 130,000 gallons a day and in 1912 the amount of water pumped was said to be less. The air lifts were operated during the day time only.

In 1922 two of these wells were in use. Three could be used but the yield was no greater than when using two. This may have been due in large part to arrangement and operation of equipment or in part to lack of water. The air lifts were operated 9 hours a day with decreasing yield and an average yield of near 100,000 gallons for the 9 hours. Additional water required was purchased from the Benjamin Electric Company.

Another well into sand and gravel was installed in 1915. It was dug to a depth of 102 feet. A hole was then bored 7 feet into sand and gravel and water raised and flooded the well to within 15 feet of the top. Eight-inch pipe was then sunk from the bottom of the well into the sand stratum. The yield was small. In 1919-1920 two of the 8-inch holes were drilled deeper. One to a depth of 175 feet. The well was equipped with a deep-well pump but when pumping the water was drawn down rapidly and fine sand was drawn into the well.

A well 1670 feet deep was drilled by W. L. Thorne of Des Plaines in 1922-1923, and furnished part of the supply in 1924. The well is 16 inches in diameter at the top and 6 inches in diameter at the bottom. This well is in soft formation all the way down and is cased to the bottom. The well is nearly one-half mile southeast of the well drilled years before by F. M. Gray which was abandoned

at a depth of 1800 feet. This well and the two wells into sand and gravel were pumped 9 hours a day in 1924. The 8 and 13 by 12-inch compound compressor was operated 260 revolutions a minute and the yield of the three wells was said to be about 300,000 gallons in the 9 hours.

Additional wells into sand and grave1 were drilled by the Layne and Bowler Company in 1924. These had not been equipped in November.

Water from the city well 1670 feet deep had a mineral content of 1644, a total hardness of 543, and a content of iron of 0.7 parts per million as shown by the analysis of sample number 52577, collected on October 2, 1924.

Analysis of Sample Number 52577 from City Well 1670 Feet Deep.

Determinations Made.	Parts per million.
Iron, Fe	0.7
Manganese, Mn	0.0
Silica, SiO_2	32.8
Nonvolatile	8.0
Alumina, Al_2O_3	2.6
Calcium, Ca	112.3
Magnesium, Mg	64.2
Ammonia, NH_4	2.3
Sodium, Na	355.8
Potassium, K	14.4
Sulfate, SO_4	189.7
Nitrate, NO_3	0.0
Chloride, Cl	670.0
Alkalinity Methyl Orange	250.
Residue	1660.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Chloride KCl	27.6	1.61
Sodium Chloride NaCl	904.2	52.80
Ammonium Chloride NH_4Cl	6.9	0.40
Magnesium Chloride $MgCl_2$	139.1	8.12
Magnesium Sulfate $MgSO_4$	141.6	8.27
Calcium Sulfate $CaSO_4$	180.6	10.55
Calcium Carbonate $CaCO_3$	200.5	11.71
Iron Oxide Fe_2O_3	1.0	0.06
Silica SiO_2	32.8	1.91
Nonvolatile	8.0	0.47
Alumina Al_4O_3	2.6	0.15
Total	1644.9	96.05

DIXON (8191). Dixon is located in the northwestern part of Lee County on the banks of Rock River. Information is as given by George W. Hawley, Secretary of the Water Company.

A public water supply was installed by the Dixon Water Company in 1883. The water used was from Rock River. In 1888 the company was re-organized and two deep artesian wells were drilled. In 1902 a third deep well was drilled and in 1914 a fourth well was drilled. The wells all empty into a 500,000-gallon reservoir at the pumping station, from which water is pumped to all parts of the city. Three centrifugal pumps are available to pump from the reservoir; a single-stage pump of 850 gallons a minute capacity which is driven by a 50-horsepower electric motor; a two-stage pump of 1500 gallons a minute which is driven by a Sterling marine gasoline engine; and a two-stage pump of 2000 gallons a minute capacity at 150

pounds pressure, for use in case of fire, driven by a 200-horsepower electric motor. Either gas engines or electric motors are available to pump from the wells and from the reservoir. There are two standpipes on the system, one of 275,000 and the other of 75,000 gallons capacity. The smaller standpipe serves a portion of the city at a higher elevation and check valves prevent water from returning to the lower part of the city.

The city is one hundred per cent metered and metering has reduced the pumping almost one-third from what it was when on flat rate. There are a few over 2400 meters on the line and all are owned and controlled by the Water Company.

Water for the public supply is secured from four wells, each about 1750 feet deep. Wells number one, two, and four were drilled by the J. P. Miller Artesian Well Company of Chicago and well number three was drilled by H. W. Hambrecht of Sterling. They are in a row and the distance between the end wells is about nine hundred feet. The water level in the reservoir into which the water from wells discharge is at most times between elevation 650 and 665 feet above sea level. A record of material penetrated by well number four with part of classification given by the State Geological Survey Division, is as follows:

	Thickness in feet.	Depth in feet.
Surface	9	9
Limestone, Galena-Platteville	95	104
Sandy shale, Galena-Platteville.	56	160
Sand rock, St. Peter.	178	338
Marl, red, Prairie du Chien.	71	409
Limestone, Prairie du Chien.	114	523
Marl, red, Prairie du Chien.	17	540
Lime rock, Prairie du Chien.	172	712
Shale, blue, Prairie du Chien.	94	806
Sand rock	183	989
Shale, blue, Eau Claire, Cambrian System.	131	1120
Sand rock, Mt. Simon, Cambrian System.	645	1765

This well is cased with eight feet of 12-inch pipe with a sleeve in the bottom and 551 feet of 8-inch pipe, which covers three caves, with an 8-inch shoe at the bottom.

In well number two a flow was noted at a depth of one thousand feet and an increase in flow to one hundred gallons a minute was noted at a depth of twelve hundred feet. At time of visit in October, 1921, when water had not been pumped from the wells for some time and the water level in the reservoir was five feet below the top, the flow from the wells was 50 gallons a minute.

In 1923 a test of all of these wells was made by the Harris Air Pump Company of Indianapolis, Indiana, and it was found that the wells have a capacity of 4,250,000 gallons per day. Wells

number one and four are connected to an air compressor. This compressor is driven by a 75-horsepower electric motor. Well number two is connected to a single-stage centrifugal pump which delivers six hundred gallons per minute. It is driven by a 15-horsepower electric motor. Well number three is connected to a single-stage centrifugal pump which delivers 1000 gallons per minute and is driven by a 25-horsepower gasoline engine.

Water from the city supply had a mineral content of 311, a total hardness of 275, and a content of iron of 0.4 parts per million, as shown by the analysis of sample number 46409, collected on October 20, 1921.

Analysis of Sample Number 46409 from the City Supply.

Determinations Made.	Parts per million.
Iron, Fe.	0.4
Manganese, Mn	0.1
Silica, SiO_2	10.6
Nonvolatile	0.7
Alumina, Al_2O_3	6.8
Calcium, Ca.	50.2
Magnesium, Mg	36.5
Ammonia, NH_4	0.1
Sodium, Na.	4.4
Potassium, K.	12.1
Sulfate, SO_4	10.9
Nitrate, NO_3	0.5
Chloride, Cl.	4.0
Alkalinity Methyl Orange.	296.0
Residue	293.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	0.9	.05
Potassium Chloride KCl	7.7	.45
Sodium Chloride NaCl.	0.5	.03
Sodium Sulfate Na_2SO_4	16.1	.94
Sodium Carbonate Na_2CO_3	15.3	.90
Ammonium Carbonate $(NH_4)_2CO_3$	0.3	.02
Magnesium Carbonate $MgCO_3$	126.2	7.38
Calcium Carbonate $CaCO_3$	125.3	7.33
Silica SiO_2	10.6	.62
Nonvolatile	0.7	.04
Iron Oxide Fe_2O_3	0.6	.03
Alumina Al_2O_3	6.8	.40
Total	311.0	18.19

DOWNERS GROVE (3543). Downers Grove is located in the southeastern part of Du Page County on the drainage area of Du Page River, a tributary of Des Plaines River.

A public water supply was installed by the village in 1894. Water was secured from two wells into rock. These were equipped with steam-head deep-well pumps. Another well has been drilled and equipped and changes have been made in equipment. In 1924 two wells had been equipped with air lift and one was equipped with a deep-well pump driven by a 10-horsepower electric motor. Air was supplied by an Ingersoll-Rand 17 and 10 by 14-inch compound compressor which was driven by a 190-horsepower electric motor. Water was pumped from the wells into a reservoir 26 feet in diameter and 20 feet deep and was pumped from the reservoir into the distribution system by either of two American two-stage centrifugal pumps, each direct connected to a 20-horsepower elec-

tric motor. A standpipe located on high ground in the village is connected to the distribution system. The pumping station was operated in connection with a municipal power plant. Dynamos are driven by oil engines. The distribution system is connected with that of the village of Westmont and at times water has been purchased from Westmont.

The rates for water (for three months?) are 50 cents per 1000 gallons for the first 5000 gallons with a minimum charge of $2.50, 25 cents per 1000 gallons for the next 5000 gallons, and 20 cents per 1000 gallons for all water in excess of 10000 gallons.

In February 1925 a 24-inch well was put in service and the wells referred to above were held in reserve. This new well is located at Randall Street and Park Avenue. It was drilled by the Kelly Well Company of Grand Island, Nebraska, in 1924. A record of material penetrated as given by the company is as follows:

	Thickness in feet.	Depth in feet.
Yellow clay and boulders	10	10
Blue clay and boulders	51	61
Gravel	2	63
Hard gravel and boulders (76 feet to water)	20	83
Hard gravel	1	84
Gravel and boulders	11	95
Fine sand	5	100
Sand and gravel	5	105
Total		105

The well is cased with concrete with 21 feet 8 inches of concrete screen in the bottom. During a test the yield was 450 gallons a minute and the water level was lowered 5 feet 6 inches.

The well is equipped with an Aurora Pump Company turbine pump with stages in the well placed at a depth of 92 feet. The capacity of the pump is 500 gallons a minute and the capacity of the well is estimated at 1550 gallons a minute. When the pump was put in operation the water level was at a depth of 76 feet. It has raised to 72 feet. In April 1925 the total amount of water pumped averaged about 250,000 gallons a day.

A sample of water, number 53266, collected from this well on February 18, 1925, had a mineral content of 506, a total hardness of 445, and a content of iron of 0.2 parts per million as shown by the analysis.

Three wells located in the western part of the village were in use until 1924. The elevation at the top of the wells is about 715 feet above sea level. The depths of the wells are not known definitely and the depths, or at least the original depths, may be

of little importance as a considerable part of the water supplied is probably from the upper parts of the wells.

Analysis of Sample Number 53266 from City Well 105 Feet Deep.

Determinations Made.	Parts per million.
Iron, Fe	0.2
Manganese, Mn	0.0
Silica, SiO_2	12.3
Nonvolatile	0.5
Alumina, Al_2O_3	1.6
Calcium, Ca	101.0
Magnesium, Mg	47.0
Ammonia, NH_4	0.1
Sodium, Na	16.8
Potassium, K	3.3
Sulfate, SO_4	81.7
Nitrate, NO_3	0.5
Chloride, Cl	6.0
Alkalinity	
Phenolphthalein	0.
Methyl Orange	378.
Residue	478 |

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	0.9	.05
Potassium Chloride KCl	5.5	.32
Sodium Chloride NaCl	5.6	.33
Sodium Sulfate Na_2SO_4	45.0	2.63
Ammonium Sulfate $(NH_4)_2SO_4$	0.2	.01
Magnesium Sulfate $MgSO_4$	64.0	3.70
Magnesium Carbonate $MgCO_3$	118.0	6.90
Calcium Carbonate $CaCO_3$	252.3	14.73
Iron Oxide Fe_2O_3	0.3	.02
Alumina Al_2O_3	1.6	.09
Silica SiO_2	12.3	.72
Nonvolatile	0.5	.03
Total	506.2	29.53

One well is 850 feet deep. It is equipped with a deep-well pump with a 5¾-inch Erb cylinder. Little water could be secured from this well in 1921 when the cylinder was at a depth of 90 feet.

A well 2021 feet deep is located 32 feet north and 5 feet west of the well 850 feet deep. A record of material penetrated as given by the J. P. Miller Artesian Well Company, with part of the classification given by the State Geological Survey Division, is as follows:

	Thickness in feet.	Depth in feet.
Clay, sand, and gravel	83	83
Limestone, Silurian system, all or chiefly Niagaran	187	270
Shale, Richmond	65	335
Limestone, Richmond	45	380
Shale, Richmond	100	480
Limestone, Galena-Platteville	337	817
Sandstone, St. Peter	223	1040
Marl and shale, Prairie du Chien	20	1060
Limestone, Prairie du Chien	55	1115
Marl, red, Prairie du Chien	23	1138
Limestone, Prairie du Chien	152	1290
Sandstone, Prairie du Chien	43	1333
Shale, Prairie du Chien	75	1408
Limestone, sandy, Prairie du Chien	27	1435
Sandstane, hard, Mazomanie, Cambrian system	60	1495
Sandstone, soft, Dresbach, Cambrian system	110	1605
Limestone and shale, Eau Claire, Cambrian system	25	1630
Shale, Eau Claire, Cambrian system	40	1670
Shale, sandy, Eau Claire, Cambrian system	85	1755
Shale, streaks of lime, Eau Claire, Cambrian system	85	1840
Limestone, Eau Claire, Cambrian system	60	1900
Shale, Eau Claire, Cambrian system	5	1905
Sandstone, Mt. Simon, Cambrian system	116	2021

The well was cased with 12-inch pipe to a depth of 90 feet. It was drilled 10¼ inches in diameter to a depth of 200 feet, 8¼ inches in diameter to a depth of 500 feet, 6¼ inches in diameter to a depth of 1040 feet, and 5 inches in diameter at the bottom. Forty-three feet of 5-inch casing was placed with the bottom at a depth of 1040 feet. In 1921 when the well was equipped with a deep-well pump with a 6½-inch Erb cylinder at a depth of 140 feet and with 20 feet of suction pipe attached to the cylinder the pump was operated with 36-inch stroke at a speed of 40 revolutions a minute.

A well 1800 feet deep is located 35 feet west and 18 feet south of the well 850 feet deep. In 1921 when this well was equipped with a deep-well pump with a 5¾-inch Erb cylinder placed at a depth of 150 feet and with 20 feet of suction pipe attached the pump was operated with 36-inch stroke at 40 revolutions a minute. The amount of water pumped from this well and the well 2021 feet deep in 1921 was estimated to be about 300,000 gallons a day.

The temperature of water discharged from the well 2021 feet deep was 51 degrees Fahrenheit on February 22, 1921. The water had a mineral content of 580, a total hardness of 430, and a content of iron of 0.1 parts per million as shown by the analysis of sample number 44728, collected on February 22, 1921.

Analysis of Sample Number 44728 from City Well 2021 Feet Deep.

Determinations Made.	Parts per million.
Iron, Fe.	0.1
Manganese, Mn.	0.0
Silica, SiO_2	16.4
Nonvolatile	1.3
Alumina, Al_2O_3	0.8
Calcium, Ca.	95.1
Magnesium, Mg.	47.1
Ammonia, NH_4	0.3
Potassium, K	24.2
Sodium, Na.	27.7
Sulfate, SO_4	138.3
Nitrate, NO_3	1.2
Chloride, Cl.	6.0
Alkalinity	
Phenolphthalein	0.
Methyl Orange.	386.0
Residue	563.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	2.0	.12
Potassium Chloride KCl.	12.6	.74
Potassium Sulfate K_2SO_4	37.6	2.19
Sodium Sulfate Na_2SO_4	85.7	5.05
Ammonium Sulfate $(NH_4)_2SO_4$	1.1	.07
Magnesium Sulfate $MgSO_4$	73.6	4.30
Magnesium Carbonate $MgCO_3$	111.6	6.53
Calcium Carbonate $CaCO_3$	237.5	13.89
Silica SiO_2	16.4	.96
Nonvolatile	1.3	.08
Iron Oxide Fe_2O_3	0.2	.01
Alumina Al_2O_3	0.8	.04
Total	580.4	33.98

DU QUOIN (7285). Du Quoin is located in the southeastern part of Perry County on the drainage area of Little Muddy River. Some residents of the city use water from wells from 8 to 40 feet deep and some use cistern water for drinking.

A public water supply was installed about 1898. Water was secured from a lake about 3½ miles west of the city and several miles of spiral riveted pipe were laid. In 1907 little was left of the pipe and in that year a supply was developed from an abandoned coal mine formerly known as the Browning mine, located a short distance northeast of the city. The mine shaft was about 60 feet deep and workings extended under an area of 600 acres. Water is pumped from the mine by a Hill two-stage centrifugal pump of 600 gallons a minute capacity. The pump is driven by a 75-horsepower electric motor. The pump and motor are placed in a pit 35 feet deep.

In 1923 pumping equipment was placed in an abandoned mine known as the Greenwood mine which is located a little less than half a mile north and east of the Browning mine. Water from this mine is used only in emergency. From the bottom of a pit a 16-inch casing extends into the mine at a depth of about 90 feet. A Hill vertical-shaft centrifugal pump attached to a drop pipe inside this casing is driven by a 75-horsepower motor which is placed in the pit.

The sources of supply are owned by the Illinois Power and Light Corporation. Water from the mines is pumped through pipe lines into the distribution system and part is pumped to two reservoirs at the power plant of the public service company. Water from one of these reservoirs, after chlorination, is pumped into the city mains by a Smith-Vaile 10 and 16 by 9 by 12-inch compound duplex steam pump. A centrifugal pump driven by an electric motor is also available for this service in case of emergency.

Eight hundred and twenty-seven service connections were in use in January, 1925. The water consumption during the last six months of 1924 averaged 500,000 gallons a day. The maximum amount used in one month from the Browning mine was in August when it averaged 540,000 gallons a day, and from the Greenwood mine it was in December when it averaged 285,000 gallons a day. Meter rates per month are 42½ cents per 1000 gallons for the first five thousand gallons, 27½ cents per 1000 gallons for the next 20000 gallons, and 20 cents per 1000 gallons for water in excess of 50000 gallons, with a minimum charge of 75 cents a month. A cash discount of 5 cents per 1000 gallons is allowed.

Sample number 53146 was collected from a tap when water was pumped from the Browning mine only on January 28, 1925. It had a mineral content of 1353 and a total hardness of 720 parts per million and contained no iron, as shown by the analysis.

Analysis of Sample Number 53146 from the Browning Mine.

Determinations Made.	Parts per million.
Iron, Fe	0.0
Manganese, Mn	0.0
Silica, SiO_2	13.0
Nonvolatile	1.1
Alumina, Al_2O_3	1.8
Calcium, Na	145.2
Magnesium, Mg	86.9
Ammonia, NH_4	0.2
Potassium, K	0.8
Sodium, Na	198.9
Sulfate, SO_4	557.3
Nitrate, NO_3	1.6
Chloride, Cl	18.0
Alkalinity	
Phenolphthalein	0.
Methyl Orange	504.
Residue	1423.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	2.1	.12
Sodium Nitrate $NaNO_3$	0.4	.03
Sodium Chloride NaCl	29.7	1.74
Sodium Sulfate Na_2SO_4	578.1	33.77
Ammonium Sulfate $(NH_4)_2SO_4$	0.9	.05
Magnesium Sulfate $MgSO_4$	207.6	12.13
Magnesium Carbonate $MgCO_3$	155.8	9.10
Calcium Carbonate $CaCO_3$	362.6	21.17
Alumina Al_2O_3	1.8	.11
Silica SiO_2	13.0	.76
Nonvolatile	1.1	.07
Total	1353.1	79.05

DWIGHT (2255). Dwight is located in the northeastern part of Livingston County on the drainage area of Mazon River, a tributary of Illinois River. Dug wells from 25 to 30 feet deep and drilled wells from 130 to 275 feet deep have been in use at some residences. The Keeley Company has a well 1075 feet deep and the Chicago and Alton Railroad Company has a well 2110 feet deep.

A public water supply was installed by the village in 1891. Water was secured from a well. Additional wells have been drilled and extensive improvements have been made. Water is pumped from the wells into a collecting reservoir by deep-well pumps which are driven by belts from a shaft. The reservoir is 31 feet in diameter. Water is pumped into the mains by either an American centrifugal pump or a 7 by 8-inch triplex pump. These pumps are also driven from the shaft. The shaft is turned by a 40-horsepower electric motor. Electric power is furnished by the Public Service Company of Northern Illinois. An oil engine is available for use in emergency.

Five hundred service connections were in use in 1924 and the water consumption, measured by meter at the station, averaged about 300,000 gallons a day.

Water is secured from three wells located near the center of the village at the corners of a triangle 30 by 25 by 50 feet. The elevation of the ground surface is about 640 feet above sea level. The wells are each 136 feet deep. A record of material penetrated is as follows:

	Thickness in feet.	Depth in feet.
Loam and blue clay	15	15
Blue clay and shale	45	70
Hardpan	38	108
Sand and gravel	28	136
Shale		

One well, to the east, is 6 inches in diameter and 136 feet deep. A Cook screen 8 feet long is placed in the bottom. The, well is equipped with a Goulds deep-well pump with a 53/4-inch cylinder wedged in the casing at a depth of 126 feet. The pump is operated with 24-inch stroke and in April, 1924, was running 34 revolutions a minute.

One well, slightly to the north of a line between the other two, is 8 inches in diameter and 136 feet deep. A Cook screen 8 feet long is placed in the bottom. Thewell is equipped with a Goulds pump with a 7¾-inch cylinder placed at a depth of 126 feet. The pump is operated with 24-inch stroke and in April, 1924, was running 35½ revolutions a minute.

The west well was 8 inches in diameter and was reamed to 10 inches by J. Eyer in 1923. A number 10 Cook screen eleven feet long is placed in the bottom. This well is equipped with a Goulds double-acting deep-well pump with a 71/2-inch cylinder attached to 90 feet of drop pipe and with 20 feet of suction pipe attached to the cylinder. The pump is operated with 24-inch stroke at 28 revolutions a minute.

The yield of the wells during tests lasting about 40 minutes each was measured in the reservoir on April 16, 1924. The 6-inch well yielded 89 gallons a minute, the 8-inch well yielded 154 gallons a minute, the 10-inch well yielded 223 gallons a minute, and the three wells operating together yielded 450 gallons a minute. The total amount of water pumped during 1923 averaged 233,000 gallons a day. The depth to water when not pumping was reported to be 36 feet in 1914 and 34 feet in 1919. When not pumping from the 10-inch well in 1923 the depth to water in that well was 35 feet.

The water had a mineral content of 1266, a total hardness of 600, and a content of iron of 3.6 parts per million as shown by the analysis of sample number 51271, collected on April 16, 1924, from a tap on the discharge from the middle well after the pump had been operated for thirty minutes.

Samples collected in 1905 and 1912 were similar though a little less highly mineralized. The sample collected in 1905 had a mineral content of 1086, a total hardness of 530, and a content of iron of 2.2 parts per million.

Analysis of Sample Number 51271 from the City Supply.

Determinations Made.	Parts per million.
Iron, Fe	3.6
Manganese, Mn	0.1
Silica, SiO_2	16.1
Nonvolatile	2.5
Alumina, Al_2O_3	6.4
Calcium, Ca	142.2
Magnesium, Mg	59.3
Ammonia, NH_4	5.2
Potassium, K	23.1
Sodium, Na	168.9
Sulfates, SO_4	605.3
Nitrates, NO_3	2.1
Chloride, Cl	32.0
Alkalinity Methyl Orange.	300.
Residue	1272.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	3.4	.20
Potassium Chloride KCl.	41.5	2.42
Sodium Chloride NaCl.	20.2	1.18
Sodium Sulfate Na_2SO_4	496.9	28.99
Ammonium Sulfate $(NH_4)_2SO_4$	18.9	1.10
Magnesium Sulfate $MgSO_4$	292.6	17.08
Calcium Sulfate $CaSO_4$	30.0	1.75
Calcium Carbonate $CaCO_3$	332.7	19.43
Iron Oxide Fe_2O_3	5.1	.18
Alumina Al_2O_3	6.4	.37
Silica SiO_2	16.1	.94
Nonvolatile	2.5	.15
Total	1266.3	73.79

The Keeley Institute had a well drilled by the J. P. Miller Artesian Well Company of Chicago in 1912, to secure a softer supply for their use. The top of the well is about eight feet below the tops of the city wells. The well is 1077 feet deep and is in St. Peter sandstone between depths of 795 and 1046 feet. The diameter is 6¼ inches at the bottom. The depth to water when not pumping was 37 feet when the well was completed and about 88 feet in 1919. The rate of pumping and amount pumped were estimated from the size and operation of the pump at 5 gallons a minute and 3000 gallons a day. The water had a mineral content of 960, a total hardness of 160, and a content of iron of 0.6 parts per million as shown by the analysis of sample number 43057, collected on May 18, 1920.

Analysis of Sample Number 43057 from Keeley Institute Well.

Determinations Made.	Parts per million.
Iron, Fe	0.6
Silica, SiO_2	8.1
Nonvolatile	1.4
Alumina, Al_2O_3	0.9
Calcium, Ca	44.9
Magnesium, Mg	21.7
Ammonia, NH_4	1.4
Potassium, K } Sodium, Na }	293.5
Sulfate, SO_4	94.5
Nitrite, NO_2	0.0
Nitrate, NO_3	0.7
Chloride, Cl	300.0
Alkalinity Methyl Orange.	338.0
Residue	992.0

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Sodium Nitrate $NaNO_3$	0.9	0.05
Sodium Chloride NaCl	494.4	28.88
Sodium Sulfate Na_2SO_4	139.6	8.16
Sodium Carbonate Na_2CO_3	122.1	7.14
Ammonium Carbonate $(NH_4)_2CO_3$	3.8	0.22
Magnesium Carbonate $MgCO_3$	75.3	4.39
Calcium Carbonate $CaCO_3$	112.2	6.56
Iron Oxide Fe_2O_3	0.8	0.05
Alumina Al_2O_3	0.9	0.05
Silica SiO_2	8.1	0.47
Nonvolatile	1.4	0.08
Total	959.7	56.06

The Chicago and Alton Railroad has a well 2110 feet deep. It was drilled by the J. P. Miller Artesian Well Company of Chicago in 1920. When completed water stood at a depth of 97 feet. With a pump cylinder attached to 259 feet of drop pipe the yield was over 300 gallons a minute. When the well was 1078 feet deep it had been tested with the same equipment and the yield had been 33 gallons a minute. A sample was collected on October 16, 1923, after pumping for four hours at a rate of 8500 gallons an hour. The water had a mineral content of 1225 and a total hardness of 323 parts per million as shown by the analysis, number 50343.

Analysis of Sample Number 50343 from Chicago and Alton Railroad Well.

Determinations Made.	Parts per million.
Calcium, Ca	70.7
Magnesium, Mg	36.0
Ammonia, NH_4	1.2
Sodium, Na	530.5
Sulfate, SO_4	269.2
Nitrate, NO_3	1.0
Chloride, Cl	370.0
Alkalinity Methyl Orange	244.
Residue	1218.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Sodium Nitrate $NaNO_3$	1.4	.08
Sodium Chloride NaCl	609.8	35.60
Sodium Sulfate Na_2SO_4	278.7	16.30
Ammonium Sulfate $(NH_4)_2SO_4$	4.5	.26
Magnesium Sulfate $MgSO_4$	96.7	5.65
Magnesium Carbonate $MgCO_3$	57.7	3.37
Calcium Carbonate $CaCO_3$	176.6	10.31
Total	1225.4	71.57

EARLVILLE (1012). Earlville is located in the northern part of La Salle County on the drainage area of Indian Creek, a tributary of Fox River.

A public water supply was installed by the city in 1894. Water from wells is pumped directly into a standpipe and the distribution system. The standpipe is 12 feet in diameter and 110 feet high. The pumps are driven by electric motors and the current is purchased from the Illinois Northern Utility Company. Two hundred and ninety service connections were in use in 1922 and the average consumption was estimated at 75,000 gallons a day. The charge is 30 cents per 1000 gallons when less than 75,000 gallons is used in three months and the lowest charge, when the amount used is over 525,000 gallons, is 13 cents per 1000 gallons. The minimum charge is $1.50 for three months.

Water for the public supply is secured from three wells located at the pumping station near the center of the city. The elevation of the station floor is about 700 feet above sea level. The two original wells are 12 feet apart. Each is 10 inches in diameter and 150 feet deep. These wells have been equipped with steam-head

deep-well pumps. At the time of last visit, on March 8, 1922, they were not in use but new equipment was being placed in one of the wells. The other well, the one in use at the time of visit, is 650 feet deep. It is located 17 feet from one of the old wells and 25 feet from the other. No exact record of material penetrated is available. Blue clay was entered at a depth of about 16 feet, rock was entered at a depth of about 40 feet, and St. Peter sandstone was entered at a depth of 60 or 65 feet. The well is 16 inches in diameter at the top and 12 inches in diameter at the bottom. It is equipped with an American double-stroke deep-well pump with 18-inch stroke and 9½-inch cylinder placed at a depth of 65 feet. The pump is driven by a 15-horsepower electric motor and operates about 22 revolutions a minute. At the time of visit- the discharge was estimated at from 180 to 190 gallons a minute. When the pump was idle for eleven hours the depth to water from the floor was 17.5 feet in this well and 17 feet in the well 17 feet distant. Pumping for 1½ hours lowered the water level 29 feet in this well and 4 feet in the well 17 feet distant. The total amount of water pumped was estimated at 75,000 gallons a day.

Water from the well 650 deep had a mineral content of 309, a total hardness of 240, and a content of iron of 0.8 parts per million as shown by the analysis of sample number 37765, collected on August 8, 1917.

Analysis of Sample Number 37765 from City Well 650 Feet Deep.

Determinations Made.	Parts per million.
Iron Oxide, Fe_2O_3	1.2
Silica, SiO_2	11.7
Alumina, Al_2O_3	7.5
Calcium, Ca	57.3
Magnesium, Mg	23.8
Potassium, K	2.7
Sodium, Na	24.3
Sulfate, SO_4	2.7
Nitrate, NO_3	1.3
Chloride, Cl	5.0
Alkalinity Methyl Orange	278.
Residue	315.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	2.1	.12
Potassium Chloride KCl	3.6	.21
Sodium Chloride NaCl	5.4	.31
Sodium Sulfate Na_2SO_4	4.0	.23
Sodium Carbonate Na_2CO_3	48.1	2.81
Magnesium Carbonate $MgCO_3$	82.4	4.80
Calcium Carbonate $CaCO_3$	143.0	8.34
Iron Oxide Fe_2O_3	1.2	.07
Alumina Al_2O_3	7.5	.44
Silica SiO_2	11.7	.68
Total	309.0	18.01

EAST ALTON (1669). East Alton is located in Madison County near the eastern limits of Alton. Water for a public supply is purchased from the Western Cartridge Company who have several wells from 75 to 90 feet deep into sand and gravel. The main source of supply in 1923 was a well 26 inches in diameter and 90

feet deep cased with porous concrete. The well is equipped with a Glendora pump with the cylinder placed at a depth of 60 feet. A large part of the supply is used by the Western Cartridge Company. They supply water to the New York Central Railroad, the village, and the Beal Machine Company. The total water supplied for eight months to August, 1923, averaged 700,000 gallons a day. The water level in a test hole 62 feet deep, 3 feet from the well, is at a depth of 36 feet when the pump is idle for three hours and is lowered to a depth of 46 feet when pumping.

A sample of water, number 42310, collected on December 22, 1919, from a well 85 feet deep then in use by the company, had a mineral content of 394 and a total hardness of 285 parts per million. It contained no iron.

Analysis of Sample Number 42310 from the Village Supply.

Determinations Made.	Parts per million.
Iron, Fe	0.00
Silica, SiO_2	22.10
Alumina, Al_2O_3	1.70
Calcium, Ca	80.50
Magnesium, Mg	20.16
Ammonia, NH_4	0.06
Potassium, K / Sodium, Na	17.14
Sulfate, SO_4	99.30
Nitrite, NO_2	0.00
Nitrate, NO_3	33.66
Chloride, Cl	22.00
Nonvolatile	1.10
Alkalinity Methyl Orange	158.
Residue	394.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Sodium Nitrate $NaNO_3$	46.07	2.69
Sodium Chloride NaCI	11.54	.68
Ammonium Chloride NH_4Cl	0.18	.01
Magensium Chloride $MgCl_2$	19.76	1.16
Magnesium Sulfate $MgSO_4$	76.37	4.47
Calcium Sulfate $CaSO_4$	56.15	3.28
Calcium Carbonate $CaCO_3$	159.82	9.35
Alumina Al_2O_3	1.70	.10
Silica SiO_2	22.10	1.30
Nonvolatile	1.10	.07
Total	394.79	23.11

EAST DUBUQUE (1163). East Dubuque is located in the northwestern part of Jo Davies County near the bank of Mississippi River. In the southern part of the city, where the ground is low, water is obtained in drift at a depth of from 28 to 40 feet. In other parts of the city rock is encountered within a few feet of the ground surface. On high land in the northern part of the city are some wells 200 feet deep.

A public water supply was installed by the city about 1885. Water from a well flows into a collecting reservoir from which it is pumped into the mains by an Alberger 3-inch four-stage centrifugal pump which is driven by a 25-horsepower electric motor. The discharge is measured by meter. The East Dubuque Electric Company furnishes power and pumps water for 9 cents per 1000

gallons. In 1923 one hundred and ninety-six service connections were in use. In six months, to October, 1923, the amount of water pumped, as registered by meter, averaged 33,000 gallons a day.

Water is secured from a well. The well was drilled about 1885 to a depth of 940 feet. In the Illinois Glacial Lobe, published in 1899, a statement is made that "the water is obtained from Potsdam standstone and has a head nearly 100 feet above the surface and a capacity estimated at 420 gallons a minute." The well casing corroded and tools were lost in the well. A 4-inch casing was installed to a depth of 165 feet and water was said to escape below this casing. In 1913 the yield was 60 gallons a minute. In 1914 the well was drilled to a depth of 1343 feet and cased with 6-inch and 4½-inch pipe to a depth of 426 feet. At the bottom of each line of casing in a steel shoe, and a rubber packer is placed between the 6-inch and the 4½-inch casings. The well is 4 inches in diameter at the bottom. After repairs the yield was said to be 300 gallons a minute. The flow was approximately 160 gallons a minute in 1919 and 123 gallons a minute on October 11, 1923.

The temperature of the water on October 11, 1923, was 62 degrees Fahrenheit. A sample of water, number 50318, collected after the pump had been operated for one hour on October 11, 1923, had a mineral content of 327, a total hardness of 287, and a content of iron of 0.8 parts per million as shown by analysis.

Analysis of Sample Number 50318 from the City Supply.

Determinations Made.

	Parts per million.
Iron, Fe	0.8
Manganese, Mn	0.0
Silica, SiO_2	20.2
Nonvolatile	0.8
Alumina, Al_2O_3	0.1
Calcium, Ca	60.9
Magnesium, Mg	33.0
Ammonia, NH_4	0.06
Sodium, Na	11.1
Potassium, K	1.0
Sulfate, SO_4	27.4
Nitrate, NO	1.1
Chloride, Cl	3.0
Alkalinity	
Phenolphthalein	0.
Methyl Orange	258.0
Residue	294.

Hypothetical Combinations.

	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	1.7	0.10
Potassium Chloride KCl	0.7	0.04
Sodium Chloride NaCl	4.3	0.25
Sodium Sulfate Na_2SO_4	29.0	1.69
Ammonium Sulfate $(NH_4)_2SO_4$	0.2	0.01
Magnesium Sulfate $MgSO_4$	10.0	0.58
Magnesium Carbonate $MgCO_3$	107.2	6.26
Calcium Carbonate $CaCO_3$	152.1	8.88
Iron Oxide Fe_2O_3	1.1	0.06
Alumina Al_2O_3	0.1	0.01
Silica SiO_2	20.2	1.18
Nonvolatile	0.8	0.04
Total	327.4	19.10

A sample of water collected in 1908, before the well was deepened in 1914, had a mineral content of 361, a total hardness of 243, and a content of iron of 1.1 parts per million.

EAST DUNDEE (1303). East Dundee is located in the northeastern part of Kane County on the east bank of Fox River. A public water supply was installed by the village in 1902. Water from a well and from springs is pumped into the distribution system by a 10 by 10-inch triplex pump driven by a 50-horsepower gas engine at a speed of 42 revolutions a minute. A standpipe 70 feet high connected to the distribution system is located on the highest land in the village. Two hundred and three consumers were supplied with water in 1923. The only firm using large quantities is the Bowman Dairy Company. The rate is 10 cents per 1000 gallons with a minimum charge of $6.00 a year.

The water supply is secured in part from a well installed in 1902 and in part from springs developed in 1915. Water is pumped from the two supplies alternately. The well is 9 feet in diameter and 25 feet deep. When pumping the water level is drawn down rapidly. On June 27, 1923, it was lowered from a depth of 5.4 feet to a depth of 13.0 feet in twenty-five minutes. The water raised 6.1 feet during the next hour while the pump was not operating, an average rate of inflow of 48 gallons a minute.

The spring supply was developed by laying 400 feet or more of sewer pipe with open points on a hill side near the east limits of the village. These pipe lines discharge into a concrete reservoir 60 feet in diameter and 18 feet deep with a capacity of 340,000 gallons. The reservoir is divided into two parts. It is located about 40 feet above the pump. The flow when tested on July 6, 1915, was 78 gallons a minute.

Analysis of Sample Number 49661 from Village Springs.

Determinations Made.	Parts per million.
Iron, Fe	0.0
Manganese, Mn	0.0
Silica, SiO_2	19.4
Nonvolatile	1.3
Alumina, Al_2O_3	1.4
Calcium, Ca	59.8
Magnesium, Mg	40.7
Ammonia, NH_4	0.0
Sodium, Na	53.8
Potassium, K	9.1
Sulfate, SO_4	44.9
Nitrate, NO_3	131.1
Chloride, Cl	13.0
Alkalinity Methyl Orange	266.
Residue	523.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	23.4	1.36
Sodium Nitrate $NaNO_3$	159.7	9.32
Sodium Chloride NaCl	21.4	1.25
Sodium Sulfate Na_2SO_4	6.6	0.38
Magnesium Sulfate $MgSO_4$	50.7	2.96
Magnesium Carbonate $MgCO_3$	105.3	6.15
Calcium Carbonate $CaCO_3$	149.4	8.72
Alumina Al_2O_3	1.4	0.08
Silica SiO_2	19.4	1.13
Nonvolatile	1.3	0.07
Total	538.6	31.42

Water from the spring supply had a mineral content of 538 and a total hardness of 315 parts per million as shown by the analysis of sample number 49661, collected on June 27, 1923.

This sample contains no iron but there is some stain by water, especially water secured near dead ends, indicating the presence of some iron.

EAST MOLINE (8675). East Moline is located in Rock Island County about three miles east of Moline. A public water supply has been installed and is owned by the city. Practically all residences use water from the public water supply. Water from two wells is pumped by air lift into a collecting reservoir. From the reservoir it is pumped into the distribution system by either of two American 5-inch two-stage centrifugal pumps. One is driven by a 75-horsepower motor and the other by a 100-horsepower motor. Air is supplied by an Ingersoll-Rand 14 and 9 by 12-inch compound compressor driven by a 75-horsepower electric motor. A smaller compressor is in reserve. Two elevated steel tanks are connected to the distribution system. One has a capacity of 100,000 gallons and the other a capacity of 500,000 gallons.

More than 2600 service connections were in use in 1923 and the water consumption was estimated at more than 500,000 gallons a day. The charge for water is $3.00 gross and $2.25 net for 1200 cubic feet or less in three months, 21 cents per 100 cubic feet for the next 2800 cubic feet, 17 cents per 100 cubic feet for the next 4000 cubic feet, 13 cents per 100 cubic feet for next 4000 cubic feet, and 10 cents per 100 cubic feet for all over 12,000 feet.

Water is secured from two wells located about 1000 feet apart. One well, installed by the East Moline Land Company, is located at the pumping station near the center of the business district. The elevation at the top of the well is 575 feet above sea level. The well was drilled to a depth of 1340 feet by the J. P. Miller Artesian Well Company of Chicago in 1895. It was repaired by the same company in 1913 when a 6-inch hole was drilled to a depth of 1532 feet. When the well was 800 feet deep is flowed. An 11-inch crevice was struck at a depth of 1500 feet and the flow increased to from 400 to 500 gallons a minute. (This from 400 to 500 may have been an estimate only as, when working in the other well in 1913, the yield of this well was given as 210 gallons a minute). The well is equipped with an air lift. In 1923 an air line of 2-inch and 1¼-inch pipe extended to a depth of 84 feet. The depth to water when not pumping was said to be 16 feet.

The other well is located back of the city hall, about 1000 feet distant from the shallower well. The elevation at the top is 573 feet above sea level. The well was drilled by the J. P. Miller Artesian Well Company of Chicago in 1911, and was drilled to a depth of 1850 feet by the same company in 1913. A partial record of material penetrated is as follows:

Drift	22	22
Limestone	....	....
Shale	....	....
....	....	....
Shale	90	525
Limestone	....	....
Shale	....	648
Limestone	218	866
Shale	thin	streak
Limestone	121	987
Sandstone	22	1009
Shale	16	1025
Limestone	10	1035
Sandstone	55	1090
Shale	3	1093
"Sandy" and limestone	271	1371
Limestone, streaks of sand		
Mud and soft sand	....	1500
Quartz rock	5	1510
Sandstone	78	1588
Limestone	....	1600
Shale	16	1616
Limestone and sandstone	159	1775
Red marl	1	
Sandy shale	....	1840
Limestone	10	1850

The well was cased with 10-inch pipe to rock, with 8-inch pipe from the ground surface to a depth of 153 feet, and with 82 feet of 6¼-inch casing with the bottom at 1115 feet.

When the well was 795 feet deep the water level raised, when 820 feet deep the well flowed, and when completed to a depth of 1371 feet in 1911 it flowed 109 gallons a minute. The flow decreased to about 70 gallons a minute in 1913. When the well was deepened in 1913 the flow increased at a depth of 1430 feet, increased considerably at 1500 feet, then dropped, and at 1540 feet the flow again increased to about the same as the yield of well number 1, which was 210 gallons a minute. When the well was completed the flow was 250 gallons a minute. This well is equipped with an air lift. The water level in 1923 was said to be at the surface of the ground. The yield of the two wells, computed from the rise of water level in the reservoir, was 750 gallons a minute at the time of visit on November 7, 1920, and 525 gallons a minute on August 2, 1923. On the latter date the 14 and 9 by 12 compound compressor was operated 160 revolutions a minute. From

data of test and station records the average daily consumption for the year to May, 1923, was estimated at 500,000 gallons a day.

The. temperature of water from each well on August 2, 1923, was 63 degrees Fahrenheit. The water had a mineral content of 1097 and a total hardness of 253 parts per million and contained no iron as shown by the analysis of sample number 49846, collected from a tap in the pumping station on August 2, 1923, when both wells had been operated continuously for a number of days.

Analysis of Sample Number 49846 from the City Supply.

Determinations Made.	Parts per million.
Iron, Fe	0.0
Manganese, Mn	0.0
Silica, SiO_2	23.8
Nonvolatile	2.0
Alumina, Al_2O_3	2.4
Calcium, Ca	55.3
Magnesium, Mg	28.0
Ammonia, NH_4	6.4
Sodium, Na	250.2
Potassium, K	59.1
Sulfate, SO_4	228.2
Nitrate, NO_3	1.7
Chloride, Cl	322.0
Alkalinity Methyl Orange.	222.
Residue	1172.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	2.8	0.16
Potassium Chloride KCl	110.6	6.46
Sodium Chloride NaCl	444.1	25.93
Sodium Sulfate Na_2SO_4	233.3	13.62
Ammonium Sulfate $(NH_4)_2SO_4$	23.6	1.38
Magnesium Sulfate $MgSO_4$	66.6	3.89
Magnesium Carbonate $MgCO_3$	50.5	2.95
Calcium Carbonate $CaCO_3$	137.9	8.05
Alumina Al_2O_3	2.4	0.14
Silica SiO_2	23.8	1.39
Nonvolatile	2.0	0.11
Total	1097.6	64.08

Fifteen hundred meters were repaired in two years from 1921 to 1923, and two hundred were repaired in 1924.

EAST PEORIA (2214). East Peoria is located in the northern part of Tazewell County close to Illinois River, across the river from Peoria. A public water supply was installed by the village in 1916. Water is drawn from wells by suction and pumped directly into the distribution system by either of two Goulds 8¼ by 10-inch triplex pumps. Each pump is driven by an electric motor. A concrete reservoir 40 feet in diameter and 11 feet deep of 100,000 gallons capacity is located close to the wells at the pumping station. The pumps can draw water from the reservoir or can draw from the wells and discharge into the reservoir. When starting the pumps, water is first discharged into the reservoir to give a low pressure to pump against. A standpipe 15 feet in diameter and 60 feet high, located on high land, is connected to the distribution system.

The public water supply is secured from eight wells located in the southeastern part of the village in the valley of Farm Creek

on the south side of Washington Street. Four wells were installed in 1916 and the other four in 1918. The wells are each 25 feet deep. They penetrate two or three feet of loam and are in sand and gravel below the loam. Seven of the wells are 6 inches in diameter and one is 8 inches in diameter. The four older wells, each 6 inches in diameter, are each equipped with a number 10 Cook screen twelve feet long. The other four wells are equipped with screens six feet long. The pumps are operated at a speed of 51 revolutions a minte, a displacement of 350 gallons a minute. The amount of water pumped during 1922 and the first seven months of 1923 was estimated at an average of 210,000 gallons a day. When operating one pump a vacuum gauge on the suction line registers 8 inches and when operating both pumps it registers 11 inches.

The water had a mineral content of 368, a total hardness of 320, and a content of iron of 0.2 parts per million as shown by the analysis of sample number 36134, collected at the pumping station on December 13, 1916.

Analysis of Sample Number 36134 from the Village Supply.

Determinations Made.	Parts per million.
Iron, Fe	0.2
Alumina, Al_2O_3	6.4
Calcium, Ca	86.8
Magnesium, Mg	25.6
Ammonia, NH_4	0.0
Sodium, Na	13.7
Potassium, K	2.6
Sulfate, SO_4	63.2
Nitrate, NO_3	5.6
Chloride, Cl	5.0
Alkalinity Methyl Orange	298.
Residue	425.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	6.7	.39
Sodium Nitrate $NaNO_3$	2.1	.12
Sodium Chloride NaCl	8.3	.48
Sodium Sulfate Na_2SO_4	30.2	1.76
Magnesium Sulfate $MgSO_4$	53.7	3.12
Magnesium Carbonate $MgCO_3$	37.6	2.19
Calcium Carbonate $CaCO_3$	216.8	12.64
Iron Oxide Fe_2O_3	0.4	.02
Alumina Al_2O_3	0.7	.04
Silica SiO_2	12.4	.72
Total	368.8	21.52

EAST WENONA (333). East Wenona is located in the southwestern part of La Salle County east of and adjoining the city of Wenona. Water for a public supply is purchased from the city of Wenona. In 1917 thirty-seven connections were in use.

EDWARDSVILLE (5336). Edwardsville is located in the central part of Madison County. A public water supply was installed by the Edwardsville Water Works Company who were granted a franchise in 1898. They developed a supply from wells

into sand and gravel in bottom lands of Mississippi River at Poag five miles west of Edwardsville.

Water was pumped from the wells by a steam pump placed in a pit seven feet deep. Later additional wells were drilled, additional equipment was installed; and a reservoir was built. The reservoir is 70 feet square at the top and 10 feet deep with side slopes of three horizontal to two vertical, and has a dividing wall. An American 2-stage centrifugal pump of 700 gallons a minute capacity driven by a 100-horsepower electric motor and a 12 and 18 by 10 by 12-inch Gardner duplex steam pump draw water from the reservoir and pump into the pipe line to the city. Steam is supplied by a 125-horsepower fire-tube boiler.

One thousand and forty service connections including many to railroad properties, coal mines, and manufacturing plants were in use in 1923 and all were metered. The rate for 15,000 gallons or less used in three months is 50 cents per 1000 gallons and the lowest industrial rate, for quantities in excess of 1,000,000 gallons, is 11 cents per 1000 gallons. The minimum charge is $3.00 a quarter.

Water for the public supply is secured from two wells 80 feet apart located at Poag near the original Wells and other wells which have been in use until recently. The wells were drilled in 1922. Nearly all of the supply is from a well 110 feet deep. It is 24 inches in diameter and cased to a depth of 65 feet. Below the casing is 39 feet of 8-inch Baits strainer with 0.12-inch slots. The well is in sand which is coarser towards the bottom and the bottom of the well is on rock. The well is equipped with an American single-stage centrifugal pump placed at a depth of 30 feet with 31 feet of suction pipe attached. This pump can discharge into the reservoir or into the suction line of the steam pump. On August 20, 1923, the yield was about 1000 gallons a minute, as determined by computing the amount of water added to the reservoir and estimating the amount drawn from the reservoir by the steam pump, allowing 15 per cent for slip. The water level in one of the old wells stood at a depth of 23 feet below the ground surface during the test. The well pump was operating from 20 to 24 hours a day. In 1922 the total amount of water pumped, principally from this well, averaged 495,000 gallons a day.

The other well is 115 feet deep and cased 28 inches in diameter to a depth of 75 feet. Below the casing is 40 feet of Cook screen with 0.12-inch slots. The well is equipped with a Pomona two-stroke pump with 15¾-inch cylinder placed at a depth of 70 feet.

The water had a mineral content of 251, a total hardness of 175, and a content of iron of 1.8 parts per million as shown by the analysis of sample number 49965, collected from a tap in the city on August 20, 1923.

Analysis of Sample Number 49955 from City Supply.

Determinations Made.	Parts per million.
Iron, Fe	1.8
Manganese, Mn	0.0
Silica, SiO_2	24.2
Nonvolatile	0.5
Alumina, Al_2O_3	1.0
Calcium, Ca	50.4
Magnesium, Mg	11.9
Ammonia, NH_4	0.0
Sodium, Na	15.1
Potassium, K	1.7
Sulfate, SO_4	35.9
Nitrate, NO_3	6.7
Chloride, Cl	8.0
Alkalinity Methyl Orange	144.
Residue	234.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	4.4	0.25
Sodium Nitrate $NaNO_3$	5.4	0.31
Sodium Chloride NaCl	13.1	0.76
Sodium Sulfate Na_2SO_4	26.0	1.52
Magnesium Sulfate, $MgSO_4$	22.9	1.34
Magnesium Carbonate, $MgCO_3$	25.3	1.48
Calcium Carbonate, $CaCO_3$	125.9	7.35
Iron Oxide, Fe_2O_3	2.6	0.15
Alumina, Al_2O_3	1.0	0.06
Silica, SiO_2	24.2	1.41
Nonvolatile	0.5	0.03
Total	251.3	14.66

A sample of water collected in 1914 from wells 55 to 80 feet deep, then in use, was of the same quality.

EILEEN (342). Eileen is located in the eastern part of Grundy County near Coal City. A few residences are supplied with water from the Coal City supply.

EL PASO (1638). El Paso is located in the southeastern part of Woodford County on the drainage area of Mackinaw River, a tributary of Illinois River. Some water is obtained from private wells from 30 to 60 feet deep.

A public water supply was installed by the city about 1878. Water is pumped from a well directly into the distribution system to which an elevated steel tank of 112,000 gallons capacity is connected. The top of the tank is 100 feet above the foundations. The pump is a Goulds 8 by 10-inch triplex and it is driven by belt from a 20-horsepower electric motor. All water passes through a meter. Practically all residents and two canning factories located in the village use water from the public supply. One company has two wells into sand and gravel which furnish a large part of their supply. Water from the public supply is sold at a rate of 35 cents per 1000 gallons.

The public water supply is secured from a well located west of the center of the village. The well is dug 8 feet in diameter to a depth of 60 feet. In the bottom of the dug well are three tubular wells which extend to a depth of 120 feet below the ground surface. A record of material penetrated is as follows:

	Thickness in feet.	Depth in feet.
To bottom of large well	. .	60
Pink clay with gravel	10	70
Clay, yellow	15	85
Bluish gray clay with gravel (called boulder clay)	14	99
Hard cemented gravel	7	106
Clean gravel	14½	120½

One of these tubes is cased with 4-inch pipe and the other two are cased with 8-inch pipe. One was drilled to a depth of 123 feet where a stratum of brown clay was encountered. The bottom of the dug part of the well has been covered with concrete and all water gaining access to the dug well is pumped to waste through a tile drain by a pump which is operated by an electric motor with automatic control.

Analysis of Sample Number 42932 from the City Supply.

Determinations Made.	Parts per million.
Iron, Fe	1.2
Manganese, Mn	trace
Silica, SiO_2	18.4
Nonvolatile	0.4
Alumina, Al_2O_3	5.2
Calcium, Ca	84.8
Magnesium, Mg	34.9
Ammonia, NH_4	10.3
Sodium, Na / Potassium, K	45.4
Sulfate, SO_4	50.7
Nitrite, NO_2	0.0
Nitrate, NO_3	1.0
Chloride, Cl	6.0
Alkalinity Methyl Orange	420.
Residue	540.0

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Sodium Nitrate, $NaNO_3$	1.4	0.08
Sodium Chloride, NaCl	9.9	0.58
Sodium Sulfate' Na_2SO_4	74.9	4.38
Sodium Carbonate. Na_2CO_3	38.5	2.25
Ammonium Carbonate, $(NH_4)_2CO_3$	27.4	1.60
Magnesium Carbonate, $MgCO_3$	120.8	7.04
Calcium Carbonate, $CaCO_3$	211.8	12.35
Iron Oxide, Fe_2O_3	1.7	0.10
Alumina, Al_2O_3	5.2	0.31
Silica, SiO_2	18.4	1.07
Nonvolatile	0.4	0.02
Total	510.6	29.78

Water is pumped from the tubular wells into the mains by an 8 by 10-inch triplex pump. The cylinders of the pump are placed near the bottom of the dug well and a suction pipe extends into each of the tubular wells. The pump can supply more than 200 gallons a minute. Very large quantities have been supplied for road paving. The amount of water pumped from July 1, 1920, to June 16, 1924, as registered by meter, averaged 72,000 gallons a day. A vacuum gauge below the pump cylinders registers from

15 to 22 inches during pump operation. During the canning season it often registers 22 inches.

The water had a mineral content of 510, a total hardness of 355, and a content of iron of 1.2 parts per million as shown by the analysis of sample number 42932, collected from a tap on April 27, 1920.

ELBURN (571). Elburn is located in the central part of Kane County on the drainage area of Fox River. A public water supply was installed by the village about 1900. Water was pumped from a well into the mains. In 1916 a reservoir was built and water from the well is now discharged into the reservoir from the well pump and is pumped from the reservoir into the mains by a Ramsey and Company single-acting triplex pump. The reservoir is 50 feet long, 30 feet wide, and 8 feet 8 inches deep. Two steel pressure tanks, each 8 feet in diameter and 36 feet long, located in the pumping station, are connected to the mains. Air is supplied by a Challenge air compressor. Steam to operate the pumping plant and an electric light plant operated in connection with it, is supplied by a 50-horsepower boiler. Ninety-one consumers were supplied in 1917.

Analysis of Sample Number 38032 from the Village Supply.

Determinations Made.	Parts per million.
Iron, Fe	0.2
Silica, SiO_2	11.2
Nonvolatile	0.6
Alumina, Al_2O_3	2.3
Calcium, Ca	66.5
Magnesium, Mg	25.6
Ammonia, NH_4	1.5
Sodium, Na	30.3
Potassium, K	9.4
Sulfate, SO_4	3.4
Nitrate, NO_3	2.2
Chloride, Cl	4.0
Alkalinity Methyl Orange	304.
Residue	330.

Hypothetical Combinations.	Pars per million.	Grains per gallon.
Potassium Nitrate, KNO_3	3.6	.21
Potassium Chloride, KCl	8.4	.49
Potassium Sulfate, K_2SO_4	6.2	.36
Potassium Carbonate, K_2CO_3	1.4	.08
Sodium Carbonate, Na_2CO_3	69.7	4.06
Ammonium Carbonate, $(NH_4)_2CO_3$	4.0	.23
Magnesium Carbonate, $MgCO_3$	88.6	5.16
Calcium Carbonate, $CaCO_3$	165.9	9.67
Iron Oxide, Fe_2O_3	0.3	.02
Alumina, Al_2O_3	2.3	.14
Silica, SiO_2	11.2	.65
Nonvolatile	0.6	.03
Total	362.2	21.10

Water is secured from a well 1450 feet deep. It penetrates about 120 feet of drift. Records on file with the State Geological Survey Division show that a well of the Illinois Condensing Company was in sandstone between depths of 614 and 680 feet, between depths of 870 and 920 feet, and below a depth of 1105 feet. The village well is 10 inches in diameter at the top and 4 inches in

diameter at the bottom. The capacity of the deep-well pump at the speed operated in 1917 was said to be from 100 to 125 gallons a minute. The cylinder was placed at a depth of 125 or 130 feet and was later lowered to a depth of 154 feet.

The water had a mineral content of 362, a total hardness of 270, and a content of iron of 0.2 parts per million as shown by the analysis of sample number 38032, collected on September 11, 1917.

ELGIN (27,454). Elgin is located in the northeastern part of Kane County on the banks of Fox River. A public water supply was installed by the city in 1887-1888. A pumping station was built on the east bank of Fox River near the northern limits of the city. Water was pumped from the river through pressure filters into the mains. In 1901 the drilling of wells into Cambrian sandstone was started and since 1904 the supply has been principally from wells, though the filters have been maintained and have been used at times when demands were greater than the capacity of the wells.

Water from one well in the southern part of the city is pumped directly into the distribution system. Water from other wells, all near the pumping station, is discharged into either of two collecting reservoirs, each 90 feet in diameter and 21 feet deep with a capacity of 1,000,000 gallons. A Holly pump of 6,000,000 gallons capacity is used to pump water from the reservoirs into the mains. An American 8-inch centrifugal pump of 3,000,000 gallons capacity driven by a steam turbine and a Worthington compound duplex pump of 1,500,000 gallons capacity are also available for this service. Steam is supplied by four boilers, three of 200-horsepower each and one of 250-horsepower. Electric power is purchased from the Aurora Elgin and Fox River Electric Co.

The public water supply is secured from eight wells. Four wells located close to the pumping station near the northern limits of the city were completed in 1904. They were drilled into Potsdam sandstone. The wells are nearly in line extending from southwest to northeast and the distance from well number 1, the southwest well, to well number 4, the northeast well, is 450 or 500 feet. The tops of the four wells and the pumping station floor are all within a few feet of 722 feet above sea level. Well number 1 was drilled to a depth of 2005 feet.

An abstract of a log of this well, on file with the State Geological Survey Division, is as follows:

	Thickness in feet.	Depth in feet.
Clay, sand and gravel	38	38
Dolomite and limestone	27	65
Shale, Maquetoka	50	115
Dolomite (Galena-Plattville)	445	560
Sandstone (St. Peter)	142	702
Dolomite, Prairie Du Chien	198	900
Shale, Prairie Du Chien	150	1050
Sandstone, Cambrian System	250	1300
Shale, Cambrian System	50	1350
Dolomite, Cambrian System	74	1424
Sandstone, Cambrian System	156	1580
Shale, Cambrian System	55	1635
Sandstone, Cambrian System	370	2005

The well was tested and it was decided that the yield when plugged at a depth of 1400 feet was as great as when drawing from the entire well. The other three wells were then drilled to a depth of about 1300 feet.

Water is pumped from the wells by an American centrifugal pump placed in a shaft 115 feet deep. It is driven by a vertical compound high speed steam engine at the top of the shaft. Another unit is available but was in poor repair in 1924. A tunnel extends from the shaft to well number 1 and another tunnel extends from the shaft to wells 2, 3, and 4.

When the wells were drilled the depth to water was about eleven feet. In 1911 the pump used to pump from the shaft was said to discharge at a rate of 2,500,000 gallons a day. During the preceding year the average water consumption was 2,150,000 and during times of greatest demands part of the supply was taken from the river. The depth to water was about 40 feet when not pumping.

In 1917 Dabney H. Maury reported that a 25 pound weight was lowered to depths of 1159, 1272, 1178, and 589 feet in wells 1, 2, 3, and 4 respectively. From the results of tests he estimated that when all wells were in use the yields were 164 gallons a minute from number 1, 500 gallons a minute from number 2, 452 gallons a minute from number 3, and 300 gallons a minute from number 4. The water level when the pumps were idle for several hours was 52.6 feet below the pumping station floor and after all wells were pumped for four hours it was 124.5 feet below the floor.

In 1921 the yield of the four wells was estimated at 1,500,000 gallons a day.

In 1924 the yield of the four wells had decreased to probably 1,200,000 gallons a day. When not pumping the pressure on the suction line to the pumps in the pit was about 12 pounds and when

pumping the water level was drawn down to the suction line about 115 feet below the floor level.

Wells 2, 3 and 4 were drilled deeper in 1924. Wells 2 and 3 were drilled to depths of 1950 and 1960 feet and work was progressing on well number 4 which was to be drilled to the same depth. Well number 4 was shut off from the supply works in the fall, but turbid water was pumped while drilling showing that part of the water pumped was secured from that well. The water pumped from these deep wells, and the discharge from a well about 36 feet deep was said to fill the two reservoirs at a rate of about one foot an hour. Allowing 350 gallons for the discharge from the well 36 feet deep, the yield of the deep wells was probably close to 1200 gallons a minute. The pressure on the suction line to the pumps in the pit was thirty pounds when not pumping and six or seven pounds when pumping.

A sample of water, number 53090, was drawn from the discharge line from these wells on January 13, 1925 when the pump had operated for six hours and when drillers had not worked on well number 4 during the preceding 18 hours. The water had a mineral content of 341, a total hardness of 230, and a content of iron of 0.3 parts per million as shown by the analysis.

Analysis of Sample Number 53090 from City Wells Into Cambrian Sandstone.

Determinations Made.	Parts per million.
Iron, Fe	0.3
Manganese, Mn	trace
Silica, SiO_2	16.2
Nonvolatile	2.6
Alumina, Al	14.7
Calcium, Ca	52.8
Magnesium, Mg	24.0
Ammonia, NH_4	0.5
Potassium, K	13.0
Sodium, Na	26.0
Sulfate, SO_4	14.3
Nitrate, NO_3	0.9
Chloride, Cl	12.0
Alkalinity	
Phenolphthalein	0.
Methyl Orange	296.
Residue	346.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate, KNO_3	1.4	.08
Potassium Chloride, KCl	23.8	1.39
Sodium Chloride NaCl	1.2	.07
Sodium Sulfate, Na_2SO_4	21.3	1.25
Sodium Carbonate, Na_2CO_3	42.9	2.51
Ammonium Carbonate, $(NH_4)_2CO_3$	1.2	.07
Magnesium Carbonate, $MgCO_3$	83.1	4.86
Calcium Carbonate, $CaCO_3$	131.9	7.71
Iron Oxide, Fe_2O_3	0.4	.02
Alumina, Al_2O_3	14.7	.87
Silica, SiO_2	16.2	.95
Manganese Oxide, MnO_2	0.4	.02
Nonvolatile	2.6	.15
Total	341.1	19.95

A sample collected in 1905, not long after the wells were drilled, had a mineral content of 342, a total hardness of 328, and a content of iron of 0.9 parts per million. Two samples were collected in 1915 when the lower parts of the wells were probably

partly clogged. The average mineral content was 358, the average hardness was 304, and the average iron content was 0.7 parts per million.

Three 6-inch wells have been drilled to a depth of about 37 feet. The wells are located 160 to 200 feet south and west from the nearest well into Cambrian sandstone, well number 1. The tops of the wells are 720 feet above sea level. A centrifugal pump placed in a pit about 15 feet below the ground surface at the top of the southwest well draws water from this well and the center well. The northeast well is similarly equipped but the pump draws water from only the one well. In the summer of 1921 the wells were in continuous service and the yield was estimated at 500,000 gallons a day. In 1924 one pump only was operated and the yield was thought to be about the same.

A sample of water, number 53091, collected from this supply on January 13, 1925, had a mineral content of 407, a total hardness of 340, and a content of iron of 1.4 parts per million as shown by the analysis.

Analysis of Sample Number 53091 from City Wells 37 Feet Deep.

Determinations Made.	Parts per million.
Iron, Fe	1.4
Manganese, Mn	trace
Silica, SiO_2	12.0
Nonvolatile	0.3
Alumina, Al_2O_3	13.0
Calcium, Ca	77.3
Magnesium, Mg	35.9
Ammonia, NH_4	4.6
Sodium, Na	11.2
Potassium, K	1.9
Sulfate, SO_4	49.4
Nitrate, NO_3	1.4
Chloride, Cl	10.0
Alkalinity	
Phenolphthalein	0.
Methyl Orange	320.
Residue	391.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate, KNO_3	2.3	.14
Potassium Chloride, KCl	1.9	.11
Sodium Chloride, NaCl	15.0	.88
Sodium Sulfate, Na_2SO_4	16.6	.97
Ammonium Sulfate, $(NH_4)_2SO_4$	17.0	.99
Magnesium Sulfate, $MgSO_4$	32.3	1.89
Magnesium Carbonate, $MgCO_3$	101.9	5.96
Calcium Carbonate, $CaCO_3$	193.2	11.29
Iron Oxide, Fe_2O_3	2.0	.12
Alumina, Al_2O_3	13.0	.77
Silica, SiO_2	12.0	.71
Nonvolatile	0.3	.02
Total	407.5	23.85

Samples collected in 1914 and 1915 from a well then in use which was of about the same depth were of about the same quality.

In 1921 a well was drilled in the southern part of the city on the east side of St. Charles Street between Dixon and Elgin Avenues. The well was drilled by the Kelly Well Company of Grand Island, Nebraska. The elevation at the top is 756 feet above sea level. A record of material penetrated as given by the drillers is as follows:

	Thickness in feet.	Depth in feet.
Clay, gravel and boulders	13	13
Gravel and clay	17	30
Clay	10	40
Clay, few boulders, and fine sand	23	63
Fine sand	1	64
Clay and gravel.	13	77
Coarse sand	11	88
Gravel and boulders	9	97
Boulders	4	101

To the south and southeast on higher ground are extensive gravel pits. Gravel is excavated to clay which is at about the same elevation as the top of this well so the gravel penetrated by the well seems to be in a lower stratum than the gravel in the pit. The well is cased with 24-inch concrete casing. In the bottom is twenty-two feet of concrete screen. The well was tested for several hours each day for four days and yielded 1080 gallons a minute. When testing this well the yield of a well into the same stratum at the plant of the Western Thread Company, about 1000 feet distant, was said to decrease considerably.

Analysis of Sample Number 53092 from City Well 101 Feet Deep.

Determinations Made.	Parts per million.
Iron, Fe	1.2
Manganese, Mn	0.0
Silica, SiO_2	15.2
Nonvolatile	0.0
Alumina, Al_2O_3	11.5
Calcium, Ca	57.9
Magnesium, Mg	30.3
Ammonia, NH_4	2.3
Sodium, Na	32.7
Potassium, K	4.3
Sulfate, SO_4	16.4
Nitrate, NO_3	0.5
Chloride, Cl	9.0
Alkalinity as $CaCO_3$	
Phenolphthalein	0.
Methyl Orange	344.
Residue	377.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate, KNO_3	0.9	.05
Potassium Chloride, KCl	7.4	.43
Sodium Chloride, NaCl	9.0	.53
Sodium Sulfate, Na_2SO_4	24.2	1.42
Sodium Carbonate, Na_2CO_3	49.2	2.88
Ammonium Carbonate, $(NH_4)_2CO_3$	6.0	.35
Magnesium Carbonate, $MgCO_3$	105.3	6.16
Calcium Carbonate, $CaCO_3$	145.1	8.49
Iron Oxide, Fe_2O_3	1.7	.10
Alumina, Al_2O_3	11.5	.67
Silica, SiO_2	15.2	.88
Nonvolatile	0.0	
Total	375.5	21.96

Water is pumped from the well into the distribution system by an American 8-inch centrifugal pump which is placed in a pit eleven feet deep. The pump is driven by an electric motor. The yield is about as at the time of test but varies some with variations in electric power and water pressures. The discharge is metered. The water level is about eleven feet below the ground surface when not pumping and a vacuum gauge on the suction line indicates from 16 to 20 inches when pumping. The pump is usually operated eight hours a day but during the summer it is at times

operated longer with no noticeable difference in operation. During 1924 the amount of water pumped was 235,420,000 gallons.

A sample of water, number 53092, collected from this well on January 13, 1925, had a mineral content of 375, a total hardness of 269, and a content of iron of 1.2 parts per million as shown by the analysis.

Compared to the sample of water from the wells into Cambrian sandstone the sample from the well into sand and gravel contained more iron and the sample from the wells 37 feet deep into limestone contained more iron and was harder. Samples would show some variation but the ones given are probably fairly representative.

ELIZABETH (687). Elizabeth is located in the central part of Jo Daviess County on the drainage area of Apple River, a tributary of Mississippi River. A public water supply was installed by the village in 1904. Water is pumped from a well directly into the distribution system by a deep-well pump which is driven by belt from a 20-horsepower gasoline engine. A reservoir 40 feet in diameter and 22 feet deep located on a hill a quarter of a mile southwest of the village, just outside of the village limits, is connected to the mains. One hundred and forty service connections were in use in 1923. The meter rate for water is 50 cents per 1000 gallons with a minimum charge of 50 cents a month. Rates are not subject to cash discount.

Water is secured from a well 260 feet deep which was drilled in 1904. The ground surface at the well is about 900 feet above sea level. The well is cased with 8-inch pipe to a depth of 40 feet, 20 feet into rock. It is equipped with a double-acting pump with a 4¾-inch cylinder attached to 230 feet of drop pipe and 12 feet of suction pipe is attached to the cylinder. The pump is operated with 18-inch stroke at a speed of 22 revolutions a minute. In 1923 the pump was said to have been operated about 10 hours a day for 5 days a week in the summer time. The water level is never drawn down to the pump cylinder.

The temperature of water when discharged from the well was 52 degrees Fahrenheit. The water had a mineral content of 543, a total hardness of 477, and a content of iron of 0.2 parts per million, as shown by the analysis of sample number 50291, collected on October 10, 1923, after the pump had been operated for 1¼ hours.

About twelve meters are repaired annually. Some meters were in use from 1904 to 1923 without repairs.

Analysis of Sample Number 50291 from the Village Supply.

Determinations Made.

	Parts per million.
Iron, Fe	0.2
Manganese, Mn	0.0
Silica, SiO_2	24.7
Nonvolatile	1.6
Alumina, Al_2O_3	0.0
Calcium, Ca	99.6
Magnesium, Mg	55.7
Ammonia, NH_4	0.0
Sodium, Na	13.8
Potassium, K	2.0
Sulfate, SO_4	91.8
Nitrate. NO_3	2.6
Chloride, Cl	30.0
Alkalinity Methyl Orange	340.0
Residue	559.

Hypothetical Combinations.

	Parts per million.	Grains per gallon.
Potassium Nitrate, KNO_3	4.2	0.24
Potassium Chloride, KCl	0.6	0.03
Sodium Chloride, NaCl	34.9	2.04
Magnesium Chloride, $MgCl_2$	11.4	0.66
Magnesium Sulfate, $MgSO_4$	114.9	6.71
Magnesium Carbonate, $MgCO_3$	102.3	5.97
Iron Oxide, Fe_2O_3	0.3	0.02
Alumina, Al_2O_3	0.0	0.00
Silica, SiO_2	24.7	1.44
Nonvolatile	1.6	0.09
Calcium Carbonate, $CaCO_3$	248.6	14.52
Total	543.5	31.72

ELMHURST (4594). Elmhurst is located in the eastern part of Du Page County on the drainage area of Des Plaines River. A public water supply was installed by the Elmhurst Spring Water Company in 1890. The supply was developed from Mammoth Spring located about three miles south of the city. In 1914 the amount of water supplied to the city was estimated at nearly 200,000 gallons a day. The pipe line to the city and practically all water mains were of wood stave pipe. The supply became insufficient due to the growth of the city and leakage of mains which were not replaced or repaired when the franchise was about to expire.

A public water supply to replace the spring supply was developed by the city from 1915 to 1919 with wells as a source of supply. Water is pumped from two wells into a concrete collecting reservoir 38 feet in diameter. The pumping equipment is housed in two buildings. In one building are two Cameron single-stage centrifugal pumps of 550 gallons a minute capacity, each driven by a 50-horsepower electric motor, and an Ingersoll-Rand compressor driven by a 50-horsepower electric motor. The upper floor of this building is used for offices of the water department. In the other building, on the next lot east, are a single-stage centrifugal pump, an air compressor, and a dynamo which are driven by a 105-horsepower oil engine. Power was formerly purchased from a utility company but in 1923 the oil engine was used.

Sixteen hundred service connections were in use in January, 1924. The minimum rate for water is 50 cents a month and the lowest rate, for large quantities of water is 20 cents per 1000 gallons.

Water for the public supply is secured from two wells near the southeast corner of York and Schiller Streets. The elevation of the surface of the ground is about 675 feet above sea level. The west well was drilled in 1915. It is 17 inches in diameter at the top, 12 inches in diameter below a depth of 71 feet, and 958 feet deep. It is reported that after completion this well was tested by pumping for several hours at a rate of 500 gallons a minute and that the water level was lowered seven feet. The well was formerly equipped with a deep-well pump. In 1923 an air lift was installed with a 2-inch air line to a depth of 289 feet. During November, 1923, this air lift operated 9 hours 55 minutes and yielded 166,900 gallons of water, a rate of yield of 280 gallons a minute. This well is not used when the other well can supply demands. The depth to water in this well when not pumping in 1918 was 35 feet. In 1924 the water level when not pumping was said to be 62 feet below the ground surface.

The other well was drilled in 1918-1919 by F. M. Gray, Jr. It is 100 feet east of the well drilled in 1915. An abstract of a log with part of the classifications given by the State Geological Survey Division is as follows:

	Thickness in feet.	Depth in feet.
Glacial drift	25	25
Glacial drift, gravel	36	61
Limestone, Silurian system, all or chiefly Niagaran	217	278
Shale, Richmond	182	460
Limestone, some shale, Galena-Platteville	327	787
Sandstone, St. Peter	98	885
Shale, St. Peter	2	887
Conglomerate, St. Peter	5	892
Limestone, Prairie du Chien	188	1080
Limestone, Prairie du Chien	80	1160
Sandstone, Mazomanie, Cambrian system	110	1270
Sandstone, Dresbach, Cambrian system	120	1390
Marl, Eau Claire, Cambrian system	8	1398

The well is cased with 12-inch pipe to a depth of 195 feet, is 10 inches in diameter between depths of 195 and 700 feet, and is 8 inches in diameter below a depth of 700 feet. The well is equipped with an air lift with 298 feet of 2-inch air line. On January 14, 1924, the well yielded 526 gallons a minute for one hour as computed from the change in water level in the reservoir and readings of a Republic meter which records water pumped from the reservoir. The air pressure during operation was 101 pounds. During November and December, 1923, the air lift in this well operated 788 hours and the amount of water pumped from both wells was 24,137,000 gallons as recorded by a Venturi meter. Allowing for 166,900 gallons which

was pumped from the other well the average rate of yield for this well was 528 gallons a minute. The water level when not pumping is said to be 62 feet below the ground surface.

A sample of water, number 43323, collected from the deeper well on June 23, 1920, had a mineral content of 447, a total hardness of 365, and a content of iron of 0.6 parts per million as shown by the analysis.

Analysis of Sample Number 43323 from the City Well 1398 Feet Deep.

Determinations Made.	Parts per million.
Iron, Fe	0.6
Silica, SiO_2	14.6
Alumina, Al_2O_3	1.9
Calcium, Ca	84.2
Magnesium, Mg	37.5
Ammonia, NH_4	0.4
Sodium, Na / Potassium, K	26.1
Nitrite, NO_2	0.0
Nitrate, NO_3	0.3
Sulfate, SO_4	73.4
Chloride, Cl	7.0
Nonvolatile	0.7
Alkalinity Methyl Orange.	342.
Residue	477.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Sodium Nitrate, $NaNO_3$	0.5	.03
Sodium Chloride, NaCl	11.5	.67
Sodium Sulfate, Na_2SO_4	66.1	3.86
Ammonium Sulfate, $(NH_4)_2SO_4$	1.5	.09
Magnesium Sulfate, $MgSO_4$	34.4	2.01
Magnesium Carbonate, $MgCO_3$	105.8	6.19
Calcium Carbonate, $CaCO_3$	210.2	12.29
Iron Oxide, Fe_2O_3	0.8	.05
Alumina, Al_2O_3	1.9	.11
Silica, SiO_2	14.6	.86
Nonvolatile	0.7	.04
Total	447.2	26.20

Water from the well 958 feet deep is of similar quality. A sample, number 43322, collected on June 23, 1920, had a mineral content of 423, a total hardness of 372, and a content of iron of 0.6 parts per million.

A sample of water collected from the spring supply formerly in use had a mineral content of 511 and a total hardness of 425 parts per million. Other samples collected were similar.

ELMWOOD (1242). Elmwood is located in the western part of Peoria County on the drainage area of Kickapoo Creek, a tributary of Illinois River. Some water is obtained from private wells from 35 to 40 feet deep.

A public water supply was installed by the city in 1896. Several changes in equipment have been made. Water is now pumped from a well into a collecting reservoir by an air lift. Air is compressed by an Ingersoll-Rand 9 by 8-inch compressor which is driven by a 25-horsepower electric motor. The reservoir is 21 feet in diameter. During regular operation water is pumped from the collecting reser-

voir into two steel pressure tanks and the distribution system by either of two McGowan 4½ by 6-inch triplex pumps, each driven at a speed of 53 revolutions a minute by a 5-horsepower electric motor, with automatic control regulating the pressure between 30 and 50 pounds. At times of fire, water is pumped by a McGowan centrifugal pump. One pressure tank is 6 feet in diameter and 14 feet long and the other is 6feet in diameter and 16 feet long. In case of emergency power is furnished by a 30-horsepower gas engine.

Two hundred and fifty consumers were supplied in 1923. The rates per 1000 gallons for three months are 52 cents for the first 3000 gallons, 25 cents for the next 5000 gallons, 20 cents for the next 100,000 gallons, and 15 cents for all over 108,000 gallons. The minimum charge is $1.56 for three months. A discount of twenty per cent is allowed for prompt payment.

Water is secured from a well. This has been reported to be 1498 feet deep and to contain 100 feet of 10-inch casing, 347 feet of 8-inch casing, and 710 feet of 6-inch casing. The well is equipped with an air lift with a 1¼-inch air line extending to a depth of 342 feet. On July 23, 1923, the air lift operated for 4 hours and the discharge, measured in the reservoir, including the air compressor cooling water discharged into the well, was 95 gallons a minute. The air pressure was 96 pounds when starting and 90 pounds while operating. The amount of water pumped averaged near 25,000 gallons a day. The depth to water when not pumping was 72 feet in 1917 and 78 feet in January, 1922.

Analysis of Sample Number 49784 from the City Supply.

Determinations Made.	Parts per million.
Iron Fe	0.2
Manganese Mn	0.0
Silica SiO_2	15.1
Nonvolatile	1.4
Alumina Al_2O_3	3.6
Calcium Ca	87.6
Magnesium Mg	36.0
Ammonia NH_4	0.1
Sodium Na	340.3
Potassium K	40.5
Sulfate SO_4	622.4
Nitrate NO_3	5.6
Chloride Cl	196.0
Alkalinity Methyl Orange	234.
Residue	1531.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate, KNO_3	9.2	0.54
Potassium Chloride, KCl	70.5	4.12
Sodium Chloride, NaCl	267.8	15.66
Sodium Sulfate, Na_2SO_4	725.8	42.44
Ammonium Sulfate, $(NH_4)_2SO_4$	0.5	0.03
Magnesium Sulfate, $MgSO_4$	163.9	9.57
Magnesium Carbonate, $MgCO_3$	9.7	0.56
Calcium Carbonate, $CaCO_3$	218.6	12.76
Iron Oxide, Fe_2O_3	0.3	0.02
Alumina Al_2O_3	3.6	0.21
Silica, SiO_2	15.1	0.88
Nonvolatile	1.4	0.08
Total	1486.4	86.87

The water had a mineral content of 1486, a total hardness of 366, and a content of iron of 0.2 parts per million as shown by the

nalysis of sample number 49784, collected on July 23, 1923, from a tap at the station.

A sample collected in 1914 was similar but the iron content was 0.7 parts per million. The water stains plumbing fixtures.

ERIE (957). Erie is located in the southwestern part of Whiteside County on the drainage area of Rock River. A public water supply was installed by the village in 1920. Water is pumped from a well directly into two steel pressure tanks and the distribution system by either of two triplex pumps which are placed in a pit eight feet deep at the top of the well. The smaller pump is driven by a 10-horsepower electric motor and the larger one is driven by a 20-horsepower electric motor. A 25-horsepower gas engine is available to furnish power. The pressure tanks are 8 feet in diameter and 36 feet long. Fifty service connections were in use in 1923 and all were metered. The rate for water is $1.50 for three months for the first 5000 gallons of water, 25 cents per 1000 gallons for the next 5000 gallons, and 20 cents per 1000 for all water over 10,000 gallons.

Water for the public supply is secured from a well drilled by Mr. Eatinger of Dixon in 1920. It is 10 inches in diameter at the top, 8 inches in diameter at the bottom, and 567 feet deep. The elevation of the ground surface at the well is about 585 feet above sea level. The well is cased with 10-inch pipe to a depth of 175 feet, 8 feet into rock. Water is drawn from the well by suction by either of two single-acting triplex pumps. The one usually used is 4 by 12 inches in size. A larger pump is used when this pump cannot supply demands. The suction pipe extends to a depth of 34 feet below the pump room floor. On August 3, 1923, an approximate test of yield was made by determining the consumption as shown by the lowering of the water level in the pressure tanks when the pumps were not operating and noting the rise in water level when pumping, the yield being equal to the amount added to the tank plus consumption. The yield was calculated at 70 gallons a minute. The water level was at a depth of 5.6 feet when not pumping and was lowered to a depth of 10.3 fet by pumping. The amount of water pumped during the two months preceding the test was estimated to have averaged 10,000 gallons a day.

The temperature of water from the well was 53.5 degrees Fahrenheit. The water had a mineral content of 366, a total hardness of 275, and a content of iron of 0.6 parts per million, as shown by the analysis of sample number 49848, collected on August 3, 1923.

Analysis of Sample Number 49848 from the Village Supply.

Determinations Made.	Parts per million.
Iron Fe	0.6
Manganese Mn	0.4
Silica SiO_2	19.4
Nonvolatile	1.0
Alumina Al_2O_3	1.4
Calcium Ca	71.4
Magnesium Mg	23.8
Ammonia NH_4	0.1
Potassium K	3.2
Sodium Na	15.8
Sulfate SO_4	17.5
Nitrate NO_3	62.0
Chloride Cl	13.0
Alkalinity Methyl Orange	232.
Residue	381.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate, KNO_3	8.3	0.48
Sodium Nitrate, $NaNO_3$	58.4	3.41
Ammonium Nitrate, NH_4NO_3	0.3	0.02
Magnesium Nitrate, $Mg(NO_3)_2$	16.6	0.97
Magnesium Chloride, $MgCl_2$	17.4	1.01
Magnesium Sulfate, $MgSO_4$	21.9	1.28
Magnesium Carbonate, $MgCO_3$	42.0	2.45
Calcium Carbonate, $CaCO_3$	178.3	10.41
Iron Carbonate, Fe_2O_3	0.8	0.04
Alumina, Al_2O_3	1.4	0.08
Silica, SiO_2	19.4	1.13
Nonvolatile	1.0	0.06
Manganese Oxide, MnO	0.5	0.03
Total	366.3	21.37

Plumbing fixtures are slightly stained by iron in the water. The water mains are flushed every 6 weeks.

EUREKA (1559). Eureka is located in the southern part of Woodford County on the drainage area of Mackinaw River, a tributary of Illinois River.

A public water supply was installed by the city about 1889. The supply was developed from a well 90 feet deep in the northern part of the city. In 1908 this well and the equipment were abandoned. A well was then drilled at the city hall which for a time furnished the entire supply. Water is now pumped from three wells into a collecting reservoir. The reservoir is in the shape of an ellipse with 17 and 24-foot axes. The capacity is 200 gallons per inch depth. Water is pumped from the reservoir into the distribution system by a 9 by 9-inch National Construction Company single-acting triplex pump and a Goulds 8 by 10-inch single-acting triplex pump. Each is driven by an electric motor equipped with automatic control. A gas engine is available for use in emergency. A steel pressure tank 8 feet in diameter and 35 feet long located in the pumping station is connected to the mains.

The Dickenson Canning Company has a private water supply from wells into sand and gravel and can supply water to the city in case of emergency.

The average consumption from the public supply was estimated at 60,000 gallons a day in 1924. The charge is 35 cents per 1000 gallons for the first 2000 gallons, 30 cents per 1000 gallons for the next 3000 gallons, 25 cents per 1000 gallons for the next 5000 gallons, and 20 cents per 1000 gallons for all over 10,000 gallons.

The public water supply is secured from three wells. The oldest well is located at the city hall. The elevation at the ground surface is about 760 feet above sea level. This well was the third well drilled of three wells in a row 10 feet apart. It was drilled in the hope of securing a greater supply than was secured from the first and second wells and was drilled to a greater depth in the hope of striking another water bearing vein but without success. The first two wells drilled were abandoned. This well is 10 inches in diameter and 84 feet deep. It penetrates clay and three strata of water bearing sand, one between depths of 15 and 20 feet, the second between depths of 72 and 75 feet, and the third between depths of 82 and 90 feet. (The depth of well or depth of strata is a few feet in error). In the bottom of the well is a Cook strainer 10 feet long. The well is equipped with a single-acting deep-well pump with 3¾-inch cylinder and 15-inch stroke. It is driven by a 3-horsepower electric motor at a speed of 29 revolutions a minute. This pump discharges about 20 gallons a minute.

In 1913 the supply was increased by developing an abandoned coal shaft in the eastern part of the village as a well. This well is 1900 feet east and 200 feet north of the city hall. The elevation at the top is about 750 feet above sea level. The shaft had been abandoned at a depth of 90 feet on account of a strong inflow of water. It is oval in shape about 4 by 8 feet at the bottom and 8 by 14 feet at the top and is lined with brick. The well was equipped with a pump placed on a platform at a depth of 48 feet. The yield with this equipment was, at times, less than 20,000 gallons a day.

A 6-inch hole was drilled in the bottom of this well to a depth of 160 feet below the ground surface about 1921. It is cased with 6-inch pipe and a Cook screen is placed in the bottom. The well is now equipped with a Myers single-acting deep-well pump with a 5¾-inch cylinder and 24-inch stroke. It operates 30 revolutions a minute and in 1924 was operating from 7:00 A. M. to about 9:00 P. M. The discharge was 75 gallons a minute in the morning and with lowering of the water level decreased to about 50 gallons a minute in the afternoon.

The third well was drilled by M. Ebert in 1921. It is located 22 feet west and 4 feet south of the well 84 feet deep in the city hall. The well is 12 inches in diameter and 184 feet deep. A screen made of perforated pipe is placed in the bottom. The well is equipped with a Keystone Driller Company double-stroke deep-well pump with a 7¾-inch cylinder placed close to the top of the well screen. The pump is driven by a 20-horsepower electric motor. It was

operated with 18-inch stroke 17½ to 18 revolutions a minute for five or six hours a day in 1924. In 1922 the discharge was 40 gallons a minute. A valve has been replaced and the discharge is now thought to be slightly greater. While repairs were being made the water level in this well was lowered 9 feet 11 inches by pumping from a well of the Dickenson Canning Company.

The Dickenson Canning Company has wells into the sand stratum penetrated by the city well 84 feet deep. One well at their plant on ground about 30 feet lower than at the city hall was drilled to a depth of about 186 feet and was in shale below a depth of 146 feet. The hole was abandoned. In 1922 a well was drilled about 500 feet east of the city wells at the city hall, on ground about 10 feet lower than at the city hall. The well is 179 feet deep and penetrates a water bearing stratum containing some coarse sand and some fine sand. In the bottom is a Cook screen 10 feet long with number 80 openings in the upper four feet and number 50 openings in the lower six feet. The well was equipped with a deep-well pump with a suction pipe placed close to the bottom of the well to help clear the well of fine sand. In December, 1922, the pump displacement, at the speed operated, was 124 gallons a minute and the discharge was 113 gallons a minute. When the well was completed, before pumping, the depth to water was 60 feet.

Water from the city well 184 feet deep had a mineral content of 380, a total hardness of 202, and a content of iron of 0.8 parts per million as shown by the analysis of sample number 48837, collected on December 12, 1922.

Analysis of Sample Number 48837 from the City Well 184 Feet Deep.

Determinations Made.	Parts per million.
Iron Fe	0.8
Manganese Mn	0.0
Silica SiO_2	9.6
Nonvolatile	1.3
Alumina Al_2O_3	0.5
Calcium Ca	34.4
Magnesium Mg	28.3
Ammonia NH_4	6.5
Sodium Na	64.9
Potassium K	8.9
Sulfate SO_4	0.0
Nitrate NO_3	1.4
Chloride Cl	9.0
Alkalinity Methyl Orange	358.
Residue	383.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate, KNO_3	23.3	.13
Potassium Chloride, KCl	15.3	.89
Sodium Chloride, NaCl	2.9	.17
Sodium Carbonate, Na_2CO_3	146.9	8.54
Ammonium Carbonate, $(NH_4)_4 CO_3$	17.2	1.01
Magnesium Carbonate, $MgCO_3$	98.0	5.72
Calcium Carbonate, $CaCO_3$	85.8	5.14
Silica, SiO_2	9.6	.56
Nonvolatile	1.3	.08
Iron Oxide, Fe_2O_3	1.1	.06
Alumina, Al_2O_3	0.5	.03
Total	380.9	22.33

FAIRBURY (2532). Fairbury is located in the southern part of Livingston County on the drainage area of Vermilion River, a tributary of Illinois River. Extensive gravel deposits are reported near the southeastern limits of the city and at one time, during repairs on a city well, water was supplied to the city from a well driven in this sand and gravel.

A public water supply was installed by the city about 1887. Water was pumped from a well into the distribution system by a steam pump. An elevated tank was connected to the mains. The well which was 25 feet in diameter and 25 feet deep has since been abandoned. Water is secured from two deep wells, one equipped with a deep-well pump and the other with air lift. Water is discharged into two collecting reservoirs from which it is pumped into the distribution system by either of two duplex steam pumps, one a Deane 14 by 8 by 12-inch crank and fly-wheel pump and the other a Worthington 14 by 10¼ by 12-inch pump. Compressed air to operate the air lift is supplied by an Ingersoll-Rand compound compressor with 7 and 11-inch steam cylinders, 10 and 6½-inch air cylinders, and 10-inch stroke. Steam is supplied by two 50-horsepower boilers. A steel tank 20 feet in diameter and 25 feet high on a brick tower 85 feet high is connected to the mains. One of the collecting reservoirs is 19 feet long, 9 feet wide, and 7½ feet deep. The other reservoir is 35 feet in diameter.

Seven hundred service connections were in use in 1924. The minimum charge is $1.60 for three months and the lowest rate, for water in excess of 31,000 gallons, is 20 cents per 1000 gallons.

The public water supply is obtained from two wells located 35 feet apart, one 2002 feet deep and the other 2172 feet deep. The elevation of the tops of the wells is about 685 feet above sea level. The well 2002 feet deep was drilled by the J. P. Miller Artesian Well Company of Chicago in 1892. It was cased with 10-inch pipe to a depth of 40 feet and 378 feet of 6¼-inch pipe was placed in the upper part of the well. The well was 4 inches in diameter below a depth of about 1500 feet. This well furnished the entire water supply from 1892 to 1920. The upper part has been reamed to 8-inch diameter. The well is equipped with an American steam-head double-acting deep-well pump with 5¾-inch water cylinder and 36-inch stroke. The cylinder is placed at a depth of 240 feet and a short length of suction pipe is attached. The depth to water was reported to be 60 feet in 1896 and 80 feet when not pumping in 1914. In 1918 the depth to water was 87 feet and when pumping 100 gallons a minute water was drawn down to the bottom of a suction

pipe 22 feet long on the cylinder. The cylinder was at a depth of 252 feet. The average discharge at the time was said to be 85 gallons a minute and the pump was operated about 18 hours a day. The discharge of this pump when the air lift on the other well was not operating was about 85 gallons a minute in 1921 and in 1923 during short time tests by W. T. Burns, Superintendent of Water Works. In 1922, when the pump had been idle for several days and the supply was being drawn from the well 35 feet distant, the water level was at a depth of 122 feet.

The well 2172 feet deep is located 35 feet south of the other well. It was drilled by the Cambridge Driller Company about 1916. A record of material penetrated is as follows:

Gravel (water at 30 feet, water at 130 feet)	0 to 130 feet
Material not given	130 " 170 "
Coal	170 " 175 "
Fire clay and slate	175 " 350 "
Limestone (little water at 500 feet)	350 " 520 "
Sand (water at 525 feet)	520 " 525 "
Limestone	525 " 660 "
Hard limestone	660 " 775 "
Shale	775 " 855 "
Limestone	855 " 860 "
Slate and shale	860 " 900 "
Limestone	900 " 925 "
Shale	925 " 950 "
Limestone	950 " 1350 "
St. Peter sandstone (hard)	1350 " 1603 "
Break of shale	1603 " 1612 "
Hard limestone and small streaks of hard sand	1612 " 2000 "
Hard limestone	2000 " 2100 "
Hard limestone and small veins of hard sand	2100 " 2172 "

The well is cased from the top with 41 feet of 18-inch outside diameter easing and 407 feet of 14-inch outside diameter casing, with 195 feet of 10-inch casing placed with the bottom at a depth of 920 feet, and with 47 feet of 8-inch casing placed below St. Peter sandstone with the bottom at a depth of 1615 feet. The well is 8 inches in diameter at the bottom. In 1918 the depth to water was given as 109 feet. During a test the yield of the well decreased from 125 to 75 gallons a minute and the water level was drawn down to a depth of 300 feet. The well is equipped with an air lift with a 1¼-inch air line extending to a depth of 574 feet and an auxiliary line to a depth of 474 feet. During several tests. by Mr. Burns, Superintendent of Water Works, made in 1920 and 1921, the yield was from 74 to 84 gallons a minute depending partly upon the length of time the air lift operated. At the time of visit on March 27, 1924, when water had been pumped from both wells for several hours, the deep-well pump was shut down and the yield of this well was 65 gallons a minute. The compressor was operated

from 66 to 90 revolutions a minute with little increase in yield with increase in speed.

The yield of the two wells when tested by Mr. Burns in 1923 after pumping for twelve hours was 154 gallons a minute. In March, 1924, the well pump and air lift were operated from 16 to 18 hours a day. At the time of visit on March 27, 1924, the yield of the two wells was 118 gallons a minute.

A sample of water, number 51384, collected in 1924 from the well 2000 feet deep, had a mineral content of 1185, a total hardness of 195, and a content of iron of 1.4 parts per million as shown by the analysis.

Analysis of Sample Number 51384 from Well 2000 Feet Deep.

Determinations Made.

	Parts per million.
Iron Fe	1.4
Manganese Mn	0.1
Silica SiO_2	16.7
Nonvolatile	5.2
Alumina Al_2O_3	17.8
Calcium Ca	44.4
Magnesium Mg	20.5
Ammonia NH_4	0.8
Sodium Na	326.0
Sulfate SO_4	72.6
Potassium K	66.5
Nitrate NO_3	0.9
Chloride Cl	410.0
Alkalinity	
Phenolphthalein	0.0
Methyl Orange	330.
Residue	1190.

Hypothetical Combinations.

	Parts per million.	Grains per gallon.
Potassium Nitrate, KNO_3	1.4	.08
Potassium Chloride, KCl	125.8	7.35
Sodium Chloride, NaCl	577.0	33.70
Sodium Sulfate, Na_2SO_4	107.4	6.28
Sodium Carbonate, Na_2CO_3	148.2	8.65
Ammonium Carbonate, $(NH_4)_2CO_3$	2.2	.13
Magnesium Carbonate, $MgCO_3$	70.8	4.13
Calcium Carbonate, $CaCO_3$	110.8	6.48
Iron Oxide, Fe_2O_3	2.0	.12
Alumina, Al_2O_3	17.8	1.04
Silica, SiO_2	16.7	.97
Nonvolatile	5.2	.30
Manganese Oxide, MnO	0.1	.01
Total	1185.4	69.24

Analysis of Sample Number 51385 from Well 2172 Feet Deep.

Determinations Made.

	Parts per million.
Iron Fe	0.2
Manganese Mn	0.0
Silica SiO_2	10.5
Nonvolatile	14.0
Alumina Al_2O_3	2.7
Calcium Ca	20.7
Magnesium Mg	12.8
Ammonia NH_4	2.5
Potassium K	24.5
Sodium Na	680.1
Sulfate SO_4	92.5
Nitrate NO_3	0.9
Chloride Cl	750.0
Alkalinity	
Phenolphthalein	0.0
Methyl Orange	412.0
Residue	1940.0

Hypothetical Combinations.

	Parts per million.	Grains per gallon.
Potassium Nitrate, KNO_3	1.4	0.08
Potassium Chloride, KCl	45.8	2.67
Sodium Chloride, NaCl	1199.4	70.04
Sodium Sulfate, Na_2SO_4	136.6	7.98
Sodium Carbonate, Na_2CO_3	377.9	22.07
Ammonium Carbonate, $(NH_4)_2CO_3$	6.6	0.38
Magnesium Carbonate, $MgCO_3$	44.2	2.58
Calcium Carbonate, $CaCO_3$	51.7	3.02
Iron Oxide, Fe_2O_3	0.3	0.02
Alumina, Al_2O_3	2.7	0.16
Silica, SiO_2	10.5	0.61
Nonvolatile	14.0	0.82
Total	1891.1	110.43

Each of two samples collected previously had a mineral content of about 1300, a total hardness of 160, and a content of iron of 0.1 parts per million or less.

A sample, number 51385, collected in 1924 from the well 2172 feet deep had a mineral content of 1891, a total hardness of 104, and a content of iron of 0.2 parts per million as shown by the analysis.

A feed water heater at the pumping station is cleaned every two weeks. A brown scale is deposited and some corrosion occurs in meters. About 30 meters are repaired each year. Valves on the water mains are reported to leak after a few years use.

FARMER CITY (1678). Farmer City is located in the northeastern part of DeWitt County on the drainage area of Salt Creek, a tributary of Sangamon River. A public water supply was installed by the city in 1891 (1894?) replacing a privately operated plant which had furnished a limited supply of water for some years. Water from wells is pumped directly into the distribution system to which an elevated steel tank of 75,000 gallons capacity is connected. The tank is located at the side of the pumping station. It is 22 feet in diameter and the top of the side is 117 feet above the foundations of the tower. Steam to operate the pumps and electrical equipment for a municipal light plant is generated by three Kewanee boilers, two of 150-horsepower each and one of 100-horsepower. Water is sold at a rate of $2.00 per 1000 cubic feet without discount.

Water is secured from two wells located six feet apart in the northern part of the city near the northwest corner of Allen and Center Streets. One was drilled in 1907 and the other in 1910. The elevation of the tops of the wells is about 730 feet above sea level. The wells are 8 inches in diameter and 176 feet deep. They are in fine sand and gravel below a depth of 156 feet and are equipped with Cook screens 20 feet long. Each well is equipped with a single-acting steam-head deep-well pump with 5¾-inch water cylinder and 36-inch stroke. One cylinder is placed at a depth of 120 feet and the other at a depth of 129 feet. T. M. Wence, Superintendent, stated in 1923 that at times of maximum demand both pumps are operated 24 hours a day at a rate of 12 strokes a minute, a displacement for the two of 144,000 gallons a day. At the time of visit in May, 1923, one pump was operating at a speed of 17 revolutions a minute. In April, 1923, when operating a pump in one well the depth to water in the other well was 80 feet. In 1913 the depth to water when not pumping was reported to be 30 feet.

Water flowed from a well drilled in 1894, a well which was abandoned as the hole was crooked.

The temperature of water from the wells is 53½ degrees Fahrenheit. The water had a mineral content of 700, a total hardness of 295, and a content of iron of 0.4 parts per million as shown by the analysis of sample number 49553, collected on May 24, 1923.

Analysis of Sample Number 49553 from the City Supply.

Determinations Made.	Parts per million.
Iron Fe	0.4
Manganese Mn	0.0
Silica SiO_2	10.3
Nonvolatile	0.9
Alumina Al_2O_3	5.4
Calcium Ca	70.4
Magnesium Mg	28.8
Ammonia NH_4	10.8
Sodium Na	135.4
Potassium K	27.9
Sulfates SO_4	0.2
Nitrate NO_3	1.8
Chloride Cl	110.0
Alkalinity Methyl Orange	520.0
Residue	740.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate, KNO_3	2.8	0.16
Potassium Chloride, KCl	51.2	2.99
Sodium Chloride, NaCl	141.1	8.24
Sodium Sulfate, Na_2SO_4	0.3	0.02
Sodium Carbonate, Na_2CO_3	183.7	10.73
Ammonium Carbonate, $(NH_4)_2CO_3$	28.7	1.67
Magnesium Carbonate, $MgCO_3$	99.9	5.83
Calcium Carbonate, $CaCO_3$	175.8	10.26
Iron Oxide, Fe_2O_3	0.6	0.03
Alumina, Al_2O_3	5.4	0.31
Silica, SiO_2	10.3	0.60
Nonvolatile	0.9	0.05
Total	700.7	40.89

The iron content in a sample collected in 1917 was 1.0 parts per million. Water for use in boilers at the station is heated in a Cookson heater from which the pans have been removed. Excelsior is changed and the heater flushed every month and the heater is thoroughly cleaned once a year. One boiler was used for 25 years without leaks. An elevated steel tank formerly used was replaced by another tank in 1923. Deterioration was from the outside, probably due in large part to the action of moisture and smoke from the chimney which was close by. The inside was never painted. The surface on the inside was smooth.

FARMINGTON (2631). Farmington is located in the northeastern part of Fulton County on the drainage area of Illinois River. A public water supply was installed by the city in 1893. Water was secured from a well in the southern part of the village. The well was 1461 feet deep and was cased to a depth of 1145 feet. Part of the well was through an entry of an abandoned coal mine. Equipment was changed several times and some material was lost in the well and the yield was greatly decreased.

The old supply was abandoned in 1918 when another well was drilled and other extensive improvements were made. Water is pumped from a well into a concrete collecting reservoir by a deep-

well pump driven through gears by a 15-horsepower electric motor. Water is pumped from the reservoir into the distribution system by a J. H. McGowan 6-inch by 10-inch triplex pump driven through gears by a 7½-horsepower electric motor. The deep-well pump is automatically controlled to stop when the reservoir is full and the triplex pump is started and stopped by an automatic device regulated by the water level in the elevated tank. An Appleton Machine Company two-stage centrifugal pump direct connected to a 35-horsepower electric motor is installed for use at times of fires. Electric current to operate the pumps is purchased from the Central Illinois Light Company. In 1921 a steel standpipe connected to the mains was to be torn down and replaced by an elecated steel tank of 50,000 gallons capacity.

Two hundred and sixteen service connections were in use in 1921 and the water consumption was estimated to average 30,000 gallons a day during the winter and 50,000 gallons a day during the summer. It was expected that with the construction of a sewer system then being installed and the extension of mains that the consumption of water would greatly increase.

Water is secured from a well located on high ground about a quarter of a mile east of the east city limits on the north side of East Fort Street. The well was drilled by C. P. Brant of Chicago in 1918. The elevation of the top of the well is about 775 feet above sea level.

Samples of material were collected during drilling and a detailed record is on file with the State Geological Survey Division. The materials penetrated with part of the classification is as follows:

	Thickness in feet.	Depth in feet.
"Soil"	30	30
Yellow, hard, limestone	10	40
Coal	1	41
Shale, gray, fine grained	134	175
Coal	5	180
Shale, bluish gray	140	320
Coal	5	325
Shale	80	405
Sand	20	425
Shale	45	470
Gray limestone	165	635
Shale, greenish gray	245	880
Gray lime	60	940
Dolomite	5	945
Gray lime	140	1085
Light greenish gray shale, Maquoketa	70	1155
Gray limestone shaley, Maquoketa	40	1195
Light greenish gray shale, Maquoketa	50	1245
Gray limestone, Galena-Platteville	265	1510
Brown limestone, Galena-Platteville	70	1580
Sandstone, St. Peter	130	1710

Water was encountered at 405 feet and a big flow at 930 feet which raised to within 200 feet of the surface. Water at 1045? feet raised to 150 feet below the surface. (On the Geological Survey log water is noted at 1235 feet and not at 1045 feet).

The well is 10 inches in diameter to a depth of 1020 feet and 8 inches in diameter below that depth. It is cased to a depth of 1260 feet. The main flow is from St. Peter sandstone and if water above 1260 feet depth is excluded by the casing nearly all water is from this stratum. The cost of the well was said to exceed $11,000. The well is equipped with a Keystone Driller Company deep-well pump with the cylinder at a depth of 290 feet. A suction pipe 20 feet long is attached to the cylinder.

The yield of the well, measured in the reservoir, was 60 gallons a minute during a test lasting 1¾ hours on May 10, 192l. The depth to water was 210 feet when the pump had been idle for 4 hours, 258 feet when the pump had operated for 25 minute, and 261 feet at the end of the test. The depth to water when the well was completed was 202 feet.

In 1921 it was stated that the well pump was operated about 18 hours a day in the summer and yielded an average of 3000 gallons an hour and that it was operated about 8 hours a day in the winter and yielded an average of about 4000 gallons an hour.

Analysis of Sample Number 51714 from the City Supply.

Determinations Made.

	Parts per million.
Iron Fe	1.4
Silica SiO_2	10.8
Nonvolatile	4.6
Alumina Al_2O_3	1.6
Calcium Ca	65.8
Magnesium Mg	31.9
Ammonia NH_4	2.0
Sodium Na, Potassium K	425.8
Sulfate SO_4	664.5
Nitrite NO_2	0.0
Nitrate NO_3	2.1
Chloride Cl	227.7
Alkalinity	
Phenolphthalien	0.0
Methyl Orange	228 .0
Residue	1620.0

Hypothetical Combinations.

	Parts per million.	Grains per gallon.
Sodium Nitrate $NaNO_3$	2.9	0.17
Sodium Chloride NaCl	375.4	21.95
Sodium Sulfate Na_2SO_4	854.3	50.00
Ammonium Sulfate $(NH_4)_2SO_4$	7.5	0.44
Magnesium Sulfate $MgSO_4$	101.2	5.92
Magnesium Carbonate $MgCO_3$	39.4	2.29
Calcium Carbonate $CaCO_3$	164.5	9.62
Iron Oxide Fe_2O_3	2.0	0.12
Alumina Al_2O_3	1.6	0.09
Silica SiO_2	10.8	0.63
Nonvolatile	4.6	0.27
Total	1564.2	91.50

A sample of water collected when the well was drilled to a depth of 970 feet had a mineral content of 1756 and a total hardness of 448 parts per million. The next sample collected when the well was 1170 feet deep and cased to a depth of 1025 feet had a mineral

content of 1546 and a total hardness of 74. A sample, number 41714, collected on September 8, 1919, sometime after the well was completed, had a mineral content of 1564, a total hardness of 295, and a content of iron of 1.4 parts per million as shown by the analysis.

A sample collected from the old well 1461 feet deep in 1914 was similar in quality to the sample of water from the new well.

FLANAGAN (637). Flanagan is located in the western part of Livingston County on the drainage area of Vermilion River, a tributary of Illinois River. A number of wells have been drilled in the village into sand and gravel at a depth of about 170 feet. Water flows from some wells. Allowing water to flow from wells at lower elevation or pumping from a well stops the flow in nearby wells.

A public water supply has been installed by the village. Water is pumped from a well directly into the distribution system and an elevated tank connected to the system by a Goulds 7 by 8-inch single-acting triplex pump. The pump is driven by a 10-horsepower electric motor, and a 12-horsepower gas engine which was in regular service until 1917 is held in reserve. The elevated tank is 20 feet in diameter. One hundred and fifty service connections were in use in 1924. The meter rate for water is 40 cents for 1000 gallons with a minimum charge of $2.00 a year.

Analysis of Sample Number 37577 from the Village Supply.

Determinations Made.	Parts per million.
Iron Fe	0.1
Silica SiO_2	14.3
Alumina Al_2O_3	1.6
Calcium Ca	20.2
Magnesium Mg	12.7
Ammonia NH_4	1.4
Sodium Na	191.0
Potassium K	5.9
Sulfate SO_4	89.9
Nitrate NO_3	6.2
Chloride Cl	15.0
Nonvolatile	0.8
Alkalinity Methyl Orange	390.
Residue	620.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	10.1	.59
Potassium Chloride KCl	3.8	.22
Sodium Chloride NaCl	21.8	1.27
Sodium Sulfate Na_2SO_4	133.0	7.76
Sodium Carbonate Na_2CO_3	320.6	18.70
Ammonium Carbonate $(NH_4)_2CO_3$	3.7	0.21
Magnesium Carbonate $MgCO_3$	44.0	2.57
Calcium Carbonate $CaCO_3$	50.4	2.94
Iron Oxide Fe_2O_3	0.1	.01
Alumina Al_2O_3	1.6	.09
Silica SiO_2	14.3	.83
Nonvolatile	0.8	.05
Total	604.2	35.24

The water stains plumbing fixtures.

Water for the public supply is secured from a well 6 inches in diameter and 170 feet deep. Water is obtained from sand and gravel. The top of the well is about 675 feet above sea level. A screen 6 feet long is placed in the bottom of the well. A suction

line from the triplex pump extends to a depth of 20 feet in the well. On March 26, 1924, the pump was operating at 29 revolutions a minute and the yield, as nearly as could be determined by measurements made in the elevated tank, was 105 gallons a minute. The amount of water pumped in 1923 was estimated to be 23,000 a day. The well is capped to prevent water flowing to waste and drawing water from other wells.

The water had a mineral content of 604, a total hardness of 102, and a content of iron of 0.1 parts per million, as shown by the analysis of sample number 37577, collected on July 17, 1917.

FLORA (3558). Flora is located in the southern part of Clay County on the drainage area of Little Wabash River, a tributary of Wabash River. Many private wells from 20 to 60 feet deep are in use. The Baltimore & Ohio Railroad secures some water from a small impounding reservoir in the city.

A public water supply was installed by the city in 1911-1912. Water was pumped from wells into a collecting reservoir of 200,000 gallons capacity. From the reservoir it was pumped into the mains by an Alberger two-stage centrifugal pump of 500 gallons a minute capacity. Later a well was drilled in the eastern part of the city, and two wells were leased and for a few years none of the old city wells were used. The three wells then in use were at a considerable distance from the reservoir. They were equipped with deep-well pumps driven by electric motors and water discharged directly into the distribution system. When the pressure was greater than 18 pounds water was bypassed to the reservoir at the old station and at times of maximum demands water, if available, could be pumped from the reservoir. All water that could be secured was used. In January, 1925, seven wells were in use. Water from all but two was discharged into the reservoir. Water from these two, now pumped directly into the mains, and water from wells to be drilled, was to be piped to the reservoir.

Four hundred and twenty-four service connections were in use in January, 1925. The rate for water is 50 cents per 1000 gallons with a minimum charge of $1.00 a month.

Water is secured from wells into rock which is entered about ten feet below the ground surface. Five wells were drilled by Charles Butler in 1923 and 1924. Four of these wells, two wells drilled in 1912, and one well drilled about 1917 are in use. A record

of material penetrated by one well, located half a block east of the pumping station and known as number 6, is as follows:

Material	Thickness in feet.
Clay	12
Sand rock	78
Coal	1
Soapstone	3
Sand rock	5
Shale	1
Sand rock	9
Soap stone	5
Sand rock blue	6
Sand rock	16
Total depth	136

At some wells strata of limestone and soapstone were noted in the sandstone below clay. In general the records are similar. The depth of the wells is from 112 to 160 feet with the exception of the two wells drilled in 1912 which were drilled 240 feet deep to allow the installation of air lifts. Two wells were drilled in 1923 to a depth of 200 feet and were filled below a depth of 160 feet as salt water was encountered.

Each well is equipped with a deep-well pump with a Myers pump-head and a Goulds single-acting cylinder. Well number three, which is located near the corner of Olive and Third Streets, is the only well in which measurements to water level can be made. This is 157 feet deep. It is equipped with a pump with a 3¾-inch cylinder and 18-inch stroke. The well has been in use since 1917 and on January 27, 1925, when the pump had operated continuously for 29 hours at a speed of 30 revolutions a minute, a displacement of 25 gallons a minute, the water level was between 120 and 125 feet below the ground surface.

One well, number 8, when completed in 1924 yielded 27 gallons a minute as measured approximately in a pail. Other wells have little yield and one, number 4, when completed in 1923, yielded one and one-half gallons a minute and was abandoned. In the summer time all pumps are operated continuously and the amount of water supplied is estimated at 75,000 gallons a day.

Water from the well 157 feet deep at the corner of Olive and Third Streets had a mineral content of 624, a total hardness of 418, and a content of iron of 0.7 parts per million as shown by the analysis of sample number 37658, collected on July 24, 1917.

The Ebner Ice Company at a plant located in the city had a well 900 feet deep. Water from this well had a mineral content of 61,026, a total hardness of 6946, and a content of iron of 4.2 parts per

million as shown by the analysis of sample number 37656, collected on August 24, 1917.

Analysis of Sample Number 37658 from City Well 157 Feet Deep.

Determinations Made.	Parts per million.	Hypothetical Combinations.	Parts per million.	Grains per gallon.
Iron Fe	0.7	Potassium Nitrate KNO_3	2.1	.12
Silica SiO_2	28.7	Potassium Chloride KCl	6.3	.37
Alumina Al_2O_4	1.5	Sodium Chloride NaCl	41.2	2.40
Calcium Ca	62.4	Sodium Sulfate Na_2SO_4	94.2	5.49
Magnesium Mg	63.9	Sodium Carbonate Na_2CO_3	70.9	4.13
Ammonia NH_4	0.4	Ammonium Carbonate $(NH_4)_2CO_3$	1.1	.06
Sodium Na	77.5	Magnesium Carbonate $MgCO_3$	221.3	12.91
Potassium K	4.1	Calcium Carbonate $CaCO_3$	155.8	9.09
Sulfate SO_4	63.7	Iron Oxide Fe_2O_3	1.0	.06
Nitrate NO_3	1.3	Alumina Al_2O_3	1.5	.09
Chloride Cl	28.0	Silica SiO_2	28.7	1.67
Alkalinity Methyl Orange	484.	Total	624.1	36.39
Residue	620.			

Analysis of Sample Number 37656 from Well 900 Feet Deep.

Determinations Made.	Parts per million.	Hypothetical Combinations.	Parts per million.	Grains per gallon.
Iron Fe	4.2	Potassium Nitrite KNO_2	2.3	.13
Silica SiO_2	80.0	Potassium Chloride KCl	1,971.4	114.99
Alumina Al_2O_3	54.0	Sodium Chloride NaCl	51,632.4	3011.72
Calcium Ca	1393.8	Ammonium Chloride NH_4Cl	76.1	4.44
Magnesium Mg	844.4	Magnesium Chloride $MgCl_2$	3,302.1	192.61
Ammonia NH_4	25.7	Calcium Carbonate $CaCO_3$	142.3	8.30
Sodium Na	20,344.1	Calcium Chloride $CaCl_2$	3,709.6	216.38
Potassium K	1,035.5	Iron Oxide Fe_2O_3	6.0	.35
Nitrate NO_3	1.4	Alumina Al_2O_3	54.0	3.15
Chloride Cl	37,106.0	Silica SiO_2	80.0	4.67
Nonvolatile	50.0	Nonvolatile	50.0	2.92
Alkalinity Methyl Orange	144.	Total	61,026.2	3559.66
Residue	64,400.			

FOREST PARK (10768). Forest Park is located in the central part of Cook County on the east bank of Des Plaines River. A public water supply was installed by the village in 1892. Water from two wells equipped with air lifts is discharged into a collecting reservoir from which it is pumped into the distribution system. At times of maximum demand Lake Michigan water from the Chicago supply is drawn through the Oak Park mains. There are three collecting reservoirs with a total capacity of 150,000 gallons. Four pumps are available to pump from the reservoirs. Three of the pumps are R. D. Wood 6-inch single-stage centrifugal pumps, each direct connected to a 50-horsepower electric motor. The other pump

is a 2-stage centrifugal of 1200 gallons a minute capacity driven by a four cylinder gas engine of from 80 to 125-horsepower. A Sullivan angle type air compressor of 1230 cubic feet a minute capacity at the speed run supplies air to operate both air lifts. An Ingersoll-Rand compressor of 440 cubic feet a minute capacity supplies air to operate the air lift in well number 1 at times when one well only is used. An elevated tank formerly connected to the mains has been removed. In 1924 a new well was drilled, a reservoir 116 feet long, 94 feet wide, and 12 feet deep was built, and a 23 and 13 by 16-inch air compressor driven by a 300-horsepower electric motor was installed. These were not in use at the time of our last visit.

The amount of water pumped is measured by meter. Meter readings, pressures, pumps operating, and all important station data is recorded hourly. About 3000 service connections were in use in 1924. The rate for water was 42 cents per 1000 gallons with a minimum charge of $3.00 for six months.

Water is secured from two wells located 27 feet apart near the center of the village. One, known as number 1, is 10 inches in diameter at the top, 5 inches in diameter at the bottom, and 1650 feet deep. It is equipped with an air lift with a 2-inch air pipe extending to a depth of 550 feet. Well number 2 is 14 inches in diameter at the top, 6 inches in diameter at the bottom, and 2000 feet deep. It is equipped with an air lift with 2½-inch air pipe extending to a depth of 500 feet.

A record of material penetrated by a well 200 feet east of these wells, drilled by S. B. Geiger in 1924, with part of classification given by the State Geological Survey Division, is as follows:

	Thickness in feet.	Depth in feet.
Sand and gravel	8	8
"Shale", blue	42	50
Lime, brown, Niagaran	5	55
Lime and shale, Niagaran	40	95
Lime, soft, Niagaran	10	105
Lime, hard, Niagaran	210	315
Lime, red, Niagaran	5	320
Lime, gray, Alexandrian	80	400
Lime, brown, Alexandrian	3	403
Lime and shale, Richmond	27	430
Shale, Richmond	155	585
Lime, Galena-Platteville	347	932
Sand, St. Peter	138	1070
Shale, cave, St. Peter	5	1075
Sand, cave, St. Peter	10	1085
Lime, white, Prairie du Chien	105	1190
Shale, Prairie du Chien	5	1195
Lime, Prairie du Chien	55	1250
Lime, crevices, Prairie du Chien	100	1350
Lime, Prairie du Chien	40	1390
Sand, green, Mazomanie, Cambrian system	30	1420

	Thickness in feet.	Depth in feet.
Lime and sand, Mazomanie, Cambrian system	45	1465
Sand, white, Dresbach, Cambrian system	165	1630
Lime, black, Eau Claire, Cambrian system	10	1640
Shale, blue, Eau Claire, Cambrian system	105	1745
Shale, red Eau Claire, Cambrian system	35	1780
Lime and blue shale, Eau Claire, Cambrian system	50	1830
Lime, Eau Claire, Cambrian system	20	1850
Sand, white, Eau Claire, Cambrian system	10	1850
Shale, blue and green, Eau Claire, Cambrian system	30	1890
Sand, white, Eau Claire, Cambrian system	30	1920
Shale, green, Eau Claire, Cambrian system	10	1930
Sand, white, Eau Claire, Cambrian system	55	1985
Shale, Eau Claire, Cambrian system	13	1998
Lime, Eau Claire, Cambrian system	2	2000
Sand, white, Mt. Simon, Cambrian system	114	2114

The depth to water in the two wells then in use was given as 93 feet in 1901. In 1912, when the average daily water consumption was estimated at 500,000 gallons a day, well number 1 yielded 331 gallons a minute; well number 2, then equipped with an impeller pump with the impeller at a depth of 200 feet, yield 700 gallons a minute; the depth to water was 150 feet; and when pumping the water level was lowered to the impeller of the pump at a depth of 200 feet. During the first half of August, 1922, both air lifts were operating together an average of 18 hours a day and the yield averaged 637 gallons a minute. The air lift in well number 1 was operated alone an average of 5½ hours a day and yielded an average of 275 gallons a minute. The total yield as operated averaged 780,000 gallons a day. The depth to water was said to be 275 feet. In 1924 conditions were about the same as in 1922.

The water level in the well drilled in 1924 was at a depth of 275 feet from the ground surface when drilled into St. Peter sandstone. It was at a depth of 245 feet when the well was 1860 feet deep, at a depth of 225 feet when the well was 1985 feet, and at a depth of 206 feet when the well was completed at a depth of 2114 feet. The first flow of water was from a depth of 125 feet and "sulphur water" which raised to a depth of 120 feet below the ground surface was noted at a depth of 300 feet.

The well was tested by pumping with an air lift. Data is as given by Suhr and Berryman. A 3-inch air line extended to a depth of 586 feet and the discharge line was 12-inch. The pressure was 140 pounds at start and 97 pounds during operation and the discharge was 540 gallons a minute. The discharge pipe was large to provide for an anticipated larger yield.

The temperature of water from the well 200 feet deep was 62 degrees Fahrenheit. It had a mineral content of 671, a total hard-

ness of 327, and a content of iron of 0.1 parts per million as shown by the analysis of sample number 47066, collected from this well on February 14, 1922.

Analysis of Sample Number 47066 from City Well 2000 Feet Deep.

Determinations Made.

	Parts per million.
Iron Fe	0.1
Manganese Mn	0.0
Silica SiO_2	13.4
Nonvolatile	1.0
Alumina Al_2O_3	2.2
Calcium Ca	76.3
Magnesium Mg	33.3
Ammonia NH_4	0.5
Sodium Na	103.8
Potassium K	13.9
Sulfate SO_4	188.4
Nitrate NO_3	0.9
Chloride Cl	88.0
Alkalinity Methyl Orange	256.
Residue	672.

Hypothetical Combinations.

	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_8	1.4	.08
Potassium Chloride KCl	25.4	1.48
Sodium Chloride NaCl	125.1	7.32
Sodium Sulfate Na_2SO_4	168.5	9.85
Ammonium Sulfate $(NH_4)_2SO_4$	1.6	.09
Magnesium Sulfate $MgSO_4$	91.6	5.36
Magnesium Carbonate $MgCO_3$	51.0	2.98
Calcium Carbonate $CaCO_3$	190.5	11.14
Silica SiO_2	13.4	.78
Nonvolatile	1.0	.06
Iron Oxide Fe_2O_3	0.2	.01
Alumina Al_2O_3	2.2	.12
Total	671.9	39.27

A discharge pipe in use when this well was equipped with a turbine pump was eaten through in places after sixteen years use.

FORREST (965). Forrest is located in the southeastern part of Livingston County on the drainage area of Vermilion River, a tributary of Illinois River. Many shallow dug wells are in use in the village. Mr. Carmen stated that water is obtained from a sand and gravel stratum below blue clay and above hard clay and soap stone. East of the Wabash Railway a stratum of sand and gravel about 10 feet thick is encountered at a depth of about 25 feet. West of the railway the depth to the stratum may be less with less gravel and more quick sand.

A public water supply was installed by the village about 1895. Water was secured from a dug well near the center of the business district. An elevated wooden tank on a brick tower located close to the well was connected to the mains. About 1900 two coal shafts were dug near the southwestern limits of the village and were abandoned at a depth of 80 feet. The shafts were then leased by the village and the pumping equipment was moved to a pumping station built between the two shafts with the floor about 4 feet below the ground surface. The shafts are each 7 by 14 feet at the top. The pump is a Goulds 8 by 9¼-inch single-acting triplex and is driven at a speed of about 29 revolutions a minute by a 10-horse-

power electric motor. Water at times raises to within 6 feet of the top of the shafts and is drawn down at times to a depth of 30 feet.

Forty-five consumers were supplied with water in 1922 and the amount of water pumped was estimated at from 15,000 to 20,000 gallons a day. The original wooden tank was replaced by another wooden tank of 47,000 gallons capacity placed on the old tower in 1921.

The water had a mineral content of 636, a total hardness of 492, and a content of iron of 2.0 parts per million as shown by the analysis of sample number 35940, collected on November 14, 1916.

Analysis of Sample Number 35940 from the Village Supply.

Determinations Made.	Parts per million.
Iron Fe	2.0
Silica SiO_2	13.2
Alumina Al_2O_3	2.6
Calcium Ca	110.9
Magnesium Mg	52.5
Ammonia NH_4	1.0
Sodium Na	36.5
Potassium K	4.0
Sulfate SO_4	165.7
Nitrate NO_3	0.8
Chloride Cl	15.0
Nonvolatile	0.8
Alkalinity Methyl Orange	328.
Residue	625.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	1.3	0.07
Potassium Chloride KCl	6.7	0.40
Sodium Chloride NaCl	19.5	1.10
Sodium Sulfate Na_2SO_4	88.8	5.10
Ammonium Sulfate $(NH_4)_2SO_4$	3.7	0.20
Magnesium Sulfate $MgSO_4$	129.1	7.60
Magnesium Carbonate $MgCO_3$	91.4	5.30
Calcium Carbonate $CaCO_3$	276.8	16.10
Iron Oxide Fe_2O_3	2.8	0.20
Alumina Al_2O_3	2.6	0.20
Silica SiO_2	13.2	0.80
Nonvolatile	0.8	0.05
Total	636.5	37.12

FORRESTON (884). Forreston is located in the northwestern part of Ogle County on the drainage area of Rock River. A few private wells in use secure water from sand above rock which is encountered at a depth of from 30 to 40 feet.

A public water supply was installed by the village in 1894. Water is pumped by air lift from a well into a collecting reservoir four feet square. From the reservoir it is pumped into the distribution system and an elevated wooden tank connected to the system by a Goulds 7 by 8-inch single-acting triplex pump. A Gardner 8 by 6-inch air compressor and the pump are driven by a 22-horsepower gas engine. The water pumped is measured by a meter at the station. About 175 service connections were in use in 1924 and the consumption was 30,000 gallons a day. Meter rates for three months are 45 cents for the first 2000 gallons with decreases to 15 cents per 1000 gallons for the fourth 10,000 gallons. The minimum charge is $1.50.

Water is secured from a well drilled in 1894. It is located near the business district. It is 300 feet deep, 8 inches in diameter to limestone at a depth of 40 feet, and 6 inches in diameter in limestone to the bottom of the well. Water was first drawn from the well by suction. With lowering of the water level the well was equipped with an air lift with 175 feet of ¾-inch air pipe. At the time of visit in 1920 the displacement of the triplex pump was 135 gallons a minute and the amount registered on the meter was 110 gallons a minute. For some time after the air lift was started it discharged more than the pump was pumping and after a few hours operation it discharged a little less than that amount. The air pressure at start was 75 pounds and during operation it was 72 pounds.

In August, 1924, the triplex pump was operating at a displacement of 132 gallons a minute and the meter on the discharge line registered 98 gallons a minute. The air lift during two hours after starting discharged about 13 gallons more than did the triplex pump. The air compressor operated at a speed of 275 revolutions a minute. The air pressure at start was 70 pounds and during operation it was 65 pounds. The amount of water pumped during 1923 was about 30,000 gallons a day.

The water had a mineral content of 566, a total hardness of 432, and a content of iron of 0.2 parts per million as shown by the analysis of sample number 52204, collected on August 19, 1924.

Analysis of Sample Number 52204 from the Village Supply.

Determinations Made.	Parts per million.
Iron Fe	0.2
Manganese Mn	0.0
Silica SiO_2	19.5
Nonvolatile	1.1
Alumina Al_2O_3	4.9
Calcium Ca	88.9
Magnesium Mg	51.2
Ammonia NH_4	3.9
Sodium Na	33.1
Potassium K	2.6
Sulfate SO_4	59.3
Nitrate NO_3	39.0
Chloride Cl	55.0
Alkalinity Methyl Orange	350.
Residue	600.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	6.8	0.40
Sodium Nitrate $NaNO_3$	47.6	2.78
Sodium Chloride NaCl	51.2	2.99
Ammonium Chloride NH_4Cl	11.4	0.66
Magnesium Chloride $MgCl_2$	22.0	0.13
Magnesium Sulfate $MgSO_4$	74.2	4.33
Magnesium Carbonate $MgCO_3$	105.8	6.18
Calcium Carbonate $CaCO_3$	222.0	12.96
Iron Oxide Fe_2O_3	0.3	0.02
Alumina Al_2O_3	4.9	0.29
Silica SiO_2	19.5	1.14
Nonvolatile	1.1	0.06
Total	566.8	31.94

A sample collected in 1913 was of similar quality.

FRANKFORT (497). Frankfort is located in Will County on the drainage area of Des Plaines River. Water for a public supply

is pumped from a well into an elevated steel tank and the distribution system by a deep-well pump driven by an electric motor. The tank is above the pumping station. It has a capacity of 100,000 gallons and the top is 100 feet above the ground surface.

Eighty service connections were in use in 1923. The rate for six months is 40 cents per 1000 gallons for the first 10,000 gallons and 35 cents per 1000 gallons for the next 10,000 gallons. The minimum charge is $4.00. The lowest rate, 23 cents per 1000 gallons, is for water in excess of 60,000 gallons but no consumers using large quantities were supplied in 1923. The rates are not subject to discount. Water has been used by paving contractors and by the Elgin, Joliet and Eastern Railway. The railway now has a private supply from a well of about the same depth as the village well.

Water for the public supply is secured from a well 165 feet deep located near the center of the village. The elevation of the ground surface is estimated to be near 750 feet above sea level. The well is said to be in drift to a depth of 102 feet, in limestone between depths of 102 and 122 feet, and in hard blue rock below a depth of 122 feet. The well is cased with 8-inch pipe into the limestone. It is equipped with a Deming single-acting deep-well pump. The pump cylinder is placed at a depth of 121 feet and has one length of suction pipe attached. The capacity of the pump when new was 90 gallons a minute and the discharge is now thought to be a little less. The pump has operated from twelve to fifteen hours a day for six months. In 1923 an official stated that the depth to water when not pumping was 40 feet.

Analysis of Sample Number 49185 from the Village Supply.

Determinations Made.

	Parts per million.
Iron Fe	0.8
Manganese Mn	0.0
Silica SiO_2	15.0
Nonvolatile	1.4
Alumina Al_2O_3	1.3
Calcium Ca	87.9
Magnesium Mg	46.4
Ammonia NH_4	0.6
Sodium Na	13.3
Potassium K	3.9
Sulfate SO_4	34.0
Nitrate NO_3	1.9
Chloride Cl	2.0
Alkalinity Methyl Orange	414.0
Residue	445.0

Hypothetical Combinations.

	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	3.1	.18
Potassium KCl	4.6	.27
Potassium Sulfate K_2SO_4	1.0	.06
Sodium Sulfate Na_2SO_4	41.1	2.40
Ammonium Sulfate $(NH_4)_2SO_4$	7.8	.46
Ammonium Carbonate $(NH_4)_2CO_3$	10.8	.63
Magnesium Carbonate $MgCO_3$	160.6	9.38
Calcium Carbonate $CaCO_3$	219.5	12.82
Silica SiO_2	15.0	.88
Nonvolatile	1.4	.08
Iron Oxide Fe_2O_3	1.1	.06
Alumina Al_2O_4	1.3	.08
Total	467.3	27.30

The temperature of water when discharged from the well is 50 degrees Fahrenheit. The water had a mineral content of 467, a total hardness of 410, and a content of iron of 0.8 parts per million as shown by the analysis of sample number 49185, collected fifty minutes after the pump was started on March 1, 1923.

FRANKLIN GROVE (589). Franklin Grove is located in the northern part of Lee County on the drainage area of Franklin Creek, a tributary of Rock River. A public water supply was installed by the village in 1902. Water is pumped from a well directly into the distribution system and a steel pressure tank connected to the system by a deep-well pump which is driven by belt from a 20-horsepower electric motor. A gas engine is available for use in emergency. The tank is 8 feet in diameter and 36 feet long. Fifty service connections were in use in 1923.

Water for the public supply is secured from a well 298 feet deep located near the center of the business district. The well was drilled in 1902. The elevation at the top is about 810 feet above sea level. The well is cased with 10-inch pipe to a depth of sixty feet, thirty feet into rock. It is equipped with a deep-well pump with the cylinder at a depth of 75 feet. The depth to water when not pumping in 1923 was 30 feet. The yield on October 26, 1923, as nearly as could be determined by short time measurements, was 100 gallons a minute.

Analysis of Sample Number 50387 from the Village Supply.

Determinations Made.

	Parts per million.
Iron Fe	1.6
Manganese Mn	0.0
Silica SiO_2	13.1
Alumina Al_2O_3	2.3
Nonvolatile	2.5
Calcium Ca	97.5
Magnesium Mg	48.9
Ammonia NH_4	0.0
Potassium K	3.5
Sodium Na	7.0
Sulfate SO_4	74.3
Nitrate NO_3	1.2
Chloride Cl	2.0
Alkalinity Methyl Orange	340.
Residue	523.

Hypothetical Combinations.

	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	1.9	0.11
Potassium Chloride KCl	5.1	0.30
Sodium Chloride NaCl	1.8	0.10
Ammonium Chloride NH_4Cl	0.0	0.00
Magnesium Chloride $MgCl_2$	9 .1	0.53
Magnesium Sulfate $MgSO_4$	93.0	5.43
Magnesium Carbonate $MgCo_3$	96.0	5.61
Calcium Carbonate $CaCO_3$	243.5	14.22
Iron Oxide Fe_2O_3	3.2	0.19
Alumina Al_2O_3	2.3	0.13
Silica SiO_2	13.1	0.76
Nonvolatile	2.5	0.15
Total	471.5	27.53

The water had a mineral content of 471, a total hardness of 444, and a content of iron of 1.6 parts per million as shown by the

analysis of sample number 50387, collected from a tap on the distribution system on October 26, 1923.

Plumbing fixtures are stained considerably by the water.

FRANKLIN PARK (914). Franklin Park is located in Cook County near the west bank of Des Plaines River. A public water supply was installed by the village about 1910. Water was secured from a well 750 feet deep which has been abandoned. Water is now pumped from a well into a concrete reservoir by a deep-well pump driven by a 35-horsepower electric motor and from the reservoir into the mains by either of two single-stage centrifugal pumps, each driven by a 20-horsepower motor. The reservoir is 30 feet in diameter and has a capacity of 100,000 gallons. A reinforced concrete elevated tank of 80,000 gallons capacity located near the well is connected to the mains. The amount of water pumped is recorded by a Venturi meter at the station. Two hundred and sixty service connections were in use in 1922. The rate for water for domestic consumption for three months is $2.10 for 6000 gallons or less, 24 cents per 1000 gallons for the next 6000 gallons, and 16 cents per 1000 gallons for additional water. Industrial concerns pay monthly. Rates decrease to 10 cents per 1000 gallons for water in excess of 2,000,000 gallons.

The Indiana Harbor Belt Railroad has a private supply. At times they use water from the public supply and their consumption is greater than the entire domestic consumption. A well 1938 feet deep was drilled for the company by the J. P. Miller Artesian Well Company of Chicago in 1922.

Water for the public supply is secured from a well 1242 feet deep drilled by S. B. Geiger in 1917. The elevation of the top of the well is about 645 feet above sea level. A record of material penetrated as prepared by the driller with part of classifications given by the State G.eological Survey Division is as follows:

Clay	23 feet
Gravel	4 feet
Clay	20 feet
Sand and gravel	3 feet
Gravel mixed with clay	23 feet
Limestone, white, Silurian system	137 feet
Limestone, red, Silurian system	40 feet
Shale, blue, Richmond	247 feet
Limestone, gray Galena-Platteville	93 feet
Limestone, brown, Galena-Platteville	30 feet
Limestone, gray, Galena-Platteville	220 feet
Sandstone, St. Peter	122 feet
Limestone, Prairie du Chien	88 feet
Unrecorded	
Total	1242feet5in.

The well is equipped with a Layne turbine pump with the impellors placed at a depth of 240 feet. During a test made about 1920 the water level was said to have been drawn to a depth of 190 feet when pumping 264 gallons a minute. On January 17, 1924, during the first 25 minutes of operation the pump discharged 214 gallons a minute. The amount pumped during 1923 averaged close to 200,000 gallons a day as recorded by meter.

F. M. Gray was drilling another well for the village in 1923. The water had a mineral content of 589 and a total hardness of 390 parts per million as shown by the analysis of sample number 47768, collected on June 22, 1922.

Analysis of Sample Number 47768 from Village Well 1242 feet Deep.

Determinations Made.	Parts per million.
Iron Fe	0.0
Manganese Mn	0.0
Silica SiO_2	9.6
Nonvolatile	1.0
Alumina Al_2O_3	2.4
Calcium Ca	94.7
Magnesium Mg	37.1
Ammonia NH_4	0.5
Sodium Na	51.4
Potassium K	16.7
Sulfate SO_4	139.8
Nitrate NO_3	0.5
Chloride Cl	61.0
Alkalinity Methyl Orange	300.0
Residue	643.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	0.9	.05
Potassium Chloride KCl	31.1	1.82
Sodium Chloride NaCl	76.2	4.45
Sodium Sulfate Na_2SO_4	66.3	3.88
Ammonium Sulfate $(NH_4)_2SO_4$	1.8	.11
Magnesium Sulfate $MgSO_4$	117.4	6.87
Magnesium Carbonate $MgCO_3$	46.4	2.71
Calcium Carbonate $CaCO_3$	236.4	13.82
Silica SiO_2	9.6	.56
Nonvolatile	1.0	.06
Alumina Al_2O_3	2.4	.14
Total	589.5	34.47

Although no iron was found in this sample the supply at services contain iron. Red slime collects in the service pipe and is removed by using a high back pressure. From 50 to 60 meters are repaired each year. Hot-water coils clog in a few months.

FREEPORT (19669). Freeport is located near the center of Stephenson County on the drainage area of Pecatonica River, a tributary of Rock River. A public water supply was installed by the Freeport Water Company in 1882. For a few years some water was obtained from a spring and part of the supply was drawn directly from Pecatonica River. Since about 1890 practically all of the supply has been obtained from wells and water from the river has been used on only a few occasions. A plant to remove iron from the water was installed.

Water is drawn from wells by suction and is discharged to the iron-removal plant by either of two tandem compound duplex steam pumps, each of 2,000,000 gallons capacity, one a Snow 8 and 12 by 14 by 12-inch and the other an Epping Carpenter 8 and 12 by 15 by 18-inch. The main parts of this plant are two sedimentation tanks, eight filters, and three concrete clear water or storage tanks. The sedimentation tanks are 25 feet in diameter and 16 feet high and have false bottoms with a slope of 6 feet to a waste pipe in the center of the bottom of the tank. The capacity of each tank above the false bottom is 44,000 gallons. Ordinarily half of the supply passes through each tank. It enters at about mid-depth and is discharged horizontally along the side of the tank giving the water a whirling motion. Water flows from each tank through a pipe supported 18 inches below the water surface by a float, to the filters. Four of these, installed in 1903, are in circular wooden tanks of 15 feet inside diameter. The other four, installed in 1914, have concrete floors and walls and are 16 feet by 12 feet inside. New York Continental Jewell Filtration Company equipment is used. Reservoirs, to which water flows from the filters, have a combined capacity of 800,000 gallons. Provision is made to treat the water as it enters the sedimentation tanks with milk of lime. This treatment was used for some years using about two grains of hydrated lime per gallon. During the past few years lime has seldom been used.

Water from one well, when it is used, is discharged directly into the clear water reservoirs.

Water is pumped from the reservoirs into the mains by any of three pumps, one Epping Carpenter cross-compound fly-wheel pump of 4,000,000 gallons capacity, one Holly cross-compound fly-wheel pump of 3,000,000 gallons capacity ,and one Knowles compound duplex pump of 1,750,000 gallons capacity.

The entire supply is generally secured from twenty-five wells into sand and gravel located near the north limits of the city near the south bank of Pecatonica River. At times of maximum demand part of the supply is obtained from three wells into rock. The wells into sand and gravel are 6 inches in diameter and about 40 feet deep. They penetrate from 30 to 40 feet of drift and from 5 to 10 feet of limestone. Below the limestone is coarse water bearing sand and gravel from which the supply is obtained. The wells are drilled to the bottom of the limestone and are not provided with screens. They are connected to a 16-inch suction line to the pumps. On October 8, 1920, when the yield was 700 to 800 gallons a minute a vacuum gauge on the suction line stood at

23 inches.

One of the wells into rock was drilled in 1900. It is 8 inches in diameter at the top, 6 inches in diameter at the bottom, and 265 feet deep. This well enters St. Peter sandstone at a depth of about 165 feet and is cased into hard limestone at a depth of 150 feet. The well is equipped with an air lift with 140 feet of air line. The air pressure at start and during operation in 1920 was 43 pounds.

The second of the three wells into rock was drilled about 1914 and was equipped in 1918. The well is 16 inches in diameter and 303 feet deep. It is cased to a depth of 50 feet. Water is drawn from the well by one of the low lift pumps. In 1920 the yield was given as 900 gallons a minute.

The third well into rock was drilled by P. E. Millis of Byron in 1920. A record of material penetrated is as follows:

Soil and clay	34 feet
Limestone, Galena-Platteville	114 feet
Sandstone, St. Peter	316 feet
Dolomite, Prairie du Chien	18 feet
Sandstone, Prairie du Chien	18 feet
Limestone, Prairie du Chien	3 feet
Total depth	503 feet

The well is 16 inches in diameter to a depth of 400 feet and 8 inches in diameter below that depth. It is cased with 16-inch pipe into solid rock at a depth of 60 feet and with about 316 feet of 10-inch pipe. The 10-inch pipe is sealed to the rock at a depth of 130 feet with a rubber packer. In 1921 the water level stood at a depth of 20 feet when not pumping and was lowered 92 feet when pumping 1500 gallons a minute. Water from this well is discharged directly into the reservoir without passing through the purification plant.

Water from the wells into sand and gravel had a mineral content of 445, a total hardness of 395, and a content of iron of 0.8 parts per million as shown by the analysis of sample number 42820, collected on April 6, 1920.

Samples collected in the past have been similar. Water from the well 300 feet deep had a mineral content of 409, a total hardness of 370, and a content of iron of 1.4 parts per million as shown by the analysis of sample number 42821, collected on April 6, 1920.

Casings and seals in wells placed to shut off flows from certain strata may leak, especially after many years service. The first complete mineral analysis of water from the well into St. Peter sandstone from which water above the sandstone was cased out, number 19439, was collected in 1909.

Analysis of Sample Number 42820 from Wells Into Sand and Gravel.

Determinations Made.	Parts per million.
Iron Fe	0.8
Silica SiO_2	13.1
Nonvolatile	0.4
Alumina Al_2O_3	0.6
Calcium Ca	86.8
Magnesium Mg	43.5
Ammonia NH_4	0.0
Sodium Na / Potassium K	13.1
Sulfate SO_4	56.5
Nitrate NO_3	15.0
Nitrite NO_2	0.0
Chloride Cl	20.0
Alkalinity Methyl Orange	320
Residue	454

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Sodium Nitrate, $NaNO_3$	20.6	1.20
Sodium Chloride, NaCl	19.2	1.12
Ammonium Chloride, NH_4Cl	0.1	
Magnesium Chloride, $MgCl_2$	11.1	.65
Magnesium Sulfate, $MgSO_4$	70.7	4.14
Magnesium Carbonate, $MgCO_3$	91.4	5.34
Calcium Carbonate, $CaCO_3$	216.7	12.68
Iron Oxide, Fe_2O_3	1.1	.07
Alumina, Al_2O_3	0.6	.04
Silica, SiO_2	13.1	.77
Nonvolatile	0.4	.02
Total	445.2	26.03

Analysis of Sample Number 42821 from Well 300 Feet Deep.

Determinations Made.	Parts per million.
Iron Fe	1.4
Silica SiO_2	12.5
Nonvolatile	0.5
Alumina Al_2O_3	0.9
Calcium Ca	77.7
Magnesium Mg	42.7
Ammonia NH_4	0.3
Sodium Na / Potassium K	12.0
Sulfate SO_4	35.7
Nitrate NO_3	14.1
Chloride Cl	15.0
Alkalinity Methyl Orange	318.
Residue	405.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Sodium Nitrate $NaNO_3$	19.4	1.13
Sodium Chloride NaCl	17.2	1.00
Ammonium Chloride NH_4Cl	0.9	.06
Magnesium Chloride $MgCl_2$	5.2	.31
Magnesium Sulfate, $MgSO_4$	44.7	2.62
Magnesium Carbonate $MgCO_3$	11.8	6.54
Calcium Carbonate $CaCO_3$	194.0	11.35
Iron Oxide Fe_3O_2	2.0	.12
Alumina Al_2O_3		.05
Silica SiO_2	12.5	.73
Nonvolatile	0.5	.03
Total	409.3	23.94

Analysis of Sample Number 19439 from St, Peter Sandstone,

Determinations Made.	Parts per million.
Iron Fe	0.7
Silica SiO_2	16.1
Alumina Al_2O_3	1.3
Calcium Ca	84.7
Magnesium Mg	44.4
Ammonia NH_4	0.2
Sodium Na	10.4
Potassium K	2.2
Sulfate SO_4	30.0
Nitrate NO_3	15.0
Chloride Cl	18.0
Nonvolatile	2.3
Alkalinity Methyl Orange	335.
Residue	414.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate, KNO_3	5.7	.33
Sodium Nitrate, $NaNO_3$	15.8	.92
Sodium Chloride, NaCl	15.5	.90
Ammonium Chloride, NH_4Cl	0.6	.03
Magnesium Chloride, $MgCl_2$	11.0	.64
Magnesium Sulfate, $MgSO_4$	37.6	2.19
Magnesium Carbonate, $MgCO_3$	117.7	6.86
Calcium Carbonate, $CaCO_3$	211.4	12.31
Iron Carbonate, $FeCO_3$	1.5	1.08
Alumina, Al_2O_3	1.3	.07
Silica, SiO_2	16.1	.94
Nonvolatile	2.3	.13
Total	436.5	25.40

FULTON (2445). Fulton is located in Whiteside County on the east bank of Mississippi River. On bottom lands sufficient water is secured for residences from wells 20 to 25 feet deep. On uplands private wells are generally from 60 to 70 feet deep and enter rock at a depth of about 30 feet.

A public water supply was installed by the city in 1890. Water was secured from a flowing well. The original well has been abandoned and another has been drilled. The well is equipped with an air lift from which water is discharged into two reservoirs, one 15 feet in diameter and 24 feet deep, and the other 36 feet in diameter and 20 feet deep. A gauge at the station shows the quantity of water in the reservoirs in gallons. Water is pumped from the reservoirs by either of two duplex steam pumps, one a Smedley 16 by 10 by 15-inch and the other a Smith-Vaile 14 by 9 by lo-inch. Steam is supplied by two Murray 100-horsepower return tubular boilers. Air is compressed by an Ingersoll-Rand two-stage compressor with 8-inch steam cylinders, 12 and 7½-inch air cylinders and 12-inch stroke. A masonry storage reservoir of 120,000 gallons capacity, located on high land, is connected to the distribution system. Four hundred and seventy-five service connections were in use in 1924. The system is partly metered. The rate for 4500 gallons or less in three months is 35 cents per 1000 gallons. The lowest rate, for water in excess of 150,000 gallons, is 10 cents per 1000 gallons. The minimum charge is $2.00.

The well from which the supply was originally secured was located at the side of the pumping station at the southeast corner of Fourth Street and Thirteenth Avenue. The top of the well is about 595 feet above sea level. It was drilled by the J. P. Miller Artesian Well Company in 1890. The well was cased with 6-inch galvanized pipe to a depth of 238 feet and this casing was sealed in the well with a lead and rubber packer. The well was 5 inches in diameter at the bottom and 1214 feet deep. The drillers noted a flow of water at a depth of 480 feet and a flow of 300 gallons a minute at a depth of 1020 feet. When the well was completed water raised 54 feet above the ground surface. In 1908 the supply was insufficient for the needs of the city. In 1912 this well was equipped with an air lift with 208 feet of 2-inch air pipe. When the city was visited in 1913 the yield of this well, using the air lift, was 100 gallons a minute. The well has since been abandoned.

The well now in use is located about 300 feet west of the original well. It was drilled by Mr. Shaw in 1908. The ground surface at the well is about 595 feet above sea level. The well is

8 inches in diameter, is cased with 8-inch pipe to a depth of 337 feet, and is about 1500 feet deep. The flow when completed was said to be 270 gallons a minute. In 1912 the flow had decreased to 80 gallons a minute and the well was equipped with an air lift with a 2-inch air line extending to a depth of 208 feet. The yield with the air lift was 1200 gallons a minute and using the air lift is said to have increased the natural flow to 125 gallons a minute which in 1913 was sufficient for ordinary demands. On December 17, 1919, the natural flow from the top of the casing which is four or five feet above the ground surface was 44 gallons a minute and the discharge when using the air lift was 1090 gallons a minute. The average quantity supplied during the year was near 150,000 gallons a day. The yield with air lift and total amount pumped in 1924 was about the same as in 1919. The air pressure was 88 pounds when starting and 75 pounds during operation. There was no flow in 1924 when not operating the air lift.

The water had a mineral content of 340, a total hardness of 241, and a content of iron of 0.2 parts per million as shown by the analysis of sample number 52205, collected on August 21, 1924, after the air lift had been operated for one hour.

Analysis of Sample Number 52205 from the City Supply.

Determinations Made.	Parts per million.
Iron Fe	0.2
Manganese Mn	0.0
Silica SiO_2	8.1
Nonvolatile	1.6
Alumina Al_2O_3	1.2
Calcium Ca	49.7
Magnesium Mg	28.7
Ammonia NH_4	0.6
Sodium Na	32.1
Potassium K.	9.0
Sulfate SO_4	29.4
Nitrate NO_3	0.9
Chloride Cl.	19.0
Alkalinity Methyl Orange	290.
Residue	366.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate, KNO_3.	1.4	0.08
Potassium Chloride, KCl.	16.0	0.93
Sodium Chloride, NaCl	18.8	1.10
Sodium Sulfate, Na_2SO_4	43.5	2.54
Sodium Carbonate, Na_2CO_3.	24.5	1.43
Ammonium Carbonate, $(NH_4)_2CO_3$	1.5	0.09
Magnesium Carbonate, $MgCO_3$.	99.2	5.79
Calcium Carbonate, $CaCO_3$.	124.1	7.25
Iron Oxide, Fe_2O_3.	0.3	0.02
Alumina, Al_2O_3	1.2	0.07
Silica, SiO_2	8.1	0.47
Nonvolatile	1.6	0.09
Total	340.2	19.86

A sample collected in 1910 had a mineral content of 388 and a total hardness of 261 parts per million.

Considerable sludge is deposited in a preheater at the pumping station. The boilers are cleaned about every three weeks. The original boiler, installed in 1886, was sold for use at a greenhouse after 24 years use at the station and was used at the greenhouse until 1924. There is a strong odor of hydrogen sulphide in the vicinity of the well when using the air lift.

GALENA (4742). Galena is located on Galena River in the northwestern part of Jo Daviess County. A public water supply was installed by a private company in 1886. Water was secured from a flowing well. The city purchased the plant in 1918, drilled another well, and repaired the old well. New pumping equipment was installed in 1922. Water is pumped from the wells into the mains by either a Worthington 9 by 10-inch triplex or a Worthington centrifugal of 500 gallons a minute capacity. Each pump is driven by a 30-horsepower electric motor. The pumps are operated

---

Analyses of Samples of Water

Sample number	43975
Date	Oct. 7, 1920
Depth in feet	400
Flow in gallons a minute	2

Determinations Made.	Parts per million.
Iron Fe	.4
Manganese Mn	.0
Silica SiO_2	11.1
Nonvolatile	.9
Alumina Al_2O_3	2.4
Calcium Ca	54.9
Magnesium Mg	33.2
Ammonia NH_4	.1
Sodium Na	13.9
Potassium K, Sulfate SO_4	18.9
Nitrate NO_3	2.8
Chloride Cl	3.0
Alkalinity	
Phenolphthalein	0
Methyl Orange	276.0
Residue	328

Hypotheitcal Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	.....	.....
Potassium Chloride KCl	.....	.....
Potasium Sulfate K_2SO_4	.....	.....
Sodium Nitrate $NaNO_3$	3.9	.23
Sodium Chloride NaCl	5.0	.29
Sodium Sulfate Na_2SO_4	227.9	1.63
Sodium Carbonate Na_2O_3	43	.25
Ammonium Sulfate $(NH_4)_2SO_4$	.....	.....
Ammonium Carbonate $(NH_4)_2CO_3$	.2	.01
Magnesium Carbonate $MgCO_3$	114.9	6.72
Magnesium Sulfate $MgSO_4$	.....	.....
Calcium Carbonate $CaCO_3$	137.3	8.03
Iron Oxide Fe_2O_3	.6	.03
Nonvolatile	.9	.05
Silica SiO_2	11.1	.65
Alumina Al_2O_3	2.4	.14
Total	308.5	18.03

with automatic control. The controls are set so that pumping is generally done by the triplex pump. An elevated steel tank of 105,000 gallons capacity, located on high ground in the western part of the city, is connected to the mains.

The amount of water used in 1922 probably averaged close to 500,000 gallons a day. Meter rates are 60 cents per 1000 gallons for 100 to 1000 gallons a day and are lower for greater quantities. The lowest rate, for water in excess of 10,000 gallons a day, is 18 cents per 1000 gallons. Bills are not subject to cash discount.

From Well Number 2—Galena.

46395		46633		46743	
Oct. 19, 1921		Nov. 21, 1921		Dec. 7, 1921	
720		1260		1470	
45		370		560	
Parts per million.		Parts per million.		Parts per million.	
1.4		0.1		0.1	
.2		0.0		Trace	
22.5		11.6		12.1	
1.2		.7		.7	
2.1		.6		.8	
5.17		40.0		50.8	
28.7		31.0		31.5	
.1		.0		.0	
13.9		5.0		4.1	
3.4		2.3		2.4	
20.0		16.8		16.0	
.5		1.8		.9	
2.0		4.0		3.0	
0		0		0	
248.		216.0		242.	
296		254		263	
Parts per million.	Grains per gallon.	Parts per million.	Grains per gallon.	Parts per million.	Grains per gallon.
.8	.05	2.8	.16	1.4	.08
4.2	.24	2.5	.14	3.7	.21
1.8	.11	.....	.....	.....	.....
.....	.....	.....	.....	.....	.....
.....	.....	4.7	.28	2.1	.12
28.3	1.66	9.7	.56	10.1	.59
10.0	.64	.....	.....	.....	.....
.....	.....	.1	.00	.2	.01
.2	.01	.....	.....	.....	.....
99.3	5.80	98.4	5.76	101.0	5.91
.....	.....	12.8	.77	11.3	.66
129.0	7.54	100.0	5.85	126.9	7.42
2.0	.12	.2	.01	.1	.00
1.2	.07	.7	.04	.7	.04
22.5	1.31	11.6	.68	12.1	.71
2.1	.12	.6	.04	.8	.05
302.3	17.67	244.1	14.30	270.4	15.81

The public water supply is obtained from two wells. The elevation of the ground surface at the wells is about 610 feet above sea level. One well was drilled in 1886. It was eased with 12-inch pipe into rock to a depth of 60 feet, was 6 inches in diameter at the bottom, and was 1547 feet deep. It is said that when the well was drilled the pressure at the ground surface was 36 pounds and the flow was 500 gallons a minute. About 1896 a valve was placed on the discharge pipe and Mr. Myers states that water raised to the top of 32 feet of pipe placed vertical. Closing the valve was said to have forced water up around the casing and the valve was removed. Records of the water company give the flow of the well in 1916 as 450 gallons a minute and in 1918, when measured by the city, the flow was 250 gallons a minute. The well was recased in 1922.

Well number 2 was drilled by the W. L. Thorne Company of Des Plaines in 1920-1921 at a distance of 130 feet from well number 1, near the corner of Park Avenue and Bouthillier Streets. It was drilled 16 inches in diameter to a depth of 150 feet, cased with 16-inch pipe to a depth of 60 feet and with 10-inch pipe to a depth of 150 feet, and filled with 104 sacks of cement outside of the 10-inch casing. Below the 10-inch casing the well is 8 inches in diameter to the bottom at a depth of 1513 feet and an 8-inch casing extends from the ground surface to a depth of 448 feet. A record of material penetrated with part of classifications given by the State Geological Survey Division is as follows:

	Thickness in feet.	Depth in feet.
Clay	58	58
Limestone, Platteville	82	140
Sandstone, St. Peter	205	345
Limestone, Prairie du Chien	90	435
Shale, red, Prairie du Chien	20	455
Sandstone, white, Jordan, Cambrian system	30	485
Limestone, gray, St. Lawrence, Cambrian system	115	600
Shale, St. Lawrence, Cambrian system	80	680
Sandstone, Franconia and Dresbach, Cambrian system	230	910
Limestone, sandy, brown, Eau Claire, Cambrian system	40	950
Clay, blue, Eau Claire, Cambrian system	10	960
Shale, sandy, red, Eau Claire, Cambrian system	10	970
Sandstone, Mt. Simon, Cambrian system	430	1400

At a depth of 400 feet when the well was through St. Peter sandstone the flow was about two gallons a minute. When Cambrian sandstone was entered the flow was about 10 gallons a minute. As the well penetrated Cambrian sandstone the flow increased as follows:

Depth in feet.	Yield in gallons a minute.	
720	45	
....	175	flow measured day after 720 feet was reached.
900	210	
1100	350	
1250	370	
1330	410	
1370	475	
1400	530	
1435	550	
1445	560	
1513	560	

The flow of this well at various depths may have been considerably affected by the flow of the other well, water flowing part way up the other well from near the bottom then through porous strata into this well.

Recent data is sent by J. B. Christy, one of the Board of Water Commissioners. The wells are connected by an 8-inch pipe line. A relief valve on the line is set at 17 pounds and when the pumps are not operated some water flows to waste through the line. A gauge on the suction line of the pumps then shows a pressure of 14 pounds. When pumping with the triplex pump at a rate of 350 gallons a minute the pressure is reduced to 9 pounds. When pumping 400 gallons a minute with the centrifugal pump the pressure is reduced to 6½ pounds and when operating both pumps and discharging 750 gallons a minute the pressure is reduced to 3½ pounds. When the two pumps discharge 850 gallons a minute the pressure on the suction line is practically zero.

The waters secured from well number 2 at different depths did not differ greatly as shown by the analysis given. When the well was 720 feet deep the temperature of the flowing water was 13 degrees centigrade and when a depth of 1450 feet was reached the temperature of the water was 15 degrees centigrade.

GALESBURG (23,834). Galesburg is located in the western part of Knox County on the water shed between Mississippi and Illinois Rivers. A large part of the city drainage is into Cedar Creek, a tributary of Mississippi River. Many private wells which have been in use are from 20 to 30 feet deep.

A public water supply was installed by the city in 1890. Water was drawn by suction from wells drilled to depths of from 70 to 80 feet near the bank of Cedar Creek close to the present water works building. Sand was entered below blue clay at a depth of about 50 feet. Shortly after 1890 wells were drilled to St. Peter

sandstone and for many years the supply was partly from wells into sand and partly from wells into St. Peter sandstone. The depth to water in the wells first drilled into St. Peter sandstone was about 100 feet. The wells into sand have been abandoned and a well which now furnishes a large part of the supply has been drilled into Cambrian sandstone. Water from this well is pumped into a concrete reservoir of 6,000,000 gallons capacity. From the reservoir water is pumped into the mains by either of two American single-stage centrifugal pumps, each of 600 gallons a minute capacity. Each pump is driven by a 40-horsepower electric motor. Two centrifugal pumps, each driven by a gas engine, have been installed as stand-by units. One has a capacity of 600 gallons a minute and the other a capacity of 1500 gallons a minute. Two wells into St. Peter sandstone, each at considerable distance from the main station, are equipped with air lifts. Each discharges water into a small reservoir from which it is pumped into the mains by an American single-stage centrifugal pump. The total water consumption in 1921 averaged near 1,000,000 gallons a day.

The public water supply is secured from three wells. Nearly all water is pumped from a well 2414 feet deep into Cambrian sandstone at the main pumping station, known as the Geiger well. It was drilled by S. B. Geiger in 1919 and put in service in 1920. It has 219 feet of 21-inch and 354 feet of 16-inch outside diameter casing. Below the casing the well is 15 inches in diameter to a depth of 1225 feet, 12 inches in diameter between depths of 1225 and 2100 feet, 11 inches in diameter between depths of 2100 and 2175 feet, and 10 inches in diameter between depths of 2175 and 2414 feet. The well was tested by pumping at a rate of 1200 gallons a minute and the water level was lowered 46 feet. After the first test water stood at a depth of 156 feet which is said to be a little higher than before the test. The well is equipped with an American 20-inch three-stage turbine pump driven by a 100-horsepower electric motor. The bottom of the pump is placed at a depth of about 204 feet and has 40 feet of suction pipe attached. The pump operated about 15 hours a day in 1921.

A well drilled in 1917 at the Central fire station near the central part of the business district is used occasionally. The well is 24 inches in diameter at the top, 10 inches in diameter at the bottom, and 1252 feet deep. It is in St. Peter sandstone below a depth of 1090 feet and is cased from the top to within 3 feet of the sandstone to exclude water encountered above the sandstone. The well was shot with two 200-pound charges of 100 per cent gelatin, cover-

ing the entire sandstone stratum, and was cleaned out after shooting. The well is equipped with an air lift with 2½-inch air pipe extending to a depth of 566 feet and 5-inch and 6-inch discharge pipe. Air is supplied by a Sullivan angle-compound 16 by 9¾ by 12-inch air compressor driven by an electric motor. During a test the air compressor was operated to furnish 450 cubic feet of free air a minute. The well yielded 450 gallons a minute with a lowering of the water level of 118 feet. The depth to water when not pumping was 186 feet.

A well known as the Brooks Street station well, drilled at the side of the Brooks Street fire station in 1918, is used occasionally. The well is 15 inches in diameter to a depth of 360 feet, 14¼ inches in diameter between depths of 360 and 610 feet, and 13½ inches in diameter below a depth of 610 feet to the bottom at a depth of 1245 feet. The well is cased to St. Peter sandstone. It is equipped with an air lift with 3-inch air pipe to a depth of 600 feet and with 6-inch, 7-inch, and 8-inch discharge pipe. During a test on March 8, 1919, the compressor was operated to furnish 719 cubic feet of free air a minute. The well yielded 650 gallons a minute, lowering the water level 157 feet. The depth to water when not pumping was 190 feet. The air lift is operated occasionally and has discharged considerably more than at the time of test. On May 5, 1921, the discharge was 820 gallons a minute.

Water from the well 2414 feet deep had a mineral content of 1052, a total hardness of 246, and a content of iron of 0.3 parts per million as shown by the analysis of sample number 45201, collected on May 13, 1921.

Analysis of Sample Number 45201 from Well 2414 Feet Deep.

Determinations Made.

	Parts per million.
Iron Fe	0.3
Manganese Mn	0.0
Silica SiO_2	10.4
Nonvolatile	0.8
Alumina Al_2O_3	1.8
Calcium Ca	56.6
Magnesium Mg	25.6
Ammonia NH_4	0.9
Potassium K	16.1
Sodium Na	272.1
Sulfate SO_4	332.1
Nitrate NO_3	1.8
Chloride Cl	170.0
Alkalinity	
Phenolphthalein	0
Methyl Orange	248.
Residue	1033.

Hypothetical Combinations.

	Parts per million.	Grains per gallon.
Potassium Nitrate, KNO_3	2.9	.17
Potassium Chloride, KCl	28.6	1.67
Sodium Chloride, NaCl	257.7	15.07
Sodium Sulfate, Na_2SO_4	490.7	28.70
Sodium Carbonate, Na_2CO_3	27.4	1.60
Ammonium Carbonate, $(NH_4)_2CO_3$	2.4	.14
Magnesium Carbonate, $MgCO_3$	88.4	5.20
Calcium Carbonate, $CaCO_3$	141.3	8.26
Silica, SiO_2	10.4	.61
Nonvolatile	0.8	.05
Iron Oxide, Fe_2O_3	0.4	.02
Alumina, Al_2O_3	1.8	.11
Total	1052.8	61.60

Water from the Central Station well into St. Peter sandstone had a mineral content of 1689, a total hardness of 455, and a content of iron of 0.3 parts per million as shown by the analysis of sample number 39697, collected on July 2, 1918.

Analysis of Sample Number 39697 From Central Station Well.

Determinations Made.	Parts per million.
Iron Fe	0.3
Alumina Al_2O_3	0.1
Manganese Mn	0.0
Silica SiO_2	13.8
Nonvolatile	0.4
Calcium Ca	103.8
Magnesium Mg	47.8
Ammonia NH_4	1.0
Sodium Na / Potassium K	402.3
Sulfate SO_4	797.1
Nitrate NO_3	2.7
Chloride Cl	155.0
Alkalinity Methyl Orange	259.0
Residue	1751.0
Carbon Dioxide CO_2	1.0
Hydrogen Sulphide H_2S	0.4

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Sodium Nitrate, $NaNO_3$	3.6	.21
Sodium Chloride. NaCl	255.4	14.83
Sodium Sulfate, Na_2SO_4	927.2	53.60
Ammonium Sulfate, $(NH_4)_2SO_4$	3.8	.22
Magnesium Sulfate, $MgSO_4$	203.1	11.77
Magnesium Carbonate, $MgCO_3$	23 .1	1.33
Calcium Carbonate, $CaCO_3$	259.2	15.25
Iron Carbonate, $FeCO_3$	0.6	.03
Alumina, Al_2O_3	0.1	.01
Silica, SiO_2	13.8	.80
Nonvolatile	0.4	.02
Total	1689.2	95.81

Tests of the wells into sand which were formerly used were conducted by Dabney H. Maury in September, 1912. The combined yield of one well with a 10-inch strainer and four wells each with 8-inch strainers was 481 gallons a minute. He concluded that not much more than 500 gallons per minute could be pumped from the six wells into sand with the equipment as it existed in September, 1912. It was never possible to operate all of the wells continuously as men were constantly engaged in making repairs. In 1913 or 1914 a well of large diameter was installed. It was six feet in diameter and cased with steel to a depth of 60 feet. Below this, to a depth of 80 feet, were two concentric perforated casings with a space of 18 inches between them filled with gravel. The yield of this well was reported in 1914 to be 250 gallons a minute. Three 6-inch wells into sand were then in use. Two were reported to yield 200 gallons a minute each and the other was reported to yield 100 gallons a minute. It is doubtful if this quantity of water was secured continuously for any great length of time.

A sample of water, number 28653, collected from one of the wells into sand, well number 1, on August 31, 1914, had a mineral content of 510, a total hardness of 405, and a content of iron of 1.4 parts per million as shown by the analysis.

Analysis of Sample Number 28653 from City Well 80 Feet Deep.

Determinations Made.	Parts per million.
Turbidity	16.
Residue	510.
Iron Fe	1.4
Sulfate SO_4	69.1
Nitrate NO_3	1.77
Chloride Cl	13.0
Alkalinity Methyl Orange	383.
NonCarbonate hardness	22.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Sodium Nitrate, $NaNO_3$	2.4	.14
Sodium Chloride, NaCl	21.5	1.25
Sodium Sulfate, Na_2SO_4	70.8	4.13
Magnesium Sulfate, $MgSO_4$	26.4	1.54
Magnesium Carbonate, $MgCO_3$	72.2	4.21
Calcium Carbonate, $CaCO_3$	297.0	17.32
Iron Carbonate, $FeCO_3$	2.9	.17
Undetermined	16.8	.98
Total	510.0	29.75

GALVA (2974). Galva is located in the southeastern part of Henry County on the water-shed between Mississippi and Illinois Rivers. Some wells in use at residences are from 25 to 30 feet deep but now practically all residents and industrial plants in the city secure water from the public supply.

A public water supply was installed by the city in 1894. Water from three wells is discharged into two collecting reservoirs, one of 96,000 gallons capacity and the other of 100,000 gallons capacity. Air to operate air lifts is supplied by a Sullivan two-stage air compressor with 16-inch steam cylinder, 18 and 11-inch air cylinders, and 16-inch stroke. Water is pumped from the reservoirs into the mains by either of two Deane duplex steam pumps, one 14 by 8½ by 10-inch and the other 16 by 9½ by 10-inch. A steel tank 11 feet in diameter and 55 feet high of 36,000 gallons capacity on a brick tower 60 feet high is connected to the mains. The average water consumption in 1921 was estimated at 200,000 gallons a day. The water rate for the first 1250 cubic feet is 50 cents per 100 cubic feet with a minimum charge of $2.10 for three months. The lowest rate, for all over 100,000 cubic feet, is 35 cents per 100 cubic feet.

Water is secured from three wells into St. Peter sandstone located to the east of the business district of the city. The tops of the wells are about 850 feet above sea level. Well number 1 was drilled in 1894. A record of material as given by Mr. Lundberg, Superintendent, with part of the classification by the State Geological Survey Division, is as follows:

	Thickness in feet.	Depth in feet.
Drift	62	62
Coal measures	393	455
Limestone	427	882
Shale, Maquoketa	148	1030
Shale, Maquoketa	25	1055
Limestone, Galena-Platteville	326	1381
Sandstone, St. Peter	96	1477

The well is cased with 12-inch pipe to a depth of 110 feet, with 9-inch pipe from the surface to a depth of 455 feet, and with 6-inch pipe from the 9-inch to St. Peter sandstone. The well is equipped with a steam-head pump with 36-inch stroke and with 6¾-inch water cylinder placed at a depth of 300 feet. In 1920 the pump delivered full capacity at 18 strokes per minute and drew air at 22 strokes per minute. The yield was 85 gallons a minute and was said to be not appreciably affected by operating well number 2. The depth to water when not pumping in 1912 was given as 235 feet.

Well number 2 was drilled in 1899. It is fifteen feet distant from well number 1 and is 1525 feet deep. It is similar to well number 1 except that the 9-inch pipe does not come to the ground surface. It was equipped in 1920 with an air lift with 660 feet of 2-inch air pipe and 4-inch, 4½-inch, and 5-inch discharge pipe. The air lift operated in 1921 with gauge at 138 pounds and discharged 125 gallons a minute. In July 1920 the depth to water when not pumping was 268 feet.

Well number 3 was drilled by the Whitney Well Drilling Company in 1920-1921. It is 40 feet distant from well number 1 and 54 feet distant from well number 2. It is cased with 15-inch pipe to a depth of 450 feet and with 12-inch pipe between depths of 450 and 1050 feet and is 1524 feet deep. The material penetrated is as shown by the log of well number 1. In the Galena-Platteville formations a sand stratum 25 feet thick, encountered at a depth of about 1260 feet, yielded an abundant supply of water. The St. Peter sandstone was very hard and was blasted with 300 pounds of nitro-glycerine. The well, equipped with an air lift with 464 feet of air pipe, yielded 230 gallons a minute during a 6-hour test before blasting. An air gauge indicated 126 pounds pressure at the start and 80 pounds during operation. After adding 43 feet of air pipe the yield was 250 gallons a minute during a 2-hour test. One other well was operating during the test. After blasting the well yielded 320 gallons a minute. The water level in 1921 was about 270 feet below the ground surface when not pumping and the lowering when pumping, estimated from the drop in air pressure, was 60 or 70 feet. The air lift equipment in 1921 included a number 4½ Selvin foot-piece attached to 447 feet of air line.

The temperature of water from well number 3 in 1921 was 72 degrees Fahrenheit. A sample of water, number 39702, collected from the well number 2 on July 5, 1918, had a mineral content of 935, a total hardness of 157, and a content of iron of 1.0 parts per million as shown by the analysis.

Analysis of Sample Number 39702 from Well Number 2.

Determinations Made.	Parts per million.
Iron Fe	1.0
Manganese Mn	0.0
Silica SiO_2	11.6
Nonvolatile	0.0
Alumina Al_2O_3	0.0
Calcium Ca	35.3
Magnesium Mg	16.7
Ammonia NH_4	1.8
Sodium Na	284.9
Sulfate SO_4	249.5
Nitrate NO_3	1.1
Chloride Cl	170.0
Carbon Dioxide	2.0
Hydrogen Sulphide	0.5
Alkalinity Methyl Orange.	238.0
Residue	928.6

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Sodium Nitrate, $NaNO_3$	1.4	.09
Sodium Chloride, NaCl	280.1	16.34
Sodium Sulfate, Na_2SO_4	368.9	21.52
Sodium Carbonate, Na_2CO_3	125.1	7.30
Magnesium Carbonate, $MgCO_3$	57.9	3.38
Calcium Carbonate, $CaCO_3$	88.6	5.17
Iron Carbonate, $FeCO_3$	2.0	.12
Silica, SiO_2	11.6	.68
Total	935.6	54.60

An open feed water heater in use at the pumping station is cleaned out once a month by washing out slush and the boilers are flushed out every three weeks. Some meters in the city have been in use for as much as 20 years. Although repeated analysis have shown 0.6 parts per million or more of iron the water does not stain plumbing fixtures or clothes.

GENESEO (3375). Geneseo is located in Henry County on low land about two miles south of Green River a tributary of Rock River. Water for a public water supply was first secured from a well about 400 feet deep located near the center of the city. Later a well 2500 feet deep was drilled for the city by the J. P. Miller Artesian Well Company. Water was reported to have raised about 30 feet above the ground surface. In 1902 a supply was developed from springs located about a mile north of the northeast limits of the city near the Hennepin canal. At the present time water is secured from the springs and from two wells located on the same plot of ground.

Water from the springs flows into a reservoir 50 feet in diameter and 12 feet deep. Water from the wells flows to a reservoir 10 feet in diameter and 20 feet deep. The two reservoirs are connected by a pipe line. Water is pumped from the smaller reservoir by an American two-stage centrifugal pump which discharges into a pipe line connecting with the distribution system. The pump discharge at the time of visit in 3.924 was about 500 gallons a minute. A Goulds 8 by 8-inch triplex pump driven by

a 45-horsepower gas engine can be used in emergency. An elevated tank is connected to the distribution system.

About 930 service connections were in use in 1924. The meter rate for three months is 35 cents per 1000 gallons for the first 5000 gallons, 30 cents per 1000 gallons for the next 10,000 gallons, 25 cents per 1000 gallons for the next 10,000 gallons, and 20 cents per 1000 gallons for additional quantities, with a minimum charge of $1.50.

Analysis of Sample Number 39701 from Village Springs.

Determinations Made.

	Parts per million.
Iron Fe	0.0
Manganese Mn	0.0
Silica SiO_2	15.1
Nonvolatile	2.1
Alumina Al_2O_3	2.2
Calcium Ca	64.5
Magnesium Mg	43.8
Ammonia NH_4	0.0
Sodium Na	7.6
Sulfate SO_4	65.1
Nitrate NO_3	2.1
Chloride Cl	8.0
Alkalinity Methyl Orange	288.
Residue	394.
Carbon Dioxide	3.0

Hypothetical Combinations.

	Parts per million.	Grains per gallon.
Sodium Nitrate, $NaNO_3$	2.9	.17
Sodium Chloride, NaCl	11.7	.68
Sodium Sulfate, Na_2SO_4	6.3	.37
Ammonium Sulfate, $(NH_4)_2SO_4$	0.1	.01
Magnesium Sulfate, $MgSO_4$	75.5	4.40
Magnesium Carbonate, $MgCO_3$	98.9	5.77
Calcium Carbonate, $CaCO_3$	161.1	9.39
Alumina, Al_2O_3	2.2	.13
Silica, SiO_2	15.1	.87
Nonvolatile	2.1	.12
Total	375.8	21.91

Water for the public supply is secured from two springs and two wells located about a miles north of the city. The wells are from 17 to 19 feet deep. They are cased with 8-inch pipe and have screens 6½ feet long below the casings. A record of well number two shows 4 feet of soil, 4½ feet of yellow sand, 3 feet of red sand and gravel, and 7½ feet of gravel. The well extends to the bottom of the gravel. A 4-inch drop pipe extends to within one or two feet of the bottom of each well. These drop pipes are connected to a 5-inch pipe line through which water flows to the larger reservoir. The line is carried downward in the reservoir to within five feet of the bottom and acts as a siphon, when there are no leaks in the line, when the water level in the reservoir is drawn below any part of the line. On December 4, 1924, when the water level in the reservoir was drawn down to a depth of more than 11 feet below the top of the small reservoir, the inflow from the springs and wells was 170 gallons a minute. When the water level raised to 10 feet 6 inches below the top of the reservoir the rate of inflow was 128 gallons a minute. There was a small leak in the pipe line from the wells at the time. During twelve months

to March, 1923, the amount of water pumped averaged 175,000 gallons a day. This is computed from the time the pumps are operated, using 500 gallons a minute and 350 gallons a minute as the capacities of the centrifugal and triplex pumps respectively.

Samples of water collected from the springs have had mineral contents of from 370 to 376, total hardness of from 290 to 340, and iron contents of from 0.0 to 0.3 parts per million. The analysis of sample number 39701, collected on July 5, 1918, is given.

Water from the wells may be a little more highly mineralized and contain a little more iron. The water stains plumbing fixtures and has some action on meters. Meters were repaired by local plumbers until the last few years when extensive repairs were made by regular meter readers and repairmen.

GENEVA (2803). Geneva is located in the eastern part of Kane County on the banks of Fox River. A public water supply was installed by the city in 1896. Water is pumped from wells into a collecting reservoir by air lift and from the reservoir into the mains by either of two American centrifugal pumps each of 350 gallons a minute capacity against a head of 170 feet or an American centrifugal pump of 1400 gallons a minute capacity against a head of 210 feet. Air is furnished either by an Ingersoll-Rand 14 by 12-inch class E. R. compressor, or a Worthington 11 and 7 by 12-inch feather valve straight line compressor. The reservoir has two compartments, each 28 by 48 feet in plan and 14 feet deep. Nearly all residents use water from the public supply and the consumption in 1921 was estimated at between 225,000 gallons and 250,000 gallons a day. The amount pumped in 1924 was about 250,000 gallons a day.

The rates for water for three months are $1.75 for the first 500 cubic feet, 30 cents per 100 cubic feet for the next 2500 cubic feet, 25 cents per 100 cubic feet for the next 3000 cubic feet, and 15 cents per 100 cubic feet for water in excess of 6000 cubic feet. The minimum charge is $1.75.

The Chicago and Northwestern Railway and an Ice Company have private water supplies from wells.

The public water supply is secured from two wells. The first well was drilled in 1896. It is located close to the west bank of Fox River near the center of the city. The depth has been reported as 850 feet, 890 feet, and 1000 feet. The well is 8 inches or 10 inches in diameter at the bottom. In 1911 the well had a natural flow of 50 gallons a minute and the yield when pumping

with an air lift with 170 feet of air pipe was said to be 500 gallons a minute. In 1918 a Sullivan air lift was installed. In 1922 the length of air line was thought to be 270 feet and the gauge pressure when operating was 87 pounds. The yield after several hours operation on April 17, 1922, was 234 gallons a minute and the depth to water while pumping was 50 feet. The depth to water when not pumping in January, 1922, was 29 feet. The length of time the air lift had been idle is not known but it was seldom idle many hours at a time.

The other well was drilled for the city by the W. L. Thorne Company of Des Plaines and was completed in 1924. The well is 1156 feet deep. The well is cased with 12-inch pipe to a depth of 224 feet and is 12 inches in diameter at the bottom. Rock was entered within four feet of the ground surface and the bottom of the well is in sandstone. The well was tested at a rate of 300 gallons a minute. Water stood 60 feet below the ground surface and was lowered to a depth of 100 feet.

This well is equipped with an air lift with 412 feet of 6-inch discharge line and 381 feet of 2-inch air pipe. Water is pumped at a rate of about 340 gallons a minute. The water level was reported in April, 1925, to be at a depth of 62 feet when not pumping and 186 feet when pumping.

Water from the city well had a temperature of 54 degrees Fahrenheit. It had a mineral content of 409 and a total hardness of 237 parts per million as shown by the analysis of sample number 38886, collected on January 30, 1918.

Analysis of Sample Number 38886 from City Well in Use in 1918.

Determinations Made.	Parts per million.
Iron Fe	0.0
Manganese Mn	0.0
Silica SiO_2	11.9
Alumina Al_2O_3	1.7
Calcium Ca	45.4
Magnesium Mg	30.1
Sodium Na	55.5
Potassium K	11.9
Sulfate SO_4	61.0
Nitrate NO_3	8.0
Chloride Cl	11.0
Alkalinity Methyl Orange	284.
Residue	415.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate, KNO_3	13.0	.76
Potassium Chloride, KCl	13.2	.77
Sodium Chloride, NaCl	7.9	.46
Sodium Sulfate, Na_2SO_4	90.1	5.26
Sodium Carbonate, Na_2CO_3	53.5	3.12
Magnesium Carbonate, $MgCO_3$	104.4	6.09
Calcium Carbonate, $CaCO_3$	113.4	6.61
Manganese Carbonate, $MnCO_3$	0.1	.00
Alumina, Al_2O_3	1.7	.10
Silica, SiO_2	11.9	.69
Total	409.2	23.87

The sample is similar to one collected in 1911.

Water from a spring in an old creamery which was considered as a possible source of supply in 1918 had a mineral content of

626, a total hardness of 450, and a content of iron of 1.8 parts per million as shown by the analysis of sample number 38885, collected on January 30, 1918.

Analysis of Sample Number 38885 from a Spring.

Determinations Made.	Parts per million.
Iron Fe	1.8
Manganese Mn	0.0
Silica SiO_2	17.4
Alumina Al_2O_3	5.8
Calcium Ca	137.3
Magnesium Mg	26.4
Sodium Na	37.4
Potassium K	4.4
Sulfate SO_4	105.0
Nitrate NO_3	44.2
Chloride Cl	39.0
Alkalinity Methyl Orange	304.
Residue	630.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate, KNO_3	11.3	.66
Sodium Nitrate, $NaNO_3$	51.0	2.97
Sodium Chloride, NaCl	60.0	3.50
Magnesium Chloride, $MgCl_2$	2.6	.15
Magnesium Sulfate, $MgSO_4$	126.2	7.36
Calcium Sulfate, $CaSO_4$	5.6	.34
Calcium Carbonate, $CaCO_3$	343.0	20.01
Iron Carbonate, $FeCO_3$	3.7	.22
Alumina, Al_2O_3	5.8	.34
Silica, SiO_2	17.4	1.02
Total	626.9	36.57

This water is not of as good quality as the city supply.

An ice company has two wells located about a block north of the city plant, one 1000 feet deep and the other 2000 feet deep. The deeper well was formerly in use by the Pope Glucose Company and was said to have furnished water to the fourth floor of their plant without pumping. The depth to water in 1922 was 25 feet. The well was equipped with an air lift of 100 gallons a minute capacity. Water from this well is said to be softer than the city supply.

GENOA (1228). Genoa is located in the northeastern part of DeKalb County on the drainage area of Kishwaukee River, a tributary of Rock River. Some water is obtained from private wells about 50 feet deep. A public water supply was installed by the city in 1900. Water from two wells is pumped directly into the mains to which two steel pressure tanks are connected. The tanks are 8 feet in diameter and 36 feet long and are located in the pump ing station. The pumps are driven by electric motor and a gas engine is available in case of emergency.

Four hundred and three consumers were supplied with water in June, 1923. The minimum rate, $2.50 for three months, is for quantities less than 5000 gallons and the lowest rate, 10 cents per 1000 gallons, is for quantities in excess of 100,000 gallons. A discount of 50 cents is allowed for prompt payment.

Water is obtained from two wells located 25 feet apart. The ground surface is about 810 feet above sea level. One well, to the

north, was drilled in 1900. It is 12 inches in diameter at the top, 6 inches in diameter at the bottom, and 1500 feet deep. It is cased to rock at a depth of 73 feet and casing is placed in a stratum of limestone. It is equipped with a Downey deep-well pump with the cylinder placed at a depth of 80 feet. This well is seldom used since the other well was drilled.

At one time when pumping from this well the water level in the other well was lowered 4 feet to a depth of 51 feet. When the pump was stopped the water level raised to a depth of 47 feet in a few minutes.

The second well was drilled by the W. L. Thorne Company of Des Plaines in 1922. A record of material penetrated, secured from the city, with part of the classifications given by the State Geological Survey Division, is as follows:

	Thickness in feet.	Depth in feet.
Clay	8	8
Gravel	7	15
Sand	20	35
Gravel	15	40
Hardpan	15	55
Gravel	13	68
Limestone, Silurian system, all or chiefly Niagaran	52	120
Shale, Richmond	22	142
Limestone, Galena-Platteville	368	510
Sandstone, St. Peter	220	730

The well is 12 inches in diameter to a depth of 507 feet and 10 inches in diameter below that depth. It is cased to a depth of 60 feet. The depth to water when the well was completed was 47 feet. It is equipped with an American double-stroke deep-well pump with a 9½-inch cylinder placed at a depth of 70 feet and with 20 feet of suction pipe attached to the cylinder. This well furnishes a large part of the supply and the electric motor driving the pump is automatically controlled by the water pressure. On the afternoon of June 26, 1923, the pump was operated with 24-inch stroke at a speed of 26 revolutions a minute for about nine minutes at a time and stood idle about 30 minutes at a time. The discharge when pumping, estimated from the rise in water level in the tanks, was 250 gallons a minute.

Water from the well 730 feet deep had a mineral content of 369, a total hardness of 295, and a content of iron of 0.4 parts per million as shown by the analysis of sample number 49659, collected from the pressure tank on June 26, 1923.

An odor of hydrogen sulphide is noticeable when drawing water from the pressure tanks. A sample of water, number 2637-1, collected in 1913 from the well 1500 feet deep, had a mineral con-

tent of 334, a total hardness of 310, and a content of iron of 0.0 parts per million.

Analysis of Sample Number 49659 from the Well 730 Feet Deep.

Determinations Made.

	Parts per million.
Iron Fe	0.4
Manganese Mn	0.0
Silica SiO_2	15.1
Nonvolatile	1.2
Alumina Al_2O_3	1.2
Calcium Ca	70.4
Magnesium Mg	28.9
Ammonia NH_4	0.3
Potassium K	4.4
Sodium Na	26.2
Sulfate SO_4	13.1
Nitrate NO_3	1.2
Chloride Cl	7.0
Alkalinity Methyl Orange	324
Residue	366

Hypothetical Combinations.

	Parts per million.	Grains per gallon.
Potassium Nitrate, KNO_3	2.0	0.11
Potassium Chloride, KCl	6.9	0.40
Sodium Chloride, NaCl	6.1	0.35
Sodium Sulfate, Na_2SO_4	19.4	1.13
Sodium Carbonate, Na_2CO_3	40.4	2.36
Ammonium Carbonate, $(NH_4)_2CO_3$	0.9	0.05
Magnesium Carbonate, $MgCO_3$	100.0	5.84
Calcium Carbonate, $CaCO_3$	175.6	10.25
Iron Oxide, Fe_2O_3	0.5	0.03
Alumina, Al_2O_3	1.2	0.07
Silica, SiO_2	15.1	0.88
Nonvolatile	1.2	0.07
Total	369.3	21.54

GIBSON CITY (2234). Gibson City is located in the southwestern part of Ford County on the drainage area of Sangamon River. Some private wells in use are from 12 to 25 feet deep and others are from 45 to 55 feet deep.

A public water supply was installed by the city in 1895. Water is drawn from wells by suction and discharged into the distribution system by pumps placed in a pit 10 feet deep. A Western Pump and Engineering Company 8 by 10-inch triplex pump driven by an electric motor is generally used. This unit is automatically controlled to maintain a supply of water in an elevated tank connected to the mains. The tank is 40 feet high and is supported on a brick tower 60 feet high. A 16 by 10¼-inch Deane duplex steam pump is available for use. A collecting reservoir of 115,000 gallons capacity is located close to the wells. This is filled with water to be used at times of fires and emergency and the pumps can discharge into or draw water from the reservoir.

The public water supply is secured from seven wells each about 55 feet deep. The ground surface at the wells is about 760 feet above sea level. The wells penetrate clay and hardpan and at the bottom a stratum of sand 5 feet thick. They are equipped with screens 5 feet long made of perforated pipe wrapped with woven wire. Three of the wells were installed in 1895. They are six inches in diameter. The other four were drilled by A. Swanson of Gibson City in 1920 and are 3 inches in diameter. The four 3-inch

wells and one 6-inch well are in a line spaced about 30 feet apart. One well is 35 feet distant on one side of this line and the other is 65 feet distant on the other side of the line. On May 23, 1922, the triplex pump was running 38 revolutions a minute and if there was little slip the yield of the wells was near 250 gallons a minute. A vacuum gauge on the suction line indicated a vacuum of 20½ inches after a few minutes pumping and 22½ inches after 2 hours pumping. During the summer of 1921 the pump at times operated almost continuously. Depths to water when not pumping were reported some years ago at one time as 10 feet and at another as 15 feet below the ground surface.

In 1915 a well 12 feet in diameter was dug in the bottom of the reservoir to a depth of 27 feet and an 8-inch well was drilled in the bottom to a total depth of 60 feet. A pump was installed and this well furnished practically all of the supply for about a year when it became clogged with sand and was cemented over.

The water had a mineral content of 271, a total hardness of 171, and a content of iron of 1.0 parts per million as shown by the analysis of sample number 38909, collected on Febuary 5, 1918.

Analysis of Sample Number 38909 from the City Supply.

Determinations Made.	Parts per million.
Iron Fe	1.0
Manganese Mn	0.0
Silica SiO_2	14.2
Alumina Al_2O_3	1.1
Calcium Ca	49.4
Magnesium Mg	11.6
Ammonia NH_4	0.5
Potassium K	2.5
Sodium Na	33.7
Sulfate SO_4	16.7
Nitrate NO_3	0.7
Chloride Cl	3.0
Alkalinity Methyl Orange	232.
Residue	260.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate, KNO_3	1.1	0.06
Potassium Chloride, KCl	4.0	0.23
Sodium Chloride, NaCl	1.9	0.11
Sodium Sulfate, Na_2SO_4	24.6	1.43
Sodium Carbonate, Na_2CO_3	57.6	3.36
Ammonium Sulfate, $(NH_4)_2SO_4$	1.3	0.08
Magnesium Carbonate, $MgCO_3$	40.2	2.34
Calcium Carbonate, $CaCO_3$	123.4	7.20
Iron Carbonate, $FeCO_3$	2.0	0.12
Manganese Carbonate, $MnCO_3$	0.0	
Alumina, Al_2O_3	1.1	0.06
Silica, SiO_2	14.2	0.83
Total	271.4	15.82

GILMAN (1448). Gilman is located in the western part of Iroquois County on the drainage area of Iroquois River, a tributary of Kankakee River. Many flowing wells are located in and close to the city.

A public water supply was installed by the city about 1896. Water is secured from wells. A Deming 8 by 10-inch triplex pump driven by a 20-horsepower electric motor draws water from two

of the wells and from two collecting reservoirs into which water flows from the other wells. The pump discharges into the mains to which an elevated steel tank is connected. A 25-horsepower oil engine can be used to drive this pump. A Laidlaw-Dunn-Gordon steam pump and two boilers formerly in regular service are available but have not been used for some time. One reservoir is 17 feet in diameter and is 30 feet deep and the other is 28 feet in diameter and 14 feet deep. The reservoirs are connected by a 6-inch pipe a few feet below the ground surface. Electric power is purchased from the Central Illinois Public Service Company.

Three hundred service connections were in use in 1923 and the average water consumption from April to October inclusive was estimated at 63,000 gallons a day. The rate for water is 50 cents per 1000 gallons with a minimum charge of 50 cents a month. Bills are not subject to cash discount.

Water is secured from five wells located in the eastern part of the city in an area about 150 feet in diameter. The elevation of the tops of the wells is about 655 feet above sea level. Each well is about 120 feet deep and the bottom of each is in a stratum of sand. Water from the first wells drilled raised to the ground surface and flowed into a reservoir. With a lowering of the water level wells were connected to the reservoir through pipe lines laid 4 feet below the ground surface and one well was equipped with an air lift. The air lift has not been used for a few years. In 1923 water from three wells flowed into the reservoirs. Two of these wells are 6 inches in diameter and are located 70 feet apart. The other is a 4-inch well located between the two 6-inch wells. Water enters at the bottom of the 6-inch wells and the 4-inch well has a screen formed by boring holes in a 3-foot length of pipe. At the time of visit on April 18, 1924, the yield of these three wells was 55 gallons a minute when the water level was below the discharge lines into the reservoir and decreased to 30 gallons a minute when the water level raised to two feet six inches below the top of the reservoir. The yield was not appreciably affected by pumping for two hours and drawing the water level in the two eight-inch wells, one hundred feet distant, to a depth of thirteen feet.

Two 8-inch wells were drilled by O. H. Steigman of Roberts in 1921. They are about 50 feet apart and 100 feet distant from the other three wells. These wells are 8 inches in diameter and 133 feet deep. Screens were formed by drilling a seven-sixteenth inch hole in every square inch of the lower four feet of the casings. The driller installed air lifts with 4-inch discharge lines and

pumped 400 gallons a minute from each well. Water is now pumped from these wells by the triplex pump. At the top of each well is a reservoir 6 feet in diameter and 9 feet deep. The well casings extend one foot above the bottoms of the reservoirs. A suction line from the triplex pump extends to a depth of 30 feet in each of these wells. On April 18, 1924, the yield when the water level was drawn down to a depth of twelve feet below the top of the six-foot diameter reservoir at the north well was 90 gallons a minute. This was computed assuming five per cent slip in the pump. When the pumps were stopped and the water level raised to seven feet below the top, the inflow into the two wells was 55 gallons a minute. When the water level raised to one and one-half feet below the top, the inflow was less than one gallon a minute.

The water had a mineral content of 961, a total hardness of 635, and a content of iron of 0.1 parts per million as shown by the analysis of sample number 36194, collected on April 1, 1917.

Analysis of Sample Number 36194 from the City Supply.

Determinations Made.	Parts per million.
Iron Fe	0.1
Silica SiO_2	13.2
Alumina Al_2O_3	5.3
Calcium Ca	154.5
Magnesium Mg	60.6
Ammonia NH_4	0.4
Sodium Na	73.4
Potassium K	4.0
Sulfate SO_4	442.3
Nitrate NO_3	5.3
Chloride Cl	22.0
Alkalinity Methyl Orange	320.
Residue	1040.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate, KNO_3	8.6	.50
Potassium Chloride, KCl	1.3	.08
Sodium Chloride, NaCl	35.3	2.06
Sodium Sulfate, Na_2SO_4	183.4	10.69
Ammonium Sulfate, $(NH_4)_2SO_4$	1.4	.08
Magnesium Sulfate, $MgSO_4$	299.4	17.46
Calcium Sulfate, $CaSO_4$	111.4	6.49
Calcium Carbonate, $CaCO_3$	302.1	17.62
Iron Oxide, Fe_2O_3	0.1	.05
Alumina, Al_2O_3	5.3	.30
Silica, SiO_2	13.2	.77
Total	961.5	56.10

GLASFORD (645). Glasford is located in the southern part of Peoria County two miles north of Illinois River. The principal industry is coal mining and a mine near the-village is the principal water consumer.

A public water supply was installed by the village in 1917. Water is pumped from a well into an elevated tank by air lift. Compressed air is supplied by a Chicago Pneumatic Tool Company 8 by 8-inch compressor which is driven by a 20-horsepower electric motor. The elevated tank has a capacity of 50,000 gallons and the top is 117 feet above the ground surface. The machinery is installed in the rear of the village hall and the well and tank are

on the same lot. Ninety-seven service connections were in use in 1923. Meter rates for three months are 40 cents for the first 1000 gallons, 35 cents per 1000 gallons for the next 4000 gallons, and 30 cents per 1000 gallons for the next 5000 gallons, with a minimum charge of $1.00.

Water is secured from a well 1669 feet deep, drilled in 1917. It is located close to the center of the village. A. record of material penetrated as furnished by the driller with classification of the lower strata as given by the State Geological Survey Division is as follows:

	Thickness in feet.	Depth in feet.
Drift	...	....
Sandstone (some water)	...	160
Sandstone	15	175
Shale, black	50	225
Limestone	10	235
Shale	65	300
Sandstone (a little water, salty)	20	320
Shale	50	370
Limestone, white	10	380
Shale	90	470
Limestone, gray and white	180	650
Shale, light and dark	230	880
Limestone, white and gray (little water)	250	1130
Shale and slate, Maquoketa	220	1350
Limestone, Galena-Platteville	280	1630
Sandstone, St. Peter (water)	55	1685

The well is cased to a depth of 620 feet with 10-inch wrought iron pipe. The diameter is 10 inches to a depth of 1130 feet and 8 inches below that depth. The well is equipped with an air lift with a l-inch air line extending to a depth of about 280 feet and a 3-inch discharge line through which water is discharged into the top of the elevated tank. When operated for a few minutes on October 19, 1923, the air compressor operated 220 revolutions a minute and the air pressure at the start and during operation registered from 105 to 106 pounds on a gauge. The actual discharge depends upon the power available. J. Barron, who is in charge, estimated the yield at a little less than 100 gallons a minute. The depth to water when not pumping was 67 feet on October 19, 1923. The air lift had been operated on the preceding day and, for a few minutes, about two hours before measurement was made.

The water had a mineral content of 1646, a total hardness of 295 and a content of iron of 2.2 parts per million as shown by the analysis of sample number 38936, collected on January 16, 1918.

Analysis of Sample Number 38936 from the Village Supply.

Determinations Made.

	Parts per million.
Iron Fe	2.2
Manganese Mn	0.0
Silica SiO_2	19.8
Alumina Al_2O_3	0.2
Calcium Ca	69.0
Magnesium Mg	30.2
Ammonia NH_4	1.8
Sodium Na	430.0
Potassium K	14.8
Sulfate SO_4	624.4
Nitrate NO_3	1.0
Chloride Cl	257.
Alkalinity Methyl Orange	234.
Residue	1630.

Hypothetical Combinations.

	Parts per million.	Grains per gallon.
Potassium Nitrate, KNO_3	1.6	0.09
Potassium Chloride, KCl	27.5	1.60
Sodium Chloride, NaCl	450.8	26.30
Sodium Sulfate, Na_2SO_4	838.0	48.88
Ammonium Sulfate, $(NH_4)_2SO_4$	6.9	0.40
Magnesium Sulfate, $MgSO_4$	66.8	3.90
Magnesium Carbonate, $MgCO_3$	7.3	3.34
Calcium Carbonate, $CaCO_3$	172.5	10.06
Iron Carbonate, $FeCO_3$	4.6	0.27
Alumina, Al_2O_3	0.2	0.01
Silica, SiO_2	19.8	1.15
Total	1646.0	96.00

GLEN ELLYN (2851). Glen Ellyn is located in the central part of DuPage County on the drainage of the east branch of DuPage River. A public water supply using water from a well as the source of supply was installed by the village in 1907. Another well has been drilled and extensive changes have been made in equipment. The wells are equipped with air lifts which discharge into a collecting reservoir of 70,000 gallons capacity. Air for one air lift is supplied by an Ingersoll-Rand 9 by 14-inch duplex compressor which is driven by a 25-horsepower electric motor and air for the other air lift is supplied by a Sullivan angle compound compressor which is driven by a 75-horsepower electric motor. The Sullivan compressor is rated at 454 cubic feet per minute at 270 revolutions per minute. From the reservoir water is pumped into the distribution system by either of two single-stage centrifugal pumps, each of 450 gallons a minute capacity and each driven by a 25-horsepower electric motor. The quantity of water pumped is measured by a venturi meter. An elevated steel tank in connected to the mains.

Thirteen hundred and eighty-two service connections were in use in January, 1924, and all were metered. The meter rate is 20 cents per 1000 gallons with a minimum charge of $1.50 every three months.

Water for the public supply is secured from two wells located near the business district of the village. One well was drilled in 1907. Data is principally from W. J. Catlin. The well is 8 inches in diameter and 310 feet deep and is cased with 8-inch pipe to rock. The material penetrated was classed as yellow clay 95 feet, blue clay 20 feet, and limestone 195 feet. Red shell stone 11 feet thick was

noted at a depth of 210 feet and blue shell stone was noted at a depth of 260 feet. The first vein of water was at a depth of 125 feet, a second vein at a depth of 196 feet, and a water bearing stratum 13 feet thick was at a depth of 266 feet. Below a depth of 279 feet the stone was hard and dry. The well is equipped with an air lift and air is supplied by the Ingersoll-Rand compressor. The yield of the well in 1914 was said to be 250 gallons a minute. A test was run in 1916 and the yield was reported to be 500 gallons a minute. The water level was 42 feet below the ground surface when not pumping and was drawn down 93 feet during the test. This well is used in winter and when demands are small.

Another well was drilled by the W. L. Thorne Company of Des Plaines in 1922. It is 97 feet north of the older well. The well is 12 inches in diameter to a depth of 230 feet and is cased with 12-inch pipe to a depth of 116 feet. Sixty-four feet of 10-inch pipe is placed to case off shale. The well is 360 feet deep and is ten inches in diameter at the bottom. It was tested at a rate of 800 gallons a minute. The well is equipped with an air lift with a 2-inch air line to a depth of 330 feet and a 6-inch discharge line. Air is supplied by the Sullivan compressor operated 190 revolutions per minute. Tests were run in 1922 and 1923. The maximum yield is said to have been 1000 gallons a minute. This well is used in summer and the air lift has been operated 20 hours a day.

The water had a mineral content of 405, a total hardness of 186, and a content of iron of 0.8 parts per million as shown by the analysis of sample number 50865, collected at the well on January 16, 1924, after pumping for one hour.

Analysis of Sample Number 50865 from the Village Supply.

Determinations Made.	Parts per miilion.
Iron, Fe	0.8
Manganese, Mn	0.0
Silica, SiO_2	20.8
Nonvolatile	2.2
Alumina, Al_2O_3	0.4
Calcium, Ca	26.6
Magnesium, Mg	29.2
Ammonia, NH_4	3.1
Sodium, Na	70.4
Potassium, K	6.3
Sulfate, SO_4	80.6
Nitrate, NO_3	1.8
Chloride, Cl	5.0
Alkalinity Methyl Orange	254.
Residue	421.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate, KNO_3	2.8	.16
Potassium Chloride, KCl	10.0	.58
Sodium Chloride, NaCl	0.4	.02
Sodium Sulfate, Na_2SO_4	119.1	6.95
Sodium Carbonate, Na_2CO_3	73.1	4.26
Ammonium Carbonate, $(NH_4)_2CO_3$	7.8	.46
Magnesium Carbonate, $MgCO_3$	100.9	5.89
Calcium Carbonate, $CaCO_3$	66.5	3.88
Iron Oxide, Fe_2O_3	1.1	.06
Alumina, Al_2O_3	0.4	.02
Silica, SiO_2	20.8	1.21
Nonvolatile	2.2	.13
Total	405.1	23.62

A sample, number 28349, collected in 1914, had a mineral content of 405, a total hardness of 280, and a content of iron of 0.4 parts per million.

GLENVIEW (760). Glenview is located in the northern part of Cook County on the drainage area of the north branch of Chicago River. A public water supply was installed by the village in 1916. Water is pumped from a well directly into the distribution system and an elevated steel tank connected to the system by a Keystone Driller Company deep-well pump which is driven through gears by a 10-horsepower electric motor. Electric current is purchased from the Public Service Company of Northern Illinois.

Two hundred and twenty-seven service connections were in use in 1924. The rate for water is 26 cents per 1000 gallons with a minimum charge of $3.00 every three months.

Water is secured from a well located at the corner of Glenview and Pine Streets. It is 12 inches in diameter at the top, 6 inches in diameter at the bottom, and 1251 feet deep. The top of the well is about 630 feet above sea level. A partial record of material penetrated is as follows:

	Thickness in feet.	Depth in feet.
Limestone	145	250
Shale, Richmond	235	485
Limestone, Galena-Platteville	330?	815
Sandstone, St. Peter.	125	940
Limestone, Prairie du Chien.	308	1248
Sandstone, Mazomanie, Cambrian system.	3	1251

The depth to water before pumping was 53 feet. The well was tested when completed by pumping for 8 hours. During the first part of the test the rate of pumping was 146 gallons a minute and during the last three hours it was 135 gallons a minute. The water level had lowered 13.8 feet at the end of the test.

The well is equipped with a double-stroke deep-well pump with a 5½-inch cylinder and 18-inch stroke. The cylinder is at a depth of 148 feet. No suction pipe is attached. The pump is operated 29 strokes a minute. The discharge is said to have been about 100 gallons a minute but in 1924 it was estimated at 75 gallons a minute. The amount of water pumped during the year to September, 1924, is estimated at an average of 39,000 gallons a day. The depth to water in 1924 was said to be 102 feet when not pumping and 108 feet when pumping.

The temperature of water when discharged from the well was 53 degrees Fahrenheit on October 2, 1924. The water had a mineral

content of 601, a total hardness of 315, and a content if iron of 1.1 parts per million as shown by the analysis given below of a sample, number 39977, collected on August 14, 1918.

Analysis of Sample Number 39977.

Determinations Made.	Parts per million.
Iron Fe	1.1
Manganese Mn	0.0
Silica SiO_2	19.2
Nonvolatile	1.1
Alumina Al_2O_3	0.3
Calcium Ca	65.6
Magnesium Mg	36.7
Ammonia NH_4	0.7
Sodium Na	89.4
Sulfate, SO_4	194.0
Nitrate NO_3	0.4
Chloride Cl	40.0
Hydrogen Sulphide.	0.2
Carbon dioxide	4.0
Alkalinity Methyl Orange	223.
Residue	584.6

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Sodium Nitrate $NaNO_3$	4.8	.28
Sodium Chloride NaCl	65.9	3.85
Sodium Sulfate Na_2SO_4	191.6	11.12
Ammonium Sulfate $(NH_4)_2SO_4$	2.6	.15
Magnesium Sulfate $MgSO_4$	78.2	4.53
Magnesium Carbonate $MgCO_3$	72.1	4.18
Calcium Carbonate $CaCO_3$	163.8	9.49
Iron Carbonate $FeCO_3$	2.2	.13
Alumina Al_2O_3	0.3	.02
Silica SiO_2	19.2	1.15
Nonvolatile	1.1	.06
Total	601.8	34.96

GRAND RIDGE (389). Grand Ridge is located in the southern part of LaSalle County on the drainage area of Illinois River. Nearly all private wells are from 20 to 40 feet deep. A few are from 175 to 200 feet deep.

A public water supply was installed by the village in 1914-1915. Water is pumped from a well into an elevated tank and the distribution system by a deep-well pump driven through gears by a 10-horsepower electric motor. The tank is 24 feet in diameter and 20 feet high. Electric power is purchased from the Chicago, Ottawa and Peoria Railroad Company.

About one hundred service connections were in use in 1922 and the amount of water pumped probably averaged near 11,000 gallons a day excepting when water was furnished for road paving. The rates for three months are 25 cents per 100 cubic feet for quantities less than 1700 cubic feet and 20 cents per 100 cubic feet for additional quantities, with a minimum charge of $3.00.

Water is secured from a well 10 inches in diameter and 160 feet deep. The elevation at the top is about 650 feet above sea level. The well is in sand below a depth of 115 feet. A Cook screen was placed in the bottom of the well. The screen became loose and in 1920 it was replaced by a screen made by perforating a 16-foot length of 8-inch pipe with ¾-inch holes and wrapping with copper

gauze. The well was tested by pumping for 22 hours at a rate of 70 gallons a minute.

The well is equipped with a Keystone Driller Company double-stroke deep-well pump with a 5¾-inch cylinder and 18-inch stroke. Before changing the screen the pump had operated 30 revolutions per minute and now operates 24 revolutions a minute, a displacement rate of 97 gallons a minute. The depth to water when not pumping was reported to be about 125 feet in 1915 and measured 125 feet in 1922 when the pump was idle for four hours. Pumping for two hours lowered the water level five feet. In July, 1922, when water was furnished for concrete road construction the pump would hammer if operated continuously for five hours and it was thought that the water level was drawn down to the pump cylinder at a depth of 150 feet.

The temperature of water from the well was 56 degrees Fahrenheit. The water had a mineral content of 326, a total hardness of 99, and a content of iron of 0.3 parts per million as shown by the analysis of sample number 48467, collected at the well on October 18, 1922.

Analysis of Sample Number 48467 from the Village Supply.

Determinations Made.	Parts per million.
Iron Fe	0.3
Manganese Mn	0.0
Silica SiO_2	7.8
Nonvolatile	0.0
Alumina Al_2O_3	0.9
Calcium Ca	25.0
Magnesium Mg	8.8
Ammonia NH_4	1.8
Sodium Na	81.2
Potassium K	17.5
Sulfate SO_4	9.0
Nitrate NO_3	0.7
Chloride Cl	5.4
Alkalinity Methyl Orange	304.0
Residue	329.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	1.1	0.06
Potassium Chloride KCl	11.3	0.66
Potassium Carbonate K_2CO_3	19.7	1.15
Sodium Carbonate Na_2CO_3	187.2	10.94
Ammonium Carbonate $(NH_4)_2CO_3$	4.8	0.28
Magnesium Carbonate $MgCO_3$	30.5	1.78
Calcium Carbonate $CaCO_3$	62.4	3.65
Silica SiO_2	7.8	0.45
Nonvolatile	0.0	0.00
Iron Oxide Fe_2O_3	0.4	.02
Alumina Al_2O_3	0.9	.05
Total	326.1	19.04

GRANT PARK (459). Grant Park is located in the northeastern part of Kankakee County on the drainage area of Kankakee River. A public water supply was installed by the village in 1887 and extensive improvements were made in 1904. Water is pumped from a well into the distribution system by a deep-well pump which is driven by a 10-horsepower electric motor. Two steel pressure tanks, each 8 feet in diameter and 36 feet long, located in the pump-

ing station, are connected to the mains. The pumping unit is automatically controlled by the water pressure. A 25-horsepower gas engine formerly in regular use in available to drive the pump. Water from another well can be pumped into the mains in case of emergency.

One hundred and twelve consumers were supplied with water in 1925. The rate for six months for the first 20,000 gallons is 33½ cents per 1000 gallons with a minimum charge of $4.00 and the lowest rate, for water in excess of 50,000 gallons, is 22½ cents per 1000 gallons. Bills are not subject to discount.

Water is obtained from two wells into limestone. The elevation of the tops of the wells is about 695 feet above sea level. Nearly all of the supply is from a well 8 inches in diameter and 251 feet deep. This well was drilled to a depth of 147 feet in 1904 and was deepened about 1919. It is cased to a depth of 75 feet. The well is equipped with a single-acting deep-well pump with 5¾-inch cylinder and 24-inch stroke and operates 28 revolutions a minute. The cylinder is at a depth of 130 feet. The depth to water when not pumping has been reported as 30 feet before the well was deepened and at the same depth since it was deepened. Since it was deepened it was tested by pumping at a rate of 87 gallons a minute. The pump was operated about 3 hours a day during the year to May, 1923.

In emergency water is secured from a well 10 inches in diameter and 180 feet deep, located in a brick yard. This is equipped with a double-acting deep-well pump with 24-inch stroke, driven by a 10-horsepower electric motor.

Analysis of Sample Number 49641 from Village Well 251 Feet Deep.

Determinations Made.

	Parts per million.
Iron Fe	2.4
Manganese Mn	0.0
Silica SiO_2	16.4
Nonvolatile	1.7
Alumina Al_2O_3	1.0
Calcium Ca	102.9
Magnesium Mg	41.3
Ammonia NH_4	0.3
Potassium K	11.7
Sodium Na	9.3
Sulfate SO_4	54.4
Nitrate NO_3	1.2
Chloride Cl	9.0
Alkalinity Methyl Orange	380.
Residue	481.

Hypothetical Combinations.

	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	2.0	0.11
Potassium Chloride KCl	18.8	1.09
Potassium Sulfate K_2SO_4	2.3	0.13
Sodium Sulfate Na_2SO_4	28.6	1.67
Ammonium Sulfate $(NH_4)_2SO_4$	1.2	0.07
Magnesium Sulfate $MgSO_4$	41.1	2.40
Magnesium Carbonate $MgCO_3$	114.3	6.67
Calcium Carbonate $CaCO_3$	256.8	14.99
Iron Oxide Fe_2O_3	3.4	0.20
Alumina Al_2O_3	1.0	0.06
Silica SiO_2	16.4	0.95
Nonvolatile	1.7	0.10
Total	487.6	28.44

Water from the well 251 feet deep had a mineral content of 487, a total hardness of 425, and a content of iron of 2.4 parts per million as shown by the analysis of sample number 49641, collected direct from the well after the pump had operated for 30 minutes on June 19, 1923.

GRANVILLE (1427). Granville is located in the northern part of Putnam County on the drainage area of Illinois River. A public water supply was installed by the village in 1911. Water is pumped from a well into two collecting reservoirs by a deep-well pump which is driven by a 20-horsepower electric motor. One reservoir has a capacity of 63,000 gallons and the other has a capacity of 100,000 gallons. Water is pumped from the reservoir into the mains and two steel pressure tanks connected to the mains by a triplex pump which is driven by a 25-horsepower gas engine. Each tank is 10 feet in diameter and 40 feet long. A small air compressor driven by the gas engine supplies air to the tanks. The Chicago and Alton Railroad is the principal water consumer in Granville. Water is also supplied to the village of Mark.

Water is secured from a well 1742 feet deep drilled by the J. P. Miller Artesian Well Company of Chicago in 1909-1910. A record prepared by the driller is on file with the village. The material penetrated was mostly shale with strata of limestone to a depth of 1389 feet, mostly limestone between depths of 1389 and 1650 feet, and mostly St. Peter sandstone below a depth of 1650 feet. The well was cased with 8-inch pipe to a depth of 345 feet, with 244 feet of 6-inch pipe with the bottom at a depth of 578 feet, 620 feet of 5-inch pipe with the bottom at a depth of 1192 feet, 100 feet of 6-inch and 5-inch pipe with the bottom at a depth of 1292 feet, and 124 feet of 4¼-inch pipe with the bottom at a depth of 1389 feet. Packers were placed between the 8 and 6-inch pipe and between the 6 and 5-inch pipe and the 4½-inch casing was belled out against the 5-inch casing. The well is 4¼ inches in diameter at the bottom. A 10-inch casing outside of the 8-inch extends to a depth of 130 feet. The depth to water was 140 feet when the well was 1700 feet deep and 125 feet when it was 1710 feet deep. When the well was 1318 feet deep it was tested with a pump cylinder attached to 249 feet of drop pipe. The water was exhausted in three minutes and the rate of pumping (after pumping for three minutes?) was three gallons a minute. The depth to water before the test was 115 feet.

The well is equipped with a single-acting deep-well pump rated at 90 gallons a minute with the cylinder placed at a depth of 180 feet. In May, 1918, it was operated from 8 to 10 hours a day. The depth to water when not pumping was said to be 125 feet.

The water had a mineral content of 1010, a total hardness of 260, and a content of iron of 1.2 parts per million as shown by the analysis of sample number 39437, collected from a tap on Map 7, 1918.

Analysis of Sample Number 39437 from the Village Supply.

Determinations Made.	Parts per million.
Iron Fe	1.2
Manganese Mn	0.0
Silica SiO_2	22.4
Alumina Al_2O_3	13.3
Calcium Ca	58.0
Magnesium Mg	27.8
Ammonia NH_4	1.2
Sodium Na	272.4
Sulfate SO_4	128.9
Nitrate NO_3	2.1
Chloride Cl	305.0
Nonvolatile	6.4
Alkalinity Methyl Orange	268.
Residue	975.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Sodium Nitrate KNO_3	2.6	.15
Sodium Chloride NaCl	502.7	29.31
Sodium Sulfate Na_2SO_4	190.5	11.11
Sodium Carbonate Na_2CO_3	26.4	1.53
Ammonium Carbonate $(NH_4)_2CO_3$	3.3	.19
Magnesium Carbonate $MgCO_3$	96 .1	5.60
Calcium Carbonate $CaCO_3$	144.4	8.41
Iron Carbonate $FeCO_3$	2.5	.15
Alumina Al_2O_3	13.3	.78
Silica SiO_2	22.4	1.30
Nonvolatile	6.4	.37
Total	1010.6	58.90

A sample collected in 1911 was similar in quality.

GRAYS LAKE (736). Grays Lake is located in the central part of Lake County on the drainage area of Des Plaines River. Along the western edge of the village is a lake nearly 200 acres in area. A public water supply was installed by the village in 1914-1915. Water is pumped from a well into the distribution system by a deep-well pump which is driven through gears by a 20-horsepower electric motor. An elevated steel tank of 60,000 gallons capacity, located on the same lot as the well, is connected to the mains. In December, 1922, about 18,000 gallons of water was pumped daily. During the canning season water is sold to the Interrieden Canning Company and the demands are three or four times as great as during other seasons.

Water for the public supply is obtained from a well located on Hawley Street near Whitney Street. The well was drilled by Charles Thorn. It is 12 inches in diameter at the top and 6 inches in diameter at the bottom. The exact depth of the well is not known. It is probably 1039 feet deep and cased to a depth of 246

feet. The material penetrated by this well is probably similar to that penetrated by a well located 500 feet to the east which belongs to the Grays Lake Gelatin Company. An abstract of the log of that well, with part of the classifications given by the State Geological Survey Division, is as follows:

	Thickness in feet.	Depth in feet.
Drift	230	230
Dolomite, Silurian system	110	340
Shale, Silurian system	20	360
Dolomite, Silurian system	50	410
Shale and dolomite, Maquoketa	130	540
Dolomite, Galena-Platteville	300	840
Sandstone, St. Peter	30	870
Dolomite, St. Peter	20	890
Sandstone, St. Peter	150	1040

The village well is equipped with a double-acting deep-well pump with 6¾-inch cylinder and 16-inch stroke which is operated 31 strokes a minute, a displacement rate of 150 gallons a minute. During canning seasons the pump is operated eight hours a day.

Water from the village well had a mineral content of 418, a total hardness of 294, and a content of iron of 0.2 parts per million as shown by the analysis of sample number 40919, collected on April 19, 1919.

Analysis of Sample Number 40919 from the Village Supply.

Determinations Made.	Parts per million.	Hypothetical Combinations.	Parts per million.	Grains per gallon.
Iron Fe	0.2	Sodium Nitrate $NaNO_3$	2.0	.11
Silica SiO	23.5	Sodium Chloride NaCl	9.6	.56
Nonvolatile	4.0	Sodium Sulfate Na_2SO_4	42.0	2.46
Alumina Al_2O_3	21.8	Ammonium Sulfate $(NH_4)_2SO_4$	3.0	.18
Calcium Ca	41.9	Magnesium Sulfate $MgSO_4$	162.3	9.50
Magnesium Mg	46.1	Magnesium Carbonate $MgCO_3$	45.9	2.69
Ammonia NH	0.8	Calcium Carbonate $CaCO_3$	104.4	6.10
Sodium Na	17.7	Iron Carbonate $FeCO_3$	0.4	.03
Sulfate SO_4	160.3	Alumina Al_2O_3	21.8	1.28
Nitrate NO_3	1.4	Silica SiO_2	23.5	1.38
Chloride Cl	5.5	Nonvolatile	4.0	.26
Alkalinity Methyl Orange	184.0	Total	418.9	24.55
Residue	450.			

Hydrogen sulphide was not determined in the analysis given above. The hydrogen sulphide content as determined on December 1, 1922, was 1.4 parts per million.

The Grays Lake Gelatin Company has two wells. One well, 1040 feet deep, the log of which is given above, was not in use in 1922. The other well is 1640 feet deep. It is cased with 12 and 10-inch pipe to a depth of 260 feet and is 8 inches in diameter at the bottom. This well is equipped with an air lift with an air pipe

extending to a depth of 300 feet. In 1921 duriug a test the well yielded from 225 to 240 gallons a minute. On December 1, 1922, when the air lift was operated for 5 hours the water level was lowered to a depth of 147 feet.

GREENVIEW (755). Greenview is located in the northeastern part of Menard County on the drainage area of Sangamon River. Many dug wells from 15 to 30 feet deep are in use.

A public water supply was installed by the village about 1893. The installation included a dug well, a pump driven by a wind-mill, an elevated wooden tank, and a few blocks of mains. Extensive improvements have been made. Water is now pumped from the well into the distribution system and an elevated steel tank of 40,000 gallons capacity connected to the system by a pump driven by a 20-horsepower electric motor. A triplex pump formerly in regular service can be driven by a traction engine in emergency. About 112 service connections were in use in 1924. Water is sold at flat rates.

Water was obtained, until 1924, from a dug well located at the southwest corner of the public square. It is 8 feet in diameter to a depth of 20 feet 6 inches, 6 feet in diameter below that depth, and 37 feet deep. The well is lined with iron casing. The material penetrated is given as surface soil 30 feet, hardpan 4 feet, and sand and gravel 6 feet. (Some private wells are said to enter sand 5 or 6 feet below the ground surface). The well is equipped with a single-acting deep-well pump with 5¾-inch cylinder and 18-inch stroke. In July, 1924, it was operated 27 revolutions a minute. Operating for two hours would draw the water level down to the pump cylinder at a depth of 32 feet. When the pump was idle for twelve hours or more the water level would raise to 12 feet below the ground surface. The rate of inflow when the water level was drawn down to a depth of 32 feet on July 10, 1924 was 25 gallons a minute. The pump was operated about three hours a day and the amount of water pumped during June, 1924, was estimated at 8,300 gallons a day.

The water had a mineral content of 751, a total hardness of 624, and a content of iron of 0.6 parts per million as shown by the analysis of sample number 51797, collected on July 10, 1924.

The village clerk, George C. Roberts, wrote in April, 1925, that water is now secured from a well 10 inches in diameter and 153 feet deep. It is cased with wrought iron pipe. The well is equipped with a Pomana pump of 160 gallons a minute capacity. During a test

the well was pumped continuously for eight hours and the water level was lowered about seven feet. About 10,000 gallons of water is pumped daily.

Analysis of Sample Number 51797 from the Village Well 37 Feet Deep.

Determinations Made.	Parts per million.
Iron Fe	0.6
Manganese Mn	0.5
Silica SiO_2	17.4
Nonvolatile	7.7
Alumina Al_2O_3	1.1
Calcium Ca	141.8
Magnesium Mg	65.8
Ammonia NH_4	0.4
Potassium K	2.3
Sodium Na	11.0
Sulfate SO_4	275.7
Nitrate NO_3	3.9
Chloride Cl	43.0
Alkalinity Methyl Orange	294.0
Residue	763.0

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	6.0	.35
Sodium Nitrate $NaNO_3$	0.3	.02
Sodium Chloride NaCl.	27.8	1.62
Ammonium Chloride $(NH_4)Cl$	1.1	.06
Magnesium Chloride $MgCl_2$	34.1	1.99
Magnesium Sulfate $MgSO_4$	281.8	16.45
Calcium Sulfate $CaSO_4$	71.8	4.19
Calcium Carbonate $CaCO_3$	301.0	17.58
Iron Oxide Fe_2O_3	0.9	.05
Silica SiO_2	17.4	1.02
Nonvolatile	7.7	.45
Alumina Al_2O_3	1.1	.06
Manganese Oxide MnO	0.6	.04
Total	751.6	43.88

GREENVILLE (3091). Greenville is located in the central part of Bond County on the drainage area of Kankaskia River, a tributary of Illinois River. A public water supply was installed by the city in 1884. Water was drawn by suction from wells located in the southern part of the city. With increasing demands and lowering of the water level deep-well pumps were installed. Additional wells have been drilled and some wells have been abandoned. Water from the wells is discharged into a collecting reservoir 20 feet in diameter and about 38 feet deep. Water is pumped by the Southern Illinois Light Company who have installed, at their plant across the street from the reservoir, two centrifugal pumps for pumping from the reservoir into the mains. All pumps are driven by electric motor.

The public water supply is secured from wells from 45 to 50 feet deep into sand and gravel. Eight wells were in use in 1923. They are located in the southern part of the city north of the depot grounds between Second and Third Streets. The elevation of the ground surface is about 560 feet above sea level. Seven of the wells nearest Third Street are in an area of about 240 feet by 75 feet. One well is close to Second Street about 160 feet distant from the nearest of the other seven wells. Vance McLain who has worked on the wells states that in the middle of the block between Second

and Third Streets the sand vein is not over 3 feet thick and at either end of the block it is 10 or 12 feet thick. The wells are 8 inches in diameter and are equipped with Johnson and Cook number 14 screens. The yield of the eight wells, estimated by measuring the flow into the reservoir for a few minutes was 195 gallons a minute on May 18, 1923. The rate of yield undoubtedly varies with the demands, being least when the total amount pumped is greatest. W. G. Kaeser of the Board of Water Commissioners stated that the maximum yield of the best well was 1200 gallons an hour and that the total amount of water pumped was less than 100,000 gallons a day.

The yield of the city wells is undoubtedly affected by pumping from other wells in the same stratum. The Helvetia Condensed Milk Company has sixteen wells, ten of which are from 500 to 600 feet distant from the city wells. An ice plant and a glove factory each have two wells. The total amount of water pumped from these private wells and the city wells probably averages near 500,000 gallons a day.

The thickness of the water bearing stratum varies greatly. At the ice plant it is said to be 18 feet thick. Some oil and gas wells near the city penetrate 50 to 100 feet of sand but much of this is known to be very fine sand from which it would be difficult to secure water.

The water from the public supply had a mineral content of 672 and a total hardness of 473 parts per million as shown by the analysis of sample number 37302, collected at a hydrant on July 11, 1917.

Analysis of Sample Number 37302 from the City Supply.

Determinations Made.	Parts per million.
Iron Fe	0.0
Silica SiO_2	19.3
Alumina Al_2O_3	3.8
Calcium Ca	118.7
Magnesium Mg	43.0
Potassium K	2.2
Ammonia NH_4	0.0
Sodium Na	49.8
Sulfate SO_4	87.3
Nitrate NO_3	91.9
Chloride Cl	38.0
Nonvolatile	0.3
Alkalinity Methyl Orange	354.
Residue	665.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	5.7	.33
Sodium Nitrate $NaNO_3$	121.2	7.07
Sodium Chloride NaCl	43.1	2.52
Magnesium Chloride $MgCl_2$	16.1	.94
Magnesium Sulfate $MgSO_4$	109.5	6.39
Magnesium Carbonate $MgCO_3$	57.5	3.35
Calcium Carbonate $CaCO_3$	296.3	17.29
Alumina Al_2O_3	3.8	.22
Silica SiO_2	19.3	1.13
Nonvolatile	0.3	.02
Total	672.8	39.26

GRIDLEY (720). Gridley is located in the northern part of McLean County on the drainage area of Mackinaw River, a tributary of Mississippi River. A public water supply was installed by the village in 1923. Water is pumped from a well into the distribution system by a deep-well pump driven by a 15-horsepower oil engine. An elevated steel tank of 100,000 gallons capacity located at the side of the pumping station is connected to the mains. The quantity of water pumped is registered by a meter at the station. Fifty-five service connections had been installed in June, 1924, and considerable water had been used in concrete road construction. The length of time the pump is operated and meter readings are recorded daily. The average amount of water used during the first half of 1924 was 9600 gallons a day.

The rates for water for three months are 50 cents per 1000 gallons for the first 10,000 gallons, 45 cents per 1000 gallons for the next 10,000 gallons, 40 cents per 1000 gallons for the next 10,000 gallons, and 35 cents per 1000 gallons for the next 10,000 gallons. The minimum charge is $2.25.

The public water supply is secured from a well located near the center of the village. It was drilled by John Bollinger of Fairbury in December, 1922. The top is about 750 feet above sea level. A record of material penetrated by a test well drilled before the larger well was drilled is as follows:

	Thickness in feet	Depth in feet.
Soil and blue clay	71	71
Hardpan	66	137
Sand, water bearing	4	141
Clay, blue, some sand and gravel	121	262
Sand and gravel, water bearing	8	270
Clayey sand and gravel	10	280
Sand and gravel, water bearing	10	290

The well is cased with 8-inch pipe and a number 30 Johnson screen 20 feet long is placed in the bottom. After completion the well was tested by pumping for 56 hours. After pumping for 52 hours, when the rate of pumping was 50 gallons a minute, the water level was at a depth of 60 feet below the ground surface. Pumping for another hour at the same rate and then pumping for one hour at a rate of 70 gallons a minute lowered the water level to a depth of 64 feet. Continuing this rate of pumping for one-half hour and then pumping at a rate of 77 gallons a minute for one-half hour lowered the water level to a depth of 65 feet.

The well is now equipped with a Cook double-stroke deep-well pump with 5¾-inch cylinder and 18-inch stroke. It is operated at 25 revolutions a minute. From January 31 to June 14, 1924, the

pump operated an average of one hour fifty-eight minutes a day and discharged 82 gallons a minute. The water level on June 16 when the pump had operated for two hours was 59 feet below the floor level. In 1925 it was reported that water levels remain the same.

The water had a mineral content of 694, a total hardness of 190, and a content of iron of 1.8 parts per million as shown by the analysis of sample number 48971, collected on January 15, 1923.

Analysis of Sample Number 48971 from the Village Supply.

Determinations Made.	Parts per million.
Iron Fe	1.8
Manganese Mn	0.2
Silica SiO_2	24.4
Nonvolatile	14.0
Alumina Al_2O_3	4.6
Calcium Ca	37.7
Magnesium Mg	23.6
Ammonia NH_4	5.7
Sodium Na	163.6
Potassium K	9.5
Sulfate SO_4	160.1
Nitrate NO_3	1.8
Chloride Cl	18.0
Alkalinity	
Methyl Orange	378.0
Phenolphthalein	8.
Residue	701.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	2.9	.17
Potassium Chloride KCl	15.9	.93
Sodium Chloride NaCl	17.2	1.01
Sodium Sulfate Na_2SO_4	236.6	13.82
Sodium Carbonate Na_2CO_3	184.8	10.80
Ammonium Carbonate $(NH_4)_2CO_3$	15.1	.88
Magnesium Carbonate $MgCO_3$	81.8	4.76
Calcium Carbonate $CaCO_3$	94.4	5.51
Silica SiO_2	24.4	1.43
Nonvolatile	14.0	.82
Iron Oxide Fe_2O_3	2.6	.15
Alumina Al_2O_3	4.6	.27
Total	694.3	40.55

The sample contained some sediment and analysis made now when the well is in regular use might show some differences.

HAMPSHIRE (618). Hampshire is located in the northwestern part of Kane County on the drainage area of Kishwaukee River, a tributary of Rock River. A public water supply was installed by the village in 1902. Water was pumped from a well into an elevated tank from which it flowed into the distribution system two blocks long. Another well was completed in 1924. Both wells are equipped with electrically driven deep-well pumps. The elevated tank has been removed and a steel pressure tank 6 feet in diameter and 20 feet long has been installed. The mains were not extended until 1921 and in 1923 many private wells were in use. The Inderrieden Canning Company has five wells. The shallowest is about 65 feet deep and the deepest, which furnishes the principal supply, is 352 feet deep. This deepest well is said to have yielded not to exceed 90 gallons a minute during a test.

Fifty consumers were using the public supply in 1923. The minimum meter charge is $2.50 for three months which allows the

use of 5000 gallons of water. The charge for the next 5,000 gallons is 25½ cents per thousand gallons, and the lowest rate is 10 cents per 1000 gallons for quantities in excess of 100,000 gallons. A charge of 25 cents is made for a meter and a cash discount of 50 cents is allowed.

Water for the public supply is secured from two wells located close to the business district. The tops of the wells are about 900 feet above sea level. One well was drilled in 1902. It is 6 inches in diameter and 72 feet deep and the bottom is in a stratum of sand and gravel. The well is equipped with a Fairbanks-Morse single-acting deep-well pump with a 4½-inch cylinder placed at a depth, of 60 feet. The yield during tests in April, 1922, and June, 1923, was 22 gallons a minute. The depth to water when not pumping was 35 feet in 1922. This well is used about one hour a week when a small air compressor is driven from a pulley on the pump.

Water from this well had a mineral content of 370, a total hardness of 343, and a content of iron of 0.1 parts per million as shown by the analysis of sample number 47403, collected on April 20, 1922.

Analysis of Sample Number 47403 from Village Well 72 Feet Deep.

Determinations Made.	Parts per million.
Iron Fe	0.1
Manganese Mn	0.0
Silica SiO_2	12.6
Nonvolatile	4.0
Alumina Al_2O_3	0.9
Calcium Ca	76.6
Magnesium Mg	36.9
Ammonia NH_4	0.0
Sodium Na	2.2
Potassium K	1.4
Sulfate SO_4	68.4
Nitrate NO_3	0.7
Chloride Cl	10.0
Alkalinity Methyl Orange	154.8
Residue	388.0

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	0.1	0.01
Potassium Chloride KCl	2.6	0.15
Sodium Chloride NaCl	5.7	0.33
Ammonium Chloride NH_4Cl	0.1	0.01
Magnesium Chloride $MgCl_2$	6.9	0.41
Magnesium Sulfate $MgSO_4$	85.5	4.98
Magnesium Carbonate $MgCO_3$	61.5	3.59
Calcium Carbonate $CaCO_3$	190.5	11.14
Silica SiO_2	12.6	0.72
Nonvolatile	4.0	0.23
Iron Oxide Fe_2O_3	0.1	0.01
Alumina Al_2O_3	0.9	0.05
Total	370.6	21.63

A well located twenty feet southwest of the older well was completed in 1924. This well is cased into rock with 178 feet of 10-inch pipe, is 8 inches in diameter below the 10-inch casing, and is 1178 feet deep. When completed it was pumped for six hours and yielded 120 gallons a minute. The well is equipped with a McDonald double-stroke deep-well pump which is operated 24 revolutions a minute. The pump cylinder is said to be at a depth of 208 feet. The yield on November 14, 1924, estimated from water levels in the pressure tank, was 105 gallons a minute. The pump operated

three minutes at a time and was then idle for more than thirty minutes.

The temperature of water from this well was 50 degrees Fahrenheit. The water had a mineral content of 277, a total hardness of 183, and a content of iron of 0.7 parts per million as shown by the analysis of sample number 52438, collected on September 17, 1924.

Analysis of Sample Number 52438 from Village Well 1178 Feet Deep.

Determinations Made.

	Parts per million.
Iron Fe	0.7
Silica SiO_2	12.2
Manganese Mn	0.0
Nonvolatile	0.6
Alumina Al_2O_3	7.1
Calcium Ca	38.8
Magnesium Mg	21.1
Ammonia NH_4	0.7
Sodium Na	32.3
Potassium K	5.2
Sulfate SO_4	trace
Nitrate NO_3	2.6
Chloride Cl	trace
Alkalinity Methyl Orange	280.
Residue	302.

Hypothetical Combinations.

	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	4.3	0.25
Potassium Chloride KCl	trace	trace
Potassium Sulfate K_2SO_4	trace	trace
Potassium Carbonate K_2CO_3	6.3	0.37
Sodium Carbonate Na_2CO_3	74.4	4.34
Ammonium Carbonate $(NH_4)_2CO_3$	1.8	0.10
Magnesium Carbonate $MgCO_3$	73.2	4.27
Calcium Carbonate $CaCO_3$	96.8	5.65
Iron Oxide Fe_2O_3	1.0	0.06
Alumina Al_2O_3	7.1	0.41
Silica SiO_2	12.2	0.71
Nonvolatile	0.6	0.03
Total	277.7	16.19

HANOVER (737). Hanover is located in the southwestern part of Jo Daviess County about five miles distant from Mississippi River. A public water supply was installed by the village in 1923. A Fairbanks-Morse centrifugal pump driven by a 25-horsepower electric motor draws water from a well by suction and discharges into the distribution system to which an elevated steel tank of 40,000 gallons capacity is connected. Power is purchased from the Interstate Light and Power Company. The charge for water is 50 cents per month.

Water is secured from a well 1090 feet deep which was drilled in 1921 by the Ohio Drilling Company of Massillon, Ohio. The top of the well is about 625 feet above sea level. A record of material pentrated with part of the classifications given by the State Geologcial Survey Division is as follows:

	Thickness in feet	Depth in feet.
Clay	15	15
Clay, sandy	10	25
Mud, black	7	32
Limestone, Galena-Platteville	56	88
Sandstone, Galena-Platteville	165	253
Limestone, Galena-Platteville	80	333
Clay, blue, St. Peter	7	340
Sandstone, St. Peter	20	360
Sandstone, gray, St. Peter	71	431
Sand	249	680
Limestone, Prairie du Chien	40	720
Sandstone, Jordan, Cambrian system	80	800
Limestone, St. Lawrence, Cambrian system	50	850
Shale, sandy with blue clay, St. Lawrence, Cambrian system	70	920
White sand, Franconia and Dresbach, Cambrian system	137	1057
Shale, Eau Claire, Cambrian system	3	1060

The well is cased with 12-inch pipe to a depth of 50 feet, with 10-inch pipe between depths of 50 and 350 feet, and with 8-inch pipe from the top of the well to a depth of 500 feet. Water from outside the 12-inch casing flows to waste in Apple River. In February 1922, the natural flow of the well from inside the 8-inch casing was estimated at 300 gallons a minute and the pressure with no flow was 20 pounds. Pumping 600 gallons a minute lowered the water level to 13½ feet below the top of the casing. The capacity of the pump drawing water from the well is given as 400 gallons a minute. A suction line extends to a depth of 30 feet. The amount of water pumped was reported in April, 1925, to be about 40,000 gallons a day.

The temperature of water drawn from a tap in the pumping station was 57 degrees Fahrenheit. The water had a mineral content of 243 and a total hardness of 198 parts per million as shown by the analysis of sample number 50290, collected on October 10, 1923.

Analysis of Sample Number 50290 from the Village Supply.

Determinations Made.

	Parts per million.
Iron Fe	0.0
Manganese Mn	0.0
Silica SiO_2	11.8
Nonvolatile	0.4
Alumina Al_2O_3	0.6
Calcium Ca	44.3
Magnesium Mg	21.5
Ammonia NH_4	0.0
Sodium Na	14.1
Potassium K	3.5
Sulfate SO_4	16.0
Nitrate NO_3	0.9
Chloride Cl	5.0
Alkalinity Methyl Orange	208.0
Residue	254.

Hypothetical Combinations.

	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	1.4	0.08
Potassium Chloride KCl	5.7	0.33
Sodium Chloride NaCl	3.8	0.22
Sodium Sulfate Na_2SO_4	23.6	1.38
Sodium Carbonate Na_2CO_3	11.4	0.66
Ammonium Carbonate $(NH_4)_2CO_3$	0.0	0.00
Magnesium Carbonate $MgCO_3$	74.4	4.34
Calcium Carbonate $CaCO_3$	110.7	6.46
Alumina Al_2O_3	0.6	0.03
Silica SiO_2	11.8	0.69
Nonvolatile	0.4	0.02
Total	243.8	14.21

HARMON (202). Harmon is located in the western part of Lee County on the drainage area of Rock River. Many private wells driven into sand and gravel are in use. In the southern part of the village some wells are as shallow as 28 feet and in the northern part of the village some are as deep-as 45 feet.

A public water supply owned by the village was completed in 1912. The installation includes a deep well equipped with a deep-well pump driven by a. 14-horsepower gas engine, an elevated steel tank of 30,000 gallons capacity on a steel tower 80 feet high, a pumping station, and a distribution system. In 1916 six service connections were in use serving the depot, three business houses and two residences. Seven service connections were in use in 1925.

Water is secured from a well drilled in 1909 near the center of the village. It is 5 inches in diameter and 532 feet deep. It is equipped with a double-acting deep-well pump with a 3¼-inch cylinder and 24-inch stroke. The pump is operated 35 revolutions a minute. The cylinder is at a depth of 90 feet. The pump discharged 33 gallons a minute when discharging at the ground surface. The discharge into the mains was estimated in 1916 at 28 or 30 gallons a minute. The pump was operated six or seven hours a week. The water level when not pumping was at a depth of 7 feet. Air was drawn into the cylinder when the cylinder was placed at a depth of 60 feet. The cylinder was lowered to a depth of 120 feet and was later raised to a depth of 90 feet and no air was drawn into the cylinder.

E. T. McCormick, Village Clerk, wrote in April, 1925, that seven service connections are in use and that part of the supply is now secured from eight wells, each 32 feet deep.

Analysis of Sample Number 36191 from Village Well 532 Feet Deep.

Determinations Made.	Parts per million.
Iron Fe	0.6
Alumina Al_2O_3	0.4
Silica SiO_2	6.6
Calcium Ca	66.6
Magnesium Mg	32.3
Ammonia NH_4	2.8
Sodium Na	21.4
Potassium K	5.2
Sulfate SO_4	0.5
Nitrate NO_3	1.2
Chloride Cl	6.0
Alkalinity Methyl Orange	336.
Residue	366.

Hypothetical Combinations.	Parts Per million.	Grains per gallon.
Potassium Nitrate KNO_3	1.9	.11
Potassium Chloride KCl	8.6	.50
Sodium Chloride NaCl	3.1	.18
Sodium Sulfate Na_2SO_4	0.7	.04
Sodium Carbonate Na_2CO_3	44.8	2.60
Ammonium Carbonate $(NH_4)_2CO_3$	2.8	.16
Magnesium Carbonate $MgCO_3$	11.8	6.51
Calcium Carbonate $CaCO_3$	166.2	9.69
Iron Oxide Fe_2O_3	0.8	.05
Alumina Al_2O_3	0.4	.02
Silica SiO_2	6.6	.38
Total	347.7	20.25

Water from the well 532 feet deep had a mineral content of 347, a total hardness of 300, and a content of iron of 0.6 parts per million as shown by the analysis of sample number 36191, collected on December 27, 1916.

A sample of water, number 36192, from a well 42 feet deep into sand, had a mineral content of 316, a total hardness of 274, and a content of iron of 1.6 parts per million. It contained 48.5 parts of sulfate compared to 0.5 parts in the village supply.

HARVARD (3294). Harvard is located in the northwestern part of McHenry County on the drainage area of Kishwaukee River, a tributary of Rock River.

A public water supply was installed by the city in 1892. Water is obtained from two wells, one equipped with air lift and the other with a deep-well pump. Air is supplied by an Ingersoll-Rand two-stage compressor of 250 cubic feet per minute capacity driven by a 75-horsepower electric motor. The deep-well pump is driven by a 20-horsepower electric motor. A 25-horsepower gas engine is available for use in emergency. Water is discharged into two collecting reservoirs, one 40 feet in diameter and 8½ feet deep and the other 40 feet in diameter and 10 feet deep. Three pumping units are available to pump water from the reservoirs into the mains. One is a Goulds 8¼ by 10-inch triplex pump driven by a 25-horsepower electric motor. Another is a Downey two-stage centrifugal pump of 600 gallons a minute capacity driven by a 35-horsepower electric motor. The other, added in 1922 for use in emergency, is a Fairbanks-Morse two-stage centrifugal pump driven by a four-cylinder gas engine. An elevated steel tank of 100,000 gallons capacity is connected to the mains. Electric power is purchased from the Northern Illinois Utilities Company.

More than 800 service connections were in use in 1922 and the consumption averaged near 125,000 gallons a day. Large quantities of water are at times supplied to the Bowman Dairy Company and the Chicago and Northwestern Railway who have private supplies from wells. The minimum charge is $2.00 for three months, which allows the use of 500 cubic feet. The charge for the next 1000 cubic feet is 37½ cents per 100 cubic feet and the lowest rate is 13½ cents per 100 cubic feet, which is for water in excess of 7000 cubic feet. The bills are not subject to discount.

Water for the public supply is secured from two wells located 28 feet apart in the southwestern part of the city. The ground surface at the top of the wells is about 930 feet above sea level.

Well number 1 was drilled to a depth of 1600 feet in 1891. It is cased with 10-inch pipe to a depth of 150 feet. In 1921 a 6-inch pipe was lowered in the well to a depth of 178 feet, a 5-inch pipe was lowered to a depth of 418 feet, and a 4-inch pipe to a depth of 1074 feet. In 1913 the depth to water was reported to be 20 feet. In 1921 pumping at a rate of 88 gallons a minute lowered the water level to a depth of 176 feet. In 1922 a Harris air lift was installed. A 2-inch air line inside the discharge pipe extended to a depth of 551 feet and the discharge line was of 5-inch and 5⅝-inch pipe. During a test in August, 1922, the yield was 315 gallons a minute and the water level was lowered 210 feet to a depth of 243 feet. The starting and operating pressures were 202 and 146 pounds respectively. Since the test the air line has been extended to a depth of 587 feet. The starting and working pressures are 235 and 148 pounds respectively. In November, 1922, the discharge was 286 gallons a minute. With the air lift in this well idle for one and one-half hours the water level in well number 2 raised to 50 feet below the station floor. Operating the air lift lowered the water level in well number 2 to a depth of 91 feet in 10 minutes, 102 feet in 30 minutes and 109 feet in 4 hours.

Well number 2 was drilled in 1913. It is 8 inches in diameter to a depth of 100 feet, 6 inches in diameter at the bottom, and 742 feet deep. It is equipped with a Luitwieler pump of 156 gallons a minute capacity. In 1914 it was reported that water was drawn down to the pump cylinder at a depth of 95 feet. This well is seldom used. It can be used at the same time as the other well. No log of this well is available. A driller's log of a well owned by the Chicago and Northwestern Railway shows 35 feet of soil and clay, 24 feet of gravel and boulders, 30 feet of sand and gravel and 12 feet of hardpan above rock. St. Peter sandstone was encountered at a depth of 640 feet.

The temperature of water discharged by the air lift in the well 1600 feet deep was 51 degrees Fahrenheit. The water had a mineral content of 488, a total hardness of 424, and a content of iron of 0.4 parts per million as shown by the analysis of sample number 48603, collected after three hours pumping on November 6, 1922.

Water from the well 742 feet is similar in quality. A sample, number 48605, collected in 1922, had a mineral content of 530, a total hardness of 464, and a content of iron of 2.4 parts per million. The high content of iron may be due to iron from the casing as the well was not in regular service.

Analysis of Sample Number 48603 from the City Wells 1600 Feet Deep.

Determinations Made.

	Parts per million.
Iron Fe	0.4
Manganese Mn	0.0
Silica SiO_2	12.1
Nonvolatile	1.5
Alumina Al_2O_3	2.0
Calcium Ca	84.0
Magnes'm Mg	52.2
Ammonia NH_4	0.2
Sodium Na	17.5
Potassium K	3.3
Sulfate SO_4	77.6
Nitrate NO_3	1.1
Chloride Cl	33.0
Alaklinity Methyl Orange	340.
Residue	512.

Hypothetical Combinations.

	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	1.7	.10
Potassium Chloride KCl	5.1	.30
Sodium Chloride NaCl	44.7	2.61
Ammonium Chloride NH_4Cl	0.7	.04
Magnesium Chloride $MgCl_2$	4.1	.24
Magnesium Sulfate $MgSO_4$	97.2	5.68
Magnesium Carbonate $MgCO_3$	108.8	6.36
Calcium Carbonate $CaCO_3$	209.8	12.25
Silica SiO_2	12.1	.71
Nonvolatile	1.5	.08
Iron Oxide Fe_2O_3	0.6	.04
Alumina Al_2O_3	2.0	.12
Total	488.3	28.53

HARVEY (9216). Harvey is located in Cook County about nineteen miles south of the center of Chicago. A public water supply was installed in 1890 before the city was incorporated and few private wells have been in use. The water works was acquired by the city in 1924. Before this time part of the supply was secured from wells into Cambrian sandstone and part from the city of Chicago. The wells are now available for emergency. The wells are equipped with air lifts. Air is supplied by an Ingersoll-Rand two-stage compressor driven by a 200-horsepower electric motor. A steam driven air compressor formerly in regular service is also available for use. Water from the wells, when used, and from the Chicago supply, flows into a collecting reservoir 40 feet in diameter and about 25 feet deep. From the reservoir it is pumped into the mains by any of four units. One of these is a Worthington steam pump of 350 gallons a minute capacity which was formerly in regular service. One unit consists of two 2-stage Byron-Jackson centrifugal pumps, each of 350 gallons a minute capacity, direct connected, one on either side, to a 50-horsepower electric motor. The other two units consist of two 2-stage American centrifugal pumps, each of 700 gallons a minute capacity, direct connected, one on either side, to a 100-horsepower electric motor. The pumps of either unit may be operated in parallel or in series.

Water rates for one month are 22 cents per 100 cubic feet for the first 1000 cubic feet, 18 cents per 100 cubic feet for the next 2000 cubic feet, 15 cents per 100 cubic feet for the next 7000 cubic

feet, and 14 cents per 100 cubic feet for additional water. In addition a service charge is made depending upon the size of the meter. It is 33⅓ cents for 1-inch and smaller sizes and $12.00 for 6-inch. A penalty of 10 per cent is added after fifteen days.

Water from the Chicago supply is discharged into the reservoir through a 4-inch line and a 12-inch line. A 1-inch connection on the 12-inch line discharges at all times to give circulation in the pipe. One industrial plant in the city and two small plants in Riverdale draw water direct from the 12-inch line. A steel standpipe 15 feet in diameter and 95 feet high, located close to the pumping station and wells, is connected to the mains.

The wells from which water has been secured are located in the northwestern part of the city. Four wells, number 1, number 2, number 3, and number 4 have been drilled. Each is about 1600 feet deep. A record of well number 3 prepared by the driller with part of the classification by the State Geological Survey Division is as follows:

	Thickness in feet.	Depth in feet.
Drift	16	16
Limestone, Silurian system, all or chiefly Niagaran	275	291
Shale, Richmond	125	416
Limestone, Galena-Platteville	400	816
Sandstone, St. Peter	40	856
Shale, St. Peter	60	916
Limestone, Prairie du Chien	500	1416
Sandstone, Mazomanie-Dresbach, Cambrian system	200	1616

Well number 1 is six inches in diameter at the top. It was drilled to a depth of 2100 feet and plugged at a depth of about 1600 feet. Part of the well caved in and the yield has since been small.

Well number 2 is ten inches in diameter at the top and five inches in diameter at the bottom. In 1915 with an air lift, with 360 feet of air line, the discharge was said to be at a rate of 270,000 gallons a day. In 1921 the air lifts in the three wells were operating continuously and this well was thought to discharge nearly half of the total which was about 500,000 gallons a day.

Well number 3 is 15½ inches in diameter at the top and the lower 606 feet is 6 inches in diameter. The well is cased with 15½-inch pipe to a depth of 60 feet, with 103 feet of 10⅝ -inch pipe with the bottom at a depth of 548 feet, and with 53/16-inch casing with the top at a depth of 1040 feet. Thirty-six feet of 7 and 6-inch casing was placed with the bottom at a depth of 670 feet, opposite tools which were lost in the well. (Either this log or record of casing appears to be in error).

Well number 4, which was similar to well number 3, has been abandoned.

In September, 1924, the wells were furnishing not to exceed 250,000 gallons a day.

The depth to water in 1896 was reported in the U. S. Geological Survey Seventeenth Annual Report to be 10 feet. In March, 1913, it was 120 feet and in 1915 it was 155 feet. In 1921 it was thought to be 220 feet. These levels are little affected by other wells close by as the distance to the nearest well is more than a mile, but the depths given are not directly comparable as the time the pumps were idle was probably not the same. When measured in 1921 it is probable that the shut down was for a very short time or that some wells were operating when the measurement was made.

A sample of water, number 31509, collected from the supply on September 13, 1915, had a mineral content of 1298 and a total hardness of 640 parts per million as shown by the analysis.

Analysis of Sample Number 31509 from the City Wells.

Determinations Made.

	Parts per million.
Iron Fe	trace
Manganese Mn	None
Silica SiO_2	12.8
Alumina Al_2O_3	5.6
Calcium Ca	172.6
Magnesium Mg	50.8
Ammonia NH_4	0.5
Sodium Na	165.1
Potassium K	20.0
Sulfate SO_4	569.6
Nitrate NO_3	32.7
Chloride Cl	165.0
Nonvolatile	0.4
Alkalinity Methyl Orange	250.
Residue	1448.

Hypothetical Combinations.

	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	51.7	3.02
Sodium Nitrate $NaNO_3$	1.6	.09
Sodium Chloride NaCl	272.3	15.88
Sodium Sulfate Na_2SO_4	176.4	10.28
Ammonium Sulfate $(NH_4)_2SO_4$	1.8	.10
Magnesium Sulfate $MgSO_4$	251.1	14.65
Calcium Sulfate $CaSO_4$	352.6	20.56
Calcium Carbonate $CaCO_3$	171.7	10.01
Iron Oxide Fe_2O_3	trace	trace
Alumina Al_2O_3	5.6	.33
Silica SiO_2	12.8	.75
Nonvolatile	0.4	.02
Total	1298.0	75.69

Well number one was drilled to a depth of 2100 feet. Salty water was encountered and the well was plugged at a depth of 1600 feet.

HAVANA (3614). Havana is located in the western part of Mason County on the east bank of Illinois River. A number of private wells about 35 feet deep are in use at residences.

A public water supply was installed by the city about 1889. No important changes have been made in the system. Water is drawn from wells and pumped into the distribution system by either of two Deane 12 and 18½ by 12 by 10-inch tandem compound duplex

steam pumps. The pumps are placed in a pit 15 feet deep. Steam is furnished by two 150-horsepower boilers. An elevated steel tank of 48,000 gallons capacity on a brick tower 50 feet high is connected to the system. The rates for water are 35 cents per 1000 gallons for the first 9000 gallons, 25 cents per 1000 gallons for the next 91,000 gallons, and 10 cents per 1000 gallons for additional quantities, with a discount of ten per cent for cash in ten days.

Water is secured from ten wells, each 6 inches in diameter and 72 feet deep. Two are located in the pump pit and four in each of two pits which are about 16 feet in diameter and 15 feet deep. All are in an area of about 40 feet by 20 feet. The wells are in sand and gravel and are equipped with screens 20 feet long. In September, 1921, the average amount of water pumped was estimated at 350,000 gallons a day. It is said that 3,00,000 gallons of water has been pumped in 24 hours. The depth to water varies with the stage of the river which is half a mile distant.

The water had a mineral content of 197, a total hardness of 165, and a content of iron of 0.2 parts per million as shown by the analysis of sample number 46148, collected on September 23, 1921.

Analysis of Sample Number 46148 from the City Supply.

Determinations Made.	Parts per million.
Iron Fe	0.2
Manganese Mn	0.0
Silica SiO_2	9.3
Nonvolatile	0.7
Alumina Al_2O_3	2.0
Calcium Ca	41.8
Magnesium Mg	15.0
Ammonia NH_4	0.0
Potassium K	1.9
Sodium Na	4.5
Sulfate SO_4	27.0
Nitrate NO_3	8.0
Chloride Cl	6.0
Alkalinity Methyl Orange	136.
Residue	237.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	4.8	.28
Sodium Nitrate $NaNO_3$	6.8	.39
Sodium Chloride NaCl	6.7	.39
Ammonium Chloride NH_4Cl	0.1	.01
Magnesium Chloride $MgCl_2$	2.5	.14
Magnesium Sulfate $MgSO_4$	33.8	1.97
Magnesium Carbonate $MgCO_3$	26.0	1.52
Calcium Carbonate $CaCO_3$	104.4	6.10
Silica SiO_2	9.3	.54
Nonvolatile	0.7	.04
Iron Oxide Fe_2O_3	0.3	.02
Alumina Al O_3	2.0	.12
Total	197.4	11.52

A sample of water, number 46611, collected from a well 1170 feet deep located near the city had a mineral content of 2400 and a total hardness of 440 parts per million.

HEBRON (631). Hebron is located in the northern part of McHenry County on the drainage area of Fox River. Sandy soil is encountered within 20 feet of the ground surface and private wells are from 20 to 100 feet deep.

A public water supply was installed by the village in 1904-1905. The installation included a well equipped with a deep-well pump, a collecting reservoir 20 feet in diameter and 16 feet deep, an 8 by 8-inch triplex pump, a distribution system, and two steel pressure tanks connected to the system. Air is pumped into the tanks by a Curtis compressor. The pumps and compressor are driven by a 25-horsepower kerosene engine.

A few services are metered. The rate to the Borden Company, which used about 6000 gallons a day from the public supply in 1919, was 20 cents per 1000 gallons.

Water is secured from a well 270 feet deep into sand and gravel, located in the northwestern part of the village. It was drilled by W. J. Miller of Genoa Junction, Wisconsin, in 1904-1905. It is cased with 8-inch pipe to a depth of 100 feet or more and with 6-inch pipe below the 8-inch. It is equipped with a screen of perforated pipe wrapped with copper wire and covered with a brass screen. The screen is 16 feet long and 11 feet of it is exposed. The well is equipped with a deep-well pump with 4¾-inch cylinder and 24-inch stroke. The discharge from the well in 1919 was said to raise the water level in the reservoir two feet in one hour, a rate of 78 gallons a minute. In 1919 the pump was operated a total of four or five hours a day. In May, 1925, the yield was reported to be 70 gallons a minute and the time operated 10 hours a day.

Water from the village supply had a mineral content of 273, a total hardness of 212, and a content of iron of 0.1 parts per million as shown by the analysis of sample number 40946, collected on April 16, 1919.

Analysis of Sample Number 40946 from the Village Supply.

Determinations Made.	Parts per million.
Iron Fe	0.1
Silica SiO_2	4.0
Nonvolatile	0.5
Calcium Ca	42.9
Magnesium Mg	25.6
Ammonia NH_4	1.3
Potassium K } Sodium Na }	26.0
Alumina Al_2O_3	9.1
Sulfate SO_4	0.0
Nitrite NO_2	0.0
Nitrate NO_3	0.7
Chloride Cl	4.0
Alkalinity Methyl Orange	270.
Residue	267.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Sodium Nitrate $NaNO_3$	0.9	0.06
Sodium Chloride NaCl	6.6	0.39
Sodium Sulfate Na_2SO_4	53.3	3.12
Ammonium Carbonate $(NH_4)_2CO_3$	3.5	0.21
Magnesium Carbonate $MgCO_3$	88.6	5.18
Calcium Carbonate $CaCO_3$	107.1	6.27
Iron Carbonate $FeCO_3$	0.2	0.01
Alumina Al_2O_4	9.1	0.53
Silica SiO_2	4.0	0.23
Nonvolatile	0.5	0.03
Total	273.9	16.03

HENNEPIN (377). Hennepin is located in the northwestern part of Putnam County on the east bank of Illinois River. A public water supply was installed by the village in 1875. It is little used at residences and in 1917 only 8 service connections were in use. Private wells are in general use and three have been drilled to a depth of 100 feet.

The public water supply is obtained from a well drilled in 1875. The original depth was about 800 feet. It was cased with 4-inch pipe to a depth of 400 feet. When drilling the bottom 40 feet the flow from the well increased rapidly and was estimated at 80 gallons a minute when the well was completed. The pressure with no flow was 32 pounds. Water flowed into the mains and an elevated tank. In 1910 the pressure had decreased to 18 pounds, which was not sufficient to fill the elevated tank. The well was then recased with 4-inch pipe to a depth of 480 feet and drilled deeper. A record of material penetrated, secured from the State Geological Survey Division, is as follows :

	Thickness in feet.	Depth in feet.
Soil	3	3
Gravel, coarse	27	30
Gravel, fine	35	65
Conglomerate	8	73
Sand	38	111
Gravel	1	112
Clay, gray (pebbly)	48	160
Clay, blue	6	166
Clay, blue, sandy	9	175
Sand and fine gravel	25	200
Clay, sandy, blue	30	230
Soapstone? blue	20	250
Soapstone? gray	10	260
Soapstone, pink and gray	15	275
Hardpan (shale?)	25	300
Clay, sandy	25	325
Clay, blue	25	350
Shale? (glistening)	10	360
Sand, fine	40	400
Limestone	25	425
Sandstone	10	435
Lime rock	30	465
Sandstone, white	10	475
Sandstone, white	25	500
Limestone, becomes lighter downward	350	850

Three different logs of this well show slight differences.

The flow was not increased with the improvements made in 1910 and a small pump operated by a 2½-horsepower gas engine was installed. This pump was used to fill an elevated wooden tank 10 feet in diameter and 10 feet high. Water in the tank is for use in case of fire or other emergency. The tank is cleaned and refilled once a year.

The water had a mineral content of 2909, a total hardness of 35, and a content of iron of 1.0 parts per million as shown by the analysis of sample number 38602, collected on November 23, 1917.

Analysis of Sample Number 38602 from the Village Supply.

Determinations Made.

	Parts per million.
Iron Fe	1.0
Silica SiO_2	7.7
Alumina Al_2O_3	4.1
Calcium Ca	13.1
Magnesium Mg	0.7
Ammonia NH_4	1.3
Sodium Na	1085.4
Potassium K	54.8
Sulfate SO_4	184.8
Nitrate NO_2	0.0
Nitrate NO_3	0.3
Chloride Cl	1250.0
Alkalinity Methyl Orange	596.
Residue	2904.

Hypothetical Combinations.

	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	0.5	.03
Potassium Chloride KCl	103.9	6.06
Sodium Chloride NaCl.	1980.0	115.49
Sodium Sulfate Na_2SO_4	273.5	15.95
Sodium Carbonate Na_2CO_3	500.2	29.17
Ammonium Carbonate $(NH_4)_2CO_3$	3.5	.20
Magnesium Carbonate $MgCO_3$	2.4	.14
Calcium Carbonate $CaCO_3$	32.7	1.91
Iron Oxide Fe_2O_3	1.4	.08
Alumina Al_2O_3	4.1	.24
Silica Si_2O_2	7.7	.45
Total	2909.9	169.72

The analysis of a sample, number 3761, collected in 1898, was similar.

HENRY (1637). Henry is located in the northern part of Marshall County on the west bank of Illinois River. A public water supply was installed in 1902. Part of the cost was financed by the contractors, who were later repaid by the city and the entire plant is now owned by the city. Water is drawn from wells and pumped into the distribution system and two steel pressure tanks connected to the system. The tanks are each 8 feet in diameter and 36 feet long. The pumps are placed in a pit 8 feet deep. One is a Roots rotary pump of 350 gallons a minute capacity driven by a 30-horse-power electric motor with automatic control regulated by the water pressure. The other pump is an American centrifugal pump of 500 gallons a minute capacity which is driven by an electric motor. Electric current is supplied by the Public Service Company of Northern Illinois. Five hundred service connections were in use in 1921.

The public water supply is secured from three wells into sand and gravel, located about 200 feet distant from Illinois River. Two wells, each 8 inches in diameter and 40 feet deep, are located 8 feet apart in the pumping station. Each is equipped with a Johnson strainer 8 feet long. The well casings are connected to the pump suction line. These two wells did not furnish sufficient water and a third well was installed about 1903. This well is 8 feet in diameter

and 40 feet deep and is located about 10 feet distant from the 8-inch wells. The well is lined with brick laid with open joints in the lower part and laid in cement mortar in the upper ten feet.

The water had a mineral content of 461, a total hardness of 335, and a content of iron of 0.0 parts per million as shown by the analysis of sample 46217, collected on September 30, 1921.

Analysis of Sample Number 46217 from the City Supply.

Determinations Made.	Parts per million.
Iron Fe	0.0
Manganese Mn	0.0
Silica SiO_2	13.0
Nonvolatile	0.9
Alumina Al_2O_3	1.2
Calcium Ca	61.6
Magnesium Mg	44.6
Ammonia NH_4	0.0
Potassium K	3.8
Sodium Na	38.7
Sulfate SO_4	49.5
Nitrate NO_3	31.9
Chloride Cl	47.0
Alkalinity Methyl Orange	280.
Residue	490.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	9.9	.58
Sodium Nitrate $NaNO_3$	35.3	2.06
Sodium Chloride NaCl	74.1	4.33
Ammonium Chloride NH_4Cl	0.1	.01
Magnesium Chloride $MgCl_2$	2.6	.15
Magnesium Sulfate $MgSO_4$	62.0	3.62
Magnesium Carbonate $MgCO_3$	108.6	6.35
Calcium Carbonate $CaCO_3$	153.8	8.99
Silica SiO_2	13.0	.76
Nonvolatile	0.9	.05
Alumina Al_2O_3	1.2	.07
Total	461.5	26.99

Some water meters have been in use for many years and others have lasted but a few years. Hot water coils are said to clog rapidly.

HINCKLEY (665). Hinckley is located in the southeastern part of DeKalb County on the drainage area of Fox River, a tributary of Illinois River. A public water supply was installed by the village about 1893. Water was obtained from a well 350 feet deep until expenses of operation became very high. A contract was then made with a company operating a local tile plant to install a well and supply water. The expenses of operation again increased and in 1913 the village drilled another well which has since been in use. Water is pumped from the well into the mains, to which an elevated steel tank of 60,000 gallons capacity is connected, by either of two centrifugal pumps. One pump is an American of 200 gallons a minute capacity and is driven by a 20-horsepower gas engine. The other pump has a capacity of 200 gallons a minute and is driven by a 15-horsepower electric motor. Electric power is purchased from the Illinois Northern Utilities Company.

About 175 service connections were in use in 1922 and nearly all were metered. The rate is 75 cents for three months plus 25 cents per 1000 gallons of water used, with a discount of 10 per cent

for cash. The Chicago, Burlington and Quincy Railroad has a private supply. They pump water from Little Rock Creek and treat with soda ash.

The public water supply is secured from a well 708 feet deep, drilled by Wm. Cater in 1913-1914. The top of the well is about 740 feet above sea level. R. Clark, a member of the water committee, thinks that a 12-inch casing extends to a depth of about 120 feet and that St. Peter sandstone was encountered at a depth of about 400 feet. Water is pumped by either of two pumps placed in a pit, with the centers of the pumps eleven feet below the ground surface. Each pump is of 200 gallons a minute capacity. In 1913 the water level was at a depth of four feet when not pumping and was lowered twenty-four feet by pumping for one hour at a rate of 250 gallons a minute. In 1922 one pump was operated a total of about five hours a day and could be operated continuously for that length of time. A vacuum gauge on the suction line showed little increase in vacuum after fifteen minutes pumping. From the readings it was estimated that the water level was lowered to more than twenty-five feet below the ground surface when pumping and that it raised to less than seventeen feet below the ground surface when not pumping for three hours. Both pumps could be operated for forty minutes.

A slight odor of hydrogen sulphide could be detected when drawing water from a faucet in the pumping station. The water had a mineral content of 316, a total hardness of 274, and a content of iron of 1.0 parts per million as shown by the analysis of sample number 47180, collected from a tap at the pumping station on March 7, 1922.

Analysis of Sample Number 47180 from the Village Supply.

Determinations Made.

	Parts per million.
Iron Fe	1.0
Manganese Mn	trace
Silica SiO_2	10.9
Nonvolatile	0.7
Alumina Al_2O_3	0.9
Calcium Ca	51.1
Magnesium Mg	35.6
Ammonia NH_4	0.0
Sodium Na	19.8
Potassium K	1.4
Sulfate SO_4	0.6
Nitrate NO_3	0.4
Chloride Cl	1.0
Alaklinity Methyl Orange	312.0
Residue	314.

Hypothetical Combinations.

	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	0.6	.03
Potassium Chloride KCl	2.1	.12
Potassium Sulfate K_2SO_4	0.2	.01
Sodium Sulfate Na_2SO_4	0.7	.04
Sodium Carbonate Na_2CO_4	45.1	2.64
Ammonium Carbonate $(NH_4)_2CO_3$	2.4	.14
Magnesium Carbonate $MgCO_3$	123.4	7.22
Calcium Carbonate $CaCO_3$	127.6	7.46
Silica SiO_2	10.9	.64
Nonvolatile	0.7	.04
Iron Oxide Fe_2O_3	1.4	.08
Alumina Al_2O_3	0.9	.05
Total	316.0	18.47

HINSDALE (4042). Hinsdale is located in the southeastern part of Du Page County on the drainage area of Des Plaines River, a tributary of Illinois River. A public water supply was installed by the village in 1890. Water was obtained from a well 864 feet deep for about 10 years when the well now in use was drilled and the old well was abandoned. A water softening plant was installed by the Kennicott Water Softening Company in 1915.

Water is pumped from a well by pumps placed in the pit 18 feet 6 inches deep. The pump generally used is a Cameron 4-inch centrifugal which is driven by an electric motor. Water is discharged through an orifice box into a central compartment in a softening and settling tank. This tank is 33 feet in diameter and 39 feet high. On entering the tank the water is dosed with lime and soda ash, the dose being automatically regulated by the height of water in, or the rate of flow through, the orifice box. The water and chemicals are mixed by paddles placed in the inner compartment of the tank, the paddles being operated by the water. The treated water passes downward through the central compartment of the tank to near the bottom and flows upward in the outer part of the tank. It is drawn off at the top and flows to filters or to a storage tank 33 feet in diameter and 39 feet high. Water flows from the tanks through rapid sand filters to a clear water well. A small amount of alum is added by means of a pot placed in the line leading to the filters. The filter area is divided into three units, each 9 by 10 feet in plan. The filters are cleaned by agitation with air and are washed with water. The clear water basin has a capacity of 16,000 gallons. This basin and the filter tanks are built of concrete. Water is pumped from the clear well into the mains by a Laidlaw-Dunn-Gordon 12 and 18½ by 12 by 12-inch tandem compound duplex steam pump. A Smith-Vaile steam pump in the pump pit, rated at 1000 gallons a minute, is available to pump water from the well or from the clear water reservoir.

The well first used was drilled by the J. P. Miller Artesian Well Company in 1890. The well is in limestone of the Silurian system between depths of 42 and 353 feet, in shale of the Richmond series between depths of 353 and 496 feet, and in Galena-Platteville limestone below a depth of 496 feet. It is cased with 8-inch pipe to rock. The well is not now in use.

Water is obtained from a well 12 inches in diameter and 200 feet deep. By 1924 the amount of water pumped had reached an average of 400,000 gallons a day and on some days in 1923 as much as 700,000 gallons a day had been pumped. J. A. M. Robinson made

a test in February, 1924. The water level when not pumping for two or three hours was 16.5 feet below the floor of the pump pit. Pumping 487 gallons a minute lowered the water level two and six-tenths feet. After pumping for half an hour the vacuum on the suction line and the rate of discharge remained practically constant for 3½ hours.

The water had a mineral content of 603, a total hardness of 478, and a content of iron of 3.0 parts per million as shown by the analysis of sample number 47056, collected on February 13, 1922.

Analysis of Sample Number 47056 of Water from the Village Supply.

Determinations Made.	Parts per million.
Turbidity	30.0
Residue	604.0
Iron Fe	3.0
Manganese Mn	0.0
Nitrate NO_3	1.8
Chloride Cl	5.0
Sulfate SO_4	1736.0
Alkalinity Methyl Orange	366.0
Magnesium Mg	36.3
Calcium Ca	132.0

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Calcium Carbonate $CaCO_3$	329.5	19.75
Magnesium Carbonate $MgCO_3$	30.7	1.79
Magnesium Sulfate $MgSO_4$	135.6	7.92
Sodium Sulfate Na_2SO_4	97.0	5.67
Sodium Chloride NaCl.	8.2	0.48
Sodium Nitrate $NaNO_3$	2.4	0.14
Total	603.3	35.25

The water is treated with lime and soda ash. In February, 1924, thirteen hundred pounds of lime and 300 pounds of soda ash was used at a time and treated about 400,000 gallons of water. The quality of water after treatment is shown by the analysis of sample number 47057, collected on February 13, 1922.

Analysis of Sample Number 47057 of Softened Water.

Determinations Made.	Parts per million.
Turbidity	50.0
Residue	393.0
Iron Fe	0.1
Manganese Mn	0.0
Nitrate NO_3	2.7
Sulfate SO_4	177.1
Chloride Cl	6.0
Alkalinity Methyl Orange	116.0
Magnesium Mg	12.6
Calcium Ca	12.8

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Calcium Carbonate $CaCO_3$	32.1	1.87
Magnesium Carbonate $MgCO_3$	43.6	2.55
Sodium Carbonate Na_2CO_3	34.2	2.00
Sodium Sulfate Na_2SO_4	261.2	15.26
Sodium Chloride NaCl.	9.9	0.58
Sodium Nitrate $NaNO_3$	3.7	0.21
Total	384.7	22.47

Another well was drilled in 1924 by M. T. Peterson of Madison, Wisconsin. It is located 350 feet east of the older well. It is cased with 20-inch pipe to a depth of 56 feet, is 19 inches in diameter at

the bottom, and is 271 feet deep. A crevice was encountered at a depth of 116 feet. The well was tested when completed. It yielded 1100 gallons a minute for 50 hours with a lowering of the water level of 23½ feet to a depth of 60 feet below the ground surface, where it stood during the test.

The building of a new water softening plant was started in July, 1924. This plant will be ready for operation about September 1, 1925.

HOMEWOOD (1389). Homewood is located in the southern part of Cook County on the drainage area of Calumet River. A public water supply was installed by the village in 1911. Water was pumped from a well into the distribution system by a deep-well pump driven by a 25-horsepower electric motor. Another well has been drilled and equipped with a deep-well centrifugal pump. An elevated steel tank of 80,000 gallons capacity, located close to the well, is connected to the mains. The rates for water for three months are 30 cents per 1000 gallons for the first 10,000 gallons, 25 cents per 1000 gallons for the next 10,000 gallons, and 20 cents per 1000 gallons for additional quantities, with a cash discount of 10 per cent and a minimum charge of $1.50.

The public water supply is from two wells located 75 feet apart near the business discount of the village. One well was drilled in 1911. It is 250 feet deep. It was cased with 12-inch pipe to rock at a depth of 70 feet and is 10 inches in diameter in rock. The elevation at the top of the well is about 650 feet above sea level. The well is equipped with an American double-acting deep-well pump with a 7½-inch cylinder placed at a depth of 70 feet. Yields of from 170 to 200 gallons a minute during tests have been reported. In 1914 the average amount of water pumped was estimated at 21,000 gallons a day and the depth to water was given as 16 feet. In 1923, during a test, water was pumped at a rate of 170 gallons a minute. The depth to water was 26 feet before pumping and 48 feet after pumping for one hour. During the winter of 1922 and 1923 the pump had operated about 6 hours a day and during the summer of 1922 it had operated from 16 to 20 hours a day.

The other well was drilled in 1924. It is located 75 feet west of the older well. The well is 16 inches in diameter to a depth of 165 feet and 10 inches in diameter below that depth to the bottom at a depth of 360 feet. The well is equipped with a Layne vertical-shaft centrifugal pump. In 1925 the pump discharged 300 gallons a minute.

The pumps were used alternately in the spring of 1925. Each pump was operated every day. The total time pumps were operated was about as given for the older pump in 1923.

The water had a mineral content of 682, a total hardness of 468, and a content of iron of 0.4 parts per million as shown by the analysis of sample number 48931, collected in March 24, 1923.

Analysis of Sample Number 48931 from the Village Supply.

Determinations Made.	Parts per million.
Iron Fe	0.4
Manganese Mn	0.2
Silica SiO_2	15.6
Nonvolatile	0.8
Alumina Al_2O_3	0.0
Calcium Ca	93.4
Magnesium Mg	57.6
Ammonia NH_4	0.6
Sodium Na	45.8
Potassium K	13.1
Sulfate SO_4	270.4
Nitrate NO_3	0.7
Chloride Cl	6.0
Alaklinity Methyl Orange	334.0
Residue	725.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	1.1	.06
Potassium Chloride KCl	12.6	.74
Potassium Sulfate K_2SO_4	13.4	.78
Sodium Sulfate Na_2SO_4	141.4	8.26
Ammonium Sulfate $(NH_4)_2SO_4$	2.0	.12
Magnesium Sulfate $MgSO_4$	207.6	12.12
Magnesium Carbonate $MgCO_3$	53.8	3.14
Calcium Carbonate $CaCO_3$	233.6	13.64
Silica SiO_2	15.6	.81
Nonvolatile	0.8	105
Iron Oxide Fe_2O_4	0.6	.03
Alumina Al_2O_3	0.0	.00
Total	682.5	39.75

Another sample of water collected contained 1.8 parts of iron. The iron content is sufficient to stain fixtures and laundry fabrics. The temperature of water as discharged from the older well in November, 1921, was 52 degrees Fahrenheit.

HOOPESTON (5451). Hoopeston is located in the northeastern part of Vermilion County on the drainage area of Vermilion River, a tributary of Wabash River. A public water supply was installed by the city in 1888. Nearly all residents use water from the public supply. Several industrial plants have private supplies from wells 100 to 120 feet deep into sand and gravel. Water bearing material is entered at a depth of about 55 feet and at greater depths the material is coarser.

Water for the public supply is pumped from wells into two collecting reservoirs, one 25 feet 4 inches in diameter and the other about 50 feet in diameter. Both are 7 feet deep. From the reservoirs it is pumped into the mains by either of two Deane 12 and 18½ by 12 by 10-inch compound duplex steam pumps. One well is equipped with an air lift. Compressed air is supplied by an Ingersoll-Sargent 12 by 14-inch compressor. Steam is supplied by

two 60-horsepower boilers. The rates for water are 44 cents per 1000 gallons for less than 700 gallons per day, 31 cents per 1000 gallons for from 700 to 1500 gallons a day, and 25 cents per 1000 gallons for quantities above 15,000 gallons a day. The consumption of water has decreased for several years due to the installation of meters and repairs of leaks.

Water is secured from four wells located west of the center of the city. The elevation of the tops of the wells is about 710 feet above sea level. A well which had been drilled to a depth of 2100 feet in 1886 was plugged at a depth of 360 feet and used to furnish water when the water works was installed. This well is still in use. It is equipped with a steam-head deep-well pump with 4¾-inch double-acting cylinder and 36-inch stroke. The bottom of a suction pipe on the cylinder is at a depth of 122 feet. The well is used only when necessary.

Another well drilled to a depth of 360 feet when the water works was installed has been abandoned.

The other three wells are 10 inches in diameter and from 106 to 110 feet deep. The bottoms of the wells are in sand and gravel. The wells were drilled by O. A. Musson, one in 1906 and the other two in 1914. Each is equipped with a number 10 Cook screen 12 feet long. One of these wells, located in the station, is equipped with a steam-head deep-well pump with 36-inch stroke and $7\,^{5}/_{8}$-inch Erb double-acting cylinder placed at a depth of 77 feet. Another well in the station, the well farthest west, is equipped with a steam-head deep-well pump with 36-inch stroke and a 5¾-inch Erb double-acting cylinder placed at a depth of 91 feet. On May 10, 1923, when the larger pump was operating 16½ up strokes a minute and the smaller pump was operating 12 up strokes a minute the discharge from these two wells, measured in the reservoir, was 270 gallons a minute. The pumps had operated 25 strokes a minute and pumped to capacity which, from test, indicates a yield of 450 gallons a minute.

The other 10-inch well is located outside of and to the west of the pumping station. It is equipped with an air lift with a 2-inch air line to a depth of 90 feet. The capacity, as given in 1923, was 230 gallons a minute. The cylinder in the west well in the pumping station is placed low as that well is affected by using the air lift in this well.

Many years ago the depth to water in the wells was said to be 21 feet. In 1922 when the average water consumption was es-

timated at 330,000 gallons a day the depth to water in one well when pumps in other wells were operating was 32 feet.

Some information in regard to the yield of wells into this sand and gravel stratum is available from other wells. One well at the Hoopeston Canning Company plant is 12 inches in diameter and 111 feet deep. It is equipped with a number 70 Cook screen 15 feet long. Equipped with a Jackson-Byron pump with 14 stages the discharge at the ground surface was 690 gallons a minute and the discharge into an elevated tank was 413 gallons a minute. Fine sand was drawn into the well and three stages of the pump were removed. The yield in 1922, discharging into the elevated tank, was estimated at 340 gallons a minute. The water level was at a depth of 33 feet and was lowered 5 feet by pumping.

Water from the public supply had a mineral content of 357 and a total hardness of 275 parts per million as shown by the analysis of sample number 49481, collected at the pumping station on May 10 ,1923.

Analysis of Sample Number 49481 from the City Supply.

Determinations Made.	Parts per million.
Iron Fe	0.0
Manganese Mn	0.0
Silica SiO_2	13.3
Nonvolatile	0.5
Alumina Al_2O_3	3.4
Calcium Ca	63.5
Magnesium Mg	28.3
Ammonia NH_4	25.7
Sodium Na	2.8
Potassium K	3.8
Sulfate SO_4	3.3
Nitrate NO_3	2.1
Chloride Cl	1.0
Alkalinity Methyl Orange	346.0
Residue	360.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	3.4	0.20
Potassium Chloride KCl	2.1	0.12
Potassium Sulfate K_2SO_4	3.0	0.17
Sodium Sulfate Na_2SO_4	2.3	0.13
Sodium Carbonate Na_2CO_4	4.8	0.28
Ammonium Carbonate $(NH_4)_2CO_3$	68.5	4.00
Magnesium Carbonate $MgCO_3$	97.9	5.72
Calcium Carbonate $CaCO_3$	158.5	9.25
Alumina Al_2O_3	3.4	0.20
Silica SiO_2	13.1	0.76
Nonvolatile	0.5	0.03
Total	357.5	20.86

Other analyses have been similar to that given above excepting that the iron content has been from one to two parts per million.

HOPEDALE (556). Hopedale is located in the southeastern part of Tazewell County on the drainage area of Mackinaw River, a tributary of Illinois River. Many residents secure water from private wells from 16 to 20 feet deep and secure gas from wells 80 to 100 feet deep.

A public water supply was installed by the village about 1892. A well was drilled which has since been abandoned. Water is

pumped from two wells into the distribution system to which an elevated tank of 80,000 gallons capacity is connected. The pumps are driven by electric motors. Water rates are 35 cents per 1000 gallons for less than 500 gallons a day, 30 cents per 1000 gallons for from 500 to 1000 gallons a day, and 25 cents per 1000 gallons for quantities in excess of 1000 gallons a day.

Water for the public supply is secured from two wells located close to the center of the business district of the village. The elevation of the tops of the wells is about 635 feet above sea level. Mr. Cochran, who drilled one of the wells, states that in general blue clay is entered at a depth of from 12 to 16 feet, buried drift with wood, etc., is encountered at depths of from 30 to 60 feet, and a gas vein at a depth of from 60 to 100 feet. At the village wells the drift is at a depth of 50 feet and cemented sand and gravel containing gas is at a depth of 80 feet. Below this gas vein one village well passed through about 50 feet of blue clay before entering sand and another well nine feet distant was said to pass through little clay before entering sand. The wells are 180 feet deep. The lower 15 or 16 feet is said to be in gravel.

The supply is generally pumped from an 8-inch well which was drilled by Mr. Cochran in 1921. In the bottom is a Cook screen 16 feet long. The well is equipped with a Keystone Driller Company double-stroke deep-well pump with a 5½-inch cylinder placed at a depth of 165 feet. The pump is operated with 18-inch stroke at a speed of 25 revolutions a minute and in 1922 was run from 4 to 4½ hours a day. It is thought that water stood at a depth of 60 feet when the well was drilled.

Analysis of Sample Number 48355 from the Village Supply.

Determinations Made.

	Parts per million.
Iron Fe	1.8
Manganese Mn	0.0
Silica SiO_2	19.0
Nonvolatile	0.4
Alumina Al_2O_3	0.6
Calcium Ca	69.3
Magnesium Mg	36.2
Ammonia NH_4	1.6
Sodium Na	21.0
Potassium K	2.7
Sulfate SO_4	0.0
Nitrate NO_3	1.4
Chloride Cl	4.0
Alkalinity Methyl Orange	366.0
Residue	370.

Hypothetical Combinations.

	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	2.3	.14
Potassium Chloride KCl	3.3	.19
Sodium Chloride NaCl	4.0	.23
Sodium Carbonate Na_2CO_3	46.0	2.69
Ammonium Carbonate $(NH_4)_2CO_3$	4.4	.25
Magnesium Carbonate $MgCO_3$	125.2	7.32
Calcium Carbonate $CaCO_3$	172.6	10.12
Silica SiO_2	19.0	1.11
Nonvolatile	0.4	.02
Iron Oxide Fe_2O_3	2.5	.14
Alumina Al_2O_3	0.6	.03
Total	380.3	22.24

The other well was drilled about 1900. It is 6 inches in diameter. It is equipped with a Goulds single-acting deep-well pump.

The Chicago and Alton Railroad has an 8-inch well into the same water-bearing stratum. The yield as equipped was said to be 8,000 gallons an hour and during nine months of the year the pump operated about six hours a day.

Water from the village supply had a mineral content of 380, a total hardness of 322, and a content of iron of 1.8 parts per million as shown by the analysis of sample number 48355, collected from the 8-inch well on October 5, 1922.

Water from the railroad well is of the same quality.

HUNTLEY (720). Huntley is located in the southern part of McHenry County on the drainage area of Kishwaukee River, a tributary of Illinois River. A public water supply was installed by the village in 1905. Water is pumped from wells into the mains by a Goulds 7 by 8-inch single-acting triplex pump which is driven by a 10-horsepower electric motor. An elevated wooden tank located close to the wells is connected to the mains. One hundred and twenty-five service connections were in use in 1924 and water was sold on a flat rate.

Water is secured from three 6-inch wells. Two of the wells located 6 feet apart are each 74 feet deep. The other well is located 40 feet distant from these two and is 69 feet deep. The bottoms of the wells are in sand and gravel. Water is drawn from the wells by a triplex pump placed in a pit three feet deep. The capacity of the pump as operated in 1918 was given as 175 gallons a minute. A gauge on the suction line was said to indicate 25 inches vacuum when pumping. The pump was operated 38 revolutions a minute, a displacement of 150 gallons a minute, at the time of visit in 1924. An approximate test, measuring the water in the elevated tank, showed a yield of 120 gallons a minute. (The tank was taken to be 20 feet in diameter). The average amount pumped during the year to June, 1924, was estimated at 35,000 gallons a day. Water is sold at flat rates.

The J. F. Jelke Company can supply water to the village from four wells similar to the village wells, located about 300 feet east of the village wells. The company pumps about 150,000 gallons of water a day.

The Victory Mey Dairy Company have wells similar to the village wells, located about a quarter of a mile distant, from which they pump about 50,000 gallons a day.

Water from the village supply had a mineral content of 430, a total hardness of 374, and a content of iron of 0.8 parts per million as shown by the analysis of sample number 38795, collected on January 2,1918.

Analysis of Sample Number 38795 from the Village Supply.

Determinations Made.	Parts per million.
Iron Fe	0.8
Silica SiO_2	13.3
Alumina Al_2O_3	13.4
Calcium Ca	90.4
Magnesium Mg	36.1
Ammonia NH_4	0.3
Sodium Na	15.5
Potassium K	2.4
Sulfate SO_4	23.0
Chloride Cl	10.0
Alkalinity Methyl Orange	364.
Residue	430.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Chloride KCl	4.6	.26
Sodium Chloride NaCl	12.9	.75
Sodium Sulfate Na_2SO_4	32.1	1.87
Ammonium Sulfate $(NH_4)_2SO_4$	1.2	.07
Magnesium Sulfate $MgSO_4$	0.5	.03
Magnesium Carbonate $MgCO_3$	124 .7	7.27
Calcium Carbonate $CaCO_3$	225.7	13.16
Iron Carbonate $FeCO_3$	1.7	.10
Alumina Al_2O_3	13.4	.78
Silica SiO_2	13.3	.77
Total	430.1	25.06

IPAVA (720). Ipava is located in the southwestern part of Fulton County on the drainage area of Spoon River, a tributary of Illinois River. A public water supply was installed by the village about 1890. The installation included a well 1570 feet deep equipped with a deep-well pump, a distribution system and an elevated tank connected to the system. The original well was abandoned and well from which the supply has since been secured was drilled in 1915. Water is pumped from the well into a collecting reservoir, which is 14 feet in diameter, by a deep-well pump. It is pumped from the reservoir into the mains and an elevated tank by a 5½ by 7-inch Aldrich triplex pump. The tank in use was erected in 1921. About 90 service connections are in use. The meter rate is 35 cents per 1000 gallons for the first 2000 gallons, 30 cents per 1000 gallons for the next 4000 gallons, and 25 cents per 1000 gallons for addition1 quantities, with a minimum charge of $1.00 for three months use.

Water for the public supply is secured from a well drilled in 1915 by M. T. Smith of Bushnell. Records of material penetrated by deep wells in or near the village were apparently classified differently by different drillers. A record of the village well showed mostly slate and shale to limestone at a depth of 1025 feet. The thickness of the limestone is given as 279 feet and the lower 20 feet of the well, to a depth of 1324 reet, is classified as St. Peter sandstone. A record on file with the village clerk shows 54 feet

of 12½-inch casing, 195 feet of 10-inch casing, 481 feet of 8¼-inch casing, and 429 feet of 65/8-inch casing. A vein of black water was reported at a depth of 525 feet.

When the well was completed water stood 84 feet below the ground surface. During a test by the driller the well is said to have yielded 240 gallons a minute. The well is equipped with a Luitwieler deep-well pump with 5½-inch cylinder and 14-inch stroke. The cylinder is placed at a depth of 120 feet. The pump is operated 38 revolutions a minute. The yield on December 17, 1924, measured in the reservoir, was 30 gallons a minute.

The temperature of water discharged from the well on December 18, 1924, after pumping for one hour was 67 degrees Fahrenheit. A sample, number 52997, collected on that date after pumping for twenty minutes, had a mineral content of 2958, a total hardness of 630, and a content of iron of 0.16 parts per million as shown by the analysis.

Analysis of Sample Number 52997 from the Village Supply.

Determinations Made.

	Parts per million.
Iron Fe	0.1
Manganese Mn	0.0
Silica SiO_2	11.0
Nonvolatile	2.2
Alumina Al_2O_2	12.6
Calcium Ca	150.7
Magnesium Mg	61.4
Amonia NH_4	3.1
Sodium Na	780.4
Potassium K	28.1
Sulfate SO_4	961.0
Nitrate NO_3	0.5
Chloride Cl	825.0
Alkalinity	
Phenolphthalein.	0
Methyl Orange	244.
Residue	2941.

Hypothetical Combinations.

	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	0.8	.05
Potassium Chloride KCl	52.9	3.09
Sodium Chloride NaCl	1319.0	77.13
Sodium Sulfate Na_2SO_4	806.9	47.04
Ammonium Sulfate $(NH_4)_2SO_4$	11.2	.66
Magnesium Sulfate $MgSO_4$	304.0	17.78
Calcium Sulfate $CaSO_4$	232.1	13.57
Calcium Carbonate $CaCO_3$	205.5	12.01
Iron Oxide Fe_2O_4	0.2	.01
Alumina Al_2O_3	12.6	.73
Silica SiO_2	11.0	.64
Nonvolatile	2.2	.13
Total	2958.4	172.84

A sample collected in 1914 from the well 1570 feet deep which was then in use was of about the same quality.

JACKSONVILLE (15,713). Jacksonville is located in the central part of Morgan County on the drainage area of Mauvaise Terre Creek, a tributary of Illinois River. Many dug wells from 15 to 40 feet deep have been in use at residences and some wells into sand at a depth of 100 to 130 feet are in use.

A public water supply was installed by the city in 1871. The supply was from an impounding reservoir and a large part of the supply has at all times been surface water.

The installation now includes an impounding reservoir of about 600,000,000 gallons capacity formed by a dam across the south branch of Mauvaise Terre Creek near the southern limits of the city, a pumping station and a filtration plant of 2,120,000 gallons nominal capacity.

At times part of the public water supply has been secured from wells. The city purchased a well which had been drilled to a depth of 1600 feet in 1885 by a gas and oil syndicate. The depth was increased to 2200 feet. On account of the small supply the well was sold to J. Capps and Son.

In 1888 a well was drilled by the city on the pumping station grounds near the southern limits of the city, to a depth of 3110 feet. Later two other wells were drilled close by to about the same depth. A record of material penetrated by one of the wells was given by A. M. Upham, Superintendent of Water Works. An interpretation by the State Geological Survey Division shows St. Peter sandstone between depths of 1540 and 1837 feet and Cambrian? sandstone below a depth of 2080 feet. At the bottom of the record is a note "flow 500 gallons a minute." On a similar record of the original well is a note "flow 425 gallons—natural pressure 50 pounds." Water from the wells flowed into a reservoir from which it was pumped into the mains.

The water had a mineral content of 2431, a total hardness of 494, and a content of iron of 2.6 parts per million as shown by the analysis of sample number 3712, collected on June 21, 1898. The water also contained considerable hydrogen sulphide.

Analysis of Sample Number 3712 from Wells 3100 Feet Deep.

Determinations Made.

	Parts per million:
Iron Fe	2.6
Silica SiO_2	12.1
Alumina Al_2O_3	2.4
Calcium Ca	123.0
Magnesium Mg	45.4
Ammonia NH_4	1.5
Sodium Na	678.6
Potassium K	32.7
Sulfate SO_4	439.7
Nitrate NO_3	2.2
Chloride Cl	1000.
Residue	2466.

Hypothetical Combinations.

	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	3.5	.20
Potassium Chloride KCl	59.9	3.50
Sodium Chloride NaCl	1601.0	93.38
Sodium Sulfate Na_2SO_4	150.4	8.77
Ammonium Sulfate $(NH_4)_2SO_4$	5.5	.30
Magnesium Sulfate $MgSO_4$	225.9	13.17
Calcium Sulfate $CaSO_4$	217.6	12.69
Calcium Carbonate $CaCO_3$	147.5	8.59
Iron Carbonate $FeCO_3$	5.3	.30
Alumina Al_2O_3	2.4	.14
Silica SiO_2	12.1	.75
Total	2431.1	141.79

In 1905 the Jacksonville Water Works Company developed a supply of water for the city from wells into sand and gravel in bottom lands of Illinois River near Bluffs about nineteen miles west of Jacksonville. Fourteen 10-inch wells with 20-foot strainers were sunk to bed rock at a depth of from 68 to 70 feet. Some water was pumped to the city reservoir from October, 1907, to April, 1908. Water was drawn from the wells by suction. When pumping at a rate of 5,000,000 gallons a day the water level was lowered 57 inches outside of the well casings. Individual wells were tested at rates of from 750,000 to 1,000,000 gallons a day. At times of tests when pumping water to the city the pressure at the pumps was 195 pounds. Some breaks occurred in a 20-inch pipe line of number 10 gauge steel which had been laid to the city. After litigation with the city the plant was dismantled.

A sample of water, number 14,072, collected on March 1, 1906, had a mineral content of 383, a total hardness of 363, and a content of iron of 0.8 per million as shown by the analysis.

Analysis of Sample Number 14072 from Wells at Bluffs.

Determinations Made.	Parts per million.	Hypothetical Combinations.	Parts per million.	Grains per gallon.
Iron Fe	0.8	Potassium Nitrate KNO_3	2.0	.12
Silica SiO	17.1	Sodium Chloride NaCl	4.1	.24
Alumina Al_2O_3	2.3	Sodium Sulfate Na_2SO_4	15.1	.88
Calcium Ca	84.5	Ammonium Sulfate $(NH_4)_2SO_4$	0.4	.02
Magnesium Mg	37.1	Magnesium Sulfate $MgSO_4$	4.8	.28
Sodium Na	6.5	Magnesium Carbonate $MgCO_3$	125.0	7.29
Potassium K	0.8	Calcium Carbonate $CaCO_3$	210.9	12.30
Ammonia NH_4	0.1	Iron Carbonate $FeCO_3$	1.7	.10
Sulfate SO_4	14.3	Alumina Al_2O_4	2.3	.13
Nitrate NO_3	1.2	Silica SiO_2	17.1	1.00
Chloride Cl	2.5			
		Total	383.4	22.36

Wells were drilled in the valley of Mauvaise Terre Creek near the northern limits of the city about 1910. From 1913 until 1921 a considerable part of the public supply was drawn from these wells and other wells drilled nearby. Water was secured from sand and gravel at depths of from 58 to 74 feet. In May, 1917, when the wells were pumped continuously the yield of five wells then in use was a little less than 500,000 gallons a day and the water level in a test well was 50 feet below the ground surface. The wells and test well were in an area of approximately 430 feet by 30 feet. Other test wells were drilled nearby and some were put in regular service for a time. In a test well three-quarters of a mile to the east no sand or gravel was encountered to a depth

of 90 feet. Wells had been drilled about three-quarters of a mile to the southeast to a depth of 125 feet. They penetrated quick sand and had been abandoned. Many years ago the Chicago, Burlington and Quincy Railroad had used water from a well in the creek valley about a third of a mile northwest of the location of the city wells. This well was dug to a depth of 25 feet and drilled holes extended from the bottom of the dug well to a depth of 50 feet or more from the ground surface. Water was pumped from the dug part of the well. In 1917, when pumping the city wells, the water level in this railroad well was 4 feet below the bottom of the dug well, about 25 feet below the ground surface at the city wells. It was concluded that the supply available from this sand and gravel stratum in the immediate vicinity of the city wells was approximately one half million gallons a day.

Water from these city wells in the creek valley differed slightly in quality. In all the samples of water collected from these wells in 1917 the mineral content was from 390 to 580, the hardness from 335 to 485, and the content of iron from 2 to 3 parts per million.

One test well was drilled near the city wells to a depth of 170 feet. A lower stratum of water bearing sand was encountered between depths of 140 to 146 feet. This water, sample number 38335, had a mineral content of 935, a total hardness of 232, and a content of iron of 3.0 parts per million.

JERSEYVILLE (3839). Jerseyville is located in the central part of Jersey County on the drainage areas of Macoupin and Otter Creeks, tributaries of Illinois River. Many private dug wells from 12 to 45 feet deep are in use.

A public water supply was installed by the city in 1889. Water was secured from a deep-well and later another well was drilled. The wells have been abandoned and the supply is now from springs located about six miles distant from the city. Water from the springs flows into a reservoir which is 41 feet in diameter and 15 feet deep. From the reservoir water is pumped through a 10-inch pipe line to the city by either of two Worthington 9 by 10-inch triplex pumps. Each pump is driven by a 50-horsepower oil engine. Part of the water pumped during the day time is discharged into a reservoir 60 feet in diameter, located in the city, a reservoir into which water pumped from wells was formerly discharged. Water is pumped from this reservoir into the distribution system during the night by a Worthington 7 by 10-inch triplex pump which is

driven by a 25-horsepower electric motor. A standpipe is connected to the distribution system in the city.

About 300 service connections were in use in January, 1925. Several industrial Plants secure water from private wells.

A well which furnished all water for the public supply for eight years was drilled in 1888 by the J. P. Miller Artesian Well Company of Chicago. The well was 2003 feet deep. It was later plugged at a depth of 894 feet. In 1912 forty pounds of dynamite was exploded at a depth of 750 feet and 60 pounds was exploded at a depth of 560 feet. The well was then cleaned to a depth of 750 feet and equipped with an air lift with 500 feet of 1-inch air pipe. The yield was said to be 100 gallons a minute. Later the well was abandoned.

A well was drilled for the city in 1895-1896 by J. A. Johnson and Charles Johnson. It was 1468 feet deep and was deepened in 1896 to 1542 feet. This well furnished a large part of the public water supply until 1923 when it was abandoned. The top of the well is 640 feet above sea level. A record of material penetrated as furnished by the city is as follows:

Stratum.	Thickness in feet.	Depth in feet.
Soil, clay and traces of gravel	26	26
Black slate	74	100
Lime and flint rock	16	116
Slate	24	140
Limestone	5	145
Slate	23	168
Lime	12	180
Slate	27	207
Lime	10	217
Slate	4	221
Lime	229	450
Blue flint	30	480
Lime	50	530
Slate	25	555
Lime	10	565
Slate	10	575
Limestone (very hard)	65	640
Slate	10	650
Lime and flint	160	810
Slate	80	890
Grey limestone	50	940
Shale	35	975
Lime	65	1040
Lime (contains salt)	40	1080
Limestone	235	1315
Limestone with mud seams	35	1350
Limestone and St. Peter sandstone	12	1362
St. Peter sandstone	106	1468

A note on the record states there were indications of a mud seam a depth of 1425 feet.

The upper 896 feet was cased with 10-inch wrought iron pipe weighing 40 pounds per foot and 8-inch wrought iron pipe was placed from the 10-inch pipe to a depth of 5 feet into St. Peter sandstone. A seed bag packer was placed at the first coupling above the lower end of the 8-inch pipe. Below a depth of 1367 feet the well was 8 inches in diameter. The natural head of water when the well was 600 to 800 feet deep was 25 feet below the ground surface. When cased to 896 feet it was necessary to add water for drilling until a depth of 1040 feet was reached when salt water was encountered. The amount of water below that depth remained about constant until St. Peter sandstone was reached. When the well was drilled to a depth of 1468 feet and cased to a depth of 896 feet it was pumped for eight hours at a rate of 90 gallons a minute with the pump cylinder at a depth of 220 feet. It was estimated that 40 gallons a minute of this total was from above the St. Peter sandstone. The water level was drawn down to the pump cylinder. The 8-inch casing was then placed, 88 pounds of dynamite was exploded in the lower part of the well, and the well was cleaned with a sand bucket. The water level was originally 117 feet below the ground surface.

In 1912 the well was recased and a packer was placed to exclude water from above the St. Peter sandstone. Before repairs the maximum yield was said to be 100,000 gallons a day and after repairs the yield was given as 150 gallons a minute, a rate of 220,000 gallons a day. Additional information was secured in 1921. The well was equipped with an air lift with 600 feet of 2-inch air line. When in good condition the discharge was said to be 178 gallons a minute. At the time of visit the air line leaked. The air lift was operating 20 to 22 hours a day and the amount of water pumped was estimated at 150,000 gallons a day.

Water from this well had a mineral content of 3012, a total hardness of 472, and a content of iron of 0.1 parts per million as shown by the analysis of sample number 46513, collected on November 3, 1921.

A sample collected from this well in 1898 contained less sodium and less chloride. It had a mineral content of 2506, a total hardness of 478, and a content of iron of 1.2 parts per million.

Many persons used water from cisterns and dug wells in preference to water from the city supply from deep wells. Meters were not used on account of the action of the water. Scale was removed from valve parts on the distribution system about every five months. Lead service pipes were used to the stop cocks. In 1921 one gal-

vanized iron main had been in use for nine or ten years. At the pumping station a feed water heater and the boilers then in use were cleaned once a week.

Analysis of Sample Number 46513 from City Well.

Determinations Made.

	Parts per million.
Iron Fe	0.1
Manganese Mn	0.0
Silica SiO_2	10.5
Nonvolatile	2.0
Alumina Al_2O_3	10.3
Calcium Ca	106.1
Magnesium Mg	50.7
Ammonium NH_4	1.5
Potassium K	77.2
Sodium Na	887.4
Sulfate SO_4	394.8
Nitrate NO_3	0.5
Chloride Cl	1347.0
Alkalinity	
Phenolphthalein	0
Methyl Orange	240.
Residue	3099.

Hypothetical Combinations.

	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	8.0	.47
Potassium Chloride KCl	146.8	8.58
Sodium Chloride NaCl	2105.0	123.10
Sodium Sulfate Na_2SO_4	183.1	10.71
Ammonium Sulfate $(NH_4)_2SO_4$	5.6	.33
Magnesium Sulfate $MgSO_4$	250.4	14.64
Calcium Sulfate $CaSO_4$	94.5	5.53
Calcium Carbonate $CaCO_3$	195.6	11.41
Silica SiO_2	10.5	.61
Nonvolatile	2.0	.12
Iron Oxide Fe_2O_3	0.2	.01
Alumina Al_2O_3	10.3	.60
Total	3012.0	176.11

Some information in regard to the water secured from three private wells in the city from strata above St. Peter sandstone is available. One well is 630 feet deep. It is cased with 8-inch pipe to a depth of 300 feet and to a slightly greater depth with 6-inch pipe. It is equipped with an air lift with 530 feet of air line. At times when the other two wells were not in use in 1921 it yielded 14,000 gallons in 8 hours. The other two wells, 160 feet and 430 feet distant from this well, are similar. Pumping from two wells at the same time greatly reduced the yield per well. When not pumping water stood at a depth of 150 feet. The water was used for industrial purposes in preference to the city supply from deep wells.

In 1923 the city developed a supply from springs located in the northeast quarter of the southeast quarter of section 4, Otter Creek Township, about six miles south and west from the city. The flow of three of the springs, called number 1, number 2, and number 3, was given by engineers as 110,000 gallons, 180,000 gallons, and 180,000 gallons a day respectively on July 15, 1921. Springs number one, or Stamp Spring, and number two, or Humiston Spring, were developed. Water flows to a reservoir 41 feet in diameter built around spring number one. Water is pumped from the reservoir at a rate of about 330 gallons a minute and at all times the water level in the reservoir is above the bottom of an overflow pipe and some water is flowing to waste. Opposite these

springs above the entrance of water overflowing from the reservoir, a small stream into which water from the springs formerly discharged is now dry during part of the time.

Water from the spring supply had a mineral content of 363 and a total hardness of 302 as shown by the analysis of sample number 51409, collected from the reservoir at the springs on May 6, 1924.

Analysis of Sample Number 51409 From City Springs.

Determinations Made.

	Parts per million.
Iron Fe	0.0
Manganese Mn	0.0
Silica SiO_2	15.3
Nonvolatile	5.0
Alumina Al_2O_3	0.0
Calcium Ca	86.7
Magnesium Mg	20.7
Ammonium NH_4	0.0
Potassium K	5.2
Sodium Na	10.6
Sulfate SO_4	19.9
Nitrate NO_3	23.9
Chloride Cl	6.0
Alkalinity	
Phenolphthalein	0
Methyl Orange	280.
Residue	355.

Hypothetical Combinations.

	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	13.4	.78
Sodium Nitrate $NaNO_3$	21.4	1.25
Sodium Chloride NaCl	9.9	.58
Sodium Sulfate Na_2SO_4	2.9	.17
Magnesium Sulfate $MgSO_4$	22.5	1.31
Magnesium Carbonate $MgCO_3$	56.2	3.28
Calcium Carbonate $CaCO_3$	216.4	12.64
Silica SiO_2	15.3	.89
Nonvolatile	5.0	.29
Total	363.0	21.19

JOLIET (38442). Joliet is located in the northwestern part of Will County on the banks of Des Plaines River. Rock is encountered in the city at a depth of a few feet. Many private wells enter rock. Some as shallow as 25 feet are in use.

A public water supply was installed by a private company in 1884 and was purchased by the city in 1888. Considerable data was secured from A .S. Calkins, City Engineer, and from a report of tests made in 1922 by F. G. Crockett. Water was first secured from wells into sand and gravel north of Washington Street near the eastern limits of the city. Later wells were drilled into rock and at times water has been taken from Hickory Creek and from a stone quarry nearby. Twelve wells into rock were in use in 1923. Water from four of these wells located close to the original wells, near the eastern limits of the city, is discharged into one of two collecting reservoirs from which it is pumped into the mains. The combined capacity of the reservoirs is 4,800,000 gallons. Water is pumped from the reservoirs into the mains by four Goulds single-stage centrifugal pumps driven by electric motors. Water can also

be drawn direct from wells into sand and gravel. (Out of service in 1925.) The other wells into rock are at a considerable distance from the main station or old station. Water is pumped from each well directly into the mains or into a small reservoir near the top of the well from which it is pumped into the mains. All equipment is electrically operated.

About seven thousand service connections were in use in 1925 of which one thousand were outside the city limits. At times the consumption was as much as 4,000,000 gallons a day which was near the total capacity of the supply works. The installation of additional wells was started in 1924. The rate for water inside the city limits in 1923 were 40 cents per 100 cubic feet for the first 3000 cubic feet, 35 cents per 100 cubic feet for the next 3000 cubic feet, with further reductions to 15 cents per 100 cubic feet for water in excess of 60,000 cubic feet. The minimum charge for three months was $3.00. Many industries in and near the city have private water supplies.

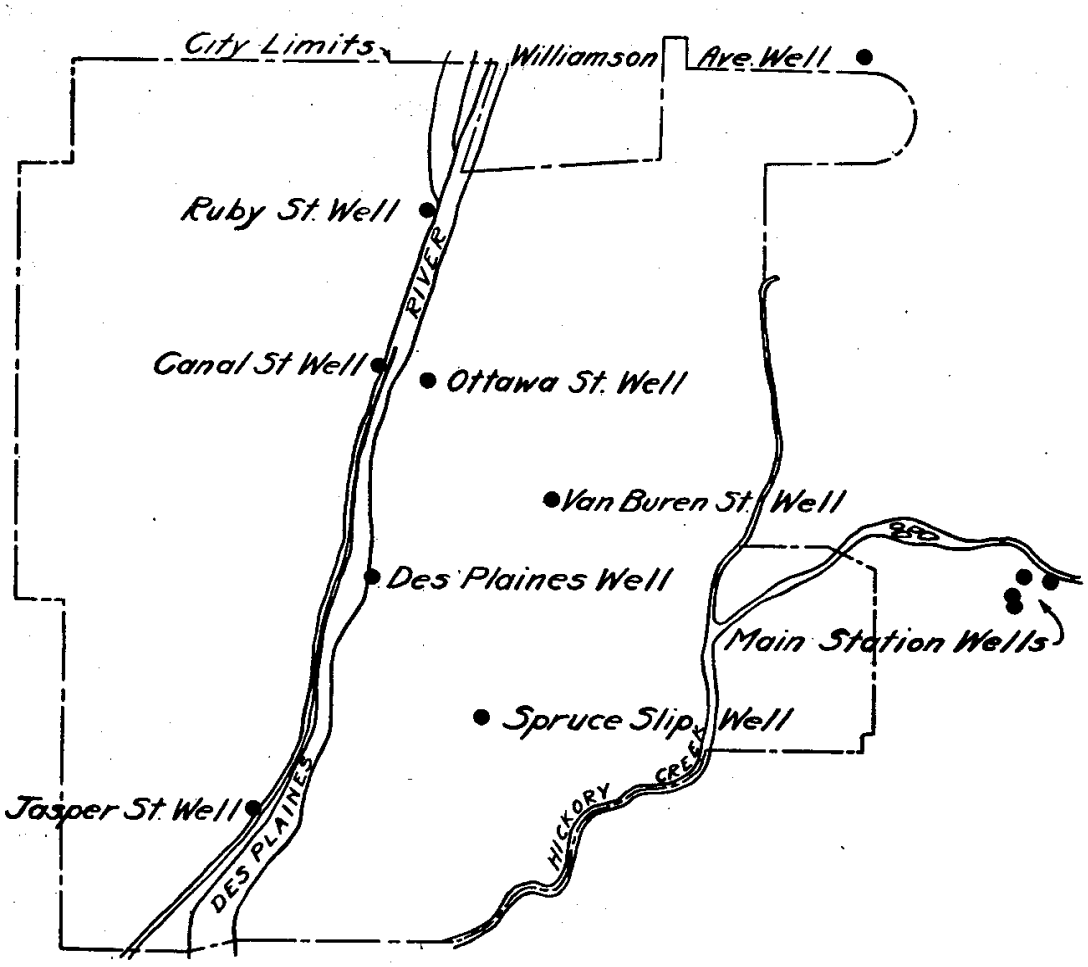
The original wells, located at what is known as the Washington Street Station near the eastern limits of the city, were 6 inches in diameter and 40 feet deep in drift. Water was drawn from the wells by suction. In 1913 the capacity of 20 wells was estimated at 1,250,000 gallons a day. A few of these wells, or drift wells replacing the original wells, can be used now but water is seldom drawn from this source. (Not in use in 1925.)

The source of supply in 1923, excepting a small amount from the drift wells, was ten wells into Cambrian sandstone. The location of the wells is shown on the map on the following page. A record of material penetrated by one of these wells is as follows:

	Thickness in feet.	Depth in feet.
Sand and gravel	3½	3½
Dolomite, Silurian system, all or chiefly Niagaran	226½	230
Shale, Richmond	90	320
Dolomite, Galena-Platteville	300	620
Sandstone, St. Peter	200	820
Dolomite, Prairie du Chien	435	1255
Sandstone, Prairie du Chien	25	1280
Dolomite, Prairie du Chien	50	1330
Sandstone, Mazomanie-Dresbach Cambrian system	240	1570

A complete record of this well and other of the wells is on file with the State Geological Survey Division.

The first rock wells were drilled near the drift wells at the Washington Street Station. A record prepared in 1900 gave well numbers, size of casings, and depths as follows: Number 1, 8 inches, 1700 feet; number 2, 6 inches, 1600 feet; number 3, 4 inches,



LOCATION OF WELLS OF THE CITY OF JOLIET

1600 feet; number 4, 8 inches, 1600 feet; number 5, 8 inches, 1700 feet; and number 6, 6 inches, 1200 feet. (The J. P. Miller Artesian Well Company gave the depth of two of the wells drilled by their company as 1196 feet and 1203 feet). The depth of casing in each well was given as 400 feet, the depth to water when not pumping 40 feet, and the depth to water when pumping 80 feet. The wells were equipped with air lifts. The air lines were 2½-inch in wells number 1 and 4, two inch in well number 5, and 1½-inch in the other wells. The length of air lines was from 210 to 225 feet excepting in well number 2 for which the length was given as 150 feet. A test of yield of these six wells was made by D. W. Mead on April 26-27, 1900. Well number 1 when pumped alone yielded 425 gallons a minute and "the average distance below the floor of the station from which water was raised" was 85 feet. Wells 1 and 2 yielded 608 gallons a minute and water was raised 107 feet. Pumping more wells did not lower the water level, due undoubtedly in large part to a smaller quantity of air being supplied to each well.

Pumping from all six wells the yield was 979 gallons a minute and the average depth from which water was raised was 81½ feet. In 1923 air lines of 2½-inch pipe extended to depths of from 425 to 509 feet in wells 1, 4, 5, and 6, the wells then in use, and the total discharge was estimated at 300 gallons a minute.

In 1907 a well was drilled near the center of Ottawa and Crowley Streets to a depth of 1621 feet. It is cased with 16-inch outside diameter pipe to a depth of 198 feet and with 8-inch pipe between depths of 924.5 and 997 feet. The bottom 312 feet is 7 inches in diameter. The well is equipped with an air lift. The discharge in 1907 was about 1, 225,000 gallons a day. In 1913, with 346 feet of 2½-inch air pipe, the discharge was 1,000,000 gallons a day. In 1922, with 435 feet of air pipe and 8-inch discharge pipe, and with the compressor operating at a displacement of 651 cubic feet per minute, the discharge was 546 gallons a minute. The water level, computed from air pressures, was lowered from a depth of 180 feet to a depth of 246 feet.

In 1911 a well was drilled at the corner of Canal and Division Streets near the west bank of the Illinois and Michigan Canal. The well is 16 inches in diameter at the top, 8 inches in diameter at the bottom, and 1575 feet deep. A small quantity of oil was encountered at a depth of 220 feet. The well was cased with 14-inch pipe to a depth of 318 feet and with 10 5/8-inch pipe to a depth of 893 feet. The space around the inner casing was filled with concrete but the taste of oil was not eliminated and an aerator was installed. The well was equipped with an air lift and in 1913 the yield was about 800,000 gallons a day. In 1922 with a Harris air pump attached to a 2½-inch air line at a depth of 450 feet, with 398 cubic feet of free air per minute, the discharge was 292 gallons a minute and the water level, computed from air pressures, was lowered 129 feet to a depth of 289 feet.

A well known as the Spruce Slip well was drilled in 1912 east of Chicago Street and north of Third Avenue. The well is 1565 feet deep. It is cased with 14-inch pipe to a depth of 320 feet and is 10 inches in diameter at the bottom. After completion water stood 36 feet below the ground surface. The well was pumped at a rate of 577,000 gallons a day and the water level was lowered to a depth of 142 feet. In 1922, during tests, the discharge was 184 gallons a minute but the equipment was evidently not in good condition. The well was not in use at the time of visit in 1923.

A well was drilled at the corner of Des Plaines and La Fayette Streets near the east bank of the river in 1913. The well is 1575

feet deep. It is cased to a depth of 300 feet with 14-inch pipe, between depths of 600 and 824 feet, and between depths of about 1200 and 1300 feet with 7-inch and 5 7/8-inch pipe. When completed the water level was 64 feet below the ground surface when not pumping and was lowered to a depth of 180 feet when pumping at a rate of 650,000 gallons a day. In 1922 with a Harris air pump at a depth of 448 feet, with 2½-inch air line, with 504 cubic feet of free air per minute, the discharge was 305 gallons a minute and the water level, as determined by air pressures, was lowered 89 feet to a depth of 278 feet.

A well was drilled on Van Buren Street, west of Eastern Avenue in 1913. The well is 1547 feet deep. It is cased with 14-inch pipe to a depth of 328 feet and with 100 feet of 10-inch pipe at a depth of about 800 feet. The diameter at the bottom is 8 inches. When completed water stood 63 feet below the ground surface and was lowered to a depth of 240 feet when pumping at a rate of 650,000 gallons a day. During tests in 1922 with a Harris air pump at a depth of 690 feet attached to 2½-inch air pipe the discharge was 485 gallons a minute and the water level, computed from air pressures, was lowered to a depth of 418 feet. The equipment was not in good running order at the time of tests.

A well was drilled at the corner of Ruby and Canal Streets near the west bank of the canal in 1915. The well is 1564 feet deep. It is cased with 14-inch pipe to a depth of 303 feet and the bottom 1019 feet is 10 inches in diameter. At the time of completion the discharge was 1,500,000 gallons a day. In 1922, equipped with a Harris air pump attached to a 2½-inch air line at a depth of 507 feet, with 650 cubic feet of free air a minute the discharge was 532 gallons a minute. The air line or discharge line leaked at the time of test.

A well in Jasper Street close to the west bank of the Illinois and Michigan Canal was drilled by William Cater in 1924. The well is 22 inches in diameter at the bottom and 1565 feet deep. It is cased to a depth of 341 feet and no casing is placed below that depth. This is the only deep city well that does not have some casing in the lower part. The well was equipped with a turbine pump and the discharge at the ground surface was 1,800,000 gallons a day. The well was pumped continuously for six weeks and the water level was lowered from a depth of 165 feet to a depth of about 265 feet below the ground surface.

A well was drilled in 1924 in the northeastern part of the city at the corner of Williamson and Charlsworth Avenues. The well

is 12 inches in diameter at the bottom and 1595 feet deep. Sixty feet of liner was placed at a depth of about 1165 feet.

Water from the Van Buren Street well had a mineral content of 537 and a total hardness of 238 parts per million and contained no iron, as shown by the analysis of sample number 39358, collected on April 24, 1918.

Analysis of Sample Number 39358 from the Van Buren Street Well.

Determinations Made.

	Parts per million.
Iron Fe	0.0
Manganese Mn	0.0
Silica SiO_2	13.9
Alumina Al_2O_3	1.2
Calcium Ca	58.0
Magnesium Mg	22.7
Ammonia NH	0.7
Sodium Na	92.3
Potassium K	16.9
Sulfate SO_4	109.0
Nitrate NO_3	0.7
Chloride Cl	43.0
Nonvolatile	2.5
Alkalinity	
Methyl Orange	264.
Residue	515.

Hypothetical Combinations.

	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	1.1	.06
Potassium Chloride KCl	31.9	1.86
Sodium Chloride NaCl	46.2	2.69
Sodium Sulfate Na_2SO_4	161.1	9.40
Sodium Carbonate Na_2CO_3	54.7	3.19
Ammonium Carbonate $(NH_4)_2CO_3$	1.9	.11
Magnesium Carbonate $MgCO_3$	78.7	4.59
Calcium Carbonate $CaCO_3$	144.7	8.44
Alumina Al_2O_3	1.2	.07
Silica SiO_2	13.9	.81
Nonvolatile	2.5	.15
Total	537.9	31.37

Some samples collected show a content of iron of from 0.1 to 0.4 parts per million. The quality of water from the Canal Street well which has a strong taste and odor was not improved by casing the well or by long continued pumping. The water is now aerated by passing over a cascade of four steps built of concrete.

Water from a well 880 feet deep into St. Peter sandstone at the High School had a mineral content of 547, a total hardness of 210, and a content of iron of 0.2 parts per million. The rate of pumping this well in 1923 was estimated at 30 gallons a minute.

Many wells into Niagaran and Galena-Platteville limestones are in use in the city. Analyses of waters from these wells differ considerably. In general water from the Niagaran limestone is much harder than the city supply. One sample had a hardness of more than 2,000 parts per million but this does not represent average conditions. A sample from another well had a hardness of 560 parts per million.

JONESBORO (1090). Jonesboro is located in the central part of Union County on the drainage area of Mississippi River. The city purchased a well formerly used at a light plant and planned to install a public water supply in 1924. The top of the well is

about 515 feet above sea level. Mr. Baker who was present when the first well was drilled states that it was in clay to a depth of about 28 feet and in limestone between depths of 28 and 233 feet and that the drill dropped 34 feet from a depth of 233 feet and drilling was then discontinued. The well is 4 feet in diameter to a depth of 28 feet and is cased with 6-inch pipe to a depth of about 200 feet. In 1921 water was pumped with a deep-well pump for 120 hours and the average yield was 30 gallons a minute. The water level on July 22, 1924, was 10 feet below the top of the well.

JOY (529). Joy is located in the western part of Mercer County on the drainage area of Edwards River, a tributary of Mississippi River. A public water supply was installed by the village in 1922-1923. Water is pumped from a well into the distribution system and an elevated steel tank connected to the system by a deep-well pump which is driven by a 15-horsepower electric motor. Electric current is supplied by the Illinois Public Service Company. Fifty-four service connections were installed before March, 1924. The meter rate for water is 60 cents per 1000 gallons with a minimum charge of 60 cents a month. Bills are subject to a ten per cent discount for prompt payment.

Water for the public supply is secured from a well 332 feet deep located east of Federal Street and south of Main Streets. The top of the well is about 690 feet above sea level. The well is cased into rock with 80 feet of 8-inch pipe.

Analysis of Sample Number 51209 from the Village Supply.

Determinations Made.

	Parts per million.
Iron Fe	1.6
Manganese Mn	0.0
Silica SiO_2	9.2
Nonvolatile	1.3
Alumina Al_2O_3	1.0
Calcium Ca	36.4
Magnesium Mg	19.4
Ammonia NH_4	2.3
Sodium Na	129.3
Potassium K	13.0
Sulfate SO_4	84.8
Nitrate NO_3	3.9
Chloride Cl	47.0
Alkalinity Methyl Orange	340.
Residue	610.

Hypothetical Combinations.

	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	63.6	3.72
Potassium Chloride KCl	20.1	1.17
Sodium Chloride NaCl	61.6	3.60
Sodium Sulfate Na_2SO_4	125.2	7.31
Sodium Carbonate Na_2CO_3	148.7	8.68
Ammonium Carbonate $(NH_4)_2CO_3$	6.0	.35
Magnesium Carbonate $MgCO_3$	67.2	3.92
Calcium Carbonate $CaCO_3$	90.9	5.31
Iron Oxide Fe_2O_3	2.3	.13
Alumina Al_2O_3	1.0	.06
Silica SiO_2	9.2	.54
Nonvolatile	1.3	.08
Total	597.1	34.87

The well is equipped with a Cook double-acting deep-well pump with a 5¾-inch cylinder attached to 225 feet of 6-inch drop pipe. There is no suction pipe below the cylinder. The pump is operated with an 18-inch stroke at 25 revolutions a minute. The water level is drawn down to the pump cylinder after the pump is operated a few minutes. In December, 1922, the elevated tank of 48,000 gallons capacity was filled in 12½ hours, a rate of a little over 64 gallons a minute. In March, 1924, the pump was operated continuously for about two hours every day.

The water had a mineral content of 597, a total hardness of 170, and a content of iron of 1.6 parts per million as shown by the analysis of sample number 51209, collected on April 3, 1924, after pumping for thirty minutes.

KANSAS (944). Kansas is located in the southwestern part of Edgar County on the drainage area of Embarrass River, a tributary of Wabash River. Some private wells in the village are into sand and gravel at a depth of from 20 to 40 feet.

A public water supply was installed by the village in 1914-1915. Water is pumped from a well into the distribution system by a deep-well pump which is driven by a 7½-horsepower electric motor. A 50,000-gallon steel tank on a tower 90 feet high is connected to the system. Electric power is supplied by the Central Illinois Public Service Company. Fifty service connections were in use at the time of visit in January, 1918. The water consumption recorded by meters on service connections during the last four months of 1917 averaged 7,300 gallons a day.

Water is secured from a well drilled in 1914 in the southern part of the village. The well is 10 inches in diameter and 80 feet deep and the lower part is in sand and gravel. When drilled it was tested for 48 hours. The rate of pumping during the greater part of the test was 55 gallons a minute. When the discharge was increased to 75 gallons a minute large quantities of sand were discharged. The well is equipped with a Luitwieler deep-well pump with 5¾-inch cylinder and 12-inch stroke. The cylinder is placed at a depth of 64 feet. At the time of visit in 1918 the pump speed was 38 revolutions a minute and the discharge, as recorded by meter, was 47 gallons a minute.

The water had a mineral content. of 413, a total hardness of 340, and a content of iron of 3.0 parts per million as shown by the analysis of sample number 38810, collected on January 8, 1918.

Analysis of Sample Number 38810 from the Village Supply.

Determinations Made.	Parts per million.
Iron Fe	3.0
Manganese Mn	0.0
Silica SiO_2	25.5
Alumina Al_2O_3	0.2
Calcium Ca	81.9
Magnesium Mg	33.2
Ammonia NH	8.2
Sodium Na	15.7
Potassium K	0.8
Sulfate SO_4	2.2
Nitrate NO_3	0.7
Chloride Cl	6.0
Alkalinity Methyl Orange	368.
Residue	450.

Hypothetical Combinations.	Parts per million.	Grains. per gallon.
Potassium Nitrate KNO_3	1.1	0.06
Potassium Chloride KCl	0.7	0.04
Sodium Chloride NaCl	9.4	0.55
Sodium Sulfate Na_2SO_4	3.3	0.19
Sodium Carbonate Na_2CO_3	25.3	1.48
Ammonium Carbonate $(NH_4)_2CO_3$	21.9	1.28
Magnesium Carbonate $MgCO_3$	115.1	6.71
Calcium Carbonate $CaCO_3$	204.6	11.93
Iron Carbonate $FeCO_3$	6.2	0.36
Alumina Al_2O_3	0.5	0.03
Silica SiO_2	25.5	1.49
Total	413.6	24.12

KEITHSBURG (1148). Keithsburg is located in the southwestern part of Mercer County on the east bank of Mississippi River. A public water supply was installed by the city in 1893. Water was drawn from wells by suction and discharged into the distribution system to which a standpipe 10 feet in diameter and 85 feet high was connected. Some years later a contract was made with the Ridgeway Electric Light and Power Company to supply water from their wells which were similar to the city wells. In 1918 the city built a new pumping station on Second Street near Washington Street close to their wells and installed new equipment and since that time water has been supplied from seven of the wells. Each well has a 6-inch casing about 27 feet long and a Cook screen about 8 feet long. The screens were recut at the factory in 1918. The wells are in sand and gravel deposits in an area 120 feet long within 75 feet of Mississippi River. All are at or close to the intersection of Washington and Second Streets. Water is pumped from the wells by a Platt Iron Works 9 by 10-inch single-acting triplex pump driven at a speed of 58 revolutions per minute, a displacement of 480 gallons a minute, by a 25-horsepower electric motor. A duplex steam pump and a boiler are installed for use in case of emergency. The pumps are in a pit, the bottom of which is from 530 to 535 feet above sea level and at the time of visit was about 10 feet above the water level in the river. The discharge of the triplex pump probably varies with the change in water level. It is said to pound at times of low water and the electric motor is overloaded at times of high water.

The quality of the water varies somewhat from time to time. One sample had a mineral content of 1195, a total hardness of 690, and a content of iron of 0.3 parts per million. A sample, number 48957, collected on January 11, 1923, had a mineral content of 950 and a total hardness of 535 parts per million and contained no iron as shown by the analysis.

Analysis of Sample Number 48957 from the City Supply.

Determinations Made.

	Parts per million.
Iron Fe	0.0
Manganese Mn	0.3
Silica SiO_2	28.0
Nonvolatile	2.4
Alumina Al_2O_3	0.6
Calcium Ca	145.6
Magnesium Mg	41.8
Ammonia NH_4	0.6
Sodium Na	86.9
Potassium K	35.5
Sulfate SO_4	213.3
Nitrate NO_3	88.6
Chloride Cl	135.0
Alkalinity Methyl Orange	288.0
Residue	947.

Hypothetical Combinations.

	Parts per million.	Grains. per gallon.
Potassium Nitrate KNO_3	91.7	5.36
Sodium Nitrate $NaNO_3$	44.0	2.57
Sodium Chloride NaCl	190.5	11.13
Ammonium Chloride NH_4Cl	1.8	.11
Magnesium Chloride $MgCl_2$	24.4	1.43
Magnesium Sulfate $MgSO_4$	175.5	10.25
Calcium Sulfate $CaSO_4$	103.7	6.05
Calcium Carbonate $CaCO_2$	287.6	16.78
Silica SiO_2	28.0	1.64
Nonvolatile	2.4	.14
Alumina Al_2O_3	0.6	.04
Total	950.2	55.50

KEMPTON (266). Kempton is located in the northern part of Ford County on the drainage area of Vermilion River, a tributary of Illinois River. A limited public water supply was installed by the village in 1894, using water from a well as the source of supply. The original well was abandoned about 1909. The plant has been extended from time to time and in 1925 one hundred and fifteen service connections were reported in use.

Water is pumped from a well into two steel pressure tanks and the distribution system by a deep-well pump which is driven by an electric motor. A gas engine, formerly in regular service, can be used in emergency. The tanks are each eight feet in diameter and twenty feet long. One tank is maintained under 60 pounds pressure for use in case of fire and the other tank is in requlr service. A concrete reservoir in the rear of the station can be filled with water from the well and is maintained full of water for use in emergency. Water is pumped from this reservoir into the mains when needed by a Fairbanks-Morse 7 by 10-inch horizontal duplex pump.

One hundred and one service connections were in use in 1923. The rate for water is 60 cents per 1000 gallons with a minimum

charge of $2.00 for three months use. Bills are not subject to cash discount.

Water is secured from a well 8 inches in diameter and 404 feet deep. The well penetrated soil, clay, hardpan, blue clay, and, at a depth of about 230 feet, ten feet of sand and gravel. Below the sand and gravel are two layers of coal and soapstone above rock which was entered at a depth of about 285 feet. The well is equipped with a deep-well pump. After pumping for a short time air is drawn into the pump cylinder. In 1916 the cylinder was thought to be at a depth of 318 feet and the capacity was estimated at 8 gallons a minute. The pump was operated an average of 10 hours a day in the summer. In 1923 the depth to the pump cylinder was given as 220 feet. The yield, determined approximately from measurements of water levels in the pressure tank, was ten gallons a minute when starting to pump and 5 gallons a minute after long continued pumping.

The water had a mineral content of 809, a total hardness of 26, and a content of iron of 0.2 parts per million as shown by the analysis of sample number 50541, collected on November 14, 1924.

Analysis of Sample Number 50541 from the Village Supply.

Determinations Made.	Parts per million.
Iron Fe	0.2
Manganese Mn	0.0
Silica SiO_2	13.8
Nonvolatile	1.7
Alumina Al_2O_3	1.4
Calcium Ca	6.6
Magnesium Mg	2.3
Ammonia NH_4	0.4
Sodium Na	309.3
Potassium K	26.4
Sulfate SO_4	0.6
Nitrate NO_3	0.0
Chloride Cl	43.0
Alkalinity Methyl Orange	678.0
Residue	825.

Hypothetical Combinations.	Parts per million.	Grains. per gallon.
Potassium Chloride KCl	50.3	2.94
Sodium Chloride NaCl	31.4	1.83
Sodium Sulfate Na_2SO_4	0.9	0.05
Sodium Carbonate Na_2CO_3	683.7	39.93
Ammonium Carbonate $(NH_4)_2CO_3$	1.1	0.06
Magnesium Carbonate $MgCO_3$	8.0	0.47
Calcium Carbonate $CaCo_3$	16.4	0.96
Iron Oxide Fe_2O_3	0.3	0.02
Alumina Al_2O_3	1.4	0.08
Silica SiO_2	13.8	0.80
Nonvolatile	1.7	0.10
Total	809.0	47.24

A sample collected in 1916 was similar.

KEWANEE (16,026). Kewanee is located in the southeastern part of Henry County on the water shed between tributaries of Illinois River and Mississippi River. Wells at private residences are generally from 30 to 50 feet deep but some are shallower and some wells are more than 100 feet deep. Many wells more than 1000 feet deep are in use at industrial plants.

A public water supply was installed by the city about 1884. Water was obtained from a well into sand and gravel. The yield was small in long continued dry weather.

Water is now secured from a well into Cambrian sandstone. The well is equipped with an air lift. Air is supplied by a Sullivan compressor with 16 and 28-inch steam cylinders, 14½ and 24-inch air cylinders and 24-inch stroke. Water is discharged into a reservoir of 500,000 gallons capacity. Water is pumped from the reservoir into the mains by a double-acting duplex pump with 10 and 20-inch steam cylinders, 8¾-inch water cylinders and 14-inch stroke. Steam is supplied by three 200-horsepower Kewanee boilers.

The water consumption in the summer of 1921 was near 500,000 gallons a day. The rate for the first 6000 cubic feet used in three months is $3.00 per 1000 cubic feet and the lowest rate, for quantities in excess of 60,000 cubic feet, is $1.50 per 1000 cubic feet. The minimum charge is $2.00. An additional charge is made for a meter. For a 5/8-inch meter it is 50 cents and for a ¾-inch meter it is 75 cents.

In 1897-1898 three wells were drilled near the north limits of the city. The depth of each was about 1460 feet and the bottom was in St. Peter sandstone. One report states that wells 1 and 3 were 6 inches in diameter and number 2 was 4 inches in diameter and that each well was cased to a depth of 700 feet. In 1898 just after the wells were drilled a sample was sent in and the well was said to be 1480 feet deep and cased to 1300 feet. The depth to water was given as 140 feet and the yield, with a pump at a depth of 300 feet, 50,000 gallons in a day of 12 hours. A fourth well, number 4, was drilled by the J. P. Miller Artesian Well Company in 1905-1906, and well number 3 was abandoned. In well number 4 a 10-inch galvanized casing extended from the ground surface to a depth of 500 feet and an 8-inch casing is said to have been placed from the 10-inch casing to a depth of 1003 feet. This well was 8 inches in diameter at the bottom and was 1426 feet deep. Sixteen and twelve inch casings outside the 10-inch casing extended to a depth of 300 feet. Shale was recorded between depths of 279 and 405 feet, limestone at 405 feet, another stratum of limestone at 1000 feet, and sandstone at 1345 feet. The city supply was from these wells until about 1913. Well number 4 was tested (in 1905?) for 30 hours. The yield was 150 gallons a minute and the water level was lowered from 246 feet below the ground surface to 494 feet below the ground surface. When wells 1, 2, and 4 were

operating the yield of number 4 was 142 gallons a minute. During the last years these wells were used about ten tons of sediment was removed from the reservoir every six months, due probably to leaks in the well casings.

The water had a mineral content of 1304, a total hardness of 266, and a content of iron of 1.2 parts per million as shown by the analysis of sample number 3390, collected on March 24, 1898.

Analysis of Sample Number 3390 From Wells Into St. Peter Sandstone.

Determinations Made.	Parts per million.
Iron Fe	1.2
Silica SiO_2	8.4
Calcium Ca	65.1
Magnesium Mg	25.3
Ammonia NH_4	1.9
Sodium Na	365.9
Potassium K	18.9
Sulfate SO_4	256.9
Nitrate NO_3	0.3
Chloride Cl	400.
Residue	1284.

Hypothetical Combinations.	Parts per million.	Grains. per gallon.
Potassium Nitrate KNO_3	5.4	.31
Potassium Chloride KCl	32.3	1.88
Sodium Chloride NaCl	633.9	36.97
Sodium Sulfate Na_2SO_4	360.9	21.05
Ammonium Sulfate $(NH_4)_2SO_4$	6.9	.40
Magnesium Sulfate $MgSO_4$	11.7	.68
Magnesium Carbonate $MgCO_3$	79.8	4.64
Calcium Carbonate $CaCO_3$	162.7	9.48
Iron Carbonate $FeCO_3$	2.5	.14
Silica SiO_2	8.4	.49
Total	1304.5	76.04

Two wells were drilled into St. Peter sandstone to a depth of 1464 feet in 1908. The wells are 30 feet apart on the east side of Tremont Street on the north side of the Chicago, Burlington and Quincy Railroad, at the water works plant now in use. These wells were placed in service and the wells in the north part of the city were abandoned in 1913. One well was cased to a depth of 35 feet with 15-inch pipe, from the ground surface to a depth of 294 feet with 12-inch pipe, between depths of 294 and 392 feet with 10-inch pipe, and between depths of 393 and 976 feet with 6-inch pipe. The well is 6 inches in diameter at the bottom. The other well was cased to a depth of 35 feet with 15-inch pipe, from the ground surface to a depth of 274 feet with a 12-inch pipe, between depths of 274 and 392 feet with 10-inch pipe, and between depths of 392 and 1001 feet with 6-inch pipe and was 6 inches in diameter at the bottom. C. A. Dunbar states that the static water level was at a depth of 270 feet, that the west well yielded 165 gallons a minute, and that the two wells pumped together yielded 210 gallons a minute of which 95 gallons a minute was from the east well. The water level was lowered to a depth of 400 feet. The rate of discharge was determined by measuring in a tub but the results are approximately correct. These wells were pumped on July 26,

1921, for 2 hours 20 minutes and the water level in the well into Cambrian sandstone, 32 feet distant from the nearer of these two wells, was lowered 1 foot 10 inches.

A well into Cambrian sandstone was drilled for the city by the Whitney Well Company in 1919. A record of material penetrated with part of the classification made by the State Geological Survey Division is as follows:

	Thickness in feet.	Depth in feet.
Clay, sand and till		60
Pennsylvania system	60	200
No samples	196	396
Limestone	384	780
No samples	10	790
Shale, Maquoketa	170	960
Limestone, Galena-Platteville	360	1320
Sandstone, St. Peter	65	1385
Limestone, shale and sand, Prairie du Chien	565	1950
Sandstone, Cambrian system	10	1960
Dolomite, Cambrian system	220	2180
Sandstone, Cambrian system	10	2190
Dolomite, Cambrian system	140	2330
Sandstone, Cambrian system	90	2420
Missing	77	2497

A complete record of material penetrated excepting the lower 77 feet and other parts where no samples were collected is on file with the State Geological Survey Division. The upper 500 feet of the well is cased with 16-inch pipe. Below this casing and joined to it by a swedge nipple is 506 feet of 14-inch pipe. Below the 14-inch pipe the well is 12 inches in diameter and is not cased. The well is equipped with an air lift with 600 feet of 3-inch air line and 6, 7, and 8-inch discharge line. In 1919 the depth to water when not pumping was 260 feet and the water level was said to have been lowered 21 feet when pumping 834 gallons a minute. During tests in June, 1920, and July, 1921, the yield was close to 744 gallons a minute. Before the latter test, when not pumping, the water level was 259½ feet below the top of the well casing (257½ feet below the ground surface). It was lowered to a depth of over 300 feet in 15 minutes and to a depth of 302.7 feet in 8 hours. Previous to the test the air lift had been operated daily and during the six days preceding had operated 13 hours a day.

A sample of water, number 45785, collected from this well on July 26, 1921, had a mineral content of 1309, a total hardness of 262, and a content of iron of 0.2 parts per million as shown by the analysis.

Analysis of Sample Number 45785 From Well 2497 Feet Deep.

Determinations Made.	Parts per million.
Iron Fe	0.2
Manganese Mn	0.0
Silica SiO_2	10.2
Nonvolatile	1.0
Alumina Al_2O_3	0.7
Calcium Ca	59.9
Magnesium Mg	27.5
Ammonia NH_4	1.3
Potassium K	18.9
Sodium Na	372.9
Sulfate SO_4	240.6
Nitrate NO_3	1.2
Chloride Cl	437.5
Alkalinity	
Phenolphthalein	0
Methyl Orange	264.0
Residue	1325.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	2.0	.12
Potassium Chloride KCl	34.5	2.02
Sodium Chloride NaCl	693.1	40.53
Sodium Sulfate Na_2SO_4	307.8	18.00
Ammonium Sulfate $(NH_4)_2SO_4$	4.7	.27
Magnesium Sulfate $MgSO_4$	36.2	2.12
Magnesium Carbonate $MgCO_3$	69.9	4.09
Calcium Carbonate $CaCO_3$	149.5	8.74
Silica SiO_2	10.2	.60
Nonvolatile	1.0	.06
Iron Oxide Fe_2O_3	0.3	.02
Alumina Al_2O_3	0.7	.04
Total	1309.9	76.61

Other samples analyzed were similar. The temperature of water discharged from the well is 71 degrees Fahrenheit. This water is used in three 200-horsepower boilers at the pumping station in which the pressure carried is 140 pounds. A hard scale is formed. Two boilers are used at a time and one is cleaned every three weeks. Water grates burned out every few months until they were replaced by solid grates. The same type of boiler with water grates is giving excellent service with other water.

The city mains are connected with mains in the plant of the Kewanee Boiler Company. Water can be supplied to the company or some water may be furnished the city from the boiler company's supply. The supply is from two wells 470 feet apart into Galena-Platteville limestone. Well number 1, drilled by the J. P. Miller Artesian Well Company in 1904, is 1073 feet deep. Galena-Platteville limestone was entered at a depth of 946 feet and the well is cased with 8 5/8-inch and 6-inch casing to a depth of 953 feet. A 12-inch outer casing extends to a depth of 89 feet. The well is 6 inches in diameter at the bottom. The hole was practically dry to a depth of 412 feet when water raised to 300 feet but the quantity of water was small. The main supply was entered below a depth of 1030 feet and water raised to 221 feet below the ground surface. On February 4, 1919, this well was shot between depths of 975 and 1025 feet with 160 quarts of nitro-glycerine and the casings were renewed. During a test in June 1921, the yield was 214 gallons a minute with 120 pounds air pressure.

Well number 2, drilled in 1918, is 1084 feet deep. Galena-Platteville limestone is entered at a depth of 950 feet. The well

is cased with 16-inch, 12-inch, and 10-inch pipe to a depth of 995 feet. A 20-inch outer casing extends to a depth of 36 feet. The well is 10 inches in diameter at the bottom. Water was encountered at depths of 455 feet and 980 feet. The well was shot in 1918 between depths of 970 and 995 feet with 100 quarts of nitroglycerine. The well was then cleaned out and drilled to a depth of 1110 feet. The yield after shooting was 225 gallons a minute. In June, 1921, with 662 feet of 2-inch air line, with 6-inch discharge line, and with 120 pounds pressure the yield was 199 gallons a minute. The water level was lowered from a depth of 282 feet to a depth of 425 feet in about one-half hour and to a depth of 430 feet after 6 hours. The yield of the two wells was 410 gallons a minute.

Water from these wells into Galena-Platteville limestone is of better quality than water secured from wells into St. Peter sandstone or the well into Cambrian sandstone. The water had a mineral content of 1064, a total hardness of 190, and a content of iron of 0.2 parts per million as shown by the analysis of sample number 45561, collected on June 30, 1921.

Analysis of Sample Number 45561 from Wells Into Galena-Platteville Limestone.

Determinations Made.	Parts per million.
Iron Fe	0.2
Manganese Mn	0.0
Silica SiO_2	13.0
Nonvolatile	0.8
Alumina Al_2O_3	3.1
Calcium Ca	42.5
Magnesium Mg	20.8
Ammonia NH_4	1.2
Potassium K	14.1
Sodium Na	307.4
Sulfate SO_4	239.2
Nitrate NO_3	1.6
Chloride Cl	273.8
Alkalinity	
Phenolphthalein	14.0
Methyl Orange	274.0
Residue	1083.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	2.6	.15
Potassium Chloride KCl	25.0	1.46
Sodium Chloride NaCl	431.8	25.25
Sodium Sulfate Na_2SO_4	353.5	20.66
Sodium Carbonate Na_2CO_3	53.5	3.13
Ammonium Carbonate $(NH_4)_2CO_3$	3.2	.18
Magnesium Carbonate $MgCO_3$	72.1	4.22
Calcium Carbonate $CaCO_3$	106.0	6.20
Silica SiO_2	13.0	.76
Nonvolatile	0.8	.05
Iron Oxide Fe_2O_3	0.3	.02
Alumina Al_2O_3	3.1	.18
Total	1064.9	62.26

Kewanee boilers with water grates exactly the same as were in use at the city plant were in use at the boiler plant. A pressure of 140 pounds was carried. Boilers were flushed out every nine weeks. In 1921 a boiler four years old with the original tubes in the water grate was in excellent condition.

Water can be supplied to the city from wells of the Walworth Manufacturing Company. The company had four wells in 1921, two into Galena-Platteville limestone and two into St. Peter sandstone. The depth to water in one of the wells into St. Peter sandstone was originally 235 feet and in 1921 it was 280 feet.

KINSMAN (167). Kinsman is located in the southwestern part of Grundy County on the drainage area of Waupecan Creek, a tributary of Illinois River. A public water supply was installed by the village about 1895 and extensive improvements were made about 1909. Water is secured from a well equipped with a deep-well pump which discharges water into a reservoir. The reservoir measures about 20 feet in diameter. A Deming 7 by 8-inch triplex pump pumps from the reservoir into the distribution system and a steel pressure tank connected to the system. A Fairbanks-Morse compressor is used to force air into the tank. Fifty-six service connections were in use in March, 1923, serving all but five residences in the village. Water is sold at flat rates.

Analysis of Sample Number 49184 from the Village Supply.

Determinations Made.	Parts per million.
Iron Fe	0.4
Manganese Mn	0.0
Silica SiO_2	7.2
Nonvolatile	1.8
Alumina Al_2O_3	.8
Calcium Ca	62.9
Magnesium Mg	35.8
Ammonia NH_4	1.1
Sodium Na	184.1
Potassium K	37.1
Sulfate SO_4	102.8
Nitrate NO_3	2.1
Chloride Cl	240.
Alkalinity Methyl Orange	312.
Residue	878.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	3.4	.20
Potassium Chloride KCl	68.2	3.98
Sodium Chloride NaCl	342.2	19.97
Sodium Sulfate Na_2SO_4	151.8	8.88
Sodium Carbonate Na_2CO_3	.8	.05
Ammonium Carbonate $(NH_4)_2CO_3$	3.3	.19
Magnesium Carbonate $MgCO_3$	123.9	7.24
Calcium Carbonate $CaCO_3$	157.1	9.17
Silica SiO_2	7.2	.42
Nonvolatile	1.8	.11
Alumina Al_2O_3	.8	.05
Iron Oxide Fe_2O_3	.6	.04
Total	861.1	50.31

Water is secured from a well 710 feet deep located in the western part of the village. It was drilled by Mr. Johnson of Seneca. The upper part is cased with 8-inch pipe. The bottom is said to be in St. Peter sandstone. The well is equipped with a single-acting deep-well pump with a 4-inch cylinder at a depth of 135 feet. One length of suction pipe is attached to the cylinder. The pump has a 22-inch stroke and is operated at a speed of 30 revolutions a minute. On March 2, 1923, the deep-well pump discharged 1.04 feet depth of

water in the reservoir in 2 hours and 9 minutes, a rate of discharge of 19 gallons a minute. The pump was operated about five hours a day and the amount pumped was estimated to be 5700 gallons a day. The water level when not pumping was said to be about 20 feet above the pump cylinder.

The water had a mineral content of 861, a total hardness of 304, and a content of iron of 0.4 parts per million as shown by the analysis of sample number 49184, collected after two hours pumping on March 2, 1923.

The temperature of water discharged from the well was 57 degrees Fahrenheit. The water contains some hydrogen sulphide, the odor of which is noticeable when the pump is operated.

KIRKWOOD (882). Kirkwood is located in the western part of Warren County on the drainage area of Henderson Creek, a tributary of Mississippi River. Many private wells have been dug or drilled to a depth of about 20 feet and some have been drilled into rock which is entered at a depth of from 70 to 100 feet.

A public water supply was installed by the village about 1894. Water was obtained from a well 216 feet deep located one block from the business dsitrict. The well was cased with 6-inch pipe to rock at a depth of 75 feet. The yield was insufficient and in 1907 the well now in use was drilled. Water is pumped from the well directly into the distribution system by a deep-well pump which is driven by a 3-horsepower electric motor. A steel standpipe 10 feet in diameter and 100 feet high is connected to the system.

Water is obtained from a well 127 feet deep located in the western part of the village. A record of material penetrated is as follows:

	Thickness in feet.	Depth in feet.
Soil and yellow clay	20	20
Clay, blue	67	87
Cemented sand and gravel	15	102
Limestone	10	112
Rock, yellow	5	117
Limestone	10	127

The well was cased to rock with 6-inch pipe. It was tested for 24 hours at a rate of from 30 to 54 gallons a minute. The well was equipped with a pump with 4-inch cylinder. This drew in fine sand and the cylinder was replaced by a 3-inch cylinder. In May, 1921, the well was pumped for about five hours a day. The amount of water used was limited by the amount available.

The water had a mineral content of 531, a total hardness of 420, and a content of iron of 1.4 parts per million as shown by the analysis of sample number 37606, collected on July 17, 1917.

Analysis of Sample Number 37606 From the Village Supply.

Determinations Made.	Parts per million.
Iron Fe	1.4
Silica SiO_2	15.5
Alumina Al_2O_3	13.3
Calcium Ca	95.1
Magnesium Mg	44.8
Sodium Na	41.2
Potassium K	2.2
Sulfate SO_4	18.1
Nitrate NO_3	1.4
Chloride Cl	4.0
Nonvolatile	0.9
Alkalinity	
Methyl Orange	522.
Residue	530.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	2.1	.12
Potassium Chloride KCl	2.7	.16
Sodium Chloride NaCl	4.4	.26
Sodium Sulfate Na_2SO_4	26.8	1.56
Sodium Carbonate Na_2CO_3	70.9	4.13
Magnesium Carbonate $MgCO_3$	155.2	9.05
Calcium Carbonate $CaCO_3$	237.2	13.83
Iron Oxide Fe_2O_3	2.0	.12
Alumina Al_2O_3	13.3	.78
Silica SiO_2	15.5	.90
Nonvolatile	0.9	.05
Total	531.0	30.96

Practically all services are metered and few repairs to meters have been necessary. The mains are flushed frequently on account of the high content of iron in the water.

KNOXVILLE (1708). Knoxville is located in the central part of Knox County on the drainage area of Spoon River, a tributary of Illinois River. Many private wells in the city are from 20 to 25 feet deep.

A public water supply was installed by the city in 1896. Water is pumped from a well into a reservoir, by air lift. The reservoir is 30 feet 8 inches in diameter and 8 feet deep. Water is pumped from the reservoir into the distribution system and an elevated tank connected to the system by an American 3-inch single-stage centrifugal pump which is driven by belt from a 20-horsepower electric motor. Air is supplied by a Sullivan 12 and 7½ by 10-inch tandem compound compressor which is driven by belt from a 35-horsepower electric motor. Two hundred and sixty-nine service connections were in use in May, 1921, and all but nine were metered. The amount of water recorded by meters on services in 1920 was 7,823,227 gallons, an average of 21,430 gallons a day.

Water is obtained from a well 1350 feet deep. The elevation of the ground surface at the well is 769 feet above sea level. A record of material penetrated is as follows:

	Thickness in feet.	Depth in feet.
Drift	20	20
Shale	10	30
Coal	½	30½
Clay and shale	106	136½
Coal	½	137
Shale	348	485
Limestone	188	673
Shale, Maquoketa	92	765
Limestone, Galena-Platteville	70	835
Shale, Galena-Platteville	39	874
Limestone, Galena-Platteville	306	1180
Sandstone, St. Peter	170	1350

The well is cased into Galena-Platteville limestone at a depth of 1056 feet with 8-inch and 6-inch pipe and is 6 inches in diameter at the bottom. When completed the well was pumped for 32 hours and a yield of 150 gallons a minute was obtained. The well is equipped with an air lift with 398 feet of 1½-inch galvanized iron air pipe to which a foot piece 10½ feet long is attached. In November, 1920, the rate of discharge as measured in the reservoir, was 130 gallons a minute. In 1921 when the plant was visited the air lift was operated a few minutes. When starting the air pressure was 104 pounds and during operation it was 83 pounds. The depth to water when not pumping when the well was completed was 140 feet and in 1920 it was 187 feet.

The temperature of water as discharged from the well was 64 degrees Fahrenheit. The water had a mineral content of 1168, a total hardness of 283, and a content of iron of 0.4 parts per million as shown by the analysis of sample number 45204, collected on May 14, 1921.

Analysis of Sample Number 45204 from the Village Supply.

Determinations Made.

	Parts per million.
Iron Fe	0.4
Manganese Mn	0.0
Silica SiO_2	9.8
Nonvolatile	1.0
Alumina Al_2O_3	1.3
Calcium Ca	64.1
Magnesium Mg	30.0
Ammonia NH_4	0.8
Potassium K	17.6
Sodium Na	295.2
Sulfate SO_4	400.8
Nitrate NO_3	2.5
Chloride Cl	175.0
Alkalinity	
Phenolphthalein	14.0
Methyl Orange	276.0
Residue	1114.

Hypothetical Combinations.

	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	4.1	.24
Potassium Chloride KCl	30.4	1.78
Sodium Chloride NaCl	264.6	15.40
Sodium Sulfate Na_2SO_4	589.9	34.50
Ammonium Sulfate $(NH_4)_2SO_4$	2.2	.13
Ammonium Carbonate $(NH_4)_2CO_3$	0.4	.02
Magnesium Carbonate $MgCO_3$	103.8	6.07
Calcium Carbonate $CaCO_3$	160.2	9.37
Silica SiO_2	9.8	.57
Nonvolatile	1.0	.06
Iron Oxide Fe_2O_3	0.6	.04
Alumina Al_2O_3	1.2	.07
Total	1168.2	68.25

In 1912 an investigation was made because of complaints of red water. A sample of water collected five minutes after starting the pump contained 87.2 parts of iron. Complaints had been few while an air lift was operated in the well and were more numerous when a deep-well pump was installed in 1911. The discharge from the deep-well pump was then changed to 2 feet above high water level in the collecting reservoir to give aeration and some years later the deep-well pump was replaced by another air lift.

LA GRANGE (6525). La Grange is a suburban city located a few miles west of the western limits of Chicago. A public water supply was installed by a private company in 1889 and it is now owned by the Public Service Company of Northern Illinois. Water is pumped from three wells into a collecting reservoir 47 feet by 125 feet in plan and 14 feet deep. Two of the wells are equipped with deep-well pumps, each driven by an electric motor. One well is equipped with air lift. Air is supplied by an Ingersoll-Rand cross-compound 22 and 13 by 16-inch compressor which is driven by a 200-horsepower electric motor. This compressor is of sufficient size to operate air lifts in all wells. Water is pumped from the reservoir into the mains by either of two units. One unit consists of two 2-stage American centrifugal pumps driven by an electric motor. The other unit consists of two 2-stage Byron-Jackson centrifugal pumps driven by an electric motor. The two pumps of either unit may be operated in parallel or in series. A steam boiler, a steam engine, a dynamo, and a steam pump are maintained for emergency use. A standpipe 15 feet in diameter and 120 feet high is connected to the system.

Water is obtained from three wells. The two older wells are 30 feet apart and the other is 150 to 200 feet distant. The elevation of the ground surface is about 640 feet above sea level. Each well is about 2000 feet deep. Well number 3 was reamed and repaired by F. M. Gray, Jr., of Milwaukee, in 1923-1924. An abstract of a record of material penetrated as furnished by the driller is as follows:

	Thickness in feet.	Depth in feet.
Drift	20	20
Limestone, Niagaran	300	320
Shale, Maquoketa	160	480
Limestone, Galena-Platteville	320	800
Sandstone, St. Peter	130	930
Shale, chert, and limestone, St. Peter	90	1020
Limestone, Prairie du Chien	210	1230

	Thickness in feet.	Depth in feet.
Sandstone, Cambrian system	140	1370
Sandstone, Cambrian system	140	1510
Sandstone, Cambrian system	60	1570
Marl, Cambrian system	170	1740
Not recorded	222	1962

The diameter of the well is 15 inches to a depth of 205 feet, 13 inches between depths of 205 and 500 feet, 12 inches between depths of 500 and 1000 feet, 8⅝ inches between depths of 1000 and 1430 feet, and 7 inches at the bottom. Some 8⅝-inch casing is placed below the St. Peter sandstone. Part of this casing in the Prairie du Chien limestone is perforated.

The other two wells are four inches in diameter at the bottom. One, drilled by the J. P. Miller Artesian Well Company in 1890, is 2014 feet deep.

Wells 1 and 3 are equipped with centrifugal pumps. In 1910, during a 24 hour test, the yield of well number 3 was 1020 gallons a minute. In 1921 the yield of one well, with a centrifugal pump placed at a depth of 126 feet with from 22 to 30 feet of suction pipe attached, was 585 gallons a minute with practically continuous operation. Occasionally two wells were pumped at the same time and the yield was 900 gallons a minute.

An American 12-inch centrifugal pump was installed in well number 3 in 1924. The bowls are at a depth of 155 feet and about 22 feet of suction pipe is attached. During a test the yield was 1100 gallons a minute.

Well number 2 is equipped with an air lift. The yield in 1921 with 365 feet of 1½-inch air pipe and 5-inch discharge pipe was 377 gallons a minute.

Measurements of depths to water are made in wells when the pumps are taken out. Records of some of the water levels are as follows:

	Depth to water in feet.		Water pumped.
	When not pumping.	When pumping.	Average in gallons a day.
1910	47	53	.....
1912	58	70	370,000
1914	70	99	550,000
1921	107	115 to 125	800,000 approx.
1924	135		960,000

The depth to water is measured in a well when the pump is removed. There is little difference in the depth to water 30 feet distant and 200 feet distant from a well in which a pump is operating. The two figures for depth to water when pumping given for 1921 are for one well pump operating and two well pumps operating respectively. One important factor in the lowering of water levels

is the considerable increase in the amount of water drawn from the wells. An additional factor is the length of time the pumps are idle. A measurement made in 1910 might have been made when all pumps were idle for many hours. In 1921 all pumps were very seldom idle for more than an hour at a time.

The water had a mineral content of 743, a total hardness of 505, and a content of iron of 1.4 parts per million as shown by the analysis of sample number 39919, collected from well number 1 on August 5, 1918.

Analysis of Sample Number 39919 from the City Supply.

Determinations Made.	Parts per million.
Iron Fe	1.4
Manganese Mn	0.0
Silica SiO_2	14.8
Nonvolatile	1.4
Alumina Al_2O_3	21.2
Calcium Ca	130.0
Magnesium Mg	44.1
Ammonia NH_4	0.3
Sodium Na	34.7
Sulfate SO_4	209.0
Nitrate NO_3	1.2
Chloride Cl	23.0
Alkalinity Methyl Orange	346.0
Residue	737.2
Hydrogen Sulphide H_2S	0.4
Carbon Dioxide CO_2	6.0

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Sodium Nitrate $NaNO_3$	0.9	.05
Sodium Chloride NaCl	37.9	2.21
Sodium Sulfate Na_2SO_4	60.2	3.51
Ammonium Sulfate $(NH_4)_2SO_4$	11.1	.65
Magnesium Sulfate $MgSO_4$	209.6	12.23
Magnesium Carbonate $MgCo_3$	59.0	3.44
Calcium Carbonate $CaCO_3$	324.6	18.93
Iron Carbonate $FeCO_2$	2.8	.16
Alumina Al_2O_3	21.2	1.24
Silica SiO_2	14.8	.86
Nonvolatile	1.4	.08
Total	743.5	43.36

It is necessary to flush dead ends occasionally. A standpipe erected in 1889 was apparently in good condition in 1921.

LA GRANGE PARK (1684). The village of La Grange Park adjoins the village of La Grange and secures water for a public supply from the La Grange supply.

LAHARPE (1323). La Harpe is located in the northeastern part of Hancock County on the drainage area of Crooked Creek, a tributary of Illinois River. Many private wells from 20 to 30 feet deep are in use.

A public water supply was installed by the city in 1894. Water was secured from a dug well 47 feet deep located to the rear of the city hall. Later a second well was drilled and the original well has been abandoned. Water is pumped from the well into an elevated tank and the distribution system by a Goulds 8 by 10-inch triplex

pump which is driven by a gas engine. A wooden elevated tank was replaced by a steel tank about 1915. Water was supplied to 120 consumers in 1923. The rate is 30 cents per 1000 gallons and the minimum charge is $5.00 a year.

Water is secured from a dug well located one block east of the city hall. The elevation at the top of the well is about 695 feet above sea level. Water is obtained from sand and gravel. The well is curbed with brick. A curbing about 20 feet 9 inches inside diameter extends to a depth of 40 feet and a curb of 13 feet 6 inches average inside diameter extends from a depth of 35 feet to the bottom of the dug part of the well. Between the casings the depth from the ground surface is from 37 to 39 feet and the total depth of the dug well measures 57 feet. Eight-inch pipes 20 feet long equipped with strainers are said to have been driven in the bottom of this dug well in 1920. On May 29, 1923, when the water level was drawn down to a depth of 47 feet 6 inches and the pump was stopped, the inflow during the first 23 minutes filled the well 1.8 feet, a rate of inflow of 85 gallons a minute. Several hours after pumping when the water surface was at a depth of 40.8 feet-the inflow raised the water level ¼-inch an hour. The amount of water pumped before these measurements were made had for sometime averaged near 15,000 to 20,000 gallons a day.

The water had a mineral content of 556, a total hardness of 232, and a content of iron of 1.6 parts per million as shown by the analysis of sample number 49565, collected on May 29, 1923.

Analysis of Sample Number 49565 from the City Supply.

Determinations Made.	Parts per million.
Iron Fe	1.6
Manganese Mn	0.1
Silica SiO_2	21.9
Nonvolatile	1.3
Alumina Al_2O_3	3.8
Calcium Ca	41.6
Magnesium Mg	31.4
Ammonia NH_4	0.9
Sodium Na	107.6
Potassium K	20.3
Sulfate SO_4	66.2
Nitrate NO_3	1.4
Chloride Cl	23.0
Alkalinity	
Methyl Orange	396.0
Residue	575.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	2.3	0.13
Potassium Chloride KCl	37.0	2.16
Sodium Chloride NaCl	8.8	0.51
Sodium Sulfate Na_2SO_4	97.8	5.71
Sodium Carbonate Na_2CO_3	166.9	9.74
Ammonium Carbonate $(NH_4)_2CO_3$	2.3	0.13
Magnesium Carbonate $MgCO_3$	108.6	6.34
Calcium Carbonate $CaCO_3$	103.7	6.05
Iron Oxide Fe_2O_3	2.3	0.13
Alumina Al_2O_3	3.8	0.22
Silica SiO_2	21.9	1.28
Nonvolatile	1.3	0.07
Manganese Oxide MnO	0.1	0.01
Total	556.8	32.48

LAMOILLE (547). LaMoille is located in the northeastern part of Bureau County on the drainage area of Big Bureau Creek,

a tributary of Illinois River. Many private wells are from 18 to 30 feet deep. A few driven wells are from 185 to 255 feet deep. A well three-fourths of a mile north of the village is 321 feet deep and to the east are several wells into the same vein. The Chicago, Burlington and Quincy Railroad has a private supply from a creek west of the village.

A public water supply was installed by the village in 1916-1917. Water is pumped from a well into an elevated steel tank and the distribution system. The pump is driven by belt from a 20-horse-power electric motor. Seventy-five service connections were in use in 1923 and the amount of water pumped averaged near 25,000 gallons a day. The rates for water are 35 cents per 1000 gallons for the first 2000 gallons, 30 cents per 1000 gallons for the next 2000 gallons, and 25 cents per 1000 gallons for additional water. The minimum charge is $1.50 for three months.

Water is obtained from a well 268 feet deep located west of the business district. An approximate record of material penetrated as given from memory by the driller, R. M. Lippencott, is as follows:

	Thickness in feet.	Depth in feet.
Surface soil and yellow clay	20	20
Sand	2	22
Clay, blue	88	110
Clay, red (stony)	75	185
Hard (like sandstone)	30	215
Clay	29	244
Sand or sandstone	24	268

The sandstone at the bottom was reported to be harder than St. Peter sandstone but to require a screen to keep it from caving after a short period of use. The well is cased to the bottom and equipped with a Mark screen 4½ inches in diameter and 14 feet long. The screen is of perforated iron, galvanized after perforating, covered with number 60 gauze screen which is protected by a covering of brass with 1/8-inch perforations. The upper 200 feet of the casing is 8 inches in diameter. The water level when the well was completed was at a depth of 137 feet. Pumping on October 20, 1916, for 1 hour 30 minutes at an average rate of 31 gallons a minute lowered the water level 3 feet 6 inches. The well is equipped with a Goulds double-acting deep-well pump with 4¾-inch cylinder and 24-inch stroke. The bottom of a suction pipe attached below the cylinder is at a depth of 200 feet. The pump is operated 25 revolutions a minute. It was operated with the original leather packing in 1923 and considerable slip might be expected but during a test in 1922 the discharge at the ground surface, measured approximately in a tub, was about 80 gallons a minute. The discharge into the

elevated tank and mains would be somewhat less. In 1923 the pump was operated an average of six hours a day.

The water had a mineral content of 441, a total hardness of 290, and a content of iron of 4.8 parts per million as shown by the analysis of sample number 50232, collected on October 3, 1923, after the pump had been operated for three hours.

Analysis of Sample Number 50232 from the Village Supply.

Determinations Made.

	Parts per million.
Iron Fe	4.8
Manganese Mn	0.0
Silica SiO_2	31.3
Nonvolatile	3.6
Alumina Al_2O_3	3.5
Calcium Ca	71.6
Magnesium Mg	27.4
Ammonia NH_4	13.4
Sodium Na	29.6
Potassium K	4.9
Sulfate SO_4	1.9
Nitrate NO_3	1.0
Chloride Cl	3.0
Alkalinity Methyl Orange	402.
Residue	452.

Hypothetical Combinations.

	Parts per million.	Grains per gallon.
Potassium Nitrates KNO_3	1.7	.09
Potassium Chloride KCl	6.3	.36
Potassium Sulfate K_2SO_4	2.1	.12
Sodium Sulfate Na_2SO_4	0.9	.05
Sodium Carbonate Na_2CO_3	67.5	3.94
Ammonium, Carbonate $(NH_4)_2CO_3$	41.2	2.40
Magnesium Carbonate $MgCO_3$	94.8	5.54
Calcium Carbonate $CaCO_3$	183.2	10.70
Iron Oxide Fe	6.9	.40
Aluminna Al_2O_3	3.5	.20
Manganese Mn	0.0	0.00
Silica SiO_2	31.3	1.83
Nonvolatile	3.6	.21
Total	443.0	25.84

The temperature of water discharged from the well is 52 degrees Fahrenheit. The water corrodes pipe. J. S. Allen, President of the village, stated that nine-tenths of all leaks were where nipples are screwed into mains. The greatest trouble is on a short line of steel or iron pipe from the pump to the elevated tank. Apparently brass and meter parts are not seriously affected.

Mr. Lippencott thinks that the well 321 feet deep located north of the village and some wells to the east are in a lower stratum and furnish a better quality of water.

LA SALLE (13,050). La Salle is located in the western part of La Salle County on the north bank of Illinois River. A public water supply was installed by the city in 1888. Water was secured from springs until 1904 when wells were drilled and the springs were abandoned. Additions and improvements have been made from time to time. Water is pumped from wells by either of two Fairbanks-Morse centrifugal pumps which are placed in a pit 40 feet deep. Each pump is driven by a 225-horsepower electric motor. A booster pump draws water from mains serving the lower part of the city and discharges into a system of mains serving part of

the city at a higher elevation. The two elevated steel tanks, each of 150,000 gallons capacity are connected to the mains, one on each system. Two thousand five hundred service connections were in use in 1923 and the water consumption averaged 2,500,000 gallons a day.

Meter rates are 20 cents per 100 cubic feet for the first 3000 cubic feet used in one month and 9 cents per 100 cubic feet for additional water.

The public water supply is secured from three wells in bottom lands of Illinois River near the southeastern limits of the city. The wells are from 38 to 40 feet deep. They penetrate 10 feet of soil and clay and 30 feet of gravel. Rock is at a depth of about 40 feet. In the bottom of each well is a steel cylinder, the lower part of which has ½-inch perforations spaced 1½ inches center to center. The cylinders in two of the wells are 7 feet 6 inches in diameter and the cylinder in the other well, installed in 1915, is 14 feet in diameter. The upper parts of the wells are cased with brick and the tops are closed with man hole covers to prevent the entrance of river water at times of high water. Water is drawn from the wells by either of two Fairbanks-Morse 8-inch three-stage centrifugal pumps, each of 1800 gallons a minute capacity. In the summer of 1923 one pump was operated about 12 hours a day, operating continuously about two hours at a time.

The water had a mineral content of 471, a total hardness of 360, and a content of iron of 0.2 parts per million as shown by the analysis of sample number 39458, collected on May 8, 1918.

Analysis of Sample Number 39458 from the City Supply.

Determinations Made.	Parts per million.
Iron Fe	0.2
Manganese Mn	0.0
Silica SiO_2	10.9
Nonvolatile	4.0
Alumina Al_2O_3	4.0
Calcium Ca	90.1
Magnesium Mg	33.2
Ammonia NH_4	1.6
Sodium Na	27.3
Sulfate SO_4	109.6
Nitrate NO_3	1.4
Chloride Cl	22.0
Alkalinity Methyl Orange	258.
Residue	464.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Sodium Nitrate $NaNO_3$	1.9	.11
Sodium Chloride NaCl	36.2	2.11
Sodium Sulfate Na_2SO_4	38.7	2.26
Ammonium Sulfate $(NH_4)_2SO_4$	6.0	.35
Magnesium Sulfate $MgSO_4$	99.0	5.77
Magnesium Carbonate $MgCO_3$	45.6	2.66
Calcium Carbonate $CaCO_3$	224.9	13.11
Iron Oxide Fe_2O	0.2	.01
Alumina Al_2O_3	4.0	.23
Silica SiO_2	10.9	.64
Nonvolatile	4.0	.23
Total	471.4	27.48

LACON (1464). Lacon is located in the central part of Marshall County on the east bank of Illinois River. A public water supply

was installed by the city in 1893. Water is pumped from wells into the distribution system by either of two American two-stage centrifugal pumps, each direct connected to a 20-horsepower electric motor.

The pumps arc in a pit 6 feet deep. An elevated steel tank of 65,000 gallons capacity, located on high ground, is connected to the distribution system.

Water is secured from two wells located 6 feet apart on Sixth Street, 200 feet distant from Illinois River. The wells are 8 inches in diameter and 60 feet deep and are in sand and gravel. They are equipped with screens and it has never been necessary to remove the screens. At the time of visit in 1921 when the elevated tank was full the discharge when operating one pump was 211 gallons a minute as. registered by meter. The water level in the north well was lowered in 5 minutes from a depth of 10.6 feet below the top of the casing to a depth of 13 feet. It then remained constant for 15 minutes until the pump was stopped and 3 minutes after stopping the pump the water level was again at a depth of 10.6 feet. In 1924, when tested, the rate of pumping was 222 gallons a minute and the water level while pumping was at a depth of 10 feet. The amount of water pumped from January, 1923, to June, 1924, as registered by meter, averaged 99,000 gallons a day.

The water had a mineral content of 528, a total hardness of 382, and a content of iron of 0.4 parts per million as shown by the analysis of sample number 51661, collected on June 18, 1924.

Analysis of Sample Number 51661 from the City Supply.

Determinations Made.	Parts per million.
Iron Fe	0.4
Manganese Mn	0.0
Silica. SiO_2	21.9
Nonvolatile	2.3
Alumina Al_2O_3	6.4
Calcium Ca	84.1
Magnesium Mg	38.2
Sodium Na	32.1
Ammonia NH_4	0.0
Potassium K	7.4
Sulfate SO_4	47.8
Nitrate NO_3	83.3
Chloride Cl	53.0
Alkalinity Methyl Orange	248.
Residue	585.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	19.0	1.11
Sodium Nitrate $NaNO_3$	98.0	5.72
Sodium Chloride NaCl	14.1	.82
Magnesium Chloride $MgCl_2$	59.7	3.49
Magnesium Sulfate $MgSO_4$	59.7	3.49
Magnesium Carbonate $MgCO_3$	37.3	2.18
Calcium Carbonate $CaCO_3$	209.8	12.25
Iron Oxide Fe_2O_3	.6	.04
Alumina Al_2O_3	6.4	.37
Silica SiO_2	21.9	1.28
Nonvolatile	2.3	.13
Total	528.8	30.88

The water formed a hard scale in boilers formerly operated at an electric light plant. The nitrate in. other samples analyzed has been less.

LADD (2040). Ladd is located in a coal mining district in the eastern part of Bureau County five miles north of Illinois River. A public water supply was installed by the city in 1893-1894. Several changes have been made. Water is now pumped from a well directly into the distribution system to which an elevated steel tank 22 feet in diameter is connected. In October, 1923, sixty-five or seventy service connections were in use and the water consumption was near 34,000 gallons a day. The meter rates for three months are 25 cents per 100 cubic feet for the first 500 cubic feet, 20 cents per 100 cubic feet for the next 1000 cubic feet, 15 cents per 100 cubic feet for the next 3,500 cubic feet, and 10 cents per 100 cubic feet for all in excess of 5000 cubic feet. The minimum charge is $1.25.

In 1894 water was secured from a coal mine.

In 1907 a well was drilled to a depth of 187 feet. It was equipped with an air lift and water was discharged into a well or reservoir which was 9 by 12 feet in plan to a depth of 22 feet and 6 feet square below a depth of 22 feet to the bottom at a depth of 42 feet.

In 1919 the city well became clogged and water was again purchased from the coal company, the Illinois Third Vein Coal Company. The mine is 468 feet deep and about 300 gallons a minute was pumped from the bottom of the shaft in 1920. Part of this water was furnished to the city. The coal company secured some water of much better quality from a pump shaft 280 feet deep which passed through quicksand and gravel at a depth of 180 feet. This supply furnished about 150,000 gallons a day of which one-third was used by the company and the remainder was sold for railroad use.

A main from the coal mine to the city was broken by settlement in 1919 and a well was drilled for the city that year by A. B. Bell and his son of St. Charles. The well was 300 feet deep but practically no water was secured.

In 1920 the old dug well was cleaned preparatory to use by the city. At the time of visit on December 9, after the workmen stopped work, the water level when at a depth of 32 feet was rising at a rate of 11 inches in 15 minutes. If the well was just six feet square the inflow was sixteen gallons a minute.

The well from which water is now secured is located near the southeastern limits of the village. It was drilled by the J. P. Miller Artesian Well Company in 1922. The elevation at the top is 650 feet above sea level. A record of material penetrated as furnished by Marr-Green and Company, engineers, is as follows:

	Thickness in feet.	Depth in feet.
Soil and yellow clay	15	15
Sand, mud, and gravel	150	165
Limestone	50	215
Shale	42	257
Coal	3	260
Limestone	80	340
Shale, black	25	365
Mixed shale, slate, and limestone	110	475
Coal	4	479
Limestone	246	725
Limestone, sandy	90	815
Limestone	150	965
Shale, broken, Maquoketa	200	1165
Limestone, Galena-Platteville	365	1530
Sandstone, St. Peter	135	1665

The well is cased with 12-inch pipe weighing 49 pounds per foot from the surface to a depth of 165 feet, with 10-inch pipe weighing 40 pounds per foot between depths of 185½ and 524 feet, and with 8-inch pipe between depths of 498 and 840 feet. Lead seals are placed between the 12 and 10-inch and between the 10 and 8-inch casings. The well is 8 inches in diameter to a depth of 960 feet. It is cased with 6-inch pipe weighing 18.76 pounds per foot between depths of 960 and 1200 feet and is 6 inches in diameter to the bottom at a depth of 1665 feet 8 inches. All casing is genuine wrought iron.

The well was tested on May 2, 1922, when it was pumped for 12 hours. During the first two hours the rate of pumping was from 160 to 183 gallons a minute and during the next 9 hours it varied from 170 to 183 gallons a minute. Before pumping the water level was at a depth of 26 feet. At the end of two hours when pumping 183 gallons a minute the water level was at a depth of 83 feet and at the end of 11 hours when pumping 183 gallons a minute the water level was at a depth of 88 feet. During the last hour of the test the rate of pumping was for a time 230 gallons a minute and the water level was lowered to a depth of 106 feet.

The well is equipped with a Layne pump driven by an electric motor. The depth to the bottom of the suction pipe on the pump is 120 feet. On October 4, 1923, the amount of water pumped into the elevated tank in the morning and the amount used in the afternoon when the pump was not operating were determined by a record of water levels. Assuming the consumption was the same in the morning as in the afternoon the discharge of the pump was 105 gallons a minute. During the preceding 11 months the pump had operated an average of 5½ hours a day.

Water from the well had a temperature of 53 degrees Fahrenheit. It had a mineral content of 342, a total hardness of 295, and a content of iron of 1.6 parts per millions as shown by the analysis

of sample number 50233, collected on October 4,1923, after the pump had been operated for one hour and fifteen minutes.

Analysis of Sample Number 50233 from City Well 1665 Feet Deep.

Determinations Made.

	Parts per million.
Iron Fe	1.6
Manganese Mn	0.0
Silica SiO_2	17.7
Nonvolatile	3.7
Alumina Al_2O_3	1.8
Calcium Ca	63.4
Magnesium Mg	33.4
Ammonia NH_4	2.8
Sodium Na	14.7
Potassium K	4.0
Sulfate SO_4	1.0
Nitrate NO_3	1.4
Chloride Cl	2.0
Alkalinity Methyl Orange	330.
Residue	348.

Hypothetical Combinations.

	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	2.3	.13
Potassium Chloride KCl	4.1	.24
Potassium Sulfate K_2SO_4	1.9	.11
Potassium Carbonate K_2CO_3	0.0	.00
Sodium Carbonate Na_2CO_3	33.8	1.97
Ammonium Carbonate $(NH_4)_2CO_3$	7.4	.43
Magnesium Carbonate $MgCO_3$	115.1	6.73
Calcium Carbonate $CaCO_3$	153.2	8.95
Iron Oxide Fe	2.3	.13
Silica SiO_2	17.7	1.02
Nonvolatile	3.7	.21
Alumina Al_2O_3	1.8	.10
Total	343.3	20.02

LAKE BLUFF (819). Lake Bluff is located in Lake County on the shore of Lake Michigan. A water supply was installed by the village in 1904. Water was secured from a well. Other wells have been drilled and the original well has been abandoned. Water was pumped from the wells directly into the distribution system and an elevated tank connected to the system. In 1924 a new pumping station and a concrete reservoir of 110,000 gallons capacity were built. Water from the wells will be discharged into this reservoir. A Goulds 6½-inch by 8-inch single acting triplex pump driven by 15-horsepower electric motor and a Goulds centrifugal pump of 500 gallons a minute capacity driven directly by a 25-horsepower electric motor have been intalled to pump from the reservoir.

The water supply was first obtained from a well into Cambrian sandstone. This well furnished the entire supply until 1908 and a considerable part of the supply until 1913. The depth of the well has been reported as 1600 feet, 1900 feet, and 2000 feet. When the village was visited in 1911 water was pumped from this well by a 3-inch centrifugal pump which was placed in a pit 4 feet in diameter and 33 feet deep at the top of the well. The pump was driven by a 10-horsepower gas engine and was operated about eight hours a day. In 1921 water was pumped from this well by the Goulds triplex pump now installed in the pumping station. One plunger had been removed to reduce the capacity. The pump was then

in a shaft 55 feet deep and drew water from the well through a suction pipe 30 feet long. Water raised to within 10 feet of the pump. The pump would deliver 25 or 30 gallons a minute when started but would draw air after a few minutes pumping. In 1920 a weight had been lowered in this well to a depth of 450 feet. In 1924 this well was not in use. The depth was then about 250 feet. A sample of water, number 12166, collected from this well in 1904, had a mineral content of 625, a total hardness of 395, and a content of iron of 0.4 parts per million as shown by the analysis.

Analysis of Sample Number 12166 from the Old Village Well.

Determinations Made.	Parts per million.
Iron Fe	.4
Silica SiO_2	4.5
Alumina Al_2O_3	12.5
Calcium Ca	126.9
Magnesium Mg	18.9
Potassium K	14.6
Sodium Na	15.8
Sulfate SO_4	187.8
Nitrate NO_3	1.0
Chloride Cl	14.5
Residue	580.8

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	1.7	.10
Potassium Chloride KCl	26.6	1.55
Sodium Chloride NaCl	3.0	.18
Sodium Sulfate Na_2SO_4	156.2	9.11
Magnesium Sulfate $MgSO_4$	94.2	5.49
Calcium Sulfate $CaSO_4$	13.1	.76
Calcium Carbonate $CaCO_3$	307.4	17.93
Ferrous Carbonate $FeCO_3$	.8	.05
Alumina Al_2O_3	12.5	.73
Silica SiO_2	9.5	.55
Total	625.0	36.45

A sample collected in 1914 was similar. It had a mineral content of 553, a total hardness of 375, and a content of iron of 0.2 parts per million.

A 6-inch well 300 feet deep was drilled in 1908. The lower 100 feet was in rock. The well was equipped with a single-acting deep-well pump with the cylinder placed at a depth of 70 feet. The water from this well was of better quality than water from the deeper well but the quantity available was limited and the well was abandoned after a few years use. The water had a mineral content of 446, a total hardness of 196, and a content of iron of 0.2 parts per million.

A well 498 feet deep was drilled for the village in 1913 by William Cater and has since furnished a large part of the public supply. The diameter is 10 inches to a depth of 350 feet and 8 inches at the bottom. The well was cased to a depth of 197 feet with 10-inch wrought iron pipe. The discharge in January, 1921, when the well was equipped with a deep-well pump with the cylinder at a depth of 135 feet, was said to be about 50 gallons a minute. At times during the summer the pump had been operated nearly continuously. In 1924 the well was equipped with a Layne pump driven by a 20-horsepower electric motor. The pump drew

air after operating for one minute. One length of suction pipe was then added putting the bowls at a depth of 125 feet. The pump is supposed to discharge 100 gallons a minute.

A well 1804 feet deep was drilled for the village by Wm. Cater in 1920-1921. A record of material penetrated is given by the driller as follows:

	Thickness in feet.	Depth in feet.
Clay	55	55
Quicksand	7	62
Gravel	5	67
Clay	45	112
Gravel	4	116
Clay	65	181
Gravel	3	184
Rock	6	190
Rock, soft	110	300
Rock	190	490
Shale	2	492
Rock	28	520
Shale	5	525
Rock	105	630
St. Peter Rock	264	934
Blue Shale	212	1146
Sand	54	1200
"Potsdam," white sand	19	1275
Pencil rock	129	1404
Lime, shale and sand	261	1665
"Potsdam" sand	139	1804

The well is 12 inches in diameter to a depth of 670 feet, 8 inches in diameter between depths of 670 and 1256 feet, and 6¼ inches in diameter below a depth of 1256 feet. The well was tested by Alvord and Burdick on January 21, 1921. Before pumping the water level was 58 feet below the ground surface. Pumping at a rate of 134 gallons a minute lowered the water level to a depth of 76 feet in less than an hour and with continued pumping for a total of three hours at the same rate the water level remained at a depth of 76 feet. Equipment had not been placed in this well in 1924.

A sample of water, number 44524, collected from this well at the time of the test had a mineral content of 556, a total hardness of 340, and a content of iron of 1.2 parts per million as shown by the analysis.

This water is similar in quality to the water secured from the original well. The higher iron content is undoubtedly due to new casing and iron on the equipment used in the test.

Analysis of Sample Number 44524 from Village Well 1804 Feet Deep.

Determinations Made.	Parts per million.
Iron	1.2
Manganese	0.0
Silica	28.8
Nonvolatile	.7
Alumina	12.6
Calcium	115.7
Magnesium	20.7
Ammonium	.3
Potassium	15.4
Sodium	24.9
Sulfate	172.2
Nitrate	.7
Chloride	10.00
Alkalinity	
Phenolphthalein	0
Methyl Orange	248.0
Residue	609.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate	1.1	.07
Potassium Chloride	21.0	1.23
Potassium Sulfate	8.7	.51
Sodium Sulfate	77.0	4.50
Ammonium Sulfate	1.1	.07
Magnesium Sulfate	102.2	5.98
Calcium Sulfate	46.7	2.73
Calcium Carbonate	254.8	14.90
Silica	28.8	1.68
Nonvolatile	0.7	.04
Iron Oxide	1.7	.10
Alumina	12.6	.74
Total	546.4	32.55

LAKE ZURICH (316). Lake Zurich is located in the southwestern part of Lake County. It is on the east shore of a lake of about 300 acres area known as Lake Zurich. A public water supply was installed by the village in 1912. Water was pumped from a well into a collecting reservoir from which it was pumped into the distribution system and an elevated tank by a 5½ by 6-inch Deming triplex pump. The reservoir is 10 feet by 36 feet in plan and 10 feet deep. The elevated tank has a capacity of 50,000 gallons. Another well which now furnishes nearly the entire supply has been drilled and equipped with a deep-well pump which is driven by a 15-horsepower electric motor. The pump discharges directly into the mains and elevated tank. Power is purchased from the Public Service Company of Northern Illinois. The water consumption in 1922 averaged about 30,000 gallons a day during the year and near 48,000 gallons a day during the summer when many visitors are in the village. The rate is 30 cents per 1000 gallons with a minimum charge of $1.50 for three months.

The public water supply is obtained from two wells into sand and gravel. The elevation of the tops of the wells is about 855 feet above sea level. One well, drilled in 1912, is 6 inches in diameter and 218 feet deep. This well is equipped with a Keystone Driller Company double-stroke deep-well pump with 4¼-inch cylinder and 18-inch stroke. The pump is now used occasionally and kept in good working order.

The other well was drilled in 1921 by Raymond Reke of Barrington. It is located 40 feet west of the old well. This well is 214 feet deep and is cased with 10-inch pipe to the bottom. There is no screen. When the well was drilled the water level was 95 feet below the ground surface. It is stated that pumping at a rate of 100 gallons a minute for 12 hours lowered the water level 20 feet. The well is equipped with a Keystone Driller Company double-stroke deep-well pump with a 5¾-inch cylinder placed at a depth of 150 feet. When the pump was installed it was operated with 18-inch stroke, 35 revolutions a minute, a displacement of 140 gallons a minute. After three hours of pumping the water level was drawn down to the pump cylinder. The speed was reduced to 24 revolutions a minute, a displacement of 97 gallons a minute. Pumping at this speed for three hours on November 11, 1922, lowered the water level in the 6-inch well, 40 feet distant, to a depth of 99.5 feet below the ground surface. When not pumping for one hour the water level in the 6-inch well raised two feet to a depth of 97.5 feet and when the pump was not operated for 10 hours the water level remained at a depth of 97.5 feet.

The temperature of water discharged from the well was 52 degrees Fahrenheit. The water had a mineral content of 1584, a total hardness of 977, and a content of iron of 0.2 parts per million as shown by the analysis of sample number 48622, collected on November 11, 1922.

Analysis of Sample Number 48622 from the Village Supply.

Determinations Made.	Parts per million.
Turbidity	5.0
Residue	1753.0
Manganese	0.0
Nitrates NO_3	1.4
Chlorides Cl	7.0
Sulfates SO_4	1103.0
Alkalinity	
Phenolphthalein	0.0
Methyl Orange	72.0
Magnesium	114.1
Calcium	203.5
Iron Fe	0.2

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Calcium Carbonate $CaCO_3$	71.9	4.20
Calcium Sulfate $CaSO_4$	592.5	34.60
Magnesium Sulfate $MgSO_4$	564.0	32.90
Sodium Sulfate Na_2SO_4	343.0	20.10
Sodium Chloride NaCl	11.5	0.67
Sodium Nitrate $NaNO_3$	1.9	0.11
Total	1584.8	92.58

Analysis of samples collected in the past have been similar to the analysis given.

LANARK (1297). Lanark is located in the central part of Carroll County on the watershed between small streams tributary

to Mississippi River and Rock River. A public water supply was installed by the city in 1888. A well was dug 18 feet in diameter to a depth of 60 feet and in the bottom of the dug well two wells were drilled, the deeper to a depth of 400 feet from the ground surface. The lower 40 feet of the dug well was then filled and a deep-well pump was installed in the 400-foot well. This supply was used until 1895 when another well was drilled. The old well was capped and the dug part has since been used as a reservoir. Water is pumped from the well into the reservoir by a steam-head deep-well pump and is pumped from the reservoir into the mains and an elevated wooden tank of 63,000 gallons capacity by a Smedley duplex steam pump. Steam is furnished by a 60-horsepower boiler.

Three hundred and twenty-five service connections were in use in 1924 and few of them were metered.

Analysis of Sample Number 52196 from the City Supply.

Determinations Made.

	Parts per million.
Iron Fe	2.0
Manganese Mn	0.0
Silica SiO_2	13.9
Nonvolatile	6.2
Alumina Al_2O_3	0.9
Calcium Ca	51.6
Magnesium Mg	32.7
Ammonia NH_4	0.4
Potassium K	1.9
Sodium Na	26.2
Sulfate SO_4	0.0
Nitrate NO_3	1.2
Chloride Cl	1.8
Alkalinity Methyl Orange	324.
Residue	351.

Hypothetical Combinations.

	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	2.0	0.11
Potassium Chloride KCl	2.1	0.12
Potassium Carbonate K_2CO_3	0.1	0.01
Sodium Carbonate Na_2CO_3	60.5	3.53
Ammonium Carbonate $(NH_4)_2CO_3$	1.1	0.06
Magnesium Carbonate $MgCO_3$	113.2	6.61
Calcium Carbonate $CaCO_3$	128.9	7.53
Iron Oxide Fe_2O_3	2.9	0.17
Alumina Al_2O_3	0.9	0.05
Silica SiO_2	13.9	0.81
Nonvolatile	6.2	0.36
Total	331.8	19.36

Water is obtained from a well 600 feet deep, drilled in 1895. Records on file with the State Geological Survey Division show that Galena-Platteville limestone was entered at a depth of 40 feet and that St. Peter sandstone was entered at a depth of 200 feet. The well is cased with 10-inch pipe to a depth of 200 feet and is six inches in diameter below that depth. The elevation at the top is 895 feet above sea level. The well is equipped with a Stilwell-Bierce single-acting steam-head deep-well pump with 7½-inch water cylinder and 31-inch stroke. The cylinder is placed at a depth of 180 feet and has 20 feet of 6-inch suction pipe attached. When new leathers were put on the pump it is said that after pumping for two hours four feet depth of water was pumped in the tank

in one hour, a rate of discharge if the tank is 26 feet in diameter as has been stated, of 130 gallons a minute. The pump is operated 11 or 12 hours a day in the summer time and an average during the year of about 9 hours a day. Water stood 80 feet below the ground surface when not pumping in 1920 and 79 feet below the ground surface in August, 1924, when the pump had not been operated for 22 hours.

The temperature of water discharged from the well was 52 degrees Fahrenheit. The water had a mineral content of 331, a total hardness of 263, and a content of iron of 2.0 parts per million as shown by the analysis of sample number 52196, collected on August 19, 1924, after pumping for six hours.

LANSING (1409). Lansing is located in the southeastern part of Cook County on the drainage area of Little Calumet River. A public water supply was installed by the village in 1921. The installation includes a deep well equipped with a deep-well pump which is driven by a 30-horsepower motor, a pumping station, a distribution system, and an elevated steel tank of 75,000 gallons capacity connected to the system. Two hundred and twelve service connections had been installed in June, 1922, and all were metered. A minimum rate of $1.00 a month with a discount of 15 cents for cash allows the use of 4000 gallons of water and the charge for additional water is 21½ cents per 1000 gallons.

Water is secured from a well 1632 feet deep, located in the southern part of the village. It was drilled by the Miller Artesian Well Company in 1921. The well is 12 inches in diameter at the top and 8 inches in diameter at the bottom. The material penetrated as given by the Gray Engineering Company is as follows:

	Thickness in feet.	Depth in feet.
Drift	14	14
Clay, blue	93	107
Limestone, Silurian system, all or chiefly Niagaran	421	528
Shale, Richmond	212	740
Limestone, Galena-Platteville	295	1035
Sandstone, St. Peter	145	1180
Limestone, Prairie du Chien	183	1363
Shale? Prairie du Chien	160	1523
Limestone? Prairie du Chien	109	1632

A 12-inch casing extends to a depth of 112 feet, a 10-inch casing is placed between depths of 530 and 751 feet, and 8-inch casing is placed between depths of 1148 and 1361 feet. The water level in the well dropped from a depth of 75 feet to a depth of 145 feet when the drillers reached a depth of 1560 feet. A final test was

made with a pump attached to 185 feet of drop pipe and the yield was 250 gallons a minute.

The well is equipped with a Cook deep-well pump and the yield as operated was estimated in 1922, from the time required to fill the elevated tank, at about 180 gallons a minute. Many private wells in the village at considerable distance from the village well are said to be affected by pumping from the village well. In 1922 the water level in a well 180 feet deep located several hundred feet from the village well is said to have dropped from a depth of 27 feet below the ground surface to a depth of 79 feet below the ground surface when pumping from the village well.

The temperature of water from the well after the pump was operated for fifteen minutes was 54 degrees Fahrenheit. The comparatively low temperature and the lowering of water in shallow wells indicates that a considerable part of the water is from upper water bearing strata. The water had a mineral content of 368 and a total hardness of 20 parts per million and contained no iron as shown by the analysis of sample number 47769, collected on June 19, 1922.

Analysis of Sample Number 47769 from the Village Supply.

Determinations Made.

	Parts per million.
Iron Fe	0.0
Manganese Mn	0.0
Silica SiO_2	10.0
Nonvolatile	0.3
Alumina Al_2O_3	1.0
Calcium Ca	5.6
Magnesium Mg	1.6
Ammonia NH_4	0.1
Sodium Na	132.3
Potassium K	15.0
Sulfate SO_4	8.5
Nitrate NO_3	0.4
Chloride Cl	17.0
Alkalinity Methyl Orange	298.0
Residue	386.

Hypothetical Combinations.

	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	0.6	.03
Potassium Chloride KCl	28.3	1.65
Sodium Chloride NaCl	5.8	.34
Sodium Sulfate Na_2SO_4	12.6	.74
Sodium Carbonate Na_2CO_3	290.0	16.96
Ammonium Carbonate $(NH_4)_2CO_3$	0.4	.12
Magnesium Carbonate $MgCO_3$	5.5	.32
Calcium Carbonate $CaCO_3$	13.9	.81
Silica SiO_2	10.0	.58
Nonvolatile	0.3	.02
Alumina Al_2O_3	1.0	.06
Total	368.4	21.63

LAWRENCEVILLE (5080). Lawrenceville is located in the central part of Lawrence County on the drainage area of Embarrass River about 5 miles distant from the Wabash River. A public water supply was installed by a private company in 1898. Water was secured from a well about 250 feet deep into sandstone. It was located in the city. The yield was about 20 gallons a minute and this well was the main source of supply for more than ten years.

Shortly after the first well was drilled another well was drilled through the sandstone to a depth of 375 feet to allow the installation of an air lift. The yield of this well was about the same as the yield of the other well but considerable trouble was experienced with this well. Later a third well was drilled. A sample of water number 29896, from a well at the Court House, of about the same depth as the wells which formerly furnished the city supply, had a mineral content of 476, a total hardness of 118, and a content of iron of 0.1 parts per million.

During times of maximum demands some water was obtained from a well located at some distance from the water works. This water is said to have been very hard.

Industrial plants use some water from wells and some from Embarrass River.

With increasing demands the supply of water from the city wells was inadequate. The wells were abandoned and water from the Embarrass River was filtered to furnish a public supply until Christmas Day 1924. At times the water from the river was very salty due to salt water from oil wells on the drainage area. There were great variations in the taste of the water and the supply was not considered satisfactory.

The public water supply is owned by the Central Illinois Public Service Company. Water is secured from a well east of the city and is pumped from the well into a 10-inch pipe line to the city by either of two units. Each unit consists of two Manistee multi-stage centrifugal pumps operated in series, both direct connected to an electric motor. The pumps are operated with automatic control, distant control, or direct hand control. The pumps and equipment are located in a concrete station close to the well. The floor of the station is about five feet below the ground surface and the top is above high water line. The land in the vicinity is flat and at times considerable areas are covered with water. An elevated steel tank of 75,000 gallons capacity located on the grounds of the old plant in the city is connected to the mains. Water is stored in the coagulating basins and clear water basin of the filter plant formerly in use. In case of need this water can be pumped into the mains by two single-stage centrifugal pumps, each driven by an electric motor. The pumps can be operated singly, in parallel, or in series.

The City of Bridgeport is supplied with water from the Lawrenceville supply. Higher pressure is necessary and water is pumped to the city of Bridgeport by a booster pump in the station in the city of Lawrenceville.

Water for the public supply is secured from a well located in the northeast quarter of the southwest quarter of section two, Allison Township, about four miles east of the city and four miles distant from Wabash River. Before choosing this source of supply water from farm wells in the vicinity had been analyzed and a test well had been installed about one mile east of the well now in use and had been tested for yield. The Central Illinois Public Service Company made additional tests and drilled several test holes in order to select a location to insure an ample supply and avoid as much as possible troubles due to fine sand.

Analysis of Sample Number 53156 from the Public Supply.

Determinations Made.

	Parts per million.
Iron Fe	0.0
Manganese Mn	0.0
Silica SiO_2	12.1
Nonvolatile	0.9
Alumina Al_2O_3	0.7
Calcium Ca	57.8
Magnesium Mg	12.6
Ammonia NH_4	0.0
Sodium Na	5.2
Potassium K	2.1
Sulfate SO_4	24.4
Nitrate NO_3	5.3
Chloride Cl	7.0
Alkalinity	
Phenolphthalein	0
Methyl Orange	174.
Residue	214.

Hypothetical Combinations.

	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	5.5	.32
Sodium Nitrate $NaNO_3$	2.7	.16
Sodium Chloride NaCl	11.4	.66
Magnesium Chloride $MgCl_2$	1.8	.11
Magnesium Sulfate $MgSO_4$	30.6	1.78
Magnesium Carbonate $MgCO_3$	22.0	1.28
Calcium Carbonate $CaCO_3$	144.2	8.40
Alumina Al_2O_3	0.7	.04
Silica SiO_2	12.1	.71
Nonvolatile	0.9	.05
Total	231.9	13.51

The well was drilled by the Sickle Water Production Company of Aurora in 1924. The elevation at the top is about 415 feet above sea level. The well is 57 feet deep. Below about 6 feet of sandy loam it is in sand and gravel to the bottom which is on clay. At the top of the well is a concrete pit about 5 feet deep with an opening slightly above the ground surface covered by a steel plate which is screwed down against a gasket. A 36-inch casing extends from the bottom of the pit to a depth of twenty feet. A 24-inch casing extends from a little above the bottom of the pit to a 24-inch screen 40 feet long, in the bottom of the well. When pumping during installation some gravel was placed between the casings. A suction pipe from each of the two pumping units extends into the well. One pumping unit is used at a time and the rate of pumping is about 700 gallons a minute. When not pumping the water level in January, 1925, was about six feet below the ground surface and when pumping it was lowered about six feet. The water level

lowered in one or two minutes and then remained stationary. The total amount of water pumped averaged 300,000 gallons a day. The water level will probably vary with the water level of Wabash River, about four miles distant.

A sample of water from the well supply now in use had a mineral content of 231 and a total hardness of 296 parts per million and contained no iron as shown by the analysis, number 53156.

LEROY (1680). Le Roy is located in the southern part of MeLean County on the drainage area of Sangamon River. A public water supply was installed by the city in 1895. Water was secured from wells. In 1918 the pumping station and wells formerly in use were abandoned and wells were drilled in the northwestern part of the city. Water is pumped from the wells directly into the distribution system. The pumps are driven by either a 25-horsepower electric motor or a 20-horsepower gas engine. Two hundred and twenty-two service connections were in use in 1924. The meter rate for water is 40 cents per 1000 gallons for less than 200,000 gallons used in three months and 30 cents per 1000 gallons for additional quantities with a minimum charge of $1.50 in three months. A penalty of ten per cent is added after ten days.

When the water works was installed two wells were drilled 20 feet apart near the business district. The wells were 8 inches in diameter and 87 feet deep. In 1912 these two wells supplied 31,500,000 gallons of water, an average of 90,000 gallons a day. A 12-inch well was drilled in 1912 to a depth of 90 feet.

The supply from three wells in use in 1918 was inadequate due, at least in part, to an increase in demands following the installation of sewers. One of the old wells was then drilled to a total depth of 321 feet where coal was encountered. Little water was encountered below the bottoms of the old wells. A well was then drilled south of the elevator near the Cleveland, Cincinnati, Chicago and St. Loius Railroad, to a depth of 105 feet. Some water was found but it was quickly pumped out. Next a well was drilled near the corner of Green and White Streets to a depth of 175 feet. It is reported that little water was encountered in the sand penetrated and wells from which the supply is now obtained were then drilled a short distance south of this hole.

Water is secured from three wells drilled by N. J. Ross of Bloomington in 1918. They are located in the northwestern part of the city near the southwest corner of Green and White Streets and are in a row spaced 9 feet 3 inches apart. The tops of the wells

are about 790 feet above sea level. Each well is 86 feet deep. The west well is 12 inches in diameter and the other two are 10 inches in diameter. A sand and gravel stratum from which water is secured is 16 feet thick at the center well and 12 feet thick at the end wells. Each well is equipped with a Cook screen.

The discharge from the west well in 1922 as measured by a meter on the discharge line, was 100 gallons a minute. An American double-acting deep-well pump was installed in this well in 1924. A 7½-inch cylinder was placed at a depth of 76 feet and 8 feet of suction pipe was attached. The discharge was said to be 135 gallons a minute. The meter has since been removed. In 1924 the pump was operated occasionally. The stroke was 24-inches and the speed 22 revolutions a minute. The speed was later reduced to 16 revolutions a minute and the pump was then used daily.

The center well is equipped with a Goulds double-acting deep-well pump with a 5½-inch cylinder placed at a depth of about 71 feet and with about six feet of suction pipe below the cylinder. The pump is operated with 24-inch stroke at a speed of 21 revolutions a minute. The discharge from this well and the east well is measured by a meter and at the time of visit in 1922 the discharge from this well was 75 gallons a minute.

The east well is equipped with a deep-well pump with an Erb 6½-inch cylinder placed at a depth of about 76 feet. The pump is operated with 24-inch stroke at a speed of 20 revolutions a minute. The yield from this well in 1922, with different equipment than given above, was 40 gallons a minute and the total for this well and the center well was 115 gallons a minute. The yield of the two wells in 1924, with equipment as given, was 128 gallons a minute.

During twelve months to March 1, 1923, when all water was metered, the amount of water pumped averaged 92,800 gallons a day. The depth to water in the wells in 1922 and in 1924 was about 36 feet. Pumping from one well had little effect on the water level in the other wells.

Water from the public supply had a mineral content of 464, a total hardness of 405, and a content of iron of 3.6 parts per million as shown by the analysis of sample number 51783, collected on July 8, 1924.

A sample collected from the former. supply in 1910, number 21706, was similar but the iron content was less, 0.8 parts per million. The average iron content in the supply is probably less than the 3.6 parts given.

Analysis of Sample Number 51783 from the Public Supply.

Determinations Made.	Parts per million.
Iron Fe	3.6
Manganese Mn	0.0
Silica SiO_2	21.6
Nonvolatile	1.5
Alumina Al_2O_3	3.1
Calcium Ca	97.1
Magnesium Mg	39.6
Ammonia NH_4	9.0
Sodium Na	8.8
Potassium K	4.5
Sulfate SO_4	0.8
Nitrate NO_3	0.7
Chloride Cl	1.0
Alkalinity Methyl Orange	454.
Residue	458.0

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	1.1	.06
Potassium Chloride KCl	2.1	.12
Potassium Sulfate K_2SO_4	1.4	.08
Potassium Carbonate K_2CO_3	4.8	.28
Sodium Carbonate Na_2CO_3	20.3	1.18
Ammonium Carbonate $(NH_4)_2CO_3$	24.0	1.40
Magnesium Carbonate $MgCO_3$	136.8	7.99
Calcium Carbonate $CaCO_3$	242.5	14.16
Iron Oxide Fe_2O_3	5.1	.30
Alumina Al_2O_3	3.1	.18
Silica SiO_2	21.6	1.26
Nonvolatile	1.5	.09
Total	464.3	27.10

LEAF RIVER (388). Leaf River is located in the northern part of Ogle County on Leaf River, a tributary of Rock River. A public water supply was installed by the village in 1914. Two blocks of water mains had been laid about twenty years earlier and with water from a dug well and pumping equipment of the Chicago, Milwaukee and St. Paul Railway, a limited fire protection had been afforded. The system installed in 1914 included a well equipped with a deep-well pump which was driven by a 14-horsepower gas engine, a distribution system, and an elevated steel tank of 30,000 gallons capacity connected to the system. The tank is located on high ground at some distance from the well. A 15-horsepower electric motor has been installed to drive the pump and the gas engine is used in case of emergency. Water is sold at flat rates.

Water is secured from a well 125 feet deep located near the center of the village. It was drilled by William Piper in 1914. Galena-Platteville limestone was entered at a depth of 20 feet and casing was placed to a depth of 22 feet. The well is equipped with a Keystone Driller Company double-stroke deep-well pump with a 5¾-inch cylinder placed at a depth of 75 feet. Ten feet of suction pipe is attached to the cylinder. The pump is operated with 18-inch stroke at a speed of 25 revolutions a minute, a displacement of 100 gallons a minute. The pump is operated about two hours a day. The water level in 1914 was about 20 feet below the ground surface and in 1923 it was at about the same depth.

The temperature of water when discharged from the well was 50 degrees Fahrenheit. The water had a mineral content of 295 and a total hardness of 256 parts per million as shown by the analysis of sample number 50373, collected on October 23, 1923.

Analysis of Sample Number 50373 from the Village Supply.

Determinations Made.

	Parts per million.
Iron Fe	0.0
Manganese Mn	0.0
Silica SiO_2	23.4
Nonvolatile	1.7
Alumina Al_2O_3	7.1
Calcium Ca	55.4
Magnesium Mg	28.8
Ammonia NH_4	0.0
Potassium K	1.8
Sodium Na	3.3
Sulfate SO_4	16.6
Nitrate NO_3	15.0
Chloride Cl	6.0
Alkalinity Methyl Orange	234.
Residue	345.

Hypothetical Combinations.

	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	4.7	0.27
Sodium Nitrate $NaNO_3$	12.3	0.72
Ammonium Nitrate NH_4NO_3	0.0	0.00
Magnesium Nitrate $Mg(NO_3)_2$	3.8	0.22
Magnesium Chloride $MgCl_2$	8.0	0.47
Magnesium Sulfate $MgSO_4$	20.8	1.21
Magnesium Carbonate $MgCO_3$	75.8	4.43
Calcium Carbonate $CaCO_3$	138.3	8.08
Alumina Al_2O_3	7.1	0.41
Silica SiO_2	23.4	1.37
Nonvolatile	1.7	0.10
Total	295.9	17.28

Plumbing fixtures are stained by iron. Although the sample collected contained no iron, water discharged when the pump is started may contain considerable iron.

LEE (289). Lee is located in Lee and De Kalb Counties on the drainage areas of tributaries of Rock River. A few shallow dug wells in blue clay are in use at residences. A limited public water supply owned by a private company was operated for some years until 1904 when the village took over the water works and made extensive improvements. A 3-inch well 315 feet deep, formerly in use, was abandoned and another well was drilled. Water is pumped from the well into the distribution system to which a steel pressure tank 8 feet in diameter and 36 feet long is connected. The pump is driven by a gas engine.

Water is secured from a well 335 feet deep. It is 6 inches in diameter into hard clay at a depth of about 235 feet and the lower part is 4½ inches in diameter. The bottom of the well is in sand and gravel. The well is cased the entire depth and a screen is placed in the bottom. It is equipped with a single-acting deep-well pump with a 4½-inch cylinder at a depth of 234 feet. In 1919 the pump was operated with 24-inch stroke at a rate of 28 strokes a minute for from five to seven hours a day, a displacement, of 46 gallons a minute and from 14,000 to 20,000 gallons a day.

The water had a mineral content of 274, a total hardness of 147, and a content of iron of 0.4 parts per million as shown by the analysis of sample number 41149, collected on June 4, 1919.

Analysis of Sample Number 41149 from the Village Supply.

Determinations Made.	Parts per million.
Iron Fe	0.4
Silica SiO_2	15.0
Nonvolatile	0.8
Alumina Al_2O_3	1.6
Calcium Ca	29.2
Magnesium Mg	18.0
Ammonia NH_4	0.6
Sodium Na, Potassium K	50.4
Sulfate SO_4	0.0
Nitrate NO_3	4.8
Chloride Cl	4.0
Alkalinity Methyl Orange	240.
Residue	274.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Sodium Nitrate $NaNO_3$	6.8	.40
Sodium Chloride NaCl	6.4	.38
Sodium Carbonate Na_2CO_3	106.0	6.20
Ammonium Carbonate $(NH_4)_2CO_3$	1.4	.08
Magnesium Carbonate $MgCO_3$	62.4	3.65
Calcium Carbonate $CaCO_3$	73.0	4.27
Iron Oxide Fe_2O_3	0.6	.03
Alumina Al_2O_3	1.6	.09
Silica SiO_2	15.0	.88
Nonvolatile	0.8	.05
Sulfates SO_4	trace	trace
Total	274.1	16.03

LELAND (588). Leland is located in the northern part of LaSalle County on the drainage area of Fox River, a tributary of Illinois River. A public water supply was installed by the village in 1915. Water is pumped from a well directly into the distribution system to which an elevated steel tank of 40,000 gallons capacity is connected. The pump is driven by a 15-horsepower electric motor. One hundred and twenty service connections were in use in 1922. The rate for less than 2000 gallons of water a month is 50 cents per 1000 gallons and the lowest rate, for large quantities of water, is 21 cents per 1000 gallons. Electric current is purchased from the Illinois Northern Utility Company.

Water for the public supply is secured from a well 10 inches in diameter and 230 feet deep. It is cased to rock at a depth of about 100 feet. When the well was drilled water stood at a depth of eight feet below the ground surface. The well is equipped with a Goulds deep-well pump. Specifications called for a double-acting pump with 24-inch stroke and 7¾-inch cylinder attached to 100 feet of drop pipe and it is probable that such equipment is in the well. The pump was operated at a speed of 23 revolutions a minute until the water level was drawn down to the pump cylinder. The speed has been reduced to 11½ revolutions a minute, a displacement of about 100 gallons a minute. In 1921-1922 the pump was operated an average of six hours a day.

The water had a mineral content of 325, a total hardness of 302, and a content of iron of 1.6 parts per million as shown by the analysis of sample number 47191, collected on March 9, 1922.

Analysis of Sample Number 47191 from the Village Supply.

Determinations Made.	Parts per million.
Iron Fe	1.6
Manganese Mn	0.1
Silica SiO_2	8.3
Nonvolatile	0.8
Alumina Al_2O_3	1.5
Calcium Ca	69.9
Magnesium Mg	31.1
Ammonia NH_4	0.8
Sodium Na	10.3
Potassium K	1.2
Nitrate NO_3	3.0
Chloride Cl	1.0
Alkalinity	
Methyl Orange	324.0
Residue	323.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	3.1	.18
Sodium Nitrate $NaNO_3$	1.4	.08
Sodium Chloride NaCl	1.6	.09
Sodium Carbonate Na_2CO_3	21.3	1.25
Ammonium Carbonate $(NH_4)_2CO_3$	2.1	.12
Magnesium Carbonate $MgCO_3$	107.7	6.29
Calcium Carbonate $CaCO_3$	174.4	10.20
Silica SiO_2	8.3	.48
Nonvolatile	0.8	.05
Iron Oxide Fe_2O_3	2.3	.13
Alumina Al_2O_3	1.5	.09
Total	325.5	18.96

Plumbing fixtures are stained by the iron in the water.

LEMONT. (2322). Lemont is located in the southwestern part of Cook County on the southeast side of Des Plaines River and the Chicago Sanitary and Ship Canal. A public water supply was installed by the village about 1882. Water was secured from a well 1366 feet deep. Later another well was drilled to a greater depth. A number of changes in pumping equipment have been made. One well was in use in 1924 and it was equipped with an air lift. Water was discharged into a steel tank 24 feet 6 inches in diameter and 11 feet deep. Air was supplied by an Ingersoll-Rand 9 by 8-inch compressor which was driven by a 25-horsepower electric motor. Water was pumped from the tank into the distribution system by a Platt Iron Works 7 by 8-inch triplex pump which was driven by a 15-horsepower electric motor. An equalizing reservoir built on high ground is connected to the distribution system. The reservoir is built of stone and reinforced concrete and is 36 feet in diameter and 32 feet deep. At the side of the reservoir is a small pumping station which houses a Platt Iron Works 6-inch centrifugal pump and an electric motor. This pump may be used to pump from the reservoir into the mains at high pressure at times of fire or other emergency. Power is purchased from the Public Service Company of Northern Illinois.

Five hundred service connections were in use in 1924. The rates per 1000 gallons are $1.00 for the first 10,000 gallons, 60

cents for the next 10,000 gallons, 50 cents for the next 10,000 gallons, 20 cents for the next 30,000 gallons, and 15 cents for all water over 60,000 gallons.

When the original well was drilled water flowed to the ground surface. The U. S. Geological Survey seventeenth annual report gives the head as about 60 feet above the ground surface. In 1916 the well, then equipped with an air lift with a 1½-inch air line to a depth of 100 feet, yielded 35 or 40 gallons a minute. A few years later this well was abandoned.

The other well was drilled to a depth of 2000 feet or more. Rock was entered a foot or two below the ground surface. The well was eight or ten inches in diameter at the top and six inches in diameter at the bottom. It was probably cased to a depth of a little more than 300 feet. In 1916 when pumping from the well with a deep-well pump with the cylinder placed at a depth of 85 or 90 feet the discharge was 160 gallons a minute. The well was later equipped with an air lift. In 1923 the air lift discharged 142 gallons a minute for one hour. During November, 1923, the air lift operated an average of 15½ hours a day. The amount of water pumped was estimated at 120,000 gallons a day. The depth to water when not pumping was about 60 feet for several years until 1924. In-that year when the air lift equipment dropped it was fished out from a depth of 325 feet and while repairs were made the water raised to within 40 feet of the top. In October, 1924, with an air line to a depth of 291 feet the yield was good for a few days and then rapidly decreased to practically zero.

Analysis of Sample Number 50674 from the Deeper City Well.

Determinations Made.	Parts per million.
Iron Fe	0.4
Manganese Mn	0.0
Silica. SiO_2	15.8
Nonvolatile	5.2
Alumina Al_2O_3	3.0
Calcium Ca.	66.2
Magnesium Mg	17.8
Ammonia NH_4	0.6
Potassium K	62.0
Sodium Na	306.4
Sulfate SO_4	34.8
Nitrate NO_3	1.4
Chloride Cl	500.0
Alkalinity Methyl Orange	244.
Residue	1299.6

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	2.3	.13
Potassium Chloride KCl	117.1	6.84
Sodium Chloride NaCl	733.1	42.81
Sodium Sulfate Na_2SO_4	51.2	3.06
Sodium Carbonate Na_2CO_3	3.5	.21
Ammonium Carbonate $(NH_4)_2CO_3$	1.7	.09
Magnesium Carbonate $MgCO_3$	61.6	3.70
Calcium Carbonate $CaCO_3$	165.4	9.65
Iron Oxide Fe_2O_3	0.6	.04
Alumina Al_2O_3	3.0	.18
Silica SiO_2	15.8	.95
Nonvolatile	5.2	.31
Total	1160.5	67.97

The temperature of water when discharged from the deeper well by air lift in 1923 was 66 degrees Fahrenheit. The water had a mineral content of 1160, a total hardness of 238, and a content of iron of 0.4 parts per million as shown by the analysis of sample number 50674, collected on December 5, 1923.

A sample of water, number 36301, collected in 1916 from the original well (1300 ? feet deep) had a mineral content of 1120, a total hardness of 271, and a content of iron of 1.7 parts per million.

In October, 1924, the village was without water. Equipment was then installed to pump water from a stone quarry located about one mile northeast of the village. This water had a mineral content of 526 and a total hardness of 458 as shown by the analysis of sample number 52718, collected on October 24, 1924.

Analysis of Sample Number 52718 from Stone Quarry.

Determinations Made.	Parts per million.
Iron Fe	0.0
Manganese Mn	0.0
Silica SiO_2	14.
Calcium Ca	97.1
Magnesium Mg	52.4
Ammonia NH_4	0.0
Sodium Na_4*	12.9
Sulfate SO_4	148.9
Nitrate NO_3	1.8
Chloride Cl	11.0
Alkalinity Methyl Orange	314.
Residue	546.

* Inclues potassium.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Sodium Nitrate $NaNO_3$	2.4	0.14
Sodium Chloride NaCl	18.2	1.06
Sodium Sulfate Na_2SO_4	15.9	0.93
Ammonium Sulfate $(NH_4)_2SO_4$	0.1	0.01
Magnesium Sulfate $MgSO_4$	172.9	10.10
Magnesium Carbonate $MgCO_3$	60.4	3.53
Calcium Carbonate $CaCO_3$	242.5	14.16
Iron Oxide Fe_2O_3	0.0	0.00
Silica SiO_3	14.0	0.82
Manganese Oxide MnO	0.0	0.00
Total	526.4	30.75

This water is less highly mineralized and harder than water from the deep well.

Water from a well into limestone 360 feet or more deep at the plant of the Aluminum Products Company is more highly mineralized and softer than the quarry water but less highly mineralized and harder than the deep well water. A sample, number 52719, had a mineral content of 737 and a total hardness of 297 parts per million.

LENA (1149). Lena is located in the western part of Stephenson County on the drainage area of Pecatonica River. A public water supply was installed by the town in 1895. Water is pumped from a well into a collecting reservoir 49 feet 6 inches in diameter. In 1923 an air lift was in use and air was supplied by an Ingersoll-Rand 10 by 10-inch compressor driven by a 40-horsepower electric motor. Water is pumped from the reservoir into the distribution

system, to which an elevated wooden tank 20 feet in diameter and 24 feet high is connected, by a 5 by 16-inch single-acting triplex pump which is driven by a 10-horsepower electric motor. Electric power is purchased from the Wisconsin Power Company.

Three hundred and fifty service connections were in use in 1923 and all were metered. The rates for three months are 30 cents per 1000 gallons for the first 5000 gallons, 25 cents per 1000 gallons for the next 5000 gallons, and 20 cents per 1000 gallons for water in excess of 10,000 gallons, with a minimum charge of $1.50.

The public water supply is from a well 604 feet deep. The elevation of ground surface at the well is about 695 feet above sea level. A record of material penetrated, furnished by the town, is as follows:

	Thickness in feet.	Depth in feet.
.....	...	....
Limestone, Galena-Platteville.....	...	400
.....	...	....
Sandstone, red	25	500
Sandstone, St. Peter.....	104	604

Analysis of Sample Number 50250 from the Town Supply.

Determinations Made.

	Parts per million.
Iron Fe	0.0
Manganese Mn	0.0
Silica SiO_2	24.2
Nonvolatile	0.7
Alumina Al_2O_3	0.6
Calcium Ca	82.7
Magnesium Mg	51.3
Ammonia NH_4	0.0
Sodium Na	33.2
Potassium K	17.1
Sulfate SO_4	66.9
Nitrate NO_3	2.6
Chloride Cl	16.0
Alkalinity Methyl Orange ...	370.0
Residue	507.

Hypothetical Combinations.

	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	43.3	2.53
Potassium Chloride KCl.....	0.6	0.03
Sodium Chloride NaCl.....	25.8	1.51
Sodium Sulfate Na_2SO_4.....	71.1	4.15
Ammonium Sulfate $(NH_4)_2SO_4$..	0.1	0.01
Magnesium Sulfate $MgSO_4$.....	23.5	1.37
Magnesium Carbonate $MgCO_3$..	161.3	9.42
Calcium Carbonate $CaCO_3$ 206.5		12.06
Alumina Al_2O_3	0.6	0.03
Silica SiO_2	24.2	1.41
Nonvolatile	0.7	0.04
Total	557.7	32.56

A large part of the water secured is said to be from the lower fifteen feet of the well. The well is 10 inches in diameter to a depth of 300 feet and 6 inches in diameter below that depth. It is cased to a depth of 150 feet. In 1913 the depth to water when not pumping was reported to be 127 feet. It was also reported that the supply of water available had decreased since a well of the same depth, a block away, had been put in service by the Illinois Central Railroad. Equipment in the town well has been changed several times. In

1923 an air lift was in use with 200 feet of 1½-inch and 80 feet of ¾-inch air pipe, the bottom at a depth of 280 feet. The discharge on October 8, 1923, when the air lift was operated for one hour, was 90 gallons a minute. The depth to water when the air lift had not operated for 10 hours was 70 feet and the water was said to be lowered to a depth of 134 feet when pumping. The amount of water pumped was estimated at 40,000 gallons a day.

A sample of water, number 50250, collected at the well on October 8, 1923, after the air lift had been operated for 30 minutes, had a mineral content of 557 and a total hardness of 416 parts per million and contained no iron, as shown by the analysis.

LEONORE (189). Leonore is located in the southwestern part of La Salle County on the drainage area of Vermilion River, a tributary of Illinois River. Many private wells about 30 feet deep are in use. A public water supply was installed in 1900 and was sold to the village the following year. The village then dug a well and abandoned a well which had been in use. Water is pumped from the well into the mains and a steel pressure tank 8 feet in diameter and 36 feet long, connected to the mains, by a 6 by 8-inch single-acting triplex pump. Eleven service connections were in use in 1925. The rate is 50 cents a month.

The public water supply is secured from a well located near the center of the village. The well is 10 feet in diameter and 34 feet deep. The materials penetrated are as follows:

	Thickness in feet.	Depth in feet.
Loam	4	4
Yellow clay and gravel	11	15
Clay, blue	7	22
Thin layer of hardpan	1	23
Hard clay, blue	9	32
Gravel	2	34
Bottom of gravel		36

In 1923 the triplex pump which draws water from the well was operated about ten minutes a day. The water level when not pumping has been, for several years, 22 feet below the ground surface.

The water had a mineral content of 432, a total hardness of 325, and a content of iron of 0.2 parts per million as shown by the analysis of sample number 38595, collected on December 21, 1917.

Analysis of Sample Number 38595 from the Village Supply.

Determinations Made.	Parts per million.
Iron Fe	0.2
Silica SiO_2	9.3
Alumina Al_2O_3	1.0
Calcium Ca	68.3
Magnesium Mg	37.9
Ammonia NH_4	0.0
Sodium Na	45.6
Potassium K	5.8
Sulfate SO_4	5.0
Nitrate NO_3	5.3
Nitrite NO_2	0.0
Chloride Cl	3.0

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	8.6	.50
Potassium Chloride KCl	4.8	.28
Sodium Chloride NaCl	1.1	.06
Sodium Sulfate Na_2SO_4	7.4	.43
Sodium Carbonate Na_2CO_3	98.4	5.75
Magnesium Carbonate $MgCO_3$	131.2	7.64
Calcium Carbonate $CaCO_3$	170.5	9.95
Iron Oxide Fe_2O_3	0.3	.02
Alumina Al_2O_3	1.0	.06
Silica SiO_2	9.3	.54
Total	432.6	25.23

LEWISTOWN (2279). Lewistown is located in the central part of Fulton County on the drainage area of Spoon River, a tributary of Illinois River. A public water supply was installed by the city in 1888. Water was secured from wells in bottom lands of Spoon River. The original wells have been abandoned and other wells have been installed nearby. Water is pumped from the wells through an 8-inch pipe line to the city by either of two 8 and 12 by 7 by 12-inch duplex steam pumps, one a Canton-Hughes and the other an Epping-Carpenter. A steel tank of 80,000 gallons capacity is connected to the distribution system. Steam is supplied by two 50-horsepower fire-tube boilers.

The rate for water for three months per 1000 gallons is 40 cents for the first 10,000 gallons, 35 cents for the next 10,000 gallons, 30 cents for the next 10,000 gallons, 25 cents for the next 10,000 gallons, 20 cents for the next 10,000 gallons, and 15 cents for water in excess of 50,000 gallons. Bills are subject to a 20 per cent discount for prompt payment.

Water is secured from four wells in bottom lands of Spoon River about 2½ miles southwest of the city, one mile from the river channel near the edge of the valley, and about 400 feet distant from Speedway Creek, a small tributary of the river. The upper four feet of material in the bottom lands is loam and below that is fine sand to a depth of about 30 feet where rock is encountered.

The oldest well in use, installed in 1911, is 12 feet in diameter and 25 feet deep. The top is drawn in to a diameter of 4½ feet add carried up above high water level. The well was constructed by building a brick wall on a steel shoe and lowering the shoe by excavating below it. The wall, from 1 foot to 5 feet above the

bottom, is of porous brick laid without cement and with sand the size of wheat in the spaces between the brick around the outside. In 1913 when the entire supply was from this well the average amount of water pumped was estimated at 100,000 gallons a day.

Three additional wells were installed in 1920. Each is of about the same depth as the old well. In constructing a well a 12-inch casing was first placed, an 8-inch casing and a Cook screen were then placed in the 12-inch pipe, sand the size of wheat was then placed around the screen, and the 12-inch casing was withdrawn. A 4-inch suction pipe extends into each well and the space between the 4-inch pipe and the top of the 8-inch pipe is closed with screw pipe fittings. At the time of visit in 1921 a pump was operating at 40 revolutions a minute, a displacement of 310 gallons a minute. A pump is said to run at times at more than 60 revolutions a minute, a displacement of more than 460 gallons a minute.

A sample, number 46149, collected on September 22, 1921, had a mineral content of 434 and a total hardness of 325 parts per million and contained no iron as shown by the analysis.

Analysis of Sample Number 46149 from the City Supply.

Determinations Made.	Parts per million.
Iron Fe	0.0
Manganese Mn	0.0
Silica SiO_2	12.4
Nonvolatile	0.8
Alumina Al_2O_3	1.0
Calcium Ca	74.8
Magnesium Mg	33.8
Ammonia NH_4	0.0
Potassium K	3.0
Sodium Na	30.1
Sulfate SO_4	104.2
Nitrate NO_3	1.8
Chloride Cl	9.0
Alkalinity Methyl Orange	254.
Residue	460.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	2.9	.17
Potassium Chloride KCl	3.4	.20
Sodium Chloride NaCl	12.2	.71
Sodium Sulfate Na_2SO_4	78.1	4.57
Ammonium Sulfate $(NH_4)_2CO_3$	0.2	.01
Magnesium Sulfate $MgSO_4$	64.1	3.75
Magnesium Carbonate $MgCO_3$	72.1	4.22
Calcium Carbonate $CaCO_3$	186.9	10.93
Silica SiO_2	12.4	.72
Nonvolatile	0.8	.05
Iron Oxide Fe_2O_3	0.0	0.00
Alumina Al_2O_3	1.0	.06
Total	434.1	25.38

A sample collected on April 23, 1914, was similar. The mineral content was 358, the total hardness 305, and the content of iron 0.2 parts per million.

A well 2245 feet deep in a creek valley about three miles northwest of the city was drilled for J. B. Depler by W. H. Gray and Brother. Shale and coal measures were entered at a depth of 39 feet and limestone was entered at a depth of 130 feet. At a depth of 600 feet a flow of water with considerable sulphur was recorded.

Between depths of 1000 and 1100 feet were cavities through which the drill would drop from 6 to 18 inches. Water flows from the well through a swimming pool and from the time required to fill the pool the flow was given in 1917 as about 770 gallons a minute. This does not include some water which flows to the ground surface around the casing of the well. Some persons report that when the well reached a depth of 1100 feet the flow was 1500 gallons a minute and that later some water formed a channel below the ground surface to the creek valley. Mr. Deper noticed on great change in the flow. A sample of water, number 12808, collected from this well in 1904 had a mineral content of 2138 and a total hardness of 515 parts per million.

LEXINGTON (301). Lexington is located in the northeastern part of McLean County on the drainage area of Mackinaw River, a tributary of Illinois River. A public water supply was installed by the village about 1894. Water was first secured from one well and later another well was drilled. Each well is equipped with a deep-well pump which discharges directly into the distribution system. An elevated steel tank located close to the wells is connected to the system. Each pump is driven by belt from a shaft which is driven by a 15-horsepower electric motor. The motor is not large enough to drive both pumps at the same time. In case of emergency the shaft can be driven by a 20-horsepower gas engine which was formerly in regular service. The meter rate for water is 35 cents per 1000 gallons.

Water for the public supply is secured from two wells into sand and gravel. They are located fourteen feet apart. The elevation at the top of the wells is about 750 feet above sea level. One well was drilled about 1894. It is 10 inches in diameter and 115 feet deep. The other well was drilled in 1902 to the east of the older well and is 8 inches in diameter and 115 feet deep. A Cook screen 15 feet long is placed in the bottom of each well. The larger well is equipped with a single-acting deep-well pump with a 9¾-inch cylinder. It is operated with 24-inch stroke at a speed of 25 strokes a minute. The smaller well is equipped with a single-acting deep-well pump with a 7¼-inch cylinder. It is operated with 24-inch stroke at 23 strokes a minute. The amount of water pumped was estimated in 1924 at about 40,000 gallons a day. The depth to water when not pumping was reported to be 40 feet in 1914 and was thought to be about 50 feet in 1921.

The water had a mineral content of 390, a total hardness of 303, and a content of iron of 1.4 parts per million as shown by the analysis of sample number 51171, collected on March 25, 1924, after a pump had operated for one hour.

Analysis of Sample Number 51171 from the Village Supply.

Determinations Made.	Parts per million.
Iron Fe	1.4
Manganese Mn	0.0
Silica SiO_2	19.3
Nonvolatile	1.1
Alumina Al_2O_3	0.6
Calcium Ca	72.2
Magnesium Mg	29.8
Ammonia NH_4	14.4
Potassium K	3.1
Sodium Na	15.2
Sulfate SO_4	14.5
Nitrate NO_3	0.5
Chloride Cl	1.0
Alkalinity Methyl Orange	357.
Residue	390.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	0.9	.05
Potassium Chloride KCl	2.1	.12
Potassium Sulfate K_2SO_4	3.7	.22
Sodium Sulfate Na_2SO_4	18.4	1.08
Sodium Carbonate Na_2CO_3	21.2	1.24
Ammonium Carbonate $(NH_4)_2CO_3$	38.3	2.24
Magnesium Carbonate $MgCO_3$	103.0	6.02
Calcium Carbonate $CaCO_3$	179.8	10.46
Iron Oxide Fe_2O_3	2.0	.12
Alumina Al_2O_3	0.6	.04
Silica SiO_2	19.3	1.13
Nonvolatile	1.1	.06
Total	390.4	22.78

A sample collected in 1914 was similar. Meters are clogged by a deposit containing iron and in 1924 it was reported that about twenty-four meters are repaired in a year. The water stains plumbing fixtures.

LIBERTYVILLE (2125). Libertyville is located in the central part of Lake County on the drainage area of Des Plaines River. Gravel outcrops near the eastern limits of the village and has been excavated to a depth of from 20 to 40 feet from an area of 20 acres or more.

A public water supply was installed by the village in 1905. Water was first secured from a 4-inch well, 170 feet deep, into sand and gravel. The well is located in the pumping station on the north side of Sprague Street west of Second Street. Water from the well flowed into a reservoir of about 70,000 gallons capacity from which it was pumped into the mains. A short time after this well was drilled a 5-inch well was drilled in Second Street 120 feet distant from the 4-inch well. The 5-inch well is 180 feet deep. The two wells are equipped with air lifts. An 8-inch well 180 feet deep located 50 feet distant from the 5-inch well and 70 feet distant from the 4-inch well was drilled about 1910. A well 8 inches in diameter and 240 feet deep was drilled in 1921. This

well is about 50 feet distant from the 4-inch well, the nearest of the old wells. It is cased to rock at a depth of 200 feet. This well is equipped with a deep-well pump which discharges directly into the distribution system. The pump is driven by a 10-horse-power electric motor. An elevated steel tank of 65,000 gallons capacity is connected to the system. Water from the older wells is discharged into the reservoir and is pumped from the reservoir into the mains by a Goulds 8¼ by 10-inch triplex pump.

The water consumption in 1912 was estimated at nearly 30,000 gallons a day. At that time the three wells into sand and gravel were in use and air lift equipment had been installed in the 4-inch and 5-inch wells. In October, of that year it was reported that the air lifts had been operated only once during the preceeding year, the natural flow from the wells being sufficient to supply demands at all other times.

More than 600 service connections were in use in 1925. The meter rate for 25,000 gallons or less in three months is 35 cents per 1000 gallons. The lowest rate, charged when 125,000 gallons or more is used, is 25 cents per 1000 gallons. These rates are subject to a discount of 10 cents per thousand gallons if bills are paid promptly and the minimum charge is $1.00 every three months.

The water consumption in 1912 was estimated at nearly 30,000 gallons a day. At that time the three wells into sand and gravel were in use and air lift equipment had been intalled in the 4-inch and 5-inch wells. In October of that year it was reported that the air lifts had been operated only once during the preceding year, the natural flow from the wells being sufficient to supply demands at all other times.

In June 1921 the 5-inch and 8-inch wells into sand were in use and the water consumption was said to be about 140,000 gallons a day (this is probably high for average consumption). The yield of the 5-inch well with the air lift operating was said to be from 200 to 300 gallons a minute. A 6-inch casing with a Johnson strainer had been placed in the 8-inch well and a pump had been installed. The yield was small and the pump had been removed. Sand may have been drawn into the well against the strainer, thus clogging the well.

The well drilled in 1921 was tested when drilled into sand. All sand encountered was very fine and no screen was placed for the test. The amount of water secured was small. When the well was completed it is reported that it was pumped at a rate of 70 gallons a minute and that the water level was lowered 35 feet. Air

lift equipment was then installed using the 8-inch casing for a discharge pipe. Little water was secured as the discharge line was too large. The well was tested at the time of visit on June 26, 1921. Pumping for ten minutes at a rate of 45 gallons a minute lowered the water level from two feet above the ground surface to 85 feet below the ground surface. Continued pumping at the same rate for 15 minutes and then pumping at a rate of 60 gallons a minute for 15 minutes lowered the water level in the well to 123 feet below the ground surface. At this time the test was stopped by a break down. The inflow during the next nine minutes, during which time the water level raised to within eight feet of the ground surface, averaged 35 gallons a minute. The air lift in the 5-inch well 115 feet distant was started at the beginning of this test and was operated until after the test was completed.

In 1922 the 8-inch well into rock and the 4-inch and 5-inch wells into sand and gravel were in use. The parties in charge of the water works estimated the yield of the 8-inch well at 33 gallons a minute and the yield of the 4-inch and 5-inch wells equipped with air lift at 230 gallons a minute. During nine hours at night the natural flow from the 4-inch and 5-inch wells raised the water level in the reservoir about two feet, a flow of about 20 gallons a minute. The total amount of water pumped, estimated from the above and time of operation, was 110,000 gallons a day.

Water from the wells into sand had a mineral content of 666, a total hardness of 336, and a content of iron of 0.8 parts per million as shown by the analysis of sample number 38318, collected on October 15, 1917.

Analysis of Sample Number 38318 from Village Wells into Sand.

Determinations Made.	Parts per million.
Iron Fe	0.8
Silica SiO_2	15.6
Alumina AlO_3	4.7
Calcium Ca	70.8
Magnesium Mg	38.9
Ammonia NH_4	0.3
Sodium Na	78.8
Potassium K	8.0
Sulfate SO_4	364.6
Nitrate NO_3	1.2
Chloride Cl	4.0
Alkalinity Methyl Orange	110.
Residue	730.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	1.9	.11
Potassium Chloride KCl	8.4	.49
Potassium Sulfate K_2SO_4	6.5	.38
Sodium Sulfate Na_2SO_4	243.0	14.17
Magnesium Sulfate $MgSO_4$	192.2	11.20
Calcium Sulfate $CaSO_4$	61.6	3.58
Calcium Carbonate $CaCO_3$	131.0	7.64
Iron Oxide Fe_2O_3	1.1	.06
Alumina Al_2O_3	4.7	.27
Silica SiO_2	15.6	.91
Total	666.0	38.81

Water from the well into rock is similar in quality. A sample collected at the time of test on June 16, 1921, had a mineral content of 670, a total hardness of 348, and a content of iron of 2.6 parts per million. The comparatively high iron content was probably due to iron from the well casing and pump equipment.

LINCOLN (11882). Lincoln is located in the central part of Logan County on the drainage area of Salt Creek, a tributary of Sangamon River. A public water supply was installed in 1886-1887. The plant is now owned by the Lincoln Light and Water Company. Water was first secured from a dug well near the bank of Salt Creek south of the city. Later additional wells and a collecting gallery were installed. Water is pumped from the wells directly into the distribution system by four pumps located about 2000 feet distant from the wells. Two suction lines are in use, one 14 inches in diameter and the other 24 inches in diameter. Two of the pumps are Snow 14 and 20 by 12 by 16-inch tandem-compound duplex steam pumps of 1,500,000 gallons capacity each. One is a 7 3/8 by 16-inch Hamilton pump of 1,250,000 gallons capacity which is driven by belt from a shaft turned by a 75-horsepower motor. The other is a De Lava1 direct-connected motor-driven two-stage centrifugal of 1,500,000 gallons daily capacity. Steam to operate the steam pumps and electric machinery is supplied by two 350-horsepower, one 250-horsepower, and one 125-horsepower boilers. A steel standpipe 16 feet in diameter and 100 feet high is connected to the distribution system.

More than 2000 service connections were in use in 1921 and during the summer the water consumption averaged about 1,200,000 gallons a day. The meter rates for one month are 20 cents per 100 cubic feet for the first 1000 cubic feet, 9½ cents per 100 cubic feet for the next 99,000 cubic feet, and 5 cents per 100 cubic feet for all over 100,000 cubic feet. The minimum gross charge depends upon the size of the meter. It is $0.67 for 5/8-inch or smaller meter and $45.00 for 6-inch meters. A discount of 10 per cent is allowed for prompt payment.

The public water supply is secured from wells and a collecting gallery located near Salt Creek a short distance south of the city. At this location sand and gravel is entered a short distance below the ground surface and a large gravel pit has been excavated to within about 125 feet of the nearest well. One well is 26 feet in diameter to a depth of 16 feet. In this large well tubular wells have been driven to a depth of 27 feet below the ground surface

and other tubes have been driven out horizontally three feet above the bottom of the large well. The elevation at the top of this well is 51.8, about 7 feet above ordinary water level in the creek. Another well, to the north and 60 feet distant, is 12 feet in diameter and the bottom is at elevation 30. These two wells are connected by a 14 and 16-inch pipe line. A third well to the south and about in line with the two described and, at the nearest point, about 15 feet distant from the well 26 feet in diameter, is 14 feet wide and 46 feet long. It is connected to the 26-foot well by a 12-inch pipe line. The bottom is at elevation 37. A fourth well or infiltration gallery is located on the opposite side of the creek to the west of and about 160 feet distant from the other three wells. It is 12 feet wide, 92 feet long, and 12 feet deep inside. The bottom is at elevation 33.3. The stream at times flows against one side of this gallery. A line of 30-inch tile laid along the bank of the stream a distance of about 150 feet, collects water which flows ino this infiltration gallery. A 16-inch line connects the gallery and 12-foot circular well and also connects directly with a suction line to the pumps.

A sample, number 45434, collected on June 18, 1921, had a mineral content of 334 and a total hardness of 278 parts per million as shown by the analysis.

Analysis of Sample Number 45434 from the City Supply.

Determinations Made.	Parts per million.
Iron Fe	trace
Manganese Mn	trace
Silica SiO_2	8.9
Nonvolattle	1.0
Alumina Al_2O_3	1.6
Calcium Ca	64.3
Magnesium Mg	28.8
Ammonia NH_4	0.0
Potassium K	1.1
Sodium Na	16.8
Sulfate SO_4	49.3
Nitrate NO_3	3.9
Chloride Cl	9.0
Alkalinity	
Phenolphthalein	0
Methyl Orange	244.
Residue	345.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	2.8	.16
Sodium Nitrate $NaNO_3$	3.0	.17
Sodium Chloride NaCl.	14.8	.86
Sodium Sulfate Na_2SO_4	31.3	1.83
Ammonium Sulfate $(NH_4)_2SO_4$	0.1	.01
Magnesium Sulfate $MgSO_4$	35.1	2.05
Magnesium Carbonate $MgCO_3$	75.0	4.39
Calcium Carbonate $CaCO_3$	160.6	9.39
Silica SiO_2	8.9	.52
Nonvolatile	1.0	.06
Alumina Al_2O_3	1.6	.09
Total	334.2	19. 53

The mineral content of the supply varies slightly from time to time. Other samples have been similar to that for which analysis is given above. The iron content has varied from a trace to 0.2 parts per million.

LITTLE YORK (355). Little York is located in the northwestern part of Warren County on the drainage area of Henderson River, a tributary of Mississippi River. Many private wells in the village and vicinity are 20 or 30 feet deep and others, from which a softer water is said to be obtained, are drilled to the bottom of blue clay at the top of a stratum of soapstone. A few wells extend through the soapstone into limestone. The Chicago, Burlington and Quincy Railroad has a private supply at this place. Water is taken from Cedar Creek about half a mile west of the village. Water from the stream is of poor quality as it is polluted by sewage from Galesburg and Monmouth.

A public water supply was installed by the village in 1915. Water is pumped from a well directly into the mains by an American deep-well pump driven by a 5-horsepower electric motor. Mains 4 inches in diameter extend to practically all parts of the village and an elevated steel tank is connected to the mains. Electric power is purchased from S. Pardee who operates an electric plant in the village. In January, 1923, forty-nine service connections were in use and the amount of water used during the previous year was estimated to average a little more than 4000 gallons a day. The rate for small quantities of water is 35 cents per 1000 gallons and practically all water sold is sold at this rate. The minimum charge for three months is $3.00

Analysis of Sample Number 39773 from the Village Supply.

Determinations Made.	Parts per million.
Iron Fe	0.4
Manganese Mn	0.0
Silica SiO_3	2.6
Nonvolatile	1.6
Alumina Al_2O_3	0.1
Calcium Ca	18.1
Magnesium Mg	12.1
Ammonia NH_4	0.1
Sodium Na	528.6
Sulfate SO_4	399.0
Nitrate NO_3	4.4
Chloride Cl	232.6
Alkalinity Methyl Orange	474
Residue	1535
Carbon Dioxide CO_2	2.0

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Sodium Nitrate $NaNO_3$	60.6	3.51
Sodium Chloride NaCl	383.3	22.25
Sodium Sulfate Na_2SO_4	589.4	34.19
Sodium Carbonate Na_2CO_3	391.1	22.69
Ammonium Carbonate $(NH_4)_2CO_3$	0.2	.01
Magnesium Carbonate $MgCO_3$	41.8	2.42
Calcium Carbonate $CaCO_3$	45.1	2.61
Iron Carbonate $FeCO_3$	0.8	.05
Alumina Al_2O_3	0.1	.01
Silica SiO_2	2.6	.15
Nonvolatile	1.6	.09
Total	1516.6	88.12

Water is secured from a 6-inch well 326 feet deep, located in the business district. The elevation at the top of the well is about 625 feet above sea level. It was drilled by Mr. Van Tuyl in 1915 who states that the well penetrated 66 feet of soil and clay,

78 feet of blue shale, 56 feet of soapstone, and 126 feet of limestone. The well cost $1200. The well is equipped with an American double-acting deep-well pump. A 4½-inch cylinder was first placed at a depth of 160 feet and was later lowered to a depth of 260 feet. The cylinder was then replaced by a 3½-inch cylinder which was placed at less depth. In 1923 the pump was operating 28 revolutions a minute and the yield was said to be 2000 gallons an hour. The depth to water when the well was completed was 40 or 50 feet and when measured in 1922 it was about 45 feet.

The water had a mineral content of 1516, a total hardness of 95, and a content of iron of 0.4 parts per million as shown by the analysis of sample number 39773, collected on July 16, 1918.

LOCKPORT (2684). Lockport is located in the northern part of Will County on the east bank of Des Plaines River. A public water supply was installed by the city in 1896. Water is secured from a well equipped with an air lift which discharges into a reservoir 42 feet in diameter and 19 feet deep. Air is supplied by either of two compressors, one an Ingersoll-Rand driven by a 50-horsepower electric motor, and the other a Sullivan 12 by 12-inch with a displacement of 350 cubic feet a minute when operating 200 revolutions a minute, driven by a 60-horsepower electric motor. Water is pumped from the reservoir into the mains by either of two pumps, one a single-stage Dayton-Dowd centrifugal pump of 1000 gallons a minute capacity which is connected directly to a 75-horsepower electric motor and the other a two-stage Dayton-Dowd centrifugal pump of 1000 gallons a minute capacity which is connected directly to an 85-horsepower gas engine. Electric current is purchased from the Public Service Company of Northern Illinois.

Four hundred and fifty-five service connections were in use in 1922 and the average consumption from April to September inclusive was about 180,000 gallons a day. Approximately one-quarter of this total was used by the Northern Illinois Cereal Company. Water is sold at a rate of $5.00 for the first 8000 gallons used in three months, 70 cents per 1000 gallons for the next 5000 gallons, and 60 cents per 1000 gallons for water in excess of 13,000 gallons. Bills are subject to a ten per cent cash discount.

The cereal company secures a small part of its supply from a 6-inch private well 810 feet deep. The Barrows Lock Company uses water from a private well 4 inches in diameter and 88 feet deep. It is cased to rock which is close to the surface. The well is equipped with a steam-head deep-well pump which, in 1923, was

operated from 10 to 16 hours a day and the discharge was said to be 1000 gallons an hour.

Water for the public supply is secured from a well located near the bank of Des Plaines River at Ninth Street. The elevation of the top of the well casing is 570 feet above sea level. The well was drilled by the J. P. Miller Artesian Well Company of Chicago in 1895. A record of material penetrated, furnished by the driller, with part of the classication by the State Geological Survey Division, is as follows:

	Thickness in feet.	Depth in feet.
Surface	3	3
Limestone	200	203
Shale, Richmond	87	290
Limestone, Galena	245	535
Limestone, hard brown, Platteville	95	630
Sandstone, St. Peter	230	860
Caving shale and red marl, Prairie du Chien	60	920
Limestone, sandy, Prairie du Chien	280	1200
Limestone, hard, Prairie du Chien	75	1275
Limestone, sandy, Prairie du Chien	55	1320
Sandstone, Mazomanie-Dresbach, Cambria nsystem	155	1475
Shale, sandy, Eau Claire, Cambrian system	75	1550
Marl, red, Eau Claire, Cambrian system	55	1605
Shale, Eau Claire, Cambrian system	155	1850
Sandstone, waterbearing, salt water Mt. Simon, Cambrian system	72	1922

The figures show some omissions or errors.

On account of salt water encountered at the bottom of the well, the well was plugged at a depth of 1650 feet. The diameter of the well is 10 inches to a depth of 78½ feet, 8 inches between depths of 78½ and 325 feet, 7 inches between depths of 325 and 860 feet, 6 inches between depths of 860 and 1210 feet, and 5 inches below a depth of 1210 feet. It is cased with 10-inch pipe to a depth of 51 feet and with 70 feet of 6-inch pipe through the shale and marl below St. Peter sandstone.

When at a depth of 1565 feet the drillers noted “between 50 and 75 gallons of water.” When the well was completed water flowed at a rate of 275 gallons a minute. The flow decreased and in 1904 the air lift equipment was installed. In 1915 the depth to water was 6 feet when the air lift had not operated for sometime and was said to be lowered to a depth of 100 feet when pumpin at a rate of 160 gallons a minute.

The well is now equipped with a Harris air lift with 4½-inch discharge pipe extending to a depth of 300 feet and an air nozzle placed close to the bottom of the discharge pipe. An auxillary 1-inch air line extends to a depth of 195 feet. On September 28, 1922, the yield of the air lift, as measured in the

reservoir, was 140 gallons a minute. The water level when not pumping for 6 hours was at a depth of 11 feet. It was lowered 158 feet during the first hour of pumping and an additional foot during the next three hours of pumping. It raised 152½ feet in 35 minutes after pumping ceased and 4½ feet during the next hour when the water level stood within two feet of the level when pumping started.

The discharge, after repairs to the air line in the summer of 1924, with the Sullivan compressor running from 190 to 200 revolutions a minute, was 133 gallons a minute (This and the 140 gallons given as yield in 1922 may include cooling water for the compressor). When shut down for two days in 1924 for repairs to the air line the depth to water is said to have been forty feet.

The temperature of water drawn from the well is 57 degrees Fahrenheit. The water had a mineral content of 1331 and a total hardness of 638 parts per million as shown by the analysis of sample number 48280, collected on September 27, 1922 at the discharge from the well.

Analysis of Sample Number 48280 from the City Supply.

Determinations Made.	Parts per million.
Iron Fe	0.0
Manganese Mn	0.0
Silica SiO_2	15.6
Nonvolatile	1.6
Alumina Al_2O_3	4.0
Calcium Ca	158.3
Magnesium Mg	59.4
Ammonia NH_4	.4
Potassium K	21.1
Sodium Na	225.9
Sulfate SO_4	160.6
Nitrate NO_3	7.1
Chloride Cl	560.0
Alkalinity Methyl Orange	234.0
Residue	1458.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	11.5	.67
Potassium Chloride KCl	31.7	1.85
Sodium Chloride NaCl	574.1	33.57
Ammonium Chloride NH_4Cl	1.2	.07
Magnesium Chloride $MgCl_2$	232.3	13.58
Calcium Chloride CaCl	35.6	2.08
Calcium Sulfate $CaSO_4$	227.4	13.29
Calcium Carbonate $CaCO_3$	196.0	11.47
Silica SiO_2	15.6	.91
Nonvolatile	1.6	.10
Alumina Al_2O_3	4.0	.23
Total	1331.0	77.82

A sample collected in 1915 had a mineral content of 1162, a total hardness of 560, and a content of iron of 0.1 parts per million.

LOMBARD (1331). Lombard is located in the eastern part of Du Page County about twenty miles from Chicago on the drainage area of Du Page River, a tributary of Des Plaines River. A public water supply has been installed by the village. Water is pumped from a well into the distribution system by either of two pumps placed in a pit six feet below the ground surface. One pump

is a Morris two-stage centrifugal of 350 gallons a minute capacity which is driven by a 40-horsepower electric motor. The other is an American two-stage centrifugal of 300 gallons a minute capacity which is driven by a 30-horsepower electric motor. An elevated steel tank of 60,000 gallons capacity is connected to the mains.

Five hundred and fifty service connections were in use in January, 1924. The meter rate is 30 cents per 1000 gallons with a minimum charge of $2.00 every three months.

Water for the public supply is secured from a well 8 inches in diameter and 93 feet deep. The ground surface at the well is about 745 feet above sea level. The upper 60 feet is in drift and the lower part is in limestone. It is said that the well was tested and that the water level was lowered two feet to a depth of five feet below the ground surface when pumping at a rate of more than 800 gallons a minute, the capacity of the weir provided for the test. During a more recent test it is said that the well was pumped at a rate of 350 gallons a minute, that the water level was at a depth of from 14 to 16 feet and was not lowered after 4 hours of pumping.

The water had a mineral content of 451, a total hardness of 338, and a content of iron of 1.6 parts per million as shown by the analysis of sample number 38895, collected on January 31, 1918.

Analysis of Sample Number 38895 from the Village Supply.

Determinations Made.

	Parts per million.
Iron Fe	1.6
Manganese Mn	0.0
Alumina Al_2O_3	1.0
Calcium Ca	119.0
Magnesium Mg	10.0
Ammonia NH_4	0.1
Sodium Na	31.6
Potassium K	1.6
Sulfate SO_4	48.7
Nitrate NO_3	1.0
Chloride Cl	4.0
Silica SiO_2	19.6
Alkalinity Methyl Orange	340.
Residue	445.

Hypothetical Combinations.

	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	1.6	.09
Potassium Chloride KCl	1.8	.11
Sodium Chloride NaCl	5.1	.30
Sodium Sulfate Na_2SO_4	72.0	4.20
Sodium Carbonate Na_2CO_3	14.5	.85
Ammonium Carbonate $(NH_4)_2CO_3$	0.3	.02
Magnesium Carbonate $MgCO_3$	34.7	2.02
Calcium Carbonate $CaCO_3$	297.3	17.34
Iron Carbonate $FeCO_3$	3.3	.19
Manganese Carbonate $MnCO_3$	0.0	0.0
Alumina Al_2O_3	1.0	.06
Silica SiO_2	19.6	1.14
Total	451.2	26.32

LOSTANT (911). Lostant is located in the southwestern part of La Salle County on the drainage area of Sandy Creek, a tributary of Illinois River. A well was drilled and equipped with a deep-well pump driven by a 10-horsepower gasoline engine, a 50,000 gallons elevated tank was erected, and one hydrant was

installed in 1911. Little use was made of this installation until after 1913 when a distribution system was installed. The water works is owned by the village. In 1922 forty service connections were in use and the water consumption during the summer averaged 4,500 gallons a day. Meter rates, not subject to cash discount, are 50 cents per 1000 gallons.

Water is secured from a well 5 feet in diameter and 70 feet deep. The top is about 707 feet above sea level. The material penetrated was mostly clay until a depth of 70 feet was reached where water bearing sand was encountered. Water entered so rapidly at that depth that the curbing was not completed and broken stone and brick were thrown into the bottom of the well. The depth then measured 66½ feet. The well is equipped with a deep-well pump with the cylinder at a depth of 57 feet. Four feet of suction pipe is attached to the cylinder. On October 20, 1922, when the pump had not operated for thirteen hours the depth to water was 35 feet. Pumping for 53 minutes lowered the water level to the bottom of the suction pipe. If the well is 5 feet inside diameter as given, the rate of pumping was 70 gallons a minute. During regular operation the pump was not operated more than 45 minutes continuously and the total time operated as shown by daily records averaged near 60 minutes a day. When the elevated tank of 50,000 gallons capacity was completed it was filled in three days, pumping when water was available.

The water had a mineral content of 552, a total hardness of 153, and a content of iron of 0.1 parts per million as shown by the analysis of sample number 39439, collected on May 6, 1918.

Analysis of Sample Number 39439 from the Village Supply.

Determinations Made.

	Parts per million.
Iron Fe	0.1
Manganese Mn	0.0
Silica SiO_2	19.3
Alumina Al_2O_3	0.3
Calcium Ca	47.8
Magnesium Mg	8.4
Sodium Na	117.2
Potassium K	14.5
Sulfate SO_4	68.6
Nitrate NO_3	8.8
Chloride Cl	65.0
Alkalinity Methyl Orange	314.
Residue	555.

Hypothetical Combinations.

	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	14.4	0.84
Potassium Chloride KCl	17.2	1.00
Sodium Chloride NaCl	93.9	5.48
Sodium Sulfate Na_2SO_4	101.4	5.91
Sodium Carbonate Na_2CO_3	156.2	9.11
Magnesium Carbonate $MgCO_3$	29.1	1.70
Calcium Carbonate $CaCO_3$	120.3	7.02
Iron Carbonate $FeCO_3$	0.2	0.01
Alumina Al_2O_3	0.3	0.02
Silica SiO_2	19.3	1.13
Total	552.3	32.22

LOVINGTON (1479). Lovington is located in a coal mining region in the northern part of Moultrie County on the drainage area of Kaskaskia River, a tributary of Mississippi River. Many private wells from 12 to 80 feet deep are in use. The Vandalia Railroad has a 6-inch well 120 feet deep.

A public water supply was installed in 1891. For many years water was secured from a privately owned well which was about 50 feet deep. In 1906 the village drilled two wells located fifteen feet apart and made other improvements and at the present time the entire plant is owned by the municipality. The tops of the wells are about 685 feet above sea level. The wells were 6 inches in diameter and 147 feet deep and were in drift the entire depth. They were equipped with deep-well pumps. In 1923 one of these wells was out of service with a hole in the casing. The other well was equipped with a Cook single-acting deep-well pump which was driven by a 7½-horsepower electric motor. The cylinder was at a depth of 114 feet. The pump was operated 15 hours a day and the amount of water pumped was estimated at 50,000 gallons a day. The well pump discharged into a reservoir 8 feet in diameter and 16 feet deep. Water was pumped from the reservoir into the distribution system and an elevated steel tank connected to the system, by an 8 by 6 by 7-inch Blake steam pump.

An 8-inch well was drilled in 1923 by Meister Brothers of Tuscola. It was equipped with a deep-well pump which was to be driven by a 7½-horsepower electric motor. It is reported that a 10-inch casing was installed and was broken when hardpan was encountered at 144 feet, that all but two lengths of the 10-inch casing was then removed and an 8-inch casing and a sand screen 10 feet long were installed with the bottom of the screen at a depth of 129 feet. Water was encountered at a depth of 103 feet and raised to within 40 feet of the ground surface.

A centrifugal pump of 200 gallons a minute capacity driven by a 20-horsepower electric motor was to be installed in 1923 to pump from the reservoir. Power is furnished by an oil engine which, with another unit to be installed in 1923, was to be used also to furnish power to light the village. Three hundred service conections were in use in 1923 and all were metered. The meter rate is 25 cents per 1000 gallons.

The temperature of water when discharged from the well was 54 degrees Fahrenheit. The water had a mineral content of 582, a total hardness of 385, and a content of iron of 1.0 parts per million as shown by the analysis of sample number 49412, collected after two hours fifteen minutes of pumping on April 26, 1923.

Analysis of Sample Number 49412 from the Village Supply.

Determinations Made.	Parts per million.
Iron Fe	1.0
Manganese Mn	0.0
Silica SiO_2	43.0
Nonvolatile	1.3
Alumina Al_2O_3	11.9
Calcium Ca	84.8
Magnesium Mg	42.2
Ammonia NH_4	6.9
Sodium Na	50.0
Sulfate SO_4	0.3
Nitrate NO_3	2.3
Potassium K	15.6
Chloride Cl	21.0
Alkalinity Methyl Orange	504.
Residue	582.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	3.7	0.22
Potassium Chloride KCl	27.0	1.58
Sodium Chloride NaCl	13.4	0.78
Sodium Sulfate Na_2SO_4	4.8	0.28
Sodium Carbonate Na_2CO_3	99.5	5.81
Ammonium Carbonate $(NH_4)_2CO_3$	18.5	1.08
Magnesium Carbonate $MgCO_3$	146.0	8.52
Calcium Carbonate $CaCO_3$	211.7	12.36
Iron Oxide Fe_2O_3	1.4	0.08
Alumina Al_2O_3	11.9	0.69
Silica SiO_2	43.0	2.52
Nonvolatile	1.3	0.07
Total	582.2	33.99

A sample collected in 1914 had a mineral content of 572, a total hardness of 450, and a content of iron of 1.3 parts per million. The iron stains pumbing fixtures and laundry fabrics.

LYONS (2564). Lyons is located in Cook County near the western limits of the city of Chicago. The village completed the installation of a public water supply in 1913. Water is secured from a deep-well said to be 1650 feet deep. The well was at first equipped with a deep-well pump. In 1916 a connection was made with the Berwyn supply and at times when demands are greater than the yield of the well, water is taken from the Berwyn mains. The Berwyn supply is Lake Michigan water which is purchased from the city of Chicago.

The well is equipped with an air lift and in 1922 it was said that all water used was secured from the well. Air is supplied by a Worthington 11 by 6 by 10-inch compressor which is driven at a speed of approximately 280 revolutions a minute by an electric motor. Water is discharged into a reservoir 15 feet wide and 50 feet long and is pumped from this reservoir into the mains by a centrifugal pump which is driven by an electric motor. The discharge of the centrifugal pump on June 20, 1923, as measured by a meter on the discharge, was from 265 to 273 gallons a minute. The yield of the well, determined by deducting the loss of water in the reservoir from the discharge of the centrifugal pump, was 237 gallons a minute. When the air is cooler the discharge is somewhat greater. The air lift was operated about thirteen hours a day so the total amount of water pumped probably averaged near 180,000 gallons a day.

The water had a mineral content of 531 and a total hardness of 417 parts per million as shown by the analysis of sample number 39907, collected on August 6, 1918.

Analysis of Sample Number 39907 from the Village Well.

Determinations Made.	Parts per million.
Iron Fe	0.0
Manganese Mn	0.0
Silica SiO_2	10.0
Nonvolatile	1.5
Alumina Al_2O_3	1.0
Calcium Ca	90.2
Magnesium Mg	46.7
Ammonia NH_4	0.0
Sodium Na	27.6
Sulfate SO_4	150.9
Nitrate NO_3	15.9
Chloride Cl	23.0
Alkalinity Methyl Orange	255.0
Residue	582.7
Carbon Dioxide CO_2	2.0

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Sodium Nitrate $NaNO_3$	22.0	1.28
Sodium Chloride NaCl	37.8	2.20
Sodium Sulfate Na_2SO_4	20.7	1.21
Ammonium Sulfate $(NH_4)_2SO_4$	0.2	.01
Magnesium Sulfate $MgSO_4$	171.2	9.99
Magnesium Carbonate $MgCO_3$	41.6	2.42
Calcium Carbonate, $CaCO_3$	225.2	13.14
Alumina Al_2O_3	1.0	.06
Silica SiO_2	10.0	.58
Nonvolatile	1.5	.09
Total	531.2	30.99

A sample collected in 1914 was of the same quality. It contained 0.1 part per million of iron.

McHENRY (1146). McHenry is located in the eastern part of McHenry County on the west bank of Fox River. A public water supply was installed by the village in 1897. The installation included a well, a collecting reservoir at the top of the well, a pumping station, a distribution system, and a steel standpipe of 160,000 gallons capacity connected to the system. The standpipe is located on high ground in the village. Water was pumped from the reservoir into the mains by an 8 by 10-inch Smith-Vaile triplex pump. Another well has been drilled and a Fairbanks-Morse 3-inch two-stage centrifugal pump driven by a 20-horsepower electric motor has been installed to pump from the collecting reservoir. The triplex pump driven by a gas engine is held in reserve.

The water consumption during the year to May, 1923, evidently secured by adding consumption recorded on meters on service connections, averaged 22,000 gallons a day. The consumption during the summer is much above the average and with the completion of a sewer system installed in 1923 it is probable that the demands in summer will soon equal the capacity of the wells in use. The meter rate for quantities less than 5000 gallons in three months is 37½ cents per 1000 gallons. For quantities greater than 100,000 gallons the charge is 19 cents per 1000 gallons. The minimum

charge is $1.50 for three months. Bills are not subject to discount.

The Borden Company has a private supply from three wells 74 to 80 feet deep into sand and gravel. Water stood 11 to 12 feet below the ground surface in these wells in 1923.

The public water supply is secured from two flowing wells about 70 feet deep. The wells are located on low land near a small stream. About 300 feet upstream from the wells a dam has been built across the valley forming a pond known as Borden's pond. The surface of the pond when at the overflow is 10 feet or more above the ground surface at the wells.

One well 6 or 8 inches in diameter was drilled in 1897. It passes through 20 feet of soft earth, 35 feet of blue clay, and coarse water bearing gravel. A collecting reservoir at the top of the well is about 20 feet in diameter, measured a foot below the overflow. The yield of this well decreased and a second well 6 inches in diameter has been drilled at a distance of 25 feet from the first well. Water flows to the reservoir through a pipe line which discharges a few inches above the overflow in the reservoir. The flow from the two wells on November 20, 1923, filled the reservoir at an average rate of 20 inches in depth in an hour, a rate of 65 gallons a minute, when the water level in the reservoir was drawn down to five feet below the ground surface and decreased with the rise in water level in the reservoir to not more than 5 gallons a minute when the water level was at the overflow.

The water had a mineral content of 339, a total hardness of 270, and a content of iron of 0.5 parts per million as shown by the analysis of sample number 40039, collected on August 22, 1918.

Analysis of Sample Number 40039 from the Village Supply.

Determinations Made.

	Parts per million.
Iron Fe	0.5
Manganese Mn	trace
Silica SiO_2	17.4
Nonvolatile	0.0
Alumina Al_2O_3	0.4
Calcium Ca	56.9
Magnesium Mg	31.0
Ammonia NH_4	8.2
Sodium Na	20.1
Sulfate SO_4	7.1
Nitrate NO_3	0.0
Chloride Cl	3.0
Alkalinity Methyl Orange	328.
Residue	355.

Hypothetical Combinations.

	Parts per million.	Grains. per gallon.
Sodium Nitrate $NaNO_3$	0.5	.03
Sodium Chloride NaCl	4.9	.28
Sodium Sulfate Na_2SO_4	10.5	.61
Sodium Carbonate Na_2CO_3	33.6	1.95
Ammonium Carbonate $(NH_4)_2CO_3$	21.9	1.27
Magnesium Carbonate $MgCO_3$	107.4	6.21
Calcium Carbonate $CaCO_3$	142.2	8.25
Iron Carbonate $FeCO_3$	1.0	.06
Alumina Al_2O_3	0.4	.02
Silica SiO_2	17.4	1.01
Total	339.8	19.69

An odor of hydrogen sulphide is noticeable at the reservoir.

MACKINAW (828). Mackinaw is located in the eastern part of Tazewell County on the drainage area of Mackinaw River, a tributary of Illinois River. Some private wells at residences are from 20 to 25 feet deep and others are from 40 to 60 feet deep. The Peoria and Eastern Railway has a 6-inch well 195 feet deep into sand and gravel. The pump with which it is equipped was operated in 1919 from two to four hours a day at a displacement of 50 gallons a minute.

A public water supply was installed by the village in 1893. Water was pumped from a dug well 60 feet deep, located in the public square. Later other wells were installed and the original well is not now in use to furnish water for the public supply. Water is pumped from three wells directly into the distribution system to which a steel pressure tank 8 feet in diameter and 36 feet long is connected. The well pumps are driven by belt from a shaft which is turned by an automatically controlled 10-horsepower electric motor. In case of emergency the shaft may be turned by a small steam engine. Steam is supplied by a boiler formerly in regular use when the wells were equipped with steam-head pumps. Air is supplied to the pressure tank by a small compressor which is driven by an electric motor. A concrete reservoir of 50,000 gallons capacity, located close to the wells is kept full of water. In case of fire, water is pumped from this reservoir into the mains by a single-stage centrifugal pump which is driven by a 20-horsepower electric motor. Electric power is purchased from the Mackinaw Electric Light and Power Company.

One hundred and seventy-five service connections were in use in 1924. The meter rate for three months is 50 cents per 1000 gallons for the first 5000 gallons, 40 cents per 1000 gallons for the next 10,000 gallons, and 30 cents per 1000 gallons for additional water. Bills are not subject to cash discount.

Water for the public supply may be obtained from three wells but practically all water is now pumped from one of the wells. The wells are located eight feet apart in the northern part of the village. The ground surface at the wells is about 640 feet above sea level. Each well is about 163 feet deep. A record of material penetrated by one well, as given by George Albrendt, is as follows:

	Thickness in feet.	Depth in feet.
Soil	15	15
Gravel	50	65
Clay, blue	55	120
Gravel and stone	30	150
Rock	1	151
Gravel	12	163

One well was drilled in 1904. It is 4 inches in diameter. It is equipped with a deep-well pump with the cylinder wedged in the well casing. This pump was used but little after the second well was drilled and has not been used since the third well was drilled.

A well 5 inches in diameter was drilled in 1906. It is 8 feet south of the 4-inch well. It is equipped with a deep-well pump with the cylinder placed close to the bottom of the well. In 1919 the pump was operated nine or ten hours a day at twenty revolutions a minute and the rated capacity at that speed was 60 gallons a minute. This pump has not been used since 1923.

An 8-inch well located 8 feet north and east of the 4-inch well was drilled by Mike Ebert in 1923. A screen twelve feet long is placed in the bottom of the well. The well was equipped in March, 1924, with a Cook double-stroke deep-well pump with 5¾-inch cylinder and 18-inch stroke. The cylinder is placed at a depth of 151 feet. The pump was operated in 1924 at 18 revolutions a. minute, for about five hours a day. The total amount of water pumped was estimated at 21,000 gallons a day. The motor driving the pump is operated with automatic control.

The water level was reported to be about 30 feet below the ground surface in 1914, 46 feet below the ground surface in 1919, and 30 feet below the ground surface when the well drilled in 1923 was completed.

The water had a mineral content of 570, a total hardness of 478, and a content of iron of 2.0 parts per million as shown by the analysis of sample number 51680, collected on June 20, 1924, from a tap at the pumping station.

Analysis of Sample Number 51680 from the Village Supply.

Determinations Made.

	Parts per million.
Iron Fe	2.0
Manganese Mn	0.0
Silica SiO_2	18.4
Nonvolatile	1.6
Alumina Al_2O_3	1.3
Calcium Ca	110.3
Magnesium Mg	49.5
Ammonia NH_4	4.6
Potassium K	6.9
Sodium Na	27.5
Sulfate SO_4	21.7
Nitrate NO_3	2.5
Chloride Cl	16 .0
Alkalinity Methyl Orange	494.
Residue	553.0

Hypothetical Combinations.

	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	4.0	.23
Potassium Chloride KCl	10.2	.60
Sodium Chloride NaCl	18.4	1.07
Sodium Sulfate Na_2SO_4	32.0	1.87
Sodium Carbonate Na_2CO_3	23 .0	1.34
Ammonium Carbonate $(NH_4)_2CO_3$	12.3	.72
Magnesium Carbonate $MgCO_3$	171.4	9.94
Calcium Carbonate $CaCO_3$	275.3	16.08
Iron Oxide Fe_2O_3	2.8	.16
Alumina Al_2O_3	1.3	.76
Silica SiO_2	18.4	1.07
Nonvolatile	1.6	.09
Total	570.7	33.93

The water stains plumbing fixtures due to the iron content. A sample, number 28505, collected in 1914 was similar.

MACOMB (6714). Macomb is located in the central part of McDonough County on the drainage area of Crooked Creek, a tributary of Illinois River. A public water supply was installed about 1894. Water was secured from wells into St. Peter sandstone. About 1905 a water supply was developed from wells in the southeastern part of the city. The wells penetrated a 10 foot stratum of sand and gravel at a depth of about 40 feet. The supply was limited and the deep wells were maintained for use in emergency until a surface water supply was developed in 1911. Since 1911 water has been taken from Crooked Creek and filtered.

The public water supply for several years was obtained from two wells 20 feet apart drilled into St. Peter sandstone, one about 1360 feet deep and the other 1630 feet deep. A record of material penetrated by the deeper well, furnished by W. E. Thompson, Superintendent of Water Works, with part of the classifications given by the State Geological Survey Division, is as follows:

	Thickness in feet.	Depth in feet.
Drift	145	145
Limestone and flint, pyrites	255	400
Blue soapstone or shale	245	645
Rotten soapstone, Maquoketa	55	700
Limestone, Kimmswick-Plattin	435	1135
Sandstone, St. Peter	225	1360
Limestone, Prairie du Chien	270	1630

The wells were cased to St. Peter sandstone and were sealed to the rock at the cottom of the casing with rubber packers. The water level in 1906 when little water was taken from the wells was at a depth of 65 feet.

Analysis of Sample Number 8094 from City Wells into St. Peter Sandstone.

Determinations Made.	Parts per million.
Iron Fe	5.6
Silica SiO_2	6.6
Alumina Al_2O_3	4.4
Calcium Ca	183.6
Magnesium Mg	71.5
Ammonia NH_4	1.2
Potassium K	94.3
Sodium Na	668.8
Sulfate SO_4	996.4
Nitrate NO_3	1.6
Chloride Cl	935.0
Residue	3222.4

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	2.6	.15
Potassium Chloride KCl	178.0	10.41
Sodium Chloride NaCl	1400.8	81.94
Sodium Sulfate Na_2SO_4	369.6	21.62
Calcium Sulfate $CaSO_4$	623.9	36.50
Ammonium Sulfate $(NH_4)_2SO_4$	4.5	0.26
Magnesium Sulfate $MgSO_4$	355.2	20.78
Iron Sulfate $FeSO_4$	15.2	.89
Alumina Al_2O_3	4.4	.25
Silica SiO_2	14.0	.82
Total	2968.2	173.62

Water from the well 1360 feet deep had a mineral content of 2968, a total hardness of 752, and a content of iron of 5.6 parts per million as shown by the analysis of sample number 8094, collected on August 4, 1900.

In a sample collected in 1901 the sodium and chloride contents were considerably higher, being 948 and 1148 respectively.

MALTA (391). Malta is located in the western part of DeKalb County on the drainage area of Kishwaukee River, a tributary of Rock River. A public water supply was installed by the village in 1914-1915. The system included a well, a pump, a distribution system, and a steel tank 9 feet in diameter and 36 feet long.

The well was drilled by the W. L. Thorne Company of Des Plaines. It is 8 inches in diameter and 853 feet deep. The depth to rock was about 230 feet and the bottom of the well is in sandstone. The well is equipped with a deep-well pump which is driven by a 20-horsepower oil engine. In 1918 it was reported that the depth to the pump cylinder was 140 feet and that the depth to the bottom of the suction pipe on the cylinder was 148 feet. The yield was given as 92 gallons a minute and the average time of operating the pump was given as 3 hours a day. The depth to water when not pumping was 100 feet.

The water had a mineral content of 267, a total hardness of 188, and a content of iron of 0.1 parts per million as shown by the analysis of sample number 38022, collected on September 11, 1917, from a tap on the distribution system.

Analysis of Sample Number 38022 from the Village Supply.

Determinations Made.

	Parts per million.
Iron Fe	0.1
Silica SiO_2	10.1
Alumina Al_2O_3	3.0
Calcium Ca	36.7
Magnesium Mg	23.5
Ammonia NH_4	0.5
Sodium Na	30.6
Potassium K	4.7
Sulfate SO_4	2.0
Nitrate NO_3	0.9
Chloride Cl	3.0
Alkalinity Methyl Orange	242.
Residue	265.0

Hypothetical Combinations.

	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	1.5	.09
Potassium Chloride KCl	6.3	.37
Potassium Sulfate K_2SO_4	1.8	.10
Sodium Sulfate Na_2SO_4	1.5	.09
Sodium Carbonate Na_2CO_3	69.3	4.04
Ammonium Carbonate $(NH_4)_2CO_3$	1.3	.08
Magnesium Carbonate $MgCO_3$	81.4	4.74
Calcium Carbonate $CaCO_3$	91.6	5.34
Iron Oxide Fe_2O_3	0.1	.01
Alumina Al_2O_3	3.0	.17
Silica SiO_2	10.1	.59
Total	267.9	15.62

MANHATTAN (525). Manhattan is located in the central part of Will County on the watershed between Kankakee and Des Plaines Rivers. Several private wells into rock about 100 feet deep are in use. One well is in use at a creamery. The Wabash Railway has two wells, each 112 feet deep, which yield about 50 gallons a minute. The water is obtained from crevices in limestone.

A public water supply was installed by the village in 1892. Water is pumped from a well into the distribution system and two steel pressure tanks connected to the system, by a deep-well pump which is driven by an electric motor. The tanks are 8 feet in diameter and 36 feet long. Electric power is purchased from the Joliet Public Service Company. One hundred and forty service connections were in use in April, 1924. The meter rate is 30 cents per 100 cubic feet and the minimum charge is $20.00 a year.

Analysis of Sample Number 38552 from the Village Supply.

Determinations Made.

	Parts per million.
Iron Fe	0.2
Silica SiO_2	15.2
Alumina Al_2O_3	5.3
Calcium Ca	88.4
Magnesium Mg	42.9
Ammonia NH_4	0.4
Sodium Na	23.1
Potassium K	4.5
Sulfate SO_4	70.6
Nitrate NO_3	1.8
Nitrite NO_2	0.0
Chloride Cl	0.0
Alkalinity Methyl Orange	374.
Residue	464.

Hypothetical Combinations.

	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	2.9	.17
Potassium Sulphate K_2SO_4	7.6	.44
Sodium Sulfate Na_2SO_4	71.2	4.15
Ammonium Sulfate $(NH_4)_2SO_4$	1.5	.09
Magnesium Sulfate $MgSO_4$	21.6	1.26
Magnesium Carbonate $MgCO_3$	133.3	7.78
Calcium Carbonate $CaCO_3$	220.6	12.86
Iron Oxide Fe_2O_3	0.3	.02
Alumina Al_2O_3	5.3	.31
Silica SiO_2	15.2	.89
Total	479.5	27.97

Water is secured from a well located near the center of the village. The ground surface at the top of the well is about 680 feet above sea level. The well is 6 inches in diameter and 98 feet deep. It is cased into limestone which is entered at a depth of 30 or 40 feet. The well is equipped with a Goulds deep-well pump with the cylinder attached to 80 feet of 4-inch drop pipe. There is no suction pipe attached to the cylinder. On April 7, 1924, the pump was operated with 24-inch stroke, 28½ strokes a minute. The discharge into the pressure tanks was 25 gallons a minute and allowing for consumption the total discharge was between 30 and 40 gallons a minute. The pump was operated about 7 hours a day in 1923. In October, 1923, the depth to water when not pumping was 20 feet.

The water had a mineral content of 479, a total hardness of 396, and a content of iron of 0.2 parts per million as shown by the analysis of sample number 38552, collected on November 14, 1917.

MANTENO (1182). Manteno is located in the northern part of Kankakee County on the drainage area of Kankakee River. A public water supply was installed by the village in 1897. Water is pumped from wells directly into the distribution system to which three steel pressure tanks are connected. The pumps are driven by belts from a line shaft which is driven by a 20-horsepower electric motor. The tanks are each 8 feet in diameter and 36 feet long. Three hundred and forty service connections were in use in 1923. Water is sold at flat rates.

Water for the public supply is secured from wells. The original well was 3½ inches in diameter at the bottom and 93 feet deep. As demands for water increased larger wells were drilled and this well was abandoned. The next well drilled, number 2, is 10 inches in diameter at the top, 8 inches in diameter at the bottom, and 310 feet deep. It is located 10 feet north of the original well. Well number 3 is 58 feet east of number 2. It is 10 inches in diameter to rock at a depth of 17 feet, is 8 inches in diameter in rock to a depth of 300 feet, and is 6 inches in diameter from a depth of 300 feet to the bottom of the well which is at a depth of 426 feet. A fourth well was installed in 1913. This well is 15 feet in diameter and 60 feet deep. It is located 15 feet east of well number 3 to which it is connected by a tunnel at a depth of 60 feet. The well is curbed with concrete to a depth of 20 feet, 3 feet below the top of the limestone. The water consumption in 1913, before well number 4 was installed, was said to be 40,000 gallons a day and this was said to be near the maximum capacity of wells number 2 and number 3 which were then in use.

After well number 4 was drilled, it, with the water that flowed in from well number 3, furnished a large part of the total supply for a few years. It was equipped with a 4-inch centrifugal pump placed in the bottom of the well. The pump was driven by an electric motor placed at the top of a vertical shaft. Water stood at a depth of 40 feet when not pumping. It is said that the capacity of the pump was 450 gallons a minute and that the water level was lowered to the bottom of the well by pumping for two hours. Allowing for water which had been stored in the well this gives an average rate of inflow during the two hours of 230 gallons a minute.

The actual rate of pumping may have been considerably less than 450 gallons a minute and it may have been a long time before the pump could have been operated again for that length of time. In March, 1914, the motor driving the pump was operated with automatic control actuated by the pressure in the steel tanks. It operated 5 or 6 minutes at a time and the total time of operation was estimated at 1½ hours a day. The pump in well number 4 has not been in use for several years as the capacity of the pump is too great for the yield of the well.

In July, 1923, wells number 2 and 3 were in use. Each was equipped with a deep-well pump. The pump in number 2 was operated at 19 revolutions a minute and that in number 3 was operated 28 revolutions a minute. The yield of well number 3 is probably larger than that of well number 2 due to the connection with well number 4. When the pumps were not operated at midnight on July 19, 1923, the lowering in water level in the tanks indicated a consumption, probably to a large extent leakage, of 36 gallons a minute. When pumping from well number 2 at 2 a. m. eight gallons of water a minute was added to the tanks, indicating a yield of 36 plus 8, or 44 gallons a minute from this well. At 3.00 a. m. when pumping from wells 2 and 3 water was added to the tanks at a rate of 75 gallons a minute. Adding the consumption and deducting for the lowering in water level in well number four the inflow into the two wells was 80 gallons a minute.

Analysis of Sample Number 52524 from Well Number 2.

Determinations Made.

	Parts per million.
Iron Fe	0.1
Manganese Mn	0.0
Silica SiO_2	14.2
Nonvolatile	1.7
Alumina Al_2O_3	3.4
Calcium Ca	142.9
Magnesium Mg	45.7
Ammonia NH_4	0.0
Sodium Na	26.4
Potassium K	5.5
Sulfate SO_4	230.0
Nitrate NO_3	17.7
Chloride Cl	27.0
Alkalinity Methyl Orange	310.
Residue	743.

Hypothetical Combinations.

	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_2	14.3	0.83
Sodium Nitrate $NaNO_3$	12.2	0.71
Sodium Chloride NaCl	44.5	2.60
Sodium Sulfate Na_2SO_4	17.3	1.01
Ammonium Sulfate $(NH_4)_2SO_4$	0.1	0.01
Magnesium Sulfate $MgSO_4$	226.0	13.20
Calicum Sulfate $CaSO_4$	53.4	3.12
Calcium Carbonate $CaCO_3$	317.4	18.54
Iron Oxide Fe_2O_3	0.1	0.01
Alumina Al_2O_3	3.4	0.20
Silica SiO_2	14.2	0.83
Nonvolatile	1.7	0.10
Total	704.6	41.16

The waste at time of test may have been unusual, but has been very high at other times. At one time it was customary to shut off the distribution system during the night to save waste. Assuming

the test data to represent average conditions during the day the total amount of water pumped in 24 hours on June 19-20, 1923, was 110,000 gallons and of this total about one half was wasted.

The temperature of water discharged from well number 2 was 52 degrees Fahrenheit. The water had a mineral content of 704, a total hardness of 545, and a content of iron of 0.1 parts per million as shown by the analysis of sample number 52524, collected from well number 2 on September 29, 1924.

The water is said to cause a deposit in meters.

MAPLE PARK (384). Maple Park is located in the western part of Kane County on the drainage area of Kishwaukee River, a tributary of Rock River. A public water supply was installed by the village in 1894. The installation now includes a well equipped with a deep-well pump, an 8-horsepower gas engine which drives the pump, an elevated wooden tank, and a distribution system. The tank in use replaced the original tank in 1914. Ninety-two service connections were in use in April, 1922, and the average consumption was estimated at 14,000 gallons a day. The Bowman Dairy Company which uses large quantities of water have a private supply from two wells. The Chicago and Northwestern Railway has a dug well from which they use a small quantity of water.

Analysis of Sample Number 31118 from the Village Supply.

Determinations Made.	Parts per million.
Iron Fe	0.1
Silica SiO_2	15.4
Alumina Al_2O_3	1.3
Calcium Ca	52.4
Magnesium Mg	26.9
Ammonia NH	0.5
Sodium Na	26.7
Potassium K	5.0
Sulfate SO_4	23.5
Nitrate NO_3	2.5
Chloride Cl	2.0
Nonvolatile	0.2
Alkalinity Methyl Orange	306.
Residue	307.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	4.1	.24
Potassium Chloride KCl	3.1	.18
Potassium Sulfate K_2SO_4	5.1	.30
Sodium Sulfate Na_2SO_4	30.6	1.78
Sodium Carbonate Na_2CO_3	38.7	2.25
Ammonium Carbonate $(NH_4)_2CO_3$	1.3	.08
Magnesium Carbonate $MgCO_3$	93.2	5.43
Calcium Carbonate $CaCO_2$	130.8	7.63
Iron Carbonate $FeCO_3$	0.2	.01
Alumina Al_2O_3	1.3	.08
Silica SiO_2	15.4	.90
Nonvolatile	0.2	.01
Total	324.0	18.89

Water for the public supply is obtained from a well located in the eastern part of the village. The elevation of the top is 860 feet above sea level. The well is 6 inches in diameter and 250 feet deep. It is thought that water is obtained from sand and gravel. The well is equipped with a deep-well pump with a 3¾-

inch cylinder placed at a depth of 140 feet. The pump is operated with 24-inch stroke at a speed of 28 revolutions a minute. The discharge in the spring of 1922 was said to be 20 gallons a minute. The pump, when in good condition. was operated about nine hours a day during the summer and seven hours a day in the winter. The depth to water when measured several years ago was 127 feet.

The water had a mineral content of 324, a total hardness of 241, and a content of iron of 0.1 parts per million as shown by the analysis of sample number 31118, collected on July 31, 1915.

MARENGO (1758). Marengo is located in the southwestern part of McHenry County on the drainage area of Kishwaukee River, a tributary of Rock River. A public water supply was installed by the city in 1893. Water is pumped from a well directly into the distribution system by a Smith-Vaile 7 by 8-inch triplex pump which is driven by belt from a 20-horsepower electric motor. The amount of water pumped is measured by meter. The rate for water is 25 cents per 1000 gallons for the first 20,000 gallons, 20 cents per 1000 gallons for the next 20,000 gallons, 15 cents per 1000 for the next 30,000 gallons, 10 cents per 1000 for the next 30,000 gallons, and 9 cent per 1000 gallons for water in excess of 100,000 gallons. The minimum charge is $5.00 a year. Several companies using large quantities of water have private supplies. The Marengo Public Service Company and the Chicago and Northwestern Railway have wells into sand and gravel. The Borden Company have a well into rock.

Water for the public supply is secured from a well 20 feet in diameter and 15 feet deep. The upper three feet is in soil and clay and below a depth of three feet the well is in sand and gravel. The elevation at the top of the well is about 810 feet above sea level. Water is pumped from the well by a 7 by 8-inch triplex pump which is operated at a speed of about 55 revolutions a minute. It has been necessary at times to operate the pump for short periods of time at frequent intervals due to scarcity of water in the well. The depth to water when not pumping in 1913 was given as about eight feet. During a ten hour test by the Randolph-Perkins Company in May, 1924, the rate of pumping at the start averaged near 160 gallons a minute and during the latter part of the test it averaged near 150 gallon a minute. The water level in the well was lowered from a depth of 8 feet 4 inches below the top to a depth of 13 feet below the top and during the latter part of the test when pumping 150 gallons a minute the water level remained at a depth of 13 feet. At the end of the test, when the rate of

pumping decreased slightly, the water level raised a few inches. The top of the well is about two feet above the ground surface. During the test measurements to the water level were made in test wells which had been drilled to a depth of 14 feet. The water level in a test well 95 feet distant from the well tested was lowered 0.27 feet and in a test well about 200 feet distant it was lowered 0.09 feet.

Another test lasting about 12 hours was run on November 12, 1924. Conditions were almost exactly as during the test in May, 1924. The water level after lowering 4 feet 8 inches remained stationary when pumping 150 gallons a minute. The water level in the well and in the test wells was about two inches lower than it was during the test in May.

The water had a mineral content of 403, a total hardness of 346, and a content of iron of 0.4 parts per million as shown by the analysis of sample number 51538, collected from a tap on May 27, 1924.

Analysis of Sample Number 51538 from the City Supply.

Determinations Made.	Parts per million.
Iron Fe	0.4
Manganese Mn	0.0
Silica SiO_2	11.8
Nonvolatile	0.5
Alumina Al_2O_3	1.0
Calcium Ca	80.2
Magnesium Mg	35.5
Ammonia NH_4	0.2
Potassium K	2.9
Sodium Na	12.2
Sulfate SO_4	57.1
Nitrate NO_3	14.2
Chloride Cl	26.0
Alkalinity Methyl Orange	268.
Residue	408.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	7.6	0.44
Sodium Nitrate $NaNO_3$	13.0	0.76
Sodium Chloride NaCl	22.1	1.29
Ammonium Chloride NH_4Cl	0.7	0.04
Magnesium Chloride $MgCl_2$	16.2	0.95
Magnesium Sulfate $MgSO_4$	71.5	4.17
Magnesium Carbonate $MgCO_3$	58.5	3.42
Calcium Carbonate $CaCO_3$	200.2	11.69
Iron Oxide Fe_2O_3	0.6	0.03
Alumina Al_2O_3	1.0	0.06
Silica SiO_2	11.8	0.69
Nonvolatile	0.5	0.03
Total	403.7	23.57

Some water has been supplied to the city from a well of the Borden Company. This well is 796 feet deep. The elevation at the top is about 820 feet above sea level. The well is equipped with a double-acting deep-well pump with 5¾-inch cylinder and 36-inch stroke. The depth to water when not pumping in 1921 was 50 feet. The pump cylinder was attached to 100 feet of pipe. The pump was operated 15 revolutions a minute. A possible yield of 500 gallons a minute is said to have been indicated by tests.

Water from this well had a mineral content of 350 and a total hardness of 313 parts per million as shown by the analysis of sample number 51537, collected on May 27, 1924.

Analysis of Sample Number 51537 from a Well 796 Feet Deep.

Determinations Made.	Parts per million.
Iron Fe	0.0
Manganese Mn	0.0
Silica SiO_2	11.6
Nonvolatile	0.4
Alumina Al_2O_3	0.8
Magnesium Mg	36.6
Calcium Ca	65.0
Ammonia NH_4	0.7
Potassium K	4.6
Sodium Na	15.9
Sulfate SO_4	0.0
Nitrate NO_3	3.5
Chloride Cl	2.0
Alkalinity Methyl Orange	336.
Residue	332.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	5.7	0.33
Potassium Chloride KCl	4.2	0.24
Potassium Carbonate K_2CO_3	0.3	0.02
Sodium Carbonate Na_2CO_3	36.7	2.14
Ammonium Carbonate $(NH_4)_2CO_3$	1.8	0.10
Magnesium Carbonate $MgCO_3$	126.6	7.39
Calcium Carbonate $CaCO_3$	162.2	9.47
Iron Oxide Fe_2O_3	0.0	0.00
Alumina Al_2O_3	0.8	0.05
Silica SiO_2	11.6	0.68
Nonvolatile	0.4	0.02
Total	350.3	20.44

MARION (9582). Marion is located in the central part of Williamson County on the drainage area of Big Muddy River. A public water supply was installed in 1904 by the Marion Light, Power and Water Company. Water was secured from wells until 1920 when the city purchased the plant and developed a supply by building an impounding reservoir on the drainage area of Limb Branch, a small stream east of the city. The water is treated in a filtration plant before pumping into the distribution system.

The public water supply was secured from wells until 1920. The wells were from 700 to 960 feet in depth and penetrated strata of shale, coal, slate, limestone, and sandstone. The water level was originally at a depth of about 50 feet. The yield of a well when new was about 60 gallons a minute but the yield of each well decreased when it was pumped continuously and at one time when seven wells were in use the total yield was said to be about 60 gallons a minute.

The plant was installed by the Marion Light, Power and Water Company and later was owned by the Central Illinois Public Service Company. The latter company gave information in regard to one of the wells drilled in 1915. It was cased to a depth of 122 feet to shut out sulphur water. When in sandstone at a depth of 707 feet a bailer test showed a yield of about nine gallons a minute. The well was drilled to a depth of 934 feet. The principle yield was from sandstone between depths of 860 and 930 feet and when bailed at a rate of 46½ gallons a minute the water level was lowered to 187 feet below the ground surface.

Samples of water from the wells 700 feet deep had mineral contents of from 1100 to 1800 and chloride contents of from 158 to 580 parts per million. It is probable that the wells from which these samples were collected were cased only to rock and variation in quality may have been due in large part to the rate of pumping from a well. When the yield was small a relatively large part may have been from strata which furnished a small part of the total when the yield was comparatively high. All of the waters were soft. The last sample analyzed, number 38028, collected on September 10, 1917, from a well 950 feet deep, had a mineral content of 810, a total hardness of 16, and a content of iron of 0.7 parts per million as shown by the analysis.

Analysis of Sample Number 38028 from City Well 950 feet Deep.

Determinations Made.

	Parts per million.
Iron Fe	0.7
Silica SiO_2	16.2
Alumina Al_2O_3	0.4
Calcium Ca	2.0
Magnesium Mg	2.7
Ammonia NH_4	0.5
Sodium Na	312.2
Potassium K	14.9
Sulfate SO_4	27.7
Nitrate NO_3	2.8
Chloride Cl	132.0
Alkalinity Methyl Orange	526.
Residue	865.

Hypothetical Combinations.

	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	4.6	.27
Potassium Chloride KCl	25.0	1.46
Sodium Chloride NaCl	198.2	11.55
Sodium Sulfate Na_2SO_4	41.0	2.39
Sodium Carbonate Na_2CO_3	508.2	29.64
Ammonium Sulfate $(NH_4)_2SO_4$	1.4	.08
Magnesium Carbonate $MgCO_3$	9.3	.54
Calcium Carbonate $CaCO_3$	5.0	.29
Iron Oxide Fe_2O_3	1.0	.06
Alumina Al_2O_3	0.4	.02
Silica SiO_2	16.2	.94
Total	810.3	47.24

MARK (1300). Mark is located in the northern part of Putnam County. Water for a public supply is purchased from the village of Granville which is east of and adjoins Mark.

MAROA (1193). Maroa is located in the northern part of Macon County on the drainage area of Sangamon River, a tributary of Illinois River. A public water supply was installed by the city in 1892. Water is pumped from three wells into a collecting reservoir 17 feet in diameter and 12 feet deep which is located beneath the pumping station floor. From the reservoir water is pumped into the distribution system by a Platt Iron Works compound duplex double-acting steam pump of 1,000,000 gallons a day capacity. An elevated tank of 75,000 gallons capacity on a steel tower 80 feet high is connected to the mains. Steam is supplied by

two boilers, one of 75 and the other of 80-horsepower. Water from two of the wells can be pumped directly into the distribution system.

Two hundred and thirty-two service connections were in use in 1919 and all were metered. The total consumption was estimated at 160,000 gallons a day. The minimum charge for three months is $2.00 which allows the use of 3000 gallons of water. Additional water is sold at a rate per thousand gallons of 35 cents for the next 2000 gallons, 30 cents for the next 3000 gallons, 25 cents for the next 3000 gallons, and 20 cents for additional quantities. Bills are not subject to cash discount.

Analysis of Sample Number 51806 from the City Supply.

Determinations Made.	Parts per million.
Iron Fe	2.8
Manganese Mn	0.0
Silica SiO_2	14.8
Nonvolatile	2.9
Alumina Al_2O_3	1.4
Calcium Ca	88.0
Magnesium Mg	37.9
Ammonia NH_4	11.3
Potassium K	0.9
Sodium Na	3.4
Sulfate SO_4	8.5
Nitrate NO_3	3.0
Chloride Cl	10.0
Alkalinity	
Methyl Orange	374.0
Residue	407.0

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	2.6	.15
Sodium Nitrate $NaNO_3$	1.9	.11
Sodium Chloride NaCl	7.4	.43
Ammonium Chloride NH_4Cl	8.3	.49
Ammonium Sulfate $(NH_4)_2SO_4$	11.7	.68
Ammonium Carbonate $(NH_4)_2CO_3$	14.2	.83
Magnesium Carbonate $MgCO_3$	131.2	7.66
Calcium Carbonate $CaCO_3$	219.5	12.82
Iron Oxide Fe_2O_3	4.0	.23
Alumina Al_2O_3	1.4	.08
Silica SiO_2	14.8	.86
Nonvolatile	2.9	.17
Total	419.9	24.51

Water is secured from three wells from 83 to 85 feet deep into a stratum of sand and gravel. The tops of the wells are about 720 feet above sea level. The original installation was three wells. One of these has been abandoned and two have been recased to smaller size and are now about 6 inches in diameter. These wells are located 48 feet apart. Each is equipped with a single-acting steam-head deep-well pump with 5¼-inch cylinder and 36-inch stroke. When noted in 1924 one pump was operating at 22 strokes a minute and the other at 28 strokes a minute. A well 10 inches in diameter was drilled in 1920. A number 12 Cook screen six feet long is placed in the bottom. This well is located fifteen feet distant from one of the six inch wells and thirty feet distant from the other one. The well is equipped with a Cook single-acting steam-head deep-well pump with 9½-inch cylinder and 36-inch stroke. When noted in 1924 it was operating 10 strokes a minute. The pump cylinders are placed at the top of the screens. The

yield of the three wells in 1921, when pumps were operating at higher speeds than given above, was said to be 300 gallons a minute. The yield on July 11, 1924, during a thirty minute test, decreased from 160 to 127 gallons a minute. In April, 1925, it was reported that pumps had been overhauled and that the yield was 175 gallons a minute.

The water had a mineral content of 419, a total hardness of 371, and a content of iron of 2.8 parts per million as shown by the analysis of sample number 51806, collected at the pumping station on July 11, 1924.

It was reported in 1924 that about fifty meters are repaired annually.

MARSEILLES (3391). Marseilles is located in the eastern part of La Salle County on the north bank of Illinois River. Several industrial plants which manufacture paper products are located in the city. A public water supply was installed by a private corporation in 1902. Water for the public supply is secured from two flowing wells which discharge into a reservoir. The reservoir, not including cross walls, is about 50 feet long and 17 feet wide. Water is pumped from the reservoir by triplex pumps, each driven by an electric motor. The average water consumption was given in June, 1920, as 125,000 gallons a day. The minimum meter charge is 50 cents a month which allows the use of 1500 gallons of water. When the average consumption does not exceed 200 gallons a day the charge for water above 1500 gallons is 4 cents per 100 gallons. The lowest rate, for consumers using an average of more than 2000 gallons a day, is 1½ cents per 100 gallons.

Water is secured from wells located between Illinois River and the Illinois and Michigan Canal. The first well drilled was 8 inches in diameter at the top, 6 inches in diameter at the bottom, and 600 feet deep. This well was equipped with an air lift. Later another well was drilled. It is 8 inches in diameter at the top, 6 inches in diameter at the bottom, and 800 feet deep. These two wells furnished the city supply for many years. In 1915 the yield of the well equipped with air lift was said to be 67 gallons a minute and the natural flow from the deeper well was estimated at 45 gallons a minute. By 1919 it was necessary at times to operate the air lift continuously and water was drained from some private wells into St. Peter sandstone. In 1920 the National Biscuit Company, who had acquired possession of the land on which the 600-foot well was located, cleaned out the well, recased it with 6-inch pipe,

and drilled it to a total depth of 615 feet. The natural flow was increased to 45 or 50 gallons a minute.

In 1919-1920 the National Biscuit Company had a well drilled for the water company, the Consumers Water and Light Company, in exchange for the 600 foot well which they had acquired. The well was drilled by Wm. Cater of Chicago. A record of material penetrated is as follows:

Fillings, log, and rocks	15 feet
Shale, blue	50 feet
Fire clay	14 feet
Cap rock, Platteville	5 feet
Sandstone, St. Pete	243 feet
Marl, red, Prairie du Chien	23 feet
Limestone, Prairie du Chien	12 feet
Sandstone, Prairie du Chien	75 feet
Limestone, Prairie du Chien	233 feet
	670 feet

Mr. Cater states that drilling was continued to a depth of 700 feet. The limestone in the bottom of the well was very hard. Mr. Davidson of the National Biscuit Company states that the stratum of sandstone encountered below the St. Peter sandstone varies greatly. At some places the flow may be large and at others, as at this well, the flow is small. The well is cased from the ground surface with 120 feet of 12-inch pipe and from the ground surface with 368 feet of 10-inch pipe. The diameter below the casing is 10 inches. The well was first drilled to a depth of 602 feet and the yield was 150 gallons a minute. The depth was then increased but the yield is said to have remained the same. The pressure at the ground surface with no flow when the well was completed in February, 1920, was 14 pounds. At the time of visit in December, 1920, the yield of this well, computed from the rise of water level in the reservoir, was 120 gallons a minute.

Water from the well 670 feet deep which furnishes a large part of the public supply had a mineral content of 511 and a total hardness of 318 parts per million as shown by the analysis of sample number 42435, collected on January 14, 1920.

Water from the stratum below the St. Peter sandstone is of better quality than water from that sandstone. Samples of water collected in 1920, one from the well 600 feet deep and the other from the same well after it had been drilled to a depth of 615 feet and recased to shut out water from St. Peter sandstone, showed a reduction in total residue from 618 to 500, a reduction in chlorides from 98 to 59, and a reduction in sulfates from 110 to 54.

Analysis of Sample Number 42435 from City Well 670 Feet Deep.

Determinations Made.

	Parts per million.
Iron Fe	0.0
Silica SiO_2	5.7
Alumina Al_2O_3	0.4
Calcium Ca	77.5
Magnesium Mg	30.4
Ammonia NH_4	0.8
Sodium Na / Potassium K	72.1
Sulfate SO_4	73.0
Nitrate NO_3	0.7
Nitrite NO_2	0.0
Chloride Cl	62.0
Nonvolatile	0.1
Alkalinity Methyl Orange	304.
Residue	497.

Hypothetical Combinations.

	Parts per million.	Grains per gallon.
Sodium Nitrate $NaNO_3$	0.9	.06
Sodium Chloride NaCl	102.2	5.98
Sodium Sulfate Na_2SO_4	97.4	5.70
Ammonium Sulfate $(NH_4)_2SO_4$	2.9	.17
Magnesium Sulfate $MgSO_4$	7.6	.42
Magnesium Carbonate $MgCO_3$	100.7	5.90
Calcium Carbonate $CaCO_3$	193.6	11.32
Alumina Al_2O_3	0.4	.02
Silica SiO_2	5.7	.33
Nonvolatile	0.1	.00
Total	511.5	29.90

A sample of water, number 8578, collected on September 29, 1900, from a well 2180 feet deep into Cambrian sandstone, located n section 32, township 34 north, range 5 east, had a mineral content of 2658, a total hardness of 451, and a content of iron of 2.8 parts per million as shown by the analysis.

Analysis of Sample Number 8578 from a Well 2180 Feet Deep.

Determinations Made.

	Parts per million.
Iron Fe	2.8
Silica SiO_2	6.8
Alumina Al_2O_3	8.8
Calcium Ca	135.5
Magnesium Mg	27.5
Ammonia NH_4	1.7
Sodium Na	801.7
Potassium K.	51.8
Sulfate SO_4.	74.4
Nitrate NO_3.	0.8
Chloride Cl	1450.0
Residue	2806.0

Hypothetical Combinations.

	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	1.3	.07
Potassium Chloride KCl	97.8	5.67
Sodium Chloride NaCl	2038.0	118.20
Ammonium Chloride $(NH_4)_2SO_4$	5.0	.29
Magnesium Sulfate $MgSO_4$	42.7	2.48
Magnesium Carbonate $MgCO_3$	65.9	3.82
Calcium Chloride $CaCl_2$	329.3	19.10
Calcium Sulfate $CaSO_4$	57.0	3.31
Iron Carbonate $FeCO_3$.	5.8	.34
Alumina Al_2O_3	8.8	.51
Silica SiO_2	6.8	.39
Total	2658.4	154.18

MARSHALL (2222). Marshall is located in the northeastern part of Clark County on the drainage area of Wabash River. Water bearing sandstone underlies drift at a depth of about 20 feet and few private wells are more than 25 feet deep.

A public water supply was installed by the city in 1900. Water was secured from wells in bottom lands of Big Creek about two miles east and north of the city. The original wells have been abandoned and others have been installed close by. In 1922 water was pumped from the wells into a pipe line to the city by either of

two steam pumps placed in a pit six feet deep. One pump had a capacity of 500 gallons a minute and the other pump had a capacity of about 400 gallons a minute. Contracts had been let for two Worthington 8 by 10-inch triplex pumps of 350 gallons a minute capacity, each to be driven by an electric motor. In 1922 the average water consumption was estimated at 250,000 gallons a day. A considerable part of the total was used by railroads.

Six 6-inch wells, each from 16 to 20 feet deep, were drilled in 1900. Later they were replaced by 10-inch wells from 40 to 50 feet deep. The 10-inch wells were equipped with number 14 Cook screens 17 feet long. In 1914 five wells were in use. Water was drawn from the wells by suction. During tests of pumps in that year the discharge was computed from pump revolutions and the records show an average rate of pumping of near 330 gallons a minute.

Analysis of Sample Number 38796 from the City Supply.

Determinations Made.

	Parts per million.
Iron Fe	0.0
Manganese Mn	0.1
Silica SiO_2	11.5
Alumina Al_2O_3	0.8
Calcium Ca	69.0
Magnesium Mg	17.2
Sodium Na	10.9
Potassium K	2.6
Sulfate SO_4	34.4
Nitrate NO_3	8.8
Chloride Cl	1.0
Alkalinity Methyl Orange	232.
Residue	286.

Hypothetical Combinations.

	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	6.7	.39
Sodium Nitrate $NaNO_3$	6.4	.37
Sodium Chloride NaCl	1.7	.10
Sodium Sulfate Na_2SO_4	26.2	1.53
Magnesium Sulfate $MgSO_4$	20.9	1.22
Magnesium Carbonate $MgCO_3$	41.6	2.43
Calcium Carbonate $CaCO_3$	172.2	10.04
Manganese Carbonate $MnCO_3$	0.2	.01
Alumina Al_2O_3	0.8	.05
Silica SiO_2	11.5	.67
Total	288.2	16.80

Water is now secured from two wells each 6 feet in diameter and about 27 feet deep. One of these wells was dug in 1916 and the other, located 14 feet distant center to center, was dug in 1920. The casings are of boiler plate. They were built in 5-foot sections at the ground surface and sunk by excavating underneath them. The material penetrated was said to be eight feet of coarse gravel, three feet of sand, nine feet of fine gravel, and seven and one-half feet of fine white gravel and quicksand. At the time of visit in 1922 a steam pump drawing water from the wells was operating at a displacement of 330 gallons a minute. The total amount of water pumped was estimated at 250,000 gallons a day. At times it was difficult to supply all demands due in part to fine sand flowing into the wells. A few days before the visit an accumulation

of about five feet depth of sand had been removed from one of the wells. The water level varies with rainfall. At the time of visit it was twenty feet below the tops of the wells.

The water had a mineral content of 288 and a total hardness of 243 parts per million as shown by the analysis of sample number 38796, collected on January 7, 1918.

MASCOUTAH (2343). Mascoutah is located in the eastern part of St. Clair County on the drainage area of Silver Creek, a tributary of Kaskaskia River. Many private wells about 20 feet deep are in use.

A limited public water supply was installed by the city in 1905. For a year or two water was secured from a well 48 feet deep. That well was then abandoned and ten wells were driven or drilled to depths of from 35 to 40 feet. One well was 6 inches in diameter and the others were 4 inches in diameter. All were in an area about 100 feet by 200 feet. Water was drawn from the wells by suction by a Fairbanks-Morse 10 by 6 by 12-inch duplex steam pump placed in a pit eight feet deep. In 1918, when nine wells were in use, it was reported that the pump could not be operated more than 18 strokes a minute without drawing air. The total amount of water pumped at that time was estimated at 15,000 gallons a day.

The water from the wells was very hard and in 1921 a water softening plant was installed.

In 1923 wells formerly in use were abandoned due to clogging of screens with fine sand and a well drilltd in 1922 was put in service. This well is 9 inches in diameter and 87 feet deep. The top is about 425 feet above sea level. The well passes through an upper water bearing sand from which the other wells secured a supply and another stratum which overlies shale at the bottom of the well. One screen is placed between depths of 22 and 43 feet and another between depths of 73 and 87 feet. In the lower stratum some fairly coarse sand was encountered. One half of one sample was held on a sieve with 14 meshes to the inch. Both strata contained some very fine sand. The sand strata are not continuous as a well drilled to a depth of 80 feet in 1922 at a location 100 feet north of this well yielded no water. The well is equipped with a double-acting deep-well pump with a 3¾-inch cylinder placed at a depth of 82 feet. Two feet of suction pipe is attached. The pump is driven by an electric motor and in 1923 was operated with 24-inch stroke at a speed of 26 revolutions

a minute. The discharge, measured by meter, was 38 gallons a minute. The water level six hours after pumping stopped was at a depth of 30 feet and remained at that depth for several hours until the pump was again started. In 1923 the amount of water pumped varied from less than 10,000 gallons on some Sundays to as high as 49,800 gallons and averaged near 30,000 gallons a day.

The water softening plant includes a Kennicott continuous lime-soda water softener, a filter, and two Permutit water softeners. Water is pumped to the top of the lime-soda water softener tank which is 34 feet 9 inches high and 10 feet in diameter. Lime and soda are dissolved in a tank on the floor of the filter house and, after thorough mixing, are raised by means of a steam injector to a chemical dosing tank placed on top of the softening tank. After passing through the tank the water is treated with alum to decrease the alkalinity and is then pumped by a centrifugal pump driven by a 10-horsepoper electric motor to a pressure filter. This pressure filter or clarifier is six feet in diameter and is used to complete the removal of calcium and magnesium carbonates and hydroxides which would otherwise incrust the zeolite. From the filter water passes to either of two Permutit zeolite softeners, each 6 feet 6 inches in diameter. When one softener is in use the other is regenerated with salt solution.

The water had a mineral content of 933, a total hardness of 535, and a content of iron of 8.0 parts per million as shown by the analysis of sample number 48961, collected in January, 1923, from the wells then in use.

Analysis of Sample Number 48961 from the City Supply before Treatment.

Determinations Made.

	Parts per million.
Iron Fe	8.0
ManganeseMn	0.7
Silica SiO_2	18.6
Nonvolatile	1.6
Alumina Al_2O_3	3.2
Calcium Ca	136.3
Magnesium Mg	47.5
Ammonia NH_4	1.3
Sodium Na	107.8
Potassium K	28.1
Sulfate SO_4	165.7
Nitrate NO_3	5.2
Chloride Cl	203.0
Alkalinity Methyl Orange	342.
Residue	943.

Hypothetical Combinations.

	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	8.7	.51
Potassium Chloride KCl	47.0	2.74
Sodium Chloride NaCl	274.0	16.02
Ammonium Chloride NH_4Cl	4.0	.23
Magnesium Chloride $MgCl_2$	15.7	.92
Magnesium Sulfate $MgSO_4$	207.4	12.12
Magnesium Carbonate $MgCO_3$	5.1	.30
Calcium Carbonate $CaCO_3$	336.2	19.63
Silica SiO_2	18.6	1.09
Nonvolatile	1.6	.09
Iron Oxide Fe_2O_3	11.4	.67
Alumina Al_2O_3	3.2	.18
Total	933.1	54.50

Analysis number 48962 is of a sample of the treated water collected in January 1923.

Analysis of Sample Number 48962 of the City Supply after Softening.

Determinations Made.

	Parts per million.
Iron Fe	0.1
Manganese Mn	0.2
Silica SiO_2	2.8
Nonvolatile	1.8
Alumina Al_2O_3	2.3
Calcium Ca	0.0
Magnesium Mg	1.2
Ammonia NH_4	0.4
Sodium Na	287.3
Potassium K	39.0
Sulfate SO_4	234.1
Nitrate NO_3	4.3
Chloride Cl	260.0
Alkalinity	
Phenlophthalein	30.0
Methyl Orange	78.0
Residue	892.

Hypothetical Combinations.

	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	7.0	.41
Potassium Chloride KCl	69.2	4.03
Sodium Chloride NaCl	374.2	21.85
Sodium Sulfate Na_2SO_4	345.9	20.20
Sodium Carbonate Na_2CO_3	64.6	3.77
Ammonium Carbonate $(NH_4)_2CO_3$	1.1	.06
Magnesium Carbonate $MgCO_3$	4.2	.25
Silica SiO_2	2.8	.16
Nonvolatile	1.8	.11
Alumina Al_2O_3	2.3	.13
Iron Oxide Fe_2O_3	0.1	.01
Total	873.2	50.98

The hardness had been reduced by treatment from 535 to 5 parts per million. A large part of the water is used in boilers at the electric light plant. Before installing the softening plant it was necessary to scrape out the boilers at least once a week and since that time the boilers are washed out with a hose about once a month. In January, 1923, although power was required to operate the water softening plant and the demands for electric current were practically doubled, the amount of coal purchased was about the same as before the softening plant was installed.

MASON CITY (1880). Mason City is located in the southeastern part of Mason County on the drainage area of Sangamon River, a tributary of Illinois River. A public water supply was installed by the city in 1889. The installation included two wells with steam-head deep-well pumps which discharged directly into the distribution system, two 100-horsepower boilers, a distribution system, and a steel tank of 40,000 gallons capacity on a brick tower 60 feet high. One of the original wells has been abandoned and another well was drilled in 1916. It was estimated in 1919 that more than 90 per cent of the population used water from the public supply. During the summer, when about 40,000 gallons a day was used in building a concrete road and about 10,000 gallons a day was used by the Illinois Central Railroad, the amount of water pumped averaged near 260,000 gallons a day. The Chicago

and Alton Railroad Company and the Federal Ice Company have private supplies from wells about 200 feet deep into sand and gravel. At the Ice Company plant slate was struck at a depth of 216 feet. The meter rate for small quantities is 40 cents per 1000 gallons and the rate to the railroad is 20 cents per 1000 gallons. No discount is allowed. The minimum charge is $4.00 a year.

The public water supply is secured from two wells. One was drilled by J. D. Mount in 1889. An approximate record of material penetrated is as follows:

	Thickness in feet.	Depth in feet.
Loam	15	15
Sand and water	1	16
Clay, blue	20	36
Sand	65	101
Sand and gravel	20	121
Sand, fine	14	135
Fine sand and gravel	55	190
Gravel	10	200

The diameter of the well is 10 inches to a depth of 80 feet, 8 inches between depths of 80 and 135 feet, and 6 inches below a depth of 135 feet. The well is equipped with a Cook steam-head deep-well pump with 7¾-inch water cylinder and 36-inch stroke. The pump was operated from 10 to 12 hours a day in 1919 and the discharge was said to be about 170 gallons a minute.

The other well was drilled by C. P. Brant of Indanapolis, Indiana, in 1916. It is located 40 feet south of the older well. It is 12 inches in diameter and 197 feet deep. The material penetrated is similar to that penetrated by the older well. The water bearing stratum is here 13 feet thick and is said to contain some coarse gravel and some fine sand. A number 30 Cook screen is placed in the bottom of the well. The well is equipped with a Cook single-acting steam-heap deep-well pump with the water cylinder at a depth of 83 feet. The pump is operated 15 strokes a minute and is said to have a displacement at this speed of 255 gallons a minute. It was operated in 1919 a total of from 10 to 12 hours a day.

The water had a mineral content of 299, a total hardness of 272, and a content of iron of 0.8 parts per million as shown by the analysis of sample number 42053, collected on November 5, 1919, after pumping for fifteen minutes.

No boiler compounds are used at the station and the scale formed in the boilers is soft and easily removed. The casings in the wells, one 30 years old, were said to be in good condition in 1919.

Analysis of Sample Number 42053 from the City Supply.

Determinations Made.

	Parts per million.
Iron Fe	0.8
Silica SiO_2	16.7
Manganese Mn	0.3
Nonvolatile	0.5
Alumina Al_2O_3	1.6
Calcium Ca	63.4
Magnesium Mg	27.9
Ammonia NH_4	1.5
Sodium Na, Potassium K	7.8
Sulfate SO_4	2.0
Nitrate NO_3	0.8
Chloride Cl	4.0
Alkalinity Methyl Orange	280.
Residue	285.

Hypothetical Combinations.

	Parts per million.	Grains per gallon.
Sodium Nitrate $NaNO_3$	1.1	.07
Sodium Chloride NaCl	6.6	.39
Sodium Sulfate Na_2SO_4	2.9	.17
Sodium Carbonate Na_2CO_3	8.9	.52
Ammonium Carbonate $(NH_4)_2CO_3$	4.1	.24
Magnesium Carbonate $MgCO_3$	96.4	5.64
Calcium Carbonate $CaCO_3$	158.4	9.26
Iron Oxide Fe_2O_3	1.1	.07
Manganese Carbonate $MnCO_3$	0.6	.03
Alumina Al_2O_3	1.6	.09
Silica SiO_3	16.7	.98
Nonvolatile	0.5	.03
Total	299.2	17.49

MATTESON (485). Matteson is located in the southern part of Cook County on the drainage area of Calumet River. Many private wells into quicksand at a depth of from 10 to 20 feet are in use in the village. A public water supply was installed by the village in 1914. The installation included a well, a concrete block pumping station, a distribution system, and a 100,000-gallon elevated steel tank located on the same lot as the well. Water is pumped from the well into the distribution system by a deep-well pump driven by a 15-horsepower electric motor. Sixty-five service connections were in use in 1925. Water is sold on a graduated scale of from 25 cents per 100 cubic feet for 1000 cubic feet or less to 5 cents per 100 cubic feet for from 200,000 to 300,000 cubic feet. A cash discount of 10 per cent is allowed. The Michigan Central Railroad and the Illinois Central Railroad have private supplies from wells into rock, 110 and 127 feet deep respectively.

Water for the public supply is secured from a 10-inch well 282 feet deep, located near the center of the village. The lower part of the well is in Niagaran limestone. When the well was completed in 1914 it was pumped for eight hours at a rate of 200 gallons a minute and the water level was lowered 8 feet to a depth of 22 feet below the ground surface. The well is equipped with a Keystone Driller Company double-stroke deep-well pump with a 7¾-inch cylinder placed at a depth of 96 feet. The pump is operated with 18-inch stroke at a speed of 29 revolutions a minute, a displacement of a little over 200 gallons a minute. In 1925 the pump was operated three or four hours a day.

The water had a mineral content of 688 and a total hardness of 516 parts per million as shown by the analysis of sample number 50653, collected from a tap on the distribution system on December 3, 1923.

Analysis of Sample Number 50653 from the Village Supply.

Determinations Made.	Parts per million.
Iron Fe	0.0
Manganese Mn	0.0
Silica SiO_2	14.6
Nonvolatile	1.6
Alumina Al_2O_3	2.5
Calcium Ca	124.6
Magnesium Mg	50.2
Ammonia NH_4	0.4
Sodium Na	32.1
Potassium K	14.5
Sulfate SO_4	221.7
Nitrate NO_3	3.0
Chloride Cl	1.0
Alkalinity	
Methyl Orange	340.
Residue	681.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	4.9	.29
Potassium Chloride KCl	2.1	.12
Potassium Sulfate K_2SO_4	25.5	1.48
Sodium Sulfate Na_2SO_4	99.4	5.77
Ammonium Sulfate $(NH_4)_2SO_4$	1.7	.10
Magnesium Sulfate $MgSO_4$	173.9	10.09
Magnesium Carbonate $MgCO_3$	51.4	2.98
Calcium Carbonate $CaCO_3$	310.8	18.03
Alumina Al_2O_3	2.5	.15
Silica SiO_2	14.6	.85
Nonvolatile	1.6	.09
Total	688.4	39.95

Although the sample collected contained no iron, plumbing fixtures are stained by iron. No service connections or meters had been repaired in 1923 since the system was installed in 1914.

MATTOON (13552). Mattoon is located in the southwestern part of Coles County, part on the drainage area of Embarrass River and part on the drainage area of Little Wabash River. Many private wells have been dug or drilled to depths of from 10 to 50 feet and a few have been drilled deeper.

A public water supply was installed by the Mattoon Clear Water Company in 1885 and some years later it was sold to the Central Illinois Public Service Company. The original supply was from wells and the supply has been increased by installing additional wells. The amount of water available is limited and to supply water for industrial purposes a supply from tile drains and an impounding reservoir on the Little Wabash River was developed by a company in 1908. This supply for industrial purposes, by agreement, was taken over by the city.

The ground-water supply was originally from three wells into sand and gravel, each about 65 feet deep, located near the corner of Marshall Avenue and Twelfth Street. Water from the wells was discharged into a reservoir from which it was pumped into the distribution system. The pumping station and the standpipe connected to the mains were located close to the wells.

Ten drilled wells were installed later, at what was known as the Kickapoo station located 1800 feet south of the main station and they were connected into what was known as a gang well system. Three of these wells were located in a pit 48 feet deep which was 9 feet in diameter below a depth of 8 feet. The other wells were located nearby and were connected to the pit by tunnels. Water was drawn from the wells by suction by either of two steam pumps placed in the pit and was discharged through a pipe line into a receiving well at the main station. One of these wells was 6 inches in diameter, another was 4 inches in diameter, and the others were 5 inches in diameter. Later some of these wells were equipped with steam-head pumps. This station was abandoned several years ago. In 1923 some of he wells were again to be equipped with steam-head pumps to be used for extreme emergencies.

The wells near the main station at the corner of Marshall Avenue and Twelfth Street have been practically abandoned and water is secured from wells located in the southern part of the city in an area extending nearly two miles east and west. The elevation of the ground surface at the wells is between 710 and 720 feet above sea level. With the exception of one well they are about 70 feet deep. These wells pass through surface soil and clay, about 50 feet of blue clay or hardpan, and a water bearing sand which lies above peat. One well, number 26, located on the east side of the Illinois Central Railroad about in line with Walnut Street, is drilled through the peat and below the peat at a depth of 84 feet passes through 12 feet of water bearing sand. Below the sand is shelly slate which overlies coal at a depth of 106 feet.

Most of the wells are constructed according to the Clark patent, that is the top of the well is sealed air tight and the water bearing stratum is under a vacuum. In some wells the space between the well casing and the drop pipe is used as an air chamber by drilling holes near the bottom of the drop pipe and placing a gum packer between the pump cylinder and the casing. Gas discharged with the water insures against the casing filling with water.

Extensive improvements were made in 1923. Several of the wells were moved short distances and, although designated by old numbers, are new wells of new construction. In constructing these wells a screen and casing were installed smaller than the drilled hole and coarse sand and fine gravel was placed outside the screen through 2-inch pipes, the flow of gravel being aided by moving

rods placed inside the pipes. The new well number 26, into the water bearing stratum below peat, yielded 138 gallons a minute during a test.

In November, 1923, eight wells were available for use, another was completed excepting for equipment to be installed, and four other wells at the old Kickapoo Station were to be equipped with steam-head pumps. All but one of the wells were owned by the company and were 10 inches in diameter. One dug well, leased from the Cleveland, Cincinnati, Chicago and St. Louis Railroad, is 71 feet deep and is equipped with a screen of perforated pipe 8 feet in diameter. The amount of water supplied in 1923 averaged 375,000 to 400,000 gallons a day and on some days demands as high as 600,000 gallons were supplied. The water level in the wells is within a few feet of the bottom of the water bearing stratum.

The discharge of water from some wells is considerably less than the displacement of the pumps with which they are equipped on account of pumping gas. A well on Marshall Street in line with Thirty-fifth Street penetrated 5 feet 6 inches of sand above peat. Twenty-eight bags of fine gravel were placed around the screen. The discharge, when pumping with a pump of 200 gallons a minute capacity, was for a time 60 gallons a minute and decreased to 45 gallons a minute. This well was later abandoned.

A sample of water, number 39660, collected on June 26, 1918, from well number 27, one of the wells about 70 feet deep which furnish nearly the entire supply, had a mineral content of 532, a total hardness of 378, and a content of iron of 3.8 parts per million as shown by the analysis.

Analysis of Sample Number 39660 from Well Number 27.

Determinations Made.

	Parts per million.
Iron Fe	3.8
Manganese Mn	0.0
Silica SiO_2	20.9
Alumina Al_2O_3	4.1
Calcium Ca	87.6
Magnesium Mg	39.0
Ammonia NH_4	18.0
Sodium Na, Potassium K	41.1
Sulfate SO_4	2.9
Nitrate NO_3	1.1
Chloride Cl	11.1
Alkalinity Methyl Orange	490.
Residue	515.

Hypothetical Combinations.

	Parts per million.	Grains per gallon.
Sodium Nitrate $NaNO_3$	1.4	.08
Sodium Chloride NaCl	18.1	1.06
Sodium Sulfate Na_2SO_4	4.2	.24
Sodium Carbonate Na_2CO_3	73.9	4.31
Ammonium Carbonate $(NH_4)_2CO_3$	48.0	2.80
Magnesium Carbonate $MgCO_3$	136.5	7.96
Calcium Carbonate $CaCO_3$	218.8	12.76
Iron Oxide Fe_2O_3	5.3	.31
Alumina Al_2O_3	4.1	.24
Silica SiO_2	20.9	1.22
Nonvolatile	0.8	.05
Total	532.0	31.03

Water from the sand stratum below the peat contains more sodium and is not so hard as shown by the analysis of sample number 39665, collected from well number 26 on June 26, 1918.

Analysis of Sample Number 39665 from Well Number 26.

Determinations Made.

	Parts per million.
Iron Fe	2.0
Manganese Mn	0.0
Silica SiO_2	15.9
Alumina Al_2O_3	3.4
Calcium Ca	62.6
Magnesium Mg	28.2
Ammonia NH_4	9.0
Sodium Na / Potassium K	91.6
Sulfate SO_4	0.0
Nitrate NO_3	1.1
Chloride Cl	28.0
Alkalinity Methyl Orange	436.
Residue	520.

Hypothetical Combinations.

	Parts per million.	Grains per gallon.
Sodium Nitrate $NaNO_3$	1.4	.08
Sodium Chloride NaCl	46.2	2.69
Sodium Carbonate Na_2CO_3	164.7	9.60
Ammonium Carbonate $(NH_4)_2CO_3$	24.0	1.40
Magnesium Carbonate $MgCO_3$	97.6	5.69
Calcium Carbonate $CaCO_3$	156.3	9.11
Iron Oxide Fe_2O_3	2.8	.16
Alumina Al_2O_3	3.4	.20
Silica SiO_2	15.9	.93
Nonvolatile	1.6	.09
Total	513.9	29.95

MAYWOOD (12072). Maywood is a suburban village located in Cook County near the west bank of Des Plaines River. A public water supply was installed by the village in 1895. Wells were drilled near the center of the village. Later other wells were drilled and one well has been abandoned. In 1923 the installation included four wells, three of which were equipped with air lift. Air was supplied by three compressors, one a Sullivan 20 and 12 by 14-inch angle compound driven by a 200-horsepower electric motor, one a Sullivan 18 and 11 by 14-inch driven by a 125-horsepower motor, and the other an Ingersoll-Sargent. Water from these wells is discharged into a reservoir 80 by 90 feet in plan and 17 feet deep. Four pumps are available to pump water from the reservoir. One is a 12 and 17 by 8½ by 15-inch compound duplex steam pump and three are single-stage centrifugal pumps, each mounted on a shaft with a 40-horsepower electric motor. The other pump is a two-stage centrifugal which is driven by a gas engine. Steam is available from a plant of the American Can Company. One well is equipped with a centrifugal pump driven by a 187-horsepower vertical electric motor. A centrifugal pump at the top of this well, driven by a 62½-horsepower electric motor, discharges into the distribution system.

About 3000 service connection were in use in 1923. The total amount of water pumped in August averaged near 2,000,000 gallons a day. Water was furnished to the village of Broadview

in which water mains had been laid in 1922. Other large consumers were the Edward Hines Jr. Memorial Hospital, American Can Company, and Chicago Sanitary District.

The hospital, located southwest of the city, has a well 1803 feet deep, cased to a depth of 1015 feet. It is 10 inches in diameter at the bottom. During a test lasting several days water was pumped at a rate of 450 gallons a minute and the water level was lowered to a depth of 278 feet. This well was not in use in September 1923 on account of suspected contamination.

The American Can Company has two wells. One well 2060 feet deep was pumped about 20 hours a day in 1923 and the yield was estimated at 275 gallons a minute. This well is about 680 feet distant from the nearest city well. The company has another well 1600 feet deep which was to be cleaned out and put into service.

The city has drilled five wells, known as number 1, number 2, and number 3, number 4, and number 5. Well number 1, located near the center of the village, is 17 inches in diameter to a depth of 151 feet, 5 inches in diameter at the bottom, and 1595 feet deep. Casing was placed with the bottom at a depth of 575 feet. Well number 2 was drilled 32 feet south of well number 1. This well is 17 inches in diameter at the top, 5 inches in diameter at the bottom, and 2200 feet deep. When the city was visited in 1912 the wells were equipped with air lifts with air lines to a depth of 307 feet. The yield of wells number 1 and number 2 was 500 gallons a minute. The installation of a new air lift in number 2 well was completed in September 1913 and a newspaper item stated that the yield of this well was increased to 500 gallons a minute. Number 1 well has been abandoned and number 2 now has a small yield.

Well number 3 was completed in 1910. It is 26 feet distant from well number 1 and 22 feet northeast of well number 2. It is 16 inches in diameter at the top, 8 inches in diameter at the bottom, and 1600 feet deep. St. Peter sandstone was penetrated between depths of 840 and 980 feet and Cambrian sandstone was entered at a depth of 1400 feet. The yield in 1912 was reported to be 700 gallons a minute. After the installation of new air lift equipment in 1914 it was reported that the discharge was 800 gallons a minute and that when the air compressor was run at a high speed a discharge of 930 gallons a minute was secured. Soon after placing the equipment in operation the yield was 725 gallons a minute. In 1922 this well with number 4 well yielded 890 gallons a minute

of which the discharge from this well was probably considerably less than one-half.

Well number 4 is located about 160 feet southwest of well number 2. It was completed in 1918. The well is 2048 feet deep. St. Peter sandstone was entered at a depth of 897 feet and the thickness recorded by the drillers was 80 feet. Cambrian sandstone was entered at a depth of 1400 feet. The well was cased 612 feet, about 50 feet into Galena-Platteville limestone. In 1922 this well was in almost constant service. On August 21, 1922, when the air lifts in this well and in number 3 well had operated for many hours, the total yield of the two was 890 gallons a minute, of which well number 4 yielded considerably more than one-half. The total amount of water pumped from wells 2, 3, and 4 in 1922 averaged near 1,500,000 gallons a day. In the fall of 1923, when water was available from well number 5, the air lift in well number 4 was operated from 16 to 20 hours a day. On September 11 when the air lifts in number 2 and 3 were idle the yield of number 4 was 500 gallons a minute. Number 3 well was used in place of number 4 when demands were small and well number 2 was seldom used.

The water consumption grew to exceed the yield of wells 2, 3, and 4 and well number 5 was drilled by S. B. Geiger in 1922. It is located on Eleventh Street close to the Chicago Great Western Railroad tracks about 1½ miles distant from wells 2, 3, and 4. A record of material penetrated with part of the classifications given by the State Geological Survey Division is as follows:

	Thickness in feet.	Depth in feet.
Drift	74	74
Limestone, Silurian system, all or chiefly Niagaran	290	364
Shale, Richmond	176	540
Limestone, Galena-Platteville	343	883
Sandstone, St. Peter	105	988
Limestone, Prairie du Chien	17	1005
Cavey Shale, Prairie du Chien	25	1030
Limestone, Prairie du Chien	10	1040
Shale, cave, Prairie du Chien	305	1345
Sandstone, Mazomanie-Dresbach, Cambrian system	200	1545
Limestone, Eau Claire, Cambrian system	45	1590
Sandy shale, Eau Claire, Cambrian system	76	1666
Rock, red, Eau Claire, Cambrian system	39	1705
Limestone, Eau Claire, Cambrian system	100	1805
Sandstone, Eau Claire, Cambrian system	10	1815
Limestone, Eau Claire, Cambrian system	20	1835
Shale, Eau Claire, Cambrian system	10	1845
Shale, sandy, Eau Claire, Cambrian system	55	1900
Limestone, Eau Claire, Cambrian system	15	1915
Shale, Eau Claire, Cambrian system	8	1923
Sand, white, Mt. Simon, Cambrian system	151	2074
Sand, red, Mt. Simon, Cambrian system	2	2076

The well is 17 inches in diameter at the top and is cased to a depth of 545 feet. A 10-inch liner is placed between depths of 1040 and 1100 feet. The well is 10 inches in diameter at the bottom. The depth to water when the well was completed was 150 feet.

The well is equipped with an 8-stage centrifugal pump placed at a depth of 330 feet with 40 feet of suction pipe attached. During a test after completion of the well the discharge was from 1200 to 1500 gallons a minute. In the fall of 1923 the pump was operated from 23 to 24 hours a day and the discharge was estimated at 1000 gallons a minute. A meter was to be placed on the discharge lines.

Another well located east of well number 5 was drilled by S. B. Geiger and completed at a depth of 2090 feet in November 1924.

Depths to water have been as follows:

July 1907	80	feet	No. 1 and 2 wells
July 1908	90	feet	No. 1 and 2 wells
July 1909	100	feet	No. 1 and 2 wells
July 1910	110	feet	No. 3 well
July 1911	114	feet	No. 3 well
July 1912	140	feet	No. 3 well
July 1913	180½	feet	No. 3 well
July 1919	228	feet	No. 4 well
December 1922	150	feet	No. 5 well

When wells 3 and 4 were idle for three or four hours in 1921 and the air lift in either well was then started the water level in the other well, about 180 feet distant, was lowered one foot.

Analysis of Sample Number 50092 from well Number 5.

Determinations Made.

	Parts per million.
Iron Fe	0.2
Manganese Mn	0.0
Silica SiO_2	10.8
Nonvolatile	1.9
Alumina Al_2O_3	1.0
Calcium Ca	68.6
Magnesium Mg	32.9
Ammonia NH_4	0.5
Sodium Na	113.2
Potassium K	26.7
Sulfate SO_4	176.4
Nitrate NO_3	1.4
Chloride Cl	82.0
Alkalinity	
Methyl Orange	268.0
Residue	720.

Hypothetical Combinations.

	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	2.3	0.13
Potassium Chloride KCl	49.2	2.87
Sodium Chloride NaCl	96.6	5.64
Sodium Sulfate Na_2SO_4	232.2	13.56
Ammonium Sulfate $(NH_4)_2SO_4$	1.8	0.10
Magnesium Sulfate $MgSO_4$	22.4	1.31
Magnesium Carbonate $MgCO_3$	102.4	5.98
Calcium Carbonate $CaCO_3$	171.2	10.00
Iron Oxide Fe_2O_3	0.3	0.02
Alumina Al_2O_3	1.0	0.06
Silica SiO_2	10.8	0.63
Nonvolatile	1.9	0.11
Total	692.1	40.41

The temperature of water from well number five was 61 degrees Fahrenheit. Water from well number five had a mineral content of 692, a total hardness of 305, and a content of iron of 0.2

parts per million as shown by the analysis of sample number 50092, collected on September 11, 1923.

A sample of water collected from well number 4, which is 2048 feet deep, had a mineral content of 585 and a total hardness of 250 parts per million. Samples from other wells have been slightly harder and hypothetical combinations show more magnesium sulfate than in the analysis given.

One of the wells of the American Can Company was drilled to a depth of 2112 feet and was then filled below a depth of 2060 feet to exclude salty water.

MELROSE PARK (7147). Melrose Park is a suburban village located in the western part of Cook County on the west bank of Des-Plaines River. A public water supply was installed by the village in 1898. The supply was from one well until 1912 when another well was drilled. The wells are equipped with air lifts which discharge into a reservoir 20 feet by 70 feet in plan and 13 feet deep. Air is supplied by two Ingersoll-Rand 14 and 9 by 12-inch two-stage compressors, each driven by an electric motor. In 1923 another compressor had been installed temporarily. Water is pumped from the reservoir by three centrifugal pumps, each driven by a 50-horsepower electric motor.

Seventeen hundred and fifty service connections were in use in 1923. The rate for water not exceeding 5000 gallons a day is 30 cents per 1000 gallons. The lowest rate, for quantities exceeding 50,000 gallons a day, is 10 cents per 1000 gallons. The minimum meter charge in $1.50 for three months.

No private wells furnishing large quantities of water are in use in the village. The Chicago and Northwestern Railway has wells at the Proviso yards four miles distant.

Water for the public supply is secured from two wells located in the southwestern part of the village. One well, number 1, was drilled in 1898. It is 15 inches in diameter at the top, 45/8 inches in diameter at the bottom, and 1620 feet deep. When the well was completed water stood 30 feet below the ground surface when not pumping and the yield with an air lift with an air line to a depth of 135 feet was 600 gallons a minute. In 1912 the water level was at a depth of 75 feet when not pumping. When operating the air lift with 135 feet of 1½-inch air line with which the well was then equipped the discharge was 350 gallons a minute and the water level was said to be lowered 10 feet. The total amount of water pumped from this well during the first five months of 1912, com-

puted from strokes of steam pumps then in use, averaged 390,000 gallons a day. In 1913, when equipped with an air lift with an air line of 373 feet of 2-inch and 2½-inch pipe, this well and well number 2 discharged 584 gallons a minute. The air line was inside of a discharge line of 4⅝-inch, 7-inch, and 8-inch pipe. The air nozzle is a Sullivan.

Well number 2 was drilled by the J. P. Miller Artesian Well Company in 1912. It is located 30 feet distant from well number 1. The material encountered was as follows:

	Thickness in feet.	Depth in feet.
Drift	...	...
Limestone, Silurian system, all or chiefly Niagaran	215	310
Shale, Richmond	230	540
Limestone, Galena-Platteville	240	780
Sandstone, St. Peter	...	....
Limestone	...	1370
Sandstone	201	1571

The well is cased with 16-inch outside diameter pipe to rock and with 200 feet of 8-inch wrought iron pipe with the bottom at a depth of 1265 feet. At a depth of 561 feet the size of hole was reduced from 12-inch to 10-inch and possibly casing was placed. The well is 8 inches in diameter at the bottom. It is equipped with air lift. In 1923 the air line extended to a depth of 291 feet. This well and well number 1 on September 13, 1923, yielded 584 gallons a minute during a test. The air pressure on a gauge was 76 pounds. The depth to water while pumping was 166 feet in this well and more than 158 feet (the greatest depth that could be reached) in well number 1. The wells were operated 24 hours a day at the time of the test and during the preceding three months had furnished an average of 800,000 gallons of water a day.

Analysis of Sample Number 50110 from the Village Supply.

Determinations Made.

	Parts per million.
Iron Fe	0.1
Manganese Mn	0.0
Silica SiO_2	12.4
Nonvolatile	0.7
Alumina Al_2O_3	0.8
Calcium Ca	58.8
Magnesium Mg	52.1
Ammonia NH_4	0.0
Sodium Na	44.8
Potassium K	10.0
Sulfate SO_4	158.1
Nitrate NO_3	2.6
Chloride Cl	10.0
Alkalinity Methyl Orange	280.
Residue	580.

Hypothetical Combinations.

	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	4.3	0.25
Potassium Chloride KCl	15.9	0.93
Sodium Chloride NaCl	4.0	0.23
Sodium Sulfate Na_2SO_4	133.6	7.80
Ammonium Sulfate $(NH_4)_2SO_4$	0.1	0.01
Magnesium Sulfate $MgSO_4$	84.6	4.94
Magnesium Carbonate $MgCO_3$	121.1	7.07
Calcium Carbonate $CaCO_3$	146.9	8.58
Iron Oxide Fe_2O_3	0.1	0.01
Alumina Al_2O_3	0.8	0.04
Silica SiO_3	12.4	0.72
Nonvolatile	0.7	0.04
Total	524.5	30.62

Well number 2 was to be equipped with an air lift with longer air pipe in 1923.

The water had a mineral content of 524, a total hardness of 360, and a content of iron of 0.1 parts per million as shown by the analysis of sample number 50110, collected on September 13, 1923.

MELVIN (540). Melvin is located in the central part of Ford County on the drainage area of Vermilion River, a tributary of Wabash River. A limited public water supply was installed in 1908. Water was pumped from a well by a deep-well pump driven by a gas engine and was discharged through 3-inch galvanized iron pipe into five cisterns located in different parts of the village. Water was pumped from the cisterns by hand pumps. A more complete system was installed by the village in 1913. This included a well, a deep-well pump operated by a gas engine, a pumping station, an elevated steel tank of 50,000 gallons capacity and a distribution system of cast iron pipe. The old well, equipped with a deep-well pump driven by a 7½-horsepower electric motor, was available for use in emergency. One hundred and sixty service connections were in use in 1925.

From 1913 until 1923 nearly all water supplied was secured from the well which was drilled in 1913. It was 8 inches in diameter and was originally 231 feet deep. In 1916 or 1917 the depth of the well was increased to 245 feet to clay at the bottom of a sand stratum about 19 feet thick from which water is secured. A Cook screen 19½ feet long was placed in the sand stratum. The well was equipped with a single-acting deep-well pump with the pump cylinder attached to a 6-inch drop pipe and with 16 feet of 4½-inch suction pipe on the bottom of the cylinder. The suction pipe was slotted and rested on the plug at the bottom of the screen. An old cylinder measured 5 9/16 inches in diameter and the one in use in 1922 was thought to be about the same size. The pump was operated with 36-inch stroke and in 1922 was operated 20 revolutions a minute. It was estimated that the pump was operated about 3½ hours a day in 1921. The depth to water when improvements were made in 1916 or 1917 was 120 feet. Considerable trouble was caused by fine sand cutting pump leathers and in 1923 another well was drilled and this well was abandoned.

Water from this well when it was 231 feet deep had a mineral content of 415, a total hardness of 335, and a content of iron of 2.4 parts per million as shown by the analysis of sample number 30591, collected on June 3, 1915.

Analysis of Sample Number 30591 from the Village Well 231 Feet Deep.

Determinations Made.	Parts per Parts
Iron Fe	2.4
Manganese Mn	0.0
Silica SiO_2	17.1
Nonvolatile	1.4
Alumina Al_2O_3	1.1
Calcium Ca	71.3
Magnesium Mg	38.2
Ammonia NH_4	2.9
Sodium Na	28.1
Potassium K	2.9
Sulfate SO_4	6.2
Nitrate NO_3	1.4
Chloride Cl	1.0
Alkalinity Methyl Orange	416.
Residue	426.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	2.3	.13
Potassium Chloride KCl	2.1	.12
Potassium Sulfate K_2SO_4	2.0	.12
Sodium Sulfate Na_2SO_4	7.5	.44
Sodium Carbonate Na_2CO_3	59.1	3.45
Ammonium Carbonate $(NH_4)_2CO_3$	7.7	.45
Magnesium Carbonate $MgCO_3$	132.3	7.72
Calcium Carbonate $CaCO_3$	178.0	10.38
Iron Carbonate $FeCO_3$	5.0	.29
Alumina Al_2O_3	1.1	.06
Silica SiO_2	17.1	1.00
Nonvolatile	1.4	.08
Total	415.6	24.24

The well drilled in 1908 was 242 feet deep. After 1913 it was used occasionally when repairs were made on the other well.

In 1925 water was supplied from a well which was drilled in 1923. The following information was secured from G. P. Hawk, Village Clerk, in May 1925. The bottom of 8-inch pipe is at a depth of 243 feet. A number 12 Cook screen 19 feet long is placed in the well and 15 feet 11 inches of screen is exposed below the casing. It is sealed to the casing with a lead packer. The well is equipped with a deep-well pump with a 24-inch stroke. The well was tested on August 18, 1923, and 58 gallons a minute was pumped. The pump is operated five hours a day. Sand does not interfere.

MENDOTA (3934). Mendota is located in the northwestern part of LaSalle County on the drainage area of Little Vermilion River, a tributary of Illinois River. A limited public water supply was installed by the city in 1887. Water was secured from a well located between railroad tracks on the south side of Eighth Street, a short distance east of the depot.

Water is now secured from two wells into St. Peter sandstone. The wells are equipped with air lifts which discharge into a concrete reservoir. The reservoir is about 84 feet in diameter at the top and slightly smaller in diameter at the bottom, giving a capacity of about 40,000 gallons per foot depth. It is 18 feet deep and the lower 7 feet is divided by a wall. Either side can be cleaned if the water level is drawn down below the top of the wall. Air

is supplied by an Ingersoll-Rand compressor with 14 and 22-inch steam cylinders, 19 and 12-inch air cylinders, and 16-inch stroke. A Chapman compressor of smaller size is also available. Water is pumped from the reservoir into the mains by either of two pumps and a third pump is available in case of emergency. One pump is a Manistee Iron Works pump of 500 gallons a minute capacity. It is driven at a speed of 2500 revolutions per minute by a steam turbine of 25-horsepower which is operated with exhaust steam from the air compressor. Steam is condensed in a surface condenser. One pump is a Deane 12 and 18½ by 12 by 10-inch compound duplex steam plump. The pump held in reserve, a pump installed in 1888, is a 14 by 9 by 9-inch Deane duplex steam pump. An elevated steel tank 12 feet in diameter and 36 feet high on a brick tower 80 feet high is connected to the mains.

More than 1200 service connections were in use in 1922. The displacement of the reciprocating pumps then in use averaged about 700,000 gallons a day. Allowing for slip and short strokes the amount pumped probably averaged near 600,000 gallons a day. The rates for three months are $3.00 for 400 cubic feet or less, 35 cents per 100 cubic feet for quantities of 400 to 3000 cubic feet, 30 cents per 100 cubic feet for quantities from 400 to 15,000 cubic feet, with decreases to 11 cents per 100 cubic feet when more than 120,000 cubic feet is used. Bills paid promptly are subject to a discount of twenty-five per cent.

Two of the largest water consumers, the Chicago, Burlington and Quincy Railroad and the Illinois Central Railroad have private water supplies from wells into St. Peter sandstone. The Chicago, Burlington and Quincy Railroad has two wells located about 600 feet distant from the city wells. The Illinois Central Railroad has a well located about 400 feet distant from the city wells and 400 feet from the other railroad wells. The total amount pumped from the city wells and these private wells in 1922 probably averaged more than 1,000,000 gallons a day. A well 470 feet deep into St. Peter sandstone, formerly in use at a brewing plant, was not in use at that time.

A well for which the city contributed a small part of the expense was drilled in 1874 on the south side of the instersection of Sixth and Main Streets. A record of material penetrated to a depth of 990 feet prepared by C. A. Harbaugh, is as follows:

	Thickness in feet.	Depth in feet.
Soil, black	2	2
Clay, yellow	10	12
Yellow clay and gravel	3	15
Clay, blue	35	50
Gravel	4	54
Clay, blue	31	85
Sand and gravel	6	91
Clay, blue	40	131
Sand	4	135
Gray boulder clay with streaks of sand and gravel	25	160
Limestone, Galena-Platteville	200	360
Sandstone, St. Peter	175	535
Calciferous group of limestone	117	652
Sandstone	60	712
Calciferous group of limestone	88	800
Shale, white	50	850
Calciferous group of limestone	16	866
Sandstone	9	875
Limestone	7	882
Sandstone	2	884
Limestone	16	900
Calciferous sand rock	90	990

Below a depth of 990 feet to a depth of 2130 feet all material was classed by Mr. Curtiss as "Potsdam" (Cambrian system).

Water for the public supply is secured from two wells located 45 feet apart at Ninth Street on the west side of Sixth Avenue. One well is in the boiler room and the other in the pump room of the station. One well is 490 feet deep. The other well, drilled by the J. P. Miller Artesian Well Company in 1891-1892, is 478 feet deep. A record of material penetrated by one well is the same as given above to a depth of 160 feet (apparently one is a copy of the other). In the city well Galena-Platteville limestone was noted 280 feet thick to the top of St. Peter sandstone at a depth of 440 feet. The wells are cased to a depth of 240 feet. Water is discharged through 7-inch pipe which may be discharge pipe placed in the wells, may be casings extending to the ground surface inside of larger casings extending to a less depth, or may be pipe originally placed as discharge pipe and, with deterioration of outer casing, now serving partly as casing. When starting an air lift with the compressor operating at high speed water can be discharged outside of the 7-inch pipe. A line was lowered in one well outside of the 7-inch pipe to a depth of about 100 feet.

The wells are equipped with air lifts. In the well in the boiler room an air nozzle 5.4 feet long is attached to 259 feet of 2-inch air line. In the well in the pump room a 1½-inch air line extends to a depth of 253 feet. Both air lifts are operated nearly 24 hours a day excepting when working on one well when demands are supplied by the other well. At the time of visit, on October 2, 1923,

demands were supplied by the well in the pump room and the discharge was regulated by changing the speed of the compressor so that there was practically no variation in the water level in the reservoir. The rate of consumption when tested by shutting down this well and measuring the lowering in water level from the top of the reservoir, was 440 gallons a minute, a rate of 630,000 gallons a day. The air pressure when starting gradually was 90 pounds, when operating with the compressor running 71 revolutions a minute it was 84 pounds, and when operating with the compressor running 97 revolutions it was 90 pounds. The average amount supplied by the wells was estimated early in 1922 at 600,000 gallons a day.

When the first of these two wells was drilled in 1896 water is said to have stood at a depth of 46 feet. In 1914 the depth to water was reported to be 66 feet. The average consumption during the preceding year, which probably did not allow for slip of pumps or short strokes, was given as 517,000 gallons a day. On October 2, 1923, when both wells had been idle for about two hours and the well in the pump room had then been operated for two hours at a rate of about 600,000 gallons a day, the water level in the well in the boiler room was at a depth of 113 feet. The air lift in the pump room well was then shut down for 30 minutes and the water level in the well in the boiler room raised 35 feet to a depth of 78 feet.

Some general information is available from records of the wells of the Chicago, Burlington and Quincy Railroad. A well 503 feet deep was drilled by the J. P. Miller Artesian Well Company in 1916. It is 12 inches in diameter at the bottom. It is on ground five or ten feet higher than ground at the city wells. The depth to water when the well was completed was 75 feet. The well was equipped with an American centrifugal pump of 500 gallons a minute capacity placed at a depth of 160 feet and for a few years the pump yielded full capacity. In 1922 it was necessary to lower the pump. Another well of smaller size, 504 feet deep, located 15 feet distant from this well, has small yield when the larger well is operated, and is seldom used.

Water from the city supply had a mineral content of 347, a total hardness of 253, and a content of iron of 2.4 parts per million as shown by the analysis of sample number 47197, collected on March 9, 1922.

Samples collected from this supply in the past have been of similar quality. Very little scale is formed in the boilers at the pumping station. The boilers are more than twenty years old

and are set to blow off at 115 pounds. One boiler is operated for a month and is then cleaned while the other boiler is operated.

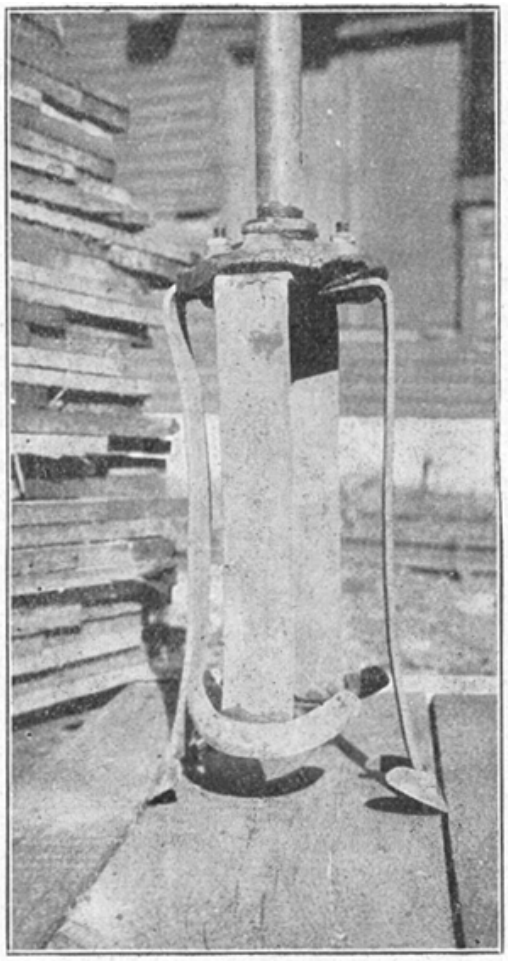
Analysis of Sample Number 47197 from the City Supply.

Determinations Made.

	Parts per million.
Iron Fe	2.4
Manganese Mn	0.2
Silica SiO_2	14.1
Nonvolatile	1.1
Alumina Al_2O_3	1.8
Calcium Ca	67.5
Magnesium Mg	21.8
Ammonia NH_4	1.2
Sodium Na	31.1
Potassium K	1.7
Nitrate NO_3	1.4
Chloride Cl	1.0
Alkalinity Methyl Orange	330.0
Residue	363.

Hypothetical Combinations.

	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	2.3	.13
Potassium Chloride KCl	1.5	.09
Sodium Chloride NaCl	0.4	.02
Sodium Carbonate Na_2CO_3	71.3	4.17
Ammonium Carbonate $(NH_4)_2CO_3$	3.2	.19
Magnesium Carbonate $MgCO_3$	79.1	4.62
Calcium Carbonate $CaCO_3$	168.6	9.86
Silica SiO_2	14.1	.82
Nonvolatile	1.1	.06
Iron Oxide Fe_2O_3	3.5	.20
Alumina Al_2O_3	1.8	.10
Total	346.9	20.26



WELL SCRAPER USED AT MENDOTA.

The wells are cleaned twice a year with a scraper, a view of which is shown on preceeding page. Four scrapers which are held against the wall of the well by springs are attached to a pipe and forced to the bottom of the well. Oxides of aluminum and iron constitute three-fourths of the material removed.

For several years the Illinois Central and Chicago, Burlington and Quincy Railroads treated their supplies which are from the same source as the city supply. The Chicago, Burlington and Quincy Railroad has discontinued treatment.

METAMORA (683). Metamora is located in the western part of Woodford County ten miles east of Illinois River. Many private wells are in use in the village. Some are as shallow as twenty feet and others as deep as eighty feet. Many gas wells have been drilled to a depth of a little more than 100 feet but few of these are now in use. One gas well was drilled to a depth of 217 feet. Water raised 150 feet. In locating a public water supply a two-inch well was drilled to a depth of 250 feet and a six-inch well was drilled to a depth of 500 feet. Both are reported to have been dry holes. A well was then dug to a depth of 66 feet and this furnished only a limited supply. The well now in use was then dug.

The public water supply was installed by the village about 1889. Water is pumped from a well into the distribution system to which an elevated wooden tank is connected. The tank is 24 feet in diameter and 16 feet high. Several changes in equipment have been made. Water is now pumped by a Myers pump which is driven by belt from a 5-horsepower electric motor. The pump formerly in regular service can also be used. The pumps are in a pit five feet deep, located at the top of the well. Electric current is purchased from the Central Illinois Light Company. The meter rate for water is 30 cents per 100 cubic feet with a minimum charge of 75 cents a month. Bills are not subject to discount.

Water is secured from a well into sand and gravel, located in the northeast corner of the public park. The well measures 8 feet in diameter at the top and 80 feet deep. A plank cover forms part of the floor of the pumping station. The pump generally used has a 3¾-inch cylinder and 18-inch stroke and is operated 27 to 28 revolutions a minute. The cylinder is attached to 65 or 70 feet of 4-inch drop pipe and has 6 feet of suction pipe attached. As nearly as could be estimated in 1924 it was operated an average of one hour forty minutes a day and discharged about 24 gallons a minute, a total of 2,400 gallons a day. The water level on June 18, 1924, was

34 feet below the ground surface before pumping and 42 feet below the ground surface after pumping for three hours. The inflow into the well while pumping was estimated at five or six gallons a minute.

The water had a mineral content of 488, a total hardness of 400, and a content of iron of 0.1 parts per million as shown by the analysis of a sample, number 31615, collected on September 23, 1915.

Analysis of Sample Number 31615 from the Village Supply.

Determinations Made.	Parts per million.
Iron Fe	0.1
Manganese Mn	none
Silica SiO_2	15.2
Alumina Al_2O_3	1.0
Calcium Ca	83.3
Magnesium Mg	47.0
Sodium Na	28.2
Potassium K	3.6
Sulfate SO_4	52.4
Nitrate NO_3	14.1
Chloride Cl	11.0
Nonvolatile	1.8
Alkalinity Methyl Orange	360.
Residue	484.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	9.3	.54
Sodium Nitrate $NaNO_3$	11.5	.67
Sodium Chloride NaCl	18.2	1.06
Sodium Sulfate Na_2SO_4	55.2	3.22
Magnesium Sulfate $MgSO_4$	18.9	1.10
Magnesium Carbonate $MgCO_3$	149.6	8.72
Calcium Carbonate $CaCO_3$	207.9	12.13
Iron Carbonate $FeCO_3$	0.2	.01
Alumina Al_2O_3	1.0	.06
Silica SiO_2	15.2	.89
Nonvolatile	1.8	.10
Total	488.8	28.50

METROPOLIS (5055). Metropolis is located in the southern part of Massac County on the north bank of Ohio River. A public water supply was installed by the city in 1892. Water was taken from Ohio River until 1906 when a well was drilled and the old pump pit 20 feet square and 35 feet deep was converted into a reservoir. The well is equipped with an air lift which discharges into a small basin at the top of the well from which water flows into the reservoir. Water may be pumped from the reservoir by either of two units. One unit consists of two McGowan 5-inch single-stage centrifugal pumps, each of 600 gallons a minute capacity, direct connected to a steam turbine. The pumps may be operated singly, in series, or in parallel. The other unit is a McGowan 12 and 20 by 10½ by 18-inch tandem compound duplex steam pump. Pumps are run continuously to supply demands and no elevated tank or standpipe is in use. Air is supplied by two Ingersoll-Rand 10 by 12 by 14-inch air compressors of 250 cubic feet per minute capacity each. The plant is operated in connection with an electric plant and the turbine is driven by exhaust steam from the engines.

Water for the public supply is secured from a well drilled in 1906. It is located about 400 feet distant from the low water line

of Ohio River. The surrounding land has been flooded at times of high water. The well is 8 inches in diameter and 125 feet deep. No record of material penerated is available. A well at the plant of the Metropolis Ice Company penetrated 22 feet of yellow clay and, below this, strata of gravel, gumbo, and sand to a depth of more than 200 feet, and "Elco" gravel at a depth of 290 feet. The city well is equipped with an air lift, with a 1½-inch air line to a depth of 125 feet and 6-inch discharge line. In 1915 the water level was 13 feet below the ground surface when not pumping and was lowered about 20 feet when pumping at a rate of 625 gallons a minute. At that time water could be drawn from the well by suction or could be pumped by air lift.

The yield of the well, during a test in 1923, was 1200 gallons a minute for twelve hours. The air lift was operated about twelve hours a day during the summer of 1924. The discharge was 650 gallons a minute and when operated continuously for six hours the water level was lowered to 25 feet below the ground surface. The water level when not pumping was at a depth of eleven feet.

The temperature of water when discharged from the well was 61 degrees Fahrenheit. The water had a mineral content of 233, a total hardness of 195, and a content of iron of 0.6 parts per million as shown by the anaylsis of sample number 51951, collected on July 24, 1924.

Analysis of Sample Number 51951 from the City Supply.

Determinations Made.	Parts per million.
Iron Fe	0.6
Manganese Mn	0.0
Silica SiO_2	11.6
Nonvolatile	0.7
Alumina Al_2O_3	10.7
Calcium Ca	62.2
Magnesium Mg	9.5
Ammonia NH_4	0.1
Sodium Na	2.9
Potassium K	3.7
Sulfate SO_4	16.8
Nitrate NO_3	2.5
Chloride Cl	3.0
Alkalinity Methyl Orange	180.
Residue	240.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	4.0	0.23
Potassium Chloride KCl	4.0	0.23
Sodium Chloride NaCl	1.8	0.10
Sodium Sulfate Na_2SO_4	6.7	0.39
Ammonium Sulfate $(NH_4)_2SO_4$	0.3	0.02
Magnesium Sulfate $MgSO_4$	15.1	0.88
Magnesium Carbonate $MgCO_3$	22.1	1.29
Calcium Carbonate $CaCO_3$	155.3	9.07
Iron Oxide Fe_2O_3	0.9	0.05
Alumina Al_2O_3	10.7	0.62
Silica SiO_2	11.6	0.68
Nonvolatile	0.7	0.04
Total	233.2	13.60

MILAN (850). Milan is located in Rock Island County on low land on the south bank of Rock River about four miles south of the city of Rock Island. A public water supply was installed by the

village in 1895. Water flowed from a well into the distribution system and an elevated wooden tank placed directly over the well. Since 1916 it flows into a reservoir at the top of the well. The reservoir is 7 feet by 5 feet 6 inches in plan and 10 feet 6 inches deep. The water is pumped from this reservoir by a pump of 200 gallons a minute capacity which is driven by a 10-horsepower electric motor. The motor is operated with automatic control. A pump driven by gas engine, formerly used at times of fire, is available for service. The old wooden tank has been replaced by a wooden tank which is 20 feet in diameter and 20 feet high and is on a tower 50 feet high. Power is furnished by the Peoples Power Company.

Water for the public supply is secured from a well. The ground surface at the well is about 566 feet above sea level. A classification of material by the State Geological Survey Division from records in council proceedings of October 1, 1894, is as follows:

	Thickness in feet.	Depth in feet.
Drift	7	7
Limestone (middle Devonian and Niagaran)	383	390
Shale, Maquoketa	160	550
Shale with streaks of limestone, Maquoketa	55	605
Limestone, Brown, Galena	95	700
Limestone, White, Galena	140	840
Limestone, Brown, Platteville	90	930
Shale, Platteville	30	960
Sandstone, St. Peter	90	1050
Sandy lime, St. Peter	10	1060
Sandy lime with shale and crevices, St. Peter	35	1095
Sandstone, hard and sharp, St. Peter	20	1115
Marl, Red, St. Peter	10	1125
Limestone, White, Prairie du Chien	32	1157

A small flow of water was noted in the upper 95 feet of the Galena limestone and a flow of 100 gallons a minute was noted in the lower 140 feet of that limestone. A flow of 200 gallons a minute was noted in the upper 90 feet of St. Peter sandstone. The first casing was 5 feet into rock. The well has been recased several times. In 1912 the J. P. Miller Artesian Well Company placed 5-inch galvanized casing to a depth of 658 feet and cleaned the hole to 5-inches diameter to the bottom at a depth of 1157 feet. The pressure at the ground surface was then 12 pounds.

When the well was drilled the pressure at the top with no flow was 67 feet and the flow was 350 gallons a minute. In 1916 when water flowed into an elevated tank 20 feet above the ground surface the flow filled the tank to a depth of 2 feet during the night. The flow at the ground surface, tested by meter in that year, was 100 gallons a minute. In 1923 the flow was 90 gallons a minute when the water level in the reservoir was 80 inches below the top and 50 gallons a minute when the water level was 20 inches below

the top. The average amount of water pumped was estimated in August, 1923, at 40,000 gallons a day.

The temperature of water from the well was 60 degrees Fahrenheit. Well casings have frequently been replaced. The water had a mineral content of 1202 and a total hardness of 180 parts per million as shown by the analysis of sample number 49838, collected on Augustt 1, 1923.

Analysis of Sample Number 49838 from the Village Well.

Determinations Made.	Parts per million.
Iron Fe	0.0
Manganese Mn	0.0
Silica SiO_2	10.5
Nonvolatile	2.3
Alumina Al_2O_3	6.3
Calcium Ca	40.8
Magnesium Mg	19.1
Ammonia NH_4	5.6
Sodium Na	322.5
Potassium K	45.0
Sulfate SO_4	382.5
Nitrate NO_3	1.7
Chloride Cl	210.0
Alkalinity Methyl Orange	276.
Residue	1186.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	2.8	0.16
Potassium Chloride KCl	83.8	4.89
Sodium Chloride NaCl	280.4	16.37
Sodium Sulfate Na_2SO_4	565.2	33.01
Sodium Carbonate Na_2CO_3	67.5	3.94
Ammonium Carbonate $(NH_4)_2CO_3$	15.1	0.88
Magnesium Carbonate $MgCO_3$	66.2	3.86
Calcium Carbonate $CaCO_3$	102.0	5.95
Alumina Al_2O_3	6.3	0.37
Silica SiO_2	10.5	0.61
Nonvolatile	2.3	0.13
Total	1202.1	70.17

A sample collected in 1918 was similar but contained 1.9 parts per million of iron. Plumbing fixtures are stained by iron.

MILFORD (1466). Milford is located in the southeastern part of Iroquois County on the drainage area of Iroquois River, a tributary of Kankakee River. A public water supply was installed by the village in 1896. The installation included a pit 16 feet in diameter and 20 feet deep, two wells drilled in the bottom of the pit to a depth of 65 feet below the ground surface, an 8 by 8-inch Goulds pump, a gas engine, a distribution system, and a steel tank 20 feet in diameter and 25 feet high supported on a steel tower 80 feet high. One of the original wells has been abandoned and another well has been drilled. A 10-horsepower electric motor is now used to drive the triplex pump which pumps from the wells into the distribution system. About three hundred service connections were in use in 1923. The water consumption was estimated at from 40,000 to 50,000 gallons a day. The rate for water is 25 cents per 1,000 gallons. The largest consumer, the Milford Canning Company, secures part of its supply from private wells of about the same depth as the village wells.

The public water supply is secured from two 8-inch wells, each 65 feet deep into a stratum of sand and gravel. The ground surface at the wells is about 665 feet above sea level. One well, one of the two original wells installed in 1896, is located in the south part of the pit. The screen with which it was equipped has been removed and holes have been drilled in the lower length of casing. The other well was drilled by C. S. Cummings in 1916. It is located west of the pit and 16 feet distant from the well in the pit. It is equipped with a Johnson screen. A suction line from the triplex pump, which is placed in the pit, is connected to the well casing at a tee placed seventeen feet below the ground surface. In 1923 the pump was operated at a speed of 24 revolutions a minute, a displacement of 125 gallons a minute. The vacuum on the pump was shown by a guage which usually recorded a vacuum of 22 inches when pumping and at times indicated as high as 27 inches. The pump was operated an average of a little more than seven hours a day during 1922, a year when the canning season was short. The total amount of water pumped probably averaged less than 50,000 gallons a day.

The water had a mineral content of 687, a total hardness of 490, and a content of iron of 1.4 parts per million as shown by the analysis of sample number 37411, collected on June 26, 1917.

Analysis of Sample Number 37411 from the Village Supply.

Determinations Made.	Parts per million.
Silica SiO_2	14.2
Nonvolatile	2.1
Iron Fe	1.4
Alumina Al_2O_3	7.6
Calcium Ca	107.3
Magnesium Mg	54.7
Ammonia NH_4	1.1
Sodium Na	47.1
Potassium K	6.5
Sulfate SO_4	213.6
Nitrate NO_3	1.1
Chloride Cl	3.0
Alkalinity Methyl Orange	360.
Residue	710.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	1.8	.10
Potassium Chloride KCl	6.3	.37
Potassium Sulfate K_2SO_4	5.6	.33
Sodium Sulfate Na_2SO_4	145.2	8.47
Ammonium Sulfate $(NH_4)_2SO_4$	4.0	.23
Magnesium Sulfate $MgSO_4$	137.2	8.01
Magnesium Carbonate $MgCO_3$	93.5	5.45
Calcium Carbonate $CaCO_3$	267.8	15.62
Iron Carbonate $FeCO_3$	2.0	.11
Alumina Al_2O_3	7.6	.44
Silica SiO_2	14.2	.83
Nonvolatile	2.1	.12
Total	687.3	40.08

Meters are clogged in five or six years with an iron deposit and it is sometimes necessary to take up lead service pipe due to clogging.

MILLEDGEVILLE (746). Milledgeville is located in the southwestern part of Carroll County on the drainage area of Rock River. A public water supply was installed by the village in 1897. Water is pumped from two wells into the distribution system by deep-well pumps. The pumps are driven by a 30-horsepower electric motor. Two steel pressure tanks, each 8 feet in diameter and 56 feet long are connected to the mains.

One hundred and ninety-one service connections were in use in 1923. The rate for water is 80 cents per 1,000 gallons for the first 5,000 gallons, 60 cents per 1000 gallons for the next 5,000 gallons, 40 cents per 1,000 gallons for the next 5,000 gallons, and 30 cents per 1,000 gallons for the next 10,000 gallons. The Chicago, Burlington and Quincy Railroad pumps water from a shallow well on the bank of Elkhorn Creek, about half a mile east of the village.

Analysis of Sample Number 50383 from the Village Supply.

Determinations Made.

	Parts per million.
Iron Fe	0.0
Manganese Mn	0.0
Silica SiO_2	15.6
Nonvolatile	2.4
Alumina Al_2O_3	1.0
Calcium Ca	71.3
Magnesium Mg	35.5
Ammonia NH_4	0.1
Sodium Na	3.5
Potassium K	1.0
Sulfate SO_4	17.5
Nitrate NO_3	0.9
Chloride Cl	5.0
Alkalinity	
Methyl Orange	286.
Residue	326.

Hypothetical Combinations.

	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	1.4	0.08
Potassium Chloride KCl	0.9	0.05
Sodium Chloride NaCl	7.5	0.44
Sodium Sulfate Na_2SO_4	1.7	0.10
Ammonium Sulfate $(NH_4)_2SO_4$	.03	0.02
Magnesium Sulfate $MgSO_4$	20.2	1.18
Magnesium Carbonate $MgCO_3$	108.8	6.35
Calcium Carbonate $CaCO_3$	178.0	10.39
Alumina Al_2O_3	1.0	0.06
Silica SiO_2	15.6	0.91
Nonvolatile	2.4	0.14
Total	337.8	19.72

The public water supply is secured from two wells located ten feet apart. No definite record of the wells is available. They have been reported to be between 250 and 300 feet deep and have also been reported to be more than 500 feet deep. The ground surface at the wells is about 760 feet above sea level. Each well is equipped with a deep-well pump with a 4¾-inch cylinder and 24-inch stroke. The cylinder in the west well is attached to 200 feet of drop pipe and the cylinder in the east well is attached to 260 feet of drop pipe. At the time of the visit in October, 1923, the west pump was operated 29½ strokes a minute and the east pump was operated 29 strokes a minute. The discharge from the two wells, as measured in the pressure tanks with allowance for consumption, was about 80 gallons a minute. The pump was operated about four

hours a day during the first eight months of 1923. The total amount of water pumped probably averaged near 19,000 gallons a day.

The temperature of the water at a tap in the pumping station after pumping for one hour was 52 degrees Fahrenheit. The water had a mineral content of 337 and a total hardness of 323 parts per million, as shown by the analysis of sample number 50,383, collected on October 24, 1923.

The analysis of a sample collected in 1916 is similar and that sample also contained no iron. Steel pressure tanks installed when the water works were built were replaced in 1921. They were badly pitted. Six or seven meters are repaired each year and two service connections have been replaced.

MINIER (789). Minier is located in the southeastern part of Tazewell County on the drainage area of Sugar Creek, a tributary of Sangamon River. A few private wells from 15 to 25 feet deep are in use.

A public water supply was installed by the village in 1891. The installation included a well equipped with a deep-well pump, an elevated wooden tank, and a distribution system. The original well has been abandoned and two other wells have been drilled. These are equipped with deep-well pumps which discharge directly into the distribution system and the elevated tank. The pumps are driven by a 10-horsepower electric motor and a 10-horsepower kerosene engine is also available for use. The original tank has been replaced by a wooden tank 20 feet in diameter and 20 feet high on a steel tower 80 feet high. Two hundred and ten service connections were in use in 1922. The meter rate is 50 cents per 1,000 gallons but meters do not work well on account of sand carried by the water.

Water is secured from two wells located nine feet apart near the center of the village. The elevation of the tops of the wells is about 633 feet above sea level. One well, installed in 1914, is 8 inches in diameter and 143 feet deep. The lower 14 feet is in a sand and gravel stratum of which the lower 5 feet is said to be fairly coarse sand or fine gravel. The well extends through the water bearing stratum and is equipped with a screen. This well is equipped with a Goulds single-acting deep-well pump with 5¾-inch cylinder and 24-inch stroke which, in 1922, was operated 27 strokes a minute. It was formerly equipped with a single-acting steam-head pump with a water cylinder about 5¾ inches in diameter and 36-inch stroke. When operating the steam pump 37 strokes

a minute, a displacement of 148 gallons a minute, in 1916 water was drawn down to the pump cylinder at a depth of 130 feet. The amount of water pumped, computed from pump displacement and pump revolutions, was from 85,000 to 90,000 gallons a day during the summer. When not pumping water stood about seventy-five feet below the ground surface.

The other well was installed in 1910. For several years this well was out of service. It is 8 inches in diameter and 138 feet deep. It is equipped with a Goulds singe-acting deep-well pump with 3½-inch cylinder and 24-inch stroke which, in 1922, was operated at near 30 strokes a minute.

At times (data in 1922) both pumps were operated from 8 to 10 hours a day. In the winter the larger pump was operated 6 or 7 hours a day. As near as could be estimated the average demand was 30,000 gallons a day.

The water had a mineral content of 361, a total hardness of 291, and a content of iron of 1.5 parts per million as shown by the analysis of sample number 36133, collected on December 13, 1917.

Analysis of Sample Number 36133 from the Village Supply.

Determinations Made.

	Parts per million.
Iron Fe	1.5
Silica SiO_2	14.7
Alumina Al_2O_3	1.5
Calcium Ca	60.9
Magnesium Mg	34.0
Ammonia NH_4	3.3
Sodium Na	26.3
Potassium K	2.3
Sulfate SO_4	0.0
Chloride Cl	1.0
Alkalinity	
Methyl Orange	354.
Residue	384.

Hypothetical Combinations.

	Parts per million.	Grains per gallon.
Potassium Chloride KCl	2.1	.12
Potassium Carbonate K_2CO_3	2.1	.12
Sodium Carbonate Na_2CO_3	60.5	3.52
Ammonium Carbonate $(NH_4)_2CO_3$	8.8	.51
Magnesium Carbonate $MgCO_3$	117.7	6.86
Calcium Carbonate $CaCO_3$	151.9	8.84
Iron Oxide Fe_2O_3	2.2	.12
Alumina Al_2O_3	1.5	.07
Silica SiO_3	14.7	.86
Total	361.5	21.04

MINONK (2109). Minonk is located in the northeastern part of Woodford County on the watershed between Vermilion and Sangamon Rivers, tributaries of Illinois River. A public water supply was installed by the city about 1887. The system included a well 16 feet in diameter and 65 feet deep, a pump, a distribution system, and an elevated wooden tank. In 1893 extensive improvements were made. A deep well was drilled and the old dug well has since been used as a collecting reservoir. The drilled well is equipped with a deep-well pump which is driven by belt from an electric motor. Water is pumped from the collecting

reservoir into the distribution system and an elevated tank by a two-stage centrifugal pump of 200 gallons a minute capacity. An elevated steel tank is connected to the mains. Water is sold at a rate of three-fourths of a cent per cubic foot.

The public water supply, at the time of our visit in March, 1922, was secured from a well which was drilled in 1893. Possibly a small part of the supply flowed into the bottom of the old well or collecting reservoir. Another well had been drilled but was not equipped in March, 1922. The well in use was 12 inches in diameter at the top, 6 inches in diameter at the bottom, and 1850 feet deep. It was cased to a depth of 600 feet. In 1893 and in 1914 the depth to water was reported to be 150 feet when not pumping. In 1914 it was said to be 180 feet when pumping. It was said that 90 gallons of water per minute had been pumped. The average consumption was then 67,500 gallons a day. The well was equipped with a Keystone Driller Company two-stage deep-well pump with 5¾-inch cylinder attached to a 6-inch drop pipe with the bottom of a screen one foot long which is attached to the bottom of the cylinder, at a depth of 366 feet. The pump was operated with 18-inch stroke at a speed slightly over 23 revolutions a minute. The discharge when the pump was in good condition was said to fill the collecting reservoir at a rate of one foot in fourteen minutes, a rate of 107 gallons a minute. In 1920 the depth to water when the pump was removed was 200 feet and in 1921 the depth to water was about 202 feet. During December, 1921, and January and February, 1922, the water consumption averaged 80,000 gallons a day. In 1922 the well was cleaned out by the J. P. Miller Artesian Well Company of Chicago to a depth of 1519 feet. Water from the well 1850 feet deep had a mineral content of 2308, a total hardness of 52, and a content of iron of 0.2 parts per million as shown by the analysis of sample number 28647, collected on September 1, 1914.

A sample collected in 1922, before the well was cleaned out in that year, was similar showing that at that time the quality of the water had not been affected by the well nearby which had recently been completed to a greater depth. The analysis given shows an iron content of 0.2 parts per million and the iron content of the other sample was 1.4 parts per million. Where galvanized pipe is cut the water acts on the joints. The water has little effect on meters, some of which are in good condition after twenty years use. The water acts on plates on the elevated tank where they are alternately wet and dry. A tank installed in 1893 was replaced in 1917.

Analysis of Sample Number 28647 from the City Well 1850 Feet Deep.

Determinations Made.	Parts per million.
Iron Fe	0.2
Silica SiO_2	20.5
Nonvolatile	2.5
Alumina Al_2O_3	4.1
Calcium Ca	8.9
Magnesium Mg	7.2
Ammonia NH_4	0.4
Sodium Na	857.7
Potassium K	33.8
Sulfate SO_4	100.1
Nitrate NO_3	4.4
Chloride Cl	1031.0
Alkalinity	
Methyl Orange	420.
Residue	2337.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	7.1	.41
Potassium Chloride KCl	59.2	3.45
Sodium Chloride NaCl	1654.8	96.52
Sodium Sulfate Na_2SO_4	148.0	8.63
Sodium Carbonate Na_2CO_3	363.5	21.20
Ammonium Carbonate $(NH_4)_2CO_3$	1.0	.06
Magnesium Carbonate $MgCO_3$	24.9	1.45
Calcium Carbonate $CaCO_3$	22.2	1.29
Iron Carbonate $FeCO_3$	0.4	.03
Alumina Al_2O_3	4.1	.30
Silica SiO_2	20.5	1.19
Nonvolatile	2.5	.14
Total	2308.2	134.67

A well 2005 feet deep was drilled in 1921-1922 by the J. P. Miller Artesian Well Company. It is located 28 feet northeast of the other well. A record of material penetrated, as given by the drillers, is as follows:

	Thickness in feet.	Depth in feet.
Blue clay	6	70
Clay and gravel	5	75
Gravel, water	25	146
Gravel, shale	25	165
Mud	15	180
Blue clay, gravel	30	210
Clay, gravel	3	213
Limestone	2	215
Red mud	5	220
Blue mud	315	535
Coal	4	539
	25	575
	80	655
Limestone	595	1250
Shale	100	1350
Limestone	440	1790
Sandstone, (St. Peter)	210	2000
Gravel, (St. Peter)	5	2005

The well is cased from the ground surface with 202 feet of 16 inch outside diameter pipe. Twelve-inch casing, sealed to the 16-inch, extends to a depth of 527 feet and ten-inch casing sealed to the 12-inch is placed between depths of 516 and 660. All pipe is wrought iron. The well is 10 inches in diameter at the bottom. The depth to water in the well was 217 feet until sandstone was entered when it raised to a depth of 202 feet.

In March, 1922, the well was equipped with a deep-well pump with the cylinder at a depth of 301 feet. The pump was operated

by the well rig. The well was pumped for ten hours. During the first five hours the yield, as measured in a tank, was between 115 and 120 gallons a minute at nearly all times. The yield 8 hours 30 minutes after the test started had decreased to 80 gallons a mniute. The rate of pumping was then increased and the maximum possible rate of pumping at the end of the test was 107 gallons a minute. During the last 7 hours 30 minutes of this test the pump in the well 28 feet distant was operating. During the preceding three months the amount of water pumped had averaged 60,000 gallons. Measurements to water level in the wells could not be made but it is probable that the water level in the well tested was drawn down to the pump cylinder at a depth of 301 feet.

The temperature of water from the well, one hour after pumping started, was 67 degrees and after pumping for 8 hours 30 minutes it was 72 degrees. The water had a mineral content of 1444, total hardness of 283, and a content of iron of 1.6 parts per million. This water is less highly mineralized but harder than water from the well 1850 feet deep.

We are advised in April, 1925, that a Keystone Driller Company pump with 6¾-inch cylinder has been installed in the well 2005 feet deep, that two American two-stage centrifugal pumps have been installed in the station, and that the water consumption averages 90,000 gallons a day.

MINOOKA (314). Minooka is located in the northeastern part of Grundy County four miles north of Illinois River. Some private wells in use are from 15 to 20 feet deep and others are into a stratum of sand which overlies rock at a depth of about 100 feet.

A public water supply was installed by the village in 1886. Water was obtained from a well which has since been abandoned. The installation now includes a well equipped with a deep-well pump which discharges directly into the distribution system and an elevated steel tank of 60,000 gallons capacity connected to the system. The pump is driven by a 15-horsepower gas engine. About 65 service connections were in use in 1924. The amount of water used was estimated at about 10,000 gallons a day.

The original well, drilled in 1886, was 2100 feet deep. When completed the flow at the ground surface was 100 gallons a minute and the pressure with no flow was 90 feet. Water flowed into the mains without pumping. In 1906 another well was drilled and since that time this well has supplied water for a watering trough.

The flow in 1919 through a 2½-inch pipe 4½ feet above the ground surface was 32 gallons a minute.

Water flowing from this well on January 16, 1925, had a temperature of 64 degrees Fahrenheit. A sample, number 31633, collected on September 25, 1915 had a mineral content of 1802, a total hardness of 302, and a content of iron of 0.3 parts per million as shown by the analysis.

Analysis of Sample Number 31633 from Well 2100 Feet Deep.

Determinations Made.	Parts per million.
Iron Fe	0.3
Manganese Mn	none
Silica SiO_2	10.4
Nonvolatile	4.0
Alumina Al_2O_3	trace
Calcium Ca	88.6
Magnesium Mg_4	19.9
Ammonium NH_4	0.41
Potassium K	29.6
Sodium Na	560.0
Sulfate SO_4	41.3
Chloride Cl	910.0

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Chloride KCl	56.4	3.29
Sodium Chloride NaCl	1421.2	82.90
Ammonium Chloride NH_4Cl	1.2	.07
Magnesium Chloride $MgCl_2$	28.5	1.66
Magnesium Sulfate $MgSO_4$	51.7	3.00
Magnesium Carbonate $MgCO_3$	7.6	.44
Calcium Carbonate $CaCO_3$	221.1	12.89
Iron Carbonate $FeCO_3$	0.6	.03
Alumina Al_2O_3	trace	trace
Silica SiO_2	10.4	.61
Nonvolatile	4.0	.23
Total	1802.7	105.12

Water is secured from a well 620 feet deep, located near the center of the village. It is in rock below a depth of about 100 feet. The elevation at the top is about 630 feet above sea level. The well is 12 inches in diameter to a depth of 118 feet, 10 inches in diameter between depths of 118 and 265 feet, 8 inches in diameter between depths of 265 and 368 feet, and 6 inches in diameter below a depth of 368 feet. The well is equipped with a deep-well pump. The depth to water when not pumping was reported to be 60 feet in 1913, 75 feet in 1917, 78 feet in 1919, and 84 feet in 1923. In 1913 it was reported that 90 gallons a minute had been pumped with the pump cylinder at a depth of 100 feet. With the lowering of the water level the water cylinder has been lowered and suction pipe has been added. In December 1919 the cylinder was at a depth of 138 feet and 10 feet 6 inches of suction pipe was attached. The pump was operated with 24-inch stroke at a rate of 30 strokes a minute. It is reported that during a test in 1919 the rate of pumping was 85 gallons a minute, that the water level was at a depth of 92 feet after pumping for one hour, 90 feet after pumping for one hour and 40 minutes, and 88 feet after pumping for 2 hours and 30 minutes. The rise in water level cannot be accounted for excepting by a change in rate of pumping, measuring after the pump was stopped, or error.

In January, 1925, it was reported that the cylinder, 5¾ inches in diameter, was at a depth of 141 feet and that 30 feet of suction pipe was attached. The pump was operated with 24-inch stroke at 28 strokes a minute and the discharge was estimated to be a little over 40 gallons a minute. The pump was operated about four hours a day.

A sample of this water, number 53083, collected at the pumping station on January 16, 1925, after the pump had been operated for thirty minutes, had a mineral content of 753, a total hardness of 169, and a content of iron of 0.4 parts per million as shown by the analysis.

Analysis of Sample Number 53083 from the Well 620 Feet Deep.

Determinations Made.

	Parts per million.
Iron Fe	0.4
Manganese Mn	0.0
Silica SiO_2	9.8
Nonvolatile	0.2
Alumina Al_2O_3	4.0
Calcium Ca	41.3
Magnesium Mg	16.0
Ammonia NH_4	1.5
Sodium Na	206.8
Potassium K	28.7
Sulfate SO_4	20.6
Nitrate NO_3	0.5
Chloride Cl	267.0
Alkalinity	
Phenolphthalein	0
Methyl Orange	352.
Residue	731.

Hypothetical Combinations.

	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	9	.05
Potassium Chloride KCl	54.1	3.17
Sodium Chloride NaCl	397.7	23.26
Sodium Sulfate Na_2SO_4	30.6	1.79
Sodium Carbonate Na_2CO_3	92.8	5.43
Ammonium Carbonate $(NH_4)_2CO_3$	4.1	.24
Magnesium Carbonate $MgCO_3$	55.5	3.24
Calcium Carbonate $CaCO_3$	103.1	6.03
Iron Oxide Fe_2O_4	.6	.04
Alumina Al_2O_3	4.0	.24
Silica SiO_2	9.8	.57
Nonvolatile	.2	.01
Total	753.4	44.07

An odor of hydrogen sulphide is noticeable at the well. The drop pipe to which the pump cylinder was attached was replaced with galvanized iron pipe in 1919. The old pipe which had been in use since 1910 was eaten through just above the pump cylinder. Meters in use are reported to give satisfactory service.

MOKENA (475). Mokena is located in the northern part of Will County on the drainage area of Des Plaines River. Many private wells are in use. Some are dug wells from 15 to 40 feet deep and others are drilled wells from 125 to 150 feet deep. The Bowman Dairy Company has two wells into limestone, one 175 feet deep and the other 325 feet deep. The other private wells do not enter rock.

A public water supply was installed by the village in 1899. Water was pumped from a well into an elevated tank and a few hundred feet of steel mains, by a pump driven by windmill. The

steel mains were replaced by cast iron in the following year and other improvements have since been made. In 1921 the original well was abandoned. Water is now pumped from a deep well into the distribution system and elevated tank by a deep-well pump which is driven by a 7½-horsepower electric motor. The elevated tank has a capacity of 60,000 gallons and is supported on a tower 80 feet high. Power is purchased from the Public Service Company of Northern Illinois.

Twenty-five service connections were in use in 1922. The meter rate is 27 cents per 1,000 gallons and the minimum charge is $1.75 for three months. Bills are not subject to discount.

When the water works was installed water was secured from a well into sand and gravel which had been drilled by private parties in 1891. The well was 139 feet deep. A screen 10 feet long was placed at the bottom. This well was abandoned in 1921.

Analysis of Sample Number 48291 from the Village Supply.

Determinations Made.

	Parts per million.
Iron Fe	1.6
Manganese Mn	0.0
Silica SiO_2	17.4
Nonvolatile	1.0
Alumina Al_2O_3	1.8
Calcium Ca	107.1
Magnesium Mg	47.1
Ammonia NH_4	0.5
Sodium Na	40.2
Potassium K	4.2
Sulfate SO_4	122.0
Nitrate NO_3	1.4
Chloride Cl	7.0
Alkalinity Methyl Orange	418.0
Residue	590.

Hypothetical Combinations.

	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	2.3	.14
Potassium Chloride KCl	6.2	.36
Sodium Chloride NaCl	6.6	.38
Sodium Sulfate Na_2SO_4	116.2	6.80
Ammonium Sulfate $(NH_4)_2SO_4$	1.8	.11
Magnesium Sulfate $MgSO_4$	52.5	3.07
Magnesium Carbonate $MgCO_3$	126.3	7.38
Calcium Carbonate $CaCO_3$	267.4	15.63
Silica SiO_2	17.4	1.02
Nonvolatile	1.0	.06
Iron Oxide Fe_2O_3	2.3	.13
Alumina Al_2O_3	1.8	.10
Total	601.8	35.18

Water for the public supply is secured from a well which was drilled in 1920 by John Mathews of Joliet. It is 8 inches in diameter and 225 feet deep. The lower part of the well is in rock. The elevation at the top of the well is about 725 feet above sea level. The well is equipped with an American double-acting deep-well pump with a 4¼-inch cylinder and 24-inch stroke. The cylinder is placed at a depth of 80 feet. The pump is operated 26 revolutions a minute, a displacement of 61 gallons a minute. The discharge in September, 1922, estimated from the rise in water level in the elevated tank, was 57 gallons a minute. When the well was completed the depth to water was 67 feet. On September 29, 1922, the water was 67 feet below the floor of the pumping station when not pumping and was lowered a little more than one foot by pumping for three hours.

During the summer of 1922 the pump was operated an average of about five hours a day and the amount of water pumped was estimated at 17,000 gallons a day.

The water had a mineral content of 601, total hardness of 460, and a content of iron of 1.6 parts per million as shown by the analysis of sample number 49291, collected on September 29, 1922, after two hours pumping.

Water from the well into sand and gravel formerly in use was a little harder. It had a mineral content of 620, total hardness of 547, and a content of iron of 0.6 parts per million.

MOMENCE (2218). Momence is located in the eastern part of Kankakee County on the banks of Kankakee River. A few private dug wells are into sand and gravel above rock. Other wells are into rock which in places is within a few feet of the ground surface. Railroads which pass through the city have private water supplies and pump from Kankakee River.

A public water supply was installed by the city in 1895. Two wells were drilled near the river bank. A pumping station and a standpipe 12 feet in diameter and 100 feet high were erected nearby and a distribution system was installed. Water was pumped from the wells into the mains by steam pumps. A Goulds 10 by 10-inch triplex pump driven by a 20-horsepower electric motor has been installed to pump water and the steam pumps are not used. Power is purchased from the Momence Utilities Company. Two more wells have been drilled and a chlorinator has been installed in the pumping station. Few meters are in use.

Water is obtained from four wells into limestone, located in the eastern part of the city near the north bank of Kankakee River. The wells are in a triangular area with sides 130 feet, 225 feet, and 260 feet. They are 30 feet to 300 feet distant from the river. The wells are 8 inches in diameter and from 85 to 135 feet deep. The elevation of the tops of the wells is about 620 feet above sea level. The triplex pump is placed in a pit 4 feet 6 inches deep and the water level in the river at the time of the visit in June, 1923, was about 5 feet below the bottom of the pit. The 10 by 10-inch triplex pump was operated at a speed of 25 revolutions a minute from which the average yield was estimated at near 230 gallons a minute. A gauge on the suction line at times indicates a vacuum of as much as 27 inches and the yield may at times be considerably less than the estimate. For the year ending May, 1923, it was estimated that the pump was operated 13 hours 30 minutes a day and that the amount of water pumped averaged 180,000 gallons a day or less.

The water had a mineral content of 496 and a total hardness of 420 parts per million as shown by the analysis of sample number 40062, collected on August 26, 1918.

Analysis of Sample Number 40062 from the City Supply.

Determinations Made.	Parts per million.
Iron Fe	0.0
Manganese Mn	trace
Silica SiO_2	9.3
Nonvolatile	0.8
Alumina Al_2O_3	3.4
Calcium Ca	98.1
Magnesium Mg	43.0
Ammonia NH_4	0.4
Sodium Na	25.0
Sulfate SO_4	162.0
Nitrate NO_3	4.4
Chloride Cl	18.0
Alkalinity Methyl Orange	238.
Residue	501.
Hydrogen Sulfide H_2S	0.1
Carbon Dixide CO_2	3.6

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Sodium Nitrate $NaNO_3$	6.0	.35
Sodium Chloride NaCl	29.6	1.73
Sodium Sulfate Na_2SO_4	36.2	2.11
Ammonium Sulfate $(NH_4)_2SO_4$	1.4	.08
Magnesium Sulfate $MgSO_4$	171.2	9.97
Magnesium Carbonate $MgCO_3$	29.0	1.69
Calcium Carbonate $CaCO_3$	244.9	14.27
Alumina Al_2O_3	3.4	.20
Silica SiO_2	9.3	.54
Manganese carbonate $MnCO_3$	0.1	.01
Nonvolatile	0.8	.05
Total	529.0	31.00

A sample collected in 1906 from a tap on the distribution system was similar. The iron content of that sample was 0.6 parts per million. The water stains plumbing fixtures.

MONEE (395). Monee is located in the eastern part of Will County on the drainage area of Kankakee River. A public water supply was installed by the village in 1897. Water was secured from a well. The water works now includes two wells, each equipped with a deep-well pump; an electric motor to drive the pumps; a distribution system; two steel pressure tanks, each 8 feet in diameter and 36 feet long, which are connected to the distribution system; and a brick pumping station which encloses the machinery and tanks. Air is pumped into the tanks by a Deming triplex compressor with 5½-inch cylinder and 3-inch stroke.

Sixty one service connections were in use in 1921. The rate for water is 45 cents per 1000 gallons with a minimum charge of 75 cents per month.

Water is secured from two wells into limestone. The elevation at the top of the wells is about 810 feet above sea level. Well number one was drilled in 1897. It is 6 inches in diameter and 166 feet deep and is cased to rock at a depth of 90 feet. When completed the well was tested by pumping at a rate of 60 gallons a minute for three days. The well is equipped with a Goulds single-

acting deep-well pump with a 4½-inch cylinder and 16-inch stroke. The cylinder is placed at a depth of 85 feet.

Well number two was drilled in 1913. It is about 20 feet distant from well number one, is 10 inches in diameter and 169 feet deep, and is cased to rock at a depth of 90 feet. It is equipped with a Keystone Driller Company double-acting deep-well pump with a 6¾-inch cylinder and 18-inch stroke. The pump cylinder is at a depth of 95 feet.

The displacement of the pumps as operated in 1915, before the electric motor was installed, was given as 35 gallons a minute for the pump in well number 1 and 165 gallons for the pump in well number 2. The depth to water when not pumping was 75 feet. When operating both pumps for an hour and a half the pump in well number two would draw air. In 1921 it was estimated that the discharge from the two wells, as the pumps were operated, was about 100 gallons a minute. The pumps were operated about one hour in the morning and one hour in the evening. When pumping continuously for one and one-half hours the pump in well number two would draw air.

A sample of water, number 30842, collected from well number 1 on June 29, 1915, had a mineral content of 902, a total hardness of 713, and a content of iron of 8.0 parts per million as shown by the analysis.

Analysis of Sample Number 30842 from Well Number 1.

Determinations Made.	Parts per million.
Iron Fe	8.0
Silica SiO_2	14.0
Nonvolatile	1.2
Alumina Al_2O_3	1.0
Calcium Ca	204.4
Magnesium Mg	49.4
Ammonia NH_4	1.3
Sodium Na	15.9
Potassium K	5.7
Sulfate SO_4	370.1
Nitrate NO_3	0.4
Nitrite NO_2	0.3
Chloride Cl	3.0
Alkalinity Methyl Orange	350.
Residue	1035.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrite KNO_2	0.1	.01
Potassium Nitrate KNO_3	0.7	.04
Potassium Chloride KCl	6.3	.37
Potassium Sulfate K_2SO_4	4.7	.27
Sodium Sulfate Na_2SO_4	49.0	2.86
Ammonium Sulfate $(NH_4)_2SO_4$	4.8	.28
Magnesium Sulfate $MgSO_4$	244.2	14.24
Calcium Sulfate $CaSO_4$	192.9	11.25
Calcium Carbonate $CaCO_3$	367.4	21.43
Iron Carbonate $FeCO_3$	16.6	.97
Alumina Al_2O_3	1.0	0.6
Silica SiO_2	14.0	.82
Nonvolatile	1.2	.07
Total	902.9	52.67

A sample, number 30843, collected from well number 2 on the same day, had a mineral content of 741, a total hardness of 602, and a content of iron of 1.2 parts per million as shown by the analysis.

Analysis of Sample Number 30843 from Well Number 2.

Determinations Made.	Parts per million.
Iron Fe	1.2
Silica SiO_2	20.6
Nonvolatile	1.2
Alumina Al_2O_3	2.5
Calcium Ca	110.1
Magnesium Mg	79.8
Ammonia NH_4	0.7
Sodium Na	30.5
Potassium K	5.4
Sulfate SO_4	215.8
Nitrate NO_3	1.1
Nitrite NO_2	0.0
Chloride Cl	3.0
Alkalinity Methyl Orange	386.
Residue	768.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrite KNO_2	0.1	.01
Potassium Nitrate KNO_3	1.8	.10
Potassium Chloride KCl	6.3	.37
Potassium Sulfate K_2SO_4	3.1	.18
Sodium Sulfate Na_2SO_4	94.1	5.49
Ammonium Sulfate $(NH_4)_2CO_3$	2.6	.15
Magnesium Sulfate $MgSO_4$	186.3	10.87
Magnesium Carbonate $MgCO_3$	145.8	8.45
Calcium Carbonate $CaCO_3$	274.8	16.03
Iron Carbonate $FeCO_3$	2.5	.15
Alumina Al_2O_3	2.5	.15
Silica SiO_2	20.6	1.20
Nonvolatile	1.2	.07
Total	741.7	43.22

The differences in analyses may be accounted for by a difference in rate of pumping, pumping at a higher rate from well number two drawing more water from a supply with a comparatively low static head. Number two well was not used much in 1915 and this may account partly for the difference in quality.

MONMOUTH (8116). Monmouth is located in the central part of Warren County on the drainage area of Henderson River, a tributary of Illinois River. A public water supply was installed by the city in 1886.

Water was first obtained from one drilled well. Later on two other wells were drilled. In 1900 a shaft was dug and connections were made with the wells by tunnels 185 feet below the ground surface. Water was pumped by a pump placed in the shaft. In 1906 the shaft and tunnel system was abandoned and air lifts were installed to pump from the wells. Air was usually supplied by an Ingersoll-Rand compressor with 14-inch steam cylinders, 20 and 11-inch air cylinders, and 16-inch stroke. Two American air compressors of smaller size, formerly in regular service, were used occasionally. Water from the wells was discharged into a collecting reservoir 50 feet in diameter and 20 feet deep and was pumped from the reservoir into the mains by a Smedley 10 and 16 by 10 by 15-inch compound duplex steam pump. A Holly pump formerly in regular service was in reserve. Steam was supplied by two 200-horsepower return tubular boilers which were installed in 1920.

The installation of another source of supply was started in 1924. Information is available from H. A. Tolburg, City Engineer.

Two wells were drilled. In April, 1925, one had been equipped with a turbine pump driven by a 75-horsepower electric motor. Water is discharged into a concrete reservoir 70 by 120 feet in plan and 12 feet deep and is pumped from the reservoir by either of two centrifugal pumps of 450 gallons a minute capacity or by a centrifugal pump of 1500 gallons a minute which is to be used at times of fires. Each pump is driven by an electric motor.

The meter rate for the first 10,000 gallons is 60 cents per 1000 gallons, with a discount of 10 cents per 1000 gallons for prompt payment. The minimum charge is $1.20 with a discount of 20 cents. The lowest rate, for water in excess of 70,000 gallons, is 15 cents per 1000 gallons.

The two wells from which the supply is to be obtained are to be similar. S. B. Geiger of Chicago is driller. The well completed is 2425 feet deep. The upper 488 feet is cased with cast iron well casing 18 inches inside diameter. The joints were brazed by the Chicago Oxwelding Corporation. Below the cast iron pipe to St. Peter sandstone the well is cased with 662 feet of copperoid pipe, 14 inches outside diameter. Below the casing, to the bottom, in Cambrian ("Potsdam") sandstone, the wells were to 12½ inches in diameter.

In the completed well water stood 183 feet below the ground surface when not pumping. During an official test the discharge was 1050 gallons a minute and the water level was lowered 28 feet. This one well supplied all demands from the city in the spring of 1925.

The remainder of this report, and parts of the preceding, were prepared before information in regard to the new wells was available.

Nineteen hundred and ninety-seven service connections were in use in 1921, about 1400 of which were metered. The water consumption for the year, to May, 1921, allowing ten per cent for slip of pumps, averaged 500,000 gallons a day.

Water for the public supply was secured from three wells from 1221 to 1230 feet deep. The elevation of the floor of the pumping station which is about the same level as the tops of the wells is 731.7 feet above sea level.

Well number 1 was installed in 1886. It is cased with 9-inch, 6-inch, and 5-inch pipe to a depth of about 890 feet. Well number 2 was drilled in 1891. It is 1232 feet deep and is cased with 10-inch pipe to a depth of 418 feet.

Well number 3 was drilled in 1899. It is 1222 feet deep and is cased with 18-inch pipe to a depth of 402 feet. In 1915 a 6-inch

discharge pipe in the well was sealed to the rock at a depth of 678 feet. A record on file of material penetrated by well number 1 is practically the same as the record given below but classifications differ. The one given below is from the State Geological Survey Division, omitting classifications of the upper strata:

	Thickness in feet.	Depth in feet.
Drift	53	53
Shale	19	72
Limestone	96	168
Shale	122	290
Shale	154	444
Limestone	78	522
Limestone	58	580
Shales, Maquoketa	81	661
Limestone, Galena-Platteville	413	1074
Sandstone, St. Peter	156	1230
Limestone, Kimmswick	2	1232

The water level in well number 1 was reported to be 60 feet below the ground surface in 1896 and 85 feet below the ground surface in 1912. When pumping from well number 2 at a rate of 366 gallons a minute in 1910 the water level was lowered to 210 feet below the ground surface.

In May, 1921, the air lines in wells 1, 2, and 3, extended to depths of 460, 550, and 558 feet respectively. During the first twelve days of May all the air lifts had operated an average of nearly twenty hours a day and one lift had operated alone for a little more than four hours a day. The total amount of water pumped, as measured by steam pump strokes, allowing ten per cent slip, averaged 526,000 gallons a day. The average amount of water pumped by each air lift, computed from the time operated, was then 125 gallons a minute. The water level in well number one was 169 feet 8 inches below the floor level. During the preceding five hours the air lift in this well had been operated a few minutes, the air lift in another well had been idle for four hours and then operated for one hour, and the air lift in the other well had been operated continuously.

The air pipe in well number 1 was extended 20 feet 9 inches in 1921 or 1922. The rate of yield during a test by Pearse, Greeley and Hansen in 1922 was 50,000 gallons a day from well number one, 220,000 gallons a day from well number two, and 280,000 gallons a day from well number three.

The temperature of water when discharged from well number 2 was 64 degrees Fahrenheit in 1921. The water had a mineral content of 1685, a total hardness of 460, and a content of iron of 0.1 parts per million as shown by the analysis of sample number 38284, collected on October 13, 1917.

Analysis of Sample Number 38284 from City Well 1232 Feet Deep.

Determinations Made.	Parts per million.
Iron Fe	0.1
Silica SiO_2	24.0
Alumina Al_2O_3	2.7
Magnesium Mg	47.6
Calcium Ca	106.0
Ammonia NH_4	0.7
Sodium Na	376.3
Potassium K	22.5
Sulfate SO_4	773.5
Nitrite NO_2	0.6
Nitrate NO_3	5.7
Chloride Cl	175.0
Alkalinity Methyl Orange	228.
Residue	1715.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrite KNO_2	1.0	.06
Potassium Nitrate KNO_3	9.3	.54
Potassium Chloride KCl	35.3	2.06
Sodium Chloride NaCl	261.0	15.24
Sodium Sulfate Na_2SO_4	843.3	49.16
Ammonium Sulfate $(NH_4)_2SO_4$	2.6	.15
Magnesium Sulfate $MgSO_4$	235.2	13.71
Calcium Sulfate $CaSO_4$	21.5	1.25
Calcium Carbonate $CaCO_3$	248.8	14.51
Iron Oxide Fe_2O_3	0.1	.06
Alumina Al_2O_3	2.7	.16
Silica SiO_2	24.0	1.39
Total	1685.7	98.29

Samples collected in 1909 were similar. The mineral content averaged 1740, the total hardness 505, and the content of iron 0.5 parts per million. Water used in boilers at the pumping station was treated with compound and the boilers were cleaned every two weeks. About 1400 meters were in use in 1921. Gears and pinions are acted upon to some extent and 12 to 18 meters were repaired each month.

MONTICELLO (2280). Monticello is located in the central part of Piatt County on the drainage area of Sangamon River. A public water supply was installed by the city in 1892. Water was secured from a well into sand and gravel. Other wells have been drilled and extensive improvements have been made. The wells are equipped with deep-well pumps which discharge into a small basin which serves as a sand catcher. From this basin the water flows to two reservoirs, one 40 feet in diameter and 6 feet deep and the other 60 feet in diameter at the bottom, 61 feet in diameter at the top, and 12 feet deep. Water is pumped from the reservoirs into the mains by either of two Epping-Carpenter tandem-compound duplex steam pumps, one 10 and 16 by 9½ by 12-inch and the other 9 and 14 by 8 by 12-inch. In the summer of 1923 the larger pump was operated about sixteen hours a day and the smaller pump about eight hours a day. At times of fire or flushing streets both pumps are operated. Steam is supplied by two 80-horsepower boilers. An elevated tank formerly connected to the mains has been removed. The rate for water for from 1000 to 3000 cubic feet is $2.50 per 1000 cubic feet. The rate is lower for larger quantities and for quantities in excess of 10,000 cubic feet

it is $1.15 per 1000 cubic feet. The minimum charge is $2.50 for three months. Bills are not subject to cash discount.

Water is secured from three wells into sand and gravel. One well is 8 inches in diameter and 212 feet deep. Another well, located 8 feet east of the 8-inch well, is 10 inches in diameter and 194 feet deep. The third well, drilled in 1916, is 47 to 50 feet distant from the other two wells. It is 12 inches in diameter and 209 feet deep. The casing extends to a depth of 195 feet and below the casing is a brass covered galvanized iron screen. A record of material penetrated is as follows:

Material	Thickness in feet.	Depth in feet.
Soil and yellow clay with a few pebbles	14	14
Clay, gray, plastic	14	28
Sand and gravel	12	40
Clay, drab-colored, with numerous pebbles	5	45
Clay, blue-gray, compact with few pebbles	5	50
Clay, yellowish-gray, sandy	25	75
Clay, yellowish-gray, sandy	20	95
Sand and fine gravel	15	110
Sand, white, fine, with some clay and gravel	40	150
Sand, white, fine	15	165
Sand, brown, very fine grained, containing much organic matter (possibly old surface)	5	170
Sand, white, fine, some dark grains	5	175
Gravel, medium coarseness	36	209

A well 303 feet deep formerly in use was in quicksand, sand and gravel below a depth of 162 feet.

Each well is equipped with a steam-head double-acting deep-well pump, operated with about 18-inch stroke. The water cylinder in the 8-inch well is said to be 6½ inches in diameter and placed at a depth of over 80 feet. The cylinder in the 10-inch well is 7¾ inches in diameter and is placed at a depth of some 90 feet. The 12-inch well is equipped with a Keystone Driller Company pump with 8½-inch water cylinder.

In 1912 the depth to water in the wells was reported to be 25 feet below the ground surface. In 1915, during a test, the 8-inch well yielded 102 gallons a minute, the 10-inch well yielded 167 gallons a minute, and a 6-inch well 309 feet deep, then in service, yielded 25 gallons a minute. With all pumps idle for one hour the water level stood 25 feet below the pumping station floor and operating the 8-inch well for one hour lowered the water level four inches in the 10-inch well which is eight feet distant. When equipment was placed in the 12-inch well measurements showed practically no change in water level when the pump was idle and when it was operated.

A short test was made on June 14, 1923, when the pumps in the 8-inch, 10-inch, and 12-inch wells were operating. The pump displacement was about 445 gallons a minute and the yield, as near as could be computed from short time measurement in the reservoir was 390 gallons a minute. The water had a mineral content of 323, a total hardness of 228, and a content of iron of 2.4 parts per million as shown by the analysis of sample number 39682, collected on June 29, 1918.

Analysis of Sample Number 39682 from the City Supply.

Determinations Made.	Parts per million.
Iron Fe	2.4
Manganese Mn	0.1
Silica SiO_2	14.0
Nonvolatile	0.4
Alumina Al_2O_3	0.8
Calcium Ca	49.5
Magnesium Mg	25.6
Ammonia NH_4	0.8
Sodium Na	40.9
Sulfate SO_4	0.0
Nitrate NO_3	4.4
Chloride Cl	5.0
Alkalinity Methyl Orange	311.
Residue	328.
Carbon Dioxide CO_2	7.0

Hypothetical Combinations.	Parts Per million.	Grains per gallon.
Sodium Nitrate $NaNO_3$	6.0	.35
Sodium Chloride NaCl	0.8	.05
Sodium Carbonate Na_2CO_3	84.2	4.91
Ammonium Carbonate $(NH_4)_2CO_3$	1.8	.10
Magnesium Carbonate $MgCO_3$	88.5	5.15
Calcium Carbonate $CaCO_3$	123.6	7.21
Iron Carbonate $FeCO_3$	3.4	.20
Alumina Al_2O_3	0.8	.05
Silica SiO_2	14.0	.82
Nonvolatile	0.4	.02
Manganese Carbonate $MnCO_3$	0.1	.01
Total	323.6	18.87

Water used at the pumping station is treated with boiler compound and little trouble is experienced with the boilers. The water heater is cleaned once a month and the pipe from the heater requires frequent cleaning or replacement.

MORRIS (4505). Morris is located in the northern part of Grundy County on the north bank of Illinois River. Many private wells have been drilled into rock at a depth of 50 feet or more and a few wells in drift above rock have been in use.

A public water supply was installed by the city in 1894. Water was secured from a well and two other wells have since been drilled. One is equipped with an air lift. Air is supplied by a Chicago Pneumatic Tool Company two-stage air compressor. Water from the wells is discharged into a concrete reservoir 47 by 67 feet in plan, of 210,000 gallons capacity. The reservoir is located beneath the city hall and fire station. Water is pumped from the reservoir into the mains by either of two single-stage Platt Iron Works centrifugal pumps, one a 6-inch pump driven by a 100-horsepower electric motor and the other a 3-inch pump driven by

a 20-horsepower electric motor. The amount of water pumped is measured by meter. Electric current is purchased from the Public Service Company of Northern Illinois.

The public water supply is secured from three wells. The elevation at the tops of the wells is about 503 feet above sea level. The oldest well is 6 inches in diameter and 650 feet deep. It is cased into rock. One well is 10 inches in diameter from top to bottom and 765 (728) feet deep. It is cased into rock. A third well, located 80 or 90 feet distant from the 10-inch well, was drilled by William Cater of Chicago in 1914-1915. A record of material penetrated is as follows:

	Thickness in feet.	Depth in feet.
Drift	50	50
Shale and coal	65	115
	24	139
Limestone (Galena-Platteville)	191	330
Sandstone (St. Peter)	170	500
Dolomite (Prairie du Chien)	220	720

A detailed record of material penetrated is on file with the State Geological Survey Division. The well is cased with 20-inch pipe to rock and with 16-inch pipe from the ground surface to St. Peter sandstone.

When the first well was drilled in 1894, water raised to above the ground surface. In 1906 the depth to water was 35 feet and in 1913 it was 59 feet. The 6-inch well, in 1913, then equipped with an air lift with a 1½-inch air line to a depth of 200 feet, yielded at a rate of 200,000 gallons a day during a 12 hour test. The 10-inch well, in 1913, then equipped with a deep-well pump with the cylinder at a depth of 225 feet, yielded at a rate of 275,000 gallons a day. The total amount pumped from these two wells in 1913 averaged 240,000 gallons a day.

In 1922 the 6-inch well, then equipped with a deep-well pump, yielded about 200 gallons a minute. This well was seldom used. The 10-inch well, then equipped with an air lift with 604 feet of 2-inch air pipe, yielded 325 gallons a minute. It was operated about six hours a day. The larger well furnished a considerable part of the supply. It was equipped with an American 15-inch, 6-stage turbine pump with the bowls 190 feet below the surface with 40 feet of suction pipe attached. The pump was driven by a 37½-horsepower vertical electric motor. The pump was operated about eight hours a day and discharged about 400 gallons a minute. From readings of a vacuum gauge installed it is thought that the water level when pumping was drawn down to a depth of 165 feet. The depth to water when not pumping was 94 feet.

Water from the well 728 feet deep, which is cased to St. Peter sandstone, had a mineral content of 403 and a total hardness of 302 parts per million as shown by the analysis of sample number 42262, collected on December 8, 1919.

Analysis of Sample Number 42262 from the City Well 728 Feet Deep.

Determinations Made.	Parts per million.
Iron Fe	0.0
Silica SiO_2	6.9
Nonvolatile	0.3
Alumina Al_2O_3	1.2
Calcium Ca	68.4
Magnesium Mg	32.1
Ammonia NH_4	0.8
Potassium K } Sodium Na }	39.8
Sulfate SO_4	45.2
Nitrite NO_2	0.0
Nitrate NO_3	0.5
Chloride Cl	15.0
Alkalinity Methyl Orange	314.
Residue	402.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Sodium Nitrate $NaNO_3$	0.73	.04
Sodium Chloride NaCl	24.72	1.45
Sodium Sulfate Na_2SO_4	66.80	3.91
Sodium Carbonate Na_2CO_3	18.82	1.10
Ammonium Carbonate $(NH_4)_2CO_3$	2.03	.12
Magnesium Carbonate $MgCO_3$	111.23	6.50
Calcium Carbonate $CaCO_3$	170.89	9.99
Alumina Al_2O_3	1.20	.07
Silica SiO_2	6.90	.40
Nonvolatile	0.30	.02
Total	403.62	23.60

Samples collected in 1914 and 1915 from the two other wells were similar in quality, slightly more highly mineralized, and a little softer. The mineral content averaged 445 and the total hardness 286 parts per million. The iron content of each sample was 0.1 parts per million or less.

MORRISON (3000). Morrison is located in the central part of Whiteside County on the drainage area of Rock River. A public water supply was installed by the city before 1880. Water was secured from a deep well. In 1881 a supply was developed from a spring and the original well was abandoned. The pumping station now in use was built close to the spring. A few years later four 6-inch wells, each from 55 to 80 feet deep, were drilled into rock near the bank of Rock Creek about 150 feet distant from the pumping station. Since that time two wells have been drilled into Cambrian sandstone and the four 6-inch wells are not in use. Water from the spring flows into a reservoir built around the top of the spring. The reservoir is 37 feet in diameter. The two wells are equipped with air lifts which discharge into this reservoir. Air is supplied by an Ingersoll horizontal compound compressor with 10 and 16-inch steam cylinders, 14-inch and 9-inch air cylinders, and 12-inch stroke. Water is pumped from the reservoir into the mains by

either of two pumps which are used alternately. One is a Laidlaw-Dunn-Gordon duplex pump with 14 and 20-inch steam cylinders, 10-inch water cylinders, and 18-inch stroke. The other is a Worthington 12 by 14-inch triplex pump.

About 900 service connections were in use in 1924. During two years to August, 1924, the water consumption was estimated at 350,000 gallons a day. The rate for less than 50,000 gallons of water a quarter is 25 cents per 1000 gallons with a minimum charge of 75 cents. The lowest rate, for water in excess of 400,000 gallons, is 10 cents per 1000 gallons.

Water for the public supply is secured from a spring and two wells. The ground surface at the source of supply is about 655 feet above sea level. The yield of the spring on August 21, 1924, measured in the reservoir, was 400 gallons a minute when the water level was drawn down to 14 feet below the top of the reservoir and about 135 gallons a minute when the water level raised to 8½ feet below the top of the reservoir. When not pumping for fourteen hours the water level raised to 4.75 feet below the top of the reservoir. The spring furnished enough water to supply demands in the winter time.

The spring water had a mineral content of 293, a total hardness of 247, and a content of iron of 0.2 parts per million as shown by the analysis of sample number 52219, collected on August 22, 1924.

Analysis of Sample Number 52219 from Springs.

Determinations Made.	Parts per million.
Iron Fe	0.2
Manganese Mn	0.0
Silica SiO_2	10.2
Nonvolatile	2.6
Alumina Al_2O_3	1.5
Calcium Ca	44.7
Magnesium Mg	32.9
Ammonia NH_4	0.0
Sodium Na	12.7
Potassium K	5.6
Sulfate SO_4	25.0
Nitrate NO_3	6.2
Chloride Cl	8.0
Alkalinity Methyl Orange	234.
Residue	291.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	10.1	0.60
Potassium Chloride KCl	3.2	0.19
Sodium Chloride NaCl	10.7	0.62
Sodium Sulfate Na_2SO_4	26.3	1.54
Ammonium Sulfate $(NH_4)_2SO_4$	0.1	0.01
Magnesium Sulfate $MgSO_4$	9.0	0.52
Magnesium Carbonate $MgCO_3$	107.7	6.29
Calcium Carbonate $CaCO_3$	111.6	6.52
Iron Oxide Fe_2O_3	0.3	0.02
Alumina Al_2O_3	1.5	0.09
Silica SiO_2	10.2	0.59
Nonvolatile	2.6	0.15
Total	293.3	17.14

One of the two wells was drilled by L. H. Wilson and Company in 1897. A record of material penetrated is as follows:

	Thickness in feet.	Depth in feet.
Drift	15	15
Limestone, Silurian system, all or chiefly Niagaran	210	225
Shale, Maquoketa	203	428
Dolomite, Galena-Platteville	322	750
Shale, Galena-Platteville	10	760
Sandstone, St. Peter	145	905
Dolomite, Prairie du Chien	50	955
Sandstone and dolomite, Prairie du Chien	35	990
Dolomite, Prairie du Chien	495	1485
Sandstone, Franconia—Dresbach, Cambrian system	160	1645
Blue shale, Eau Claire, Cambrian system	...	....

A detailed log is on file with the State Geological Survey Division. A local newspaper stated that blue shale was entered at a depth of 1643 feet 9 inches. The first flow of water was noted at a depth of 660 feet. The well was 8 inches in diameter at the top and 6 inches in diameter at the bottom. It is reported that 125 feet of the casing was placed in the well and water raised to 16 feet above the ground surface and would have raised a few feet higher had pipe joints been tight. When the well was measured about 1909 it was about 900 feet deep, which is about to the bottom of St. Peter sandstone. The well is equipped with an air lift with 184 feet of 1½-inch air pipe. The casing serves as a discharge pipe. To operate this well alone the air compressor is run slowly and the discharge is 600 gallons a minute, the capacity of a 6-inch pipe which carries water to the reservoir. In 1914 the static water level was close to the ground surface and in 1919 it was thought to be at a depth of about five feet. In 1919 the air lift started with a pressure of 78 pounds and operated at a pressure of 68 pounds. Conditions were about the same in 1924.

Analysis of Sample Number 52273 from the Older Well.

Determinations Made.

	Parts per million.
Iron Fe	0.0
Manganese Mn	0.0
Silica SiO_2	10.3
Nonvolatile	2.6
Alumina Al_2O_3	1.2
Calcium Ca	40.5
Magnesium Mg	34.9
Ammonia NH_4	0.1
Sodium Na	9.2
Potassium K	5.4
Sulfate SO_4	20.5
Nitrate NO_3	3.9
Chloride Cl	5.0
Alkalinity Methyl Orange	244.
Residue	268.

Hypothetical Combinations.

	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	6.4	0.37
Potassium Chloride KCl	5.6	0.33
Sodium Chloride NaCl	3.8	0.22
Sodium Sulfate Na_2SO_4	23.6	1.38
Ammonium Sulfate $(NH_4)_2SO_4$	0.5	0.03
Magnesium Sulfate $MgSO_4$	5.2	0.30
Magnesium Carbonate $MgCO_3$	116.9	6.83
Calcium Carbonate $CaCO_3$	101.1	5.90
Alumina Al_2O_3	1.2	0.07
Silica SiO_2	10.3	0.60
Nonvolatile	2.6	0.15
Total	277.2	16.18

Sample number 52273, collected from this well on September 1, 1924, had a mineral content of 277 and a total hardness of 244 parts per million and contained no iron as shown by the analysis.

A sample collected in 1897 was of about the same quality. The content of calcium was 60 parts per million.

The other well was drilled by H. W. Hambrecht in 1912. This well is 2048 feet deep. It is said to be 12 inches in diameter to a depth of 112 feet, 8 inches in diameter between depths of 112 and 437 feet, 7 inches in diameter between depths of 437 and 916 feet, and 6 inches or 6½ inches in diameter below a depth of 916 feet. It is said that the well is cased to a depth of 437 feet and that a liner is placed between depths of 751 and 916 feet. (Possibly one liner was placed above and another below St. Peter sandstone). In 1912 the well flowed at a rate of 85 gallons a minute. In 1914 the total supply available was inadequate and the well was equipped with an air lift. A 2-inch air line extends to a depth of 175 feet and the well casing serves as a discharge pipe. The yield is estimated at from 750 to 800 gallons a minute. The water level when not pumping is about five feet below the ground surface.

Water from this well had a mineral content of 259, a total hardness of 222, and a content of iron of 0.2 parts per million as shown by the analysis of sample number 52218, collected on August 22, 1924.

Analysis of Sample Number 52218 from the Well 2048 feet Deep.

Determinations Made.	Parts per million.
Iron Fe	0.2
Manganese Mn	trace
Silica SiO_2	13.2
Nonvolatile	0.6
Alumina Al_2O_3	0.5
Calcium Ca	36.5
Magnesium Mg	32.1
Ammonia NH_4	0.1
Sodium Na	12.2
Potassium K	1.8
Sulfate SO_4	21.4
Nitrate NO_3	3.9
Chloride Cl	7.0
Alkalinity Methyl Orange	212.
Residue	240.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	4.7	0.28
Sodium Nitrate $NaNO_3$	1.4	0.08
Sodium Chloride NaCl	11.5	0.67
Sodium Sulfate Na_2SO_4	22.7	1.32
Ammonium Sulfate $(NH_4)_2SO_4$	0.3	0.02
Magnesium Sulfate $MgSO_4$	7.2	0.42
Magnesium Carbonate $MgCO_3$	106.0	6.19
Calcium Carbonate $CaCO_3$	91.2	5.33
Iron Oxide Fe_2O_3	0.3	0.02
Alumina Al_2O_3	0.5	0.03
Silica SiO_2	13.2	0.77
Nonvolatile	0.6	0.03
Total	259.6	15.16

MORRISONVILLE (1178). Morrisonville is located in the southwestern part of Christian County on the drainage area of the South Fork of Sangamon River. Many private dug wells from 20 to 40 feet deep are in use in the village.

A public water supply was installed by the village about 1888. Water was secured from a dug well near the center of the village. Another well was dug in 1895. A well drilled for the village to a depth of 100 feet furnished little water and was abandoned. Water from each of the dug wells is pumped into the distribution system by a pump driven by an electric motor. The equipment is operated by the Southern Illinois Light and Power Company at a rate of $60.00 a month. The company at times furnishes some water from their private supply. An elevated wooden tank 18 feet in diameter and 22 feet high, supported on a tower 80 feet high, is connected to the distribution system.

Forty-two service connections were in use in 1923. The rate for water is 50 cents per 1000 gallons for the first 3000 gallons, 40 cents per 1000 gallons for the next 7000 gallons, and 35 cents per 1000 gallons for additional water. The minimum charge for three months is $1.50.

Water for the public supply is obtained from two wells located about 500 feet apart near the center of the village. The elevation at the top of the wells is about 625 feet above sea level. The older well is located near the railroad station. It is 16 feet in diameter and was originally 35 feet deep. Quicksand has flowed into the well to a few feet depth. The well is curbed with brick laid in mortar. Water is pumped by a Myers 5 by 10-inch single-acting pump driven by a 3-horsepower electric motor. The water level at the time of visit in 1923 was at a depth of 18 feet when not pumping. Water is said to be lowered 7 feet when pumping for three hours. The pump is operated about four hours a day at a speed of 22 strokes a minute and the amount of water pumped is estimated at 4000 gallons a day.

The other well is located near the village hall. It is 16 feet in diameter and similar to the older well. Water is pumped from this well by a Deane 4 by 6-inch double-acting duplex pump. The pump is operated 55 strokes a minute. This pump is used only occasionally.

Some water is taken from the supply of the power company. They have a well 5 feet in diameter and 6 feet deep, located northwest of the village. It is said that water stands 3 feet below the ground surface and is not lowered by continuous pumping at a rate of 12 gallons a minute. The company pumps water through a pipe line to a tank in the village and water is supplied to the village through a connection to a 1-inch line on the distribution system.

Water from the village supply had a mineral content of 918

and a total hardness of 660 parts per million as shown by the analysis of sample number 49726, collected on July 10, 1923.

Analysis of Sample Number 49726 from the Village Supply.

Determinations Made.	Parts per million.
Iron Fe	0.0
Manganese Mn	0.0
Silica SiO_2	14.4
Nonvolatile	1.3
Alumina Al_2O_3	28.0
Calcium Ca	168.6
Magnesium Mg	58.2
Ammonia NH_4	0.05
Sodium Na	44.6
Potassium K	14.4
Sulfate SO_4	287.6
Nitrate NO_3	9.5
Chloride Cl	75.0
Alkalinity Methyl Orange	330.
Residue	974.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	15.6	0.91
Potassium Chloride KCl	16.0	0.93
Sodium Chloride NaCl	111.0	6.48
Sodium Sulfate Na_2SO_4	3.0	0.17
Ammonium Sulfate $(NH_4)_2SO_4$	0.2	0.01
Magnesium Sulfate $MgSO_4$	287.3	16.77
Calcium Sulfate $CaSO_4$	79.1	4.62
Calcium Carbonate $CaCO_3$	362.6	21.17
Alumina Al_2O_3	28.0	1.63
Silica SiO_2	14.4	0.84
Nonvolatile	1.3	0.07
Total	918.5	53.60

This water is a little more highly mineralized and a little harder than a sample collected in March, 1913.

MORTON (1179). Morton is located in the northern part of Tazewell County on the drainage area of Mackinaw River, a tributary of Illinois River. Many private water wells from 15 to 75 feet deep are in use. About one hundred gas wells from 160 to 170 feet deep were in use in 1922.

A public water supply was installed by the village about 1895. Water was purchased from a local power company which sold their plant in 1913. The supply has since been obtained from two wells owned by the village. Each well is equipped with a deep-well pump driven by a 20-horsepower electric motor. The pumps discharge directly into the distribution system. An elevated steel tank 26 feet in diameter, of 75,000 gallons capacity, located on the same lot with the pumping station, is connected to the distribution system.

Two hundred and ten service connections were in use in 1922. It is probable that the number of consumers has increased rapidly as a sewer system was installed in that year.

Water for the public supply is secured from two wells located 45 feet apart. One was drilled in 1911 and the other in 1913. Each well is cased with 8-inch pipe to a depth of 214 feet and has a Cook screen 16 feet long placed below that depth. It is said that a thin water bearing stratum of sand was encountered at a depth of 120 feet and that another stratum of sand about 10 feet thick was en-

countered at the bottom of the wells. Each well is equipped with a deep-well pump with a 5¼-inch cylinder placed near the top of the screen. In 1922 it was estimated that the two pumps, as operated, discharged 200 gallons a minute and that they were operated about 2½ hours a day, giving a total discharge of about 30,000 gallons a day.

A sample, number 31620, collected from one of the wells on September 23, 1915, had a mineral content of 554, a total hardness of 403, and a content of iron of 1.0 parts per million gallons as shown by the analysis.

Analysis of Sample Number 31620 from the Village Supply.

Determinations Made.

	Parts per million.
Iron Fe	1.0
Silica SiO_2	16.4
Manganese Mn	0.12
Alumina Al_2O_3	2.2
Calcium Ca	91.6
Magnesium Mg	42.6
Ammonia NH_2	3.6
Sodium Na	46.5
Potassium K	3.6
Sulfate SO_4	67.3
Nitrate NO_3	7.4
Chloride Cl	21.0
Nonvolatile	1.4
Alkalinity Methyl Orange	400.
Residue	542.

Hypothetical Combinations.

	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	9.3	.54
Sodium Nitrate $NaNO_3$	2.3	.13
Sodium Chloride NaCl	34.7	2.02
Sodium Sulfate Na_2SO_4	99.6	5.80
Ammonium Carbonate $(NH_4)_2CO_3$	9.6	.56
Magnesium Carbonate $MgCO_3$	147.5	8.60
Calcium Carbonate $CaCO_3$	228.7	13.32
Iron Carbonate $FeCO_3$	2.0	.11
Alumina Al_2O_3	2.2	.12
Silica SiO_2	16.4	.96
Nonvolatile	1.4	.08
Total	554.0	32.24

A sample collected from the other well at the same time was similar with the exception that the sulfate content was 5.6 parts per million compared to 67.3 parts per million in the analysis given.

It had a mineral content of 476, a total hardness of 332, and a content of iron of 1.0 parts per million.

MORTON GROVE (1079). Morton Grove is located in the northern part of Cook County on the drainage area of the North Branch of Chicago River. A public water supply was installed by the village in 1914. Water was pumped from a well directly into the distribution system. Air lift equipment was installed in 1924 and a reservoir was built. Air is supplied by a Gardner 16 and 10 by 12-inch compound air compressor which is driven by an oil engine. Water from the well is discharged into the reservoir which is elliptical in shape with 20 and 27-foot axes. It is 16 feet deep. Water is pumped from the reservoir into the distribution system by either of two American 2-stage centrifugal pumps, each driven

by a 25-horsepower electric motor. An elevated steel tank of 50,000 gallons capacity on a tower 139 feet high is connected to the mains. When cleaning the elevated tank or repairing the pump, water is taken from a deep well owned by Poehlman Brothers. Electric power is purchased from the Public Service Company of Northern Illinois.

About 200 service connections were in use in 1924. The meter rate is 20 cents per 1000 gallons with a minimum charge of $1.75 every three months.

Water is secured from a well located near the center of the village. It was drilled by F. M Gray, Jr., of Milwaukee, in 1914. A record of material with classification by the State Geological Survey Division is as follows:

	Thickness in feet.	Depth in feet.
Drift	128	128
Limestone, Silurian system, all or chiefly Niagaran	162	290
Shale, Richmond	25	315
Shale and lime, Richmond	30	345
Shale sticky, Richmond	165	510
Limestone, Galena-Platteville	335	845
Shale, sandy, St. Peter	242	1087
Marl, red, Prairie du Chien	8	1095
Lime and marl, Prairie du Chien	47	1142
Limestone, Prairie du Chien	48	1190
Marl, red, Prairie du Chien	22	1212
Shale, sandy, Prairie du Chien	63	1275
Sandstone, Mazomanie—Dresbach, Cambrian system	187	1462

In 1915 the well was reamed out and cased to a depth of 1100 feet. The casing is 10 inches in diameter to a depth of 125 feet and 8 inches in diameter below that depth. The well was cleaned out and drilled to a total depth of 1468 feet. In 1916 water stood 74 feet below the ground surface when not pumping. At that time the well was equipped with a Luitwieler deep-well pump of 225 gallons a minute capacity with the cylinder at a depth of 110 feet and a suction pipe to a depth of 128 feet. The total amount of water pumped was estimated at an average of from 20,000 to 25,000 gallons a day.

After the air lift was installed in 1924 it was reported that the discharge from the well filled the reservoir at the rate of one foot depth in ten minutes, a rate of 350 gallons a minute. The air compressor, in September, 1924, was operated about five hours a day. The depth to water when not pumping was reported to be 112 feet.

The water had a mineral content of 635, a total hardness of 376, and a content of iron of 1.5 parts per million as shown by the analysis of sample number 36063, collected on December 1, 1916.

Analysis of Sample Number 36063 from the Village Supply.

Determinations Made.	Parts per million.
Iron Fe	1.5
Silica SiO_2	6.2
Alumina Al_2O_3	1.9
Calcium Ca	101.7
Magnesium Mg	29.9
Ammonia NH_4	0.5
Sodium Na	67.4
Potassium K	14.2
Sulfate SO_4	217.4
Nitrate NO_3	0.7
Chloride Cl	31.0
Alkalinity	
Methyl Orange	236.
Residue	616.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	1.1	.06
Potassium Chloride KCl	26.3	1.53
Sodium Chloride NaCl	30.5	1.78
Sodium Sulfate Na_2SO_4	17.8	9.96
Ammonium Sulfate $(NH_4)_2SO_4$	1.8	.10
Magnesium Sulfate $MgSO_4$	125.8	7.33
Magnesium Carbonate $MgCO_3$	15.6	.91
Calcium Carbonate $CaCO_3$	253.8	14.80
Iron Oxide Fe_2O_3	2.1	.12
Alumina Al_2O_3	1.9	.11
Silica SiO_2	6.2	.36
Total	635.9	37.06

An odor of hydrogen sulphide is noticeable when pumping from the well.

MOUND CITY (2756). Mound City is located in the southern part of Pulaski County on the bank of Ohio River. A public water supply was installed by a private company in 1900. It is now owned by the Illinois Power and Light Corporation. Water is pumped from a well into the distribution system by three Smith-Vaile 8½ by 10-inch single-acting triplex pumps. Each pump is connected directly to a 25-horsepower electric motor. An elevated steel tank of 75,000 gallons capacity on a tower 122 feet high is connected to the distribution system. A concrete reservoir 31 feet in diameter, of 150,000 gallons capacity, is kept full of water for use in case of emergency and the triplex pumps can draw water either from the well or from this reservoir.

About 400 service connections were in use in 1924. The meter rate for water is 50 cents for the first 1000 gallons, 45 cents per 1000 gallons for the next 2000 gallons, and 11 cents per 1000 gallons for additional water, with a minimum charge of 50 cents a month. Bills for more than 50 cents are subject to 10 per cent cash discount.

Water is secured from a well drilled by C. O. Wilson of St. Louis, Mo., in 1900. A. J. Dougherty, then owner of the water works, gave information in regard to the well in 1906. The elevation at the top of the well is about 320 feet above sea level. A record of material penetrated by this well, or possibly a well close by of the same depth, is as follows:

	Thickness in feet.	Depth in feet.
Soil	10	10
Sand and gravel (to bottom of river bed)	50	60
Sand from which water can be drawn. In some places quite coarse	150	210
Sand, water flowed to surface	150	360
Crust of rock, dark color like slate	20	380
Soft flint rock, white	50	430
Hard white flint rock	200	634

The flint rock is called "Elco" rock. Water from this rock raised to 75 feet above the ground service. The well was cased with 8-inch pipe. The natural flow was 85,000 gallons a day.

In 1915 and in 1924 the water level was just above the ground surface when not pumping. The pumps at the speeds operated have a capacity of 280 gallons a minute each. The average water consumption in 1917 was from 75,000 to 80,000 gallons a day. In 1924 the capacity of each pump at the speed operated was from 280 to 300 gallons a minute. One pump was operated at a time and estimating from the time operated the consumption was more than 200,000 gallons a day.

The water had a mineral content of 278, a total hardness of 134, and a content of iron of 0.3 parts per million as shown by the analysis of sample number 51944, collected on July 23, 1924.

Analysis of Sample Number 51944 from the Public Supply.

Determinations Made.

	Parts per million.
Iron Fe	0.3
Manganese Mn	0.0
Silica SiO_2	10.5
Nonvolatile	0.7
Alumina Al_2O_3	0.6
Calcium Ca	36.9
Magnesium Mg	10.2
Ammonia NH_4	0.3
Sodium Na	44.9
Potassium K	10.1
Sulfate SO_4	12.7
Nitrate NO_3	1.2
Chloride Cl	70.0
Alkalinity Methyl Orange	122.
Residue	273.

Hypothetical Combinations.

	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	2.0	0.11
Potassium Chloride KCl	17.8	1.04
Sodium Chloride NaCl	101.4	5.92
Sodium Sulfate Na_2SO_4	15.6	0.91
Ammonium Sulfate $(NH_4)_2SO_4$	1.2	0.07
Magnesium Sulfate $NgSO_4$	1.6	0.09
Magnesium Carbonate $MgCO_3$	43.2	2.00
Calcium Carbonate $CaCO_3$	92.2	5.38
Iron Oxide Fe_2O_3	0.4	0.02
Alumina Al_2O_3	0.6	0.03
Silica SiO_2	10.5	0.61
Nonvolatile	0.7	0.04
Total	278.2	16.22

MOUNDS (2661). Mounds is located in the southern part of Pulaski County on the drainage area of Cache River, on low land within five miles of both Ohio and Mississippi Rivers. Driven wells from 20 to 30 feet deep into sand and gravel have been in common use at residences.

A public water supply was installed in 1911. The city owns the distribution system and purchases water from the Central Illinois Public Service Company who own wells from which the water supply is obtained. The wells are equipped with air lifts which discharge into a reservoir of 32,000 gallons capacity. Air is supplied by a Laidlaw-Dunn-Gordon cross-compound compressor with 12½ and 23-inch steam cylinders, 20 and 11-inch air cylinders, and 16-inch stroke. A compressor of smaller size is available for use in emergency. Water is pumped from the reservoir into the distribution system by either of two 3-stage centrifugal pumps of 500 gallons capacity, each direct connected to a 50-horsepower electric motor. The pumps can be operated in series. A steam pump formerly in regular service is also available. The company uses large quantities of water at its plant and sells water to the Illinois Central Railroad Company in addition to water sold to the city. The rates to the city are 10 cents per 1000 gallons for the first 200,000 gallons, 8 cents per 1000 gallons for the next 800,000 gallons, and 7 cents per 1000 gallons for water in excess of 1,000,000 gallons a month.

From 1911 to 1921 water was secured from two 10-inch wells, each 650 feet deep, which had been in use to supply water at the company plant. These wells were known as number 1 and number 2. Each was cased to a depth of about 218 feet. In 1911 water stood 15 feet below the ground surface in one well and 19 feet below the ground surface in the other well. Water was drawn from the wells by suction by steam pumps. The yield of the two wells in 1913 was said to be 1000 gallons a minute. Later the wells were equipped with air lifts. In March, 1921, the north one of the two wells yielded 590 gallons a minute and the other yielded 400 gallons a minute. The wells had partly filled at that time.

Water is now secured from two wells each 596 feet deep. They were drilled by Meister Bros. of Tuscola in 1921 and are known as wells number 3 and 4. They are located about 200 feet apart. The ground surface at the wells is about 323 feet above sea level. Material penetrated by well number 3 is as follows:

	Thickness in feet.	Depth in feet.
Filling	6	6
Clay	4	10
Sand	45	55
Shale, La Grange	102	157
Sand, La Grange	5	162
Shale, Porters Creek	56	218
Rock, Osage	378	596

Some of the rock was fissured, some strata were hard, and between depths of 584 and 590 feet it was noted that the drillings were brought to the surface. At the top of the well is 20 feet of 16-inch outside diameter pipe and 57 feet of 12-inch pipe. A 10-inch casing 306 feet long is placed with the bottom at a depth of 323 feet. The lower 87 feet of the 10-inch pipe is pierced with about 1700 one-inch holes. This casing had been placed higher and had lowered. A charge of 14 pounds of 60 per cent dynamite was exploded at a depth of 542 feet to straighten the hole. When the well was completed water stood at a depth of six feet.

The yield of each well when completed was said to be 600 gallons a minute.

The water had a mineral content of 253, a total hardness of 150, and a content of iron of 1.6 parts per million as shown by the analysis of sample number 51943, collected on July 23, 1924, from the north well.

Analysis of Sample Number 51943 from the North Well.

Determinations Made.	Parts per million.
Iron Fe	1.6
Manganese Mn	0.0
Silica SiO_2	11.2
Nonvolatile	1.2
Alumina Al_2O_3	0.9
Calcium Ca	41.5
Magnesium Mg	11.5
Ammonia NH_4	0.3
Potassium K	7.3
Sodium Na	28.9
Sulfate SO_4	14.9
Nitrate NO_3	4.1
Chloride Cl	40.0
Alkalinity	
Methyl Orange	150.
Residue	248.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	6.7	0.39
Potassium Chloride KCl	9.1	0.53
Sodium Chloride NaCl	58.8	3.43
Sodium Sulfate Na_2SO_4	17.8	1.04
Ammonium Sulfate $(NH_4)SO_4$	0.9	0.05
Magnesium Sulfate $MgSO_4$	2.7	0.16
Magnesium Carbonate $MgCO_3$	37.9	2.21
Calcium Carbonate $CaCO_3$	103.6	6.05
Iron Oxide Fe_2O_3	2.3	0.13
Alumina Al_2O_3	0.9	0.05
Silica SiO_2	11.2	0.65
Nonvolatile	1.2	0.07
Total	253.1	14.76

MOUNT CARROLL (1806). Mount Carroll is located in the central part of Carroll County about ten miles east of Mississippi River. A public water supply was installed by the city in 1888. Water was secured from a dug well. A well was drilled into Cambrian sandstone in 1895 and this well now furnishes the entire supply. The well is equipped with an air lift which discharges into a reservoir 25 feet in diameter built around the top of the well. Air is supplied by a Worthington compressor with 9-inch steam cylindeer, 10-inch air cylinder, and 10-inch stroke. A 9 by 10 by 12-inch air compressor formerly in regular service is held

in reserve. Water is pumped from the reservoir by either of two duplex steam pumps. One is a 12 and 18½ by 12 by 10-inch Worthington compound and the other a 16 by 8¼ by 18-inch Gordon. An elevated wooden tank 30 feet in diameter and 20 feet high, located on high ground a block distant from the wells, is connected to the mains. Steam is supplied by two return tubular boilers, one of 80-horsepower and the other of 60-horsepower.

The well installed in 1888 was 20 feet in diameter and 20 feet deep. It was curbed with brick. Later two 6-inch wells and two 8-inch wells were drilled into the bottom of the dug well to a depth of 80 feet. In 1920 a service pump drew water from this well for from 1½ to 2 hours a day. The water level raised to 8 feet below the ground surface and was lowered 10 feet by pumping. The total amount pumped from this well was estimated at 36,000 gallons a day. This well has not been used since 1920.

Water for the public supply is secured from a well 2501 feet deep. It was drilled by the J. P. Miller Artesian Well Company of Chicago in 1895 and has since furnished a large part of the supply. Some notations of material penetrated were made by the drillers. Part is as follows:

Depth feet.	Material.
280	Shale
360	Sandstone
540	Sandstone, limestone
625	Caving
750	Limestone
855	Limestone
910	Caving some
1125	Shale
1200	Shale
1220 to 1635	Sandstone
1730	Sand and red marl
1765 to 1925	Sandstone
2232	Sandy limestone

The well is 10 inches in diameter to a depth of about 90 feet, 8 inches in diameter below the 10-inch to a depth of about 140 feet, 6 inches in diameter between depths of about I40 feet and 2000 feet, and 5 inches in diameter at the bottom. It is cased to a depth of 140 feet. When the well was drilled water raised to the ground surface. The well is equipped with an air lift with a 1½-inch air line extending to a depth of 212 feet. The discharge line is 4½ inches in diameter at the bottom and 5 inches in diameter at the top. On October 6, 1920, an air gauge registered 60 pounds when the air lift started and 50 pounds during operation. The discharge from the air lift on October 6, 1920, filled the reservoir at a rate of 30 inches in an hour, a rate of 150 gallons a minute.

At that time the air line in the well was probably 210 feet long, and the air conpressor in use, with a 10-inch air cylinder and 12-inch stroke, was operated 134 revolutions per minute. The air pressure was 60 pounds at start and 48 pounds during operation. No exact record of the amount of water pumped was available but it was estimated that the amount pumped from this well was usually between 50,000 and 100,000 gallons a day. It was reported that the yield three or four years before was about 225 gallons a minute.

The yield in August, 1924, as determined by a test by Ben Warfield, Superintendent of Water Works, was 250 gallons a minute. The compressor with 10-inch air cylinder and 10-inch stroke was operated 250 revolutions a minute. The pressure was 80 pounds at start and 60 pounds during operation. The compressor was said to be operated about nine hours a day.

The water had a mineral content of 363, a total hardness of 283, and a content of iron of 0.2 parts per million as shown by the analysis of sample number 52213, collected after several hours pumping on August 20, 1924.

Analysis of Sample Number 52213 from the City Well 2501 Feet Deep.

Determinations Made.	Parts per million.
Iron Fe	0.2
Manganese Mn	0.0
Silica SiO_2	11.6
Nonvolatile	0.5
Alumina Al_2O_3	1.2
Calcium Ca	47.3
Magnesium Mg	40.1
Ammonia NH_4	0.4
Sodium Na	33.4
Potassium K	1.9
Sulfate SO_4	26.0
Nitrate NO_3	0.5
Chloride Cl	10.0
Alkalinity Methyl Orange	320.
Residue	353.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	0.8	0.05
Potassium Chloride KCl	3.0	0.17
Sodium Chloride NaCl	14.1	0.82
Sodium Sulfate Na_2SO_4	38.3	2.24
Sodium Carbonate Na_2CO_3	35.5	2.07
Ammonium Carbonate $(NH_4)_2CO_3$	1.1	0.06
Magnesium Carbonate $MgCO_3$	138.9	8.11
Calcium Carbonate $CaCO_3$	118.0	6.89
Iron Oxide Fe_2O_3	0.3	0.02
Alumina Al_2O_3	1.2	0.07
Silica SiO_2	11.6	0.68
Nonvolatile	0.5	0.03
Total	363.3	21.21

A sample collected in 1915 was similar excepting that the sodium content was less (12 parts per million) and hypothetical combinations showed a small quantity of magnesium sulphate.

Water for the boilers at the pumping station is treated with boiler compound and heated in feed water heaters. A heater is cleaned after one month's use. A very light-weight scale is removed.

MOUNT MORRIS (1250). Mount Morris is located in the central part of Ogle County on the drainage area of Rock River. In the eastern part of the village are a number of wells about 40 feet deep into limestone and in the western part of the village are a number of wells from 100 to 145 feet deep into St. Peter sandstone. The Cable Printing Company, the largest water consumer, has developed a private water supply from a well said to be 70 feet deep into drift.

A public water supply was installed by the village in 1895. Water was secured from a well equipped with an air lift which discharged into a small reservoir built around the top of the well. Water was pumped from the reservoir into the distribution system and an elevater tank by a triplex pump which was driven by a gas engine. In 1920 another well was drilled and equipped with an air lift, a 10 by 10-inch Ingersoll-Rand air compressor driven by a 40-horsepower electric motor was installed, and two larger reservoirs were built. One reservoir is six by ten feet in plan and eight feet deep. The other is eleven by nineteen feet in plan and eight feet deep. Water is pumped from the reservoir by a 4 by 6-inch single-acting triplex pump driven by a 30-horsepower gas engine. A 5 by 16-inch single-acting triplex pump and 20-horsepower electric motor were being installed in 1923. A wooden tank 24 feet in diameter and 20 feet high on a tower 90 feet high is connected to the mains.

Electric power is purchased from the Public Utility Company of Oregon.

Three hundred and seventy-five service connections were in use in 1923 and all but three or four were metered. The rate for 1000 cubic feet or less is 36 cents per 100 cubic feet and the lowest rate, for water in excess of 10,000 cubic feet, is 18 cents per 100 cubic feet. The minimum charge is $3.60 for six months.

Water is secured from a well drilled in 1920. A well drilled in 1894 is also available. The elevation at the tops of the wells is about 932 feet above sea level.

The well in regular use was drilled in 1920 by P. E. Millis of Byron. It is 27 feet south of the old well. The well was drilled 12 inches in diameter to a depth of 150 feet below which depth it is 10 inches in diameter to the bottom at a depth of 878 feet. It is cased with 12-inch pipe to rock at a depth of 30 feet. A 10-inch casing extends from the ground surface to a depth of 170 feet. When the drill reached a depth of 150 feet it dropped 7 feet. Turbid water from this well then reached the old well and it was necessary three or four times to clean out the reservoir sur-

rounding the old well. Below this crevice was 8 feet of soft slate or blue clay underlain by 90 feet of sandstone. Below the sandstone was stone generally hard and in places very hard, to a depth of 685 feet. Below a depth of 685 feet, to 725 feet, was softer sandy material with some material resembling clay. Detailed information of the lower part of the well is not available. It is said that Cambrian sandstone is entered. Until the crevice was reached at a depth of 150 feet water stood to within 16 feet of the ground surface. It then lowered and when the well was 725 feet deep it was at a depth of 168 feet. A non-explosive gas is said to have come from the crevice.

The well is equipped with an air lift with an air pipe to a depth of 472 feet. The air pressure when operating is 113 pounds. During a test on October 23, 1923, the yield of the well was 114 gallons a minute shortly after the air lift started operation and 92 gallons a minute after about one hour's operation. The lift was operated a total of seven or eight hours a day.

Analysis of Sample Number 50384 from Well 878 Feet Deep.

Determinations Made.

	Parts per million.
Iron Fe	0.0
Manganese Mn	0.0
Silica SiO_2	16.3
Nonvolatile	2.2
Alumina Al_2O_3	7.2
Calcium Ca	58.7
Magnesium Mg	41.5
Ammonia NH_4	0.03
Sodium Na	4.8
Potassium K	2.8
Sulfate SO_4	28.9
Nitrate NO_3	15.94
Chloride Cl	19.0
Alkalinity	
Methyl Orange	270.
Residue	381.

Hypothetical Combinations.

	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	7.2	0.42
Sodium Nitrate $NaNO_3$	15.7	0.92
Sodium Chloride NaCl	1.3	0.07
Ammonium Chloride NH_4Cl	0.1	0.01
Magnesium Chloride $MgCl_2$	24.3	1.42
Magnesium Sulfate $MgSO_4$	36.2	2.11
Magnesium Carbonate $MgCO_3$	96.7	5.65
Calcium Carbonate $CaCO_3$	146.7	8.57
Alumina Al_2O_3	7.2	0.42
Silica SiO_2	16.3	0.95
Nonvolatile	2.2	0.13
Total	353.9	20.67

The well in regular service until 1920 was drilled by the J. P. Miller Artesian Well Company of Chicago in 1895. It is cased with 10-inch pipe to a depth of 34 feet, is 8 inches in diameter between depths of 34 and 151 feet, and 6¼ inches in diameter below a depth of 151 feet to the bottom of the well at a depth of 500 feet. The well is equipped with an air lift. On October 5, 1920, with an air line to a depth of 405 feet, the discharge as measured in the small reservor at the top of the well was 48 gallons a minute. The flow was said to be greater than it had been in the past. This is probably due to the fact that the well 27 feet distant

had reached a depth of 725 feet and water flowed from it through porous strata to the well pumped. The water level when not pumping was said to be at a depth of 150 feet and the air pressure during operation was 90 pounds, indicating that the water level lowered to a depth of more than 200 feet.

The temperature of water from the well 878 feet deep, after pumping for two hours, was 54 degrees Fahrenheit. The water had a mineral content of 353 and a total hardness of 316 as shown by the analysis of sample number 50384, collected on October 23, 1923, after pumping for two hours.

A sample of water, number 27327, collected from the well 500 feet deep in 1914, was more highly mineralized, was harder, and was very high in nitrates as shown by the analysis.

Analysis of Sample Number 27327 from Well 500 Feet Deep.

Determinations Made.	Parts per million.
Iron Fe	0.1
Silica SiO_2	14.6
Nonvolatile	0.8
Alumina Al_2O_3	2.2
Calcium Ca	83.1
Magnesium Mg	45.8
Ammonia NH_4	0.0
Sodium Na	21.5
Potassium K	3.7
Sulfate SO_4	35.6
Nitrate NO_3	70.7
Chloride Cl	45.0
Alkalinity Methyl-Orange	276.
Residue	500.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	9.6	.56
Sodium Nitrate $NaNO_3$	79.4	4.63
Magnesium Chloride $MgCl_2$	60.5	3.53
Magnesium Sulfate $MgSO_4$	44.6	2.60
Magnesium Carbonate $MgCO_3$	68.9	4.02
Magnesium Nitrate $Mg(NO_3)_2$	8.3	.48
Calcium Carbonate $CaCO_3$	207.4	12.10
Iron Carbonate $FeCO_3$	0.2	.01
Alumina Al_2O_3	2.2	.13
Silica SiO_2	14.6	.85
Nonvolatile	0.8	.05
Total	496.5	28.96

MOUNT PROSPECT (349). Mount Prospect is located in the northern part of Cook County on the drainage area of Des Plaines River. A public water supply was installed by the village in 1922-1923. The installation included a well equipped with a deep-well pump driven by a 7½-horsepower electric motor, a brick pumping station, a 25,000-gallon elevated steel tank at the side of the station, and a distribution system. About seventy service connections had been made in November 1923.

Water is secured from a well 200 feet deep which was drilled by the W. L. Thorne Company of Des Plaines in 1922. Rock was encountered at a depth of 80 feet. The upper 100 feet of the well is 12 inches in diameter and the lower 100 feet is 8 inches in diameter. The well is equipped with a Luitwieler pump with a 5¾-inch cylinder placed at a depth of 80 feet. The pump is

operated with 15-inch stroke at 32 or 33 revolutions a minute. The elevated tank was filled in 4 hours and 6 minutes, a yield of 102 gallons a minute. A small tube extends into the well to a depth of 80 feet so water levels can be determined. On November 21, 1923, when the pump had operated for about three minutes and then remained idle for 28 minutes the water level was 43 feet below the top of the well. Pumping for 32 minutes lowered the water level to a depth of 55 feet. (the gauge was not calibrated).

The water had a mineral content of 613 and a total hardness of 313 as shown by the analysis of sample number 50608, collected on November 21, 1923.

Analysis of Sample Number 50608 from the Village Supply.

Determinations Made.

	Parts per million.
Iron Fe	0.0
Manganese Mn	0.0
Silica SiO_2	19.0
Nonvolatile	5.1
Alumina Al_2O_3	2.0
Calcium Ca	62.7
Magnesium Mg	38.2
Ammonia NH_4	0.54
Sodium Na	60.1
Potassium K	19.1
Sulfate SO_4	325.8
Nitrate NO_3	0.9
Chloride Cl	13.0
Alkalinity Methyl Orange	110.
Residue	659.

Hypothetical Combinations.

	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	1.4	.08
Potassium Chloride KCl	27.3	1.58
Potassium Sulfate K_2SO_4	9.4	.56
Sodium Sulfate Na_2SO_4	185.6	10.84
Ammonium Sulfate $(NH_4)_2SO_4$	2.0	.12
Magnesium Sulfate $MgSO_4$	189.0	10.96
Calcium Sulfate $CaSO_4$	60.2	3.51
Calcium Carbonate $CaCO_3$	112.3	6.56
Alumina Al_2O_3	2.0	.12
Silica SiO_2	19.0	1.10
Nonvolatile	5.1	.30
Total	613.3	35.73

MOUNT PULASKI (1510). Mount Pulaski is located in the southeastern part of Logan County on the drainage area of Sangamon River. Private wells in use are generally from 20 to 30 feet deep. A public water supply was installed by the city in 1882. Water was secured from a well 85 feet deep, located in the public square. The plant was used principally for fire protection until another source of supply was developed in 1895.

Since 1924 water is pumped from two wells directly into the mains. Each well is equipped with a turbine pump which is driven by a 30-horsepower electric motor. A very attractive pumping station has been built. An elevated steel tank of 55,000 gallons capacity is connected to the mains. About 275 service connections were in use at the end of 1924. The rate for water is five cents per 100 gallons for the first 5000 gallons used in three months and four and one-half cents per 100 gallons for water in excess of

5000 gallons with a minimum charge of $1.50 every three months. Bills are not subject to cash discount.

In 1895 three wells were dug in the southwestern part of the city. Two of the wells were eight feet in diameter and the other one was ten feet in diameter. Each well was about 32 feet deep. They passed through soil, clay, and hardpan to the top of a stratum of fine sand. Water pumped from these three wells by steam pumps placed in a pit furnished the entire supply for a few years. A well located across the street from the wells in use was then acquired. This well had at first been dug to a depth of 33 feet and later a hole had been drilled in the bottom to a depth of 56 feet below the ground surface and a Cook screen had been placed in the bottom. The well was equipped with a single-acting steam-head deep-well pump with a cylinder about eight inches in diameter. It operated satisfactorily for a time with 36-inch stroke at 16 strokes a minute. In a few years this well was abandoned and in 1922 one ot the larger dug wells caved in.

The entire public water supply during 1922 and 1923 was from the other two dug wells. Water was pumped by a two-stage centrifugal pump of 250 gallons a minute capacity. It was driven by an electric motor which had been installed in the pump pit. When not pumping during the night water raised to from 8 to 12 feet below the ground surface. Pumping for an hour or a little more lowered the water level to a depth of 29 feet or 30 feet. After lowering the water to this depth in the morning the pump could be operated for from 20 to 30 minutes two or three times a day giving a total yield of near 30,000 gallons a day. Considerable fine sand was removed from the wells in 1922. These wells were abandoned in 1924 and the water level raised to the ground surface.

The quantity of water available from the dug wells was not sufficient to supply demands and in 1922 twenty-four test holes were drilled to locate a more abundant supply. An 8-inch well 50 feet deep, near the southeastern limits of the city close to the northwest corner of a brick plant, was euipped with a steam-head deep-well pump and tested in September. The well was in sand between depths of 39 feet and 50 feet and the lower 6 feet was said to contain considerable gravel much coarser than the sand at the city wells then in use. The well was equipped with a number 30 Cook screen 8 feet long of which 7 feet was exposed. Water was pumped for 25 hours, with only a few minutes stop, at a rate of from 75 to 85 gallons a minute. The water level in the well stood 14 feet below the ground surface at the start of the test and was drawn down to near the bottom of the suction pipe which

was at a depth of 45 feet 6 inches. The water level was drawn down to a depth of 39 feet in a test hole 2 feet distant and to a depth of 25 feet in a test hole 150 feet distant. The test holes were cased with 2-inch pipe and equipped with well points which were driven into the water bearing stratum. A shallow dug well on high ground, about 1000 feet southeast of the well tested, went dry during the first few hours of the test and the water level in a shallow dug well (Stoll well) 700 feet northeast, was reported to have lowered three feet.

In 1923 a 10-inch well was drilled near the southeast corner of the brick plant about 250 feet distant from the 8-inch well tested in 1922. This well was 61 feet deep and was equipped with a number 30 Cook screen 10 feet long. Water was pumped with a steam-head deep-well pump at an average rate of 127 gallons a minute for four days. Water was discharged into a tile line which discharged about two and one-half miles to the southeast. The water level was lowered from a depth of 12 feet to a depth of 34 feet below the ground surface. After the test the water level raised 8 feet in 45 minutes and after 45 hours it stood at a depth of 17 feet. In March, 1924, it stood at a depth of 5 feet 6 inches.

It was decided not to develop a supply in the vicinity of the brick yard and the casings and screens were pulled and sold.

Two wells from which the supply is now secured were drilled by the Sickel Water Production Company of Aurora in 1923-1924. The wells are located 27 feet apart in the northwestern part of the city on the east side of Marion Street north of Harry Street. Water is secured from a stratum of sand and gravel. The two wells and equipment are practically the same. The west well, number one, is 80 feet deep. It is cased with 20-inch steel casing to a depth of 60 feet and with 12-inch casing from a depth of 53 feet to the top of a 12-inch screen at a depth of 63 feet. Fine gravel is placed around the screen. The well is equipped with an Aurora Pump Company turbine pump direct connected to an electric motor. The bottom of a 20-foot suction pipe on the pump is at a depth of 73 feet. The well was pumped continuously for 24 hours on February 29 and March 1, 1924. The yield three hours after pumping started was 312 gallons a minute and at the end of the test it was 240 gallons a minute. The water level stood at a depth of 18 feet before the test and was lowered to a depth of 45 feet. Water in the well 27 feet distant was lowered to a depth of 27 feet and the water level in a 4-inch well of about the same depth located 125 feet east and 40 feet north remained practically

constant. A dug well 21 feet deep, located 140 feet west of the well tested, was dried.

During regular operation one pump is operated for 30 or 40 minutes in the forenoon and the other pump is operated for about the same length of time in the afternoon. A meter is installed on each discharge line. With valves wide open the discharge is near 350 gallons a minute. Valves are usually throttled to give a discharge of near 300 gallons a minute. The water level when not pumping in December, 1924, was eighteen feet below the ground surface.

Water from the public supply had a mineral content of 549, a total hardness of 433, and a content of iron of 0.1 parts per million as shown by the analysis of sample number 53033, collected from the east well on January 5, 1925.

Analysis of Sample Number 53033 from the East Well.

Determinations Made.	Parts per million.
Iron Fe	0.1
Manganese Mn	0.0
Silica SiO_2	18.2
Nonvolatile	0.6
Alumina Al_2O_3	3.9
Calcium Ca	100.9
Magnesium Mg	43.9
Ammonia NH_4	0.1
Potassium K	3.3
Sodium Na	29.2
Sulfate SO_4	70.6
Nitrate NO_3	42.5
Chloride Cl	23.0
Alkalinity	
Phenolphthalein	0
Methyl Orange	320.
Residue	535.

Hypothetical combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	8.1	0.47
Sodium Nitrate $NaNO_3$	51.9	3.03
Sodium Chloride NaCl	36.2	2.12
Magnesium Chloride $MgCl_2$	1.4	.08
Magnesium Sulfate $MgSO_4$	88.4	5.15
Magnesium Carbonate $MgCO_3$	89.0	5.19
Calcium Carbonate $CaCO_3$	252.2	14.74
Iron Oxide Fe_2O_3	0.1	.01
Alumina Al_2O_3	3.9	.22
Silica SiO_2	18.2	1.06
Total	549.4	32.07

Sample number 25667, collected on July 17, 1913, from the wells then in use in the southwestern part of the city, was more highly mineralized. It had a mineral content of 986, a total hardness of 782, and a content of iron of 0.1 parts per million as shown by the analysis.

Sample number 48276, was collected on September 27, 1922, from the test well near the northwest corner of the brickyards near the southeastern limits of the city after the pump had operated continuously for about 24 hours. It had a mineral content of 404, a total hardness of 351, and a content of iron of 0.4 parts per million as shown by the analysis.

Analysis of Sample Number 25667 from the City Supply Formerly Used.

Determinations Made.	Parts per million.
Iron Fe	0.1
Silica SiO_2	22.0
Nonvolatile	1.2
Alumina Al_2O_3	2.2
Calcium Ca	175.3
Magnesium Mg	83.8
Ammonia NH_4	0.0
Sodium Na	27.5
Potassium K	1.7
Sulfate SO_4	189.6
Nitrate NO_3	159.1
Chloride Cl	90.0
Alkalinity	
Phenolphthalein	0
Methyl Orange	362.
Residue	1060.

Hypothetical Combinations.	Parts per million.	Grains. per gallon.
Potassium Nitrate KNO_3	4.4	.26
Sodium Nitrate $NaNO_3$	101.5	5.92
Magnesium Chloride $MgCl_2$	120.9	7.05
Magnesium Sulfate $MgSO_4$	181.4	10.58
Magnesium Nitrate $Mg(NO_3)_2$	98.6	5.75
Calcium Sulfate $CaSO_4$	63.6	3.71
Calcium Carbonate $CaCO_3$	390.9	22.80
Iron Carbonate $FeCO_3$	0.2	.01
Alumina Al_2O_3	2.2	.13
Silica SiO_2	22.0	1.28
Nonvolatile	1.2	.07
Total	986.9	57.56

Analysis of Sample Number 48276 from Test Well.

Determinations Made.	Parts per million.
Iron Fe	0.4
Manganese Mn	Trace
Silica SiO_2	13.6
Nonvolatile	0.6
Alumina Al_2O_3	1.4
Calcium Ca	82.0
Magnesium Mg	35.6
Ammonia NH_4	0.1
Sodium Na	11.8
Potassium K	2.8
Sulfate SO_4	71.0
Nitrate NO_3	1.6
Chloride Cl	4.0
Alkalinity	
Phenolphthalein	0.0
Methyl Orange	288.
Residue	402.

Hypothetical Combinations.	Parts per million.	Grains. per gallon.
Potassium Nitrate KNO_3	2.6	.15
Potassium Chloride KCl	3.4	.20
Sodium Chloride NaCl	3.9	.23
Sodium Sulfate Na_2SO_4	31.7	1.85
Ammonium Sulfate $(NH_4)SO_4$	0.3	.02
Magnesium Sulfate $MgSO_4$	61.8	3.61
Magnesium Carbonate $MgCO_3$	79.9	4.66
Calcium Carbonate $CaCO_3$	204.7	11.98
Silica SiO_2	13.6	.79
Nonvolatile	0.6	.04
Iron Oxide Fe_2O_3	0.6	.04
Alumina Al_2O_3	1.4	.08
Total	404.5	23.65

MOUNT STERLING (1932). Mount Sterling is located in the central part of Brown County, about fifteen miles west of Illinois River. Water for drinking is secured from private wells from 10 to 75 feet deep.

Water for a public supply is secured in part from two wells into rock and in part from two ponds. One well is equipped with an air lift. Air is supplied by a Gardner compressor with 12-inch steam cylinder, 10-inch air cylinder, and 12-inch stroke. Water flows from the well to the ponds at the side of the pumping station and is pumped from the ponds into the distribution system by a Gardner 10 by 6 by 10-inch duplex steam pump. A smaller pump is avail-

able for use in very dry weather. The other well is equipped with a deep-well pump which discharges directly into the distribution system. The pump is driven by a 10-horsepower electric motor. The boilers and steam equipment are to be replaced by a Diesel engine.

About 180 service connections were in use in 1924 and all but two were metered. The rate for water is 30 cents per 1000 gallons with a minimum charge of 50 cents every three months.

Water for the public supply is secured from two wells and two ponds. The older well was drilled about 1888. The depth is probably close to 2235 feet although it was once reported to be 2433 feet. The well is said to be 4 inches in diameter at the bottom which is said to be in Cambrian sandstone. It was once reported that the well was cased to a depth of 1500 feet. The well is equipped with an air lift. It is operated 24 hours a day in the summer time and about 10 hours a day during the winter.

Samples number 3373 and 3374 were collected from this well on February 22, 1898.

Analysis of Sample Number 3373.

Determinations Made.	Parts per million.
Iron Fe	4.0
Silica SiO_2	5.6
Aluminum Al_2O_3	2.9
Calcium Ca	170.8
Magnesium Mg	72.4
Ammonium NH_4	0.6
Potassium K	58.6
Sodium Na	1064.6
Sulfate SO_4	855.1
Nitrate NO_3	0.7
Chloride Cl	1310.0
Residue	4076.4

Hypothetical Combinations.	Parts per million.	Grains. per gallon.
Potassium Nitrate KNO_3	1.2	.06
Potassium Chloride KCl	111.0	6.47
Sodium Chloride NaCl	2071.7	120.85
Sodium Sulfate Na_2SO_4	770.0	44.93
Ammonium Sulfate $(NH_4)_2SO_4$	2.3	.13
Magnesium Sulfate $MgSO_4$	359.9	20.99
Calcium Sulfate $CaSO_4$	63.8	3.75
Calcium Carbonate $CaCO_3$	379.8	12.15
Iron Carbonate $FeCO_3$	8.2	.48
Alumina Al_2O_3	2.9	.16
Silica SiO_2	12.0	.70
Total	3782.8	210.66

Analysis of Sample Number 3374.

Determinations Made.	Parts per million.
Iron Fe	1.4
Silica SiO_2	5.1
Aluminum Al_2O_3	1.6
Calcium Ca	39.6
Magnesium Mg	23.6
Potassium K	9.9
Sodium Na	206.7
Sulfate SO_4	61.6
Nitrate NO_3	0.9
Chloride Cl	73.0
Residue	714.

Hypothetical Combinations.	Parts per million.	Grains. per gallon.
Potassium Nitrate KNO_3	1.5	.09
Potassium Chloride KCl	17.8	1.03
Sodium Chloride NaCl	106.4	6.20
Sodium Sulfate Na_2SO_4	90.5	5.28
Sodium Carbonate Na_2CO_3	312.5	17.46
Magnesium Carbonate $MgCO_3$	82.4	4.80
Calcium Carbonate $CaCO_3$	97.8	5.70
Iron Carbonate $FeCO_3$	2.9	.16
Alumina Al_2O_3	1.6	.09
Silica SiO_2	10.8	.63
Total	724.2	41.44.

Considerable difference is shown by the analyses. It was reported that the well was tested for six days and nights at a rate of 30 gallons a minute, then stood idle for four days, and was then pumped for two hours before the collection of the samples. Sample number 3373 was taken with the pump 300 feet below the ground surface and sample 3374 was taken with the pump 200 feet below the ground surface. The water was reported to be cool when the pump was started and to be warm and salty after pumping for a few hours. Apparently a small quantity of water comes from upper strata. The actual time of pumping before collection of each sample is not known but as the water level in 1906 was reported to be at a depth of 160 feet it is probable that a considerable part of sample 3374 was from the upper strata.

A sample collected from this well in 1918 was a little more highly mineralized than sample 3373.

The other well was drilled by Joe Simmons of Mt. Sterling in 1920. Data is from the driller. A record of material penetrated is as follows:

Mud	0	to	18	feet
Soapstone	18	"	98	"
Slate	98	"	110	"
Gumbo	110	"	190	"
Slate	190	"	202	"
Fire clay	202	"	217	"
Sand rock	217	"	229	"
Shale	229	"	299	"
Lime	299	"	554	"
Shale, gray	554	"	654	"
Shale, brown, slate like	654	"	733	"

Gas and very little seepage of oil.

The well was drilled to a depth of 733 feet where a "black water" was encountered. The well was then filled below a depth of 550 feet and was plugged at a depth of 500 feet. When the well was completed it yielded 14 gallons a minute. Fifty pounds of dynamite was then exploded at a depth of 480 feet and the yield during a 24-hour test was then 18 gallons a minute. One hundred pounds of 65 per cent dynamite was then exploded at a depth of 480 feet and the well yielded 26 gallons a minute. The well is cased to a depth of 232 feet with 8-inch pipe.

The pump with which the well was first equipped drew air and was replaced with a Pomona pump with 4-inch cylinder and 36-inch stroke. The cylinder is at a depth of 465 feet. This pump is larger than the old one but is operated at a low speed. It is operated 13 revolutions a minute for 24 hours a day. F. A. Williams, Superintendent of Water Works, made a test in 1923. During the first 30 minutes the discharge was 24 gallons a minute and after that it

was 17 gallons a minute. He estimates that when pumping to the standpipe the discharge is about 15 gallons a minute.

MOWEAQUA (1591). Moweaqua is located in the northwestern part of Shelby County on the drainage area of Sangamon River. Many private wells are in use. Most of these are from 16 to 35 feet deep.

A public water supply was installed by the village in 1893. Water was secured from a dug well located in the eastern part of the village and was pumped into the mains and an elevated tank by a steam pump. The supply became inadequate and an abandoned mine shaft near the southern limits of the villages was used as a source of supply. In 1910 six wells were drilled north of the village and have since furnished the supply. Water is pumped from the wells into a pipe line to the city by either of two Deming 7 by 8-inch triplex pumps. Each pump is driven by a 15-horsepower electric motor. In 1922 the water consumption, then measured by a meter at the pumping station, averaged 33,800 gallons a day. The meter has since been out of repair. About 150 service connections were in use in 1924.

Analysis of Sample Number 52422 from the Village Supply.

Determinations Made.

	Parts per million.
Iron Fe	1.2
Magnanese Mn	0.0
Silica SiO_2	10.6
Nonvolatile	2.7
Alumina Al_2O_3	0.8
Calcium Ca	56.8
Magnesium Mg	32.4
Amonium NH_4	0.6
Sodium Na	12.6
Potassium K	1.3
Sulfate SO_4	36.7
Nitrate NO_3	0.5
Chloride Cl	4.0
Alkalinity	
Phenolphthalein	0
Methyl Orange	272.
Residue	314.

Hypothetical Combinations.

	Parts per million.	Grains. per gallon.
Potassium Nitrate KNO_3	0.8	0.05
Potassium Chloride KCl	1.8	0.10
Sodium Chloride NaCl	5.2	0.30
Sodium Sulfate Na_2SO_4	32.7	1.91
Ammonium Sulfate $(NH)_2SO_4$	2.2	0.13
Magnesium Sulfate $MgSO_4$	16.2	0.95
Magnesium Carbonate $MgCO_3$	100.7	5.88
Calcium Carbonate $CaCO_2$	141.9	8.29
Iron Oxide Fe_2O_3	1.7	0.10
Alumina Al_2O_3	0.8	0.05
Silica SiO_2	10.6	0.62
Nonvolatile	2.7	0.16
Total	317.3	18.54

Water is secured from six wells located about two miles north of the center of the village near a small stream. The wells are in sand and gravel. They are in two rows which are about 15 feet apart. Any well is 18 feet distant from the nearest well in the same row and also 18 feet distant from the nearest well in the other row. Each well is 6 inches in diameter and about 16 feet deep and is equipped with a sand point about five feet long. The wells are

capped 2 feet 6 inches below the ground surface and are connected to the suction lines of the pumps. One pump, is operated at a time at a displacement of 175 gallons a minute. It is generally operated from three to five hours a day.

The water had a mineral content of 317, a total hardness of 275, and a content of iron of 1.2 parts per million as shown by the analysis of sample number 52422, collected on September 16, 1924.

MUNDELEIN (420). Mundelein is located in the central part of Lake County on the drainage area of Des Plaines River.

A public water supply was installed by the village in 1915. Water is pumped from a well into the distribution system by a pump driven by a 7½-horsepower electric motor. An elevated steel tank of 40,000 gallons capacity on a tower 100 feet high is connected to the system. About seventy-five consumers were supplied in 1921. The minimum charge was $1.75 for three months.

The water supply is from a well drilled in 1915 near the center of the village. It is 6 inches in diameter, 242 feet deep, and cased to rock at a depth of 235 feet. It is said that at the time of completion a test showed that at least 75 gallons a minute could be pumped during a period of 48 hours without materially lowering the water level. The well is equipped with an American deep-well pump with 3¾-inch cylinder placed at a depth of 100 feet. No suction pipe it attached. The discharge is estimated at 50 gallons a minute and in the summer of 1921 the pump was operated 12 hours a day. The water level when not pumping was then at a depth of about 40 feet. It was reported at same depth in 1925 when the amount pumped was 20,000 gallons a day.

Analysis of Sample Number 38336 from the Village Supply.

Determinations Made.

	Parts per million.
Iron Fe	0.3
Silica SiO_2	13.5
Alumina Al_2O_3	6.0
Calcium Ca	15.9
Magnesium Mg	10.9
Ammonia NH_4	0.3
Sodium Na	84.4
Potassium K	5.8
Sulfate SO_4	129.2
Nitrate NO_3	0.3
Chloride Cl	12.0
Alkalinity Methyl Orange	138.
Residue	380.

Hypothetical Combinations.

	Parts per million.	Grains. per gallon.
Potassium Nitrate KNO_3	0.6	.03
Potassium Chloride KCl	10.5	.61
Sodium Chloride NaCl.	11.6	.68
Sodium Sulfate Na_2SO_4	191.2	11.15
Sodium Carbonate Na_2CO_3	40.9	2.39
Ammonium Carbonate $(NH_4)_2CO_3$	0.8	.05
Magnesium Carbonate $MgCO_3$	37.7	2.20
Calcium Carbonate $CaCO_3$	39.7	2.32
Iron Oxide Fe_2O_3	0.5	.03
Alumina Al_2O_3	6.0	.35
Silica SiO_2	13.5	.79
Total	353.0	20.60

The water had a mineral content of 353, a total hardness of 84, and a content of iron of 0.3 parts per million as shown by the analysis of sample number 38336, collected on October 17, 1917.

NAPERVILLE (3830). Naperville is located in the southern part of DuPage County on the banks of DuPage River. Wells 30 feet or less in depth are in use at some residences and wells from 50 to 80 feet into limestone are in use at some industrial plants.

A public water supply was installed by the city in 1903-1904. Water was secured from a well which was equipped with air lift. Three other wells have been drilled and the original well has been abandoned. Water is pumped from the wells into a concrete reservoir of 100,000 gallons capacity by air lift. Water is pumped from the reservoir into the distribution system by an American single-stage centrifugal pump of 300 gallons a minute capacity, which is driven by an electric motor. An American two-stage centrifugal pump, direct connected to a 30-horsepower electric motor, is also available and is used occasionally. A Gardner air compressor, with 10-inch cylinder and 8-inch stroke, driven at a speed of 275 revolutions a minute by a 20-horsepower electric motor, is generally used. A Gardner compressor, with 12-inch cylinder and 10-inch stroke, driven by a 30-horsepower electric motor, is also available. An elevated steel tank 22 feet in diameter and 28 feet high, of 100,000 gallons capacity, located close to the wells, is connected to the distribution system.

The original well was drilled by the L. Wilson Well Company in 1903. A record of material penetrated with classifications by the State Geological Survey Division is as follows:

	Thickness in feet.	Depth in feet.
Loam and limestone	20	20
Limestone, Silurian system, all or chiefly Niagaran	95	115
Limestone and shale, Richmond	190	305
Limestone, Galena-Platteville	341	646
Sandstone, St. Peter	129	775
Limestone and shale, Prairie du Chien	61	836
Limestone " " "	100	936
Shale " " "	3	939
Limestone " " "	6	945
Sandstone " " "	5	950
Limestone " " "	315	1265
Sandstone, Mazomanie-Dresbach, Cambrian system	155	1420
Sandstone, dirty " "	5	1425

The well was cased to a depth of 118 feet below the ground surface with 10-inch casing and between depths of 773 and 939 feet with 6¼-inch casing. Below the 10-inch casing the well was 91/8 inches in diameter and below the smaller casing it was 61/8 inches

in diameter. When the well was completed water stood 45 feet below the pump room floor. Pumping 79 gallons a minute lowered the water level to a depth of 65 feet and pumping 108 gallons a minute lowered the water level to a depth of 73 feet. Equipped with an air lift with 254 feet of 2½-inch air pipe the discharge during a test lasting 80 minutes was 267 gallons a minute. The air pressure at the start was 88 pounds and during operation it was 60 pounds. The length of air line was increased to 293 feet. The discharge was 273 gallons a minute during a test lasting 73 minutes. The air compressor then in use, with a 14¼-inch air cylinder and 14-inch stroke, was operated 99 revolutions a minute. The air pressure was 105 pounds at the start and 67½ pounds during operation. Operating the compressor at a speed of 86 revolutions a minute the air pressure was 71 pounds and the discharge was 271 gallons a minute. Operating the air compressor at from 135 to 140 revolutions a minute the discharge during a test lasting 50 minutes was 308 gallons a minute. The air pressure during operation was 65 pounds. In 1915 the well was said to have filled in below a depth of 700 feet and it was seldom used. It has since been abandoned.

Analysis of Sample Number 30619 from City Well 1375 Feet Deep.

Determinations Made.	Parts per million
Iron Fe	0.1
Manganese Mn	0.0
Silica SiO_2	7.8
Nonvolatile	2.0
Alumina Al_2O_3	1.3
Calcium Ca	84.6
Magnesium Mg	44.2
Ammonia NH_4	0.1
Sodium Na	20.9
Potassium K	9.6
Sulfate SO_4	121.6
Nitrite NO_2	0.1
Nitrate NO_3	8.8
Chloride Cl	20.0
Alkalinity Methyl Orange	284.
Residue	495.

Hypothetical Combinations.	Parts per million.	Grains. per gallon.
Potassium Nitrate KNO_3	14.3	.83
Potassium Chloride KCl	9.7	.57
Sodium Chloride NaCl	25.4	1.48
Sodium Sulfate Na_2SO_4	33.6	1.96
Ammonium Sulfate $(NH_4)_2SO_4$	0.3	.02
Magnesium Sulfate $MgSO_4$	123.8	7.22
Magnesium Carbonate $MgCO_3$	66.4	3.87
Calcium Carbonate $CaCO_3$	211.2	12.32
Iron Carbonate $FeCO_3$	0.2	.01
Alumma Al_2O_3	1.3	.08
Silica SiO_2	7.8	.45
Nonvolatile	2.0	.11
Total	496.0	28.92

A second well was drilled in 1913. This well furnished nearly the entire supply for ten years and is now used occasionally. It is 12 inches in diameter at the top, 8 inches in diameter at the bottom, and 1375 feet deep. Water from the upper limestone, the Niagaran, was not cased out as was done with the first well drilled. The well was first equipped with a deep-well pump. In February

1921, with the cylinder at a depth of about 200 feet and with 36 feet of suction pipe attached, when the pump was operated from 22to 23 revolutions a minute the discharge was 175 gallons a minute and the water level in the older well, about 50 feet distant, stood at a depth of 130 feet below the floor level. In June, 1922, the discharge was measured at 180 gallons a minute and the depth to water in the other well was 126 feet. At this time this pump was operating practically continuously.

Water from the well 1375 feet deep, when pumping at a rate of 175 gallons a minute, had a temperature of 54 degrees Fahrenheit. The water had a mineral content of 496, a total hardness of 392, and a content of iron of 0.1 as shown by the analysis of sample number 30619, collected on June 4, 1915.

Nearly all water for the public supply is now secured from two wells into Niagaran limestone which were drilled for the city in 1923 by Albert Dieter of Naperville. The first well drilled is 12 inches in diameter and 101 feet deep. The second well drilled is located 110 feet south of the first well drilled and 75 feet north and 45 feet east of the well 1375 feet deep. It is 12 inches in diameter and 130 feet deep. These two wells are equipped with air lifts with air lines extending to within about a foot of the bottoms of the wells. In 1924 the air lifts were operated about 20 hours a day. On October 25, when they had operated during the morning, then remained idle for two hours, and then operated for two hours, the discharge from the two wells was 250 gallons a minute.

Analysis of Sample Number 52716 from City Well 101 Feet Deep.

Determinations Made.	Parts per million.
Iron Fe	0.2
Manganese Mn	0.0
Silica SiO_2	17.1
Nonvolatile	1.0
Alumina Al_2O_3	0.8
Calcium Ca	81.8
Magnesium Mg	47.0
Ammonia NH_4	0.2
Sodium Na	12.1
Potassium K	3.4
Sulfate SO_4	83.3
Nitrate NO_3	2.3
Chloride Cl	10.0
Alkalinity	
Phenolphthalein	0
Methyl Orange	332.
Residue	469.

Hypothetical Combinations.	Parts per million.	Grains. per gallon.
Potassium Nitrate KNO_3	3.7	0.22
Potassium Chloride KCl	3.6	0.21
Sodium Chloride NaCl	13.6	0.79
Sodium Sulfate Na_2SO_4	20.9	1.22
Ammonium Sulfate $(NH_4)_2SO_4$	0.7	0.04
Magnesium Sulfate $MgSO_4$	85.9	5.02
Magnesium Carbonate $MgCO_3$	102.6	5.99
Calcium Carbonate $CaCO_3$	204.2	11.92
Iron Oxide Fe_2O_3	0.3	0.02
Alumina Al_2O_3	0.8	0.05
Silica SiO_2	17.1	1.00
Nonvolatile	1.0	0.06
Total	454.4	26.54

A sample of water, number 52716, was collected from the well 101 feet deep at the time of the test noted above. It had a mineral content of 454, a total hardness of 397, and a content of iron of 0.2 parts per million as shown by the analysis.

NEOGA (1149). Neoga is located in the northwestern part of Cumberland County on the drainage area of Little Wabash River, a tributary of Wabash River. A public water supply was installed by the village in 1915. Water was secured from a drift well. The supply became inadequate and in order to locate an additional supply test wells were drilled north of the High School which is one-half block east of the east limits of the village. The test holes were from 12 to 15 feet deep and struck a stratum of sand about 2 feet thick. A second well was installed in 1922 northeast of the north test hole. One hundred and twenty service connections were in use in 1923. The minimum charge for water is $2.50 each three months.

Water is secured from two wells. One well was installed in 1914 or January 1915. It was originally 15 feet in diameter and 16 feet deep. The bottom is in sand. The well was cased with brick and the top was arched to a smaller diameter. Sand and gravel have been taken out of the center of this well to a depth of 20 feet below the ground surface and a brick curb 4 feet high and about 4 feet in diameter has been placed in the bottom. Water is pumped from the well by a 5 by 8-inch single-acting triplex pump which is driven by a 7½-horsepower electric motor. It is operated from 37 to 38 revolutions a minute. In November, 1923, the rate of inflow when the water level was drawn down to a depth of 17 feet, estimated from the change in water level and pump capacity, was 65 gallons a minute. The inflow varies with weather conditions and the quantity of water pumped and is at times much less than 65 gallons a minute. In 1921 a small capacity pump was installed and was operated about 10 minutes every 30 minntes in order to secure as much water as possible.

The other well was installed by Mr. Kirkendall in 1922. It is located on the southeast side of the Nickel Plate Railroad about one mile norteast of the center of the village. It is about 100 feet distant from a well formerly used by the railroad and about 450 feet northeast of the north one of the three test wells referred to. The ground surface at the well is about 650 feet above sea level. The sand stratum entered by wells in this vicinity at a depth of about 12 feet was 17 inches thick at this location and contained

little water. The well was dug below this sand in hardpan to a depth of about 20 feet and lined with brick. The diameter to this depth is 7 feet 4 inches. A test hole was drilled in the bottom of the dug well and a water bearing stratum of sand thought to be about two feet thick was found at a depth of 30 feet below the ground surface. A 4-inch casing was placed to this lower water bearing stratum. In 1923 the 4-inch casing was removed and after increasing the size of the hole an old screen 2 feet in diameter was placed as a casing down to the water bearing sand. Water is pumped from the well by a 5 by 8-inch single-acting triplex pump which is placed in a pit five feet deep. The pump is driven by a 7½-horsepower electric motor and is operated about 36 revolutions a minute. In November, 1923, when the pump was idle from 5:00 P. M. to 7:30 A. M., water stood at a depth of 11 feet below the ground surface. Pumping for one hour 37 minutes lowered the water level to a depth of 19 feet 9 inches. A few minutes later the pump drew air and was stopped. The rate of inflow after stopping the pump, computed from the rise of water level, was from 45 to 50 gallons a minute. In four hours the water level raised to within one foot of the level at which it stood before pumping. From September 26 to November 13 the amount of water pumped from this well was estimated at an average of 13,000 gallons a day. Two abandoned wells into the upper water bearing sand are located near this well, one about 100 feet distant and the other, to the east, about 700 feet distant. It is said that in dry times both wells are dried by pumping from the village well.

Analysis of Sample Number 50200 from Village Well 30 Feet Deep.

Determinations Made.

	Parts per million.
Iron Fe	0.8
Manganese Mn	0.0
Silica SiO_2	18.4
Nonvolatile	0.4
Alumina Al_2O_3	1.4
Calcium Ca	33.3
Ammonia NH_4	0.5
Magnesium Mg	19.6
Potassium K	19.5
Sodium Na	75.9
Sulfate SO_4	6.1
Nitrate NO_3	0.7
Chloride Cl	33.0
Alkalinity Methyl Orange	298.0
Residue	380.

Hypothetical Combinations.

	Parts per million.	Grains. per gallon.
Potassium Nitrate KNO_3	1.1	0.06
Potassium Chloride KCl	36.2	2.11
Sodium Chloride NaCl	29.9	1.51
Sodium Sulfate Na_2SO_4	9.0	0.52
Sodium Carbonate Na_2CO_3	144.6	8.44
Ammonium Carbonate $(NH_4)_2CO_3$	1.5	0.08
Magnesium Carbonate $MgCO_3$	67.9	3.96
Calcium Carbonate $CaCO_3$	83.1	4.85
Iron Oxide Fe_2O_4	1.1	0.06
Alumina Al_2O_4	1.4	0.08
Silica SiO_2	18.4	1.07
Nonvolatile	0.4	0.02
Total	390.6	22.76

Water from the village well 30 feet deep located northeast of the village had a mineral content of 390, a total hardness of 163, and a content of iron of 0.8 parts per million as shown by the analysis of sample number 50200, collected on September 26, 1923.

A sample of water, number 29699, collected from the village well 16 feet deep on January 19, 1915, was less highly mineralized and not as hard. The mineral content was 226, the total hardness 53, and the iron content only a trace as shown by the analysis.

Analysis of Sample Number 29699 from Village Well 16 Feet Deep.

Determinations Made.	Parts per million.
Iron Fe	Trace
Manganese Mn	0.0
Silica SiO_2	30.3
Nonvolatile	2.0
Alumina Al_2O_3	0.7
Calcium Ca	13.6
Magnesium Mg	4.3
Ammonia NH_4	0.2
Sodium Na	46.9
Potassium K	12.0
Sulfate SO_4	32.9
Nitrate NO_3	1.9
Nitrite NO_2	0.2
Chloride Cl	12.0
Alkalinity	
Phenolphthalein	36.
Methy1 Orange	118.
Residue	229.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrite KNO_2	0.3	.01
Potassium Nitrate KNO_3	3.1	.18
Potassium Chloride KCl	20.5	1.19
Sodium Chloride NaCl	6.1	.35
Sodium Sulfate Na_2SO_2	48.7	2.84
Sodium Carbonate Na_2CO_3	66.0	3.84
Ammonium Carbonate $(NH_4)_2CO_3$	0.5	.03
Magnesium Carbonate $MgCO_3$	14.2	.83
Calcium Carbonate $CaCO_3$	33.6	1.96
Iron Carbonate $FeCO_3$	trace	trace
Alumina Al_2O_3	0.7	.04
Silica SiO_2	30.3	1.77
Nonvolatile	2.0	.11
Total	226.0	13.15

NEW HOLLAND (457). New Holland is located in the western part of Logan County on the drainage area of Sangamon River, a tributary of Illinois River. A public water supply was installed by the village in 1908. Water is pumped from a well into the distribution system to which an elevated wooden tank is connected, by a deep-well pump. The pump is driven by belt from a 10-horsepower electric motor. A gas engine formerly in regular service is available for use in emergency. Ninety service connections were in use in 1924. Water is sold at flat rates.

Water is secured from a well into sand and gravel, located on Lincoln Street in the western part of the business district. The surface of the ground at the well is about 545 feet above sea level. The well is 6 inches in diameter and 70 feet deep. It is cased with 6-inch pipe and a number 9 Cook screen, 10 feet long, is placed in the bottom. The well is equipped with a Goulds double-acting deep-well pump with a 4.75-inch cylinder and 24-inch stroke. The cylinder is attached to 50 feet of 5-inch drop pipe and 10 feet of

suction pipe is attached to the cylinder. The pump is operated 26 revolutions a minute. The amount of water pumped in 1924 was estimated at about 10,000 gallons a day. The water level in 1920, when a new cylinder was placed in the well, was 25 feet below the ground surface. The water had a mineral content of 521 and a total hardness of 438 as shown by the analysis of sample number 51796, collected on July 10, 1924.

Analysis of Sample Number 51796 from the Village Supply.

Determinations Made.

	Parts per million.
Iron Fe	0.0
Manganese Mn	0.0
Silica SiO_2	17.2
Nonvolatile	5.8
Alumina Al_2O_3	6.5
Calcium Ca	94.6
Magnesium Mg	49.1
Ammonia NH_3	0.0
Sodium Na	7.0
Potassium K	1.7
Sulfate SO_4	49.6
Nitrate NO_3	88.6
Chloride Cl	20.0
Alkalinity	
Methyl Orange	334.0
Residue	551.0

Hypothetical Combinations.

	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	4.3	.25
Sodium Nitrate $NaNO_3$	26.0	1.52
Magnesium Nitrate $MgNO_3$	79.8	4.66
Magnesium Chloride $MgCl_2$	26.9	1.57
Magnesium Sulfate $MgSO_4$	62.1	3.62
Magnesium Carbonate $MgCO_3$	57.0	3.33
Calcium Carbonate $CaCO_3$	236.0	13.78
Alumina Al_2O_3	6.5	.38
Silica SiO_2	17.2	1.01
Nonvolatile	5.8	.34
Total	521.6	30.46

This sample, which was collected at the pumping station, did not contain iron but the water stains plumbing fixtures.

NEW WINDSOR. See Windsor.

NILES CENTER (763). Niles Center is located in Cook County on the drainage area of Desplaines River about twelve miles northwest of Chicago. A public water supply was installed by the village in 1911. The installation included a well, a deep-well pump driven by a 35-horsepower gas engine, a brick pumping station, a distribution system, and an elevated steel tank of 40,000 gallons capacity. An electric motor was later installed to drive the pump. Since 1924 water for the public supply has been purchased from the city of Chicago.

Water was secured from a well located in the southeastern part of the village. It is 10 inches in diameter at the top, 6 inches in diameter at the bottom, and 1440 feet deep. In 1924 casing in the top of the well was replaced by 160 feet of 10-inch casing. The well was equipped with an American deep-well pump with 5¾-

inch cylinder and 36-inch stroke. In 1917 the cylinder was at a depth of 160 feet. The amount of water pumped was estimated at 24,000 gallons a day and the depth at which water stood when not pumping was said to be about 60 feet. In 1924 a larger pump was installed with the cylinder at a depth of 80 feet. The yield during a test is said to have been 250 gallons a minute. The depth to water when not pumping was 60 feet.

Water from the well had a mineral content of 353, a total hardness of 175, and a content of iron of 0.6 parts per million as shown by the analysis of sample number 38315, collected on October 16, 1917.

Analysis of Sample Number 38315 from the village Well 1440 Feet Deep.

Determinations Made.	Parts per million.
Iron Fe	0.4
Silica SiO_2	10.3
Alumina Al_2O_3	4.8
Calcium Ca	46.1
Magnesium Mg	14.7
Ammonia NH_4	0.5
Sodium Na	51.6
Potassium K	7.5
Sulfate SO_4	82.1
Nitrate NO_3	0.4
Chloride Cl	46.0
Alkalinity Methyl Orange	144.
Residue	400.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	0.6	.03
Potassium Chloride KCl	13.9	.81
Sodium Chloride NaCl	65.0	3.79
Sodium Sulfate Na_2SO_4	80.2	4.67
Ammonium Sulfate $(NH_4)_2SO_4$	1.8	.10
Magnesium Sulfate $MgSO_4$	33.3	1.94
Magnesium Carbonate $MgCO_3$	27.7	1.62
Calcium Carbonate $CaCO_3$	115.1	6.71
Iron Oxide Fe_2O_3	.6	.03
Alumina Al_2O_3	4.8	.28
Silica SiO_2	10.3	.60
Total	353.3	20.58

NOKOMIS (3465). Nokomis is located in the northeastern part of Montgomery County on the drainage area of Shoal Creek, a tributary of Kaskaskia River. Many private wells from 10 to 50 feet deep are in use in the city.

A public water supply was installed by the city in 1894. Water was secured from wells into sand and gravel and was pumped from the wells into the distribution system and an elevated tank, by pumps placed in a pit. Another supply was developed in 1923. Water is pumped from wells into the distribution system by an 8 by 8-inch Deming triplex pump which is placed in a pit eight feet deep. The pump is driven by belt from an oil engine. Another unit, a triplex pump driven by an electric motor, was to be moved from the old station to the new station in 1925. The amount of water pumped is recorded by a meter on the discharge line at the pumping station. An elevated steel tank of 125,000 gallons

capacity is connected to the distribution system.

About 150 service connections were in use in 1924. The rate for less than 10,000 gallons used in three months is 40 cents per 1000 gallons, with a minimum charge of $2.25. The lowest rate, for water in excess of 200,000 gallons, is 10 cents per 1000 gallons.

Water was secured, until 1923, from wells into sand located in the southern part of the city. The wells were 6 inches in diameter and about 40 feet deep. Water was drawn from the wells by suction by a pump placed in a pit eight feet deep. The sand from which water was secured was very fine and the supply was limited.

Test wells were drilled in various parts of the city under the direction of Taylor and Woltman and the best location in which to develope a more adequate supply appeared to be in the vicinity of test well number 8, a little more than half a mile southwest of the center of the city. This test well was 6 inches in diameter and 37 feet deep. It penetrated soil, clay and gravel and the bottom was on rock. A number 40 Cook screen ten feet long was placed in the bottom. In June, 1924, the well was pumped for about four days at a rate of from 36 to 65 gallons a minute with but few short stops. Water was pumped with a centrifugal pump placed close to the top of the well. The water level in wells in the vicinity was lowered. Following this pumping and two days with no pumping the well was pumped for more than four hours at an average rate close to 65 gallons a minute, as measured by weir. The water level was 7½ feet below the ground surface before this four-hour test. During the test it was lowered 19 feet in the well and two feet in a test hole two feet distant and was not affected in test holes ten feet and more distant from the well.

Water for the public supply is secured from four wells into sand and gravel. They are located a little more than half a mile southwest of the center of the city near test well number 8 described above. The wells are on a line. The two center wells, between which the pumping station is located, are spaced 100 feet apart and the others are spaced 88 feet apart.

The wells were drilled in 1923 by Holmes Brothers. The ground surface at the wells is about 665 feet above sea level. The wells penetrate sand and clay to a depth of 17 feet and are in gravel below that depth to rock in the bottom of the wells at a depth of about 40 feet. Each well is equipped with a 10-inch Cook screen 14 feet long. Three of the screens have number 70 slots and the one in the well next to the north has ten feet of number 7 slot below four feet of number 25 slot. In each well a suction pipe

connected to the pumps extends to within about two feet of the bottom of the well.

On January 9, 1925, when the pump was idle for five hours, the water level was 9 feet below the ground surface. After pumping for an hour and three-quarters it lowered to a depth of 15 feet. The rate of pumping was 305 gallons a minute. The number of hours the pumps are operated and meter readings are recorded daily. The records show an average of 49,400 gallons pumped per day from March 1, 1924, to January 9, 1925.

Sample number 53056, collected from this supply on January 9, 1925, had a mineral content of 592, a total hardness of 407, and a content of iron of 2.0 parts per million as shown by the analysis.

Analysis of Sample Number 53056 from the City Supply.

Determinations Made.	Parts per million.
Iron Fe	2.0
Manganese Mn	trace
Silica SiO_2	28.3
Nonvolatile	0.9
Alumina Al_2O_3	14.8
Calcium Ca	110.9
Magnesium Mg	31.6
Ammonia NH_4	.3
Sodium Na	45.5
Potassium K	2.1
Sulfate SO_4	120.3
Nitrate NO_3	0.5
Chloride Cl.	26.0
Alkalinity	
Phenolphthalein	0
Methyl Orange	320.
Residue	583.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	0.9	.05
Potassium Chloride KCl	3.4	.20
Sodium Chloride NaCl	40.2	2.35
Sodium Sulfate Na_2SO_4	91.9	5.37
Ammonium Sulfate $(NH_4)_2SO_4$	1.1	.07
Magnesium Sulfate $MgSO_4$	71.7	4.19
Magnesium Carbonate $MgCO_3$	59.3	3.47
Calcium Carbonate $CaCO_3$	277.0	16.20
Iron Oxide Fe_2O_3	2.8	.17
Silica SiO_2	28.3	1.60
Alumina Al_2O_3	14.8	.87
Nonvolatile	0.9	.05
Total	592.3	34.59

A sample collected in 1914 from the wells then in use was a little more highly mineralized. It had a mineral content of 742, a total hardness of 425, and a content of iron of 5.3 parts per million.

NORMAL (5143). Normal is located in the central part of McLean County on the drainage area of Sangamon River. A public water supply was installed by the town in 1898. Water was pumped from wells into a reservoir. The old reservoir was replaced in 1913 by a reservoir 26 feet by 74 feet in plan and 10 feet deep. Water is now pumped from the reservoir into the mains by either of two American 6-inch two-stage centrifugal pumps, each direct connected to a 35-horsepower electric motor. An elevated steel tank 13 feet in diameter and 60 feet high is connected to the distribution system. Electric current is purchased from the Illinois

Power and Light Corporation. About 1150 service connections were in use in 1924. The meter rate is 35 cents per 1000 gallons.

Water was first secured from two wells drilled near the center of the town to a depth of 180 feet. Water was secured from sand and gravel and a Cook screen 20 feet long was placed in the bottom of each well. When larger and deeper wells were later installed and equipped with pumps of large capacity these wells yielded little water and were abandoned.

Water is secured from three wells into sand and gravel at the northwest corner of Ash and Linden Streets. One well was drilled in 1913. It is 12 inches in diameter and 204 feet deep. Two Johnson screens were placed in the well, one between depths of 176 and 186 feet and the other between depths of 192 and 204 feet. The well is equipped with an American turbine pump with an 8-inch suction pipe 30 feet long extending to within 5 feet of the bottom of the well. This well is seldom used as the cost of operation is greater than that of the larger wells.

A well 15 inches in diameter was drilled to a depth of 215 feet about 1917. In 1924 the well was being repaired. The yield before repairs was 200 gallons a minute. Two 12-inch screens were placed in the well. A seven-stage pump was to be installed with the top of the bowls 174 feet below the top of the well and a booster was to be placed near the bottom of the well.

An 18-inch well was installed by the National Pump and Well Construction Company in 1920-1921. A record of material penetrated is as follows:

	Thickness in feet.	Depth in feet.
Soil	60	60
Clay	20	80
Fine sand	10	90
Boulders	2	92
Clay	10	102
Shale	30	132
Clay	5	137
Boulders	5	140
Shale	30	170
Sand	15	185
Blue clay	4	189
Gravel	26	215

The well is cased with 18-inch pipe to a depth of 178 feet and with 12-inch pipe between depths of 176½ and 191 feet. A brass screen is placed below a depth of 191 feet. The well is equipped with a six-stage turbine pump. An eight-inch suction pipe extends to within four feet of the bottom of the well. In March, 1924, the pump was operated continuously excepting for stops to oil. The discharge, measured in the reservoir, was 455 gallons a minute.

When pumping from this well the water level in the other well of the same depth, 30 feet distant, was 178 feet below the ground surface.

Water from the well 204 feet deep had a mineral content of 482, a total hardness of 255, and a content of iron of 0.7 parts per million as shown by the analysis of sample number 32851, collected on February 8, 1916.

Analysis of Sample Number 32856 from City Well 204 Feet Deep.

Determinations Made.

	Parts per million.
Iron Fe	0.7
Silica SiO_2	29.2
Nonvolatile	1.2
Alumina Al_2O_3	2.5
Calcium Ca	53.5
Magnesium Mg	29.7
Ammonia NH_4	4.1
Sodium Na	84.0
Potassium K	3.3
Nitrate NO_3	0.0
Nitrite NO_2	0.0
Chloride Cl	14.0
Alkalinity Methyl Orange	412.
Residue	465.

Hypothetical Combinations.

	Parts per million.	Grains per gallon.
Potassium Chloride KCl	6.3	.37
Sodium Chloride NaCl	18.2	1.06
Sodium Carbonate Na_2CO_3	176.8	10.31
Ammonium Carbonate $(NH_4)_2CO_3$	10.9	.64
Magnesium Carbonate $MgCO_3$	102.9	6.00
Calcium Carbonate $CaCO_3$	133.5	7.79
Iron Carbonate $FeCO_3$	1.4	.08
Alumina Al_2O_3	2.5	.15
Silica SiO_2	29.2	1.70
Nonvolatile	1.2	.07
Total	482.9	28.17

Meters are clogged by sand and iron in the water and about 50 are repaired each year.

NORTH CHICAGO (5839). North Chicago is located in Lake County on the shore of Lake Michigan, south of and adjoining the city of Waukegan. A public water supply was installed by the city in 1900. Water was pumped from Lake Michigan until a supply was developed from wells in 1921. Water can be drawn from the Waukegan supply through a connection with the mains in that city.

The wells now in use were drilled and equipped by William Cater who was paid nine cents per 1000 gallons for water furnished. They have since been purchased by the city. Each well is equipped with a deep-well pump driven by an electric motor. Water is discharged into a reservoir formerly used as an intake well. The diameter, as near as could be determined, is 25 feet 3 inches and the depth is 18 feet. Water is pumped from the reservoir by either of two centrifugal pumps. One, to the west, is driven by a 100-horsepower electric motor. The discharge depends upon electric power, water levels, and pressures. At times noted it was from 1250 to 1260 gallons a minute. The east pump is driven by a 75-

horsepower electric motor. At time noted the discharge was 775 gallons a minute. The flow from the station is recorded by a Republic flow meter. An elevated steel tank is connected to the mains.

On February 1, 1922, the number of consumers was 892 and the amount of water pumped averaged near 700,000 gallons a day. The meter rate for less than 10,000 gallons is 35 cents with a minimum charge of $12.00 a year. The lowest rate, for water in excess of 600,000 gallons, is 19 cents per 1000 gallons. Several industrial plants using large quantities of water have private supplies. The American Steel and Wire Company take a large part of their supply from Lake Michigan. Other supplies are from wells and the total amount of water supplied by private wells probably exceeds the amount furnished by the public supply.

Water for the public supply is secured from two wells drilled by William Cater of Chicago. They are located 65 feet apart close to the shore of Lake Michigan near the end of Second Avenue. The tops of the wells are about seven feet above Lake Michigan. The north well was drilled in 1920. A record of material penetrated and casings is as follows:

24-inch pipe			20 feet from surface
20-inch pipe			110 feet
Top of first lime water			110 feet
20-inch hole			170 feet
Bottom of limestone and top of shale			350 feet
12-inch pipe (from top of shale)			191 feet 7 inches
Bottom of shale and top of limestone			530 feet
Bottom of 15-inch hole			530 feet
Bottom of second limestone			820 feet
Water, first sandstone, St. Peter			820 feet
Bottom of first sandstone and top of limestone			860 feet
Sandstone, increase in water			880 feet
Top of cave			1005 feet
Bottom of cave			1014 feet
10-inch liner	990	to	1122 feet
Increase in water			1200 feet
Sandstone	1222	to	1250 feet
Sandstone and limestone	1250	to	1400 feet
Sandstone, Cambrian system	1400	to	1695 feet
Size at bottom 10-inch			

All casing is wrought iron. A weir was installed to measure the discharge and Mr. Cater states that when the well was completed the flow without pumping was between 300 and 400 gallons a minute. The well is equipped with a centrifugal pump driven by a 45-horsepower electric motor. Tests were run in March and April 1923, measuring the discharge from the well in the reservoir. The discharge a few minutes after starting the pump was 1080 gallons a minute and after one hour and fifteen minutes pumping

the discharge was 1045 gallons a minute. Pumping for one hour lowered the water level to a depth of 100 feet in this well and to a depth of 16 feet in the well 65 feet distant. When the other well pump was not operating and this well pump was shut down water started to flow over the top, nine minutes after the pump was stopped. The flow one hour after the pump was stopped was 75 gallons a minute.

Water from this well had a mineral content of 544, a total hardness of 375, and a content of iron of 0.1 parts per million as shown by the analysis of sample number 45496, collected on August 16, 1921.

Analysis of Sample Number 45496 from City Well 1695 Feet Deep.

Determinations Made.

	Parts per million.
Iron Fe	0.1
Manganese Mn	0.0
Silica SiO_2	10.2
Nonvolatile	0.6
Alumina Al_2O_3	2.2
Calcium Ca	121.2
Magnesium Mg	17.6
Ammonium NH_4	0.23
Potassium K	13.9
Sodium Na	31.9
Sulfate SO_4	174.2
Nitrate No_3	1.2
Chloride Cl	15.0
Alkalinity Methyl Orange	260.0
Residue	551.0

Hypothetical Combinations.

	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	2.0	0.11
Potassium Chloride KCl	25.4	1.48
Sodium Chloride NaCl	4.7	.27
Sodium Sulfate Na_2SO_4	93.1	5.44
Ammonium Sulfate $(NH_4)_2SO_4$	0.7	.05
Magnesium Sulfate $MgSO_4$	87.3	5.10
Calcium Sulfate $CaSO_4$	57.8	3.38
Calcium Carbonate $CaCO_3$	260.2	15.22
Silica SiO_2	10.2	.60
Nonvolatile	0.6	.04
Iron Oxide Fe_2O_3	0.2	.01
Alumina Al_2O_3	2.2	.12
Total	544.4	31.82

The south well was drilled in 1922. It is located 65 feet distant from the other well. It is similar but is drilled deeper, the depth being 2269 feet. The well is equipped with a centrifugal pump driven by a 75-horsepower electric motor. Tests were run in March and April, 1923. The discharge a few minutes after the pump was started was 1260 gallons a minute. After operating for an hour and a half the discharge was 1170 gallons a minute. The water level in this well when the pump was operated was drawn down below a depth of 55 feet and could not be measured. Pumping from this well for twenty minutes lowered the water level in the well 65 feet distant to a depth of 15 feet. When the pump in the other well was not operating and the pump in this well was shut down water started to flow in 27 minutes, and one hour after shutting the pump down the flow was 75 gallons a minute.

Water from this well is more highly mineralized than water from the well 1695 feet deep. It contains more sodium, more

sulfates, more chlorides, and is harder as shown by the analysis of sample number 49231, collected on March 17, 1923.

Analysis of Sample Number 49231 from City Well 2269 Feet Deep.

Determinations Made.	Parts per million.
Iron Fe	0.4
Manganese Mn	0.0
Silica SiO_2	10.4
Nonvolatile	2.2
Alumina Al_2O_3	2.2
Calcium Ca	135.0
Magnesium Mg	21.4
Ammonia NH_4	0.4
Sodium Na	88.6
Potassium K	19.3
Sulfate SO_4	273.0
Nitrate NO_3	1.1
Chloride Cl	78.0
Alkalinity Methyl Orange	228.
Residue	776.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	1.7	.10
Potassium Chloride KCl	13.4	.78
Sodium Chloride NaCl	118.1	6.90
Sodium Sulfate Na_2SO_4	130.2	7.60
Ammonium Sulfate $(NH_4)_2SO_4$	1.6	.09
Magnesium Sulfate $MgSO_4$	105.6	6.16
Calcium Sulfate $CaSO_4$	140.7	8.22
Calcium Carbonate $CaCO_3$	233.5	13.63
Silica SiO_2	10.4	.61
Nonvolatile	2.2	.13
Iron Oxide Fe_2O_3	0.6	.04
Alumina Al_2O_3	2.2	.13
Total	760.2	44.39

NORTH CHILLICOTHE (1002). See Chillicothe and North Chillicothe.

NORTH UTICA (1037). North Utica is located in the central part of LaSalle County about one mile north of Illinois River. The village is generally known as Utica. A well was drilled by the village in 1883 and later four other wells were drilled. Water flowed from the wells through small distribution pipe to the consumers and no pumps were in use. A new water system was installed in 1918 and the village wells formerly in use were abandoned. The new installation included a well, a concrete reservoir 40 feet in diameter at the side of the well, a distribution system, an elevated steel tank, and two pumps. When first installed water was pumped into the distribution system and elevated tank. The method of operation was soon changed. A small quantity of water was pumped into the elevated tank to serve residences on high land in the northern part of the village. A valve on the line to the elevated tank was then closed and all other parts of the city were supplied by direct pressure from the well. Two Lea Courtenay single-stage centrifugal pumps, each direct connected to a 20-horsepower electric motor, are available to pump water into the tank or pump into the mains at time of fire. A small quantity of water flows from the well into the concrete reservoir which is maintained full of water for

use in emergency. One hundred and forty service connections were in use in 1920. Some waste of water was encouraged in order to keep fresh water in the mains.

Water for a public supply was obtained, until 1918, from wells from 225 to 350 feet deep. One well was drilled in 1883 and four others were drilled later. No exact log is available. J. W. Prentice states that the wells entered limestone at a depth of 5 feet, that a stratum of sandstone about 2 feet thick was passed through at a depth of about 33 feet, that a second stratum of sandstone was passed through at a depth of about 80 feet, and that a third stratum was entered at a depth of 177 feet. Between depths of 5 feet and 177 feet the wells were in limestone excepting as noted. In the northern part of the village at the foot of bluffs the surface of the Prairie du Chien series is exposed at a higher elevation than the tops of these wells and these wells were probably all in material of the Prairie du Chien series.

The wells were cased at the top with 6-inch pipe and 4-inch drop pipe connected to the mains were sealed in the wells with wooden wedges. Leverett, in the Illinois Glacial Lobe, published in 1899, stated that water raised 50 feet above the ground surface and that the flow of the strongest wells was estimated at 150 gallons a minute. The pressure at the ground surface in 1913 was said to be 20 feet. It is probable that with this reduction in pressure and the pressure required to force water through the distribution system that the water then supplied from five wells did not exceed 200,000 gallons a day. The yield continued to decrease and another supply was developed in 1918.

Water for the public supply is now secured from a well drilled by William Faulkner of Joliet in 1918. It is reported that the well is cased with 6-inch pipe to a depth of 600 feet and is 6 inches in diameter below that depth. Water from outside the casing flows to the surface around the casing and into a nearby creek. The pressure inside the casing at the top of the well, as shown by a gauge two feet above the floor level in the pumping station, was 38 feet at 2 o'clock on December 10, 1920. Water was flowing into the distribution system at the time. The distribution system was shut off and the flow from the well turned into the reservoir. The flow for forty minutes when the water level in the reservoir was from two to three feet above the ground surface was 325 gallons a minute.

The water had a mineral content of 639, a total hardness of 384, and a content of iron of 2.0 parts per million as shown by the analysis of sample number 44313, collected on December 10, 1920.

Analysis of Sample Number 44314 from the Village Well.

Determinations Made.	Parts per million.
Iron Fe	2.0
Manganese Mn	0.0
Silica SiO_2	16.9
Nonvolatile	.7
Alumina Al_2O_3	3.2
Calcium Ca	96.7
Magnesium Mg	34.8
Ammonium NH_4	2.6
Potassium K	9.4
Sodium Na	84.7
Sulfate SO_4	18.9
Nitrate NO_3	6.4
Chlorine Cl	166.0
Alkalinity	
Phenolphthalein	0
Methyl Orange	318.0
Residue	655.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	10.4	.61
Potassium Chloride KCl	10.3	.60
Sodium Chloride NaCl	215.2	12.59
Ammonium Chloride NH_4Cl	7.6	.45
Magnesium Chloride $MgCl_2$	34.2	2.00
Magnesium Sulfate $MgSO_4$	23.6	1.58
Magnesium Carbonate $MgCO_3$	73.5	4.30
Calcium Carbonate $CaCO_3$	241.4	14.12
Silica SiO_2	16.9	.99
Nonvolatile	0.7	.04
Iron Oxide Fe_2O_3	2.9	.17
Alumina Al_2O_3	3.2	.19
Total	639.7	37.63

When the water system was installed in 1918 water to serve the entire village was pumped into the distribution system and elevated tank. Complaints were made of the taste of the water after standing and operation was changed. Water from the elevated tank was then used to supply a few residences on high ground and water flowed direct from the well to other consumers. Some waste of water was encouraged to keep fresh water in the mains.

Analysis of Sample Number 44315 from Outside Casing of the Village Well.

Determinations Made.	Parts per million.
Iron Fe	1.2
Manganese Mn	0.0
Silica SiO_2	16.8
Nonvolatile	1.1
Alumina Al_2O_3	2.2
Calcium Ca	85.6
Magnesium Mg	31.2
Ammonium NH_4	2.4
Potassium K	7.0
Sodium Na	40.6
Sulfate SO_4	7.8
Nitrate NO_3	5.7
Chloride Cl	75.0
Alkalinity	
Phenolphthalein	0
Methyl Orange	322.
Residue	474.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	9.30	.54
Potassium Chloride KCl	6.41	.37
Sodium Chloride NaCl	103.05	6.02
Ammonium Chloride NH_4Cl	7.16	.41
Magnesium Chloride $MgCl_2$	6.29	.36
Magnesium Sulfate $MgSO_4$	9.82	.57
Magnesium Carbonate $MgCO_3$	95.70	5.59
Calcium Carbonate $CaCO_3$	213.71	12.59
Silica SiO_2	16.80	.98
Nonvolatile	1.1	.06
Iron Oxide Fe_2O_3	1.71	.10
Alumina Al_2O_3	2.20	.12
Total	473.25	27.61

Water from the upper strata which flows to the surface outside of the well casing is less highly mineralized than water from the lower strata. It had a mineral content of 473, a total hardness of

340, and a content of iron of 1,2 parts per million as shown by the analysis of sample number 44315, collected on December 10, 1920.

This water is similar to but a little more highly mineralized than samples collected from the old supply in 1912 and 1913.

NORTHBROOK (554). Northbrook is located near the north line of Cook County on the drainage area of the north branch of Chicago River. The installation of a public water supply by the village was completed in 1917. Water is pumped from a well into the distribution system and a steel pressure tank connected to the system, by a deep-well pump which is driven by 20-horsepower electric motor. The pressure tank is 9 feet in diameter and 38 feet long. About 200 service connections were in use in 1924.

Water for the public supply is secured from a well 1345 feet deep. It is located on First Street in the western part of the village. It is 10 inches in diameter to a depth of 88 feet, 8 inches in diameter between the depths of 88 and 738 feet, and 6 inches in diameter at the bottom. A record of material penetrated, on file with the State Geological Survey Division, shows St. Peter sandstone between depths of 765 and 903 feet and Cambrian sandstone below a depth of 1115 feet. The water level when the well was completed was said to be at a depth of 65 feet. The well is equipped with a Meyer single-acting deep-well pump with a 5¾-inch cylinder placed at a depth of 100 feet. The pump is operated with a 24-inch stroke at a speed of 30 strokes a minute, a displacement of 80 gallons a minute. In 1924 it was operated about eight hours a day.

Analysis of Sample Nnmber 52576 from the Village Supply.

Determinations Made.

	Parts per million.
Iron Fe	0.1
Manganese Mn	0.0
Silica SiO_2	19.5
Nonvolatile	2.1
Alumina Al_2O_3	4.3
Calcium Ca	122.8
Magnesium Mg	68.7
Ammonia NH_4	1.0
Potassium K	8.0
Sodium Na	131.7
Sulfate SO_4	699.0
Nitrate NO_3	1.2
Chloride Cl	15.0
Alkalinity	
Phenolphthalein	0
Methyl Orange	140.
Residue	1226.

Hypothetical Combinations.

	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	2.0	0.11
Potassium Chloride KCl	13.8	0.80
Sodium Chloride NaCl	13.9	0.81
Sodium Sulfate Na_2SO_4	389.9	22.77
Ammonium Sulfate $(NH_4)_2SO_4$	3.8	0.22
Magnesium Sulfate $MgSO_4$	339.5	19.83
Calcium Sulfate $CaSO_4$	228.1	13.32
Calcium Carbonate $CaCO_3$	138.7	8.10
Iron Oxide Fe_2O_3	0.1	0.01
Alumina Al_2O_3	4.3	0.25
Silica SiO_2	19.5	1.14
Nonvolatile	2.1	0.12
Total	1155.7	67.48

The temperature of water discharged from the well on October 2, 1924, was 52 degrees Fahrenheit. The water had a mineral content of 1155, a total hardness of 588, and a content of iron of 0.1 parts per million as shown by the analysis of sample number 52576, collected at a tap on the pressure tank on October 2, 1924.

OAK PARK (39858). Oak Park is located in Cook County adjoining the city of Chicago. A public water supply was installed by a private company in 1885. Water was secured from wells into Cambrian sandstone. A system to supply part of the village was later installed by the village which purchased water from the city of Chicago, the supply coming from Lake Michigan. In November, 1912, the village took over the distribution system of the private company and since shortly after that time all water has been taken from the Chicago supply.

The depth of wells formerly in use was given in the United States Geological Survey, 17th annual report, as from 1568 to 2180 feet. Eleven wells were drilled. In 1908, the year in which samples were collected for complete mineral analyses, nearly all water supplied was from five wells, numbers one, five, six, ten, and eleven. The shallowest of these five wells, number six, was 1525 feet deep, and the deepest, number 10, was 1615 feet deep. A record of material penetrated as given by J. M. Strasser, Superintendent of the water company at that time, is as follows:

	Thickness in feet.	Depth in feet.
Drift	60	60
Limestone, Silurian system all or chiefly Niagaran	340	400
Shale, Richmond	175	575
Limestone, Galena-Platteville	325	900
Sandstone, St. Peter	85	985
Shale, Prairie du Chien.	25	1010
Limestone, Prairie du Chien.	320	1330
Shale, Prairie du Chien	85	1415
Sandstone, Mazomanie-Dresbach, Cambrian system	185	1600
Sand and limestone, Eau Cliare, Cambrian system	16	1616

The total amount of water supplied from the wells in the year 1908 averaged about 1,150,000 gallons a day.

Complete mineral analyses were run of samples collected on July 27, 1908, from wells number one and number eleven, which were 1568 and 1600 feet deep respectively. Sanitary analysis had indicated that the samples from these two wells might show the greatest differences in mineral content. Sample number 17804 was collected from well number one and sample number 17805 was collected from well number eleven.

Analysis of Sample Number 17804 from Well Number 1.

Determinations Made.	Parts per million.
Silica SiO_2	14.7
Calcium Ca	83.9
Magnesium Mg	35.5
Ammonium NH_4	0.3
Sodium Na	149.4
Sulfate SO_4	169.0
Nitrate NO_3	0.9
Chloride Cl	200.0
Nonvolatile	0.2
Iron Oxide Fe_2O_3 / Alumina Al_2O_3	2.2
Alkalinity	
Methyl Orange	261.
Residue	768.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Sodium Nitrate $NaNO_3$	1.2	.07
Sodium Chloride NaCl	330.0	19.25
Sodium Sulfate Na_2SO_4	58.9	3.43
Ammonium Sulfate $(NH_4)_2SO_4$	1.1	0.06
Magnesium Sulfate $MgSO_4$	161.0	9.39
Magnesium Carbonate $MgCO_3$	10.0	.58
Calcium Carbonate $CaCO_3$	209.5	12.22
Iron Oxide Fe_2O_3 / Alumina Al_2O_3	2.2	.13
Silica SiO_2	14.7	.86
Nonvolatile	0.2	.01
Total	788.8	46.00

Analysis of Sample Number 17805 from Well Number 11.

Determinations Made.	Parts per miilion.
Silica SiO_2	13.2
Calcium Ca	86.6
Magnesium Mg	38.1
Ammonium NH_4	0.5
Sodium Na	194.5
Sulfate SO_4	175.9
Nitrate NO_3	0.9
Chloride Cl	290.0
Nonvolatile	0.2
Alkalinity	
Methyl Orange	246.
Residue	954.
Iron Oxide Fe_2O_3 / Alumina Al_2O_3	2.2

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Sodium Nitrate $NaNO_3$	1.2	.07
Sodium Chloride NaCl	478.6	27.91
Sodium Sulfate Na_2SO_4	17.3	1.01
Ammonium Sulfate $(NH_4)_2SO_4$	1.8	.10
Magnesium Sulfate $MgSO_4$	188.3	10.99
Calcium Sulfate $CaSO_4$	18.0	1.05
Calcium Carbonate $CaCO_3$	202.9	11.83
Iron Oxide Fe_2O_3 / Alumina Al_2O_3	2.2	.13
Silica SiO_2	13.2	.77
Nonvolatile	0.2	.01
Total	923.7	53.87

OAKLAND (1210). Oakland is located in the northeastern part of Coles County on the drainage area of Embarrass River. Many private wells in use are from 20 to 30 feet deep. A public water supply was installed by the city in 1910. Water was secured from wells which have since been abandoned. Water is now pumped from a well into the distribution system by a Hill Machinery Company pump which is driven by a 5-horsepower electric motor. An elevated tank 18 feet in diameter and 18 feet high, on a tower 100 feet high, is connected to the mains. One hundred and thirty service connections were in use in 1923. Water is sold at 50 cents per 1000 gallons and the minimum charge is 50 cents per month. Bills are not subject to cash discount.

The original supply was obtained from two wells located ten feet apart near the center of the city. One well was 6 inches in

diameter and 115 feet deep. The other well was 6 inches in diameter and 96 feet deep. The wells passed through one stratum of sand at a depth of 30 feet and another at a depth of about 50 feet. A meter was installed in 1913 and during the next four months the average amount of water pumped was 11,600 gallons a day. During the year to June, 1918, the consumption averaged 8,600 gallons a day and the maximum for a month averaged near 12,000 gallons a day, which was probably near the capacity of the wells. Possibly the bottoms of the wells were in shale below the water-bearing stratum. The discharge from the pump in the well 96 feet deep, in 1920 when the other well had been abandoned, was six and one-half gallons a minute. The pump was then operating continuously.

In 1919 a well was drilled to a depth of 55 feet and cased with 14-inch tile to a depth of 33 feet. It was located about 100 feet distant from the old wells. The yield was estimated at from ten to eleven gallons a minute. The well was abandoned in 1920.

A well 1123 feet deep was drilled by Meister Brothers of Tuscola in 1920. Limestone was reported at a depth of 1010 feet, a 6-foot stratum of black muck at a depth of 1050 feet, and a 15-foot stratum of porous limestone below a depth of 1100 feet. The well was cased to a depth of 1010 feet and tested by bailing at a rate of about 30 gallons a minute. The water level was lowered from a depth of 25 feet to a depth of 80 feet. The well was equipped with a deep-well pump formerly used in one of the old city wells. The cylinder was placed at a depth of about 270 feet. The yield was small and at times the water was highly colored, due possibly to the presence of black muck from the stratum noted. Water from this well was used but a few months.

In 1920 one of the two original wells was blasted with dynamite opposite water-bearing strata. The elevated tank was then filled with water from the well but fine sand drawn in with the water settled in the well and it was abandoned.

In 1921 a dug well 26 feet deep located near the two original wells was in use and supplied a small quantity of water.

The supply since 1921 has been secured from a well located in the western part of the city. Water is secured from sand. The well is 1.0 feet in diameter at the bottom and is 25 feet deep. From a test made in November, 1923, the capacity was estimated at slightly less than 14,000 gallons a day.

Water from the well 25 feet deep in use in 1923 had a mineral content of 504, a total hardness of 437, and a content of iron of 8.4 parts per million as shown by the analysis of sample number 50637, collected on November 26, 1923.

Analysis of Sample Number 50637 from City Well 25 Feet Deep.

Determinations Made.

	Parts per million.
Iron Fe	8.4
Filtered	1.2
Manganese Mn	0.0
Silica SiO_2	22.5
Nonvolatile	1.5
Alumina Al_2O_3	0.4
Calcium Ca	110.7
Magnesium Mg	39.1
Ammonia NH_4	21.8
Sodium Na	1.4
Sulfate So_4	6.5
Nitrate No_3	1.8
Chloride Cl	13.0
Alkalinity	
Methyl Orange	474.
Residue	514.

Hypothetical Combinations.

	Parts per million.	Grains per gallon.
Sodium Nitrate $NaNO_3$	2.4	.14
Sodium Chloride NaCl	2.0	.11
Ammonium Chloride NH_4Cl	17.8	1.04
Ammonium Sulfate $(NH)_2SO_4$	8.9	.52
Ammonium Carbonate $(NH_4)_2CO_3$	35.8	2.08
Magnesium Carbonate $MgCO_3$	135.2	7.99
Calcium Carbonate $CaCO_3$	276.1	16.10
Iron Oxide Fe_2O_3	1.7	.10
Silica SiO_2	22.5	1.31
Nonvolatile	1.5	.09
Alumina Al_2O_3	0.4	.02
Total	504.3	29.50

Water from the wells first used as a source of supply contained about the same amount of mineral matter, contained more sodium, and was not so hard.

Water from the well 1123 feet deep was more highly mineralized. The mineral content was 1354, the total hardness 253, and the content of iron 12 parts per million as shown by the analysis of sample number 44,467, collected on January 13, 1921.

Analysis of Sample Number 44467 from City Well 1123 Feet Deep.

Determinations Made.

	Parts per million.
Iron Fe	12.0
Manganese Mn	0.0
Silica SiO_2	22.6
Nonvolatile	1.2
Alumina Al_2O_3	7.2
Calcium Ca	54.9
Magnesium Mg	28.4
Ammonium NH_4	17.5
Potassium K	15.9
Sodium Na	400.1
Sulfate SO_4	2.7
Nitrate NO_3	0.9
Chloride Cl	479.9
Alkalinity	
Methyl Orange	298.8
Residue	1455.

Hypothetical Combinations.

	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	1.4	.08
Potassium Chloride KCl	29.4	1.72
Sodium Chloride NaCl	751.6	43.96
Sodium Sulfate Na_2SO_4	4.0	.24
Sodium Carbonate	237.6	13.90
Ammonium Carbonate $(NH_4)_2CO_3$	46.6	2.73
Magnesium Carbonate $MgCO_3$	98.4	5.76
Calcium Carbonate $CaCO_3$	137.0	8.01
Silica SiO_2	22.6	1.29
Nonvolatile	1.2	.07
Iron Oxide Fe_2O_3	17.2	1.00
Alumina Al_2O_3	7.3	.42
Total	1354.3	79.18

ODELL (1069). Odell is located in the northeastern part of Livingston County on the drainage area of Mazon River, a tributary of Illinois River. A public water supply was installed by the village about 1898. Water was secured from a drilled well and later another well was drilled. Both are now equipped with air

lifts which discharge into a collecting reservoir 22 feet in diameter and 12 feet deep. Water is pumped from the reservoir by a Goulds centrifugal pump driven by a 25-horsepower electric motor. At the time of visit the pump discharged 177 gallons a minute. An 8 by 10-inch triplex pump driven by belt from a 15-horsepower electric motor, formerly in regular service, is also available. Air is supplied by a Sullivan 12 by 7½ by 10-inch two-stage compressor driven by belt from a 50-horsepower electric motor. A Sullivan 10 by 10-inch compressor is also available. Electric current is supplied by the Northern Illinois Public Service Company. An elevated wooden tank 16 feet in diameter and 18 feet high supported on a tower 100 feet high is connected to the mains.

Two hundred and seventy-five service connections were in use in 1923. The meter rate is 50 cents per 1000 gallons and the minimum charge is $1.50 for three months use.

Water for the public supply is secured from two wells located near the center of the village. The elevation at the tops of the wells is 720 feet above sea level. One well was drilled when the water works was installed. Classification of the material penetrated is given by the State Geological Survey Division as follows:

	Thickness in feet.	Depth in feet.
. . . . .	. . .	168
"Coal measures"	222	390
Limestone, Silurian system all or chiefly Niagaran . . .	60	450
Shale, Richmond	170	620
Limestone, Galena-Platteville	380	1000
Sandstone, St. Peter	298	1298

This well is 6 inches in diameter at the top, 4 inches in diameter at the bottom, and 1298 feet deep. It is equipped with an air lift with a 1½-inch air line extending to a depth of 300 feet. This well is seldom used. The depth to water in 1923 was reported to be 250 feet.

The other well was drilled by the J. P. Miller Artesian Well Company of Chicago in 1911. The well is 1360 (1584?) feet deep. It is cased with 12-inch pipe to a depth of 168 feet, with 10-inch pipe between depths of 164 and 410 feet, with 8-inch pipe between depth of 400 and 1110 feet, and with 35 feet of 8¼-inch pipe below the 8-inch. Lead seals were placed between the 12 and 10-inch and between the 10 and 8-inch casings and a Marlin packer was wrapped around the bottom of the 8-inch casing. When at a depth of 1360 feet the yield, with the pump on 284 feet of drop pipe, was 120 gallons a minute. After placing the 8-inch casing, probably when the well was completed, it was pumped at a rate of 150 gallons a minute.

The well is equipped with an air lift with a 2-inch air line to a depth of 405 feet. On November 14, 1923, the discharge. for 30 minutes, beginning four minutes after the compressor was started, was 111 gallons a minute. The air pressure was 130 pounds when starting and 90 pounds during operation. The total amount of water pumped was estimated at that time to be about 50,000 gallons a day.

The temperature of water pumped from the well 1360 feet deep, after pumping for one hour, was 65 degrees Fahrenheit. When starting to pump the water contains considerable iron sulphide due to the action of hydrogen sulphide in the water on the iron in the well. When this well was equipped with a deep-well pump the water discharged after long continued pumping contained from six to seven parts of hydrogen sulphide. An aerator was installed and the amount of hydrogen sulphide greatly reduced before the water was pumped into the mains.

O'FALLON (2379). O'Fallon is located in the northern part of St. Clair County about twenty miles east of East St. Louis. A coal shaft half a mile west of the city was abandoned at a depth of about 60 feet on account of water and was used as a well by an electric light company which located its plant at the side of the shaft. The company sold water for railroad use and laid a few mains in the city. In 1907 the city purchased the mains and extended them. The city purchases water from the company, now the Illinois Power and Light Corporation. In 1923 the city sold water to 238 consumers and about 220 of the service connections were metered. The company sells water also for railroad use. At times the pump in the well is operated continuously and some water is pumped for railroad use from a small stream near the western limits of the city. The city sells water at 40 cents per 1000 gallons.

To increase the supply of water two wells were dug to a depth of about 30 feet. The yield was small and an 8-inch well was drilled in the bottom of each of the two dug wells to a depth of about 50 feet. These two wells have been abandoned.

Water is secured from a dug well, an abandoned mine shaft. It is about 8 feet square and in 1923 the depth measured 36 feet. Fine sand flows into the well and at times it is necessary to remove it. Water is pumped by a Deming 6 by 8-inch triplex pump placed in a pit 10 feet deep. It is driven by a 15-horsepower electric motor at a speed of 24 revolutions a minute. In 1923 the pump was operated an average of from 15 to 16 hours a day and the total

amount of water pumped was estimated at 60,000 gallons a day. At times it is operated continuously. On December 19, when the pump had operated about 24 hours, the depth to water was 28 feet.

The water had a mineral content of 371, a total hardness of 335, and a content of iron of 1.3 parts per million as shown by the analysis of sample number 39788, collected on July 19, 1918.

Analysis of Sample Number 39788 from the City Supply.

Determinations Made.	Parts per million.
Iron Fe	1.3
Manganese Mn	0.2
Silica SiO	24.5
Nonvolatile	0.9
Alumina Al_2O_3	2.1
Calcium Ca	76.7
Magnesium Mg	35.3
Ammonia NH_4	0.3
Sodium Na	15.1
Sulfate SO_4	31.2
Nitrate NO_3	1.8
Chloride Cl	5.0
Alkalinity Methyl Orange	324.
Residue	392.
Carbon Dioxide CO_2	5.0

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Sodium Nitrate $NaNO_3$	2.4	.14
Sodium Chloride NaCl	8.2	.48
Sodium Sulfate Na_2SO_4	34.8	2.03
Ammonium Sulfate $(NH_4)_2SO_4$	1.0	.06
Ammonium Carbonate $(NH_4)_2CO_3$	6.7	0.39
Magnesium Carbonate $MgCO_3$	122.3	7.13
Calcium Carbonate $CaCO_3$	190.3	11.09
Iron Carbonate $FeCO_3$	2.6	.15
Manganese Carbonate $MnCO_3$	0.4	.02
Alumina Al_2O_3	2.1	.12
Silica SiO_2	24.5	1.43
Nonvolatile	0.9	.05
Total	396.2	23.09

Some trouble is experienced with meters clogging due to fine sand and iron.

OGLESBY (4135). Oglesby is located in the western part of LaSalle County on the west bank of Vermilion River about a mile south of Illinois River.

In 1912 test wells were drilled to locate a supply of water for the city. A well was drilled to a depth of 45 feet in bottom lands of Vermilion River. It penetrated 12 feet of fine sand. A test well was drilled to a depth of 40 feet in bottom lands of Illinois River. The lower 14 feet was in sand and gravel and the entire sand stratum had not been penetrated. The water secured had a mineral content of 1621, a total hardness of 1145, and a content of iron of 1.0 parts per million. It was not a desirable water for a public supply.

A public water supply was installed by the city in 1915-1916. Water is pumped from a well into a reservoir of 17,000 gallons capacity by air lift. Air is supplied by a Sullivan compressor which is driven by a 50-horsepower electric motor. Water is pumped from the reservoir into the distribution system and an elevated tank connected to the system, by a pump which is driven by a 20-

horsepower electric motor. The pump has a capacity of 500 gallons a minute. The tank has a capacity of 100,000 gallons and is supported on a tower 100 feet high.

Four hundred and fifty-six service connections were in use in 1925. The rate for water for three months is $1.00 for the first 100 cubic feet and 20 cents per 100 cubic feet for additional water.

Water is secured from a well 1645 feet deep, located in the central part of the city. It was drilled by H. H. Adkins of Sullivan, Indiana, in 1915.

The top of the well is about 642 feet above sea level. A record of material penetrated is as follows:

	Thickness in feet.	Depth in feet.
Drift	88	88
Shale, Pennsylvanian	507	595
Shale, Pennsylvanian	95	690
Limestone, Silurian system	350	1040
Shale, Richmond	160	1200
Limestone, Galena-Platteville	300	1500
Sandstone, St. Peter	145	1645

A detailed record of material penetrated is on file with the State Geological Survey Division.

The well was cased with 18-inch outside diameter pipe to a depth of 88 feet, with 15-inch outside diameter pipe to a depth of 338 feet, with 10-inch pipe between depths of 307 and 567 feet, and with 8-inch pipe between depths of 432 and 880 feet. Packers were placed between the 15 and 10-inch and between the 10 and 8-inch casings. The well is 8 inches in diameter at the bottom. Water was noted at a depth of 815 feet, between depths of 875 and 925 feet, and in St. Peter sandstone. The well was equipped with a deep-well pump with 9½-inch cylinder and 18-inch stroke. During a test lasting 13 hours the yield was 350 gallons a minute. The water level when not pumping was at a depth of 105 feet. It was soon necessary to lower the cylinder of the pump from a depth of 200 feet and it was placed at a depth of 280 feet. The pump capacity was reduced and in 1917 it was estimated at 175 gallons a minute. The pump was then operated about six hours a day. The air pressure registered on a gauge on an air pipe extending down to the cylinder was 40 pounds when the pump was operated, indicating a depth to water from the top of the well of 188 feet.

The air lift was installed in 1921. John Richardson, Commissioner, writes in 1925 that it discharges 300 gallons a minute and a total of about 190,000 gallons a day and that the depth to water is about the same as it was in 1917.

The water had a mineral content of 951, a total hardness of 218, and a content of iron of 0.5 parts per million as shown by the analysis of sample number 37098, collected on May 9, 1917.

Analysis of Sample Number 37098 from the City Supply.

Determinations Made.

	Parts per million.
Iron Fe	0.5
Silica SiO_2	13.8
Alumina Al_2O_3	1.6
Calcium Ca	49.0
Magnesium Mg	23.4
Ammonia NH_4	1.1
Sodium Na	273.8
Potassium K	11.2
Sulfate SO_4	72.8
Nitrate NO_3	4.4
Nitrite NO_2	0.0
Chloride Cl	320.0
Nonvolatile	1.8
Alkalinity Methyl Orange	332.
Residue	970.

Hypothetical Combinations.

	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	7.2	.42
Potassium Chloride KCl	16.0	.93
Sodium Chloride NaCl	516.6	30.12
Sodium Sulfate Na_2SO_4	107.8	6.29
Sodium Carbonate Na_2CO_3	79.6	4.64
Ammonium Carbonate $(NH_4)_2CO_3$	2.9	.17
Magnesium Carbonate $MgCO_3$	81.0	4.72
Calcium Carbonate $CaCO_3$	122.3	7.14
Iron Oxide Fe_2O_3	0.7	.04
Alumina Al_2O_3	1.6	.09
Silica SiO_2	13.8	.80
Nonvolatile	1.8	.10
Total	951.3	55.46

OHIO (874). Ohio is located in the northern part of Bureau County on the drainage area of Bureau Creek, a tributary of Illinois River. A public water supply was installed by the village in 1894. Water was secured from a drilled well. Tools were lost in the well and it was abandoned. Two other wells have been drilled and equipped with deep-well pumps which discharge water into the distribution system. An elevated wooden tank 16 feet in diameter and 16 feet high, located close to the wells, is connected to the mains.

Water is secured from two 6-inch wells located 38 feet apart. The tops of the wells are about 905 feet above sea level. One well is 385 feet deep and the other is 388 feet deep. F. C. Albrecht, well driller, states that the material penetrated to a depth of 300 feet is mostly clay with some streaks of sand and that below 300 feet the wells are in “lake sand.” The depth to rock in the well first drilled is given in Illinois Glacial Lobe as 412 feet. The depth to rock in a well two miles east of the city is 510 feet.

The west well, the well 385 feet deep, was drilled in 1900. A screen 24 feet long is placed in the bottom. The well is equipped with a double-stroke deep-well pump with a 41/2-inch cylinder and 18-inch stroke. The cylinder is placed 320 feet below the floor level. The depth to water in 1916, when the pump in the other well was operating, was 260 feet. An old cylinder is wedged in the

casing of this well and the yield is limited. In October, 1923, the pump was operated about two hours a day.

The well to the east, 388 feet deep, was drilled in 1912. A screen of number 60 gauze, 34 feet long, is placed in the bottom. The well is equipped with a single-acting deep-well pump with a 5¼-inch cylinder and 24-inch stroke. The pump is operated 18 revolutions a minute and in October, 1923, it was operated about 15 hours a day, giving a displacement of near 36,000 gallons a day.

The water had a mineral content of 361, a total hardness of 180, and a content of iron of 5.0 parts per million as shown by the analysis of sample number 35618, collected on October 20, 1916.

Analysis of Sample Number 35618 from the Village Supply.

Determinations Made.	Parts per million.
Silica SiO_2	22.2
Iron Fe	5.0
Alumina Al_2O_3	1.6
Calcium Ca	40.2
Magnesium Mg	19.4
Ammonia NH_4	2.6
Sodium Na	64.9
Potassium K	3.9
Sulfate SO_4	1.0
Nitrate NO_3	0.7
Chloride Cl	3.0
Alkalinity Methyl Orange	266.
Residue	345.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	1.1	.06
Potassium Chloride KCl	6.3	.36
Potassium Sulfate K_2SO_4	0.4	.02
Sodium Sulfate Na_2SO_4	1.2	.07
Sodium Carbonate Na_2CO_3	147.4	8.59
Ammonium Carbonate $(NH_4)_2CO_3$	6.9	.40
Magnesium Carbonate $MgCO_3$	67.2	3.92
Calcium Carbonate $CaCO_3$	100.3	5.84
Iron Oxide Fe_2O_3	7.1	.41
Alumina Al_2O_3	1.6	.09
Silica SiO_2	22.2	1.29
Total	361.7	21.05

ONARGA (1302). Onarga is located in the western part of Iroquois County on the drainage area of Iroquois River, a tributary of Kankakee River. A public water supply was installed by the village in 1904. Water was secured from wells which have since been abandoned. Water is now secured from two wells equipped with air lifts. Air is supplied by a Gardner duplex compressor. Water is discharged into a reservoir 6 feet 8 inches by 9 feet in plan and 8 feet deep. Water is pumped from the reservoir into the distribution system by a Goulds 8 by 8-inch triplex pump. The compressor and pump are driven by a 15-horsepower electric motor and a 15-horsepower gas engine is available for use in emergency. Electric current is purchased from the Central Illinois Public Service Company. A steel tank 18 feet in diameter and 29 feet high on a brick tower 73 feet high is connected to the mains.

Two hundred and five service connections were in use in 1923. The meter rates are 45 cents per 1000 gallons for from 7000 to

60,000 gallons, 40 cents per 1000 gallons for from 60,000 to 200,000 gallons, and 30 cents per 1000 gallons for additional water. Rates are 10 cents less to parties owning meters. Bills are not subject to cash discount.

For many years water was secured from three 6-inch wells located in the southern part of the village. One well was 105 feet deep and the other two were 110 feet deep. Water was secured from a sand stratum at the bottom of the wells. Strainers were formed by boring 3/8-inch holes in the bottom part of the casings. Water was drawn from the wells by suction by the Goulds 8 by 8-inch triplex pump. A 4-inch 'suction line extended to a depth of 30 feet in each well. In 1913 the capacity of the pump was given as 200 gallons a minute and the depth to water was given as 11 feet when not pumping and 26 feet when pumping. The pump was operated from three to four hours a day. These wells were abandoned in 1922.

Water for the public supply is secured from two wells, drilled by O. H. Stiegman of Roberts in 1922. The wells are in the southern part of the village close to the wells formerly in use. They are 6 inches in diameter and 156 feet deep. A record of material penetrated is given by the driller as follows:

Sand loam	0	to	10 feet
Blue Clay	10	to	80 feet
Hardpan	80	to	93 feet
Water sand not good	93	to	100 feet
Hardpan	100	to	104 feet
Water sand	104	to	118 feet
Hardpan	118	to	121 feet
Water sand and gravel	121	to	156 feet

Screens were made by cutting three-sixteenth-inch slots in the lower ten feet of the casings.

Each well is equipped with an air lift with a 4-inch discharge pipe extending to within 10 feet of the bottom of the well and a l-inch air pipe. A valve in the air line at the top of each well is partly closed to regulate the flow. A float, in the reservoir, when it rises, closes a valve on the main air line to the wells so that the reservoir will not overflow. Th wells were tested by Mr. Stiegman and each yielded 300 gallons a minute. The amount of water pumped in the summer of 1923 was estimated at from 100,000 to 150,000 gallons a day. In 1925 it was reported that when a to 150,000 gallons a day. In 1925 it was reported that at times a nursery company used as high as 30,000 gallons a day.

OQUAWKA (888). Oquawka is located in Henderson County on the east bank of Mississippi River. A public water supply was

installed by the village in 1900. Water was secured from a well which was abandoned the following year when other wells were drilled near the river. Water is pumped from wells into the mains, to which an elevated wooden tank of 20,000 gallons capacity is connected, by a pump driven by a 3-horsepower electric motor. A Gardner 10 by 6 by 10-inch duplex steam pump formerly in regular service is available for use at times of fire. Only 2400 feet of mains had been laid in 1923 and 24 service connections were in use, fifteen of which were metered.

Water is secured from eight wells located near Mississippi River at the foot of Warren Street. The wells in use in 1923 were drilled by Frank Boden in 1915. The elevation at the tops of the wells is about 540 feet above sea level. Material penetrated below surface soil is mostly sand. The wells are on the north side of the pumping station. They are spaced from 6 to 7 feet apart four in each of two lines which are about at right angles to each other. The intersection of the lines is about 6 feet distant from the nearest well in each line. The wells are 2 inches in diameter and 29 feet deep. A screen 3 feet long of number 60 gauze protected by perforated pipe is placed in the bottom of each well. Water is drawn from the well by a MacDonald 3-inch pump. In July, 1923, is was operated continuously with 6-inch stroke at a speed of 39 revolutions a minute and the amount of water pumped was estimated at 10,000 gallons a day.

A sample of water collected in 1923 had a mineral content of 390 and a total hardness of 218 parts per million.

OREGON (2227). Oregon is located in the central part of Ogle County on the west bank of Rock River. A public water supply was installed by the city about 1876. Water was for a time pumped directly from Rock River and later a well was dug near the river bank to give some filtration to water flowing in from the river. In 1897 a well was drilled from which the supply has since been obtained. Water flows from the well into a reservoir about 14 feet in diameter which surrounds the top of the well and a reservoir 12 feet in diameter which is connected to the larger one. Water is pumped from the reservoirs into the distribution system by either of two Goulds single-acting triplex pumps. The larger pump is 10 by 12-inch. It is driven by a 40-horsepower electric motor at a speed of 32 revolutions a minute giving a displacement, allowing 10 per cent for slip, of 350 gallons a minute. The smaller pump is 8½ by 10-inch. It is driven by a 25-horsepower electric motor at a

speed of 36 revolutions a minute giving a displacement, allowing for slip, of 240 gallons a minute. Electric power is purchased from the Northern Illinois Utilities Company. A large reservoir located on high land is connected to the distribution system.

Water for the public supply is obtained from a well located in the northern part of the city close to the bank of Rock River. The well is said to be 10 inches in diameter at the top, 8 inches in diameter at the bottom, and 1610 feet deep. Water flows into a reservoir and part of the water overflows from the reservoir about five feet above water level in Rock River, about 680 feet above sea level. In 1920 when the larger pump was operated for several hours the water level was drawn down a few feet below the overflow and the pump was then shut down. The inflow, computed from measurements made in the well, was 280 gallons a minute when the water level was three feet below the overflow. The increase in flow with additional draw down was estimated at 17 gallons per foot. The amount of water pumped at that time was estimated at 200,000 gallons a day. With long continued pumping the rate of flow would probably decrease. In 1923 it was reported that when pumping with the smaller pump, drawing from 240 to 250 gallons a minute from the reservoir, the water level was drawn down to not more than two feet below the overflow in five hours pumping. Operating the larger pump the water level was drawn down several feet.

The water had a mineral content of 316, a total hardness of 245, and a content of iron of 0.4 parts per million as shown by the analysis of sample number 49849, collected on August 3, 1923.

Analysis of Sample Number 49849 from the City Supply.

Determinations Made.	Parts per million.
Iron Fe	0.4
Manganese Mn	0.0
Silica SiO_2	10.6
Nonvolatile	0.8
Alumina Al_2O_3	0.4
Calcium Ca	81.0
Magnesium Mg	10.5
Ammonia NH_4	0.1
Sodium Na	19.3
Potassium K	5.3
Sulfate SO_4	15.0
Nitrate NO_3	1.7
Chloride Cl	9.0
Alkalinity Methyl Orange	276.
Residue	350.

Hypothetical Combinations,	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	2.8	0.16
Potassium Chloride KCl	7.9	0.46
Sodium Chloride NaCl	8.6	0.50
Sodium Sulfate Na_2SO_4	22.2	1.29
Sodium Carbonate Na_2CO_3	20.2	1.18
Ammonium Carbonate $(NH_4)_2CO_3$	4.1	0.24
Magnesium Carbonate $MgCO_3$	36.3	2.12
Calcium Carbonate $CaCO_3$	202.2	11.81
Iron Oxide Fe_2O_3	0.6	0.03
Alumina Al_2O_3	0.4	0.02
Silica SiO_2	10.6	0.62
Nonvolatile	0.8	0.04
Total	316.7	18.47

ORLAND PARK 343). Orland Park is located in the southwestern part of Cook County on the drainage area of Des Plaines River. A public water supply was installed by the village in 1897. Water is pumped from a well into the distribution system by a deep-well pump which is driven by a 10-horsepower gas engine. An elevated tank which was connected to the mains fell and a steel pressure tank 8 feet in diameter and 40 feet long was installed in the pumping station in 1918. Fifty service connections were in use in 1921.

Water is secured from a well 329 feet deep, which was drilled in 1897. The well is equipped with a Goulds single-acting deep-well pump with a 4-inch cylinder and 24-inch stroke. The cylinder is placed at a depth of 100 feet and has 20 feet of suction pipe attached. In 1921 the pump was operated for from six to seven hours a day. The depth to water when not pumping was 29 feet and had not changed materially since the well was drilled.

The water had a mineral content of 603, a total hardness of 487, and a content of iron of 0.3 parts per million as shown by the analysis of sample number 45512, collected on June 25, 1921.

Analysis of Sample 45512 from the Village Supply.

Determinations Made.

	Parts per million.
Iron Fe	0.3
Manganese Mn	0.0
Silica SiO_2	24.0
Nonvolatile	0.5
Alumina Al_2O_2	2.2
Calcium Ca	100.0
Magnesium Mg	57.9
Ammonium NH_4	0.6
Potassium K	5.8
Sodium Na	29.7
Sulfate SO_4	122.4
Nitrate NO_3	0.2
Chloride Cl	2.0
Alkalinity Methyl Orange	412.
Residue	579.

Hypothetical Combinations.

	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	3.0	.02
Potassium Chloride KCl	4.2	.24
Potassium Sulfate K_2SO_4	7.6	.45
Sodium Sulfate Na_2SO_4	91.6	5.36
Ammonium Sulfate $(NH_4)_2SO_4$	2.0	.12
Magnesium Sulfate $MgSO_4$	68.3	4.00
Magnesium Carbonate $MgCO_3$	152.6	8.92
Calcium Carbonate $CaCO_3$	249.8	14.61
Silica SiO_2	24.0	1.40
Nonvolatile	0.5	.03
Iron Oxide Fe_2O_3	0.4	.02
Alumina Al_2O_3	2.2	.13
Total	603.5	35.3

OSWEGO (676). Oswego is located in the northeastern part of Kendall County on the east bank of Fox River. A public water supply was installed by the village in 1895. Water was secured from a dug well located on the same lot on which an elevated tank was erected, the lot on which the elevated tank now in use stands. The well was 18 feet deep and the lower 13 feet was in limestone. The yield of this well decreased to a very small quantity and for

a time the village secured water from a dug well which had formerly been used by a creamery. Extensive improvements, including the drilling of a well, were made in 1921. Water is pumped from the well into the distribution system by a deep-well pump which is driven by belt from a 20-horsepower electric motor. An elevated wooden tank is connected to the mains. About 185 service connections were in use in October 1924.

Water for the public supply is secured from a well located close to the center of the business district of the village. It was drilled by C. B. Palmer of Aurora in 1921. The material penetrated is given by the driller as follows:

	Thickness in feet.	Depth in feet.
Clay and gravel	12	12
Limestone, Silurian system	43	55
Shale, Richmond	115	170
Limestone, Galena-Platteville	340	510
Sandstone, St. Peter	166	676
Limestone, Prairie du Chien	4	680

The well is eight inches in diameter to a depth of 200 feet and six inches in diameter at the bottom. Fourteen feet of eight-inch casing was placed in the top of the well. The water level was at a depth of 40 feet. The well is equipped with an American double-acting deep-well pump with the cylinder at a depth of 150 feet. The cylinder is 5¾ inches in diameter and the stroke is 24 inches. The pump was at first operated at a speed of from 28 to 30 revolutions a minute, but operation was not satisfactory. In 1924 the pump was operated about seven hours a day at a speed of 22 revolutions a minute, a displacement of 100 gallons a minute.

Sample Number 52717 from the City Supply.

Determinations Made.

	Parts per million.
Iron Fe	0.1
Manganese Mn	0.0
Silica SiO_2	7.3
Nonvolatile	0.7
Alumina Al_2O_3	0.5
Calcium Ca	48.4
Magnesium Mg	23.3
Ammonia NH_4	6.2
Sodium Na	85.6
Potassium K	20.0
Sulfate SO_4	114.1
Nitrate NO_3	1.8
Chloride Cl	25.0
Alkalinity	
Phenolphthalein	0
Methyl Orange	272.
Residue	484.

Hypothetical Combinations.

	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	2.8	0.16
Potassium Chloride KCl	36.1	2.11
Sodium Chloride NaCl	12.9	0.75
Sodium Sulfate Na_2SO_4	168.6	9.85
Sodium Carbonate Na_2CO_3	59.7	3.49
Ammonium Carbonate $(NH_4)_2CO_3$	16.5	0.96
Magnesium Carbonate $MgCO_3$	80.6	4.71
Calcium Carbonate $CaCO_3$	120.9	7.06
Iron Oxide Fe_2O_3	0.1	0.01
Alumina Al_2O_3	0.5	0.03
Silica SiO_2	7.3	0.43
Nonvolatile	0.7	0.04
Total	506.7	29.60

The water had a mineral content of 506, a total hardness of 216, and a content of iron of 0.1 parts per million as shown by the analysis of sample number 52717, collected at a tap in the pumping station on October 25, 1924. It was collected at a time when the pump was not operating and represents water secured after the pump was operated for some considerable time.

OTTAWA (10816). Ottawa is located in the central part of La Salle County on the banks of Illinois River, at the mouth of Fox River. A public water supply was installed by the city in 1895. Water is now secured from five wells equipped with air lifts. Air to operate the air lifts during the day time is supplied by an Ingersoll-Rand compound air compressor with 14 and 9-inch cylinders and 12-inch stroke. The air compressor is driven by a 79-horsepower electric motor and is operated at 220 revolutions per minute. An Ingersoll-Rand compound compressor with 12 and 7½-inch cylinders and 12-inch stroke is used nights. It is driven by a 61-horsepower electric motor. Each air lift discharges into a pit 5 feet in diameter and 5 feet deep at the top of the well. From these pits water flows into two reservoirs, one 72½ feet by 97½ feet in plan and 14 feet deep and the other 47½ feet by 97½ feet in plan and 14 feet deep. Water is pumped from the reservoir into the distribution system by either of two De Lava1 two-stage centrifugal pumps, each of 610 gallons a minute capacity. Each pump is driven by a 75-horsepower electric motor. The amount of water pumped is measured by a Venturi meter which was installed in 1923. A standpipe 20 feet in diameter and 100 feet high, located on high ground near the southern limits of the city, is connected to the mains. The pressure carried at the pumping station is from 70 to 80 pounds. Electric power is supplied by the Illinois Power and Light Corporation.

About 2600 service connections were in use in 1925. The rate for water for three months decreases from 35 cents per 100 cubic feet for the first 800 cubic feet and 30 cents per 100 cubic feet for the next 700 cubic feet to 8 cents per 100 cubic feet for all water above 12,300 cubic feet. The minimum charge is $3.00.

When the water works was installed in 1894-1895 six wells were drilled in the northeastern part of the city. Each well was from 350 to 400 feet deep. The natural flow from the wells was sufficient to supply demands for a few years. Other wells of about the same depth were in use in the city and the supply became insufficient. In 1906 four of the wells were drilled deeper. A record of ma-

terial penetrated by the wells and data in regard to one of the wells as given on a plat on file with the city is as follows:

Drilled to a depth of 380 feet by the J. P. Miller Artesian Well Company of Chicago. Finished November 28, 1894. Deepened to 1449 feet by Gray Brothers. Finished October 28, 1896. Hole below pipe 5 15/16 inches.

Surface	9 feet	
Sandstone, St. Peter	155 feet	
Blue shale, Prairie du Chien.	5 feet	
Lime rock, Prairie du Chien	124 feet	285 feet of 6-inch
Sandstone, Prairie du Chien	87 feet	380 feet; flow 25 gallons a minute.
Lime rock, Prairie du Chien	430 feet	Gradual increase in flow 810 feet-flow 300 gallons a minute.
Blue shale, Prairie du Chien	110 feet	No increase in flow.
Lime rock, Prairie du Chien	40 feet	960 feet deep.
Sandstone, Mazomanie, Cambrian system	160 feet	Increase in flow. 1120 feet-flow 400 gallons a minute.
Sandstone and blue shale, Dresbach, Cambrian system..	85 feet	No increase in flow.
Blue shale, Eau Claire, Cambrian system	244 feet	
Total	1449 feet	

The classifications given were supplied by the State Geological Survey Division. Water secured from this well 1449 feet deep was salty and a plug was placed about 200 feet above the bottom. Nearly all water was then until 1922, secured from four wells, each about 1200 feet deep. After several years the flow from the wells was not sufficient to supply demands and air lifts were installed.

In the spring and fall of 1910 the air lifts were operated about half of the time and the discharge, with the flow from the wells at other times, was sufficient to supply demands. The air compressor then in use was run at a displacement of about 135 cubic feet per minute. When operating the air lifts no water flowed from the wells 350 feet deep.

In 1918, to supply demands estimated at 800,000 gallons a day, it was necessary to operate the air lifts in all four wells about 18 hours a day. A 2-inch air line was said to extend in each well to a depth of about 200 feet.

Since August, 1924, five wells, each about 1200 feet deep, have been in use. One of these was drilled from a depth of 350 feet to a depth of 1200 feet by Zizane Brothers of Ottawa in 1922. Each well is cased with 6-inch pipe to a depth of 285 feet. A 2-inch air line extends into each well to a depth of 110 feet. In 1924 and early in 1925 the larger air compressor was operated at a speed

of 220 revolutions a minute for about twelve hours during the day time. The smaller compressor was operated for about 5 hours during the night. With the larger compressor operating on April 9, 1925, the yield during one hour after the air lifts had been in operation for three hours, was at a rate of 970 gallons a minute, as determined by meter readings of the amount of water taken from the reservoirs and changes in water levels in the reservoirs. The amount of water pumped from January 1, 1924, until the day of test, as measured by the meter, averaged 1,000,000 gallons a day.

The water has a mineral content of 414 and a total hardness of 273 parts per million and contains no iron as shown by the analysis of sample number 53584, collected on April 9, 1925, after the air lifts had operated continuously for three hours.

Analysis of Sample Number 53584 from the City Supply.

Determinations Made.

	Parts per million.
Iron Fe	0.0
Manganese Mn	0.0
Silica SiO_2	12.0
Nonvolatile	0.2
Alumina Al_2O_3	13.2
Calcium Ca	63.9
Magnesium Mg	27.7
Ammonia NH_4	0.2
Potassium K	8.3
Sodium Na	47.4
Sulfate SO_4	10.1
Nitrate NO_3	0.8
Chloride Cl	30.0
Alkalinity	
Phenolphthalein	0
Methyl Orange	324.
Residue	422.

Hypothetical Combinations.

	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	1.4	.08
Potassium Chloride KCl	14.8	.87
Sodium Chloride NaCl	37.9	2.21
Sodium Sulfate Na_2SO_4	14.9	.87
Sodium Carbonate Na_2CO_3	63.8	3.73
Ammonium Carbonate $(NH_4)_2CO_3$	0.5	.03
Magnesium Carbonate $MgCO_3$	96.2	5.63
Calcium Carbonate $CaCO_3$	159.5	9.32
Alumina Al_2O_3	13.2	.78
Silica SiO_2	12.0	.70
Nonvolatile	0.2	.01
Total	414.4	24.23

Samples from wells into St. Peter sandstone are of about the same quality. Two had mineral content of 360, total hardness of 260, and iron content of 0.1 parts per million each. Another had a mineral content of 445, a total hardness of 330, and a content of iron of 2.0 parts per million.

Sample number 31110 from a well 1800 feet deep had a mineral content of 3623, a total hardness of 630, and a content of iron of 6 parts per million.

PALATINE (1210). Palatine is located in the northwestern part of Cook County on the drainage area of Des Plaines River. A public water supply was installed by the village in 1898. Water is secured from three wells into sand and gravel. Water flows from

the wells into two collecting reservoirs which are connected by pipe line. One is 36 feet in diameter and 7 feet deep and the other in 64 feet 3 inches by 14 feet in plan and 11 feet deep. One well is equipped with an air lift which discharges into the reservoirs. Air is supplied by a Pratt Iron Works 10 by 10 by 10-inch steam driven air compressor. Water is pumped into the mains by any of three pumps. The pump generally used is an American centrifugal which is driven by a 15-horsepower electric motor. The suction line of this pump is connected to one of the reservoirs and one of the wells and the pump usually draws part of its supply from each. Two Pratt Iron Works 12 by 8¼ by 12-inch steam pumps are available to pump water from the reservoirs into the distribution system. Steam, when needed, is supplied by two 50-horsepower fire-tube boilers. A standpipe 12 feet in diameter and 90 feet high is connected to the mains.

About 400 service connections were in use in 1923. The amount of water pumped is measured by meter. Tests made by the Pitometer Company in 1923 showed considerable over-registration by the meter and in computing consumption two-thirds of the meter readings are used. The consumption during the year to November, 1923, averaged 118,000 gallons a day. Considerable leakage had been found in September. The figure given does not include water pumped by the steam pumps which operated a total of not to exceed two weeks during the year. Water is sold at a rate of 20 cents per 100 cubic feet.

Water for the public supply is secured from three wells located near the southern limits of the village at the corner of Brockway and Washington Streets. Each well is 168 feet deep and is cased to the bottom. Water is secured from a stratum of sand and gravel and enters the wells at the bottom of the casings. The ground surface at the top of the wells is approximately 740 feet above sea level. The tops of the wells are covered and cannot be readily located.

A 2-inch well was drilled in 1891. When drilled the water level was said to be 31 feet above the ground surface. The well is connected to the reservoirs.

A 6-inch well was drilled in 1904. It is located about 17 feet south and 8 feet west of the 2-inch well. This well is equipped with an air lift. Occasionally, when pumping from the reservoirs with the steam pumps, the air lift is operated to discharge water into the reservoirs. At other times the air lift is not in use.

A 10-inch well was drilled in 1911. It is located about 16 feet north and 5 feet west of the 2-inch well. A 4-inch suction line connects the well to the centrifugal pump and to a suction line from the rectangular reservoir to the pump. A 4-inch line at a lower elevation connects the well to the rectangular reservoir.

The centrifugal pump discharge on November 21, 1923, using two-thirds of the meter readings, was 150 gallons a minute. The water level in the reservoirs during the test was at all times within an inch of thirty inches below the top of the concrete reservoir. The lowering in water level during pumping showed a loss of 30 gallons a minute from the reservoirs giving a yield from the wells of about 120 gallons a minute. When the pumps were stopped a small amount of water flowed from the reservoirs into the wells and wells then began to discharge into the reservoirs. The rate of flow increased to 16 gallons a minute two hours after the pump was stopped. During the previous day the pumps had operated for nine hours and when idle for eight hours thirty minutes during the night the water level in the reservoirs had raised less than five inches showing an average inflow of less than 12 gallons a minute. The figures given do not allow for leakage from and into the reservoir and the walls are not perfectly water tight. The depth to water in the wells when pumping, noted before the wells were covered with earth, was 19 feet.

The water had a mineral content of 743, a total hardness of 430, and a content of iron of 0.8 parts per million as shown by the analysis of sample number 37351, collected on June 20, 1917.

Analysis of Sample Number 37351 from the Village Supply.

Determinations Made.	Parts per million.
Nonvolatile	0.3
Silica SiO_2	18.5
Alumina Al_2O_3	1.0
Calcium Ca	77.9
Magnesium Mg	57.4
Ammonia NH_4	0.8
Potassium K	2.0
Sodium Na	75.2
Sulfate SO_4	398.5
Nitrate NO_3	0.9
Chloride Cl	5.0
Iron Oxide Fe_2O_3	1.1
Alkalinity Methyl Orange	132.
Residue	740.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	1.4	.08
Potassium Chloride KCl	2.8	.16
Sodium Chloride NaCl	6.1	0.36
Sodium Sulfate Na_2SO_4	224.4	13.03
Ammonium Sulfate $(NH_4)_2SO_4$	2.9	.17
Magnesium Sulfate $MgSO_4$	283.6	16.55
Calcium Sulfate $CaSO_4$	26.4	1.54
Calcium Carbonate $CaCO_3$	174.9	10.20
Iron Oxide Fe_2O_3	1.1	.07
Alumina Al_2O_3	1.0	.06
Silica SiO_2	18.5	1.08
Nonvolatile	0.3	.02
Total	743.4	43.32

Drilling of a 13-inch well was started in 1925.

PALESTINE (1803). Palestine is located in the eastern part of Crawford County. Water for a public water supply is secured from a well from which the city of Robinson is also supplied. See Robinson.

PANA (6122). Pana is located in the southeastern part of Christian County on the drainage area of Kaskaskia River, a tributary of Mississippi River. A public water supply was installed by the city in 1894. Four wells were drilled about one mile northwest of the business district. The wells penetrated 15 feet of loam, 35 feet of water-bearing sand, and 30 feet of shale. The wells were equipped with deep-well pumps until 1910 when air lifts were installed. Water from the wells was discharged into a reservoir from which it was pumped into the mains.

The supply was not adequate for the needs of the city and in 1900 seven wells were drilled about one and one-half miles northeast of the city. The wells were cased with 6-inch pipe. Five wells in one group penetrated 15 feet of loam, 4 or 5 feet of clay, and 35 feet of water-bearing sand. The other two wells, located about 1200 feet distant from the group of five wells, penetrated 15 feet of loam and 50 feet of sand and gravel. The wells were equipped with deep-well pumps which discharged into a reservoir from which water was pumped to the city. These wells have been abandoned.

The supply from wells was inadequate and in 1912 a surface water supply was developed by the city. A large part of the supply is now filtered surface water.

With the equipment in use all demands can not be supplied from the surface supply and some water is secured from the wells located northwest of the business district. Water is pumped from the wells by air lift and is discharged into a reservoir 20 by 22 feet in plan and 20 feet deep. From the reservoir it is pumped into the distribution system by a Worthington 10 and 16 by 8½ by 10-inch compound duplex steam pump.

About 600 service connections were in use in April, 1925. The rates for three months are 50 cents per 1000 gallons for the first 10,000 gallons, 40 cents per 1000 gallons for the next 40,000 gallons, 25 cents per 1000 gallons for the next 250,000 gallons, and 14 cents per 1000 gallons for additional quantities. The minimum charge is $2.50.

Seven wells are available. They are located within an area of about an acre. They penetrate 10 feet of loam and clay, 50 feet

of sand, and 30 feet of hardpan. They were drilled into the hardpan for submergence for air lifts with which the wells are equipped. Five of the wells were drilled by T. L. Craddick, Superintendent of Water Works. They were 6 inches in diameter. Two wells were drilled in 1921-1922 by Otto Steigman of Roberts. They are 8 inches in diameter. The wells are equipped with screens 15 feet long. They are equipped with air lifts. The air lines in the 6-inch weells are three-fourths of an inch in diameter and the air lines in the 8-inch wells are one inch in diameter. The water level has raised to within three or four feet of the ground surface in wet seasons and in dry seasons is drawn down to the screens. When the 8-inch wells were completed the wells were tested. One 8-inch well yielded 90 gallons a minute when no other wells were pumped. Pumping from two 8-inch wells the average yield was 60 gallons a minute each. With the two 8-inch and the five 6-inch wells operating the yield averaged about 50 gallons a minute each. The five 6-inch wells yielded an average of 60 gallons a minute each.

During another test the two 8-inch wells and three 6-inch wells yielded 275 gallons a minute.

Analysis of Sample Number 53538 from City Wells at the Northwest Station.

Determinations Made.

	Parts per million.
Iron Fe	1.7
Manganese Mn	0.3
Silica SiO_2	18.5
Nonvolatile	0.2
Alumina Al_2O_3	6.2
Calcium Ca	149.5
Magnesium Mg	41.1
Ammonia NH_4	0.2
Sodium Na	29.1
Potassium K	1.7
Sulfate SO_4	183.2
Nitrate NO_3	0.4
Chloride Cl	22.0
Alkalinity	
Phenolphthalein	0
Methyl Orange	410
Residue	716

Hypothetical Combinations.

	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	0.6	.04
Potassium Chloride KCl	2.8	.16
Sodium Chloride NaCl.	34.1	2.00
Sodium Sulfate Na_2SO_4	48.5	2.83
Ammonium Sulfate $(NH_4)_2SO_4$	0.9	.05
Magnesium Sulfate $MgSO_4$	187.5	10.96
Magnesium Carbonate $MgCO_3$	11.0	.65
Calcium Carbonate $CaCO_3$	373.3	21.80
Iron Oxide Fe_2O_3	2.4	.14
Alumina Al_2O_3	6.2	.41
Silica SiO_2	18.5	1.08
Nonvolatile	0.2	.01
Total	686.0	40.13

The yield from the two 8-inch wells and two of the 6-inch wells at the time of visit on April 8, 1925, when the air compressor was operated at a speed of about 110 revolutions a minute, raised the water level in the reservoig 44 inches in an hour, a yield of 200 gallons a minute. The water level in the 8-inch well neareest the station was eight feet below the ground surface when the air lift had not operated for six hours and lowered 11 feet during the

one hour test. During the last 20 minutes the lowering was four-tenths of a foot. The discharge, as nearly as could be measured, was constant throughout the test.

A sample of water, number 53538, from the wells in use in 1925, had a mineral content of 686, a total hardness of 542, and a content of iron of 1.7 parts per million as shown by the analysis.

A sample collected in 1911 from the well supply then in use had a mineral content of 2083, a total hardness of 1052, and a content of iron of 5.6 parts per million. It was said that a vein of salt water was found in a coal mine in the vicinity of two of the wells then in use northeast of the center of the city and that may account in part for the high mineral content of the sample.

PARK RIDGE (3383). Park Ridge is located in Cook County nodthwest of and adjointing the city of Chicago. A public water supply was installed by the city in 1890. Water was secured from a well which has since been abandoned. Other wells were drilled and furnished the water supply for several years until water was purchased from the city of Chicago. Two wells and necessary pumping equipment are now maintained for use in emergency. One well is equipped with an air lift. Air is supplied by a Sullivan angle compound compressor with 14 and 8¾-inch cylinders and 10-inch stroke. It is driven by an electric motor. The other well is equipped with a deep-well pump. When the wells are used water is discharged directly into the distribution system. An elevated steel tank located on the same lot as the wells is connected to the mains.

The well first used was 1580 feet deep. When this well was drilled water is said to have raised to 15 feet above ground surface. The well caved in and was abandoned about 1894.

A well 1425 feet deep, drilled by the J. P. Miller Artesian Well Company in 1893, furnished the entire city supply until about 1910. The well was cased with 10-inch pipe to rock at a depth of 117 feet. Considerable material caved in the well. In 1911 the well was cleaned and in 1912 the depth to water was reported to be 90 feet. During the year to June, 1912, during which time a large part of the supply was from this well, the amount of water pumped averaged 135,000 gallons a day.

A sample of water, number 30,005, collected from this well on March 3, 1915, had a mineral content of 804, a total hardness of 312, and a content of iron of 1.0 parts per million as shown by the analysis.

Analysis of Sample Number 30005 from City Well 1425 Feet Deep.

Determinations Made.	Parts per million.
Iron Fe	1.0
Silica SiO_2	30.1
Nonvolatile	2.0
Alumina Al_2O_3	1.0
Calcium Ca	59.0
Magnesium Mg	40.1
Ammonia NH_4	0.5
Sodium Na	149.4
Potassium K	11.8
Sulfate SO_4	266.0
Nitrate NO_3	1.8
Chloride Cl	122.0
Alkalinity Methyl Orange	204.
Residue	820.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	2.9	.17
Potassium Chloride KCl	20.4	1.19
Sodium Chloride NaCl	185.3	10.81
Sodium Sulfate Na_2SO_4	232.2	13.54
Ammonium Sulfate $(NH_4)_2SO_4$	1.8	.10
Magnesium Sulfate $MgSO_4$	135.1	7.88
Magnesium Carbonate $MgCO_3$	44.3	2.58
Calcium Carbonate $CaCO_3$	147.3	8.59
Iron Carbonate $FeCO_3$	2.1	.12
Alumina Al_2O_3	1.0	.06
Silica SiO_2	30.1	1.76
Nonvolatile	2.0	.12
Total	804.5	46.92

A well was drilled to a depth of 190 feet about 1910. It was located 15 feet distant from the deeper well. Pumping from both wells gave little increase in supply from what could be secured from the deeper well. This well 190 feet deep was abandoned after a few years.

A well was drilled to a depth of 1806 feet about 1916.

A record of material penetrated with classifications by the State Geological Survey Division is as follows:

	Thickness in feet.	Depth in feet.
Soil clay, sand, and gravel	110	110
Limestone, Silurian system all or chiefly Niagaran	150	260
Shale, bluish gray, Richmond	240	500
Limestone, Galena-Platteville	320	820
Sandstone, St. Peter	135	955
Limestone, slightly sandy, Prairie du Chien	295	1250
Sandstone, Mazomanie-Dresbach, Cambrian system	175	1425
Shale, light greenish gray, Eau Claire, Cambrian system	300	1725
Sandstone, Mt. Simon, Cambrian system	79	1804

This well is equipped with an air lift.

Analysis of Sample Number 28675 from City Well 1806 Feet Deep.

Determinations Made.	Parts per million.
Iron Fe	0.4
Magnesium Mg	18.5
Sulfate SO_4	355.9
Nitrate NO_3	1.77
Chloride Cl	105.0
Alkalinity	213.0
Residue	919.0

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Sodium Nitrate $NaNO_3$	2.4	0.14
Sodium Chloride NaCl	173.3	10.11
Sodium Sulfate Na_2SO_4	458.6	26.75
Magnesium Sulfate $MgSO_4$	57.6	3.36
Magnesium Carbonate $MgCO_3$	23.5	1.37
Calcium Carbonate $CaCO_3$	185.0	10.79
Iron Carbonate $FeCO_3$	0.8	0.05
Aluminum Undetermined	17.8	1.04
Total	919.0	53.61

A sample of water, number 28675, collected from this well on August 26, 1914, had a mineral content of 919, a total hardness of 261, and a content of iron of 0.4 parts per million as shown by the analysis.

PAW PAW. (665). Paw Paw is located in the southeastern part of Lee County on the drainage area of Fox River, a tributary of Illinois River. A public water supply was installed by the village in 1891. Water was secured from a well which was equipped with a deep-well pump driven by a windmill. Practically all of the original installation excepting the mains has been abandoned.

Water is pumped from a well into a reservoir by a deep-well pump which is driven through gears by an electric motor. Water is pumped from the reservoir into the distribution system by an American single-stage centrifugal pump of 300 gallons a minute capacity which is directly connected to an electric motor. An elevated tank is connected to the mains. Electric current is supplied by the Illinois Northern Utilities Company. A steam pump formerly in regular service has been operated in cases of emergency, using steam from a traction engine.

About 260 service connections were in use in 1922. All but about 15 were metered and a meter was installed at the pumping station to record the amount of water delivered by the deep-well pump. Water rates are 75 cents for three months in addition to 35 cents per 1000 gallons for water used. A penalty of 10 cents per 1000 gallons is added if payment is not prompt.

Water is secured from a well 1018 feet deep. It was drilled by the J. P. Miller Artesian Well Company of Chicago in 1895. The elevation at the top of the well is 928 feet above sea level. A record of material penetrated is as follows:

	Thickness in feet.	Depth in feet.
Drift	454	454
Limestone, Galena-Platteville	296	750
Shale, Galena-Platteville	135	885
Sandstone, St. Peter	133	1018
Limestone, Prairie du Chien		
Total		1018

The well is cased with 10-inch pipe to a depth of 133 feet, with 8-inch pipe between depths of 100 and 402 feet and with 6-inch pipe between depths of 345 feet and 454 feet 6 inches. The well cost $2469.10 including a charge of $90.00 for a 72 hour test.

A newspaper item in 1895 stated that the elevated tank of 54,000 gallons capacity was filled in about 12 hours. This is a rate of discharge of about 75 gallons a minute. In 1899 the depth

to water was reported to be 196 feet. The well is equipped with a deep-well pump with a 5¾-inch cylinder and 24-inch stroke. In 1922 the pump cylinder was thought to be at a depth of 240 feet. The pump was operated at 20 revolutions a minute and the discharge, as registered by meter, was 77 gallons a minute. The amount of water pumped during the year, to March, 1922, averaged 20,500 gallons a day.

The water had a mineral content of 251 and a total hardness of 180 parts per million, and contained a trace of iron as shown by the analysis of sample number 47187, collected on March 8, 1922.

Analysis of Sample Number 47187 from the Village Supply.

Determinations Made.

	Parts per million.
Iron Fe	trace
Manganese Mn	0.0
Silica SiO_2	7.1
Nonvolatile	0.9
Alumina Al_2O_3	1.4
Calcium Ca	37.0
Magnesium Mg	21.1
Ammonia NH_4	0.6
Sodium Na	29.6
Potassium K	3.7
Nitrate NO_3	0.2
Chloride Cl	2.0
Alkalinity	
Phenolphthalein	0
Methyl Orange	242.0
Residue	256.

Hypothetical Combinations.

	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	0.3	.02
Potassium Chloride KCl	4.2	.24
Potassium Carbonate K_2CO_3	2.4	.14
Sodium Carbonate Na_2CO_3	68.4	4.00
Ammonium Carbonate $(NH_4)_2CO_3$	1.5	.09
Magnesium Carbonate $MgCO_3$	73.1	4.27
Calcium Carbonate $CaCO_3$	92.4	5.40
Silica SiO_2	7.1	.41
Nonvolatile	0.9	.05
Alumina Al_2O_3	1.4	.08
Total	251.7	14.70

Samples collected in the past have been of similar quality.

PAXTON (3033). Paxton is located in the southern part of Ford County on the drainage area of Vermilion River, a tributary of Wabash River. A public water supply was installed by the city in 1887. Water was secured from a well into sand and gravel. Additional wells have been drilled to a depth of 140 or 150 feet into the same stratum of sand and many wells have been abandoned.

About 1880 a well was drilled by the J. P. Miller Artesian Well Company to a depth of 2670 feet. This was located near the corner of Taft and State Streets. The water secured was highly mineralized and could not be used for a public supply. In 1912 a well was drilled to a depth of 200 feet without encountering any water bearing strata below a depth of 150 feet. An attempt was then made to secure water by blasting in the upper 400 feet of the old deep well but without success. The drift was said to be 400 feet thick.

Water from one of the wells in use in 1924 is pumped into a collecting reservoir 38 feet in diameter from which it is pumped into the mains by a Goulds 12 by 12-inch single-acting triplex pump driven by a 50-horsepower electric motor. Water from other wells is discharged directly into the mains. Each well pump is driven by an electric motor and electric power is purchased from the Central Illinois Public Service Company. A wooden tank 24 feet in diameter and 20 feet high on a brick tower 80 feet high is connected to the mains.

Nine hundred service connections were in use in 1924. The rates were 25 cents per 1000 gallons for the first 5000 gallons, 20 cents per 1000 gallons for the next 15,000 gallons, and 15 cents for all in excess of 20,000 gallons.

Water is secured from wells from 145 to 150 feet deep into a sand and gravel stratum. In February, 1924, four wells were in use. The elevation at the tops of the wells is from 790 to 800 feet above sea level. One of the wells is located in the rear of the city hall near the corner of Center and Market Streets. It is 8 inches in diameter. It is equipped with a Goulds deep-well pump with a 7¼-inch cylinder and 24-inch stroke. The pump is operated 13 strokes a minute and in the spring of 1924 was operated from 12 to 14 hours a day. The discharge, as measured in the reservoir, was 54 gallons a minute.

Three wells are located in an area about 30 feet square, south of State Street near Taft Street, about 750 feet distant from the well in the rear of the city hall. One of these, to the north, was drilled by O. A. Musson, of Hoopeston, in 1917. The well is 6 inches in diameter. A screen 14 feet long is placed at the bottom. The well is equipped with a Deming single-acting deep-well pump with 5¾-inch cylinder and 24-inch stroke. The pump is operated 17 revolutions a minute. One well, to the southeast, was drilled by Johnson & Son, of Bloomington, in 1923. It is 8 inches in diameter. A Cook screen 16 feet long is placed in the bottom. The well is equipped with a Goulds single-acting deep-well pump with a 5¾-inch cylinder and 24-inch stroke. The pump was formerly operated at a speed of 22 revolutions a minute but it was necessary to reduce the speed to 17 revolutions a minute, a displacement of 84 gallons a minute.

The west well was drilled by Otto Stiegman of Roberts in 1921. It is 8 inches in diameter. A number 12 Cook screen 20 feet long is placed in the bottom. The well is equipped with a Goulds single-acting deep-well pump with a 5¾-inch cylinder and 24-inch stroke, which is operated 18½ revolutions a minute.

The Public Service Company for some time was paid 5 cents per 1000gallons for pumping water and all water was metered. The average amount of water pumped during the year to May, 1922, estimated from the cost of pumping, was about 130,000 gallons a day. In July, 1921, a time of maximum consumption, 2,125,300 gallons was pumped from two wells then in use at the city hall and 3,321,800 gallons was pumped from two wells then in use on West State Street. During the year 1923 the amount of water sold was 40,000,00 gallons. During this time the Illinois Central Railroad was supplied with water for construction work.

A sample of water, number 50983, collected from the west well near West State Street, after several hours pumping on February 19, 1924, had a mineral content of 476, a total hardness of 305, and a content of iron of 1.2 parts per million as shown by the analysis.

Analysis of Sample Number 50983 from the West Well.

Determinations Made.	Parts per million.
Iron Fe	1.2
Manganese Mn	0.0
Silica SiO_2	31.1
Nonvolatile	2.0
Alumina Al_2O_3	0.5
Calcium Ca	68.5
Magnesium Mg	32.8
Ammonia NH_4	8.2
Sodium Na	42.6
Potassium K	11.8
Sulfate SO_4	38.3
Nitrate NO_3	1.2
Chloride Cl	2.0
Alkalinity	
Phenolphthalein	0
Methyl Orange	396.
Residue	471.

Hypothetical Combinations.	Parts per million.	Grains per gallon
Potassium Nitrate KNO_3	2.0	.12
Potassium Chloride KCl	4.2	.25
Potassium Sulfate K_2SO_4	19.8	1.15
Sodium Sulfate Na_2SO_4	40.5	2.36
Sodium Carbonate Na_2CO_3	67.8	3.96
Ammonium Carbonate $(NH_4)_3CO_3$	21.9	1.28
Magnesium Carbonate $MgCO_3$	113.6	6.64
Calcium Carbonate $CaCO_3$	171.1	9.97
Iron Oxide Fe_2O_3	1.7	.10
Alumina Al_2O_3	0.5	.03
Silica SiO_2	31.1	1.82
Nonvolatile	2.0	.12
Total	476.2	27.80

Samples collected from other city wells in the past have been similar in quality.

PEARL (669). Pearl is located in the southeastern part of Pike County half a mile distant from Illinois River. A public water supply was installed by Dr. F. M. Thurman in 1914. The village is nearly surrounded by high hills of limestone and several springs issue from the rock. A spring on Dr. Thurman's farm about three-fourths of a mile south of the center of the village was used as a source of supply. The flow of the spring was measured and at the time was 50 gallons a minute. Water from the spring flows downward to a number 40 Rife hydraulie ram and part of the supply

is forced to a reservoir located on the hill above the spring, about 100 feet above the business district of the village. Water flows from the reservoir to the village through a pipe line of 2-inch and 3-inch pipe. When the ram was installed it was expected to deliver 10 gallons of water a minute to the reservoir. The reservoir is 22 feet in diameter and 10 feet deep. In 1918 a small reservoir was built to catch waste water from the ram and a Rumley pump of about 25 gallons a minute capacity driven by a 3-horsepower gasoline engine was installed to pump water from this small reservoir into the pipe line. This pump is used occasionally when the discharge from the ram is insufficient. Eighty service connections were in use in 1918.

The water had a mineral content of 227, a total hardness of 192, and a content of iron of 0.l parts per million as shown by the analysis of sample number 39792, collected on July 20, 1918.

Analysis of Sample Number 39792 from the Public Supply.

Determinations Made.	Parts per million.
Iron Fe	0.1
Manganese Mn	0.0
Silica SiO_2	8.6
Nonvolatile	0.0
Alumina Al_2O_3	0.1
Calcium Ca	55.1
Magnesium Mg	13.4
Ammonia NH_4	0.0
Potassium K, Sodium Na	10.0
Sulfate SO_4	12.3
Nitrate NO_3	15.9
Chloride Cl	5.0
Alkalinity	
Phenolphthalein	0
Methyl Orange	189.
Residue	243.
Carbon Dioxide CO_2	1.0

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Sodium Nitrate $NaNO_3$	21.8	1.27
Sodium Chloride NaCl	8.2	.48
Sodium Sulfate Na_2SO_4	0.3	.02
Magnesium Sulfate $MgSO_4$	13.1	.76
Magnesium Carbonate $MgCO_3$	37.3	2.16
Calcium Carbonate $CaCO_3$	137.6	7.89
Iron Carbonate $FeCO_3$	0.2	.01
Alumina Al_2O_3	0.1	.00
Silica SiO_2	8.6	.06
Total	227.3	12.65

PEARL CITY (468). Pearl City is located in the southwestern part of Stephenson County on the drainage area of Pecatonica River, a tributary of Rock River. A public water supply was installed by the village about 1896. Water was secured from a well which was later abandoned. Water was then purchased from a creamery company until 1910 when wells and a pumping station were installed by the village. Water is pumped from the wells into the distribution system by a Goulds triplex pump which is driven by an electric motor. A gas engine is available for use in emergency. An elevated wooden tank 22 feet in diameter and 24

feet high on a steel tower 70 feet high is connected to the mains. Electric current is purchased from the Lena Electric Light and Power Company. Sixty-six service connections were in use in 1916. Water is sold at flat rates.

Water is secured from two wells located 10 feet apart. One is 6 inches in diameter and 40 feet deep and the other is 8 inches in diameter and 40 feet deep. They penetrate top soil, clay, and quicksand and end in gravel. Water is drawn from the wells by suction. Suction lines extend to a depth of 32 feet. When the village was visited in 1916 water stood at a depth of from 15 to 18 feet below the ground surface when not pumping and after pumping for several hours the depth to water was 28½ feet. The pump capacity was 85 gallons a minute. One well would not continuously supply that quantity of water. The amount pumped, as near as could be estimated, averaged 15,000 gallons a day.

The water had a mineral content of 722, a total hardness of 568, and a content of iron of 0.6 parts per million as shown by the analysis of sample number 35546, collected on October 14, 1916.

Analysis of Sample Number 35546 from Village Wells 40 Feet Deep.

Determinations Made.	Parts per million.
Silica SiO_2	18.0
Nonvolatile	1.6
Iron Fe	0.6
Alumina Al_2O_3	3.5
Calcium Ca	119.6
Magnesium Mg	65.8
Ammonia NH_4	0.5
Sodium Na	42.3
Potassium K	3.8
Sulfate SO_4	122.9
Nitrate NO_3	6.2
Nitrite NO_2	0.0
Chloride Cl	110.0
Alkalinity Methyl Orange	396.
Residue	796.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	9.8	.57
Potassium Chloride KCl	0.2	.01
Sodium Chloride NaCl	107.6	6.27
Ammonium Chloride NH_4Cl	1.5	.09
Magnesium Chloride $MgCl_2$	59.2	3.44
Magnesium Sulfate $MgSO_4$	154.0	8.98
Magnesium Carbonate $MgCO_3$	67.6	3.94
Calcium Carbonate $CaCO_3$	299.5	17.47
Iron Oxide Fe_2O_3	0.9	.05
Alumina Al_2O_3	3.5	.20
Silica SiO_2	18.0	1.05
Nonvolatile	1.6	.09
Total	722.4	42.18

Since the above was written we are informed by M. W. Hooker, Village Clerk, that the village is now (1925) supplied with water from an 8-inch well 322 feet deep. It is equipped with a Johnson type double-stroke deep-well pump which is driven by a 15-horsepower electric motor. The capacity of the pump is 55 gallons a minute. The cylinder is attached to 200 feet of drop pipe and 50 feet more is to be added.

PECATONICA (1088). Pecatonica is located in the western part of Winnebago County on the drainage area of Pecatonica River, a tributary of Rock River. Many private wells are about 100 feet deep into Galena-Platteville limestone. Some wells in the village are drilled into St. Peter and Cambrian sandstones.

A public water supply was installed by the village in 1889. Water is pumped from a dug well into the mains by either of two Deane 9 by 5¼ by 10-inch duplex steam pumps. Steam is supplied by a 25-horsepower boiler. A steel tank 8 feet in diameter and 40 feet high of 15,000 gallons capacity, on a brick tower 60 feet high, is connected to the mains.

One hundred and ninety-six service connections were in use in 1917 and the amount of water used was estimated at 35,000 gallons a day, but this figure may be considerably in error. The Wisconsin Condensed Milk Company has a private supply and uses about 800,000 gallons a day from three wells into St. Peter and Cambrian sandstones.

Water for the public supply is secured from a well into limestone. It is 12 feet in diameter and 20 feet deep. In 1917 when not pumping for twelve hours or more water raised to a depth of 11 feet in the well and when pumping the well was emptied.

The water had a mineral content of 357, a total hardness of 330, and a content of iron of 0.1 parts per million as shown by the analysis of sample number 26343, collected on October 20, 1913.

Analysis of Sample Number 26343 from Village Well 20 Feet Deep.

Determinations Made.	Parts per million.
Iron Fe	0.1
Silica SiO_2	24.0
Alumina Al_2O_3	0.3
Calcium Ca	67.9
Magnesium Mg	39.3
Ammonia NH_4	0.0
Sodium Na	3.2
Potassium K	2.0
Sulfate SO_4	38.5
Nitrate NO_3	0.5
Nitrite NO_2	0.0
Chloride Cl	4.0
Nonvolatile	0.8
Alkalinity Methyl Orange	866.
Residue	336.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	0.8	.05
Potassium Chloride KCl	3.2	.19
Sodium Chloride NaCl	4.1	.24
Sodium Sulfate Na_2SO_4	4.9	.29
Ammonium Sulfate $(NH_4)_2SO_4$	0.1	.01
Magnesium Sulfate $MgSO_4$	44.2	2.59
Magnesium Carbonate $MgCO_3$	105.0	6.12
Calcium Carbonate $CaCO_3$	169.5	9.88
Iron Carbonate $FeCO_3$	.02	0.01
Alumina Al_2O_3	0.3	.02
Silica SiO_2	24.0	1.40
Nonvolatile	0.8	.05
Total	357.1	20.85

Since the sample was collected and since the above was written we are informed that a supply from a spring has been developed

and that water from the spring flows into the well through a six-inch pipe line. The depth to water in the well is said to be 16 feet at all times. A sample of water collected from a nearby spring in 1917 was less highly mineralized than the sample from the well. It had a mineral content of 300 and a total hardness of 265 and contained no iron.

PEKIN (12086). Pekin is located in the western part of Tazewell County on the east bank of Illinois River. A public water supply was installed in 1886. The property is owned by the Pekin Water Works Company. Water is secured from wells drilled into sand and gravel. Pumps placed in a pit 20 feet deep draw water from the wells and discharge into the distribution system. A steel tank 20 feet in diameter and 56 feet high on a stone masonry tower 85 feet high is connected to the mains. A Worthington centrifugal pump driven by an eight-cylinder gas engine has been installed. Two Blake 12 and 22 by 12 by 18-inch compound duplex steam pumps of 1,500,000 gallons capacity each, in use since the water works was installed, are also available. Steam is supplied by four return tubular boilers of 80-horsepower each.

The charge for water, when paid promptly, is 29 cents per 1000 gallons for the first 10,000 gallons per month, 20 cents per 1000 gallons for the next 90,000 gallons per month, and 10 cents per 1000 gallons for additional water. In addition there is a service charge, depending upon the size of meter, of from 25 cents for a 5/8 -inch meter to $4.00 for a 4-inch meter.

Water is secured from wells located near the corner of Broadway and Capitol Streets. The wells are into an extensive deposit of sand and gravel in the valley of Illinois River. They are in a well house 29 feet in diameter and 25 feet deep. One extends to a depth of 103 feet below the floor of the well house and others are about 60 feet deep. One is 4 inches in diameter, two are 8 inches in diameter and the others are 6 inches in diameter. Some are equipped with drive points and others with Cook screens. In 1924 seventeen wells were in use. Four wells have been drilled in the pump house. These are not now in use. The suction main from the pumps to the well house is laid through a tunnel.

The water level in the ground around the wells is drawn down but little by pumping from the wells. In 1906 when pumping 2100 gallons a minute the water level was lowered 2 feet to 16 feet below the center of the suction main. For several years the water consumption has averaged near 800,000 gallons a day and the water level seldom varies more than one foot. The suction lift increases

with clogging of well screens. During the test in 1906 when pumping 2100 gallons a minute the suction lift was 28 feet. It varies with water levels but during regular operation seldom exceeds 19 feet. The wells were sand pumped annually and occasionally fine sand was forced from the screens by forcing water into the wells through openings made by removing plugs provided at the top. Pumping at high rate with the centrifugal pump has kept the screens in good condition recently.

The water had a mineral content of 465 and a total hardness of 362 parts per million as shown by the analysis of sample number 40586, collected on January 14, 1919.

Analysis of Sample Number 40586 from the City Supply.

Determinations Made.	Parts per million.
Iron Fe	0.0
Manganese Mn	0.0
Silica SiO_2	20.2
Nonvolatile	1.8
Alumina Al_2O_3	2.0
Calcium Ca	84.6
Magnesium Mg	36.7
Ammonia NH_4	0.0
Sodium Na	25.4
Sulfate SO_4	53.8
Nitrate NO_3	35.4
Chloride Cl	36.0
Alkalinity	
Phenolphthalein	0
Methyl Orange	264.
Residue	500.
Carbon Dioxide CO_2	20.
Hydrogen Sulfide H_2S	0.2

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Sodium Nitrate $NaNO_3$	48.46	2.83
Sodium Chloride NaCl	31.28	1.83
Magnesium Chloride $MgCl_2$	22.86	1.37
Magnesium Sulfate $MgSO_4$	67.41	3.94
Magnesium Carbonate $MgCO_3$	59.70	3.49
Calcium Carbonate $CaCO_3$	211.28	12.38
Alumina Al_2O_3	2.00	0.12
Silica SiO_2	20.20	1.18
Nonvolatile	1.80	0.11
Total	464.99	27.25

Some waters from deep wells in this vicinity and in the vicinity of Peoria are highly mineralized. A sample from a well 1000 feet deep at Mineral Springs Park had a mineral content of 3082, of which 2950 parts were compounds of sodium and potassium.

PEORIA (76121). Peoria is located in the eastern part of Peoria County on the west bank of Illinois River. A public water supply was installed by the city in 1868 and was sold to the Peoria Water Works Company in 1889. Water is pumped from a main well into the distribution system by steam pumps. During dry weather the supply from the main well is not sufficient and water from other wells is discharged into a steel tank 20 feet in diameter and 12 feet deep located in the main well. The suction lines from the steam pumps extend into this steel tank. Three Worthington, vertical, compound, double-acting, duplex pumps of 7,200,000 gallons

capacity each were installed in 1892 and are located in a pit 40 feet in diameter and 23 feet deep in what is known as the main station. These pumps are now held in reserve. An Allis Chalmers triple expansion, crank and fly-wheel pump was installed in 1913 in a pit in what is known as station number two, adjoining the main station. This pump is operated continuously. Steam is supplied by six boilers, two of 300-horsepower and the others of 200-horsepower each. A reservoir of 19,200,000 gallons capacity, located on high ground in Averyville, one mile west of the pumping station, is connected to the distribution system.

Water is secured from wells into sand and gravel in the valley of Illinois River from three to six miles upstream from the center of the business district of the city. The supply is almost all from four wells known as the main well and wells number 7, number 8, and number 9. Other wells are numbers 2, 3, 4, 5, and 6 and a "reserve well."

The main well, from which the high service pumps draw, at times furnishes enough water to supply demands during wet months. The others are auxiliary and are used only when needed.

The main well is located 60 feet east of station number 1. It is an open well 34 feet in diameter to a depth of 40 feet, with brick walls three feet thick resting on a cast iron shoe. Inside, and extending five feet below the shoe, is a 24-foot perforated steel ring and inside of this ring is a similar 10-foot ring extending 4 feet lower. Outside the 24-foot ring are four, four by five-foot elliptical steel caissons sunk to hardpan with the lower portion perforated. A Byron-Jackson centrifugal pump driven by a Pelton water wheel on the same vertical shaft is installed in each caisson. These pumps are not usually operated. When they are operated water from the pumps and water from the high service line after passing through the wheels is discharged into the steel reservoir in this well from which water is drawn by the high service pumps.

A reserve well located 40 feet northeast of the main well, in station number 2, has a 12-foot steel cylinder 40 feet deep, with the lower 22 feet perforated, and a concrete and steel bulkhead at the 22 foot level. Above the strainer is a dry well 12 feet in diameter and 34 feet deep, having a steel shell for 18 feet and a 16-inch reinforced concrete shell for 16 feet. This well is connected to the main well by two tunnels, one from the strainer and the other from the dry well for emergency suction pipes. A 10-inch and an 8-inch Byron-Jackson centrifugal pump, direct connected to 35 and 25-horsepower electric motors at the surface, deliver water to the tank in the main well.

Number 2 well is located 3,300 feet north of the main well. It is 11 feet in diameter and 45 feet deep, with brick wall on a cast iron shoe. It has four 8-inch wells with Cook strainers in the bottom and four 8-inch push wells in the sides. Two 5-inch Byron-Jackson pumps, one for reserve, each driven by a 15-horsepower motor, deliver water through a cast iron pipe line to the main well.

Number 3 well is located 1,200 feet south of the main well. It has a 9-foot strainer 21½ feet long and a brick dry well 7 feet in diameter and 30 feet deep extending above high water mark. A steel bulkhead forms the bottom of the dry well. An 8-inch Byron-Jackson centrifugal pump operated by a Pelton water wheel discharges through a 12-inch cast iron pipe line to the main well.

Well number 4 is located 700 feet southeast of the main well. It has a strainer section 7 feet in diameter and 22 feet long with steel bulkhead and a dry well 5 feet in diameter and 21 feet deep, with 12-inch concrete shell. A 6-inch pump, driven by a 15-horse-power motor, discharges through an 8-inch and 12-inch cast iron pipe line to the main well.

Well number 5 is located 1000 feet north of the main well. It has a strainer 7 by 12 feet and a dry well 4 feet 10 inches in diameter and 21 feet deep. The equipment is the same as in number 4 well. Water is discharged to a 24-inch cast iron pipe line.

Number 6 well is located 1700 feet north of the main well. It has a concrete manhole with two 8-inch wells with Cook strainers 13 feet long. This well is not in use.

Well number 7 is located about three miles upstream from the pumping station. It was completed in 1911. In the bottom is a steel strainer 7 feet in diameter and 24 feet long. At the top of the strainer is a steel and concrete bulkhead two feet thick which is the bottom of a dry pump pit. This pump pit is 8 feet square to a depth of seven feet and 4 feet 10 inches below that depth to the bulkhead which is at a depth of 64 feet. An 8-inch centrifugal pump placed near the bottom of the pit is driven by a 60-horse-power electric motor which is in a station at the top of the pit. A 10-inch suction pipe is placed through the bulkhead.

Well number 8 is near well number 7, is of the same size, and has the similar equipment. It was installed in 1914.

Well number 9 is located about 700 feet distant from wells number 7 and number 8. It was installed by the Kelly Well Company of Grand Island Nebraska in 1923. It is 25 inches inside diameter, 32 inches outside diameter, and 95 feet deep.

A record of material penetrated is as follows:

	Thickness in feet.	Depth in feet.	
Soil and clay	55	55	
Gravel	10	65	(37 feet to water)
Gravel	19	84	
Coarse gravel	11	95	

The well is cased with concrete and in the bottom is twenty-six feet of concrete screen. This well is equipped with an American two-stage turbine pump which is driven by a 60-horsepower electric motor. The bowls are placed 82 feet below the top of the well and six feet of tail pipe is attached. This well yielded 2100 gallons a minute when pumped for several days and the water level was lowered ten feet.

A 24-inch cast iron main carries water from wells number seven, eight, and nine to the main well.

A sample of water from this supply was collected on December 1, 1924, while water was pumped from the main well, well number 7, and well number 8. The water had a mineral content of 462, a total hardness of 345, and a content, of iron of 0.1 parts per million as shown by analysis of sample number 52931.

Analysis of Sample Number 52931 from the City Supply.

Determinations Made.	Parts per million.
Iron Fe	0.1
Manganese Mn	0.0
Silica SiO_2	12.8
Nonvolatile	1.6
Alumina Al_2O_3	0.7
Calcium Ca	86.6
Magnesium Mg	40.6
Ammonia NH_4	0.1
Sodium Na	25.5
Potassium K	3.8
Sulfate SO_4	51.9
Nitrate NO_3	4.2
Chloride Cl	21.0
Alkalinity	
Phenolphthalein	0
Methyl Orange	344.
Residue	456.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_2	6.9	0.40
Potassium Chloride KCl	2.1	0.12
Sodium Chloride NaCl	33.0	1.93
Sodium Sulfate Na_2SO_4	38.7	2.26
Ammonium Sulfate $(NH_4)_2SO_4$	0.4	0.02
Magnesium Sulfate $MgSO_4$	31.9	1.86
Magnesium Carbonate $MgCO_3$	118.3	6.91
Calcium Carbonate $CaCO_2$	216.3	12.63
Iron Oxide Fe_2O_3	0.1	0.01
Alumina Al_2O_3	0.7	0.04
Silica SiO_2	12.8	0.75
Nonvolatile	1.6	0.09
Total	462.8	27.02

PEORIA HEIGHTS (1111). Peoria Heights is located in the eastern part of Peoria County north of the city of Peoria. Water for a public supply is purchased from the Peoria Water Works Co. The village is on high land and the pressure maintained for Peoria is not sufficient for Peoria Heights. The village maintains a pumping station and pumps water into its distribution system and an elevated steel tank connected to the system.

PEOTONE (1000). Peotone is located in the southeastern part of Will County on the drainage area of Kankakee River. A public water supply was installed by the village in 1895. Water is pumped from a well into the distribution system by a deep-well pump which is driven by an electric motor. An elevated steel tank of 60,000 gallons capacity is connected to the mains. Nearly all persons in the village use water from the public supply and in 1923 the average water consumption was 45,000 gallons a day.

When the water works was installed water was pumped from a well 100 feet deep at an electric light plant. The plant was sold and the village developed another supply.

Water is secured from a 10-inch well 135 feet deep, drilled by Martin and Kaler, of Manteno. The ground surface at the well is about 720 feet above sea level. The well is cased to rock at a depth of 55 or 60 feet. It is equipped with a deep-well pump with a 6½-inch Erb cylinder and 24-inch stroke. The pump is operated 26 revolutions a minute at which speed the capacity is 165 gallons a minute. The water level when not pumping was at a depth of 22 feet in 1922. The pump cylinder was placed at a depth of 40 feet and in 1922 twenty feet of suction pipe was attached. In February, 1923, the pump was operated about four hours a day. It has operated continuously for twelve hours.

The water has a mineral content of 606, a total hardness of 427, and a content of iron of 0.6 parts per million as shown by the analysis of sample number 39934, collected on August 7, 1918.

Analysis of Sample Number 39934 from the Village Supply.

Determinations Made.	Parts per million.
Iron Fe	0.6
Manganese Mn	0.0
Silica SiO_2	18.6
Nonvolatile	1.2
Alumina Al_2O_3	1.1
Calcium Ca	105.8
Magnesium Mg	39.8
Ammonia NH_4	0.7
Sodium Na	47.2
Sulfate SO_4	191.5
Nitrate NO_3	0.7
Chloride Cl	3.4
Alkalinity	
Phenolphthalein	0
Methyl Orange	317.
Residue	599.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Sodium Nitrate $NaNO_3$	0.9	05
Sodium Chloride NaCl	5.6	.33
Sodium Sulfate Na_2SO_4	137.9	7.98
Ammonium Sulfate $(NH_4)_2SO_4$	2.6	.15
Magnesium Sulfate $MgSO_4$	120.4	6.98
Magnesium Carbonate $MgCO_3$	53.3	3.09
Calcium Carbonate $CaCO_3$	264.1	15.33
Iron Carbonate $FeCO_3$	1.2	.07
Alumina Al_2O_3	1.1	.06
Silica SiO_2	18.6	1.18
Nonvolatile	1.2	.07
Total	605.9	35.29

This sample was a little more highly mineralized and a little harder than a sample collected in 1913. Water used in boilers at a

laundry is treated with soda ash. The iron content is sufficient to cause some trouble in meters. Some galvanized iron service pipe were replaced with lead pipe after twenty-five years service.

PERU (8869). Peru is located in the western part of LaSalle County on the north bank of Illinois River. A public Water supply was installed in 1891 by the Peru Water Company, under arrangements by which the city acquired the property. Water was secured from flowing wells. With increasing demands it was necessary to drill additional wells and to pump from the wells at times of maximum demands. The wells are equipped with air lifts. Air can be supplied by a Sullivan W. J. 3 size 14 and 8¾ by 10-inch two-stage compressor which is driven by an electric motor or by steam driven compressor which was formerly in regular service. Water is discharged into a reservoir about 60 feet long and 50 feet wide and is pumped from the reservoir into the mains by either of two Worthington 13 by 12-inch triplex pumps. An elevated steel tank of 160,000 gallons capacity is connected to the mains.

Nineteen hundred and thirty service connections were in use in 1923. The rates are: first 400 cubic feet at 30 cents per 100 cubic feet; next 1,000 cubic feet at 25 cents per 100 cubic feet; next 5,000 cubic feet at 20 cents per 100 cubic feet; and all above 6,400 cubic feet at 18 cents per 100 cubic feet. Bills are not subject to cash discount.

Water for the public supply is secured from three wells, numbers 2, 3, and 4, located near the bank of the Illinois River. The elevation of the tops of the wells is about 460 feet above sea level. A record of material penetrated by one of the wells, number 2 or 3, is as follows:

	Thickness in feet.	Depth in feet.
Clay	70	70
Shale	530	600
Limestone and shale Devonian, Niagaran and Alexandrian	214	814
Shale, Maquoketa	181	995
Shale and limestone, Galena	13	1008
Limestone, Galena	246	1254

A log of well number four shows Galena limestone to a depth of 1360 feet, 135 feet of St. Peter sandstone to a depth of 1495 feet, and 10 feet of shale below the sandstone.

Well number 1, not now in use, is located on ground above the pumping station. It was drilled by O. K. Walling, of Ottawa, in 1889. It was about 1365 feet deep and was cased to a depth of 1000 feet. The diameter at the bottom was 6 inches. Water from

this well flowed into a reservoir of 250,000 gallons capacity surrounding the top of the well. With deterioration of casing the water became salty, the flow became smaller, and the well was abandoned. Recently after a few years with no flow there has been a small flow from this well.

Well number 2 is located near the Chicago, Burlington and Quincy Railroad depot, about 1000 feet distant from the pumping station. It was drilled by the Whitney Well Company, of St. Louis, Missouri. The well is 1254 feet deep and is cased to a depth of about 900 feet. It is thought to be 5 inches in diameter at the bottom. When the well was completed the pressure with no flow was 85 feet and the flow was 448,000 gallons a day. The flow in 1920 when the air lifts had not operated for several hours was 25 gallons a minute. The well has been equipped with an air lift with 190 feet of air pipe. The air pressure in 1920 was 100 pounds when starting and 76 pounds during operation.

Well number 3 is located in the pumping station. It was drilled by the L. Wilson Well Company, of Chicago, in 1905. It is about 1255 feet deep and is thought to be 6 inches in diameter at the bottom. It is cased to rock with 14-inch pipe and to a depth of about 900 feet with 8-inch pipe. The flow was 200 gallons a minute when the well was completed and 40 gallons a minute in 1920 when the air lifts had not operated for several hours. The well is equipped with an air lift with 150 or 160 feet of 1-inch air pipe and 4-inch discharge pipe. The air pressure in 1920 was 95 pounds at the start and 57 pounds during operation.

Well number 4 is east of and about 150 feet distant from well number 3. It was drilled by H. W. Hambrecht, of Sterling, in 1913. Salty water flowed from depths of 595 feet and 700 feet. Fresh water was encountered at the top of the Galena limestone at a depth of 990 feet and the flow increased all the way through the limestone. The well was cased with 49 feet of 16-inch pipe, 163 feet of 12-inch pipe below the 16-inch pipe, 390 feet of 10-inch pipe placed from the ground surface, 625 feet of 8-inch pipe placed from the ground surface and 374 feet of 6-inch pipe with the bottom at a depth of 990 feet and the top sealed to the 8-inch casing with a lead packer to exclude water from above a depth of 990 feet. The flow from the well was 200 gallons a minute in 1920.

The flow from the three wells was estimated in October, 1923, from two tests of short duration, one of only 17 minutes. During the tests water flowed into and was pumped out of a reservoir and results are only approximate. It was computed that the meter which records the amount of water pumped from the reservoir, over-

registered 56 per cent and that the flow of the three wells was 234 gallons a minute. The yield with air lifts operating was at a rate of about 1,000,000 gallons a day. During the first nine months of 1923 the meter registered an average of 500,000 gallons a day. The actual quantity probably averaged between 300,000 and 350,000 gallons a day.

Data for early in 1925 is available from H. J. Mueller, Superintendent of Water Works. The meter tube has been cleaned and the triplex pumps noted have been installed. This makes it possible to secure better meter readings. The natural flow of the wells will supply 350,000 gallons a day and the air lifts will supply 935,000 gallons a day.

Town	Peru
Well	700 foot
Date collected	2-13-'96
Sample number	491

	Parts per million.
Iron Fe	8.0
Manganese Mn	
Silica SiO_2	7.7
Nonvolatile	
Alumina Al_2O_3	
Calcium Ca	48.2
Magnesium Mg	15.8
Ammonia NH_4	
Sodium Na	1654.0
Potassium K	27.7
Sulfate SO_4	320.4
Nitrate NO_3	
Chloride Cl	2264.1
Alkalinity Methyl Orange	
Residue	

	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3		
Potassium Chloride KCl	52.6	3.07
Sodium Chloride NaCl	3690.	215.20
Sodium Sulfate Na_2SO_4	474.	27.74
Sodium Carbonate Na_2CO_3	112.5	6.56
Ammonium Carbonate $(NH_4)_2CO_3$		
Magnesium Carbonate $MgCO_3$	55.	3.19
Calcium Carbonate $CaCO_3$	120.4	7.02
Iron Oxide Fe_2O_3	11.5	.67
Alumina Al_2O_3		
Silica SiO_2	7.7	.44
Nonvolatile		
Total	4523.7	263.89

Water from the upper 700 feet of the wells is highly mineralized and water from the outside of the inner casing of one of the wells has been used at a bath house. A sample of water, number 491, from outside the inner casing of a city well or possibly from a well 700 feet deep, had a mineral content of 4523 of which 3690 parts were sodium chloride. A complete analysis of the sample is given on page 516. An analysis made in 1906 was similar but the sample contained more of the sodium compounds and the total mineral content was 4966. A sample for sanitary analysis was collected from the outside of the inner casing of well number 4 when it was completed. The mineral content was 4650 and the chloride content was 2370, about the same as in the sample collected

---

Peru Number 3 6-6-23 49596		Peru Number 4 6-6-23 49597		Peru Number 3 11-11-23 50508	
Parts per million.		Parts per million.		Parts per million.	
0.0		0.2		0.2	
0.0		0.0		0.0	
9.0		9.7		14.2	
1.5		0.9		2.2	
5.5		1.3		3.6	
51.1		56.4		48.4	
22.2		22.8		22.1	
		1.1		1.7	
774.7		192.2		510.4	
113.3		75.8		19.6	
60.6		89.8		71.7	
1.1		3.0		1.4	
1088.		267.		700.	
378.		308.		324.	
2267.		824.		1630.	
Parts per million.	Grains per gallon.	Parts per million.	Grains per gallon.	Parts per million.	Grains per gallon.
1.7	0.10	4.8	0.28	2.3	.13
214.7	12.53	140.9	8.23	33.6	2.08
1635.2	94.91	329.6	19.27	1126.2	65.58
69.5	5.22	132.7	7.75	160.9	9.38
244.8	14.29	44.9	2.62	76.4	4.45
3.5	0.20	3.0	0.17	4.7	.27
76.7	4.48	79.1	4.62	76.5	4.46
127.5	7.45	140.9	8.23	120.8	7.04
		0.3	0.02	0.3	.01
5.5	0.32	1.3	0.07	3.6	.21
9.0	0.52	9.7	0.56	14.2	.83
1.5	0.08	0.9	0.05	2.2	.13
2399.6	140.10	888.1	51.87	1621.7	94.57

in 1896 from a similar source.

The water secured from inside the well casings, when casings are in good condition, is from below a depth of about 990 feet and is less highly mineralized than the water from strata at a depth of 700 feet and less. With deterioration of the casings the waters show less differences. A sample, number 49597, collected from well number 4, on June 6, 1923, was one of the least highly mineralized samples that has been collected. The mineral content was 888, the total hardness 375, and the content of iron 0.2 parts per million as shown by the analysis. The air lift was not operating when this sample was collected.

When operating air lifts the discharge from a well is much greater than the free flow and a much smaller part of the total discharge may be of water from the upper strata which gains access to the well. Sample number 49596 was collected from well number 3 when the air lift was not operating and sample number 50508 was collected from the same well when the air lift had operated for five hours. A considerable reduction is shown in the content of sodium, postassium, and chloride. The water flowing from well number 2 is the same as that which flows from well number 3 as shown by analyses made in 1923. Operating the air lift for five hours affected a reduction in mineral content similar to that shown from well number 3. Water secured after operating air lift for five hours was of about the same quality as water from well number 4, as shown by analysis 49597.

Feed water heaters are in use at the pumping station and water is treated with boiler compounds. Comparatively little trouble is experienced due to scale. The principal trouble at the station is due to the action of water on steam and hot water lines. Incrustation apparently takes place on the inside of the water meter at the station accounting for the over-registration at the time of visit. About 120 meters on service connections are repaired annually. A standpipe installed in 1891 was in use until 1923. Due to deterioration of the upper part an over-flow was provided ten feet below the top after the standpipe had been in use for about 22 years.

PETERSBURG (2432). Petersburg is located in the central part of Menard County on the drainage area of Sangamon River. Some private wells from 25 to 75 feet deep are in use.

A public water supply was installed by the city in 1878. Water was secured from ten 4-inch wells, each about 60 feet deep. These were abandoned after about twenty years use and water has since

been secured from a dug well. Water is pumped from the well into the distribution system by either of two Worthington 10 and 16 by 8½ by 10-inch tandem compound duplex steam pumps. An elevated tank 30 feet in diameter and 35 feet high on a stone tower 21 feet high is connected to the mains. A Buffalo 12 by 7 by 10-inch duplex steam pump is used to pump water from the river for railroad use and for street sprinkling. Steam is supplied by two 45-horsepower fire tube boilers. Four hundred service connections were in use in 1924. Rates (for three months?) are $1.50 for the first 4500 gallons, 25 cents per 1000 gallons for the next 30,000 gallons, and 20 cents per 1000 gallons for the next 100,000 gallons. Ten per cent is added if payment is not prompt.

Water is secured from a well 25 feet in diameter and 44 feet deep located about four blocks east of the public square on the bank of Sangamon River. The well penetrates about 8 feet of loam and below the loam it is in sand and gravel. It is lined with a brick wall 27 inches thick. The water level in the well varies with the stage of the river and at low water is about six feet above the bottom of the well. At one time a dam was built in the river to raise the water level but the dam was washed out. The amount of water pumped in the summer of 1924 was probably more than 100,000 gallons a day.

The water had a mineral content of 712, a total hardness of 531, and a content of iron of 0.6 parts per million as shown by the analysis of sample number 51807, collected on July 11, 1924, at a tap in the pumping station.

Analysis of Sample Number 51807 from the City Supply.

Determinations Made.	Parts per million.
Iron Fe	0.6
Manganese Mn	0.0
Silica SiO_2	14.4
Nonvolatile	7.9
Alumina Al_2O_3	7.2
Calcium Ca	126.5
Magnesium Mg	52.4
Ammonia NH_4	0.2
Sodium Na	29.1
Potassium K	0.4
Sulfate SO_4	195.1
Nitrate NO_3	62.0
Chloride Cl	37.0
Alkalinity Phenolphthalein	
Methyl Orange	320.0
Residue	719.0

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	10.2	.59
Sodium Nitrate $NaNO_3$	76.2	4.45
Sodium Chloride NaCl	21.6	1.26
Ammonium Chloride NH_4Cl	0.5	.03
Magnesium Chloride $MgCl_2$	31.6	1.58
Magnesium Sulfate $MgSO_4$	218.8	12.76
Calcium Sulfate $CaSO_4$	28.9	1.69
Calcium Carbonate $CaCO_3$	294.5	17.20
Iron Oxide Fe_2O_3	0.9	.05
Alumina Al_2O_3	7.2	.42
Silica SiO_2	14.4	.84
Nonvolatile	7.9	.46
Total	712.7	41.60

PIPER CITY (715). Piper City is located in the southern part of Ford County on the drainage area of Vermilion River, a tributary of Illinois River. Some private water supplies are from wells into a stratum of sand at a depth of 25 or 30 feet. Other strata of sand lie at depths of about 70 feet and 170 feet. Some wells in the village and to the northeast flow at the ground surface. The Toledo, Peoria and Western Railroad has a well dug to the upper stratum of sand and drilled 6 inches in diameter from the bottom of the dug well to a depth of 166 feet below the ground surface.

A public water supply was installed by the village in 1913-1914. Water is secured from wells into sand and gravel and is pumped from the wells into the distribution system and an elevated steel tank connected to the system by a Goulds 6½ by 8-inch single-acting triplex pump which is driven by a 20-horsepower gas engine. The elevated tank is located close to the wells and pumping station. One hundred and thirty-eight service connections were in use in May, 1922. The rate for water for three months is $1.25 and, for water in excess of 3000 gallons, 35 cents per 1000 gallons. An ordinance provided for lower rates for large quantities but at time of visit the rate given had been paid by all.

Before the water works was installed some tests were made of yield. A 6-inch well penetrating the sand stratum at a depth of about 25 feet was pumped with a pump with 5¾-inch cylinder and 36-inch stroke, operated at about 25 strokes a minute, a displacement of about 100 gallons a minute. The water level is said to have been lowered four feet. A 6-inch well was drilled, penetrating the sand and gravel stratum at a depth of 170 feet. Bailing at a rate of 30 gallons a minute lowered the water level to a depth of 70 feet and it was several hours before the well refilled. The casing was then withdrawn to the second sand stratum at a depth of 70 feet.

Water for the public supply is secured from three wells into a stratum of sand at a depth of 70 feet. They are located in the eastern part of the village. The tops of the wells are about 670 feet above sea level. They were drilled by Townsell and Park in 1913. One well is 6 inches in diameter and has a strainer eight feet long. Another well located 20 feet south of the 6-inch well is 8 inches in diameter. It is equipped with a strainer 12 feet long. This well was tested for about 15 minutes by pumping with a hand operated fire pump at a rate of about 60 gallons a minute. The water level was at the ground surface before pumping. It was lowered to a depth of 27 feet in this well and was lowered about

one foot in the well 20 feet distant. The third well is located 40 feet west and north of the 6-inch well and is 8 inches in diameter. It is equipped with a strainer 8 feet long.

A 4-inch pipe extends from the pump suction into each well. When the wells were completed the water level was at the ground surface. The elevated tank of 50,000 gallons capacity was filled in about five hours, a rate of about 165 gallons a minute, and a vacuum gauge on the suction line registered 20 feet. In May, 1922, the depth to water when not pumping was 9 feet. The capacity of the pump at the speed operated, 40 revolutions a minute, was 135 gallons a minute. Flowing wells nearby ceased to flow while pumping from the village wells.

The water had a mineral content of 462, a total hardness of 380, and a content of iron of 0.6 parts per million as shown by the analysis of sample number 38926, collected on February 6, 1918.

Analysis of Sample Number 38926 from the Village Supply.

Determinations Made.	Parts per million.
Iron Fe	0.6
Manganese Mn	0.0
Silica SiO_2	23.4
Alumina Al_2O_3	1.1
Calcium Ca	93.3
Magnesium Mg	35.8
Ammonia NH_4	3.2
Potassium K	2.1
Sodium Na	28.1
Sulfate SO_4	0.5
Nitrate NO_3	0.7
Chloride Cl	1.0
Alkalinity	
Phenolphthalein	0
Methyl Orange	416.
Residue	440.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	1.1	0.06
Potassium Chloride KCl	1.6	0.09
Potassium Sulfate K_2SO_4	2.7	0.16
Potassium Carbonate K_2CO_3	0.3	0.02
Sodium Carbonate Na_2CO_3	64.8	3.78
Ammonium Carbonate $(NH_4)_2CO_3$	8.5	0.50
Magnesium Carbonate $MgCO_3$	124.1	7.24
Calcium Carbonate $CaCO_3$	233.1	13.60
Iron Carbonate $FeCO_3$	1.2	0.07
Alumina Al_2O_3	2.1	0.12
Silica SiO_2	23.4	1.36
Total	462.9	27.00

PITTSFIELD (2129). Pittsfield is located in the central part of Pike County on the drainage area of a small tributary of Mississippi River. Many wells in use at residences are about 40 feet deep. A few into rock are 100 feet or more deep. A public water supply was installed by the city about 1888. Water was secured from wells until about the end of 1924 when a supply developed from an impounding reservoir on the drainage area of Panther Creek, close to the city, was put in service. Water from the reservoir is filtered before pumping to the city.

When the public water supply was installed a well was drilled to a depth of about 2200 feet. The water secured was very salty

and in attempts to improve the quality plugs were placed at various depths, the last at a depth of 600 feet. Little water was pumped as the supply was used principally for fire protection. In 1913 the depth to water when not pumping was reported to be about 150 feet. The well was equipped with a single-acting deep-well pump with a 3¾-inch cylinder and 36-inch stroke. The cylinder was placed at a depth of 275 feet. The yield when noted in 1913 was 30 gallons a minute. The water had a mineral content of 3482, a total hardness of 807, and a content of iron of 0.4 parts per million as shown by the analysis of sample number 39791, collected on July 20, 1918.

Analysis of Sample Number 39791 from Old City Well.

Determinations Made.	Parts per million.
Iron Fe	0.4
Manganese Mn	0.0
Silica SiO_2	19.5
Nonvolatile	2.5
Alumina Al_2O_3	2.4
Calcium Ca	185.6
Magnesium Mg	83.7
Ammonia NH_4	1.3
Potassium K } Sodium Na }	990.0
Sulfate SO_4	659.8
Nitrate NO_3	17.7
Chloride Cl	1368.0
Alkalinity	
Phenolphthalein	0
Methyl Orange	276.
Residue	3518.5

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Sodium Nitrate $NaNO_3$	2.4	.14
Sodium Chloride NaCl	2255.0	131.53
Sodium Sulfate Na_2SO_4	290.9	16.97
Ammonium Sulfate $(NH_4)_2SO_4$	0.5	.03
Magnesium Sulfate $MgSO_4$	413.4	24.11
Calcium Sulfate $CaSO_4$	183.5	10.70
Calcium Carbonate $CaCO_3$	313.1	18.26
Iron Carbonate $FeCO_3$	0.8	.05
Alumina Al_2O_3	2.4	.14
Silica SiO_2	19.5	1.14
Nonvolatile	2.5	.15
Total	3484.0	203.22

Hydrogen Sulphide was present.

A well at the M. D. King Mill has been used by the city in emergency. It is five feet in diameter to rock at a depth of thirty feet. A drilled hole two or three feet deep in rock penetrates a water bearing stratum. Demands estimated at as much as 12,000 or 14,000 gallons a day were supplied at times and this was given as the maximum capacity of the well in dry times. The water is not of good quality for use in boilers and water for the mill supply was taken from a pond when pond water was available. A well 50 feet deep located 50 feet distant from the mill well furnished no water.

Some private wells into rock are about 100 feet deep. No record of any great quantity ever having been pumped from one of these wells is available. Samples from two of these wells each contained 450 parts of dissolved mineral, of which 80 parts was

nitrate, and had a total hardness of 380. The iron content of one was 4.0 parts and that of the other was 0.7 parts per million.

Water from wells in bottom lands of Bay Creek were several times proposed as a source of public water supply. In 1895 nine test wells were drilled and tested for 48 hours during a very dry time. The time of pumping from any one well is not given. The wells penetrated 8 feet of loam and 20 feet of water bearing sand and the wells pumped were equipped with sand points 4 inches in diameter and 7 feet long. One well yielded 18 gallons a minute and the water level in another well (50 feet distant?) was lowered 3½ feet. Pumping from three wells, two of which were 17 feet apart and the third probably 50 feet distant, the yield was 30 gallons a minute. Later the city dug a well in these bottom lands 4 feet 6 inches in diameter to a depth of 23 feet 6 inches. It was in fine sand below a depth of 8 feet. The well was tested in 1921 by the Caldwell Engineering Company. When the water level was drawn down nearly to the bottom of the well the yield was at first 36 gallons a minute and after pumping continuously for 9 hours it was 30 gallons a minute. The water level before the test was 8 feet below the ground surface. It was lowered to a depth of 10 feet 9 inches in four test holes located 10 feet from the well and was not lowered in four test holes at a distance of 40 feet nor in four test holes at a distance of 120 feet. A sample of water from a well in these bottom lands had a mineral content of 293, a total hardness of 137, and a content of iron of 3.0 parts per million.

A well 835 feet deep was drilled for the city by J. C. Heflin in 1922. It is located on lot 6, block 22, original town. A record of material penetrated with part of the classification given by the State Geological Survey is as follows:

	Thickness in feet.	Depth in feet.
Surface	62	62
Lime	50	112
Shale, gray	127	239
Shale, brown	45	284
Lime, gray	58	342
Shale, Maquoketa	68	410
Lime, gray, Maquoketa	26	436
Shale, brown, Maquoketa	72	508
Rock, Kimmswick-Plattin	102	610
Sand, Kimmswick-Plattin	60	670
Gray sand, Kimmswick-Plattin	55	725
Light colored sand, Kimmswick-Plattin	32	757
Dark colored sand, Kimmswick-Plattin	23	780
Light colored sand, Kimmswick-Plattin	27	807
Light gray sand, Kimmswick-Plattin	5	812
Sandstone, St. Peter	23	835
Total depth of well		835

A stratum of 15 feet of water-bearing sand was entered at a depth of about 610 feet and the well filled to a depth of 530 feet. This water was cased off before entering St. Peter sandstone. Water was struck in St. Peter sandstone at a depth of about 820 feet and the well filled to a depth of 700 feet. Four sizes of casing were installed, the smallest, 6 inches in diameter, extending from the the ground surface to a depth of 805 feet. The water secured had a mineral content of 4511, a total hardness of 815, and a content of iron of 2.0 parts per million as shown by the analysis of sample number 47979, collected on July 30, 1922.

Analysis, of Sample Number 47979 from City Well 835 Feet Deep.

Determinations Made.	Parts per million.
Iron Fe	2.0
Manganese Mn	0.0
Silica SiO_2	18.0
Nonvolatile	3.0
Alumina Al_2O_3	8.2
Calcium Ca	186.4
Magnesium Mg	85.4
Ammonia NH_4	1.5
Sodium Na	1311.0
Potassium K	51.3
Sulfate. SO_4	812.7
Nitrate NO_3	0.7
Chloride Cl	1940.0
Alkalinity	
Phenolphthalein	0
Methyl Orange	274.
Residue	4685.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	1.1	.06
Potassium Chloride KCl	96.9	6.07
Sodium Chloride NaCl	3121.0	182.50
Sodium Sulfate Na_2SO_4	256.4	15.00
Ammonium Sulfate $(NH_4)_2SO_4$	5.6	.33
Magnesium Sulfate $MgSO_4$	422.2	24.69
Calcium Sulfate $CaSO_4$	421.4	24.64
Calcium Carbonate $CaCO_3$	155.3	9.10
Silica SiO_2	18.0	1.05
Nonvolatile	3.0	.18
Iron Oxide Fe_2O_3	2.8	.16
Alumina Al_2O_3	8.2	.48
Total	4511.9	264.26

In some oil wells in the vicinity salty water is noted above St. Peter sandstone. In other oil wells and in a well drilled into St. Peter sandstone at the County Farm it was noted that little or no water was encountered at or above St. Peter sandstone.

After investigation of ground waters available and use for many years of highly mineralized ground water the city in 1924 installed a public water supply using water from an impounding reservoir on Panther Creek.

PLAINFIELD (1147). Plainfield is located in the northwestern part of Will County on the banks of DesPlaines River. A public water supply was installed by the village in 1898. The installation included a well equipped with a deep-well pump which discharged into the distribution system and an elevated wooden tank connected to the system. The tank was 20 feet in diameter and 24 feet deep. Later another well was drilled and equipped

with a deep-well pump and the original well was drilled deeper. The pumps are driven by electric motors. Two hundred and seventy service connections were in use in December, 1923. The meter rate for three months is $1.25 for 350 cubic feet or less and $1.50 per 1000 cubic feet for additional water.

Water for the public supply is secured from two wells. One well, now seldom used, was drilled to a depth of 104 feet when the water works was installed. It was cased to limestone at a depth of about 20 feet with 9-inch pipe and was 6 inches in diameter in limestone. In 1913 the depth to water when not pumping was said to be 18 feet. The pump clyinder was placed near the bottom of the well and the rate of pumping at the speed operated was said to be about 100 gallons a minute. Sample number 17878 was collected from this well on August 3, 1908, before the deeper well was drilled nearby.

Analysis of Sample Number 17878 from Village Well 104 Feet Deep.

Determinations Made.	Parts per million.
Silica SiO_2	19.4
Nonvolatile	4.8
Iron Oxide Fe_2O_3 } Alumina Al_2O_3 }	13.0
Calcium Ca	79.1
Magnesium Mg	64.2
Sodium Na	123.4
Sulfate SO_4	136.0
Nitrate NO_3	61.9
Chloride Cl	204.0
Alkalinity Methyl Orange	355.
Residue	968.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Sodium Nitrate $NaNO_3$	84.9	4.95
Sodium Chloride NaCl	254.8	14.87
Magnesium Chloride $MgCl_2$	66.6	3.88
Magnesium Sulfate $MgSO_4$	171.0	9.97
Magnesium Carbonate $MgCO_3$	42.2	2.46
Calcium Carbonate C_2CO_3	198.0	11.55
Iron Oxide Fe_2O_3 } Alumina Al_2O_3 }	13.0	.76
Silica SiO_2	19.4	1.13
Nonvolatile	4.8	.28
Total	854.7	49.85

A few years ago this well was drilled to a depth of 638 feet by S. H. Gray. A record of material penetrated as given by the driller with classifications by the State Geological Survey Division is as follows:

	Thickness in feet.	Depth in feet.
Gravel	21	21
Limestone, Silurian system all or chiefly Niagaran	114	135
Shale, Richmond	10	145
Limestone, Richmond	52	197
Shale, Richmond	76	273
Limestone, Galena-Platteville	347	620
Sandstone, St. Peter	15	635

The well is cased with 10-inch pipe to a depth of 44 feet and with 8-inch pipe between depths of 135 and 273 feet. The well is equipped with a deep-well pump with a 5¾-inch cylinder attached to 100 feet of drop pipe and with 40 feet of suction pipe attached

below the cylinder. Since deepening the well the water secured is turbid and the well is seldom used.

A well was drilled to a depth of 1380 feet in 1914-1915, and now furnishes nearly all of the public water supply. It is located 150 feet east of the older well. The elevation at the top is about 615 feet above sea level.

An abstract of a log on file with the State Geological Survey Division is as follows:

	Thickness in feet.	Depth in feet.
Sand, gravel	112	112
Shale, Richmond	248	360
Limestone, Galena-Platteville	175	535
	265	800
Limestone, Prairie du Chien	175	975
"Sandstone" and dolomite, Prairie du Chien	195	1170
"Sandstone", some dolomite, Prairie du Chien	132	1302

The well is cased to a depth of 60 feet and between depths of 150 and 300 feet. The well is equipped with a double-acting deep-well pump. The cylinder is attached to 130 feet of 6-inch drop pipe and 20 feet of suction pipe is attached to the cylinder. The pump is operated with a 24-inch stroke at 23 strokes a minute. When pumping from this well the water level in the old well was lowered from a depth of 30 feet to a depth of 56 feet. Measurements were made since the older well was drilled to a depth of 638 feet.

Analysis of Sample Number 50676 from the Village Well 1380 feet Deep.

Determinations Made.

	Parts per million.
Iron Fe	0.2
Manganese Mn	0.0
Silica SiO_2	10.5
Nonvolatile	3.0
Alumina Al_2O_3	1.6
Calcium Ca	59.8
Magnesium Mg	45.1
Ammonia NH_4	0.2
Sodium Na	80.2
Potassium K	25.1
Sulfate SO_4	143.6
Nitrate NO_3	8.0
Chloride Cl	49.0
Alkalinity	
Phenolphthalein	0
Methyl Orange	322.
Residue	637.

Hypothetical Combinations.

	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	12.9	0.75
Potassium Chloride KCl	38.2	2.23
Sodium Chloride NaCl	50.7	2.96
Sodium Sulfate Na_2SO_4	186.0	10.86
Ammonium Sulfate $(NH_4)_2SO_4$	0.8	0.05
Magnesium Sulfate $MgSO_4$	21.5	1.25
Magnesium Carbonate $MgCO_3$	141.2	8.24
Calcium Carbonate $CaCO_3$	149.4	8.73
Iron Oxide Fe_2O_3	0.3	0.02
Alumina Al_2O_3	1.6	0.09
Silica SiO_2	10.5	0.61
Nonvolatile	3.0	0.17
Total	616.1	35.96

The temperature of water from the well 1380 feet deep at a tap in the pumping station was 54 degrees Fahrenheit. The water had a slight odor of hydrogen sulphide. It had a mineral content of

616, a total hardness of 335, and a content of iron of 0.2 parts per million as shown by the analysis of sample number 50676, collected on December 5, 1923, at the pumping station.

PLANO (1473). Plano is located in the northwestern part of Kendall County on Big Rock Creek, a tributary of Fox River. A public water supply was installed by Mr. Stewart in 1891 and was given to the city. Water was secured from a well located in the Stewart Mill. In 1917 the equipment included the original well which had been deepened, two Blake duplex pumps of 150 gallons capacity each, and a four-inch two-stage centrifugal pump. The Blake pumps are belted to a shaft which is driven by water power when it is available and by gas engine at other times. The centrifugal pump is driven by a 15-horsepower electric motor. Water pumped by the centrifugal pump passes through a meter. An elevated steel tank of 80,000 gallons capacity is connected to the mains.

Water for the public supply is secured from a well in gravel located in the eastern part of the city near the bank of Rig Rock Creek. It was dug 10 feet in diameter to a depth of 14 feet and in 1916 the depth was increased slightly to 18 feet from the top of the well curbing which is two or three feet above the floor level. When visited in September, 1917, water stood ten feet deep in the well. With long continued pumping the water level was said to be lowered a little more than four feet.

The water had a mineral content of 349 and a total hardness of 297 parts per million as shown by the analysis of sample number 38019, collected on September 10, 1917, at the pumping station.

Analysis of Sample Number 38019 from the City Supply.

Determinations Made.	Parts per million.
Silica SiO_2	13.5
Nonvolatile	1.1
Alumina Al_2O_3	6.3
Calcium Ca	66.6
Magnesium Mg	32.0
Ammonia NH_4	0.1
Sodium Na	10.2
Potassium K	2.8
Sulfate SO_4	30.6
Nitrate NO_3	8.8
Chloride Cl	3.0
Alkalinity	
Phenolphthalein	0
Methyl Orange	286.
Residue	375.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	7.27	.43
Sodium Nitrate $NaNO_3$	21.33	1.25
Sodium Chloride NaCl	4.87	.29
Sodium Sulfate Na_2SO_4	7.50	.44
Ammonium Sulfate $(NH_4)_2SO_4$	0.29	.02
Magnesium Sulfate $MgSO_4$	31.64	1.85
Magnesium Carbonate $MgCO_3$	88.51	5.17
Calcium Carbonate $CaCO_3$	166.20	9.72
Alumina Al_2O_3	6.30	.37
Silica SiO_2	13.50	.79
Nonvolatile	1.10	.06
Total	348.51	20.39

POLO (1867). Polo is located in the southwestern part of Ogle County on the drainage area of Rock River. A public water supply was installed by the city in 1891. A well was drilled in the southern part of the city to a depth of 1500 feet and was abandoned after tools were lost in the well. A well was then drilled in the northern part of the city. Water was pumped from the well into a reservoir from which it was pumped into the distribution system. Later another reservoir was built and a second well was drilled. One well is equipped with a Deane steam-head deep-well pump and the other is equipped with an air lift. Air is supplied by a Sullivan 10 by 10-inch compressor which is driven by a 50-horsepower Y-type oil engine. Water is discharged into the reservoirs. One reservoir is 25 feet in diameter and 7 feet deep and the other is 34 feet in diameter and 7 feet deep. Water is pumped from the reservoirs by either of two Deane duplex steam pumps, one 12 by 8½ by 10-inch and the other 12 by 7½ by 10-inch. An elevated steel tank of 30,000 gallons capacity on a brick tower 80 feet high is connected to the mains. Nearly all people in the city use water from the public supply. The consumption in 1920 was estimated at 240,000 gallons a day. The meter charge was 30 cents per 1000 gallons with a minimum charge of $1.50 in six months.

Water for the public supply is secured from two wells located in the northern part of the city. The elevation at the tops of the wells is about 830 feet above sea level. One well was drilled by the J. P. Miller Artesian Well Company of Chicago in 1891, to a depth of 2098 feet. A record of material sent by the city shows that St. Peter sandstone was penetrated between depths of 430 and 615 feet and that Cambrian sandstone was entered at a depth of 1015 feet. A large part of the water secured was thought to come from between depths of 1500 and 1600 feet. The drillers noted that rock was entered at a depth of 37 feet and that 42 feet 9 inches of 10-inch casing was placed. The diameter of the well was reduced from 6¼ to 5¼ inches at depth of 605 feet.

This well is equipped with a steam-head deep-well pump with a 5¾-inch water cylinder and 24-inch stroke. When the well was drilled water raised to within 70 feet of the top. In 1914 and in 1920 it was reported to be at a depth of 114 feet. In 1920 the pump cylinder was at a depth of 154 feet and the pump was operated 30 strokes a minute, a displacement of 80 gallons a minute. Water. had been drawn down to the pump cylinder and 30 feet of suction pipe had been attached to the cylinder. In October, 1920, the pump was operated about ten hours a day.

Well number 2 was drilled in 1901 to a depth of 1200 feet, to the bottom of the upper stratum of sandstone in the Cambrian system. It is located about 50 feet distant from well number 1. It is cased with 15-inch pipe to a depth of 200 feet and is 8 inches in diameter below the casing. In 1914 it was said that the water level when not pumping was at a depth of 114 feet, that the water level could be drawn down to the pump cylinder at a depth of 175 feet in a short time, and that neither well would supply more than 160 gallons a minute. In 1920 a pump cylinder was at a depth of 200 feet, the discharge (pump displacement at the speed operated?) was said to be 159 gallons a minute, and the depth to water when pumping was 175 gallons a minute as measured by a float on a string. The pump was operated about 20 hours a day. The well was equipped with air lift in 1924. The nozzle is at a depth of 376 feet. The yield is said to be 200 gallons a minute.

Water from the well 2098 feet deep had a mineral content of 350, a total hardness of 310, and. a content of iron of 0.3 parts per million as shown by the analysis of sample number 43974, collected on October 6, 1920.

Analysis of Sample Number 43974 from the City Well 2098 Feet Deep.

Determinations Made.	Parts per million.
Iron Fe	0.3
Manganese Mn	0.0
Silica SiO_2	15.7
Nonvolatile	1.5
Alumina Al_2O_3	2.1
Calcium Ca	60.7
Magnesium Mg	38.5
Ammonia NH_4	1.5
Potassium K, Sodium Na	14.3
Sulfate SO_4	18.3
Nitrate NO_3	2.1
Chloride Cl	3.0
Alkalinity	
Phenolphthalein	0
Methyl Orange	314.
Residue	357.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Sodium Nitrate $NaNO_3$	2.9	.17
Sodium Chloride NaCl	5.0	.29
Sodium Sulfate Na_2SO_4	27.1	1.58
Sodium Carbonate Na_2CO_3	6.5	.38
Ammonium Carbonate $(NH_4)_2CO_3$	4.1	.24
Magnesium Carbonate $MgCO_3$	133.1	77.78
Calcium Carbonate $CaCO_3$	151.7	8.87
Silica SiO_2	15.7	.92
Nonvolatile	1.5	.09
Iron Oxide Fe_2O_3	0.5	.03
Alumina Al_2O_3	2.1	.12
Total	350.2	20.47

A sample of water collected in 1913 from the city supply, from both wells, was of practically the same quality. Water from the supply for use in boilers at the pumping station is passed through two heaters and treated with boiler compound. Two boilers installed in 1891 were in use in 1920 and in one the flues had not been replaced.

POPLAR GROVE (316). Poplar Grove is located in the central part of Boone County on the drainage area of Kishwaukee River, a tributary of Rock River. Some private wells are only a few feet deep and others, into sand and gravel, are more than 100 feet deep. A few wells more than 100 feet deep have been in use at plants using large quantities of water. The yield of a well 6 inches in diameter and 110 feet deep was reported to be 100 gallons a minute and an 8-inch well 125 feet deep was pumped at a rate of 50 gallons a minute.

A public water supply was installed by the village in 1915. Water is secured from a well equipped with a deep-well pump which discharges into the distribution system and a steel pressure tank connected to the system. The pump is driven through gears by a 9-horsepower electric motor. The tank is 8 feet in diameter and 36 feet long. A small air compressor is driven by a 7-horsepow,er electric motor. Electric current is purchased from the Illinois Northern Utilities Company.

Analysis of Sample Number 40945 from the Village Supply.

Determinations Made.	Parts per million.
Iron Fe	0.3
Silica SiO_2	10.9
Nonvolatile	2.1
Alumina Al_2O_3	19.4
Calcium Ca	78.3
Magnesium Mg	39.6
Ammonia NH_4	0.0
Sodium Na	3.1
Sulfate SO_4	60.2
Nitrate NO_3	2.5
Chloride Cl	7.0
Alkalinity Methyl Orange	290.0
Residue	387.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Sodium Nitrate $NaNO_3$	3.4	.20
Sodium Chloride NaCl	5.6	.33
Magnesium Chloride MgCl	4.7	.28
Magnesium Sulfate $MgSO_4$	75.4	4.41
Magnesium Carbonate $MgCO_3$	80.0	4.68
Calcium Carbonate $CaCO_3$	195.4	11.44
Iron Carbonate $FeCO_3$	0.6	.35
Alumina Al_2O_3	19.4	1.14
Silica SiO_2	10.9	.64
Nonvolatile	2.1	.12
Total	397.6	23.57

Water is secured from a well drilled in 1915 by Andrew Warren of Poplar Grove. The ground surface at the well is about 890 feet above sea level. The well was drilled into sand and gravel at a depth of 130 feet and was cased with 6-inch pipe. On account of sand entering the well a 4-inch screen 4½ feet long was placed below and sealed to the casing. The well was drilled in the bottom of a dug well and the dug well was then filled to the floor of the pumping station which is about 11 feet below the ground surface. The water level in 1919 was thought to be about four feet below the floor level. The well is equipped with a deep-well pump with a 3-inch cylinder and 24-inch stroke. In 1919 the cylinder was thought

to be at a depth of 60 feet and the displacement of the pump at the speed operated was 22 gallons a minute. The pump was operated less than two hours a day.

The water had a mineral content of 397, a total hardness of 357, and a content of iron of 0.3 parts per million, as shown by the anaylsis of sample number 40945, collected on April 15, 1919.

PRINCETON (4126). Princeton is located in the central part of Bureau County on the drainage area of Bureau Creek, a tributary of Illinois River. A public water supply was installed by the city in 1886. Water was secured from a deep well into rock which has since been abandoned. Water is now secured from two wells into sand and gravel. Each is equipped with an American multiple-stage vertical centrifugal pump, driven by an electric motor. Water is discharged into a reservoir which is 33 feet in diameter and 20 feet deep. Water is pumped from the reservoir by either of two pumps. One is an American centrifugal of 500 gallons a minute capacity against a head of 140 feet. It is driven by a steam turbine. The other is a tandem compound duplex steam pump which will be removed in 1925 when two other American centrifugals will be installed. An elevated steel tank 14 feet in diameter and 48 feet high, on a brick tower 80 feet high, is connected to the distribution system. The water works plant is operated in connection with a municiple electric plant.

Fifteen hundred and eighty service connections were in use in April, 1925. The minimum rate for three months is $1.00 which allows the use of 50 cubic feet and the rate for additional water is 25 cents per 100 cubic feet. A penalty of ten per cent is added after ten days.

The wells in use and wells which have been used are located near the center of the city. The elevation at the tops of the wells is about 700 feet above sea level.

A record of material penetrated by well number 1, with classifications by the State Geological Survey Division, is as follows:

	Thickness in feet.	Depth in feet.
Soil and clay	47	47
Sand	10	57
Gravel	93	150
Hardpan	25	175
Sand and gravel	197	372
Shale	75	447
Limestone	208	655
Slate, Maquoketa	5	660
Limestone, Maquoketa	377	1037
Slate, Maquoketa	13	1050

	Thickness in feet.	Depth in feet.
Limestone, Galena	245	1295
Slate, Decorah	10	1305
Limestone, Platteville	216	1521
Sandstone, St. Peter	149	1670
Slate, Shakopee	10	1680
Limestone, Shakopee	170	1850
Sandstone, New Richmond	125	1975
Limestone, Oneota	117	2092

The capacity of this well was given by Leverett as 320 gallons a minute. In 1914 this well, equipped with an air lift with about 400 feet of 1½-inch air pipe, and well number 2 together yielded 300 gallons a minute. In 1918 the yield of this well alone was less than 75 gallons a minute, and the well has since been abandoned.

Well number 2 was drilled by the J. P. Miller Artesian Well Company in 1888. The depth was 2515 feet. The well was cased with 376 feet of 8-inch casing and 221 feet of 6¼-inch casing with the bottom at a depth of 587 feet. The well was recased with 6-inch and 4-inch pipe. When the well was drilled water raised to 60 feet below the ground surface. In 1914 when the well was equipped with air lift with 1¼-inch air pipe extending to a depth of about 400 feet the yield of this well and one other well was about 300 gallons a minute. The water level when not pumping was at a depth of 140 feet. In 1918 the yield of this well was 75 gallons a minute. It was very seldom used and in 1919 it was abandoned. In 1920 the depth to water was 115 feet.

Water from well number 1 had a mineral content of 459, a total hardness of 204, and a content of iron of 0.2 parts per million, as shown by the analysis of sample number 22861, collected on January 8, 1912.

Analysis of Sample Number 22861 from Well Number 1.

Determinations Made.	Parts per million.
Iron Fe	0.2
Silica SiO_2	10.4
Alumina Al_2O_3	1.8
Calcium Ca	48.3
Magnesium Mg	20.3
Ammonia NH_4	1.0
Potassium K	17.7
Sodium Na	88.7
Sulfate SO_4	42.2
Nitrate NO_3	1.6
Nitrite NO_2	0.3
Chloride Cl	55.0
Alkalinity Methyl Orange	290.
Residue	483.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrite KNO_2	0.6	.03
Potassium Nitrate KNO_3	2.6	.15
Potassium Chloride KCl	25.5	1.49
Sodium Chloride NaCl	70.8	4.13
Sodium Sulfate Na_2SO_4	62.5	3.65
Sodium Carbonate Na_2CO_3	93.2	5.43
Ammonium Carbonate $(NH_4)_2CO_3$	0.3	.06
Magnesium Carbonate $MgCO_3$	70.3	4.10
Calcium Carbonate $CaCO_3$	120.6	7.03
Iron Carbonate $FeCO_3$	0.2	.01
Alumina Al_2O_3	1.8	.10
Silica SiO_2	10.4	.61
Total	458.8	26.79

A sample collected from-well number 2 on the same date was harder, containing 25 parts of magnesium and 60 parts of calcium. It contained slightly less of other minerals than did the sample from well number 1 and the total mineral content was 428.

Water is now secured from two wells into sand and gravel, wells number 3 and number 4. Well number 3 was completed in 1914. A record of material penetrated is as follows:

	Thickness in feet.	Depth in feet.
Soil and clay	35	35
Sand	2	37
Clay	23	60
Clay and hardpan	115	175
Sand	70	245

The well is cased with 20-inch outside diameter wrought iron pipe to a depth of 225 feet. A number 30 Johnson screen 16 inches in diameter and 20 feet long is placed below the casing. The well was equipped with an American turbine pump with the impellers at a depth of 168 feet and with 20 feet of suction pipe attached and was tested for seven and one-half days. The yield was 640 gallons a minute and the water level was lowered 5 feet. The depth to water when not pumping was 158 feet. During tests in 1919 the yield was 620 gallons a minute. In October, 1920, an average of 310,000 gallons a day was pumped from this well. In 1923 this pump was operated only at times of maximum demands.

Well number 4 was installed in 1920 by the Kelly. Well Company. It is located 50 feet distant from well number 3 and is 267 feet deep. Material penetrated is similar to that penetrated by well number 3 and is sand and gravel below a depth of 178 feet. This stratum of sand and gravel in fine at the top and coarser toward the bottom. The well is cased with concrete pipe 18 inches in diameter and 3 inches thick. A special 12-inch number 30 Johnson screen 30 feet long is placed in the bottom. The well is equipped with an American four-stage turbine pump with the bowls placed between depths of 168 and 175 feet and with 20 feet of suction pipe attached. During a test in August, 1922, the yield was 500 gallons a minute. In June, 1923, this pump was operated 467 hours and the pump in well number 3 was operated 85 hours. In July, 1923, when the pump had operated for 12 hours and was then idle for one hour thirty-five minutes, the water level was 162 feet below the floor level.

Mr. Remsburg, Superintendent, Water and Light Department, states that the pump in well number 4 was overhauled in February, 1925, and impellers of greater capacity were installed with the result that they obtain a constant yield of 760 gallons a

minute with a drawdown of 21 feet. The level when not pumping is 162 feet below the floor of the pumping station. The yield of the two wells is 1320 gallons a minute.

The temperature of water from well number four on July 30, 1923, was 53 degrees Fahrenheit. The water had a mineral content of 343, a total hardness of 223, and a content of iron of 2.5 parts per million as shown by the analysis of sample number 49831, collected on July 31, 1923.

Analysis of Sample Number 49831 from Well Number 4.

Determinations Made.	Parts per million.
Iron Fe	2.5
Manganese Mn	0.0
Silica SiO_2	12.8
Nonvolatile	1.0
Alumina Al_2O_3	1.6
Calcium Ca	52.3
Magnesium Mg	22.5
Ammonia NH_4	5.7
Potassium K	7.5
Sodium Na	37.1
Sulfate SO_4	1.3
Nitrate NO_3	2.3
Chloride Cl	7.0
Alkalinity	
Phenolnhthalein	0
Methyl Orange	314.
Residue	352.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	3.7	0.21
Potassium Chloride KCl	11.5	0.67
Sodium Chloride NaCl	2.4	0.14
Sodium Sulfate Na_2SO_4	1.9	0.11
Sodium Carbonate Na_2CO_3	81.8	4.78
Ammonium Carbonate $(NH_4)_2CO_3$	15.1	0.88
Magnesium Carbonate $MgCO_3$	77.8	4.54
Calcium Carbonate $CaCO_3$	130.5	7.62
Iron Oxide Fe_2O_3	3.6	0.21
Alumina Al_2O_3	1.6	0.09
Silica SiO_2	12.8	0.75
Nonvolatile	1.0	0.06
Total	343.7	20.06

Some complaints are made of trouble due to the iron content of the water. Tests made in 1924 showed uniform results of one part per million of iron.

PRINCEVILLE (1035). Princeville is located in the northern part of Peoria County on the drainage area of Spoon River, a tributary of Illinois River. A public water supply was installed by the village in 1914. Water is secured from a well drilleed by the Sewell Well Company of St. Louis, Missouri, in 1914. It is located near the center of the village. A record of material penetrated, on file with the State Geological Survey Division, shows that St. Peter sandstone was entered below a depth of 1500 feet. The well is 1600 feet deep. It is cased with 10-inch pipe to a depth of 370 feet and with 6-inch pipe between depths of 370 and 841 feet. It is cased to a depth of 1380 feet. Water is pumped from the well into the distribution system and an elevated tank connected to the system by a Kepstone Driller Company deep-well pump which is driven by a 20-horsepower electric motor. In 1921 it was said that the pump

was at a depth of 214 feet, the depth to water when not pumping was 144 feet, and the pump discharge was 165 gallons a minute.

The water had a mineral content of 1634, a total hardness of 394, and a content of iron of 1.4 parts per million as shown by the analysis of sample number 37916, collected on August 28, 1917.

Analysis of Sample Number 37916 from the Village Supply.

Determinations Made.	Parts per million.
Iron Fe	1.4
Silica SiO_2	10.4
Alumina Al_2O_3	7.2
Calcium Ca	95.1
Magnesium Mg	38.2
Ammonia NH_4	2.0
Sodium Na	406.5
Sulfate SO_4	721.7
Chloride Cl	210.0
Alkalinity Methyl Orange	220.
Residue	1645.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Sodium Chloride NaCl	346.5	20.18
Sodium Sulfate Na_2SO_4	832.6	48.56
Ammonium Sulfate $(NH_4)_2SO_4$	7.3	.43
Magnesium Sulfate $MgSO_4$	188.8	11.02
Calcium Sulfate $CaSO_4$	4.5	.26
Calcium Carbonate $CaCO_3$	234.5	13.68
Iron Oxide Fe_2O_3	2.0	.12
Alumina Al_2O_3	7.2	.42
Silica SiO_2	10.4	.61
Nonvolatile	1.0	.06
Total	1634.8	95.34

PROPHETSTOWN (1159). Prophetstown is located in the southern part of Whiteside County on the south bank of Rock River. A public water supply was installed by the village in 1904. Water was secured from a well near the bank of Rock River and later another well was dug. Water is pumped from the wells directly into the distribution system by either of two Goulds 7 by 8-inch triplex pumps. An elevated steel tank of 63,000 gallons capacity, located on high ground about 100 feet distant from the pumping station, is connected to the system. The pumps are placed in a pit about 5 feet deep and suction pipe extend to within a foot of the bottoms of the wells. The pump generally used is driven by belt from a shaft which is turned by an electric motor equipped with automatic control regulated by the height of water in the tank. The other pump is driven by a gas engine. Electric current is purchased from the Illinois Northern Utilities Company.

About 245 service connections were in use in 1924 and more than half were metered. The meter rate for the first 10,000 gallons is 30 cents per 1000 gallons and for water in excess of 70,000 gallons it is 7 cents per 1000 gallons. The minimum charge is 50 cents a month. Bills are not subject to discount.

Water is secured from two wells located 60 feet apart, 200 feet distant from the south bank of Rock River. Earth is banked around the wells to protect them from overflow by flood. One well is 8 feet in diameter and 16 feet deep below the ground surface. The

other is 16 feet in diameter and 16 feet deep. The wells are dug through four feet of soil and clay into coarse sand and gravel. Six or eight yards of gravel have been placed in the bottom of each well to prevent fine sand being drawn into the pumps. The water level in the wells varies with the water level in the river. In 1916 it generally stood from six to eight feet below the ground surface when not pumping. In dry weather with long continued pumping it was drawn down to the bottoms of the suctions pipes. When pumping with the two pumps with a combined capacity of 330 gallons a minute it was possible on many occasions to pump the water down to the bottoms of the suction pipes in from one to one and one-half hours. The amount of water pumped during the year 1923 probably averaged near 185,000 gallons a day.

The water had a mineral content of 316, a total hardness of 250, and a content of iron of 0.1 parts per million as shown by the analysis of sample number 36193, collected on December 28, 1916.

Analysis of Sample Number 36193 from the Village Supply.

Determinations Made.	Parts per million.	Hypothetical Combinations.	Parts per million.	Grains per gallon.
Iron Fe	0.1	Potassium Nitrate KNO_3	5.4	.31
Silica SiO_2	15.8	Sodium Nitrate $NaNO_3$	1.5	.09
Alumina Al_2O_3	2.4	Sodium Chloride NaCl	8.3	.48
Calcium Ca	66.1	Sodium Sulfate Na_2SO_4	37.9	2.21
Magnesium Mg	20.7	Magnesium Sulfate $MgSO_4$	29.1	1.70
Potassium K	2.1	Magnesium Carbonate $MgCO_2$	51.3	2.99
Sodium Na	16.0	Calcium Carbonate $CaCO_3$	165.0	9.64
Sulfate SO_4	48.8	Iron Oxide Fe_2O_3	0.1	.01
Nitrate NO_3	4.4	Alumina Al_2O_3	2.4	.14
Chloride Cl	5.0	Silica SiO_2	15.8	.92
		Total	316.8	18.48

Although this sample contained little iron, plumbing fixtures are stained by the water.

RANKIN (944). Rankin is located in the northwestern part of Vermilion County on the drainage of Iroquois River, a tributary of Kankakee River. Many private wells from 25 to 60 feet deep in clay have been in use at residences. Wells into sand at a depth of more than 100 feet have been in use at some residences and at the Lake Erie and Western Railroad shops about one mile east of the village. The wells at the shops are from 174 to 306 feet deep. An oil well on which the city had an option was drilled in 1909 near the southeastern limits of the village to a depth of 1608 feet at which depth it was abandoned.

The installation of a public water supply was begun by the village in 1916 and was completed in 1918. The installation included a well equipped with a deep-well pump, a concrete reservoir 30 feet in diameter and 10 feet deep, a Goulds 5 by 6-inch triplex pump, a Goulds 6½ by 8-inch triplex pump, a distribution system, and a steel pressure tank 8 feet in diameter and 36 feet long which is connected to the system. Each pump is driven by an electric motor equipped with automatic control. A National air compressor is driven by belt from the deep-well pump. Water from the deep-well pump is usually discharged into the concrete reservoir but may be discharged directly into the mains and pressure tank. Water is pumped from the concrete reservoir by either of the triplex pumps, the smaller pump usually being used excepting at times of fire.

One hundred and twenty-seven service connections were in use in May, 1922. Meter rates are 50 cents per 1000 gallons for the first 3000 gallons, with a minimum charge of $1.00 a month, and the lowest rate, for water in excess of 30,000 gallons, is 20 cents per 1000 gallons.

Water for the public supply is secured from a well into sand and gravel, located close to and west of the center of the village. It was drilled by Omer Kersey of Sullivan in 1916. A record of material penetrated as given by the driller is as follows:

Material	Thickness in feet	Depth in feet.
Clay	119	119
Sand	9	128
Cemented sand	13	151
Sand	6	157
Cemented sand	65	222
Sand and gravel	8	230
Cemented sand	26	256
Sand and gravel	14	270

Water from the stratum between depths of 222 and 230 feet raised to 35 feet below the ground surface. A test of yield was made at this depth with a pump placed at a depth of 50 feet. The water was quickly drawn down to the pump cylinder. The well is cased with 8-inch pipe and equipped with a number 30 Johnson screen 16 feet long. The driller states that sand near the bottom of the screen is finer than that near the top. The well was equipped for testing with a pump cylinder at a depth of 226 feet and a suction pipe extending to a depth of 249 feet. The pump was operated from the well rig. When the well had been pumped for 15 hours with only a few short stops the yield was from 60 to 70 gallons a minute and the pump was drawing air. The water level before pumping was at a depth of 50 feet.

The well is equipped with a Keystone Driller Company single-acting deep-well pump with a 5¼-inch cylinder placed at a depth of 256 feet. Operating with 24-inch stroke the pump drew air and the stroke was changed to 20-inch. In May, 1922, it was operated 30 revolutions a minute and the discharge after 14 hours continuous pumping, measured in the reservoir, was 53 gallons a minute.

The water had a mineral content of 389, a total hardness of 300, and a content of iron of 1.2 parts per million as shown by the analysis of sample number 47519, collected on May 11, 1922.

Analysis of Sample Number 47519 from the Village Supply.

Determinations Made.	Parts per million.
Iron Fe	1.2
Manganese Mn	0.0
Silica SiO_2	9.8
Nonvolatile	4.3
Alumina Al_2O_3	0.6
Calcium Ca	69.44
Magnesium Mg	31.2
Ammonia NH_4	1.5
Sodium Na	3.4
Potassium K	34.3
Sulfate SO_4	0.7
Nitrate NO_3	1.2
Chloride Cl	10.0
Alkalinity Methyl Orange	370.
Residue	382.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	2.0	0.12
Potassium Chloride KCl	4.9	0.29
Sodium Chloride NaCl	12.6	0.74
Sodium Sulfate Na_2SO_4	1.0	.06
Sodium Carbonate Na_2CO_3	66.8	3.90
Ammonium Carbonate $(NH_4)_2CO_3$	3.9	0.23
Magnesium Carbonate $MgCO_3$	108.0	6.30
Calcium Carbonate $CaCO_3$	173.5	10.11
Silica SiO_2	9.8	0.57
Nonvolatile	4.3	0.25
Alumina Al_2O_3	0.6	0.03
Iron Oxide Fe_2O_3	1.7	8.10
Total	389.1	22.70

Water from the well 308 feet deep at the railroad shops is more highly mineralized than the public supply. A sample, number 31181, collected on August 9, 1915, had a mineral content of 637, a total hardness of 440, and a content of iron of 1.6 parts per million. Samples of water from three wells, 117 feet to 125 feet deep, collected on the same date, were more highly mineralized than the water from the well 308 feet deep or the water now used for a public supply. The mineral content varied from 830 to 980, the total hardness from 556 to 608, and the iron content from 1.6 to 2.0 parts per million.

Before installing a public water supply the village took an option to secure a well drilled for oil, provided oil was not secured. The well was considered as a possible source of water supply. Material penetrated by the well to a depth of 730 feet is as follows:

	Thickness in feet.	Depth in feet.
Clay and soil	80	80
Fine gravel	97	177
Clay	33	210
Gravel and water sand	150	360

	Thickness in feet.	Depth in feet.
Slate rock	50	410
Limestone	20	430
Slate rock	40	470
Limestone	60	530
Slate rock	130	660
Limestone	30	690
Brown sand rock	40	730

The well was cased to a depth of 360 feet. A sample of water collected from this well on May 19, 1909, marked from a well 700 feet deep, was probably collected when the well was in the stratum of sandstone. The total mineral content was 1310, the total hardness was 286, and the chloride content was 470 parts per million.

RANSOM (402). Ransom is located in the southeastern part of La Salle County on the drainage area of Vermilion River, a tributary of Illinois River. A public water supply was installed by the village in 1907. The installation included a well, a deep-well pump which discharges directly into the distribution system, and an elevated steel tank which is connected to the system. The tank has a capacity of 45,000 gallons and is supported on a brick tower 32 feet high, located on ground about 25 feet higher than the ground at the well. Electric power is purchased from the Public Service Company of Northern Illinois.

The water consumption from July, 1919, to October, 1922, was estimated to average near 9000 gallons a day. The rates for water are 50 cents per 1000 gallons for the first 2000 gallons, 40 cents per 1000 gallons for the next 3000 gallons, and 30 cents per 1000 gallons for the next 5000 gallons.

Water for the public supply is secured from a well drilled by John Wormley and Charles Johnson of Seneca in 1907. It is 10 inches in diameter and 284 feet deep. The elevation at the top is about 707 feet above sea level. The well penetrates 140 feet or more of drift and is cased to a depth of 148 feet. Below drift the well penetrates soapstone and sandstone. The well is equipped with a deep-well pump with a 5¾-inch cylinder placed at a depth of 145 feet. The pump is operated with 24-inch stroke at a speed of 24-strokes a minute. The water level was at a depth of 60 feet in 1907 and at a depth of 75 feet when measured in 1920. With long continued pumping the water level was drawn down to the pump cylinder and in 1919 the pump was not operated more than four or five hours continuously. A test was once made and the discharge of the pump was 10 gallons in 10 strokes in the morning and 10 gallons in 14 strokes in the afternoon, presumably when the pump had operated continuously between times of test.

The temperature of the water from the well is 52 degrees Fahenheit. A sample of water, number 24942, collected from this supply on March 24, 1913, had a mineral content of 480, a total hardness of 145, and a content of iron of 0.3 parts per million as shown by the analysis.

Analysis of Sample Number 24942 from the Village Supply.

Determinations Made.	Parts per million.	Hypothetical Combinations.	Parts per million.	Grains per gallon.
Iron Fe	0.3	Potassium Nitrate KNO_3	3.4	.19
Silica SiO	19.2	Potassium Chloride KCl	27.1	1.57
Alumina Al_2O_3	5.0	Sodium Chloride NaCl	21.7	1.26
Calcium Ca	31.4	Sodium Sulfate Na_2SO_4	13.3	.77
Magnesium Mg	16.3	Sodium Carbonate Na_2CO_3	254.7	14.85
Ammonia NH_4	0.4	Ammonium Carbonate $(NH_4)_2CO_3$	1.0	.05
Potassium K	15.6	Magnesium Carbonate $MgCO_3$	56.5	3.28
Sodium Na	123.4	Calcium Carbonate $CaCO_3$	78.3	4.55
Sulfate SO_4	9.0	Iron Carbonate $FeCO_3$	0.6	.03
Nitrate NO_3	2.1	Alumina Al_2O_3	5.0	.29
Chloride Cl	26.0	Silica SiO_2	19.2	1.12
		Total	480.8	27.96

A partial mineral analysis of a sample collected in 1922 showed a mineral content of 504, a total hardness of 115, and no iron.

RANTOUL (1551). Rantoul is located in the northern part of Champaign County on the drainage area of Vermilion River, a tributary of Wabash River. A limited public water supply was installed by the village about 1885. The installation included a well equipped with a pump operated by windmill, an elevated tank, and a distribution system of 2-inch and 3-inch pipe. Larger wells and steam pumps were installed in 1895. A small amount of larger size mains and additional wells and equipment have been added. In 1924 four wells were in use. Two of these were equipped with steam-head deep-well pumps and each of the other two was equipped with a pump driven by an electric motor. The deep-well pumps discharge into the distribution system and an elevated wooden tank of 60,000 gallons capacity connected to the system. The amount of water pumped is registered by two meters at the station. The plant is operated in connection with a municipal electric plant. Steam is supplied by two boilers of 200-horsepower each.

About 600 service connections were in use in 1925. The largest water consumer is Chanute Aviation Field. During the last three months of 1923 an average of 121,000 gallons a day was used at the field. The rate for water for three months is 35 cents per 1000 gallons for the first 5000 gallons, 30 cents per 1000 gallons for the

next 5000 gallons, 25 cents per 1000 gallons for the next 5000 gallons, 20 cents per 1000 gallons for the next 5000 gallons, and 10 cents per 1000 gallons for all over 25,000 gallons. Bills are subject to 10 per cent discount if paid in 10 days.

Water for the public supply is secured from wells into sand and gravel. The wells are not drilled to the bottom of the sand and gravel stratum. They are located near and west of the center of the village. The ground surface at the wells is about 760 feet above sea level.

Four wells were in use in 1924. The two oldest wells are 10 inches in diameter and 120 feet deep. The bottom 60 feet is in sand and gravel and each well is equipped with a Cook screen 16 feet long. Each well is equipped with a Cook single-stroke steamhead deep-well pump with a 7 7/16-inch cylinder and 36-inch stroke. The cylinders are placed at a depth of about 80 feet. The pumps are operated at from 19 to 20 strokes a minute and are said to discharge about 120 gallons a minute. The pump in one of these two wells, the south well, was operated but little in February, 1924. The pump in the other of these two wells, located 15 feet north and 7 feet east of the south well, was operated from 18 to 20 hours a day.

The third well was drilled by John Boten, Superintendent of Water Works, in 1918. It is located 11 feet north of the south well. It is 10 inches in diameter and 141 feet deep. The well is equipped with a Cook double-stroke deep-well pump. The cylinder is 7¾ inches in diameter and is placed at a depth of 100 feet. The pump is operated with 18-inch stroke at a speed of about 30 revolutions a minute and in February, 1924, it was operated continuously. The discharge was about 200 gallons a minute.

The fourth well was drilled by Mr. Boten in 1922. It is located 34 feet north of the south well. It penetrates 60 feet of soil and clay, 20 feet of blue clay, and 62 feet of sand. Three-fourths of a sample of the sand passed through a screen with 14 meshes to the inch and one-fourth of the sample passed through a screen with 48 meshes to the inch. This well is equipped with a Cook double-stroke deep-well pump which discharges about 200 gallons a minute.

The amount of water pumped, as registered by the two meters, from February 18, 1924, to April 19, 1924, was 480,000 gallons a day. This is probably greater than the actual consumption (possibly thirty per cent greater) due to deposits in the meters. The yields of wells give above are estimates. The meters showed considerably greater yields during tests. The depth to water when not pumping in 1912 and in 1917 was reported to be 60 feet. In 1923 the depth

to water in the north well when pumping from the two closest of the other wells was 72 feet.

The water had a mineral content of 358, a total hardness of 302, and a content of iron of 2.4 parts per million as shown by the analysis of sample number 50982, collected from the well next to the south well on February 18, 1924, after the pump in the well had operated for five hours.

Analysis of Sample Number 50982 from the City Supply.

Determinations Made.	Parts per million.
Iron Fe	2.4
Manganese Mn	0.0
Silica SiO_2	17.4
Nonvolatile	1.7
Alumina Al_2O_3	1.3
Calcium Ca	61.5
Magnesium Mg	36.3
Ammonia NH_4	2.8
Potassium K	11.3
Sodium Na	11.9
Sulfate SO_4	0.1
Nitrate NO_3	1.4
Chloride Cl	1.0
Alkalinity Methyl Orange	334.
Residue	363.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	2.3	.13
Potassium Chloride KCl	2.1	.12
Potassium Sulfate K_2SO_4	0.2	.01
Potassium Carbonate K_2CO_3	16.4	.96
Ammonium Carbonate $(NH_4)_2CO_3$	7.4	.43
Sodium Carbonate Na_2CO_3	27.6	1.62
Magnesium Carbonate $MgCO_3$	125.5	7.33
Calcium Carbonate $CaCO_3$	153.5	8.96
Iron Oxide Fe_2O_3	3.4	.20
Alumina Al_2O_3	1.3	.08
Silica SiO_2	17.4	1.02
Nonvolatile	1.7	.10
Total	358.8	20.96

A hard scale forms in a feed water heater in use at the pumping station and a soft scale or sludge forms in the boilers. Staining of fixtures and laundry is caused by iron in the water.

RED BUD (1141). Red Bud is located in the northwestern part of Randolph County on the drainage area of Kaskaskia River. Shallow dug wells are in general use. A few plants using large quantities of water have wells into sandstone.

A public water supply was installed by the city in 1915. Water is pumped from a well into the distribution system and an elevated steel tank by a deep-well pump which is driven by a 20-horsepower electric motor. Forty-six service connections were in use in 1918 and the total amount of water pumped was estimated at 5000 gallons a day. Water is sold at a rate of 50 cents for the first 1000 gallons, 40 cents for the second 1000 gallons, 30 cents for the third 1000 gallons, and 20 cents per 1000 gallons for additional water.

Water for the public supply is secured from a well drilled in 1914. It is located near the center of the city to the rear of the city hall. The well is 10 inches in diameter and 294 feet deep. A record of material penetrated, secured from the city, is as follows:

	Thickness in feet.	Depth in feet.
Soil and dirt	18	18
Limestone	5	23
Hard flint	6	29
Soft slate	14	43
Hard limestone	27	70
White slate	12	82
Red rock	4	86
Limestone	5	91
Blue slate	3	94
Sandstone (small amount water)	32	126
Red rock	2	128
Limestone	23	151
Red rock	2	153
Slate	17	170
Blue slate	11	181
Limestone	7	188
Sandstone (small amount water)	11	199
Blue slate	16	215
Slate layers with lime and sandstone	21	236
Soft sandstone	4	240
Chester sandstone (water supply)	54	294

The well is cased with 10-inch pipe to a depth of 20 feet and with 8-inch pipe to a depth of 247 feet. It is equipped with a Gouds double-acting deep-well pump of about 150 gallons a minute capacity. The cylinder was first placed at a depth of 245 feet and the maximum yield was 50 gallons a minute. The cylinder was later lowered but on account of increased trouble with rods it was raised to its original position. In July, 1918, the pump was operated four hours a day and the discharge was estimated at 40 gallons a minute.

The water had a mineral content of 302, a total hardness of 223, and a content of iron of 0.3 parts per million as shown by the analysis of sample number 39787, collected in July, 1918.

Analysis of Sample Number 39787 from the City Supply.

Determinations Made.	Parts per million.
Iron Fe	0.3
Manganese Mn	0.5
Silica SiO_2	6.3
Nonvolatile	0.8
Alumina Al_2O_3	1.0
Calcium Ca	62.8
Magnesium Mg	16.3
Sodium Na	31.0
Sulfate SO_4	13.5
Nitrate NO_3	1.9
Chloride Cl	4.0
Alkalinity Methyl Orange	283.
Residue	289.

Hypothetical Combinations.	Parts per million.	Grains Per gallon.
Sodium Nitrate $NaNO_3$	2.6	.15
Sodium Chloride NaCl	6.6	.38
Sodium Sulfate Na_2SO_4	19.8	1.15
Sodium Carbonate Na_2CO_3	50.5	2.93
Magnesium Carbonate $MgCO_3$	56.3	3.27
Calcium Carbonate $CaCO_3$	156.7	9.08
Iron Carbonate $FeCO_3$	0.7	.04
Alumina Al_2O_3	1.0	.06
Silica SiO_2	6.3	.36
Nonvolatile	0.8	.05
Manganese Carbonate $MnCO_3$	1.0	.06
Total	302.3	17.53

RIVER FORREST (4358). River Forest is located in Cook County west of the city of Chicago, east of Des Plaines River. A public water supply was installed by the village in 1893. For many years the entire supply was furnished from wells. A connection has been made with Oak Park mains and some Lake Michigan water is purchased when the yield of the wells is insufficient to supply demands. In August, 1923, about 9,000.000 gallons was pumped from two wells then in use and 4,500,000 gallons was purchased from Oak Park. In the summer of 1924 nearly all water used was from the wells. One well is equipped with an air lift and the other with a deep-well pump which is driven by a 100-horsepower electric motor. Air is supplied by either of two Sullivan 14 by 8¾ by 10-inch angle compound compressors, each driven by a 40-horsepower electric motor. Water from the wells is discharged into three reservoirs, one 20 feet by 50 feet in plan and 8 feet deep, another 26 by 70 feet in plan and 11 feet deep, and the third 66 by 100 feet in plan and 13 feet deep. In 1924 a 6-inch American centrifugal pump driven by a 40-horsepower electric motor was installed to pump water from the reservoirs into the mains. Another similar unit was to be installed. Four smaller centrifugal pumps had been in use. About 1500 service connections were in use in 1924. Meter rates are 22 cents per 1000 gallons.

Water for the public supply is secured in part from wells and in part from the village of Oak Park. In 1924 two wells were in use, one 1000 feet deep and the other 2150 feet deep. A well 1000 feet deep had been abandoned and a well which was to be about 2000 feet deep was being drilled.

Water was for many years secured from two wells, each 6 inches in diameter at the bottom and 1000 feet deep. One of these wells, drilled by the J. P. Miller Artesian Well Company, of Chicago, was 12 inches in diameter to a depth of 63 feet and 9 inches in diameter between depths of 63 and 300 feet. At one time a drop pipe to which a pump was attached was lowered until it rested on the shoulder at a depth of 300 feet. Very little water could be secured until the pump was raised 12 inches when the pump again discharged the normal quantity of water, indicating that a large part of the water was from the upper 300 feet of the well. In 1915 the yield of each well was given as 160 gallons a minute. The two air compressors then in use did not furnish sufficient air to operate air lifts in both wells at one time effectively. The air compressors were operated 15 hours a day. When not pumping, water stood 50 feet below the ground surface. In 1921, with either of the two Sullivan compressors furnishing air to both wells and with 350 feet of air pipe in each

well, the two wells discharged 260 gallons a minute, 370,000 gallons a day, continuously. When demands exceeded this supply water was drawn from the Oak Park mains. In 1920 when the air lift in one well was operated the depth to water in the other well, 180 feet distant, was 97 feet. In 1922 no water could be secured from one of these wells when operating the pump in a well 1980 feet deep which had been drilled 30 feet away, and the well was abandoned.

In 1923 the well 1000 feet deep which was still in use was operated continuously. The discharge during three tests made in May and June, 1923, when pumping from this well only, averaged 150 gallons a minute and during a test on June 18 the supply was 130 gallons a minute. When operating the pump in a well 1980 feet deep, which is 150 feet distant, the air lift in this well yielded 58 gallons a minute.

A well was drilled for the city to a depth of 1980 feet by S. B. Geiger in 1921. A record of material penetrated is shown on a plat by Muir and Brooke. This, with part of classifications given by the State Geological Survey Division, is as follows:

	Thickness in feet.	Depth in feet.
Soil and clay	50	50
Gravel and sand	15	65
Limestone, dark gray, Silurian system	20	85
Limestone, white, Silurian system	35	120
Limestone, blue, very hard, Silurian system	185	305
Limestone, blue, Silurian system	85	390
Shale and clay, Richmond	185	575
Limestone, very hard, Galena-Platteville	315	890
Sandstone, soft, St. Peter	30	920
Shale, St. Peter	6	926
Sandstone, St. Peter	163	1089
Limestone, hard, Prairie du Chien	311	1400
Sandstone, Mazomanie-Dresbach, Cambrian system	280	1680
Limestone and shale, Eau Claire, Cambrian system	280	1680
Limestone, hard, Eau Claire, Cambrian system	40	1720
Limestone and shale, Eau Claire, Cambrian system	15	1735
Limestone, hard,Eau Claire, Cambrian system	98	1833
Sandstone, Eau Claire, Cambrian system	12	1845
Limestone, Eau Claire, Cambrian system	25	1870
Sandstone, Eau Claire, Cambrian system	90	1960
Limestone, Eau Claire, Cambrian system	10	1970

The well was 18 inches in diameter to a depth of 305 feet, 16½ inches in diameter between depths of 305 and 380 feet, and 10 inches in diameter at the bottom. It was cased with 18-inch pipe to a depth of 73 feet, with 12-inch pipe between depths of 380 feet and 575 feet, and with 10-inch pipe between depths of 910 and 991 feet.

This well was equipped with a Pomona pump with 14-inch cylinder and 36-inch stroke. The pump cylinder was first placed at a depth of 250 feet but as air was pumped it was lowered to a depth of 300 feet. Twenty-two feet of suction pipe was attached to

the cylinder. When installation of equipment was completed nearly all demands were supplied by this well. The yield in June, 1922, was estimated at 525 gallons a minute. In 1923 the yield had decreased and this pump and the air lift in the other well were both operating almost continuously. During two tests in June this well yielded 247 gallons a minute and 203 gallons a minute while the well 1000 feet deep at a distance of 150 feet yielded 58 gallons a minute. During other tests during the first six months of 1923 the yield of both was from 223 to 262 gallons a minute. During tests in July, August, and September, 1923, when the pumps were operated practically continuously the yield of both wells was from 203 to 205 gallons a minute. During the month of August the amount of water pumped through the meter, which equaled the yield of the two wells plus cooling water which was used at the plant and repumped, was 10,133,000 gallons.

The well formerly 1980 feet deep was drilled to a total depth of 2150 feet in 1923. Twelve-inch casing is said to have been placed between depths of 356 and 592 feet. (Apparently the old 12-inch casing was removed.) The yield in 1924 when equipped with the Pomona pump is said to have been 465 gallons a minute.

Water from the well 2150 feet deep had a mineral content of 650, a total hardness of 303, and a content of iron of 0.2 parts per million as shown by the analysis of sample number 52578, collected on October 3, 1924.

Analysis of Sample Number 52578 from the Village Well 2150 feet deep.

Determinations Made.

	Parts per million.
Iron Fe	0.2
Manganese Mn	0.0
Silica SiO_2	10.2
Nonvolatile	2.1
Alumina Al_2O_3	1.1
Calcium Ca	70.2
Magnesium Mg	31.2
Ammonia NH_4	0.3
Sodium Na	111.4
Potassium K	13.6
Sulfate SO_4	154.1
Nitrate NO_3	1.4
Chloride Cl	90.0
Alkalinity Methyl Orange	300.
Residue	636.

Hypothetical Combinations.

	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	2.3	0.13
Potassium Chloride KCl	24.1	1.41
Sodium Chloride NaCl	129.3	7.55
Sodium Sulfate Na_2SO_4	186.6	10.90
Ammonium Sulfate $(NH_4)_2SO_4$	1.0	0.06
Magnesium Sulfate $MgSO_4$	33.8	1.97
Magnesium Carbonate $MgCO_3$	84.3	4.92
Calcium Carbonate $CaCO_3$	175.3	10.24
Iron Oxide Fe_2O_3	0.3	0.02
Alumina Al_2O_3	1.1	0.06
Silica SiO_2	10.2	0.59
Nonvolatile	2.1	0.12
Total	650.4	37.97

A sample collected in 1923, when the well was 1980 feet deep, contained less minerals. The sample contained 56 parts of calcium,

39 parts of sodium, and 14 parts of chloride. The suplphate content was greater, 187 parts per million.

RIVERDALE (1166). Riverdale is located in Cook County south of the city of Chicago on the south bank of Calumet River. Few private wells are in use. Wells into Cambrian sandstone have been drilled at industrial plants in the village.

A public water supply was installed by the village in 1902. The installation included a well, a deep-well pump, a gas engine, an elevated tank, a pumping station, and a distribution system. In 1911 a reservoir was built into which water was pumped from the well and from which water was pumped into the mains by a Goulds 7 by 8-inch triplex pump. Both pumps were driven by a 20-horse-power gas engine. For some years part of the supply was purchased from Chicago and since about 1920 all water has been purchased from Chicago. The consumption is approximately 200,000 gallons a day.

Analysis of Sample Number 30853 from the Village Well.

Determinations Made.	Parts per million.
Iron Fe	0.3
Silica SiO_2	11.0
Nonvolatile	1.0
Alumina Al_2O_3	1.4
Calcium Ca	20.2
Magnesium Mg	9.0
Ammonia NH_4	0.3
Potassium K	13.2
Sodium Na	106.1
Sulfate SO_4	72.9
Nitrate NO_3	1.1
Chloride Cl	16.0
Alkalinity	
Methyl Orange	248.
Residue	418.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	1.8	.10
Potassium Chloride KCl	23.8	1.39
Sodium Chloride NaCl	7.8	.45
Sodium Sulfate Na_2SO_4	107.9	6.29
Sodium Carbonate Na_2CO_3	156.5	9.13
Ammonium Carbonate $(NH_4)_2CO_3$	0.8	.05
Magnesium Carbonate $MgCO_3$	31.2	1.82
Calcium Carbonate $CaCO_3$	50.4	2.94
Iron Carbonate $FeCO_3$	0.6	.03
Alumina Al_2O_3	1.4	.08
Silica SiO_2	11.0	.64
Nonvolatile	1.0	.06
Total	394.2	22.98

The well which furnished the public water supply for many years was located near the center of the village. It was drilled by the J. P. Miller Artesian Well Company in 1902. It is cased with 12-inch pipe to rock at a depth of 57 feet, is 10 inches in diameter below the casing to a depth of 200 feet, and 8 inches in diameter below a depth of 200 feet to the bottom of the well at a depth of 434 feet. When the well was completed in 1902 it was pumped for 46 hours at a rate of 120 gallons a minute. The depth to water in 1910 when not pumping was about 15 feet. In June, 1915, the amount of water pumped from the well was estimated at 80,000 gallons a day and when pumping continuously for 12 hours at a

rate of 140 gallons a minute the pump drew air, indicating that the water level was drawn down to the bottom of the suction pipe on the pump cylinder at a depth of 200 feet. When not pumping the depth to water was 45 feet. In November, 1921, when the well pump had not operated for three weeks or more, the water level was 32 feet below the floor of the pumping station.

Water from the well had a mineral content of 394, a total hardness of 87, and a content of iron of 0.3 parts per million as shown by the analysis of sample number 30853, collected on June 30, 1915.

This water is more highly mineralized but softer than Lake Michigan water purchased from the city of Chicago.

RIVERSIDE (2532). Riverside is located in Cook County west of the city of Chicago on the banks of Des Plaines River. A public water supply was installed by the village in 1870. Water was secured from flowing wells 600 feet deep. With decrease in yield and increase in demands other wells were drilled and equipped with pumps. Connections have been made with Brookfield and Berwyn and when the yield of the wells is insufficient or wells are under repair water can be secured from either of these municipalities. The Berwyn supply is Lake Michigan water purchased from the city of Chicago. This report was prepared before placing in service a well or wells drilled in 1924.

Two wells equipped with air lifts were in use in 1924. Air was supplied by an Ingersoll-Rand Imperial type 10, 15 and 8 by 14-inch air compressor which was driven by belt from a 100-horsepower electric motor. A 14 and 8 by 10-inch compressor driven by a 75-horsepower electric motor was available for use in emergency.

Water from the wells is discharged into a reservoir 50 by 30 feet in plan and 16 feet deep and is pumped from the reservoir into the mains and an elevated steel tank which is connected to the mains by three American 5-inch centrifugal pumps, each driven by a 25-horsepower electric motor. The tank has a capacity of 150,000 gallons and is supported on a tower 92 feet high.

Thirteen hundred service connections were in use in 1924. Water is sold at a rate of 20 cents per 1000 gallons with a minimum charge of $2.50 in three months, which allows the use of 1675 cubic feet. Charges above $2.50 are discounted 25 per cent if paid promptly.

Water for the public supply was for many years, until late in 1924, all obtained from two wells which were drilled in 1898. They

are about 65 feet apart. One well was drilled to a depth of 2200 feet and was plugged at a depth of about 2035 feet to exclude salt water. The other well, to the west, was drilled to a depth of 1980 feet.

An abstract of a log of one of the wells, on file with the State Geological Survey Division, is as follows:

	Thickness in feet.	Depth in feet.
Drift	55	55
Limestone, Silurian system all or chiefly Niagaran	300	355
Shale, Richmond	135	490
Limestone, Galena	100	590
Limestone, Platteville	235	825
Sandstone, St. Peter	95	920
Limestone, some shale and chert, Prairie du Chien	455	1375
Sandstone, Mazomanie, Cambrian system	155	1530
Sandstone, Dresbach, Cambrian system	110	1640
Shale, Eau Claire, Cambrian system	70	1710
Shale and sandstone, Eau, Claire, Cambrian system	70	1780
Sandstone, Eau Claire, Cambrian system	40	1820

Leverett, in the Illinois Glacial Lobe, published in 1899, states that when the wells were drilled they overflowed and that the water level had receded to a depth of 20 feet. In 1912 the amount of water pumped averaged near 275,000 gallons a day and the depth to water when not pumping was 70 feet. In 1913 the water level dropped to a depth of 140 feet in the east well and to 110 feet in the west well. The yield of the east well was then very small.

In 1914 the west well was reamed to 13 inches in diameter from a depth of 160 feet to a depth of 300 feet to allow the lowering of pumps. It was recased and the casing was sealed to the rock at a depth of 300 feet. The diameter between depths of 1400 and 1700 feet, as noted at time of next repair, was at least 5 inches. The depth to water, measured in July, 1914, evidently after repairs were made, when not pumping from either well for six days, was given as 109 feet. Later the water level when not pumping raised to 44 feet in this west well. The depth to water in 1920 was given as 309 feet. In 1921 and 1922 additional repairs were made. The well had partly filled below a depth of 850 feet and was cleaned out to a depth of 1740 feet. An 8-inch casing was placed from the bottom of larger casing at a depth of 300 feet to a depth of 1000 feet. A charge of 50 pounds of dynamite was placed in the bottom of the well and it is thought that the charge was exploded. The yield with the suction line of a deep-well centrifugal pump at a depth of about 300 feet was then very small. In 1922 the well was equipped with air lift with an air line of 2½-inch and 2-inch air pipe to a depth of 530 feet. During a test the well yielded 225 gallons a minute and the water level dropped from a depth of 75 feet to a depth of 325 feet.

Shortly after completion of repairs on the west well in 1914 the east well was reamed to 15 inches in diameter from a depth of 160 feet to a depth of 300 feet. It was 10 inches in diameter between depths of 300 and 750 feet, 8 inches in diameter between depths of 750 and 1000 feet, and 6 inches in diameter below a depth of 1000 feet. The 10-inch hole was cased with 8-inch pipe. Water was flowing into this well at a depth of 75 or 100 feet when the city was visited in 1913 and the same flow was noted in 1920. This well was equipped with a centrifugal pump in 1917. The entire supply was taken from this well at the time of visit in 1920. The centrifugal pump was at a depth of 275 feet with 25 feet of suction pipe attached. The pump was operated about 17 hours a day and supplied 300,000 gallons a day. The discharge of the pump was at times as much as 425 gallons a minute. Frequent repairs were necessary, due in part to action of water on the discharge pipe, water flowing through holes back into the well.

On February 23, 1921, when this pump was out of order and the west well was being repaired the depth to water in this well was 192 feet. At times when the well and equipment were in good condition the yield for a few months would be near 450 gallons a minute and the lowering of the water level was not more than twenty feet. In June, 1922, the depth of water when not pumping was 252 feet. In 1922 the well was equipped with an air lift with an air line of 2-inch and 1½-inch pipe to a depth of 496 feet. During a test the well yielded 520 gallons a minute and the water level was lowered from a depth of 250 feet to a depth of 285 feet. In the summer of 1924 this well furnished a large part of the supply and the air lift was operated from 18 to 20 hours a day.

A well was drilled by the J. P. Miller Artesian Well Company in 1923-1924 to a depth of 2047 feet. It is about 400 feet west of the nearer of the other two wells. It is 20 inches in diameter at the top and 10 inches in diameter at the bottom. The well is equipped with a Layne centrifugal pump with the bottom of a tail pipe 20 feet long at a depth of 305 feet. The yield is 1000 gallons a minute. The pump discharges into the reservoir or into the mains direct. The village can thus be supplied without any other pumping equipment.

Water from the two wells in use until 1924 is not of the same quality. Sample number 50404 was collected from the west well on October 29, 1923, and sample number 50405 was collected from the east well on the same day.

Analysis of Sample Number 50404 from the West Well.

Determinations Made.	Parts per million.
Iron Fe	1.8
Filtered	0.0
Manganese Mn	0.0
Silica SiO_2	22.4
Nonvolatile	1.6
Alumina Al_2O_3	2.5
Calcium Ca	108.44
Magnesium Mg	72.04
Ammonia NH_4	0.08
Sodium Na	42.29
Potassium K	7.08
Sulfate SO_4	298.69
Nitrate NO_3	1.59
Chloride Cl	45.0
Alkalinity Methyl Orange	322.
Residue	809.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	2.5	.14
Potassium Chloride KCl	11.6	.67
Sodium Chloride NaCl	65.0	3.79
Sodium Sulfate Na_2SO_4	51.5	3.00
Ammonium Sulfate $(NH_4)_2SO_4$	0.3	.02
Magnesium Sulfate $MgSO_4$	329.5	19.22
Magnesium Carbonate $MgCO_3$	18.2	1.06
Calcium Carbonate $CaCO_3$	286.8	16.71
Silica SiO_2	22.4	1.31
Nonvolatile	1.6	.09
Alumina Al_2O_3	2.5	.14
Iron Fe	1.8	.10
Manganese Mn	0.0	.00
Total	793.7	46.25

Analysis of Sample Number 50405 from the East Well.

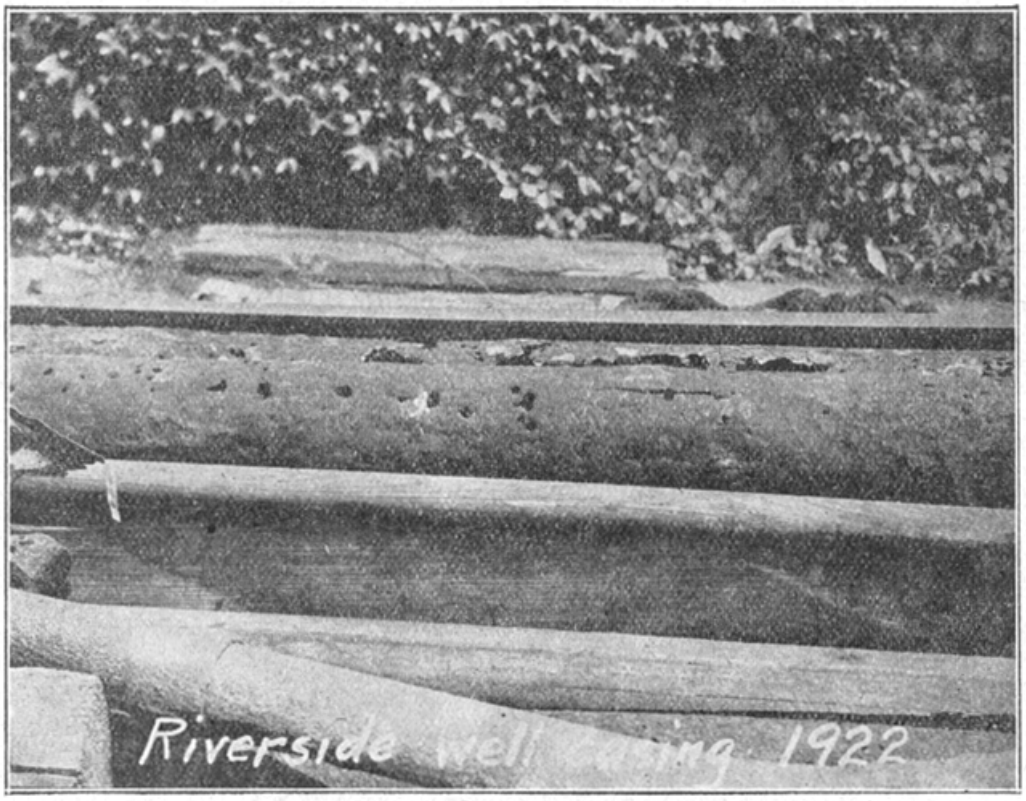
Determinations Made.	Parts per million.
Iron Fe	0.0
Manganese Mn	0.0
Silica SiO_2	16.2
Nonvolatile	1.2
Alumina Al_2O_3	2.1
Calcium Ca	44.58
Magnesium Mg	21.54
Ammonia NH_4	0.34
Sodium Na	255.59
Potassium K	26.38
Sulfate SO_4	94.51
Nitrate NO_3	0.71
Chloride Cl	290.0
Alkalinity Methyl Orange	310.
Residue	892.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	1.1	.06
Potassium Chloride KCl	49.4	2.88
Sodium Chloride NaCl	439.0	25.60
Sodium Sulfate Na_2SO_4	139.7	8.14
Sodium Carbonate Na_2CO_3	86.5	5.05
Ammonium Carbonate $(NH_4)_2CO_3$	0.8	.04
Magnesium Carbonate $MgCO_3$	74.4	4.34
Calcium Carbonate $CaCO_3$	111.4	6.50
Silica SiO_2	16.2	.94
Nonvolatile	1.2	.07
Alumina Al_2O_3	2.1	.12
Manganese Mn	0.0	.00
Total	921.8	53.74

As shown by the analyses, water from the west well contained considerably more calcium, magnesium and sulphate and less sodium and chloride than did the water from the east well. The hardness of the two samples was 566 and 200 parts per million respectively. This might be accounted for, at least in part, by the fact that the sample from the west well was collected only 10 or 15 minutes after starting the pump. Samples collected at other times, however, also showed great differences. The hardness of samples collected from the west and east wells in 1913 was 468 and 245 parts per million respectively and of samples collected in 1920 was 467 and 275 parts per million respectively. The hardness of samples collected in 1902 from the two wells was 550 and 240 parts per million. The softer

water of these two samples collected in 1902 was reported as from well number 1 and the west well is sometimes referred to as well number 1. The samples when shipped were designated only by marks on stoppers in the bottles and it may be that the sample marked number 1 was from the east well. Samples received in 1915 showed little difference.

Some water may enter the east well from depths below 2035 feet where a plug was driven. It is probable that the difference in quality and the occasional high water levels and low yields, especially of the west well are due in large part to clogging of the lower part of the wells and securing of a considerable part of the flow from upper strata. The casing has at times been in very poor condition. Below is a photograph of casing taken from the west well in 1922. This was in use for eight years.



The water stains plumbing fixtures due to the iron content. It also clogs meters and scales and corrodes pipe. Since the air lifts were installed in 1922 an incrustation forms on the brass impellers of the centrifugal pumps which pump water from the reservoir.

ROANOKE (1368). Roanoke is located in the central part of Woodford County on the drainage area of Mackinaw River. A

public water supply was installed by the village in 1913-1914. Water is secured from four wells into sand and gravel. The wells are connected to the suction of a McGowan 6 by 10-inch triplex pump which is driven by a 15-horsepower electric motor. The pump discharges into the distribution system to which an elevated steel tank of 40,000 gallons capacity is connected. Power is supplied by the Central Illinois Light and Power Company.

About 150 service connections were in use in 1924 and the average consumption was estimated at 60,000 gallons a day. The rates for water are 75 cents for the first 2000 gallons, 30 cents per 1000 gallons for the next 3000 gallons, 25 cents per 1000 gallons for the next 5000 gallons, and 15 cents per 1000 gallons for all water in excess of 10,000 gallons. Bills are not subject to a cash discount.

Water for the public supply is secured from four wells located near the business district. The tops of the wells are about 715 feet above sea level. The wells are at the corners of a square with sides 30 feet long. The material penetrated is as follows:

Black loam and clay	4 feet
Sand and gravel	8 feet
Blue clay	6 feet
Sand and gravel	12 feet

Each well is cased with 4-inch pipe to a depth of 22 feet and a Cook screen 8 feet long is placed below the casing. When the wells were drilled in 1913 water stood at a depth of four feet. Pumping one well for 48 hours at a rate of 35 gallons a minute, with one stop of 30 minutes in the early part of the test, lowered the water level in the other three wells one foot. The tops of the wells are sealed and each well is connected to the suction line of a 6 by 10-inch triplex pump which is operated at a speed of 50 revolutions a minute, a displacement of 185 gallons a minute. On December 20, 1922, when the pump had operated for four hours, drawing water from all four wells, a valve on the suction line to one well was closed and the water level in that well was 7 feet 6 inches below the ground surface. The pump was then stopped and the water level raised 27 inches in one hour and raised another inch during the next hour. The amount of water pumped in 1924 was estimated at 60,000 gallons a day.

The water had a mineral content of 617, a total hardness of 506, and a content of iron of 0.6 parts per million as shown by the analysis of sample number 48854, collected on December 20, 1922, after the pump had been operated for four hours.

Analysis of Sample Number 48854 from the Village Wells 30 Feet Deep.

Determinations Made.	Parts per million.
Iron Fe	0.6
Manganese Mn	0.0
Silica SiO_2	10.8
Nonvolatile	3.8
Alumina Al_2O_3	1.3
Calcium Ca	115.3
Magnesium Mg	53.2
Ammonia NH_4	0.4
Sodium Na	20.1
Potassium K	4.2
Sulfate SO_4	184.9
Nitrates NO_3	1.1
Chloride Cl	23.0
Alkalinity	
Methyl Orange	340.
Residue	661.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	1.7	.10
Potassium Chloride KCl	6.7	.39
Sodium Chloride NaCl	32.7	1.91
Sodium Sulfate Na_2SO_4	22.5	1.31
Ammonium Sulfate $(NH_4)_2SO_4$	1.5	.09
Magnesium Sulfate $MgSO_4$	211.2	12.33
Magnesium Carbonate $MgCO_3$	36.3	2.12
Calcium Carbonate $CaCO_3$	288.0	16.82
Silica SiO_2	10.8	.63
Nonvolatile	3.8	.22
Iron Oxide Fe_2O_3	0.9	.05
Alumina Al_2O_3	1.3	.08
Total	617.4	36.05

The sample was similar to a sample collected in 1915.

The village drilled a well years ago to a depth of 120 feet. It is northwest of the pumping station to the rear of the village hall on land 20 feet higher than wells at the pumping station. The well flows. The water had a mineral content of 468, a total hardness of 388, and a content of iron of 3.0 parts per million as shown by the analysis of sample number 48855, collected on December 20, 1922.

Analysis of Sample Number 48855 from the Village Well 120 Feet Deep.

Determinations Made.	Parts per million.
Turbidity	40.0
Residue	484.0
Iron Fe	3.0
Manganese Mn	0.0
Nitrates NO_3	0.7
Chloride Cl	3.0
Sulfate SO_4	0.0
Alkalinity	
Methyl Orange	484.0
Ammonia NH_4	5.4
Magnesium Mg	39.9
Calcium	89.8

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Calcium Carbonate $CaCO_3$	224.2	13.10
Magnesium Carbonate $MgCO_3$	138.4	8.08
Ammonium Carbonate $(NH_4)_2CO_3$	14.4	0.84
Sodium Carbonate Na_2CO_3	85.4	4.98
Sodium Chloride NaCl	5.0	0.29
Sodium Nitrate $NaNO_3$	0.9	0.05
Total	468.3	27.34

The Roanoke Mine Company uses water from a well located 100 feet south and west of the village pumping station. The well was drilled in 1903 by Mr. Husseman at an electric light plant. Three water bearing strata were encountered at depths of 100, 120, and 165 feet. The well was cased to a depth of 100 feet. The

material below was hard and may have remained open. The water is similar in quality to water from the village flowing well.

The Atchison, Topeka and Santa Fe Railway has a flowing well 110 feet deep located at the side of the tracks about 600 feet southwest of the village flowing well. Pumping from this well stops the flow from the village well.

Samples from two wells, one 97 feet deep, and the other located on the same lot, 120 feet deep, were analyzed in 1898. The waters were of the same quality. The mineral content was 537, the total hardness 390, and the content of iron 3.3 parts per million. The water was similar to the sample collected from the village flowing well.

ROBERTS (444). Roberts is located in the central part of Ford County on the drainage area of Iroquois River, a tributary of Kankakee River. A 3-inch well 216 feet deep was drilled by the village about 1890. It was equipped with a pump driven by a windmill. Water was discharged into a reservoir or cistern from which it was pumped by hand. In 1907 the well was reamed to a diameter of 4 inches and a deep-well pump, a gas engine to drive the pump, an elevated wooden tank, and a limited distribution system were installed. This well was in use until 1916. In 1916 the village purchased the plant of a creamery and installed their pumping station and municipal electric plant in the building. The creamery had one well and the village drilled another. In 1925 one of the wells was replaced by another drilled in the same place. The two wells are equipped with deep-well pumps which discharge into the distribution system to which an elevated wooden tank 18 feet in diameter and 18 feet high is connected. The pumps are driven by an oil engine which also drives a dynamo.

One hundred and twenty-five service connections were in use in 1922 and all were metered. The charge for 3000 gallons or less is $1.25 for three months and the charge for the next 3000 gallons is 45 cents per 1000 gallons.

Water for the public supply is secured from two wells located 13 feet apart. One well was drilled by Otto Steigman in 1925. It is 4½ inches in diameter and 228 feet deep. The other well was drilled by Charles Roberts in 1917. It is 4 inches in diameter and 225 feet deep. The wells pass through a sand vein at a depth of 100 feet and enter the sand from which water is secured at a depth of about 210 feet. The upper vein of sand is two feet thick in some places and six to eight feet thick in other places. The wells do not

pass through the lower vein of sand. A strainer 10 feet long made of perforated 3-inch pipe wrapped with number 60 gauze is placed in the bottom of the older well. A Cook screen ten feet long is placed in the bottom of the other well. Each well is equipped with a deep-well pump and both are operated from a walking beam. The pump cylinders are placed at the tops of the strainers. The water level in 1922 was thought to be 100 or 125 feet below the ground surface. The discharge of the two pumps in 1922 was estimated from the time required to fill the elevated tank, at 32 gallons a minute.

A sample of water was collected in 1915 from the village well then in use. The well was 216 feet deep and penetrated the same water-bearing stratum from which the public water supply is now obtained. The water had a mineral content of 653, a total hardness of 425, and a content of iron of 2.4 parts per million as shown by the analysis of sample number 30576.

Analysis of Sample Number 30576 from village Well 216 Feet Deep.

Determinations Made.	Parts per million.
Potassium K	6.8
Sodium Na	53.6
Ammonia NH_4	1.7
Magnesium Mg	37.2
Calcium Ca	109.0
Iron Fe	2.4
Alumina Al_2O_3	2.9
Nitrate NO_3	0.4
Chloride Cl	1.0
Sulfate SO_4	228.8
Silica SiO_2	14.8
Manganese Mn	0.0
Nonvolatile	3.8
Alkalinity Methyl Orange	300.
Residue	644.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	0.7	.04
Potassium Chloride KCl	2.1	.12
Potassium Sulfate K_2SO_4	12.0	.70
Sodium Sulfate Na_2SO_4	165.2	9.63
Ammonium Sulfate $(NH_4)_2SO_4$	6.2	.36
Magnesium Sulfate $MgSO_4$	133.0	7.75
Magnesium Carbonate $MgCO_3$	35.7	2.08
Calcium Carbonate $CaCO_3$	272.1	15.87
Iron Carbonate $FeCO_3$	4.8	.28
Alumina Al_2O_3	2.9	.17
Silica SiO_2	14.8	.86
Nonvolatile	3.8	.22
Total	653.3	38.08

ROBINSON (3375). Robinson is located in the central part of Crawford County eight miles east of Wabash River. A privately owned water supply was installed in 1896. Water was obtained from drilled wells from 80 to 90 feet deep located in the city, until 1910. In that year a well was dug six miles east of the city near the west limits of the village of Palestine, and the old wells were abandoned. Two more wells have since been installed. Water is pumped through an 8-inch pipe line to the city of Robinson and the village of Palestine is also supplied.

Water is pumped by either of two 4-stage Manistee Iron Works centrifugal pumps which are placed in a pit seven feet below the ground surface. Each pump is directly connected to a 75-horse-power electric motor. The total amount of water pumped is registered by a Venturi meter and the part supplied to Palestine is measured by another meter. An elevated steel tank of 75,000 gallons capacity is connected to the mains in Robinson.

One thousand and nine service connections were in use in January 1925. The rate for less than 2675 cubic feet of water in one month is 30 cents per 100 cubic feet with a minimum charge of $1.00. The lowest rate, for water in excess of 16044 cubic feet a month, is 8 cents per 100 cubic feet.

Water is secured from three wells into sand and gravel, located three miles west of Wabash River, near the west limits of the village of Palestine. The sand and gravel stratum covers a large area. One well was dug in 1910. It is 24 feet in diameter and 28 feet deep. Material penetrated is said to be 3 feet of loam and clay, 18 feet of sand, and 7 feet of gravel. The well is curbed with brick with cemented joints.

Analysis of Sample Number 53142 from the City Supply.

Determinations Made.	Parts per million.
Iron Fe	0.2
Manganese Mn	0.0
Silica SiO_2	15.2
Nonvolatile	0.8
Alumina Al_2O_3	0.8
Calcium Ca	55.3
Magnesium Mg	14.6
Ammonia NH_4	0.0
Potassium K	0.9
Sodium Na	8.0
Sulfate SO_4	25.5
Nitrate NO_3	11.5
Chloride Cl	7.0
Alkalinity	
Phenolphthalein	0
Methyl Orange	152.
Residue	211

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	2.3	.13
Sodium Nitrate $NaNO_3$	13.9	.82
Sodium Chloride NaCl	10.8	.63
Magnesium Chloride $MgCl_2$	0.7	.04
Magnesium Sulfate $MgSO_4$	32.0	1.86
Magnesium Carbonate $MgCO_3$	27.6	1.60
Calcium Carbonate $CaCO_3$	138.1	8.04
Iron Oxide Fe_2O_3	0.3	.02
Alumina Al_2O_3	0.8	.05
Silica SiO_2	15.2	.89
Nonvolatile	0.8	05
Total	242.5	14.13

Two 10-inch wells, each 50 feet deep, near the dug well, were drilled about 1916. Each is equipped with a Johnson number 30 screen 16 feet long. Suction pipes are laid six or seven feet under ground from the pumps to these wells. Water can be pumped by either pump from the dug well or from the two drilled wells. The drilled wells are generally used. Water is usually pumped at a rate of about 530 gallons a minute. At the time of visit in January, 1925, during a fire, the two pumps were operating and pumping

from the two drilled wells at a rate of 700 gallons a minute. The water level in the dug well from which water had not been pumped for two or three months was 24 feet below the ground surface. The amount of water pumped in 1924 averaged 571,000 gallons a day.

A sample of water, number 53142, collected from a tap in the pumping station on January 26, 1925, had a mineral content of 242, a total hardness of 198, and a content of iron of 0.2 parts per million as shown by the analysis.

ROCHELLE (3310). Rochelle is located in the southeastern part of Ogle County on the drainage area of Kyte River, a tributary of Rock River. A public water supply was installed by the city about 1876. Water was pumped from a stone quarry in the southwestern part of the city and the plant was used principally for fire protection. A well was drilled near the quarry in 1897 and the use of water from the quarry was discontinued. Later another well was drilled and in 1923 a third well was being drilled. The wells are equipped with air lifts. Water from one well, located near the quarry, is discharged into a concrete reservoir of 83,000 gallons capacity which surrounds the top of the well. From this reservoir water is pumped into the mains by a Deane 9 by 10-inch triplex pump which is driven by belt from a 35-horsepower electric motor with remote control from the station at the other well. The other well is located at the electric light plant and main pumping station. It is equipped with an air lift which discharges into a reservoir 50 feet by 35 feet in plan and 18 feet deep. Three pumps are available to pump from this reservoir into the mains. Two are American centrifugals of 500 gallons a minute capacity each and the other a Worthington 15 by 10 by 10-inch duplex steam pump. Air is compressed at this station by two compressors, one an Ingersoll-Rand with 12-inch steam cylinder, 12-inch air cylinder, and 14-inch stroke which is operated 90 revolutions a minute and the other a Norwalk Iron Works compressor which is operated 175 revolutions a minute. The water consumption in 1919 and in 1923 was given as about 700,000 gallons a day.

Water for the public supply is secured from two wells. One well was drilled near the stone quarry formerly used as the source of supply about 1897. The total depth was given as 1896 feet. The well was 8 inches in diameter at the top and is thought to be cased to a depth of 70 feet. This well furnished the entire supply until 1907. Its use was then discontinued until 1913 when equipment

was repaired and it has since furnished part of the supply. The well is equipped with an air lift with a 1½-inch air pipe extending to a depth of 150 feet, and a 6-inch discharge pipe. Air is discharged upward through one quarter inch pipe which are connected to the air line near the bottom. During a test in 1913 the discharge is said to have been 300 gallons a minute. The depth to water when not pumping in 1919 was 12 feet. Air is conveyed from the main station 1000 feet distant through a 2-inch air line. The air pressure at the station in 1919 was 60 pounds at start and 37 or 38 pounds during operation.

A well 1026 feet deep was drilled for the city by the J. P. Miller Artesian Well Company of Chicago in 1906. A record of material penetrated as given by the drillers with part of classifications given by the State Geological Survey Division is as follows:

	Thickness in feet.	Depth in feet.
Sand, gravel, and shelly rock	45	45
Limestone, Platteville	40	85
White sandstone, St. Peter	55	140
Dark sandstone, St. Peter	180	320
Yellow "sandstone", Prairie du Chien	65	385
Soft yellow "sandstone", Prairie du Chien	75	460
Sandy limestone, Prairie du Chien	50	510
Caving red marl, Prairie du Chien	70	580
Limestone, Prairie du Chien	20	600
Limestone and shale, Prairie du Chien	50	650
Limestone, Prairie du Chien	54	704
Sandstone, Mazomanie-Dresbach, Cambrian system	171	875
Limestone and shale, Eau Claire, Cambrian system	85	960
White sandstone, Eau Claire, Cambrian system	66	1026

The well is cased with 16-inch outside diameter pipe to a depth of 45 feet. It is 15 inches in diameter to a depth of 200 feet, 10 inches in diameter between depths of 200 and 590 feet, and 8 inches in diameter below a depth of 590 feet. Sixty-five feet of 8-inch pipe was placed with the bottom at a depth of 590 feet. The well is equipped with an air lift with 164 feet of 2-inch air pipe and 8-inch discharge pipe. In 1919 this air lift was operated 21 hours a day, the air lift in the deeper well was operated 3 hours a day, and at times of maximum consumption both wells were occasionally operated. The total amount of water supplied was estimated from operation of high service pumps at from 600,000 to 800,000 gallons a day. In 1923 the consumption was about the same and the depth to water when not pumping was 30 feet.

A sample, number 41220 collected on June 17, 1919, from the well 1896 feet deep had a mineral content of 307 and a total hardness of 300 parts per million as shown by the analysis.

Analysis of Sample Number 41220 from the Well 1896 feet Deep.

Determinations Made.	Parts per million.
Iron Oxide Fe_2O_3	0.0
Silica SiO_2	10.5
Nonvolatile	0.7
Alumina Al_2O_3	1.2
Calcium Ca	64.1
Magnesium Mg	34.2
Ammonia NH_4	.3
Potassium K, Sodium Na	4.8
Sulfate SO_4	9.0
Nitrate NO_3	1.8
Nitrite NO_2	0.0
Chloride Cl	4.0
Alkalinity Methyl Orange	310.0
Residue	364.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Sodium Nitrate $NaNO_3$	1.7	.10
Sodium Chloride NaCl.	6.4	.38
Sodium Sulfate Na_2SO_4	5.7	.33
Ammonium Sulfate $(NH_4)_2SO_4$	1.1	.07
Magnesium Sulfate $MgSO_4$	5.6	.33
Magnesium Carbonate $MgCO_3$	114.5	6.70
Calcium Carbonate $CaCO_3$	160.0	9.36
Alumina Al_2O_3	1.2	.07
Silica SiO_2	10.5	.61
Nonvolatile	0.7	.04
Total	307.5	17.99

Water from the well 1026 feet deep had a mineral content of 318, a total hardness of 277, and a content of iron of 1.0 parts per million as shown by the analysis of sample number 41221, collected on June 17, 1919.

Analysis of Sample Number 41221 from the Well 1026 Feet Deep.

Determinations Made.	Parts per million.
Iron Fe	1.0
Silica SiO_2	18.3
Alumina Al_2O_3	2.1
Calcium Ca	59.7
Magnesium Mg	31.3
Ammonia NH_4	0.1
Potassium K, Sodium Na	11.3
Sulfate SO_4	39.9
Nitrate NO_3	5.3
Nitrite NO_2	0.0
Chloride Cl	10.0
Alkalinity Methyl Orange	268.
Residue	362.0

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Sodium Nitrate $NaNO_3$	6.8	.40
Sodium Chloride NaCl.	16.4	.96
Sodium Sulfate Na_2SO_4	9.2	.54
Ammonium Sulfate $(NH_4)_2SO_4$	0.3	.02
Magnesium Sulfate $MgSO_4$	29.2	1.71
Magnesium Carbonate $MgCO_3$	87.9	5.14
Calcium Carbonate $CaCO_3$	145.6	8.52
Iron Oxide Fe_2O_3	1.4	.08
Alumina Al_2O_3	2.1	.13
Silica SiO_2	18.3	1.06
Nonvolatile	1.1	.06
Total	318.4	18.67

The average supply contains some iron and causes staining of plumbing fixtures. About 40 meters are repaired annually.

ROCK FALLS (2927). Rock Falls is located in the eastern part of Whiteside County on the south bank of Rock River, across the river from the city of Sterling. The city is furnished water by the Sterling Water Co.

ROCKDALE (1478). Rockdale is located in the northern part of Will County near the southwestern limits of the city of Joliet. Nearly all private wells in the village are into limestone which is encountered a few feet below the ground surface and are from 80 to 250 feet deep. A few wells secure water from drift above limestone and a few wells have been drilled to St. Peter and Cambrian sandstones.

A public water supply was installed by the village in 1914-1915. Water is secured from a well and is pumped directly into the mains and an elevated steel tank of 60,000 gallons capacity connected to the mains. The pump is driven by a 25-horsepower electric motor. Electric current is purchased from the Public Service Company of Northern Illinois. Fifty-three service connections were in use in 1922. Water is supplied to the American Can Company and in emergency the company can supply water to the village. The rates for water are 40 cents per 1000 gallons for less than 50,000 gallons in three months and 25 cents per 1000 gallons for additional water, with a minimum charge of 50 cents a month. Consumers located outside of the village are charged rates 10 cents higher.

Water for the public supply is secured from a well located near the center of the village. It was drilled by the Ohio Drilling Company in 1914 at a cost of $1126. A record of material penetrated is as follows:

	Thickness in feet.	Depth in feet.
. . . . .	250	250
Dolomite	230	480
Limestone	35	515
Dolomite	75	590
Sandstone, St. Peter.	70	660

Rock is entered at a depth of five feet. The well is 10 inches in diameter at the top. It is equipped with a Goulds deep-well pump with a 6½-inch double-acting cylinder and 24-inch stroke. In 1915 the cylinder was placed at a depth of 50 feet and the pump was operated 25 revolutions a minute, a displacement of 160 gallons a minute. During the test the pump was operated for 24 hours. When not pumping the water level was at a depth of 25 feet. With lowering of the water level in the well the pump cylinder was lowered first to a depth of 100 feet and, in 1921, to a depth of 200 feet. In 1922 the pump was operated 28 revolutions a minute, a displacement of 180 gallons a minute. Estimating the actual discharge at 150 gallons a minute the average amount of water pumped during the year, to September, 1922, is computed to be near 110,000 gallons a day. The depth to water when not pumping had lowered to about 100 feet.

The temperature of the water when discharged from the well in 1922 was 53 degrees Fahrenheit.

The water had a mineral content of 539, a total hardness of 464, and a content of iron of 0.4 parts per million as shown by the analysis of sample number 48327, collected on September 30, 1922.

Analysis of Sample Number 48327 from the Village Supply.

Determinations Made.	Parts per million.
Iron Fe	0.4
Manganese Mn	0.0
Silica SiO_2	15.4
Nonvolatile	1.0
Alumina Al_2O_3	1.8
Calcium Ca	94.6
Magnesium Mg	55.6
Ammonia NH_4	0.5
Sodium Na	18.2
Sulfate SO_4	111.0
Potassium K	2.8
Nitrate NO_3	1.8
Chloride Cl	11.0
Alkalinity Methyl Orange	390.0
Residue	560.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	2.8	.16
Potassium Chloride KCl	3.2	.19
Sodium Chloride NaCl	15.5	.91
Sodium Sulfate Na_2SO_4	37.2	2.18
Ammonium Sulfate $(NH_4)_2SO_4$	1.7	.10
Magnesium Sulfate $MgSO_4$	105.9	6.19
Magnesium Carbonate $MgCO_3$	118.1	6.91
Calcium Carbonate $CaCO_3$	236.3	13.82
Silica SiO_2	15.4	.90
Nonvolatile	1.0	.06
Iron Oxide Fe_2O_3	0.6	.03
Alumina Al_2O_3	1.8	.10
Total	539.5	31.55

Some hard scale is formed in service meters.

The American Steel and Wire Company has a well 950 feet deep which was drilled by W. H. Gray and Brother in 1919. The well is 9½ inches in diamater into the sandstone which was entered at a depth of 605 feet. It is cased to a depth of 100 feet and in marl below St. Peter sandstone. It is equipped with an air lift with a 1¼-inch pipe extending to a depth of 428 feet below the ground surface. During a test lasting 16 hours the air pressure was 140 pounds at the start and 101 pounds during operation. The discharge was 87 gallons a minute. The water level 1½ hours after the start was at a depth of 214 feet and at the end of the test it was at a depth of 219 feet.

In 1921 S. B. Geiger, of Chicago, drilled a well 1300 feet deep for the American Can Company. It is cased with 16-inch wrought iron pipe to a depth of 12 feet and with 10-inch wrought iron pipe to a depth of 350 feet. During an eight hour test the discharge was 300 gallons a minute. The water level before the test was at a depth of 104 feet and after the test it was at a depth of 204 feet. The water level before the test may have been affected by the operation of a well 640 feet deep which was in use until this well was drilled. On July 27, 1922, the depth to water in this well 1300 feet deep, when not pumping, was 94 feet and the depth to water in the

well 640 feet deep which had been abandoned was 70 feet. The water from the well 1300 feet deep is similar in quality to the village supply. A sample collected in 1922 had a mineral content of 592 and a total hardness of 464 parts per million.

ROCKFORD (65,651). Rockford is located in the southeastern part of Winnebago County on the banks of Rock River. A public water supply was installed by the city in 1874-1875. Information is in part from a report on enlargement and extension of the water supply and distribution system prepared in 1910 by J. W. Alvord, D. H. Maury, and D. W. Mead. Water was first secured from sand and gravel deposits. The pumping station was located near the west bank of the river north of Peach Street. The supply from sand and gravel was insufficient and for many years some water was taken from Rock River. In 1885 a well into Cambrian sandstone was drilled close to the pumping station and later additional wells were drilled nearby, some into Cambrian sandstone and others into St. Peter Sandstone. During the earlier years of the development it was necessary to use water from the river at times. In 1923 the water works plant near the bank of the river, at the site of the original water works, and the wells near by were abandoned and the principal supply is now secured from a plant installed in the western part of the city. The pumping station is located at Cedar and Fay Streets and water is secured from four wells. Water is pumped from the wells into a concrete reservoir by air lifts. Air is supplied by two compressors, one a Worthington two-stage cross-compound with 17 and 32-inch steam cylinders, 29 and 17-inch air cylinders and 30-inch stroke and the other, formerly used at the old station, an Ingersoll-Rand compound with 13 and 26-inch steam cylinders, 23 and 14-inch air cylinders, and 20-inch stroke. Water is discharged into a reservoir 215 feet by 197 feet in plan and 17 feet deep, of 5,000,000 gallons capacity. Water is pumped from the reservoir into the mains by either of two pumps, one a Worthington 23 and 54 by 23¼ by 36-inch cross-compound of 15,000,000 gallons a day capacity and the other a Worthington of 10,000,000 gallons capacity which was moved from the old station by the river.

At times of maximum demands water is also pumped from two wells equipped with electrically driven turbine pumps which discharge directly into the distribution system. One is located in the northern part and the other in the southern part of the city.

During 1923 the average number of service connections in use was 14,500 of which about 12,600 were metered. The water con-

sumption averaged 5,000,000 gallons a day. The rate for water is $1.25 for 600 cubic feet or less and 7 cents per 100 cubic feet for additional water.

When the water works was installed water was secured from an infiltration well located near the west bank of Rock River north of Peach Street at the site of several springs. Tile were laid in gravel to a well 23 feet in diameter and the water passed upward through filtering material placed in the well into a chamber connected to a pumping pit. A connection was made with Rock River and at times when the supply from the well was insufficient water was pumped from the river.

Another well was dug in 1881 or 1882, one hundred and thirty feet distant from the original well. This well was 50 feet in diameter and 38 feet deep with a 12-foot shaft in the center with an additional depth of 10 feet. Water was secured from extensive sand and gravel deposits which underlie most of the northwestern part of the city. The capacity of this well was given as about 1,00,000 gallons a day which was insufficient to supply demands by 1883. The old filter well was cleaned out and supplied some water and at times water was taken directly from the river.

An artesian well into Cambrian sandstone was drilled in 1885, near the pumping station. The well was 1530 feet deep. The water level was 135 feet above city datum, about 35 feet above average water level in Rock River, and 27 feet above the pumping station floor. Four other wells were drilled nearby into Cambian sandstone before 1891. In that year the pressure in the wells was sufficient to raise water to 115 feet above the city datum and the flow from the five wells into Cambrian sandstone which were then in use was 1,100,000 gallons a day. This was not sufficient to supply demands and four wells were drilled near the pumping station into St. Peter sandstone and were equipped with steam-head deep-well pumps. A reservoir of about 1,250,000 gallons capacity was built to supply water at hours of maximum demands. In a few years it was again necessary at times to use river water.

A shaft and tunnel system to increase the supply was installed by D. W. Mead from 1896 to 1898. Pumps were placed 79 feet below the pumping station floor in a shaft and drew water through pipe lines laid in tunnel connections to three of the six wells into Cambrian sandstone then in use and to five wells into St. Peter sandstone. The wells into Cambrian sandstone were from 1300 to 2000 feet deep. The three connected to the shaft, numbers one, four, and six, were about in line. Number four was 145 feet northeast of number one and number six was 230 feet southwest of

number one. Four of the St. Peter wells were spaced 30 to 35 feet apart in a diamond shaped area and the fifth was at the side of the shaft, 80 feet distant. The four wells were about 130 feet and 180 feet distant respectively from wells number 1 and number 5 into Cambrian sandstone.

During a test in 1891 the yield from the shaft and tunnel system was 6,800,000 gallons in 24 hours.

The water consumption for five years to 1910 averaged near 3,700,000 gallons a day of which about 2,700,000 was supplied from the shaft and tunnel system. The water plane had taken up a position of equilibrium at about 102 city datum and the water level at the shaft was lowered 76 feet by pumping. The three wells into Cambrian sandstone not connected to the shaft and tunnel system, located on Peach Street and known as numbers two, three, and five, were equipped with air lifts. The air nozzels in wells three and five were said to be at depths of from 250 to 260 feet. These two wells during a test yielded at a rate of 918,000 gallons a day. When pumping at such rate no water could be secured from well number 2 in which the air nozzle was placed at a depth of 140 feet.

On January 31, 1919, when pumping continuously from the shaft and tunnel system and not pumping from Cambrian wells two, three, and five in Peach Street, the water level was drawn down to nearly 100 feet below the level of the pumping station floor, to between 10 and 20 city datum, in the wells pumped; to 74 city datum in well number two which was 160 feet distant from the nearest well pumped; and to 92 city datum in well number five which was 1050 feet distant from the nearest well pumped.

In 1921 the shaft and tunnel system was operated continuously and the yield was about 2,750,000 gallons a day. The yield was about the same whether one or all five of the wells into St. Peter sandstone were connected. Wells two, three and five located on Peach Street were at that time equipped with air lifts and their yield, when used, was said to be at a rate of 2,000,000 gallons a day.

A well known as number seven was drilled by the Cater Contracting Company in 1912-1913 on Eleventh Street south of Seventeenth Avenue in the southeastern part of the city. The top is 129.5 feet above city datum. The well is 18 inches in diameter to a depth of 250 feet, 12 inches in diameter at the bottom, and 1503 feet deep. It is equipped with an American turbine pump with four stages placed at a depth of 108 feet and two stages placed at the top of the well. Until 1918 less than 200,000,000 gallons of water was supplied from this well. In that year this well supplied 251,000,000 gallons of water. The average rate of yield in that

year, determined from records of quantity pumped and hours operated, was 1490 gallons a minute, practically the same as the average from the time the pump was installed. In 1923 the pump was operated 689 hours and supplied 58,256,000 gallons of water, an average of 1410 gallons a minute.

A well known as number eight was drilled in 1914-1915 between Auburn, Camp, and Douglas Streets in the northeastern part of the city 2¾ miles north of well number seven. The elevation at the top is 120.5 feet above city datum. An abstract of a log on file with the State Geological Survey Division is as follows:

	Thickness in feet.	Depth in feet.
Drift	248	248
Sandstone, St. Peter	145	393
Limestone, Prairie du Chien	177	570
Cambrian system	930	1500

The upper 210 feet is 22 inches in diameter and below that depth the well is 12 inches in diameter to the bottom at a depth of 1502 feet. The well is equipped with a Layne and Bowler five-stage centrifugal pump placed at a depth of 100 feet, with 35 feet of suction pipe attached. The cost of the well was $10,488, cost of equipment $5,782, and cost of station $7,653. When not pumping water stood at a depth of 16½ feet in 1919 and was lowered to a depth of 100 feet by pumping for half a day. The yield of the well was at a rate of 2,250,000 gallons a day and at times the pump was operated as much as 18 hours a day. In 1923 the pump in this well was operated 424 hours and supplied 34,014,000 gallons, a rate of 1,340 gallons a minute or 1,900,000 gallons a day.

The supply since June, 1923, when the plant by the river was abandoned, with the exception of water supplied from wells number seven and number eight as given above, has been secured from a plant installed in the western part of the city. This plant was practically completed in 1922. The installation includes four wells drilled by S. B. Geiger known as numbers one, two, three, and four. These are 2 1/3 miles distant from well number seven and the same distance from well number eight.

Well number one is located on the northeast corner of Tay and Cedar Streets. It is cased with 16-inch pipe to a depth of 100 feet and is 12 inches in diameter below a depth of 100 feet to the bottom at a depth of 1600 feet. The well is equipped with an air lift with a 1½-inch line to a depth of 300 feet.

Well number two is located one block east of well number one. It is the same size and depth as well number one. It is equipped with an air lift with a 1½-inch air line to a depth of 300 feet.

Well number three is located one block north of well number two at the corner of Preston and Stanley Streets. This well is the same size as well number one and is 1601 feet deep. It is equipped with an air lift with a 1½-inch air line to a depth of 335 feet.

Well number four is located on block east of well number two. It is the same size as well number one and 1631 feet deep. It is equipped with an air lift with a 1½-inch air line to a depth of 300 feet.

The air pressure required in 1924 was 135 pounds to start the air lifts and 132 pounds during operation. A test was made by D. W. Mead on January 9, 1923. The yield of the four wells was 2,890,300 gallons in 10 hours, a rate of 3,487 gallons a minute. The larger compressor was used and run 46,197 revolutions in ten hours. The water level with no pumping was about 29 feet below the ground surface and it was at about the same depth in 1924.

Sample number 51536 was collected from well number three on May 28, 1924, after the air lift had been operated many hours.

The water stains plumbing fixtures. About 2200 meters have been repaired in a year due to corrosion and clogging with sand.

Analysis of Sample Number 51536 from Well Number 3.

Determinations Made.	Parts per million.
Iron Fc	0.4
Manganese Mn	0.0
Silica SiO_2	10.8
Nonvolatile	0.5
Alumina Al_2O_3	0.3
Calcium Ca	55.1
Magnesium Mg	26.2
Ammonia NH_4	0.1
Sodium Na	5.5
Potassium K	3.6
Sulfate SO_4	9.0
Nitrate NO_3	2.1
Chloiide Cl	3.0
Alkalinity	
Phenolphthalein	0
Methyl Orange	246.
Residue	298.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	3.4	0.20
Potassium Chloride KCl	4.2	0.24
Sodium Chloride NaCl	1.6	0.09
Sodium Sulfate Na_2SO_4	13.3	0.78
Sodium Carbonate Na_2CO_3	1.2	0.07
Ammonium Carbonate $(NH_4)_2CO_3$	0.3	0.02
Magnesium Carbonate $MgCO_3$	90.7	5.30
Calcium Carbonate $CaCO_3$	137.5	8.03
Iron Oxide Fe_2O_3	0.6	0.03
Alumina Al_2O_3	0.3	0.02
Silica SiO_2	10.8	0.63
Nonvolatile	0.5	0.03
Ttotal	264.4	15.44

ROCKTON (899). Rockton is located in the northeastern part of Winnebago County on the east bank of Rock River. A public water supply was installed by the village in 1909. The water works now includes three wells, a Fairbanks-Morse 6 by 10-inch duplex pump driven by belt from a 10-horsepower kerosene engine, a distribution system, and an elevated steel tank connected to the system.

The pump is placed in a pit six feet deep. It draws water from the wells and discharges directly into the distribution system. The tank is 20 feet in diameter and 18 feet, high and the top is 112 feet above the ground surface. Sixty-two service connections were in use in 1924. The supply is not metered.

Water for the public supply is secured from three wells located north of Harwick Street and west of Prairie Street. One well was drilled in 1909 when the water works was installed. This well is 6 inches in diameter and 165 feet deep. It is cased with 6-inch pipe into rock at a depth of 95 feet. A well ten feet east and north of the older well was drilled by James Welch and Fred Bruster of Beloit in 1913. The well is 6 inches in diameter and 65 feet deep. A Cook screen 20 feet long is placed in the bottom. A well 8 inches in diameter and 96 feet deep was drilled by Mr. Korea1 of Beloit in 1920. This well is six feet distant from each of the two 6-inch wells. A Cook screen 20 feet long is placed in the bottom of the well.

The casing of each well is connected to the suction line of the pump. The elevated tank of 52,000 gallons capacity has been filled in 5 hours 30 minutes, a rate of 157 gallons a minute. The pump was operated four or five hours a day in May, 1924. The water level when not pumping was said to be 15 feet below the ground surface.

The water had a mineral content of 302, a total hardness of 287, and a content of iron of 2.0 parts per million as shown by the analysis of sample number 51540, collected on May 29, 1924, at the pumping station.

Analysis of Sample Number 51540 from the Village Supply.

Determinations Made.	Parts per million.
Iron Fe	2.0
Manganese Mn	0.0
Silica SiO_2	14.4
Nonvolatile	1.5
Alumina Al_2O_3	0.5
Calcium Ca	60.7
Magnesium Mg	33.2
Ammonia NH_4	0.2
Potassium K	1.1
Sodium Na	4.4
Sulfate SO_4	4.9
Nitrate NO_3	1.8
Chloride Cl.	8.0
Alkalinity	
Phenolphthalein	0
Methyl Orange	282.
Residue	298.0

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	2.8	0.16
Sodium Chloride NaCl	11.3	0.66
Ammonium Chloride NH_4Cl	0.5	0.03
Magnesium Chloride $MgCl_2$	1.1	0.06
Magnesium Sulfate $MgSO_4$	6.1	0.36
Magnesium Carbonate $MgCO_3$	109.5	6.37
Calcium Carbonate $CaCO_3$	151.6	8.85
Iron Oxide Fe_2O_3	2.9	0.17
Alumina Al_2O_3	0.5	0.03
Silica SiO_2	14.4	0.84
Nonvolatile	1.5	0.08
Total	302.2	17.61

ROODHOUSE (2928). Roodhouse is located in the northern part of Green County on the drainage area of Apple Creek, a tributary of Illinois River. A public water supply was installed by the city in 1906. Water was secured from an impounding reservoir formed by building a dam on a small drainage area near the city. A supply from springs was developed in 1920 and has since been used as a source of public water supply. Water flows into a concrete reservoir from which it is pumped to the city through a 10-inch pipe line by a Deming 11 by 12-inch triplex pump. The pump is driven by a vertical two cylinder, 75-horsepower oil engine. An elevated tank is connected to the mains in the city. The top of the tank is 271 feet above the ground surface at the springs. Large quantities of water are used by an ice company and by the Chicago & Alton Railroad and the amount of water used by all other consumers is but a small fraction of the total. The rate for 6000 gallons or less of water per month is 50 cents per 1000 gallons with a minimum charge of $1.00. The lowest rate, for water in excess of 100,000 gallons, is 17 cents per 1000 gallons. A ten per cent penalty is added if payment is not prompt.

The public water supply is secured from springs located in the northwest quarter of section 32 about six miles northwest of the city. A tunnel 90 feet long, 30 inches wide and 54 inches high with concrete sides and top was laid from the main spring to the concrete reservoir and intercepted some water from smaller springs. In an effort to increase the supply, rock at the main spring has been excavated to a depth of 20 or 25 feet. The rock was dense and impervious and little or no additional water was secured. Water is pumped from the excavation to the reservoir.

Analysis of Sample Number 46508 from the City Springs.

Determinations Made.

	Parts per million.
Iron Fe	0.1
Manganese Mn	Trace
Silica SiO_2	16.8
Nonvolatile	0.8
Alumina Al_2O_3	2.7
Calcium Ca	84.7
Magnesium Mg	28.1
Ammonia NH_4	0.0
Potassium K	3.1
Sodium Na	15.1
Sulfate SO_4	21.5
Nitrate NO_3	2.6
Chloricle Cl	9.0
Residue	389.

Hypothetical Combinations.

	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	4.3	.25
Potassium Chloride KCl	2.7	.16
Sodium Chloride NaCl	12.7	.74
Sodium Sulfate Na_2SO_4	31.4	1.84
Ammonium Sulfate $(NH_4)_2SO_4$	0.1	.008
Magnesium Sulfate $MgSO_4$	0.1	.007
Magnesium Carbonate $MgCO_3$	97.2	5.69
Calcium Carbonate $CaCO_3$	211.5	12.37
Silica SiO_2	16.8	.98
Nonvolatile	0.8	.04
Iron Oxide Fe_2O_3	0.2	.01
Alumina Al_2O_3	2.7	.15
Total	380.5	22.24

The flow from the springs before they were developed was 480,000 gallons a day at the time measurement was made. After development the flow measured 700,000 gallons a day. During one month, to August 21, 1921, the amount of water supplied was 14,300,000 gallons, an average of 460,000 gallons a day which was probably about the capacity of the springs at that time.

The water had a mineral content of 380, a total hardness of 327, and a content of iron of 0.1 parts per million as shown by the analysis of sample number 46508, collected on November 1, 1921.

ROSEVILLE (952). Roseville is located in the southern part of Warren County on the drainage area of Spoon River, a tributary of Illinois River. A public water supply was installed by the village about 1895. Water was obtained from an abandoned coal mine. A well was drilled in 1902 and has since furnished practically the entire water supply. The mine shaft and well are each equipped with a deep-well pump belted to a shaft which is turned by belt from a lo-horsepower electric motor. A gas engine formerly in regular service can be used in case of emergency. One hundred and fifty service connections were in use in 1923, of which 130 were metered.

The older well or abandoned mine has a shaft 12 feet in diameter and 50 feet deep and three galleries of unknown dimensions. The well is equipped with an American pump with the cylinder at a depth of 49 feet. The depth to water in 1914 was 18 feet. In July, 1923, this well was in use while repairs were made on the deep well. The depth to water four hours after pumping ceased was 45 feet. Water was drawn down to the pump cylinder after 45 minutes pumping, during which time the amount of water pumped was estimated at 3,000 gallons. The total amount pumped during the day was estimated at 6,000 gallons and little water was available for use at residences.

The well drilled in 1902 is 1260 feet deep and is located 20 feet distant from the older well. It was drilled by the J. P. Miller Artesian Well Company of Chicago. The well was cased to a depth of 1070 feet. Five hundred and one feet of 6¼-inch casing was placed with the bottom at a depth of 653 feet and 435 feet of 5-inch casing was placed with the bottom at a depth of 1070 feet. Sandstone was entered at a depth of 1160 feet. The well is 5 inches in diameter at the bottom. The well is equipped with a Keystone Driller Company deep-well pump with 4¾-inch cylinder and 36-inch stroke. The cylinder is placed at a depth of 240 feet. In 1915, when the city was visited, this well was furnishing the entire supply which was estimated at from 20,000 to 25,000 gallons a day.

When the city was visited in 1923 the well was out of service during repair and the depth to water was 140 feet. The well had filled below a depth of 600 feet. Late in 1924 it was reported that the yield of this well was very small and the village was investigating the possibility of securing water from wells into sand.

When not pumping a very soft water of comparatively low mineral content flows into the deep well. When starting to pump, this water is first discharged. Sample number 29191 was collected on November 5, 1914, after the pump had operated for ten minutes.

Analysis of Sample Number 29191.

Determinations Made.	Parts per million.
Silica SiO_2	13.4
Nonvolatile	1.7
Iron Fe	0.0
Manganese Mn	0.0
Alumina Al_2O_3	3.4
Calcium Ca	5.1
Magnesium Mg	3.8
Ammonia NH_4	0.4
Potassium K	14.4
Sodium Na	195.5
Sulfate SO_4	82.4
Nitrate NO_3	0.7
Chloride Cl	19.0
Alkalinity	
Phenolphthalein	40.
Methyl Orange	356.
Residue	566.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	1.1	.06
Potassium Chloride KCl	26.7	1.56
Sodium Chloride NaCl	10.4	.61
Sodium Sulfate Na_2SO_4	121.9	7.11
Sodium Carbonate Na_2CO_3	347.7	20.28
Ammonium Carbonate $(NH_4)_2CO_4$	4.0	.23
Magnesium Carbonate $MgCO_3$	9.7	.57
Calcium Carbonate $CaCO_3$	2.7	0.16
Alumina Al_2O_3	3.4	.19
Silica SiO_2	13.4	.78
Nonvolatile	1.7	.09
Total	542.7	31.64

Analysis of Sample Number 29784.

Determinations Made.	Parts per million.
Iron Fe	1.4
Manganese Mn	0.0
Silica SiO_2	10.0
Nonvolatile	1.6
Alumina Al_2O_3	4.4
Calcium Ca	220.2
Magnesium Mg	86.9
Ammonia NH_4	1.4
Potassium K	36.0
Sodium Na	457.2
Sulfate SO_4	1327.0
Nitrate NO_3	1.2
Chloride Cl	250.0
Alkalinity	
Methyl Orange	232.
Residue	1596.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	2.0	.12
Potassium Chloride KCl	70.9	4.14
Sodium Chloride NaCl	356.9	20.82
Sodium Sulfate Na_2SO_4	976.3	56.95
Ammonium Sulfate $(NH_4)_2SO_4$	5.1	.30
Magnesium Sulfate $MgSO_4$	429.6	25.06
Calcium Sulfate $CaSO_4$	444.1	25.90
Calcium Carbonate $CaCO_3$	223.2	13.02
Iron Carbonate $FeCO_3$	2.9	.17
Alumina Al_2O_3	4.4	.26
Silica SiO_2	10.0	.58
Nonvolatile	1.6	.09
Total	2527.0	147.41

With continued pumping a larger part of the water discharged is drawn from the main source of supply. Samples collected after fifteen minutes pumping on December 21, 1914, and on February

2, 1915, contained nearly twice the mineral shown by analysis of sample number 29191.

Sample number 29784 was collected on February 2, 1915 after the pump had operated for one hour and forty-five minutes.

A sample, number 39695, collected on July 3, 1918, contained a little less mineral, a total of 2292 parts per million. Analyses made at the well at that time showed the presence of two parts per million of carbon dioxide and no hydrogen sulphide.

Sample number 39696, collected on July 3, 1918, from the well into the abandoned mine, had a mineral content of 754, a total hardness of 477, and a content of iron of 0.4 parts per million as shown by the analysis.

Analysis of Sample Number 39696 from Abandoned Mine.

Determinations Made.	Parts per million.
Iron Fe	0.4
Manganese Mn	0.1
Silica SiO_2	19.6
Nonvolatile	2.8
Alumina Al_2O_3	1.2
Calcium Ca	108.3
Magnesium Mg	50.2
Ammonia NH_4	0.1
Sodium Na	73.0
Sulfate SO_4	267.3
Nitrate NO_3	13.3
Chloride Cl	
Alkalinity Methyl Orange	275.
Residue	819.4

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Sodium Nitrate $NaNO_3$	18.2	1.06
Sodium Chloride NaCl	97.3	5.67
Sodium Sulfate Na_2SO_4	91.8	5.35
Ammonium Sulfate $(NH_4)_2SO_4$	0.4	.02
Magnesium Sulfate $MgSO_4$	248.4	14.49
Calcium Sulfate $CaSO_4$	9.3	.54
Calcium Carbonate $CaCO_3$	263.2	15.35
Iron Carbonate $FeCO_3$	0.8	.05
Manganese Carbonate $MnCO_3$	0.2	.01
Alumina Al_2O_3	2.2	.12
Silica SiO_3	19.6	1.14
Nonvolatile	2.8	.16
Total	754.2	43.96

ROSSVILLE (1588). Rossville is located in the northeastern part of Vermilion County on the drainage area of Vermilion River, a tributary of Wabash River. A public water supply was installed by the village in 1904. Water is secured from three wells into sand. The wells were abandoned in 1911 when a supply was developed from other wells into sand and gravel. Each well in use is equipped with a deep-well pump which discharges directly into the distribution system and a standpipe ten feet in diameter which is connected to the system. Each pump is driven by an electric motor.

About 400 service connections were in use in 1924. The Rossville Packing Company which uses large quantitiees of water has a private supply from wells similar to the village wells and uses little water from the village supply. The rate for water is 40 cents per 1000 gallons with a minimum charge of $1.50 every three months.

The three wells drilled in 1904 were 3 inches in diameter and

84 feet deep. A limited supply of water was secured from these wells until 1911 when they were abandoned.

Water for the public supply is now secured from three wells into sand and gravel. The elevation of the ground surface at the wells is about 710 feet above sea level. Two of the wells were drilled in 1910. One is 8 inches in diameter and 126 feet deep. It is equipped with a Cook double-stroke deep-well pump with a 5¾-inch cylinder and 18-inch stroke. The cylinder is at a depth of 82 feet and has 20 feet of suction pipe attached. In 1924 the pump was operated at a speed of 26 revolutions a minute, a displacement of 104 gallons a minute.

The other well drilled in 1910 is located 25 feet south of the one described above. It is 8 inches in diameter and 131 feet deep. It is equipped with a Cook double-stroke deep-well pump with 5¾-inch cylinder and 18-inch stroke. Twenty feet of suction pipe is attached to the cylinder. In 1924 the pump was operated at a speed of 28 revolutions a minute, a displacement of 112 gallons a minute.

The third well was drilled in 1918 by Harry Winks of Williamsport, Indiana. It is located 15 feet east and 5 feet north of the well 126 feet deep. This well is 8 inches in diameter and 132 feet deep. A Cook screen 14 feet long is placed in the bottom. The well is equipped with a Cook double-stroke deep-well pump with a 5¾-inch cylinder and 18-inch stroke. The cylinder is placed at a depth of 78 feet and has 20 feet of suction pipe attached. In 1924 the pump was operated at a speed of 28 revolutions a minute, a displacement of 112 gallons a minute.

Analysis of Sample Number 52887 from the Village Supply.

Determinations Made.

	Parts per million.
Iron Fe	2.4
Manganese Mn	0.0
Silica SiO_2	13.7
Nonvolatile	0.8
Alumina Al_2O_3	1.4
Calcium Ca	68.8
Magnesium Mg	38.3
Ammonia NH_4	1.0
Sodium Na	23.7
Potassium K	3.4
Sulfate SO_4	7.7
Nitrate NO_3	0.5
Chloride Cl	2.0
Alkalinity	
Phenolphthalein	0
Methyl Orange	376.
Residue	388.

Hypothetical Combinations.

	Parts per million.	Grains per gallon.
Potasium Nitrate KNO_3	0.9	0.05
Potassium Chloride KCl	4.2	0.24
Potassium Sulfate K_2SO_4	1.9	0.11
Sodium Sulfate Na_2SO_4	9.8	0.57
Sodium Carbonate Na_2CO_3	4.7	0.27
Ammonium Carbonate $(NH_4)_2CO_3$	2.7	0.16
Magnesium Carbonate $MgCO_3$	132.6	7.74
Calcium Carbonate $CaCO_3$	171.7	10.03
Iron Oxide Fe_2O_3	3.4	0.20
Alumina Al_2O_3	1.4	0.08
Silica SiO_2	13.7	0.80
Nonvolatile	0.8	0.05
Total	347.8	20.30

Two pumps are operated at a time. The amount of water pumped during the year to June, 1924, probably averaged near 75,000 gallons a day.

The water had a mineral content of 347, a total hardness of 329, and a content of iron of 2.4 parts per million as shown by the analysis of sample number 52887, collected at a tap in the pumping station on November 24, 1924.

The water stains plumbing fixtures.

A sample of water collected in 1910 from the well 84 feet deep was a little more highly mineralized. It contained 56 parts of sulfate and 18 parts of chloride and the total mineral content was 430 parts per million.

ROUND LAKE (251). Round Lake is located in the central part of Lake County near one of a large group of lakes in a summer resort region. The installation of a public water supply was completed by the village in 1914. Water is pumped from a well into the distribution system and a steel pressure tank connected to the system by a deep-well pump which is direct connected to a 10-horsepower electric motor. The pump is operated by automatic control. The tank is 7 feet in diameter and 36 feet long. Power is purchased from the Public Service Company of Northern Illinois. The water consumption is estimated at between 20,000 and 25,000 gallons a day of which about 18,000 gallons a day is used at a creamery. The rate to the creamery is 12½ cents per 1000 gallons. Other consumers using comparatively small quantities of water are charged 25 cents per 1000 gallons with a minimum charge of $1.00 per quarter.

Water for the public supply is obtained from a well drilled in 1912 by Adam Titus of Libertyville. It is 350 feet deep and is cased with 6-inch pipe to rock at a depth of 230 feet. When the well was completed it was pumped at a rate of 150 gallons a minute for 24 hours. The water level returned to its original level soon after the pump was stopped. An American 4¼-inch double-acting cylinder was installed at a depth of 100 feet in 1922. The pump is operated with 24-inch stroke at 22 revolutions a minute, a displacement of 52 gallons a minute. When this cylinder was installed in 1922 the depth to water was 43 feet.

The water had a mineral content of 438, a total hardness of 178, and a content of iron of 0.3 parts per million as shown by the analysis of sample number 48663, collected on November 17, 1922.

Analysis of Sample Number 48663 from the Village Supply.

Determinations Made.	Parts per million.
Iron Fe	0.3
Manganese Mn	0.0
Silica SiO_2	12.8
Nonvolatile	1.1
Alumina Al_2O_3	0.9
Magnesium Mg	22.4
Calcium Ca	34.5
Ammonia NH_4	0.6
Sodium Na	60.5
Potassium K	20.7
Sulfate SO_4	214.0
Nitrate NO_3	0.9
Chloride Cl	5.0
Alkalinity Methyl Orange	106.
Residue	438.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	1.4	0.08
Potassium Chloride KCl	12.9	0.75
Potassium Sulfate K_2SO_4	29.7	1.73
Sodium Sulfate Na_2SO_4	186.8	10.90
Ammonium Sulfate $(NH_4)_2SO_4$	2.1	0.12
Magnesium Sulfate $MgSO_4$	87.2	5.10
Magnesium Carbonate $MgCO_3$	16.4	0.10
Calcium Carbonate $CaCO_3$	86.1	5.02
Silica SiO_2	12.8	0.75
Nonvolatile	1.1	0.06
Iron Oxide Fe_2O_3	0.4	0.02
Alumina Al_2O_3	0.9	0.05
Total	438.4	24.68

RUSHVILLE (2275). Rushville is located in the central part of Schuyler County on a small tributary of and about nine miles distant from Illinois River. Many dug wells from 15 to 25 feet deep have been in use at residences in the city.

A public water supply was installed by the city in 1894. For a time water was secured from a deep well into rock. The water was highly mineralized and the well was abandoned. Water was then secured from a small impounding reservoir near the eastern limits of the city. Another deep well into rock was drilled near the reservoir and for some years furnished part of the water supply. Later a supply was developed from wells into sand and gravel near the bank of McElho branch, a small stream south of the city. The supply was less than anticipated and leakage in a 10-inch wood stave pipe line to the city was excessive and for some years it was necessary to secure as much water as possible from the deep well and reservoir in the eastern part of the city. Three wells near McElho branch were in use in 1924. Water from the wells and water from the branch was pumped through a pipe line to the city by either of two pumps. A Fairbanks-Morse pump driven by a 25-horsepower gas engine is generally used and is operated about 7 hours a day. A 4-inch centrifugal pump driven by an electric motor is used occasionally. Water is pumped through a pipe line into a reservoir of 95,000 gallons capacity which is located in the southern part of the city. From the reservoir it is pumped into the mains by a 4-inch centrifugal pump. A ten-inch wooden-stave pipe line from the station at the wells to the reservoir in the city has been replaced by an 8-inch cast iron pipe line.

The original source of public water supply was a well 2500 feet deep, located in tre public square. It was drilled by the J. P. Miller Artesian Well Company of Chicago in 1887-1888. The depth to St. Peter sandstone was reported to be 1299 feet. The depth to which it was cased was once reported to be 1870 feet but this may be in error or may refer to the total depth of the well at that time. In 1888 it was reported that a 7-inch casing extended to a depth of 91 feet 6 inches, 41 feet into solid rock and that inside of the 7-inch casing was a 6-inch casing to a depth of 317 feet 6 inches. The well was tested for 25 hours with a pump placed at a depth of 150 feet. The discharge was 60 gallons a minute. The depth to water before the test was 77 feet and after the test it was 77 feet 7 inches. The water level before the test was a little higher inside the casing than it was outside of the casing. The temperature of water discharged when pumping began was 72 degrees Fahrenheit and after pumping for 20 hours it was 80 degrees Fahrenheit.

A well was drilled by Swante Swanson for the city in 1902 at the pumping station east of the city. A record of material penetrated was given as follows:

	Thickness in feet.	Depth in feet.
Top soil and clay	7	7
Shale	142	149
Mixed shale and stone	15	164
Gray shale	14	178
Shale and sandstone	34	212
Shale	68	280
Limestone	116	396
Limestone	108	504
Gray shale	211	715
Limestone	45	760
Shale	190	950
Limestone	56	1006
White shale	118	1124
Limestone	121	1245
Sandstone, St. Peter	170	1415
Sandstone, red, St. Peter	65	1480
Sandstone, St. Peter	30	1510

The well cost $4666.75. The depth to water was 150 feet when the well was 1380 feet deep and 92 feet when the well was 1460 feet deep. The well was tested for 16 hours on May 19, 1902, when it was 1460 feet deep, and yielded 22 gallons a minute. The water level raised 28 feet after the test. The pump cylinder was probably at a depth of 200 feet as the test was delayed awaiting the arrival of 200 feet of 6-inch pipe. The yield of the completed well was from 25 to 30 gallons a minute. Water from this well had a mineral content of 4121 and a total hardness of 752 as shown by the analysis of sample number 10421, collected on May 26, 1902.

Analysis of Sample Number 10421 from City Well 1510 Feet Deep.

Determinations Made.	Parts per million.
Iron Fe, Alumina Al_2O_3	3.4
Silica SiO_2	8.4
Calcium Ca	175.5
Magnesium Mg	76.5
Ammonia NH_4	2.4
Sodium Na	1192.2
Sulfate SO_4	1026.3
Chloride Cl	1485.0
Residue	4284.8

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Sodium Chloride NaCl	2450.2	42.89
Sodium Sulfate Na_2SO_4	704.2	41.06
Ammonium Sulfate $(NH_4)_2SO_4$	8.8	.51
Magnesium Sulfate $MgSO_4$	380.4	22.18
Calcium Sulfate $CaSO_4$	339.7	19.81
Calcium Carbonate $CaCO_3$	189.0	11.02
Iron Oxide Fe_2O_3, Alumina Al_2O_3	3.4	.20
Silica SiO_2	8.4	.49
Suspended Matter	37.6	2.29
Total	4121.7	240.45

The water was too highly mineralized to be suitable for a public water supply.

The supply is now secured from three wells near the bank of McElho Branch and from the Branch. The wells are located near the southeast corner of Section 19, about six miles south of the city.

Material penetrated by a test well before the first well was dug is as follows:

Black sand soil	10 feet
Fine sand	2 feet
Coarse gravel mixed with sand and hard clay or shale	10 feet

One well, number one, was dug in 1911. It is 12 feet in diameter and 24 feet deep and is cased with brick. The lower part of the well was laid without cement. The yield of the well was not sufficient to supply demands and a tile connecting to the well was laid below the bed of the stream. Later a connection was made to the stream and part of the supply was taken from the stream. In 1915 the total amount of water used in the city was estimated at 17,000 gallons a day. Only part of the supply was from this well but a considerable quantity of water pumped leaked from the wooden pipe line then in use.

Well number two was dug in 1920 or 1921. The space between wells one and two is 3 feet 6 inches. This well is 14 feet in diameter at the top, 12 feet in diameter at the bottom, and 21 feet deep. It is lined with cement blocks laid with loose joints. When tested, during dry weather the yield was 75 gallons a minute. Wells one and two are joined by a ten-inch pipe.

Well number three was dug in 1922. It is located about 30 feet southwest of wells one and two. It is 18 feet in diameter and 20 feet deep and is curbed with cement blocks laid with loose joints.

The wells do not furnish sufficient water and considerable water is taken from McElho Branch which is fed by springs.

A sample of the supply, number 52996, collected at a tap in the pumping station on January 25, 1925, had a mineral content of 413, a total hardness of 318, and a content of iron of 0.4 parts per million as shown by the analysis.

Analysis of Sample Number 52996 from the City Supply.

Determinations Made.

	Parts per million.
Iron Fe	0.4
Manganese Mn	0.0
Silica SiO_2	21.2
Nonvolatile	0.4
Alumina Al_2O_3	6.0
Calcium Ca	72.9
Magnesium Mg	33.06
Ammonia NH_4	0.11
Sodium Na	30.3
Potassium K	3.1
Sulfate SO_4	27.26
Nitrate NO_3	5.1
Chloride Cl	7.0
Alkalinity Methyl Orange	342.
Residue	432.

Hypothetical Combinations.

	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	8.1	0.47
Sodium Chloride NaCl	11.5	.87
Sodium Sulfate Na_2SO_4	40.1	2.35
Sodium Carbonate Na_2CO_3	29.1	1.70
Ammonium Carbonate $(NH_4)_2CO_3$	0.3	.02
Magnesium Carbonate $MgCO_3$	114.2	6.69
Calcium Carbonate $CaCO_3$	182.2	10.65
Iron Oxide Fe_2O_3	0.6	.03
Alumina Al_2O_3	6.0	.35
Silica SiO_3	21.2	1.24
Nonvolatile	0.4	.03
Total	413.7	24.18

ST. ANNE (1067). St. Anne is located in the southern part of Kankakee County on the drainage area of Kankakee River. A public water supply was installed in 1898 by a private company and was later sold to the Public Service Company of Northern Illinois. Water was secured from a well. This well and equipment were used until 1923 when a plant built by the village was put in operation. The plant built by the village includes a cement block pumping station, a well, a deep-well pump geared to a 20-horsepower electric motor, a concrete reservoir 24 feet in diameter into which water from the well is discharged, two Fairbanks-Morse 3-inch centrifugal pumps to pump water from the reservoir into the mains, an elevated steel tank, and additional mains. The elevated tank is located close to the well. It is 15 feet in diameter and the sides are 18 feet 4½ inches high. Water pumped is metered at the station. About 250 consumers were supplied with water in 1923. The charge for the first 5,000 gallons is 50 cents per 1000 gallons. The lowest rate, for water in excess of 15,000 gallons, is 20 cents and the minimum charge is 75 cents a month.

The public water supply for 25 years, to 1923, was secured from a well 6 inches in diameter and 210 feet deep which was located near the center of the village. The elevation of the top of the well was about 655 feet above sea level. The well was cased to limestone

at a depth of 100 feet. The yield of the well was said to be 100 gallons a minute. The depth to water when not pumping was from 25 to 30 feet. Water from the well had a mineral content of 809, a total hardness of 525, and a content of iron of 2.6 parts per million as shown by the analysis of sample number 30628, collected on June 5, 1915.

Analysis of Sample Number 30628 from Well 210 Feet Deep.

Determinations Made.	Parts per million.
Iron Fe	2.6
Silica SiO_2	10.4
Nonvolatile	2.4
Alumina Al_2O_3	2.7
Calcium Ca	137.8
Magnesium Mg	44.0
Ammonia NH_4	1.0
Potassium K	20.4
Sodium Na	45.7
Sulfate SO_4	391.5
Nitrate NO_3	.5
Chloride Cl	7.
Alkalinity Methyl Orange	242.
Residue	832.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	.8	.05
Potassium Chloride KCl	14.7	.86
Potassium Sulfate K_2SO_4	27.6	1.61
Sodium Sulfate Na_2SO_4	140.9	8.22
Ammonium Sulfate $(NH_4)_2SO_4$	3.7	.22
Magnesium Sulfate $MgSO_4$	217.5	12.69
Calcium Sulfate $CaSO_4$	148.7	8.67
Calcium Carbonate $CaCO_3$	234.6	13.68
Iron Carbonate $FeCO_3$	5.4	.31
Alumina Al_2O_3	2.7	.16
Silica SiO_2	10.4	.61
Nonvolatile	2.4	.14
Total	809.4	47.22

Analysis of Sample Number 49642 from the Village Well.

Determinations Made.	Parts per million.
Iron Fe	1.2
ManganeseMn	0.0
Silica SiO_2	16.1
Nonvolatile	1.6
Alumina Al_2O_3	1.8
Calcium Ca	96.1
Magnesium Mg	40.9
Ammonia NH_4	0.4
Potassium K	8.9
Sodium Na	56.9
Sulfate SO_4	242.9
Nitrate NO_3	1.4
Chloride Cl	8.0
Alkalinity Methyl Orange	270.
Residue	652.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	2.3	0.13
Potassium Chloride KCl	15.3	0.89
Sodium Chloride NaCl	1.2	0.07
Sodium Sulfate Na_2SO_4	174.5	10.19
Ammonium Sulfate $(NH_4)_2SO_4$	1.6	0.09
Magnesium Sulfate $MgSO_4$	154.7	9.03
Magnesium Carbonate $MgCO_3$	33.3	1.94
Calcium Carbonate $CaCO_3$	240.0	14.02
Iron Oxide Fe_2O_3	1.7	0.10
Alumina Al_2O_3	1.8	0.10
Silica SiO_3	16.1	0.94
Nonvolatile	1.6	0.09
Total	644.1	37.59

The public water supply since 1923 is secured from a well located in the southwestern part of the village on Guertin Street about 100 feet west of St. George Street. The ground surface at the well is about 675 feet above sea level. The well is 10 inches in diameter and 257 feet deep. Rock was entered at a depth of 99 feet. The water level when the well was completed was 59 feet below the ground surface and is reported to have been lowered

15 feet during a test when pumping 200 gallons a minute. The yield was 195 gallons a minute as registered by meter during a test in June, 1923. The pump was probably at a depth of 90 feet as bids for equipment included bids on that length of drop pipe. The amount of water pumped during April and May, 1923, averaged 38,000 gallons a day.

The water had a mineral content of 644, a total hardness of 408, and a content of iron of 1.2 parts per million as shown by the analysis of sample number 49642, collected on June 18, 1923, at the pumping station.

This water is slightly more highly mineralized and not as hard as the sample of water collected from the well formerly in use.

ST. CHARLES (4099). St. Charles is located in the eastern part of Kane County on the banks of Fox River. A public water supply was installed by the city in 1907 and is operated in connection with a municipal electric plant. Water was at first secured from a well near the bank of the river. Two other wells have since been drilled. One well is equipped with a steam-head deep-well pump. Another is equipped with a centrifugal pump which is driven by a 50-horsepower electric motor. These two pumps discharge into a collecting reservoir 23 feet by 50 feet in plan and 6 feet deep. The other well is equipped with a deep-well pump driven by a 25-horsepower electric motor. This pump discharges directly into the distribution system close to a 100,000-gallon elevated steel tank connected to the system.

Eleven hundred service connections were in use in 1925. The rate for water is $300 for the first 3000 gallons, 25 cents per 1000 gallons for the next 22,000 gallons and 20 cents per 1000 gallons for additional water. A discount is allowed if paid in 30 days.

Water is secured from three wells. One well, number 1, was drilled in 1907. It is located about 100 feet east of Fox River and 125 feet north of Main Street. The well is 8 inches in diameter and 350 feet deep. Limestone is entered a few feet below the surface. This well was equipped with a deep-well pump with the cylinder at a depth of 60 feet. The yield was said to be 150 gallons a minute in 1911 and the water level was not drawn down to the pump cylinder. When not pumping the water level raised to within six or eight feet of the top of the well. In 1914 the pump in this well was at times operated 24 hours a day. The yield was then given as 120 gallons a minute. This well has not been used much since 1919.

Well number 2 was drilled in 1911. It is located about a quarter of a mile northeast of well number one on land about 50 feet higher. The well is 10 inches in diameter at the top and 850 feet deep. It was equipped with a deep-well pump with the cylinder at a depth of 125 feet. Shortly after this well was drilled it furnished practically the entire supply. The yield was said to be 160 gallons a minute. The water level was 25 feet below the ground surface when not pumping and was lowered 80 feet by pumping. In 1914 the pump in this well was at times operated 24 hours a day. The displacement of the pump at the speed operated was said to be 105 gallons a minute. This well is seldom used since 1919.

Well number three was drilled in 1918-1919 by F. M. Gray, Jr. of Milwaukee. It is located close to well number one near the main pumping station.

An abstract of a record of material penetrated, on file with the State Geological Survey Division is as follows:

	Thickness in feet.	Depth in feet.
Drift	5	5
Limestone, Silurian system, all or chiefly Niagaran	135	140
Shale, Richmond	100	240
Limestone, Galena-Platteville	320	560
Sandstone, St. Peter	320	880
Limestone, Prairie du Chien	140	1020
Sandstone, Mazomanie-Dresbach, Cambrian system	240	1260
Marl, Eau Claire, Cambrian system	130	1390
Sandstone, Eau Claire, Cambrian system	100	1490
Marl, Eau Claire, Cambrian system	150	1640
Sandstone, Eau Claire, Cambrian system	560	2200

The well was drilled 20 inches in diameter to a depth of more than 200 feet, 15 inches in diameter below the 20-inch hole to a depth of about 475 feet, 12 inches in diameter below the 15-inch hole to a depth of 489 feet, 10 inches in diameter between depths of 489 and 865 feet, and 8 inches in diameter below a depth of 865 feet. Casing 20 inches in diameter was placed to a depth of 10 feet and 12-inch and 10-inch casing connected with a coupling was placed to a depth of 489 feet. A rubber seal was placed at the bottom of the casing. About 100 feet of casing was placed with the bottom at a depth of 930 feet. Water was encountered at a depth of 65 feet with static head about 40 feet below the ground surface; at a depth of from 85 to 90 feet with a static head about 20 feet below the ground surface; and at a depth of 335 feet with a static head about 10 feet below the ground surface. This water was sealed off by the casing. Below the casing little water was encountered above St. Peter sandstone and water from that sandstone raised to within 31 feet of the top of the hole. When drilling between depths of 1180 and 1185 feet the head dropped 3½ feet.

The well is equipped with an American centrifugal pump with the bottom of the impellers at a depth of 110 feet and 40 feet of suction pipe is attached to the bottom of the pump. On completion of the well, it was tested by pumping 100,000 gallons into the reservoir and the yield was 555 gallons a minute. In 1919 the pump was operated about 18 hours a day. When not pumping for 48 hours water raised to within 14 feet of the ground surface. When pumping the water level was below the bottom of an air line placed to a depth of 104 feet. Conditions were about the same in 1924 as in 1919. The well was then operated about 6 hours a day in the winter and 24 hours a day in the summer.

Analysis of Sample Number 43318 from the City Well 2198 Feet Deep.

Determinations Made.

	Parts per million.
Iron Fe	0.4
Manganese Mn	0.0
Silica SiO_2	9.9
Nonvolatile	1.1
Alumina Al_2O_3	1.3
Calcium Ca	69.6
Magnesium Mg	14.5
Ammonia NH_4	0.7
Potassium K, Sodium Na	33.7
Sulfate SO_4	19.8
Nitrate NO_3	1.1
Chlorine Cl	24.0
Alkalinity Methyl Orange	246.
Residue	313.

Hypothetical Combinations.

	Parts per million.	Grains per gallon.
Sodium Nitrate $NaNO_3$	1.4	.09
Sodium Chloride NaCl	39.6	2.31
Sodium Sulfate Na_2SO_4	29.3	1.70
Sodium Carbonate Na_2CO_3	18.9	1.11
Ammonium Carbonate $(NH_4)_2CO_3$	1.9	.11
Magnesium Carbonate $MgCO_3$	50.1	2.93
Calcium Carbonate $CaCO_3$	173.9	10.17
Iron Oxide Fe_2O_3	0.6	.03
Alumina Al_2O_3	1.3	.08
Silica SiO_2	9.9	.58
Nonvolatile	1.1	.07
Total	328.0	19.18

Analysis of Sample Number 28354 from the City Well 350 Feet Deep.

Determinations Made.

	Parts per million.
Iron Fe	0.8
Silica SiO_2	15.4
Nonvolatile	3.0
Alumina Al_2O_3	2.6
Calcium Ca	85.1
Magnesium Mg	45.7
Ammonia NH_4	0.3
Potassium K	14.7
Sodium Na	52.8
Sulfate SO_4	98.1
Nitrate NO_3	22.1
Chloride Cl	27.0
Alkalinity Methyl Orange	332.
Residue	548.

Hypothetical Combinations.

	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	36.0	2.10
Potassium Chloride KCl	1.5	.09
Sodium Chloride NaCl	43.4	2.53
Sodium Sulfate Na_2SO_4	110.1	6.42
Ammonium Sulfate $(NH_4)_2SO_4$	1.1	.06
Magnesium Sulfate $MgSO_4$	28.7	1.67
Magnesium Carbonate $MgCO_3$	138.2	8.06
Calcium Carbonate $CaCO_3$	212.4	12.39
Iron Carbonate $FeCO_3$	1.7	.10
Alumina Al_2O_3	2.6	.15
Siica SiO_3	15.4	.90
Nonvolatile	3.0	.17
Total	594.1	34.64

Water from the well 2198 feet deep had a mineral content of 328, a total hardness of 233, and a content of iron of 0.4 parts per million as shown by the analysis of sample number 43318, collected on June 22, 1921.

A sample, number 28354, collected from the well 350 feet deep in 1914 had a mineral content of 594 and a total hardness of 400 parts per million. It contained 98 parts of sulphates, considerably more than contained in water from the well 2198 feet deep.

A sample of water, number 28355, collected in 1914 from the well 850 feet deep had a mineral content of 400, a total hardness of 287, and a content of iron of 0.4 parts per million as shown by the analysis.

Analysis of Sample Number 28355 from the City Well 850 Feet Deep.

Determinations Made.	Parts per million.
Iron Fe	0.4
Silica SiO_2	10.7
Nonvolatile	1.0
Alumina Al_2O_3	1.5
Calcium Ca	64.6
Magnesium Mg	30.7
Ammonia NH_4	1.0
Potassium K	13.0
Sodium Na	34.7
Sulfate SO_4	29.7
Nitrate NO_3	3.9
Chloride Cl	4.0
Alkalinity Methyl Orange	330.
Residue	375.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	6.4	.37
Potassium Chloride KCl	8.4	.49
Potassium Sulfate K_2SO_4	13.6	.79
Sodium Sulfate Na_2SO_4	32.8	1.91
Sodium Carbonate Na_2CO_3	55.4	3.23
Ammonium Carbonate $(NH_4)_2CO_3$	2.7	.16
Magnesium Carbonate $MgCO_3$	106.3	6.20
Calcium Carbonate $CaCO_3$	161.3	9.41
Iron Carbonate $FeCO_3$	.8	.05
Alumina Al_2O_3	1.5	.09
Silica SiO_2	10.7	.62
Nonvolatile	1.0	.06
Total	400.9	23.38

SAN JOSE (586). San Jose is located in Mason and Logan Counties on the drainage area of Salt Creek, a tributary of Sangamon River. Some private wells have been dug to a stratum of sand at a depth of about 30 feet and others have been drilled to a stratum of sand at a depth of about 100 feet.

A public water supply was installed by the village about 1885. Water was pumped from a well into a small pipe line to which two small wooden tanks were connected. The pump was operated by a windmill. Later three cisterns were built in the village. These were filled from the well and water was pumped from the cisterns by hand pumps. With increase in the number of house connections these cisterns are now little used. Another well has been drilled, steam-head pumps have been installed in the wells, and a steel pressure tank has been installed to replace the two small wooden tanks. In 1919 the Hullinger Electric Company were operating the station

for the city and were installing an electric plant in part of the pumping station building and an adjoining building. Improvements made since that date are not recorded here. Fifty feet of 6-inch pipe extends from the pumping station to a fire hydrant. All other pipe is of small size. Water is sold at flat rates.

Water for the public supply is secured from two wells into sand and gravel located 20 feet apart. The elevation at the top of the wells is about 598 feet above sea level. One well was drilled about 1885 and was drilled deeper in 1911. It is cased with 4-inch pipe to a depth of 85 feet and below the casing is 20 feet of Cook screen. The well is equipped with a deep-well pump with the cylinder wedged in the casing close to the top of the screen. The depth to water when not pumping was reported to be 80 feet in 1914.

The other well was drilled by Smith Brothers of San Jose in 1917. It is cased with 6-inch pipe to a depth of 90 feet and below the casing is 10 feet of Cook screen. The well is equipped with a deep-well pump with the cylinder wedged in the casing near the top of the screen. The pump was operated in 1919 at about 25 strokes a minute at which speed the displacement was 90 gallons a minute. At times the pump was operated as much as six hours a day.

Water from the public supply had a mineral content of 507, a total hardness of 422, and a content of iron of 1.0 parts per million as shown by the analysis of sample number 42051, collected on November 5, 1919, from the pressure tank.

Analysis of Sample Number 42051 from the Village Supply.

Determinations Made.	Parts per million.
Iron Fe	1.0
Silica SiO_2	13.0
Nonvolatile	0.3
Alumina Al_2O_3	1.4
Calcium Ca	102.1
Magnesium Mg	40.8
Ammonia NH_4	0.1
Potassium K } Sodium Na }	16.8
Sulfate SO_4	60.1
Nitrate NO_3	53.1
Nitrite NO_2	0.1
Alkalinity Methyl Orange	302.0
Residue	526.0
Chloride Cl	39.0

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Sodium Nitrate $NaNO_3$	62.1	3.63
Ammonium Nitrate $(NH_4)_2NO_3$	0.3	.02
Magnesium Chloride $MgCl_2$	52.4	3.06
Magnesium Sulfate $MgSO_4$	75.3	4.41
Magnesium Carbonate $MgCO_3$	37.0	2.16
Magnesium Nitrate $MgNO_3$	9.1	.53
Calcium Carbonate $CaCO_3$	255.1	14.92
Iron Oxide Fe_2O_3	1.4	.08
Alumina Al_2O_3	1.4	.08
Silica SiO_2	13.0	.76
Nonvolatile	0.3	.02
Total	507.4	29.67

The water is used in boilers at the pumping station without treatment. It forms hard scale and causes some corrosion. No

trouble from corrosion of service connections or well casings was reported and some casing in the 4-inch well had, in 1919, been in use for about 35 years.

SANDWICH (2409). Sandwich is located in the southeastern part of DeKalb County on the drainage area of Fox River, a tributary of Illinois River. A public water supply was installed by the city in 1884. Water was secured from two 8-inch wells, each 120 feet deep. They were located 2 feet 6 inches apart near the center of the city. Water from the wells flowed into a reservoir 10 feet in diameter and 30 feet deep, located beneath the floor of the pumping station. The flow from the wells was sufficient to supply demands until 1910 when pumps were installed. In 1911 another well was drilled and water for the public supply has been secured from this well since 1912. Water is drawn from the well by suction and is discharged directly into the distribution system and an elevated tank connected to the system. An American 2½-inch single-stage centrifugal pump driven by a 20-horsepower electric motor is generally used. An American 5-inch two-stage centrifugal pump driven by a 75-horsepower electric motor is available. A steam pump and two boilers formerly in regular service were also available in 1922.

Nearly all people in the city use water from the public supply and nearly 900 service connections were in use in 1922. The rate for 400 gallons of water or less per day is 30 cents per 1000 gallons. The lowest rate, for water in excess of 10,000 gallons a day, is 10 cents per 1000 gallons and the minimum charge is 50 cents a month.

Water is secured from a well drilled by the J. P. Miller Artesian Well Company of Chicago in 1911. It is located a short distance east of the center of the business district of the city. The top of the well is about 667 feet above sea level. The material penetrated, as given by the drillers, is as follows:

	Thickness in feet.	Depth in feet.
Clay, sand and gravel	131	131
Soft, "shelly" rock	4	135
Sandstone, fine in streaks	2	137
Soft, "shelly" rock	1	138
Sandy limestone	14	152
Limestone, brown, "shelly"	2	154
Limestone, hard	8	162
Limestone	128	290
Marl, red	5	295
Shale, green	102	397
"Quartz" rock	18	415
Sandstone, St. Peter	181	596
Shale	4	600

The well is cased with 12-inch pipe to a depth of 139 feet and is 12 inches in diameter at the bottom. When completed a pump was installed on 122 feet of drop pipe and water was pumped at a rate of 275 gallons a minute.

A suction pipe about 10 feet below the ground surface extends from a pit at the top of the well to the pumping station near by. During the summer of 1921 the amount of water pumped was estimated at from 190,000 to 200,000 gallons a day and on some days as much as 500,000 gallons was pumped. The water level on April 7, 1921, was 12 feet 9 inches below the center of the suction pipe when not pumping and it was lowered 5 feet 1 inch when pumping at a rate of 280 gallons a minute.

Water for the public supply had a mineral content of 347, a total hardness of 312, and a content of iron of 0.8 parts per million as shown by the analysis of sample number 47186, collected on March 9, 1922.

Analysis of Sample Number 47186 from the City Supply.

Determinations Made.	Parts per million.
Iron Fe	0.8
Manganese Mn	Trace
Silica SiO_2	17.1
Nonvolatile	1.1
Alumina Al_2O_3	2.0
Calcium Ca	65.6
Magnesium Mg	36.1
Ammonia NH_4	0.3
Sodium Na	11.7
Potassium K	2.8
Sulfate SO_4	10.9
Nitrate NO_3	0.2
Chloride Cl	3.0
Alkalinity Methyl Orange	336.
Residue	352.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	0.3	.02
Potassium Chloride KCl	5.2	.30
Sodium Chloride NaCl	0.8	.05
Sodium Sulfate Na_2SO_4	16.1	.95
Sodium Carbonate Na_2CO_3	14.0	.82
Ammonium Carbonate $(NH_4)_2CO_3$	0.8	.05
Magnesium Carbonate $MgCO_3$	124.8	7.30
Calcium Carbonate $CaCO_3$	163.9	9.58
Silica SiO_2	17.1	1.00
Nonvolatile	1.1	.06
Iron Oxide Fe_2O_3	1.2	.07
Alumina Al_2O_3	2.0	.12
Total	347.3	20.32

This sample was similar to a sample collected in February, 1912, shortly after the well was completed.

SAVANNA (5237). Savanna is located in the western part of Carroll County on the east bank of Mississippi River. A public water supply was installed by the city in 1890. Water was secured from a well into Cambrian sandstone. Two other wells have been drilled. Water flows from the wells into a collecting reservoir about 40 feet in diamater and 8 feet 6 inches deep. In the center of the reservoir is a pier. From measurements made by the Allis-Chalmers Company the capacity of the reservoir was taken as 9,320 gallons

per foot depth. Water is pumped from the reservoir into the distribution system by an Allis-Chalmers 6-inch centrifugal pump which is driven by an 85-horsepower electric motor. A reservoir of stone masonry located on bluffs east of the city is connected to the distribution system. The capacity of the reservoir is about 570,000 gallons.

Fifteen hundred service connections were in use in 1925. Rates for water are 18 cents per 1000 gallons for the first 250,000 gallons, 14 cents per 1000 gallons for the next 250,000 gallons, 12 cents per 1000 gallons for the next 250,000 gallons, and 10 cents per 1000 gallons for the fourth 250,000 gallons.

Water for the public supply is secured from three wells. One, number 1, was drilled by the J. P. Miller Artesian Well Company of Chicago in 1890. It is located at the foot of Washington Street on the west side of Main Street. It is 1432 feet deep, 8 inches in diameter to a depth of 400 feet, and 5 inches in diameter below that depth. Including $98.05 paid for casing and repairs the cost was $3,456.05. The pressure at the ground surface was 30 pounds in 1890,18 pounds in 1906, and 15 pounds in 1908. Water is discharged into the collecting reservoir through a pipe which goes over the top of the well about 3 feet above the floor of the pumping station. The drillers noted a flow of 500 gallons a minute. The flow, apparently recorded for 1908, was 260 gallons a minute.

Well number 2 is located on Third Street, 25 feet south of Murray Street, about 1700 feet distant from well number 1, on ground 12 or 14 feet higher than the ground surface at well number 1. It was drilled in 1908 as a cost of $3,462.25. The bore is 13 inches in diameter to a depth of 225 feet, 10 inches between depths of 225 and 445 feet, and 8 inches below a depth of 445 feet to the bottom of the well at a depth of 1443 feet. A record of material penetrated with part of the classifications by the State Geological Survey Division is as follows:

	Thickness in feet.	Depth in feet.
Drift	3	3
Limestone, Galena-Platteville	345	348
White sandstone, St. Peter	120	468
Shale (caving), Prairie du Chien	5	473
Limestone, Prairie du Chien	55	528
Red marl, Prairie du Chien	3	531
Limestone with pockets of coarse sand	367	898
Blue shale, St. Lawrence, Cambrian system	80	978
White sandstone, Franconia, Cambrian system	110	1088
Blue shale, Franconia, Cambrian system	30	1118
White sandstone, Mazomanie, Cambrian system	40	1158
Limestone, Eau Claire, Cambrian system	100	1258
Red marl, Eau Claire, Cambrian system	10	1268
White sandstone, Mt. Simon, Cambrian system	170	1438

City records give casing as follows: "The first 225 feet is cased with 10-inch galvanized pipe and packed in a 13-inch hole on a shoulder of solid limestone with a shoulder rubber packer. Then an 8-inch galvanized pipe down 135 feet. Then 82 feet of 8-inch iron pipe at a point 445 feet through shale and marl to limestone." The first flow of water was recorded at a depth of 600 feet. The flow from the well in October, 1908, was 500 gallons a minute and the pressure with no flow was 14 pounds per square inch.

Well number 3 was drilled by C. P. Brant and Company in 1917. It is located at the corner of Chicago Avenue and Main Street about 300 feet distant from well number 1, on ground about seven feet lower than the pumping station floor. The well was drilled 12 inches in diameter to a depth of 760 feet, 10 inches in diameter between depths of 760 and 880 feet, and 8 inches in diameter below a depth of 880 feet to the bottom of the well at a depth of 1852 feet. The well is cased with 15-inch pipe to rock at a depth of 30 feet, with 12-inch pipe to a depth of 80 feet, and with 8-inch pipe from the ground surface to a depth of 880 feet. Cement is placed around the 12-inch pipe above the rock surface. The first flow of water was at a depth of 375 feet and the second flow was at a depth of 910 feet. The flow was reported to have increased at a depth of 1100 feet and again at a depth of 1800 feet. The pressure at the top of the well at the time of completion was 11 pounds inside of the 8-inch casing, and 4½ pounds outside of the 8-inch casing. The flow was 312 gallons a minute. Water is discharged into the collecting reservoir four feet above the bottom.

The water consumption during the summer of 1916 was nearly 700,000 gallons a day which was about equal to the yield of the two wells then in use, wells number 1 and number 2.

The flow from the three wells when the water level in the reservoir raised from two feet above the bottom to five feet above the bottom at the time of test by the Allis-Chalmers Company in December, 1919, was 665 gallons a minute.

The yield during a test in October, 1920, was 660 gallons a minute when the water level was drawn down to near the bottom of the reservoir and about 606 gallons a minute when the reservoir was nearly full. The amount of water used in 1920 averaged near 800,000 gallons a day.

A sample of water collected on October 7, 1920, from well number 3 which is 1852 feet deep, had a mineral content of 332, a total hardness of 267, and a content of iron of 0.8 parts per million as shown by the analysis of sample number 43969.

Analysis of Sample Number 43969 from Well Number 3.

Determinations Made.	Parts per million.
Iron Fe	0.8
Manganese Mn	0.0
Silica SiO_2	18.4
Nonvolatile	1.0
Alumina Al_2O_3	1.7
Calcium Ca	69.6
Magnesium Mg	22.7
Ammonium NH_4	1.6
Potassium K, Sodium Na	18.8
Sulfate SO_4	19.3
Nitrate NO_3	3.2
Chloride Cl	7.0
Alkalinity	
Phenolphthalein	0.
Methyl Orange	272.
Residue	326.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Sodium Nitrate $NaNO_3$	4.34	.254
Sodium Chloride NaCl	11.52	.673
Sodium Sulfate Na_2SO_4	28.56	1.670
Sodium Carbonate Na_2CO_3	8.70	.509
Ammonium Carbonate $(NH_4)_3CO_3$	4.37	.256
Magnesium Carbonate $MgCO_3$	78.50	4.590
Calcium Carbonate $CaCO_3$	174.00	10.178
Silica SiO_2	18.40	1.076
Nonvolatile	1.00	.058
Iron Oxide Fe_2O_3	1.14	.066
Alumina Al_2O_3	1.66	.097
Total	332.19	19.427

Water from well number 2 which is 1443 feet deep is similar in quality though the iron content of a sample collected is lower. A sample, number 43968, collected from this well on the same day the sample referred to above was collected from well number 3; had a mineral content of 309, a total hardness of 260, and a content of iron of 0.2 parts per million as shown by the analysis.

Analysis of Sample Number 43968 from Well Number 2.

Determinations Made.	Parts per million.
Iron Fe	0.2
Manganese Mn	0.0
Silica SiO_2	12.7
Nonvolatile	0.7
Alumina Al_2O_3	1.3
Calcium Ca	59.1
Magnesium Mg	27.6
Ammonium NH_4	1.4
Potassium K, Sodium Na	16.5
Sulfate SO_4	18.4
Nitrate NO_3	2.5
Chloride Cl	6.0
Alkalinity	
Phenolphthalein	0.
Methyl Orange	266.
Residue	308.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Sodium Nitrate $NaNO_3$	3.40	.199
Sodium Chloride NaCl	9.88	.578
Sodium Sulfate Na_2SO_4	27.21	1.591
Sodium Carbonate Na_2CO_3	6.63	.388
Ammonium Carbonate $(NH_4)_2CO_3$	3.84	.225
Magnesium Carbonate $MgCO_3$	95.44	5.581
Calcium Carbonate $CaCO_3$	147.60	8.627
Silica SiO_2	12.70	.743
Nonvolatile	0.70	.041
Iron Oxide Fe_2O_3	0.28	.016
Alumina Al_2O_3	1.32	.077
Total	309.00	18.066

When the water was used in boilers at the pumping station it was first treated with boiler compound. A feed water heater in use was cleaned every three or four months. Boilers were blown off every day and cleaned about every fifty days.

SCHILLER PARK (390). Schiller Park is located in Cook County near the west bank of Des Plaines River. A public water supply was being installed by the village in 1924. Water is to be pumped from a well into the distribution system and an elevated steel tank of 50,000 gallons capacity which is connected to the system, by a Luitwieler deep-well pump.

The well was drilled by the W. L. Thorne Company of Des Plaines in 1923. The elevation of the ground surface at the well is about 630 feet above sea level. The well is cased with 12-inch pipe to rock at a depth of 77 feet. Below the casing the well is in limestone and is 10 inches in diameter to the bottom at a depth of 252 feet. The bottom is on shale. Water stands 20 feet below the ground surface. The well was tested by pumping at a rate of about 100 gallons a minute.

SEATON (297). Seaton is located in the southern part of Mercer County about ten miles east of Mississippi River. A public water supply was installed by the village in 1912. The installation includes a well, a pumping station, a deep-well pump, a distribution system, and an elevated steel tank of 20,000 gallons capacity which is connected to the system. The pump is driven by a 5-horsepower electric motor and discharges directly into the distribution system. Electric current is purchased from the Northern Illinois Utilities Company. Eighty-five service connections were in use in 1923. The rate for water is 35 cents per 1000 gallons with a minimum charge of $1.00 a quarter. Bills are not subject to cash discount.

Water is obtained from a well 244 feet deep which was drilled by W. S. Van Tile of Millersburg in 1912. The top of the well is about 615 feet above sea level. Mr. Van Tile states that the well penetrated 40 feet of soil and clay, 83 feet of sand, and 121 feet of limestone. It is cased with 5-inch pipe to a depth of 128 feet. The well is equipped with an American single-acting deep-well pump with a 3¼-inch cylinder and 24-inch stroke. The cylinder is placed at a depth of 100 feet and 36 feet of suction pipe is attached. When the pump is in good condition it is operated from five to six hours a day at 35 revolutions a minute, a displacement of 30 gallons a minute. When the well was completed the depth to water was 50 feet.

The water as it comes from the well contains some hydrogen sulphide. It had a mineral content of 564, a total hardness of 196, and a content of iron of 0.2 parts per million as shown by the analysis of sample number 49810, collected on July 26, 1923.

Analysis of Sample Number 49810 from the Village Supply.

Determinations Made.	Parts per million.
Iron Fe	0.2
Manganese Mn	0.0
Silica SiO_2	13.0
Nonvolatile	2.1
Alumina Al_2O_3	0.9
Calcium Ca	23.3
Magnesium Mg	33.7
Ammonia NH_4	14.4
Sodium Na	119.6
Potassium K	25.7
Sulfate SO_4	21.6
Nitrate NO_3	1.4
Chloride Cl	35.0
Alkalinity	
Phenolphthalein	0
Methyl Orange	460.
Residue	602.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	2.3	0.13
Potassium Chloride KCl	47.3	2.76
Sodium Chloride NaCl	20.6	1.20
Sodium Sulfate Na_2SO_4	31.9	1.86
Sodium Carbonate Na_2CO_3	233.1	13.61
Ammonium Carbonate $(NH_4)_2CO_3$	38.3	2.24
Magnesium Carbonate $MgCO_3$	116.8	6.83
Calcium Carbonate $CaCO_3$	58.3	3.40
Iron Oxide Fe_2O_3	0.3	0.02
Alumina Al_2O_3	0.9	0.05
Silica SiO_2	13.0	0.76
Nonvolatile	2.1	0.12
Total	564.9	32.98

This water is less highly mineralized and is not so hard as some waters used for public water supplies in this section of the state.

SECOR (311). Secor is located in the central part of Woodford County on the drainage area of Mackinaw River, a tributary of Illinois River. Many private wells in use are about 70 feet deep.

A public water supply was installed by the village about 1895. The installation included a well with pumping equipment, a pressure tank, and a few blocks of mains. In 1914 another well was drilled. The distribution system has been extended and other improvements have been made. Water is pumped from the wells into the mains and a pressure tank connected to the mains by two deep-well pumps driven from a shaft which is turned by a 10-horsepower electric motor. A gas engine formerly in regular service can be used in emergency. The tank is 8 feet in diameter and 36 feet long.

About 30 service connections were in use in 1924.

Water for the public supply is secured from two wells in drift, located nine feet apart near the center of the village. The elevation at the tops of the wells is about 740 feet above sea level.

The older well, which supplied all water until 1914, is 6 inches in diameter and 115 feet deep. It is equipped with a single-acting deep-well pump with a 4¼-inch cylinder and 18-inch stroke. The pump is driven by belt from a shaft at a speed of 24 revolutions a minute. The depth to water in 1915 was 60 feet and in 1922, when operating this pump, the depth to water in the well 10 feet distant was 74 feet.

The well drilled in 1914 is 10 feet south of the older well. It is 8 inches in diameter and 158 feet deep. At the bottom is a screen 17½ feet long placed in sand and gravel. It is said that four water bearing strata were cased off. The well is equipped with a Myers deep-well pump with a 5¾-inch cylinder and 24-inch stroke. The cylinder is placed at a depth of about 132 feet. No suction pipe is attached. The pump is geared to the shaft and operates 22½ revolutions a minute. The water level in 1915 was reported to be 85 feet below the ground surface, 25 feet lower than in the well into a shallower water bearing stratum. In 1922, when pumping from the shallower well, the depth to water in this well was said to be 74 feet.

Both pumps were operated at the same time for four or five hours a day in 1924. The displacement was 86 gallons a minute. Allowing twenty per cent slip the amount of water pumped was about 15,000 gallons a day.

Water from the well 115 feet deep had a mineral content of 462, a total hardness of 393, and a content of iron of 4.0 parts per million as shown by the analysis of sample number 48838, collected on December 19, 1922.

Analysis of Sample Number 48838 from Village Well 115 Feet Deep.

Determinations Made.	Parts per million.
Iron Fe	4.0
Manganese Mn	0.0
Silica SiO_2	18.9
Nonvolatile	1.1
Alumina Al_2O_3	2.2
Calcium Ca	90.2
Magnesium Mg	41.0
Ammonia NH_4	8.7
Sodium Na	13.9
Potassium K	2.8
Sulfate SO_4	0.4
Nitrate NO_3	13.9
Chloride Cl	2.0
Alkalinity	
Methyl Orange	446.
Residue	481.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	6.8	.39
Sodium Nitrate $NaNO_3$	13.6	.58
Sodium Chloride NaCl	3.3	.19
Sodium Sulfate Na_2SO_4	0.6	.04
Sodium Carbonate Na_2CO_3	20.0	1.17
Ammonium Carbonate $(NH_4)_2CO_3$	23.3	1.36
Magnesium Carbonate $MgCO_3$	141.9	8.29
Calcium Carbonate $CaCO_3$	225.1	13.15
Silica SiO_2	18.9	1.10
Nonvolatile	1.1	.06
Iron Oxide Fe_2O_3	5.7	.33
Alumina Al_2O_3	2.2	.13
Total	462.5	26.79

The analysis of a sample of water, number 48874, collected from the deeper well in December, 1922, shows that the waters are of similar quality. Water from the deeper well was a little more highly mineralized and a little harder. The mineral content was 526, the total hardness 465, and the content of iron 3.0 parts per million.

Analysis of Sample Number 48874 from Village Well 158 Feet Deep.

Determinations Made.	Parts per million.
Turbidity	55.0
Residue	563.0
Iron Fe	3.0
Manganese Mn	0.0
Nitrate NO_3	2.1
Chloride Cl	2.0
Sulfate SO_4	0.0
Alkalinity Methyl Orange	562.0
Ammonia NH_4	10.6
Magnesium	49.4
Calcium	105.2

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Calcium Carbonate $CaCO_3$	262.6	15.30
Magnesium Carbonate $MgCO_3$	168.8	9.87
Ammonium Carbonate $(NH_4)_2CO_3$	28.2	1.65
Sodium Carbonate Na_2CO_3	60.6	3.54
Sodium Chloride NaCl	3.2	.19
Sodium Nitrate $NaNO_3$	2.9	.17
Total	526.4	30.72

SHABBONA (735). Shabbona is located in the southwestern part of De Kalb County, close to the watershed between Fox and Rock Rivers. A public water supply was installed by the village in 1897. The contract price was $5,000. Water is secured from two wells, each equipped with a deep-well pump driven through gears by a 15-horsepower electric motor. The pumps can be operated by belt from a shaft driven by a 35-horsepower gas engine. Water is pumped into two steel pressure tanks each 8 feet in diameter and 36 feet long which are connected to the distribution system. A gas plant was formerly operated in the same building in which the pumping equipment is located. A tank which was used at that plant is now connected to the pressure tanks to provide additional storage. Air for the tanks is supplied by a Curtis 8 by 8-inch two-cylinder compressor driven from a shaft, or by a small compressor driven by belt from a 6-horsepower gas engine. Electric power is purchased from the Northern Illinois Utilities Company.

About 150 service connections were in use in 1922 and all were metered. The rate for water was 50 cents for three months in addition to 30 cents per 1,000 gallons. The average daily consumption was 27,000 gallons.

The Chicago, Burlington and Quincy Railroad has a private supply from a 12-inch well, 147 feet deep, which is equipped with a pump of 100 gallons a minute capacity. The well is about 300 feet distant from the nearer village well.

The public water supply is secured from two wells into sand and gravel. The tops of the wells are about 820 feet above sea level. One well is 10 inches in diameter and about 150 feet deep. The other well is 8 inches in diameter and about 150 feet deep. Each well is equipped with a single-acting deep-well pump with a

7¾-inch cylinder placed at a depth of about 140 feet. In 1922 one pump was operated with 24-inch stroke and the other with 26-inch stroke and the discharge, as computed approximately from rise in water level in the tanks, was 268 gallons a minute. The total amount of water pumped was estimated at 27,000 gallons a day. The water level in the wells when not pumping was said to be from 90 to 100 feet below the ground surface.

The temperature of water as it comes from the wells was 51 degrees Fahrenheit. The water had a mineral content of 373, a total hardness of 330, and a content of iron of 2.6 parts per million as shown by the analysis of sample number 47179, collected on March 7, 1922.

Analysis of Sample Number 47179 from the Village Supply.

Determinations Made.	Parts per million.
Iron Fe	2.6
Manganese Mn	0.0
Silica SiO_2	18.3
Nonvolatile	1.1
Alumina Al_2O_3	1.2
Calcium Ca	72.1
Magnesium Mg	36.4
Ammonia NH_4	0.8
Sodium Na	16.1
Nitrate NO_3	0.5
Chloride Cl	2.0
Potassium K	2.0
Sulfate SO_4	0.0
Alkalinity Methyl Orange	362.
Residue	371.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	0.8	.05
Potassium Chloride KCl	3.2	.24
Sodium Chloride NaCl	0.7	.04
Sodium Carbonate Na_2CO_3	36.5	2.13
Ammonium Carbonate $(NH_4)_2CO_3$	2.1	0.12
Magnesium Carbonate $MgCO_3$	126.1	7.37
Calcium Carbonate $CaCO_3$	180.1	10.53
Silica SiO_2	18.3	1.07
Nonvolatile	1.1	.06
Iron Oxide Fe_2O_3	3.7	.21
Alumina Al_2O_3	1.2	.07
Total	373.8	21.89

The water had little effect on meters or galvanized service pipes.

SHANNON (636). Shannon is located in the northeastern part of Carroll County on the drainage area of Rock River. Rock lies at a depth of about 10 feet on high land in the village and at a depth of from 20 to 30 feet on low land.

A public water supply including a well, a pumping station, a pump driven by a windmill, an elevated tank, and three or four blocks of mains, was installed by the village in 1894. The well is now equipped with a deep-well pump which is driven by a 5-horsepower electric motor. A gas engine can be used in case of emergency. Water is pumped directly to the elevated tank and distribution system. About sixty-five service connections were in use in 1921. The rate for water was 50 cents per 1,000 gallons with no fixed minimum charge.

Water is secured from a well 6 inches in diameter and 200 feet deep. The top of the well is about 940 feet above sea level. An approximate record of material penetrated was given by G. W. Whitmer, well driller, as follows:

Soil	10 feet
Limestone, Silurian system	80 feet
Slate, Maquoketa	100 feet
Hard gray rock, Galena	about 25 feet

The depth to water when the well was drilled was 80 feet. The well is equipped with a single-acting deep-well pump with a 3¾-inch cylinder placed at a depth of 190 feet. In 1921 the pump was operated from four to five hours a day with 18-inch stroke at a rate of 27 strokes a minute, a displacement of 23 gallons a minute.

The temperature of water from the well after passing through a short length of pipe was 51 degrees Fahrenheit. The water had a mineral content of 434 and a total hardness of 332 parts per million as shown by the analysis of sample number 46394, collected on October 18, 1921.

Analysis of Sample Number 46394 from the Village Supply.

Determinations Made.	Parts per million.
Iron Fe	0.1
Manganese Mn	0.1
Silica SiO_2	17.1
Nonvolatile	0.6
Alumina Al_2O_3	1.5
Calcium Ca	82.1
Magnesium Mg	30.8
Ammonia NH_4	0.0
Potassium K	2.8
Sodium Na	22.2
Sulfate SO_4	45.7
Nitrate NO_3	53.1
Chloride Cl	21.0
Alkalinity	
Phenolphthalein	0
Methyl Orange	260.
Residue	431.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	7.2	.42
Sodium Nitrate $NaNO_3$	66.7	3.90
Sodium Chloride NaCl	10.6	.62
Ammonium Chloride NH_4Cl	0.1	.00
Magnesium Chloride $MgCl_2$	19.5	1.14
Magnesium Sulfate $MgSO_4$	57.2	3.35
Magnesium Carbonate $MgCO_3$	49.2	2.88
Calcium Carbonate $CaCO_3$	205.0	11.99
Silica SiO_2	17.1	1.00
Nonvolatile	0.6	.04
Iron Oxide Fe_2O_3	0.2	.01
Alumina Al_2O_3	1.5	.09
Total	434.9	25.44

The iron content in samples varies somewhat. This water causes some stain on plumbing fixtures indicating that in the average supply the iron content is more than 0.1 parts per million as shown by the analysis.

SHEFFIELD (996). Sheffield is located in the western part of Bureau County on the drainage area of Green River, a tributary of Rock River. Water from wells 30 to 50 feet deep is in general

use for drinking and cistern water is in general use for washing. A public water supply was installed by the village about 1893. Water is pumped from a well into the distribution system and an elevated steel tank of 80,000 gallons capacity connected to the system, by an American deep-well pump which is driven by an electric motor. The amount of water pumped is registered by a meter at the station. Water is sold at a rate of 25 cents per 100 cubic feet, with a minimum annual charge of $5.00 which allows the use of 500 cubic feet.

The supply was first obtained from a well 9 feet in diameter and 46 feet deep. Later another well was drilled close by and the two wells were connected near the bottom by a 2-inch pipe. The original well has since been filled in. The well in use is 10 feet in diameter at the top and about 7 feet in diameter at the bottom. It is said to be cased with brick to a depth of about 32 feet and to be curbed with wood below that depth with the curbing driven into blue clay. The well is equipped with a deep-well pump with the bottom of the cylinder two feet above the bottom of the well. On August 1 and on August 2, 1922, when the pump had been idle over night, the depth to water was 31 feet. Pumping for two hours and fifteen minutes lowered the water level 10 feet. The water level in private wells from 400 to 500 feet distant was from 5 feet to 11 feet lower than the ground surface at the village well and remained constant during the test. The time the pump was operated during June and July, 1922, is computed to have been 5 hours 45 minutes a day. The amount of water pumped, assuming the meter to have registered 13 per cent high as it did when tested on August 4, averaged 47,000 gallons a day. In very dry times the amount of water available is less than this quantity.

Analysis of Sample Number 28972 from the Village Supply.

Determinations Made.

	Parts per million.
Iron Fe	0.1
Manganese Mn.	0.2
Silica SiO_2	14.8
Nonvolatile	3.3
Alumina Al_2O_3	3.3
Calcium Ca	96.9
Magnesium Mg.	48.7
Ammonia NH_4	0.6
Potassium K	2.6
Sodium Na	22.6
Sulfate SO_4	69.8
Chloride Cl	13.0
Alkalinity Methyl Orange.	382.
Residue	505.

Hypothetical Combinations.

	Parts per million.	Grains per gallon.
Potassium Chloride KCl	5.0	.29
Sodium Chloride NaCl.	17.5	1.02
Sodium Sulfate Na_2SO_4.	48.4	2.81
Ammonium Sulfate $(NH_4)_2SO_4$.	2.1	.12
Magnesium Sulfate $MgSO_4$.	44.5	2.59
Magnesium Carbonate $MgCO_3$.	128.8	7.51
Calcium Carbonate $CaCO_3$.	241.8	14.10
Iron Carbonate $FeCO_3$.	0.2	.01
Manganese Carbonate $MnCO_3$.	0.4	.02
Silica, SiO_2	14.8	.86
Nonvolatile	3.3	.19
Total	506.8	29.52

A sample of water, number 28972, collected from the city wells on October 13, 1914, when the two wells were in use, had a mineral content of 506, a total hardness of 442, and a content of iron of 0.1 parts per million as shown by the analysis.

A well at the Coal Creek Country Club grounds was dug to a depth of 20 feet and blasted to a depth of 38 feet. The yield was very small and a 2-inch hole was drilled to a depth of 74 feet. Water raised to the ground surface. The yield is limited. The water had a mineral content of 461 and a total hardness of 53 parts per million which is considerably less than the hardness of the village supply.

A sample of water was collected on August 13, 1922, from a well near Coal Creek in section 31 about two miles south of the village. The well is known as the Wood's well. It is 8 feet by 4 feet at the top and 27 feet deep. The flow was 3 gallons a minute. The water had a mineral content of 330, a total hardness of 315, and a content of iron of 0.5 parts per million.

SHELBYVILLE (3568). Shelbyville is locateed in the central part of Shelby County on the drainage area of Kaskaskia River, a tributary of Mississippi River. Many private wells from 15 to 30 feet deep have been in use at residences. A public water supply was installed by a private company in 1885. Water was pumped from Kaskaskia River until 1889 when a supply was developed from wells. The plant is now owned by the City Water Company. Water is pumped from wells into a concrete lined reservoir of about 1,750,000 gallons capacity. In 1923 an American 5-inch centrifugal pump and an Alberger 8-inch centrifugal pump were in use for this service. The smaller pump was generally used. A centrifugal pump was being installed to pump water from the reservoir into the mains, replacing a steam pump formerly in regular service. A standpipe 12 feet in diameter and 125 feet high is connected to the mains.

Nine hundred and seventy-five service connections were in use in 1923, of which 750 were metered. The rate for the first 10,000 gallons of water used per month is 45 cents per 1,000 gallons and the lowest rate, for water in excess of 200,000 gallons a month, is 15 cents per 1,000 gallons.

Water for the public supply is secured from wells located close to the bank of Kaskaskia River a short distance east of the city, in the southeast quarter of the southwest quarter of' Section 8. The wells penetrate about 10 feet of silt, 10 feet of sand, and

from 4 to 10 feet of gravel. A test well using a screen with two thousand 3/8-inch holes yielded 125 gallons a minute.

Twenty-two wells were drilled in 1889. They were cased with 6-inch wrought iron pipe and the average depth was about 22 feet. Each well was about 20 feet distant from a main suction line to which all were connected, one on one side of the line and the next well on the opposite side of the line. The connections were about 50 feet apart. A 4-inch wrought iron drop pipe extended to a depth of about 18 feet in each well. During 1912 these wells supplied an average of about 300,000 gallons a day. A few of these wells have been abandoned and a few similar wells have been drilled and connected to the suction line. In 1923, twenty 6-inch wells and five 8-inch wells were in use.

Three large dug wells have been intalled, the last two in 1918. One well is 22 feet in diameter and 30 feet deep. The other two are 12 feet in diameter and 28 feet deep. They are located about 25 feet from the river bank and are lined with 12-inch concrete walls which extend 3 feet above high water level.

In 1918, when one dug well and twenty-three 6-inch driven wells were in use, the supply available was estimated at 1,250,000 gallons a day. The average consumption during the previous year had averaged 300,000 gallons a day.

The two wells 12 feet in diameter were repaired in 1923. Four-inch perforated pipes were forced out horizontally into gravel 25 feet below the tops of the walls.

Analysis of Sample Number 39741 from the Public Supply.

Determinations Made.	Parts per million.
Manganese Mn	0.3
Potassium K } Sodium Na }	18.1
Magnesium Mg	26.7
Calcium Ca	77.7
Iron Fe	0.6
Alumina Al_2O_3	4.4
Nitrate NO_3	3.5
Chloride Cl	9.0
Sulfate SO_4	70.9
Carbonate CO_3	156.0
Silica SiO_2	13.0
Nonvolatile	1.1
Alkalinity Methyl Orange	260.
Residue	413.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Sodium Nitrate $NaNO_3$	4.9	.28
Sodium Chloride NaCl	14.8	.86
Sodium Sulfate Na_2SO_4	33.8	1.97
Magnesium Sulfate $MgSO_4$	60.0	3.51
Magnesium Carbonate $MgCO_3$	50.5	2.95
Calcium Carbonate $CaCO_3$	194.1	11.32
Iron Carbonate $FeCO_3$	1.2	.07
Manganese Carbonate $MnCO_3$	0.6	.03
Alumina Al_2O_3	4.4	.26
Silica SiO_2	13.0	.76
Nonvolatile	1.1	.06
Total	378.4	22.07

Samples of water collected from this supply differ somewhat in mineral content as is to be expected with shallow wells into sand. The samples are, however, similar. Sample number 39741,

collected on July 15, 1918, had a mineral content of 378, a total hardness of 304, and a content of iron of 0.6 parts per million as shown by the analysis.

The iron content of some samples collected has been as high as 1.6 parts per million. Some trouble has been experienced with the growth of algae in the reservoir. Conditions were improved by treatment with copper sulphate using 10 pounds per million gallons of water or by frequent cleaning of the reservoir.

SHELDON (1182). Sheldon is located in the eastern part of Iroquois County on the drainage area of Iroquois River. A public water supply was installed by the village in 1898. The installation included a well, a deep-well pump driven by gas engine, a pumping station, a distribution system, and an elevated steel tank connected to the system. Later, another well was drilled and equipped with a deep-well pump which is driven by a five-horsepower electric motor. A 10-horsepower motor has been installed to drive the other pump. Water from both wells is discharged directly into the distribution system. About 300 service connections were in use in 1923, of which 25 or 30 were metered.

Water is secured from two wells. One of these, located near the center of the business district, was drilled in 1898. The elevation at the top is about 685 feet above sea level. Records are on file with the Village Clerk. The material penetrated is as follows:

	Thickness in feet.	
.....	119	12 and 10-inch pipe
Hard shale rock	110	10-inch not cased
Shale	60	8-inch pipe
Lime rock	341	8-inch not cased
Shale	527	4½-inch pipe
Rock with strata of sandstone	613	6-inch not cased
Total	1770	

There is a question as to the reliability of this record.

Twelve-inch casing is said to have been placed to rock at a depth of 96 feet. The water level when the well was finished was at a depth of 47 feet. The well was repaired by the J. P. Miller Artesian Well Company in 1922. The 4½-inch casing had become filled. The well was cleaned to a depth of 1672 feet and cased to a depth of 1157 feet.

The well is equipped with a single-acting deep-well pump with a 5¾-inch cylinder and 24-inch stroke. The depth to the cylinder at time of visit in 1923 was thought to be about 184 feet. The speed of the pump had been reduced to 12¾ revolutions per minute. The

pump discharge at the ground surface when the pump had operated for one hour and had then been idle for a few minutes to arrange for the test, was 33 gallons a minute. The water level when not pumping was said to be at a depth of about 50 feet. During the year, to March, 1923, it is estimated that the pump was operated an average of 15 hours a day. In 1925 it is reported that the well has been repaired and a new pump cylinder has been installed. The pump is operated at 19 revolutions a minute for about 8 hours a day and the discharge is 50 gallons a minute.

Water from this well had a mineral content of 580, a total hardness of 24, and a content of iron of 0.1 parts per million as shown by the analysis of sample number 38916, collected on February 5, 1918.

Analysis of Sample Number 38916 from Well 1770 Feet Deep.

Determinations Made.	Parts per million.
Potassium K	2.5
Sodium Na	229.7
Ammonium NH_4	0.4
Magnesium Mg	2.7
Calcium Ca	5.1
Iron Fe	0.1
Alumina Al_2O_3	13.5
Chloride Cl	105.0
Sulfate SO_4	18.1
Residue	600.0
Silica SiO_2	17.3
Manganese Mn	0.0
Alkalinity Methyl Orange	338.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Chloride KCl	4.8	0.28
Sodium Chloride NaCl	173.2	10.10
Sodium Sulfate Na_2SO_4	26.7	1.56
Sodium Carbonate Na_2CO_3	321.4	18.75
Ammonium Carbonate $(NH_4)_2CO_3$	1.1	0.06
Magnesium Carbonate $MgCO_3$	9.4	0.55
Calcium Carbonate $CaCO_3$	12.8	0.75
Iron Carbonate $FeCO_3$	0.2	0.01
Alumina Al_2O_3	13.5	0.79
Silica SiO_2	17.3	1.01
Total	580.4	33.86

The water contains hydrogen sulphide which imparts an unpleasant taste and odor unless one is accustomed to it.

Annlysis of Sample Number 4922 from Well 1770 Feet Deep.

Determinations Made.	Parts per million.
Potassium K	8.3
Sodium Na	283.6
Ammonium NH_4	0.5
Magnesium Mg	7.4
Calcium Ca	14.2
Ferrous Fe	0.7
Aluminium Al	0.5
Silica SiO_2	3.5
Nitrate NO_3	0.5
Chloride Cl	320.0
Sulphate SO_4	17.5
Residue	788.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate	0.7	.04
Potassium Chloride KCl	15.4	.89
Sodium Chloride NaCl	515.3	30.05
Sodium Sulphate Na_2SO_4	25.9	1.51
Sodium Carbonate Na_2CO_3	166.9	9.73
Ammonium Carbonate $(NH_4)_2CO_3$	1.3	.07
Magnesium Carbonate $MgCO_3$	25.8	1.50
Calcium Carbonate $CaCO_3$	35.5	2.07
Ferrous Carbonate $FeCO_3$	1.5	.08
Alumina Al_2O_3	0.9	.05
Silica SiO_3	7.4	.43
Total	796.6	46.42

A sample of the water, number 4922, collected in 1899, was more highly mineralized as shown by the analysis.
The difference in quality may be accounted for by a filling in of the well since 1899 or by change in casing. Well casings have lasted 7 to 9 years before repair or replacement was necessary.

The other well was drilled in 1914. It is located about 2,000 feet north of the older well and the elevation of the top is about 680 feet above sea level. The well is 130 feet deep and the bottom is in sand and gravel. It is cased with 6-inch pipe. The well is equipped with a single-acting deep-well pump with a 4-inch cylinder and 24-inch stroke. The pump was operating 26½ strokes a minute at time of visit in 1923 and the discharge was thought to be about 30 gallons a minute. The pump was operated about 10 hours a day.

Water from this well into sand and gravel is free of hydrogen sulphide and less highly mineralized than water from the deeper well. A sample, number 38917, collected on February 5, 1918, had a mineral content of 339, a total hardness of 150, and a content of iron of 0.3 parts per million as shown by the analysis.

Analysis of Sample Number 38917 from Well 130 Feet Deep.

Determinations Made.	Parts per million.
Potassium K	5.6
Sodium Na	77.4
Ammonium NH_4	0.7
Magnesium Mg	18.5
Calcium Ca	29.6
Iron Fe	0.4
Alumina Al_2O_3	1.1
Nitrate NO_3	1.2
Chloride Cl	4.0
Sulfate SO_4	27.6
Silica SiO_2	15.7
Manganese Mn	0.0
Alkalinity Methyl Orange.	292.
Residue	370.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	2.0	.12
Potassium Chloride KCl	8.5	.50
Sodium Chloride NaCl	0.1	.01
Sodium Sulfate Na_2SO_4	40.8	2.38
Sodium Carbonate Na_2CO_3	147.9	8.62
Ammonium Carbonate $(NH_4)_2CO_3$	0.2	.01
Magnesium Carbonate $MgCO_3$	64.1	3.74
Calcium Carbonate $CaCO_3$	74.0	4.31
Iron Oxide Fe_2O_3	0.5	.03
Alumina Al_2O_3	1.1	.06
Total	339.2	19.78

SIBLEY (383). Sibley is located in the western part of Ford County on the drainage area of Mackinaw River, a tributary of Illinois River. A public water supply was installed by the village in 1907. Water is pumped from a well into a reservoir 23 feet 6 inches in diameter. From the reservoir it is pumped into the distribution system and a steel pressure tank connected to the system by a Goulds 8 by 8-inch single-acting triplex pump. The tank is 9 feet in diameter and 36 feet long. The charge for water for three

months is 45 cents per 1000 gallons for the first 5000 gallons, 37½ cents per 1000 gallons for the next 10,000 gallons, 30 cents per 1000 gallons for the next 20,000 gallons, 25 cents per 1000 gallons for the next 30,000 gallons, and 17½ cents per 1000 gallons for additional water. The minimum charge is $1.50.

Water is obtained from two wells. The bottoms of the wells are in sand and gravel. One well, which furnished the entire supply until 1925, was drilled by Otto Steigman of Roberts in 1907. The well is 8 inches in diameter and 111 feet deep. A number 10 Cook screen ten feet long is placed in the bottom of the well. The well was equipped with a Goulds deep-well pump with a 4¾-inch cylinder and 22-inch stroke. The depth to the bottom of the suction pipe on the cylinder was 108 feet. At the time of visit in March, 1922, the pump was operated 24 revolutions, per minute and the discharge, measured in the reservoir, was 35 gallons a minute. The amount of water pumped was estimated at about 12,000 gallons a day. The water level on February 19, 1925, when another pump cylinder was put in the well, was 46 feet below the ground surface.

The water had a mineral content of 306, a total hardness of 230, and a content of iron of 0.1 parts per million as shown by the analysis of sample number 47620, collected on May 23, 1922.

Analysis of Sample Number 47620 from the Village Supply.

Determinations Made.

	Parts per million,
Iron Fe	0.1
Manganese Mn	0.0
Silica SiO_2	12.2
Nonvolatile	1.4
Alumina Al_2O_3	1.9
Calcium Ca	52.6
Magnesium Mg	23.8
Ammonia NH_4	0.9
Sodium Na	26.0
Potassium K	7.7
Sulfate SO_4	5.2
Nitrate NO_3	0.9
Chloride Cl	1.0
Alkalinity Methyl Orange	286.0
Residue	330.

Hypothetical Combinations.

	Parts per million,	Grains per gallon.
Potassium Nitrate KNO_3	1.4	0.08
Potassium Chloride KCl	2.1	0.12
Potassium Sulfate K_2SO_4	9.4	0.55
Potassium Carbonate K_2CO_3	3.2	0.19
Sodium Carbonate Na_2CO_3	59.8	3.49
Ammonium Carbonate $(NH_4)_2CO_3$	2.4	0.14
Magnesium Carbonate $MgCO_3$	82.0	4.78
Calcium Carbonate $CaCO_3$	131.0	7.64
Silica SiO_2	12.2	0.70
Nonvolatile	1.4	0.08
Alumina Al_2O_3	1.9	0.11
Iron Oxide Fe_2O_3	0.1	0.01
Total	306.9	17.89

Another well was drilled in 1925. It is 4 inches in diameter and 108 feet deep. It is equipped with a deep-well pump with a 2¼-inch cylinder at a depth of 86 feet. The discharge, measured in a tank, was 7½ gallons a minute.

SILVIS (2541). Silvis is located in Rock Island County between Mississippi River and Rock River. A large part of the village

is on land only a few feet above the rivers. A public water supply was installed by the village in 1910. Water was secured from a well into sand and gravel. A deep well into rock was drilled in 1912 and has since furnished a large part of the supply. Water from this well flows into a reservoir 70 feet 6 inches long, 22 feet 6 inches wide, and 11 feet deep. Water is pumped from the reservoir or from either of the two wells into the distribution system by two 2-stage centrifugal pumps, each driven by an electric motor. The pumps are placed two feet below the top of the deep well. Five hundred and thirty service connections were in use in 1923.

Water is secured from two wells. One well was drilled in 1910. It is 15 feet in diameter and 28 feet deep. Water is secured from sand and gravel which extends from near the ground surface to a depth of about 28 feet. This well has furnished but a small part of the supply since 1912 when a well was drilled into rock. In 1923 water was pumped from this well twice a day. The well was pumped dry in about eighteen minutes.

Water from this well had a temperature of 54 degrees Fahrenheit. It had a mineral content of 709 and a total hardness of 487 parts per million as shown by the analysis of sample number 49883, collected on August 8, 1923.

Analysis of Sample Number 49883 from Village Well 28 Feet Deep.

Determinations Made.	Parts per million.
Iron Fe	0.0
Manganese Mn	0.0
Silica SiO_2	26.0
Nonvolatile	0.8
Alumina Al_2O_3	7.3
Calcium Ca	111.9
Magnesium Mg	50.7
Ammonia NH_4	0.0
Sodium Na	35.7
Potassium K	7.3
Sulfate SO_4	203.1
Nitrate NO_3	79.7
Chloride Cl	52.0
Alkalinity Methyl Orange	202.
Residue	706.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	19.0	1.12
Sodium Nitrate $NaNO_3$	93.1	5.44
Sodium Chloride NaCl	26.8	1.56
Magnesium Chloride MgCl	48.0	2.80
Magnesium Sulfate $MgSO_4$	189.7	11.08
Calcium Sulfate $CaSO_4$	73.0	4.26
Calcium Carbonate $CaCO_3$	225.5	13.17
Alumina Al_2O_3	7.3	0.42
Silica SiO_2	26.0	1.52
Nonvolatile	0.8	0.04
Total	709.2	41.41

The analysis indicates that the water may be corrosive. Samples collected from this supply in 1910 and 1912 had a mineral content of about 325 and contained less than 4 parts of nitrates.

Since 1912 nearly all of the water for the public supply has been secured from a deep well drilled in that year. The top of the well is about 580 feet above sea level. A record of material penetrated, as given by the drillers, is as follows:

	Thickness in feet.	Depth in feet.
Sand	36	36
Shale and hard lime rock.	714	750
Large crevice and fine sand	...	...
	...	...
Lime rock. Few veins of sandstone	650	1450
Gravel	3	1453
Rock	72	1525
Fine gravel	...	1525
Rock, harder	65	1590
Lime rock. Few veins of sandstone	335	1925
Sandstone, soft	55	1980
Lime rock, hard.	5	1985

Classification by the State Geological Survey Division shows Prairie du Chien below a depth of 1450 feet.

The well is cased with 15-inch cast iron pipe to a depth of 38 feet, with 12-inch wrought iron pipe between depths of 38 and 278 feet, and with 9-inch wrought iron pipe between depths of 278 and 1178 feet.

When the well was completed and cleaned out it started to flow. Water flowing from this well to the reservoir furnished practically the entire supply until 1923. In that year a 4-inch suction line extending to a depth of 30 feet was placed in the well and when the water level in the reservoir is drawn down to the inlet from the well, water is then drawn directly from the well. The flow from the well in 10 hours during the night of August 2-3, 1923, raised the water level in the reservoir 1.17 feet to a depth of 8.35, an average rate of flow of 23 gallons a minute. The rate of flow had decreased to a small amount. One pump when pumping from the reservoir pumped an average of 490 gallons a minute in addition to the flow of the well, a total of more than 513 gallons a minute. When pumping from the well with higher suction lift the discharge is probably less. When pumping from the well with one pump the depth to water in the well was from 21 to 22 feet. When pumping from the well with both pumps the depth to water was from 20 to 21 feet, indicating that about the same or slightly less water was secured.

Water pumped from the well 1985 feet deep on August 2, 1923, had a temperature of 67 degrees Fahrenheit. It had a mineral content of 1657, a total hardness of 440, and a content of iron of 0.4 parts per million as shown by the analysis of sample number 49882, collected on August 8, 1923, after pumping for two hours.

This water, compared to water from the well into sand and gravel, contains much more sodium chloride. Samples collected in 1912, 1918, and 1923 show an increase in hardness and an increase in total mineral content. A sample collected in 1912 had a mineral

content of 1469 and a total hardness of 330. Analysis made at the well in 1918 showed 0.4 parts of hydrogen sulphide and 2.0 parts of carbon dioxide in the water. Meters were installed in 1918 and it had been necessary to repair about 50 of them before August, 1923.

Analysis of Sample Number 49882 from Village Well 1985 Feet Deep.

Determinations Made.

	Parts per million.
Iron Fe	0.4
Manganese Mn	0.0
Silica SiO_2	11.8
Nonvolatile	3.0
Calcium Ca	102.3
Alumina Al_2O_3	1.5
Magnesium Mg	45.2
Ammonia NH_4	6.2
Sodium Na	407.6
Potassium K	39.9
Sulfate SO_4	271.6
Nitrate NO_3	2.1
Chloride Cl	650.0
Alkalinity Methyl Orange	240.
Residue	1695.

Hypothetical Combinations.

	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	3.4	0.20
Potassium Chloride KCl	73.6	4.30
Sodium Chloride NaCl	1013.3	59.17
Sodium Sulfate Na_2SO_4	27.5	1.61
Ammonium Sulfate $(NH_4)_2SO_4$	22.6	1.32
Magnesium Sulfate $MgSO_4$	223.5	13.07
Calcium Sulfate $CaSO_4$	82.2	4.80
Calcium Carbonate $CaCO_3$	194.9	11.38
Iron Oxide Fe_2O_3	0.5	0.03
Alumina Al_2O_3	1.5	0.08
Silica SiO_2	11.8	0.69
Nonvolatile	3.0	0.17
Total	1657.8	96.82

SOMONAUK (540). Somonauk is located in the southeastern part of DeKalb County on the drainage area of Somonauk Creek, a tributary of Illinois River. A public water supply was installed by the village about 1880. Water was pumped from a well into a small elevated wooden tank by a windmill. Improvements have been made from time to time, the most extensive in 1902. Water is pumped from two wells into the distribution system and an elevated wooden tank connected to the system. The pumps are electrically operated with current supplied by the Illinois Northern Utilities Company. The elevated tank is 22 feet 6 inches in diameter and is supported on a brick tower 85 feet high. About 175 service connections were in use in 1922 and the average consumption was estimated at 38,000 gallons a day. Water is sold at flat rates.

Water is secured from two wells spaced eleven feet apart. The ground surface at the tops of the wells is about 685 feet above sea level. The older well is 10 inches in diameter and 190 feet deep. Water is obtained from a gravel deposit. The well is equipped with a Deming deep-well pump. In 1912 the pump cylinder was at a depth of 24 feet. It has since been lowered 40 or 45 feet. When the deeper well was drilled nearby, drillings were

pumped from this well, so the water pumped from this well now may be partly from lower strata.

The other well was drilled by the J. P. Miller Artesian Well Company of Chicago in 1903. A record of material penetrated, obtained from the State Geological Survey Division, is as follows:

	Thickness in feet	Depth in feet.
Soil, "hard pan", stones and gravel.	?	?
Sandstone and limestone..	?	106
Sandstone, white, St. Peter..	46	152
Shale, sandy, Prairie du Chien..	21	173
Shale, "flinty", Prairie du Chien..	52	225
Limestone, Prairie du Chien..	235	460
Shale, Prairie du Chien..	10	470
Limestone, Prairie du Chien..	32	502

The well was cased with 10-inch pipe to a depth of 115 feet and 13 feet of 8-inch liner was placed with the bottom at a depth of 125 feet. Water is pumped from this well by a Deming 7 by 8-inch triplex pump which is placed in a pit about 5 feet deep. The pump is operated 50 revolutions per minute.

Both pumps are operated at a time. From the rate of filling the elevated tank the rate of discharge from the two wells in March, 1922, was estimated at 365 gallons a minute. The amount pumped during the preceding year was estimated at an average of 38,000 gallons a day. The water level when not pumping was said to be from 12 to 14 feet below the ground surface.

The water had a mineral content of 329, a total hardness of 229, and a content of iron of 1.4 parts per million as shown by the analysis of sample number 31758, collected on October 4, 1915.

Analysis of Sample Number 31758 from the Village Supply.

Determinations Made.

	Parts per million.
Potassium K	6.5
Sodium Na	39.4
Ammonium NH_4 . . .	0.2
Magnesium Mg	21.9
Calcium Ca	55.7
Iron Fe	1.4
Alumina Al_2O_3	1.2
Nitrate NO_3	1.2
Chloride Cl	3.0
Sulfate SO_4	5.8
Silica SiO_2	4.5
Manganese Mn	0.0
Alkalinity Methyl Orange . . .	334.
Residue	352.

Hypothetical Combinations.

	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	2.0	.12
Potassium Chloride KCl	6.3	.37
Potassium Sulfate K_2SO_4	5.3	.31
Sodium Sulfate Na_2SO_4	4.3	.25
Sodium Carbonate Na_2CO_3	87.5	5.10
Ammonium Carbonate $(NH_4)_2CO_3$	0.5	.03
Magnesium Carbonate $MgCO_3$ . .	75.8	4.42
Calcium Carbonate $CaCO_3$	139.0	8.11
Iron Carbonate $FeCO_3$	2.8	.16
Alumina Al_2O_3	1.2	.07
Silica SiO_3	4.5	.26
Total	329.2	19.20

SOUTH BELOIT. A public water supply is owned by the South Beloit Water, Gas, and Electric Company. Water from wells 135 feet deep located in Beloit, Wisconsin, is supplied by the Beloit Water, Gas, and Electric Company.

SOUTH CHICAGO HEIGHTS (949). South Chicago Heights is located near the southern limits of Cook County south of and adjoining the city of Chicago Heights. A public water supply has been installed by the village. Water is pumped from a well into the distribution system and two steel pressure tanks connected to the system, by a deep-well pump which is driven by a 10-horse-power electric motor. Each tank has a capacity of 15,000 gallons. In case of emergency water can be secured from the city of Chicago Heights.

One hundred and eighty-three service connections were in use in 1925. The rate for water is 20 cents per 100 cubic feet excepting a rate of 10 cents per 100 cubic feet for use at public schools. A discount of five per cent is allowed for cash within fifteen days.

Analysis of Sample Number 39993 from the Village Supply.

Determinations Made.	Parts per million.
Iron Fe	0.2
Manganese Mn	Trace
Silica SiO_2	16.8
Nonvolatile	0.2
Alumina Al_2O	0.1
Calcium Ca	93.3
Magnesium Mg	42.6
Ammonia NH_4	0.1
Sodium Na	24.0
Sulfate SO_4	37.0
Nitrate NO_3	7.1
Chloride Cl	3.0
Alkalinity Methyl Orange	409.
Residue	465.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Sodium Nitrate $NaNO_3$	9.7	.56
Sodium Chloride NaCl	4.9	.28
Sodium Sulfate Na_2SO_4	54.8	3.18
Sodium Carbonate Na_2CO_3	3.9	.23
Ammonium Carbonate $(NH_4)_2CO_3$	0.5	.03
Magnesium Carbonate $MgCO_3$	147.5	8.56
Calcium Carbonate $CaCO_3$	233.0	13.50
Iron Carbonate $FeCO_3$	0.1	.06
Alumina Al_2O_3	0.2	.01
Silica SiO_2	16.8	.97
Nonvolatile	0.2	.01
Total	473.6	27.51

Water is obtained from a well which was drilled in 1893 to secure oil or gas. Later the well was purchased by the village. The original depth is said to have been about 2756 feet. The well is cased with 8-inch pipe to rock at a depth of 60 feet. The well is equipped with a single-acting deep-well pump with a 5-inch cylinder and 36-inch stroke. It is operated at a rate of from 16 to 19 revolutions a minute and in 1924 it was operated about 12 hours a day. In May, 1925, Elizabeth C. Hansen, Village Clerk, wrote that the pump is operated fifteen hours a day and that the discharge is 90

gallons a minute. It is probable that a considerable part or all of the supply is from the upper part of the well.

The water had a mineral content of 473, a total hardness of 408, and a content of iron of 0.2 parts per million as shown by the analysis of sample number 39993, collected on August 19, 1918.

SOUTH WILMINGTON (1362). South Wilmington is located in the southeastern part of Grundy County on the drainage area of Mazon River, a tributary of Illinois River. A public water supply is obtained from a shallow dug well. Water is pumped from the well into a small wooden tank by a Goulds 8 by 10-inch single-acting triplex pump which is driven by a 30-horsepower electric motor. A reservoir 30 feet in diameter and 16 feet deep is maintained full of water for use at times of fire. The pump house, reservoir, and elevated tank are on land adjacent to the village hall in the western part of the village about three blocks distant from the well. Thirteen small hydrants equipped with valves at the top were inserted on the distribution system in 1915. Persons wishing to use the water draw it from these hydrants. There are no service connections into houses or other buildings. A coal mine operated nearby secures water from a creek. The public water supply is maintained by taxes.

Water is secured from a well into drift which was dug in 1913. It was 22 feet deep but the lower 4 feet has filled in. The well is 9 feet by 12 feet and is curbed with wood. It is covered with concrete with an opening for a hand pump and an opening to gain access to the well. At times the triplex pump will draw water from the well at nearly the rated capacity of the pump. In dry weather the yield is very small. In 1923 the pump was operated a total of about 45 minutes a day.

SPARTA (3340). Sparta is located in the northeastern part of Randolph County on the drainage area of Mary's River, a tributary of Mississippi River. A public water supply was installed by a private company in 1908. A considerable part of the supply was from two small reservoirs located south of the city. A part of the supply was from a well 400 feet deep located in the city. In 1912 a test well was drilled to a depth of 450 feet. The yield of this well was three gallons a minute.

In 1915 a supply was developed by the city from an impounding reservoir.

Sample number 32748 was collected on January 25, 1916, from the well 400 feet deep.

Analysis of Sample Number 32748 from City Well 400 Feet Deep.

Determinations Made.

	Parts per million.
Iron Oxide Fe_2O_3	0.3
Silica SiO_2	8.7
Nonvolatile	4.9
Alumina Al_2O_3	0.5
Calcium Ca	3.0
Magnesium Mg	2.1
Ammonia NH_4	0.5
Sodium Na	779.8
Potassium K	25.6
Sulfate SO_4	10.7
Nitrate NO_3	0.4
Nitrite NO_2	0.0
Chloride Cl	520.0
Alkalinity	
Phenolphthalein	56.
Methyl Orange	100.
Residue	2018.
Nonvolatile	4.9

Hypothetical Combinations.

	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	0.7	.04
Potassium Chloride KCl	48.2	2.81
Sodium Chloride NaCl	820.3	47.85
Sodium Sulfate Na_2SO_4	15.8	.92
Sodium Carbonate Na_2CO_3	1039.1	60.61
Ammonium Sulphate $(NH_4)_2SO_4$	1.3	.08
Magnesium Carbonate $MgCO_3$	7.3	.42
Calcium Carbonate $CaCO_3$	7.5	.44
Iron Carbonate $FeCO_3$	0.4	.02
Alumina Al_2O_3	0.5	.03
Silica SiO_2	8.7	.51
Nonvolatile	4.9	.29
Total	1954.7	114.02

SPRING VALLEY (6493). Spring Valley is located in the southeastern part of Bureau County near the north bank of Illinois River. A public water supply was installed by the city in 1892. Water was secured from a well. Another well has been drilled and changes in equipment have been made. Water flows from the wells to a collecting reservoir of 80,000 gallons capacity and is pumped from the reservoir into the distribution system by either of two pumps. An American centrifugal pump is driven by a 40-horsepower electric motor. A Fairbanks-Morse 8 by 12-inch double-acting duplex pump is driven by an oil engine. An elevated steel tank of 150,000 gallons capacity is connected to the distribution system. Electric current is furnished by the Spring Valley Utility Company. Eleven hundred and fifty service connections were in use in 1923.

Water for the public supply is secured from two flowing wells, each about 1480 feet deep. They are located near the southern limits of the city on the right of way of the Chicago, Rock Island and Pacific Railway near the west bank of Spring Creek. One well was drilled in 1892 and the other, 70 feet distant, in 1905. Specifications for the second well drilled called for 10-inch wrought iron casing to rock, 8-inch casing through coal measures and shale to a depth of about 400 feet, 6-inch casing below the 8-inch casing to exclude salt water, and 6-inch hole into St. Peter sandstone. The casings were to be sealed to rock and to adjoining casings. When the first well was drilled the pressure at the ground surface was 30 pounds.

The water had a mineral content of 724, a total hardness of 256, and a content of iron of 0.2 parts per million as shown by the analysis given of sample number 49594, collected on June 6, 1923, at the pumping station after the pump had been running for 45 minutes.

Analysis of Sample Number 49594 from the City Supply.

Determinations Made.	Parts per million.
Iron Fe	0.2
Manganese Mn	0.0
Silica SiO_2	8.9
Nonvolatile	1.7
Alumina Al_2O_3	1.3
Calcium Ca	62.4
Magnesium Mg	24.6
Ammonia NH_4	1.1
Sodium Na	152.5
Potassium K	36.8
Sulfates SO_4	54.5
Nitrates NO_3	1.6
Chloride Cl	198.0
Alkalinity	
Phenolphthalein	0
Methyl Orange.	316.
Residue	743.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	2.5	0.14
Potassium Chloride KCI.	68.3	3.99
Sodium Chloride NaCI.	272.9	15.94
Sodium Sulfate Na_2SO_4	80.5	4.70
Sodium Carbonate Na_2CO_3	44.1	2.57
Ammonium Carbonate $(NH_4)_2CO_3$	3.0	0.17
Magnesium Carbonate $MgCO_3$	85.2	4.97
Calcium Carbonate $CaCO_3$	155.9	9.10
Iron Oxide Fe_2O_3.	0.3	0.02
Alumina Al_2O	1.3	0.07
Silica SiO_2	8.9	0.52
Nonvolatile	1.7	0.10
Total	724.6	42.29

A sample collected in 1913 was similar.

Water from a well 2300 feet deep at St. Bede College near the east limits of the city is similar in quality as shown by the analysis of sample number 23737, collected on July 30, 1912.

Analysis of sample number 23737 from Well 2300 Feet Deep.

Determinations Made.	Parts per million.
Iron Fe	2.1
Silica SiO_2	16.2
Alumina Al_2O_3	41.2
Calcium Ca	56.2
Magnesium Mg	22.0
Ammonia NH_4	1.4
Sodium Na	156.5
Potassium K	23.8
Sulfates SO_4	56.6
Nitrates NO_3	0.9
Nitrite NO_2	trace
Chloride Cl	190.0
Alkalinity	
Methyl Orange	312.
Residue	728.
Nonvolatile	10.4

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	1.5	.09
Potassium Chloride KCl	44.2	2.57
Sodium Chloride NaCl	278.9	16.26
Sodium Sulfate Na_2SO_4	83.6	4.87
Sodium Carbonate Na_2CO_3	44.9	2.61
Ammonium Carbonate $(NH_4)_2CO_3$	3.7	.21
Magnesium Carbonate $MgCO_3$	76.0	4.43
Calcium Carbonate $CaCO_3$	140.3	8.18
Iron Carbonate $FeCO_3$	4.4	.26
Alumina $Al2O_3$	41.2	2.40
Silica SiO_2	16.2	.94
Nonvolatile	10.4	.61
Total	745.3	43.43

SPRINGFIELD (59,183). Springfield, the capitol of the state, is located in Sangamon County on the drainage area of Sangamon

River, a tributary of Illinois River. A public water supply was installed by the city in 1868. A dam was built across Sangamon River four miles north of the center of the city and water was pumped from the river above the dam. In 1884 a well was dug in the valley of the river and for a few years the entire supply was from this well. With increasing demands the supply became inadequate. In 1888 an infiltration gallery was installed and another gallery was installed during the next two years. At times the yield from the, well and galleries was ample for all demands. At times of low water, however, the supply was not adequate and in 1890 a connection was made between the river and a gallery and for many years part of the supply was secured from the river.

In 1902 wells were drilled in sand deposits in the river valley and since 1911 the well system and galleries have supplied all demands. The wells are equipped with electrically driven pumps which discharge into pipe lines leading to the original dug well, which serves as a receiving well and a suction pit for the high service pumps. Water is pumped from this well into pipe lines leading to the city by any of three pumps placed in a pump pit. The pumps are a Holly vertical triple expansion of 10,000,000 gallons capacity, a steam turbine-driven Hill Pump Corporation. two-stage centrifugal of 10,000,000 gallons capacity, and an electrically-driven Allis-Chalmers two-stage centrifugal of 6,000,000 gallons capacity.

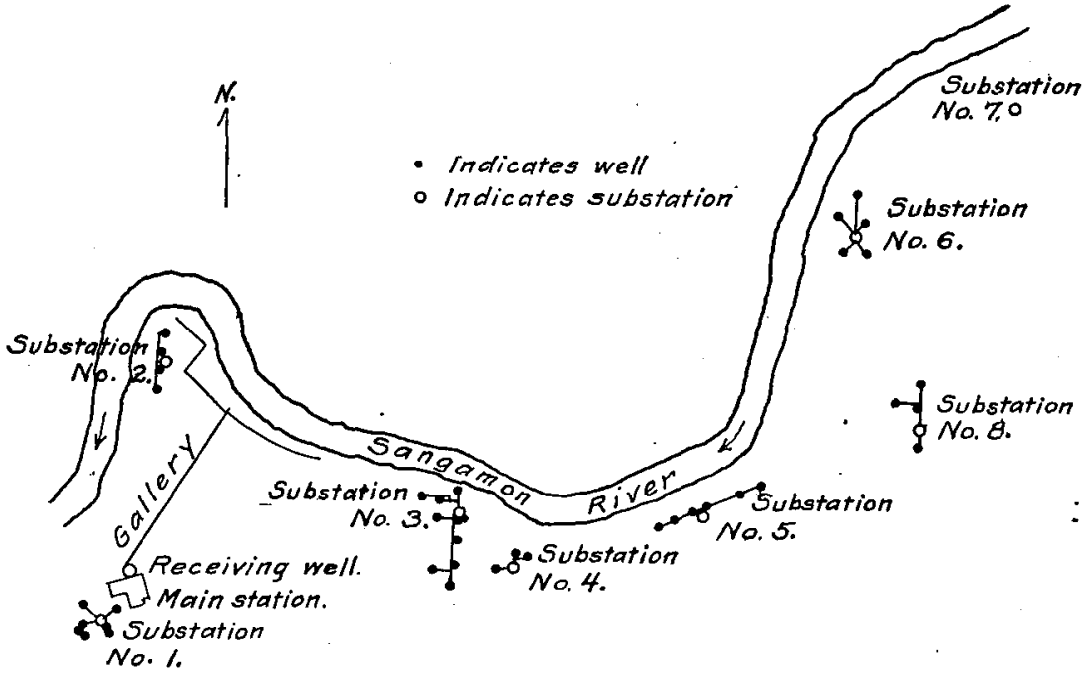
The pumping station is operated in connection with a municipal electric plant. Cooling water which amounted to about 2,000 gallons a minute in 1924 is taken from the river and discharged into a pond at the side of the pumping station. The water level in the pond is maintained nearly up to the ground surface and channels have been dug to convey water to the vicinity of the wells at some distance from the pond.

The water consumption during the year ending February 29, 1924, averaged 6,886,000 gallons a day. The rate for domestic consumers is 20 cents per 1000 gallons with a minimum charge of $1.00 per quarter.

Water for the public supply is secured from infiltration galleries and wells into a sand and gravel deposit about 40 feet thick in the valley of Sangamon River. The sand and gravel is overlaid by about 10 feet of sandy loam. The original well is now used as a collecting reservoir and suction pit. It is 50 feet in diameter and 50 feet deep. The curbing is about 30 inches thick of brick laid in mortar.

The first infiltration gallery was built in 1888. It extended about 1,000 feet in a southeasterly direction from the original well. A trench was dug into gravel above sand at a depth of 25 feet and a gallery 4 feet wide and 5 feet high was built in the bottom of the trench. The gallery was walled and covered with 3-inch elm planks supported by oak ribs. Broken stone was placed around the gallery and the trench was filled. This gallery was in use about thirty years. Another gallery three by four feet in section and 1563 feet long was installed before 1890 and an extension of 450 feet of 36-inch concrete pipe was laid about 1910. This gallery is in use and at times supplies all demands.

The wells are drilled to a depth of about 50 feet on bottom lands of the river. They are located in groups and water is pumped from all wells of one group by an electrically driven centrifugal pump placed in a substation near the center of the group. The pumps are placed from 13 to 15 feet below the ground surface. Eight substations were operated in 1923 and 1924. A plat showing the location of the stations and wells, taken from a report of the City Water, Light., and Power Department for the year ending February 29, 1924, is shown below.



LOCATION OF WELLS OF THE CITY OF SPRINGFIELD

All but one of the wells pumped from substation number 1 are cased with iron or steel about 8 inches in diameter. Other wells shown, excepting seven as noted later, are cased with iron or steel pipe about 12 inches in diameter. The 8-inch and 12-inch wells

with few exceptions are equipped with Cook screens. The sand encountered is much coarser in some places than it is in others. Some screens are number 10 and others are coarser, some number 60.

One of the wells pumped from substations number 1 and two of the wells pumped from substation number 8 were installed by the Kelly Well Company in 1921. They are 24-inch wells and the depths are 52, 53, and 57 feet. They have concrete casings and concrete screens surrounded by coarse sand. The material penetrated was mostly sand. The shortest screen is 20 feet long and the longest is 32 feet long.

Substation number 7 as shown on the plat was a Layne and Bowler well with a 24-inch shutter screen surrounded by coarse sand. In 1924 three wells were drilled nearby by the Kelly Well Company of Grand Island, Nebraska, and the four wells will be pumped by a pump in a substation to be located close to the old well.

The three Kelly wells are 100 feet apart. Below about ten feet of soil and clay the material is mostly sand to a depth of 44 or 45 feet. One well was drilled to a depth of 63 feet. Below a depth of 44 feet material was classed as blue clay, white clay, red clay, and stone. The bottom one foot was stone. The wells have concrete casings and concrete screens 24 inches in outside diameter. The shortest of the three screens is 18 feet long and the longest is 27 feet long. One of the wells was pumped for five hours at a rate of 550 gallons a minute. The water level was lowered 14 feet in the well tested, 18 inches in the well 100 feet distant, and 5 inches in the well 200 feet distant. The other two wells were pumped at rates of 600 and 630 gallons a minute with draw downs of ten feet and eleven feet respectively.

A test of yield of wells was made by the Pitometer Company in 1923. The wells at that time were as represented on the plat. The screens of some of the wells are probably clogged allowing little water to flow through them. The yield of each group of wells, determined by measuring the discharge from each substation, was as follows:

Substation Number	Rate of yield. Gallons a day.	
1	547,000	
2	600,000	
3	2,000,000	One pump operating
3	2,555,000	Two pumps operating
4	1,096,000	
5	1,416,000	
6	362,000	
7	300,000	
8	1,390,000	

A sample of water, number 53531, collected at the pumping station on April 4, 1925, had a mineral content of 329, a total hardness of 282, and a content of iron of 1 part per million as shown by the analysis.

Some variation is shown from time to time and in samples collected from the different wells and galleries.

Analysis of Sample Number 53531 from the City Supply.

Determinations Made.	Parts per million.
Iron Fe	1.0
Manganese Mn	0.6
Silica SiO_2	10.8
Nonvolatile	0.3
Alumina Al_2O_3	1.8
Calcium Ca	67.0
Magnesium Mg	28.0
Ammonia NH_4	0.3
Sodium Na	9.9
Potassium K	1.7
Sulfate SO_4	56.7
Nitrate NO_3	2.7
Chloride Cl	10.0
Alkalinity	
Phenolphthalein	0
Methyl Orange	228.
Residue	340.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	4.3	.25
Sodium Chloride NaCl	16.5	.97
Sodium Sulfate Na_2SO_4	10.6	.62
Ammonium Sulfate $(NH_4)_2SO_4$	1.0	.06
Magnesium Sulfate $MgSO_4$	61.1	3.57
Magnesium Carbonate $MgCO_3$	54.1	3.16
Calcium Carbonate $CaCO_3$	167.4	9.78
Iron Oxide Fe_2O_3	1.4	.08
Alumina Al_2O_3	1.8	.11
Silica SiO_2	10.8	.63
Nonvolatile	0.3	.02
Total	329.3	19.25

The iron content of the water as pumped from the wells is sufficient to cause trouble by staining of clothes and plumbing fixtures and is objectionable on account of promoting the growth of crenothrix. Work on the intallation of a plant to remove the iron was started in 1925.

STANDARD (980). Standard is located in the northeastern part of Putnam County about four miles south of Illinois River. A public water supply was installed in 1914. The distribution system and an elevated steel tank of 75,000 gallons capacity connected to the system, is owned by the village. Other parts of the plant are owned by the B. F. Berry Coal Company which operates a coal mine in the village. Water is pumped from a well by a steam-head deep-well pump which discharges into a wooden tank 9 feet in diameter and 12 feet high. Water is pumped from the tank into the distribution system by a Knowles 14 by 10¼ by 12-inch steam pump. A contract calls for the delivery to the village of not to exceed 500,000 gallons of water a month for $75.00 and additional water at a rate of 15 cents per 1,000 gallons. About 100 service connections were in use in 1917 and the total amount of water pumped in July of that year was 565,000 gallons.

Water for the public supply is obtained from a well 1767 feet deep. When digging a mine shaft, which is close to the well, limestone was encountered at a depth of 91 feet. Water was noted in gravel between depths of 33 and 36 feet. Between depths of 109 feet and 512 feet the material was principally clay, shale, and slate. A record of material penetrated by the well below this depth, secured from the mine foreman, is as follows:

	Thickness in feet.	Depth in feet.
Sand rock	3	515
Sandstone	50	565
Shale	15	580
Limestone	37	617
Hard shale	28	645
Red shale	190	835
Lime rock	13	848
Shale	237	1085
Limestone	77	1162
Shale	18	1180
Limestone	76	1256
Sandstone	371	1627
Sandstone, St. Peter	140	1767

The well is cased with 16-inch pipe to a depth of 95 feet, with 12-inch pipe between depths of 95 and 287 feet, with 10-inch pipe between depths of 287 and 346 feet, and with 6-inch pipe between depths of 300 and 1297 feet. It is 6 inches in diameter at the bottom. The well is equipped with a steam-head deep-well pump. In 1917 the water cylinder was at a depth of 250 feet. The pump was operated at a displacement of about 90 gallons a minute. The water level when not pumping was at a depth of 100 feet.

The water had a mineral content of 1117, a total hardness of 194, and a content of iron of 1.4 parts per million as shown by the analysis of sample number 38598, collected on November 22, 1917.

Analysis of Sample Number 38598 from the Public Supply.

Determinations Made.

	Parts per million.
Iron Fe	1.4
Silica SiO_2	8.8
Alumina Al_2O_3	6.0
Calcium Ca	48.6
Magnesium Mg	17.7
Ammonium NH_4	0.4
Potassium K	30.0
Sodium Na	319.2
Sulfate SO_4	199.2
Nitrate NO_3	2.5
Chloride Cl	340.0
Alkalinity Methyl Orange	242.
Residue	1084.

Hypothetical Combinations.

	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	4.1	.24
Potassium Chloride KCl	54.1	3.15
Sodium Chloride NaCl	518.6	30.26
Sodium Sulfate Na2SO_4	294.8	17.25
Sodium Carbonate Na_2CO_3	44.4	2.59
Ammonium Carbonate $(NH_4)_2CO_3$	1.8	.10
Magnesium Carbonate $MgCO_3$	61.3	3.57
Calcium Carbonate $CaCO_3$	121.3	7.07
Iron Oxide Fe_2O_3	2.0	.12
Alumina Al_2O_3	6.0	.35
Silica SiO_2	8.8	.51
Total	1117.2	65.21

STANFORD (500). Stanford is located in the western part of McLean County on the drainage area of Sangamon River, a tributary of Illinois River. Many private wells from 20 to 75 feet deep are in use.

A public water supply was installed by the village in 1911. Water was secured from a well which was abandoned in 1919 when another well was drilled. The well in use is equipped with a deep-well pump which discharges into the distribution system and a steel pressure tank connected to the system. The pump is driven by belt from a 15-horsepower electric motor. The tank is 9 feet in diameter and 40 feet long.

Fifty-three service connections were in use in 1922. The total amount of water supplied was estimated at 20,000 gallons a day. After repairing leaks the consumption in 1924 was 15,000 gallons or less per day. Water is sold at a rate of twenty-five cents per thousand gallons with a minimum charge of $1.50 every three months.

A well 6 inches in diameter and 131 feet deep was drilled in 1911. A Cook screen 10 feet long was placed in the bottom. The well was equipped with a deep-well pump of about 50 gallons a minute capacity with the cylinder placed at a depth of 118 feet. The depth to water when not pumping in 1915 was given as 70 feet. The screen became clogged and the well was abandoned in 1919.

Water for the public supply is secured from a well drilled by C. H. Johnson and Son in 1919. The elevation at the top is about 680 feet above sea level. The well is 8 inches in diameter and 235 feet deep. A record of material penetrated is as follows:

Yellow clay to	18 or	20 feet
Blue clay to		80 feet
Streak of sand, 1 foot, 20 feet of water		
Blue clay to		100 feet
Streak of blue hard pan to		140 feet
Water gravel, 10 inches		
Blue clay to		150 feet
Blue lead like clay to		217 feet
Water sand to		235 feet

The upper 7 feet of the sand is very fine. Water raised to within about 100 feet of the top. A number 20 Cook screen was installed. The upper part became wedged to the pump cylinder and has been removed. The well is equipped with a Goulds single-acting deep-well pump with 5¾-inch cylinder and 24-inch stroke. The cylinder was first placed near the bottom of the well and was then raised to 130 feet below the top. The discharge in October, 1922, when the pump was operating 30 strokes a minute, estimated from the rise in water level in the tank, was between 65 and 70 gallons a minute. The pump was operated about 5 hours a day. In 1924 the pump

operated about the same length of time at 24 revolutions a minute. Many leaks in mains had been repaired.

The water had a mineral content of 570, a total hardness of 345, and a content of iron of 1.2 parts per million as shown by the analysis of sample number 51792, collected on July 9, 1924.

Analysis of Sample Number 51792 from Village Well 235 Feet Deep.

Determinations Made.	Parts per million.
Iron Fe	1.2
Manganese Mn	0.0
Silica SiO_2	16.7
Nonvolatile	2.1
Alumina Al_2O_3	1.7
Calcium Ca	78.5
Magnesium Mg	36.4
Ammonium NH_4	10.3
Sodium Na	73.6
Potassium K	10.8
Sulfate SO_4	1.0
Nitrate NO_3	2.6
Chloride Cl	55.0
Alkalinity	
Phenolphthalein	0
Methyl Orange	474.
Residue	596.0

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	4.3	.25
Potassium Chloride KCl	17.4	1.02
Sodium Chloride NaCl	77.1	4.50
Sodium Sulfate Na_2SO_4	1.5	.09
Sodium Carbonate $Na2CO_3$	98.6	5.76
Ammonium Carbonate $(NH_4)_2CO_3$	27.4	1.60
Magnesium Carbonate $MgCO_3$	126.1	7.36
Calcium Carbonate $CaCO_3$	195.8	11.44
Iron Oxide Fe_2O_3	1.7	.10
Alumina Al_2O_3	1.7	.10
Silica SiO_2	16.7	.97
Nonvolatile	2.1	.12
Total	570.4	33.31

STEGER (2304). Steger is located in Cook and Will Counties five miles west of the Indiana state line. It is on the drainage area of Calumet River. A public water supply has been installed by the village. Water is pumped from a well into the distribution system and an elevated steel tank connected to the system, by a deep-well pump which is driven through gears by an electric motor. The tank has a capacity of 100,000 gallons. The Steger Piano Company at their plant in the city has a private water supply and obtains water from wells similar to the village well. They can draw water from the village supply or furnish water to the village.

Water for the public supply is secured from a well located near the center of the village. It is 12 inches in diameter and 318 feet deep. Rock was encountered at a depth of 94 feet and a casing was placed to a depth of 147 feet. The depth to water was reported in 1914 to be about 75 feet when not pumping. The pump cylinder was placed near the bottom of the casing, and the pump was operated at a displacement of a little more than 300 gallons a minute for four or five hours a day.

The water had a mineral content of 450, a total hardness of 383, and a content of iron of 0.4 parts per million as shown by the

analysis of sample number 39933, collected at the pumping station on August 7, 1918.

Analysis of Sample Number 39933 from the Village Supply.

Determinations Made.	Parts per million.
Iron Fe	0.4
Manganese Mn	0.0
Silica SiO_2	14.4
Nonvolatile	0.4
Alumina Al_2O_3	2.9
Calcium Ca	87.6
Magnesium Mg	39.9
Ammonia NH_4	0.4
Sodium Na	25.4
Sulfate SO_4	40.5
Nitrate NO_3	1.4
Chloride Cl	3.0
Alkalinity Methyl Orange	393.
Residue	470.6

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Sodium Nitrate $NaNO_3$	2.0	.11
Sodium Chloride NaCl	4.6	.27
Sodium Sulfate Na_2SO_4	59.8	3.47
Sodium Carbonate Na_2CO_3	8.1	.47
Ammonium Carbonate $(NH_4)_2CO_3$	1.0	.06
Magnesium Carbonate $MgCO_3$	138.1	8.01
Calcium Carbonate $CaCO_3$	218.7	12.66
Iron Carbonate $FeCO_3$	0.8	.05
Alumina Al_2O_3	2.9	.17
Silica SiO_2	14.4	.83
Nonvolatile	0.4	.02
Total	450.8	26.12

STERLING (8182). Sterling is located in the eastern part of Whiteside County on the north bank of Rock River. A public water supply was installed by private interests in 1885. Water was secured from a well into Cambrian sandstone and three other wells have since been drilled. Water from the wells flows into two reservoirs of 635,000 gallons capacity each. Air lifts are operated when the natural flow is not sufficient to supply demands. Air is supplied by an Ingersoll-Rand compressor with 8-inch and 12-inch cross compound steam cylinders, 12-inch air cylinders, and 14-inch stroke. Water is pumped from the reservoir by any of three steam pumps, one 14 by 24 by 13-inch Deane duplex, one 14 and 28 by 24 by 13-inch Deane tandem compound duplex, and a Prescott 14 and 26 by 10 by 24-inch cross-compound fly-wheel pump. The two Deane pumps were installed when the plant was built. A steel standpipe 20 feet in diameter and 100 feet high, located near the pumping station on higher land, is connected to the mains.

The plant is now owned by the Sterling Water Company. The Company also supplies water from this plant in Sterling to the city of Rock Falls, which is located across the river.

Water for the public supply is secured from four wells into Cambrian sandstone. The wells are located near the eastern limits of the city, about 200 feet from the bank of Rock River. They are nearly in line and spaced about 100 feet apart. The elevation at the top of the wells is about 645 feet above sea level. The wells are 8 inches in diameter at the top and 4 inches in diameter at the

bottom. The depths are 1334, 1460, 1606, and 1829 feet. One well was drilled by the J. P. Miller Artesian Well Company of Chicago and one, the deepest one, by Levi Wilson of Chicago. A record of material penetrated by well number 3, the deepest well, as given by J. B. Crandall in 1906, is as follows:

	Thickness in feet.	Depth in feet.
Shale	0	185
Lime rock	65	250
Hard lime	50	300
Shale	50	350
Hard lime	75	425
Soft lime rock	45	470
Hard lime	35	505
Gray shale	45	550
Water bearing sandstone 2-in. flow	3	553
Red shale cave, 61 ft. tubing	167	720
Red shale	10	730
Red shale	80	810
White sand, 60 ft. tubing	10	820
White lime	30	850
Sand rock	50	900
Lime rock	50	950
Water lime	25	975
Gray lime	5	980
Red sand	15	995
Second flow		
Sand rock	5	1000
Drab shale	175	1175
Gray shale	37	1212
White sand	48	1260
White rock	20	1280
Yellow sand	20	1300
White sand	20	1320
White sand running	40	1360
40-inch casing		
Blue shale	40	1400
Running sand	20	1420
White sand	54	1474
Red shale	26	1500
Blue shale	50	1550
Gray shale	10	1560
Blue shale	5	1565
Gray shale	3	1568
Blue shale	22	1590
Gray sand, 4th flow	10	1600
White sand	100	1700
Gray sand	100	1800
Sandstone	29	1829

When this well was completed the pressure at the ground surface was nine pounds and the flow was said to be 1,000,000 gallons a day. The flow from the four wells was estimated at 1,800,000 gallons a day in 1915 and at 1,400,000 to 1,500,000 gallons a day in 1921. Three wells are equipped with air lifts and an air lift in one well was usually operated a few hours each day. The water consumption in 1921 was about 800,000 gallons a day.

The water had a mineral content of 340, a total hardness of

293, and a content of iron of 0.1 parts per million as shown by the analysis of sample number 46411, collected on October 21, 1921.

Analysis of Sample Number 46411 from the Public Supply.

Determinations Made.

	Parts per million.
Iron Fe	0.1
Manganese Mn	0.0
Silica SiO_2	11.2
Nonvolatile	0.6
Aluminum Al_2O_3	3.5
Calcium Ca	69.5
Magnesium Mg	29.2
Ammonia NH_4	0.1
Potassium K	5.6
Sodium Na	12.8
Sulfates SO_4	21.8
Nitrates NO_3	0.9
Chlorides Cl	10.0
Alkalinity	
Phenolphthalein	0
Methyl Orange	280.
Residue	331.

Hypothetical Combinations.

	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	1.4	.08
Potassium Chloride KCl	9.6	.56
Sodium Chloride NaCl	8.9	.52
Sodium Sulfate Na_2SO_4	28.8	1.68
Ammonium Sulfate $(NH_4)_2SO_4$	0.4	.02
Magnesium Sulfate $MgSO_4$	2.5	.15
Magnesium Carbonate $MgCO_3$	99.6	5.82
Calcium Carbonate $CaCO_3$	173.6	10.15
Silica SiO_2	11.2	.65
Nonvolatile	0.6	.02
Iron Oxide Fe_2O_3	0.1	.006
Alumina Al_2O_3	3.5	.21
Total	340.2	19.87

A sample collected in 1898 and other samples collected since have been similar. The mineral content has varied from 325 to 340. The magnesium content of each sample was about 36 and the calcium content was about 63 parts per million.

The standpipe installed in 1885 or 1886 was in use in 1921 and was said to be in good condition. It was painted inside and out every three or four years. The water causes some corrosion on meters.

Water from Rock River is used in boilers at the pumping station.

STEWARD (253). Steward is located in the northeastern part of Lee County on the drainage area of Kyte River, a tributary of Rock River. A public water supply was installed by C. T. Beitel and Son about 1909. Water is obtained from a well located near the center of the village. The well is equipped with a deep-well pump which is driven by a 25-horsepower oil engine. The pump discharges into a steel pressure tank 8 feet in diameter and 36 feet long which is connected to the distribution system. Thirty-three service connections, seventeen of which were metered, were in use in 1923. The rate for water is 25 cents per 100 cubic feet with a minimnm charge of 50 cents per month.

Water for the public supply is secured from a well into sand and gravel. It is 8 inches in diameter and 100 feet deep. The top

of the well is about 823 feet above sea level. The well is equipped with a single-acting deep-well pump with 6-inch cylinder and 24-inch stroke. The pump was operated about 8 hours a day in 1923 at 18 strokes a minute. The water level when not pumping was said to be 30 feet below the ground surface.

The water had a mineral content of 289, a total hardness of 255, and a content of iron of 0.4 parts per million as shown by the analysis of sample number 50394, collected on October 25, 1923.

Analysis of Sample Number 50394 from the Public Supply.

Determinations Made.	Parts per million.
Iron Fe	0.4
Manganese Mn.	0.0
Silica SiO_2	18.8
Nonvolatile	2.0
Alumina Al_2O_3	1.2
Calcium Ca.	63.6
Magnesium Mg.	23.7
Ammonium NH_4	.0
Sodium Na	7.0
Potassium K	4.0
Sulfate SO_4	2.7
Nitrate NO_3	1.8
Chloride Cl.	4.0
Alkalinity	
Phenolphthalein	0
Methyl Orange.	252.
Residue	307.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	2.8	0.16
Potassium Chloride KCl.	5.6	0.33
Sodium Chloride NaCl.	2.2	0.13
Sodium Sulfate Na_2SO_4	3.9	0.23
Sodium Carbonate Na_2CO_3	11.3	0.66
Ammonium Carbonate $(NH_4)_2CO_3$	0.0	0.00
Magnesium Carbonate $MgCO_3$	81.9	4.78
Calcium $CaCO_3$	158.8	9.27
Iron Oxide Fe_2O_3	0.8	0.05
Alumina Al_2O_3	1.2	0.07
Silica SiO_2	18.8	1.10
Nonvolatile	2.0	0.11
Total	289.3	16.89

A sample collected in 1917 was similar.

STOCKTON (1449). Stockton is located in the eastern part of Jo Daviess County on high land near head waters of small tributaries of Mississippi River. A public water supply was installed by the village about 1900. Water was pumped from a well into the distribution system by a steam-head deep-well pump. A pump driven by a 30-horsepower electric motor has been installed and a concrete reservoir has been built into which water from the well is now discharged. Water is pumped from the reservoir into the distribution system by a centrifugal pump driven by an electric motor. A reservoir 40 feet in diameter and 11 feet deep, on a hill northwest of the village, is connected to the distribution system.

The village was short of water in 1923 and was drilling another well. While drilling this well part of the supply was obtained from a well nearby owned by the Chicago Great Western Railroad. A deep-well pump had been installed and was driven by belt from a tractor. Three hundred and fifty service connections were in use

in 1923. The meter rate is 55 cents per 1000 gallons and the minimum charge is $2.00 every three months. Bills are not subject. to cash discount.

The entire water supply until 1923 was secured from a well 1440 feet deep, located in the southeastern part of the village. The well was drilled by Gray Brothers of Chicago. The top of the well is about 1000 feet above sea level. A record of material penetrated as given by W. G. Kirchoffer of Madison, Wisconsin is as follows:

Surface material	65 feet
Lime rock, Galena-Platteville	380 feet
Sandstone, St. Peter	17 feet
Lime rock, Prairie du Chien	153 feet
Cave at 617 feet	
Sandstone, Madison	30 feet
Sandstone, Jordan	30 feet
Sandstone, shale, dolomite, St. Lawrence	100 feet
Cave at 723 feet	
Sandstone and shale, Franconia	170 feet
Sandstone, (Dresbach)	300 feet
Sandstone, Clay, Eau Claire	195 feet
Total depth	1440 feet

The well was repaired by the J. P. Miller Artesian Well Company of Chicago in 1908-1909. Information from the company is as follows: The well was reamed to 12-inch diameter to a depth of 300 feet and to 8¼-inches below that depth. Three hundred feet of 6-inch casing was placed with the bottom at a depth of 617 feet and one hundred and fifty-four feet of 5-inch casing was placed with the bottom at a depth of 723 feet. The well caved some at a depth of 1426 feet and caved badly at a depth of 1440 feet. (Depth finished not given). After repairs the well was pumped at a rate of 150 gallons a minute.

The well is equipped with a Keystone Driller Company deep-well pump with a 7¾-inch cylinder and 18-inch stroke. The cylinder is placed at a depth of 300 feet and has 26 feet of suction pipe attached.

During the spring of 1923 part of the supply was secured from a well owned by the Chicago Great Western Railroad. This well is 1528 feet deep. It was equipped with a Keystone Driller Company double-stroke deep-well pump with a 5¾-inch cylinder and 18-inch stroke. The cylinder was attached to 340 feet of 6-inch drop pipe.

On October 8, 1923, when the pump in the village well was operated 17½ revolutions a minute and the pump in the railroad company well was operated 27 revolutions a minute the discharge, from the two wells, measured in the reservoir, was 160 gallons a minute. The yield of the company well when operating alone was 85 gallons a minute. Both well pumps were operated from 8 to 8½ hours a day.

Water from the village well had a mineral content of 395 and a total hardness of 302 parts per million as shown by the analysis of sample number 50289, collected on October 9, 1923, after the pump had operated for two hours.

Analysis of Sample Number 50289 from Village Well 1440 Feet Deep.

Determinations Made.	Parts per million.
Iron Fe	0.0
Manganese Mn	0.0
Silica SiO_2	23.0
Nonvolatile	0.7
Alumina Al_2O_3	0.5
Calcium Ca	53.0
Magnesium Mg	41.4
Ammonium NH_4	0.1
Sodium Na	33.4
Potassium K	8.6
Sulfate SO_4	8.8
Nitrate NO_3	1.2
Chloride Cl	3.0
Alkalinity	
Methyl Orange	368.0
Residue	360.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	0.2	0.01
Potassium Chloride KCl	6.3	0.36
Potassium Sulfate K_2SO_4	10.2	0.59
Sodium Sulfate Na_2SO_4	4.7	0.27
Sodium Carbonate Na_2CO_3	73.5	4.29
Ammonium Carbonate $(NH_4)_2CO_3$	0.4	0.02
Magnesium Carbonate $MgCO_3$	143.3	8.37
Calcium Carbonate $CaCO_3$	132.3	7.73
Iron Oxide Fe_2O_3	0.0	0.00
Alumina Al_2O_3	0.5	0.03
Silica SiO_2	23.0	1.34
Nonvolatile	0.7	0.04
Total	395.1	23.05

Analysis made in the field in 1918 showed an absence of hydrogen sulphide and the presence of 3.2 parts of carbon dioxide. A sample collected at the time had a mineral content of 338, a total hardness of 323, and a content of iron of 0.2 parts per million. A sample collected in 1898, marked from a well 1500 feet deep, evidently the village well or railroad well, had a mineral content of 358, a total hardness of 395, and a content of iron of 0.7 parts per million. The temperature of water from the raiload well after six hours pumping on October 8, 1923, was 52 degrees Fahrenheit.

Determinations Made.	Parts per million.
Iron Fe	0.4
Manganese Mn	0.0
Silica SiO_2	7.0
Alumina Al_2O_3	0.0
Calcium Ca	66.8
Magnesium Mg	28.0
Ammonia NH_4	0.3
Sulfate SO_4	0.0
Nitrate NO_3	0.7
Chloride Cl	2.0
Alkalinity	
Phenolphthalein	0
Methyl Orange	3.3
Residue	322.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Sodium Nitrate $NaNO_3$	0.9	.06
Sodium Chloride NaCl	3.3	.19
Sodium Carbonate Na_2CO_3	48.0	2.80
Ammonium Carbonate $(NH_4)_2CO_3$	0.9	.05
Magnesium Carbonate $MgCO_3$	97.0	5.67
Calcium Carbonate $CaCO_3$	166.9	9.75
Iron Oxide Fe_2O_3	0.6	.04
Silica SiO_2	7.0	.41
Total	324.6	18.97

The well drilled in 1923 is 12 inches in diameter and 494 feet deep. It is equipped with a Keystone Driller Company double-stroke deep-

well pump with 53/4-inch cylinder and 18-inch stroke. The cylinder is at a depth of 341 feet and has 10 feet of suction pipe attached. The well was pumped for 24 hours at a rate of about 130 gallons a minute and a little higher rate at the end. The well was to be tested in 1925. The water had a mineral content of 324, a total hardness of 282, and a content of iron of 0.4 parts per million as shown by the analysis of sample number 53503, collected on March 30, 1925.

With long continued pumping there may be some change in the quality of the water, especially a reduction in the iron content.

STONINGTON (1466). Stonington is located in the northeastern part of Christian County on the drainage area of Sangamon River, a tributary of Illinois River. A public water supply was installed by the village in 1906. Water is secured from wells about 40 feet deep into a stratum of gravel. The supply is now principally from a dug well. Water is pumped by a Deane Brothers steam pump which is placed on a platform in the well. Steam is. supplied at 100 pounds pressure by two 60-horsepower Atlas firetube boilers.

Water was first secured from two 6-inch drilled wells, equipped with number 14 Cook screens 10 feet long. Another similar well was drilled later. Two of these wells have been abandoned. Water can be pumped from the other one with a steam-head deep-well pump but the pump is seldom used.

A well 10 feet square and 48 feet deep was dug in 1920 and has since furnished nearly the entire supply. The well passes through hardpan between depths of 14 and 22 feet. Below the hardpan is fine white sand and below the sand is about 14 feet of gravel, some of which is very coarse. The bottom of the well is in fine white sand. Water is pumped by a 9 by 6 by 12-inch duplex steam pump placed on a platform at a depth of 27 feet.

The water level when one drilled well was in use in 1913 was said to be at a depth of from 10 to 12 feet. In June, 1922, the water level in the dug well was a few inches below the platform and this was said to be its highest level. The pump discharge varies with steam pressure. At the time of visit in June, 1922, the pump displacement was 110 gallons a minute. The pump was then operated about 8 hours a day and the water level ‘was never drawn down more than four feet.

The water had a mineral content of 481, a total hardness of 368, and a content of iron of 2.5 parts per million as shown by the

analysis of sample number 37390, collected from a fire hydrant on June 25, 1917.

Analysis of Sample Number 37390 from the Village Supply.

Determinations Made.	Parts per million.
Iron Fe	2.5
Silica SiO_2	19.5
Alumina Al_2O_3	2.5
Calcium Ca	101.5
Magnesium Mg	27.9
Ammonium NH_4	1.6
Potassium K	2.7
Sodium Na	33.3
Sulfate SO_4	42.2
Nitrate NO_3	1.1
Chloride Cl	27.0
Alkalinity Methyl Orange	330.
Residue	455.
Nonvolatile	0.2

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	1.8	.10
Potassium Chloride KCl	3.8	.22
Sodium Chloride NaCl	41.6	2.42
Sodium Sulfate Na_2SO_4	52.1	3.04
Ammonium Sulfate $(NH_4)_2SO_4$	5.9	.34
Magnesium Sulfate $MgSO_4$	3.4	.20
Magnesium Carbonate $MgCO_3$	94.2	5.49
Calcium Carbonate $CaCO_3$	253.3	14.78
Iron Oxide Fe_2O_3	3.5	.20
Alumina Al_2O_3	2.5	.15
Silica SiO_2	19.5	1.11
Nonvolatile	0.2	.01
Total	481.8	28.09

Boilers at the pumping station are blown off every day and little scale is formed. Meters are installed on nearly all services. One meter in use for 17 years was in good order in 1922.

STRAWN (248). Strawn is located in the southeastern part of Livingston County on the drainage area of Vermilion River, a tributary of Illinois River. Some wells in the village are into sand and gravel at a depth of about 40 feet and others are into a lower stratum of sand and gravel at a depth of about 80 feet.

A public water supply was installed by the village about 1895. Water was secured from a dug well 40 feet deep. In 1909 a well was drilled and the dug well was abandoned. Water is pumped from the drilled well directly into the mains and an elevated steel tank connected to the mains by a Goulds 7 by 8-inch triplex pump which is driven by belt from an oil engine. The capacity of the tank is 30,000 gallons. About 42 service connections were in use in 1922. The charge for water is $5.00 a year. The Strawn Electric Light Company pumps the water for the village.

Water for the public supply is secured from a drilled well into sand and gravel. It is located in a park near the center of the village. The elevation at the top of the well is about 770 feet above sea level. The well is 6 inches in diameter. Mr. Taylor, a well driller, states that it is 80 feet deep. Water is drawn from the well by suction by a 7 by 8-inch triplex pump operating about 48 revolutions a minute, a displacement of 192 gallons a minute. After cleaning the elevated tank the pump is operated continuously

until the tank is filled and in 1922 the pump was said to operate as well when filling the tank as when pumping for a few minutes only.

The water had a mineral content of 529, a total hardness of 405, and a content of iron of 2.5 parts per million as shown by the analysis of sample number 30602, collected on June 3, 1915.

Analysis of Sample Number 30602 from the Village Supply.

Determinations Made.	Parts per million.
Iron Fe	2.5
Manganese Mn	0.0
Silica SiO_2	15.4
Alumina Al_2O_3	3.0
Calcium Ca	93.5
Magnesium Mg	41.7
Ammonium NH_4	0.3
Potassium K	3.0
Sodium Na	29.2
Sulfate SO_4	124.7
Nitrate NO_3	1.9
Chloride Cl	28.0
Alkalinity Methyl Orange	284.
Residue	532.
Nonvolatile	3.6

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Chloride KCl	3.4	.20
Potassium Nitrate KNO_3	3.1	.18
Sodium Chloride NaCl	43.6	2.54
Sodium Sulfate Na_2SO_4	37.0	2.16
Magnesium Sulfate $MgSO_4$	125.4	7.31
Magnesium Carbonate $MgCO_3$	56.4	3.29
Calcium Carbonate $CaCO_3$	233.3	13.60
Iron Carbonate $FeCO_3$	5.0	.29
Alumina Al_2O_3	3.0	.17
Silica SiO_2	15.4	.90
Nonvolatile	3.6	.31
Total	529.2	30.85

STRONGHURST (836). Stronghurst is located in the southern part of Henderson County about ten miles east of Mississippi River. A public water supply was installed by the village in 1915. Water from a well is pumped directly into the distribution system to which an elevated steel tank of 50,000 gallons capacity is connected, by a deep-well pump which is driven by a 75-horsepower oil engine. Sixty-three service connections were in use in 1925 and the amount of water used was about 10,000 gallons a day. The meter rate is 35 cents per 1000 gallons with a minimum charge of 50 cents a month.

Water for the public supply is secured from a well 1009 feet deep. The lower 137 feet is in St. Peter sandstone and is 6 inches in diameter. The well cost $2,743.55. The well is equipped with a Keystone Driller Company deep-well pump of 100 gallons a minute capacity. The cylinder is at a depth of 175 feet and has 10 feet of suction pipe attached. The depth to water when not pumping was 65 feet in 1917 and 65 feet in March, 1925.

The water had a mineral content of 2953, a total hardness of 1110, and a content of iron of 4.0 parts per million as shown by the analysis of sample number 39704, collected on July 3, 1918.

Analysis of Sample Number 39704 from the Village Supply.

Determinations Made.	Parts per million.
Iron Fe	4.0
Silica SiO_2	9.6
Alumina Al_2O_3	0.3
Calcium Ca	263.1
Magnesium Mg	110.6
Ammonium NH_4	2.5
Potassium K } Sodium Na }	543.8
Manganese Mn	0.0
Sulfate SO_4	1604.0
Nitrate NO_3	0.5
Nitrite NO_2	0.0
Chloride Cl	259.4
Alkalinity Methyl Orange	216.0
Residue	2971.2
Nonvolatile	2.0

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Sodium Nitrate $NaNO_3$	42.6	2.47
Sodium Chloride NaCl	428.1	24.81
Sodium Sulfate Na_2SO_4	1122.5	65.39
Ammonium Sulfate $(NH_4)_2SO_4$	9.4	.54
Magnesium Sulfate $MgSO_4$	545.7	31.62
Calcium Sulfate $CaSO_4$	546.5	31.69
Calcium Carbonate $CaCO_3$	239.1	13.85
Iron Carbonate $FeCO_3$	8.0	.46
Alumina Al_2O_3	0.3	.02
Silica SiO_2	9.6	.56
Nonvolatile	2.0	.12
Total	2953.8	171.53

The Stronghurst-Media Company, named from the villages of Stronghurst and Media, drilled a well in Stronghurst about 1894. The village contributed $1,000 as they contemplated using the well as a source of public water supply if oil or gas were not found. An abstract of a log prepared by the State Geological Survey Division is as follows:

	Thickness in feet.	Depth in feet.
Soil and drift	150	150
Shale	165	315
Limestone	105	420
Shale, Maquoketa	165	585
Limestone, Galena-Platteville	275	860
Sandstone, St. Peter	171	1031
Shale, St. Peter	25	1056
Limestone, white, Prairie du Chien	10	1066
Shale, white, Prairie du Chien	5	1071
Limestone, white, Prairie du Chien	24	1095
Sandstone, white, Prairie du Chien	20	1115
Limestone, Prairie du Chien	50	1165
Shale, Prairie du Chien	5	1170
Limestone, Prairie du Chien	105	1275
Sandstone, Prairie du Chien	5	1280
Limestone, Prairie du Chien	25	1305
Sandstone, Cambrian system	296	1601

Records of the company show 169 feet of 12-inch casing, 590 feet of $9\frac{5}{8}$ inch casing, and 1056 feet of $5\frac{5}{8}$-inch casing. It is understood that each size casing is from the ground surface. The smallest casing then extends through the St. Peter sandstone. Sample number 4105 was collected on September 20, 1898.

The total mineral content of samples collected in 1908 and in 1914 was about the same as given for the sample above and the waters were of similar quality. Differences shown by the analyses

may be due to deterioration of casings, filling of well, or difference in amount and rate of pumping before samples were collected.

Analysis of Sample Number 4105 from Well 1601 Feet Deep.

Determinations Made.

	Parts per million.
Iron Fe	0.3
Silica SiO_2	2.4
Aluminum Al	0.8
Calcium Ca	81.1
Magnesium Mg	34.1
Ammonium NH_4	1.4
Potassium K	27.0
Sodium Na	302.8
Sulfate SO_4	525.1
Nitrate NO_3	0.1
Chloride Cl	290.0
Residue	1319.2
Lithium Li	0.1

Hypothetical Combinations.

	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	1.7	.10
Potassium Chloride KCl	50.2	2.92
Sodium Chloride NaCl	438.5	25.57
Sodium Sulfate Na_2SO_4	401.9	23.44
Ammonium Sulfate $(NH_4)_2SO_4$	5.1	.30
Magnesium Sulfate $MgSO_4$	169.2	9.87
Calcium Sulfate $CaSO_4$	161.2	9.40
Calcium Carbonate $CaCO_3$	83.9	4.90
Ferrous Carbonate $FeCO_3$	0.6	.03
Alumina Al_2O_3	1.6	.09
Lithium Sulfate	0.7	.04
Silica SiO_2	2.4	.14
Total	1317.0	76.80

SUBLETTE (262). Sublette is located in the southeastern part of Lee County on Big Bureau Creek, a tributary of Illinois River. Many gas wells about 240 feet deep have been drilled in the village. The village drilled a well for a water supply in 1893. It was located across the street north of the center of the business district. Little water was furnished from this supply.

A complete system of water works was installed by the village in 1898. Water is pumped from a well into a concrete reservoir by a Goulds deep-well pump which is driven by chain belt from a 15-horsepower electric motor. The reservoir is 28 feet 8 inches in diameter. Water is pumped from the reservoir into the distribution system and an elevated steel tank connected to the system by an 8 by 7-inch Stilwell, Bierce and Smith-Vaile triplex pump. The pump discharges 240 gallons a minute. In 1923 all but one family in the village used water from the public supply.

Water is secured from a well 752 feet deep. It is located across the railroad tracks north of the business district. It was drilled by the J. P. Miller Artesian Well Company of Chicago in 1898. The top of the well is 920 feet above sea level. The drillers noted that rock was entered at a depth of 443 feet and that below a depth of 600 feet the well is in sandstone. The well is cased from the ground surface with about 25 feet of 12-inch pipe and 364 feet of 10-inch pipe and between depths of 300 and 443 feet with 6-inch pipe. The well is 6 inches in diameter at the bottom. It cost $1,939.81. When the well was completed water stood at a depth of 220 feet. The

well was formerly equipped with a pump with a 9½-inch cylinder wedged in the casing. The old check valve has been driven shut and a 3½-inch opening has been drilled through it. An 8-inch drop line to which a 7½-inch pump cylinder is attached has been installed and probably serves partly as a casing. The cylinder is placed at a depth of 260 feet and has 16 feet of suction pipe attached. The pump is operated with 24-inch stroke at a speed of a little over 18 revolutions a minute. The discharge in October, 1923, filled the reservoir at a rate of an inch in three minutes or 134 gallons a minute. The pump was operated about 3½ hours a day.

The water had a mineral content of 274, a total hardness of 195, and a content of iron of 0.4 parts per million as shown by the analysis of sample number 37755, collected on August 6, 1917.

Analysis of Sample Number 37755 from the Village Supply,

Determinations Made.	Parts Per million.
Iron Fe	0.4
Silica SiO_2	11.1
Nonvolatile	0.4
Alumina Al_2O_3	1.5
Calcium Ca	39.1
Magnesium Mg	23.9
Ammonium NH_4	0.4
Potassium K	2.5
Sodium Na	32.5
Sulfate SO_4	0.5
Nitrate NO_3	0.0
Chloride Cl	3.0
Alkalinity Methyl Orange	254.
Residue	270.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Chloride KCl.	4.8	.28
Sodium Chloride NaCl.	1.2	.07
Sodium Carbonate Na_2CO_3	73.6	4.29
Ammonium Carbonate $(NH_4)_2CO_3$	1.1	.06
Magnesium Carbonate $MgCO_3$	82.8	4.83
Calcium Carbonate $CaCO_3$	97.6	5.69
Iron Oxide Fe_2O_3	0.6	.03
Alumina Al_2O_3	1.5	.09
Silica SiO_2	11.1	.65
Nonvolatile	0.4	.02
Total	274.7	16.01

The water stains plumbing fixtures. The 10-inch well casing installed in 1898 was eaten through and an 8-inch pipe to which the pump cylinder is attached was installed about 1918. This 8-inch line was taken out twice in the following five years for replacements of parts of the line.

SULLIVAN (2532). Sullivan is located in the central part of Moultrie County on the drainage area of Kaskaskia River, a tributary of Mississippi River. A public water supply has been installed by the city. Water is secured from wells equipped with deep-well pumps which discharge directly into the distribution system. Two wells at the main pumping station are equipped with steam-head pumps. Other pumps are driven by electric motors. An elevated steel tank is connected to the system. About 260 service connections were in use in 1924. Nearly all consumers paid the minimum

charge of 50 cents a month or a rate of 40 cents per 1,000 gallons which allows the use of 10,000 gallons. The supply of water was not sufficient to meet all demands.

Water is secured from six wells. Two of the wells are into a stratum of sand at a depth of 80 or 90 feet and the other four are into a stratum of sandstone which is entered at a depth of 180 or 200 feet.

Two wells at the main pumping station, near the southwestern limits of the city at McGellan and Water Streets, are 300 feet deep. The elevation of the ground surface at the wells is about 685 feet feet above sea level. One well is 8 inches in diameter. It is equipped with a single-acting steam-head deep-well pump with a 4¼-inch water cylinder placed at a depth of 270 feet. It is operated continuously with 36-inch stroke at 7½ strokes a minute, a displacement of 16 gallons a minute. The other well, 60 feet distant, is equipped with a single-acting steam-head deep-well pump with a 2¾-inch water cylinder at a depth of about 270 feet. The pump is operated continuously with 18-inch stroke at 12 strokes a minute, a displacement of between five and six gallons a minute. The depth to water in one well when the pump in the other well was operating was 100 feet in 1921.

One well is located near the northeastern limits of the city at the corner of Lebanon and Jackson Streets. It is 10 inches in diameter and 260 or 270 feet deep. It is equipped with a single-acting deep-well pump with a 3¾-inch cylinder placed close to the bottom of the well. The pump is operated continuously with 24-inch stroke at 17 to 18 strokes a minute.

One well is located in the rear of the city hall at the corner of Madison and Jefferson Streets. It is 12 inches in diameter and 280 feet deep. This well was drilled by Omer Kersey in 1916. When completed a pump with a 3¾-inch cylinder placed at a depth of 245 feet, discharged 35 gallons a minute during a nine hour test. The well is equipped with a deep-well pump with the cylinder placed close to the bottom of the well. The pump is operated eighteen hours a day with 24-inch stroke at 15½ strokes a minute.

One well is located at the corner of Madison and Adams Streets on what is known as the Rork lot. It is 12 inches in diameter and 90 feet deep. It is equipped with a single-acting deep-well pump which is operated at a speed of 10 strokes a minute, a displacement near 18 gallons a minute. The depth to water in June, 1922, in an abandoned well of about the same depth, 100 feet distant, was 40 feet when pumping from this well. Several wells have been drilled on this lot and all but this one have been abandoned.

One well, on what is known as the Powers lot north of the Illinois Central Railroad and west of Hamilton Street, is rented by the city. The well is 90 feet deep. It is equipped with a deep-well pump which is operated continuously. The discharge was metered until 1923 and was 18,000 gallons a day.

Definite record of discharge of each well is not available, but it is doubtful if any well discharges much if any more than 20,000 gallons a day and the total supply from the six wells is probably near 100,000 gallons a day.

Sample number 52428 was collected from one of the wells into sandstone at the main pumping station on September 17, 1924.

Analyses of other samples of water from these wells and from wells into sandstone located in the rear of the city hall and at the county building contained more sodium and chloride. A sample collected in 1917 from a well 275 feet deep at the Illinois Masonic Home was much more highly mineralized. The total mineral content was 2210 parts per million.

Water from wells into sand at a depth of about 90 feet yield water containing less sodium compounds and less total mineral. Sample number 52428 was collected on September 17, 1924, from the well 90 feet deep on the Rork lot.

Other analyses of waters from drilled wells into this sand stratum are similar.

Analysis of Sample Number 52428 from City Well 300 Feet Deep Into Sandstone.

Determinations Made.

	Parts per million.
Iron Fe	2.0
Manganese Mn	0.0
Silica SiO_2	16.3
Nonvolatile	1.5
Alumina Al_2O_3	0.0
Calcium Ca	57.8
Magnesium Mg	33.7
Ammonia NH_4	5.7
Potassium K	56.8
Sodium Na	162.6
Sulfate SO_4	0.0
Nitrate NO_3	2.8
Chloride Cl	185.0
Alkalinity	
Phenolphthalein	0
Methyl Orange	488.
Residue	783.

Hypothetical Combinations.

	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	4.6	0.27
Potassium Chloride KCl	105.0	6.13
Sodium Chloride NaCl	222.6	13.00
Sodium Carbonate Na_2CO_3	172.8	10.09
Ammonium Carbonate $(NH_4)_2CO_3$	15.1	0.88
Magnesium Carbonate $MgCO_3$	116.8	6.82
Calcium Carbonate $CaCO_3$	144.5	8.44
Iron Oxide Fe_2O_3	2.9	0.17
Alumina Al_2O_3	0.0	0.00
Silica SiO_2	16.3	0.95
Nonvolatile	1.5	0.09
Total	802.1	46.84

SUMMIT (4019). Summit is located in Cook County about twelve miles southwest of the city of Chicago. A public water

supply was installed by the village about 1902. Water was secured from a well 505 feet deep which has since been abandoned. Two other wells have been drilled and equipped with air lifts. Air is supplied by either of two compressors, one an Ingersoll-Rand cross-compound which is driven by a 103-horsepower electric motor and the other a Worthington compound which is driven by an oil engine. Water is discharged from the wells into a concrete reservoir of 78,000 gallons capacity and is pumped from the reservoir into the distribution system by a Cameron centrifugal pump which is driven by a 25-horsepower electric motor. Eight hundred service connections were in use in 1925. The meter rate is 50 cents per 1000 gallons with a ten per cent cash discount.

One of the two wells in use was drilled by the J. P. Miller Artesian Well Company of Chicago in 1907. It was cased from the surface with 22 feet of 15-inch pipe, 55 feet of 12-inch pipe, and 63 feet of 10-inch pipe. It was drilled 10 inches in diameter to a depth of 200 feet, 8 inches in diameter through stone and shale to a depth of 525 feet, and 5 inches in diameter at the bottom. The well is in sandstone between depths of 1247 and 1530 feet. Two hundred and three feet of 6¼-inch casing was placed through the shale and 60 feet of 5-inch casing was placed with the bottom at a depth of 960 feet. The well was repaired in 1918. It was reamed 8 inches in diameter to a depth of at least 602 feet and was cleaned out to the bottom at a depth of 1544 feet.

The other well was drilled by the J. P. Miller Artesian Well Company in 1912-1913. The material penetrated, as recorded by the drillers with some classification as given by the State Geological Survey Division, is as follows:

	Thickness in feet.	Depth in feet.
Drift	59	59
Limestone, Silurian system all or chiefly Niagaran	280	339
Shale, Richmond	141	480
Limestone, Galena-Platteville	324	804
Sandstone and sandy limestone, St. Peter	131	935
Limestone, Prairie du Chien	405	1340
Sandstone, Mazomanie-Dresbach, Cambrian system	195	1535
Limestone, Eau Claire, Cambrian system	30	1565
Shale, Eau Claire, Cambrian system	80	1645
Marl, Eau Claire, Cambrian system	65	1710
Shale, Eau Claire, Cambrian system	70	1780
Limestone, Eau Claire, Cambrian system	23	1803
Sandstone, Mt. Simon, Cambrian system	64	1867
Measured depth, 1861		

Crevices were noted between depths of 1112 and 1120 feet. The well was cased with 18-inch outside diameter pipe to rock. It was drilled 17 inches in diameter to a depth of 105 feet, 16¼ inches to 303 feet, 12½ inches to 830 feet, 10½ inches to 939 feet, and

8 inches in diameter at the bottom. It was reamed to 12 inches to a depth of 873 feet. When the well was completed it was tested and the rate of pumping was as much as 555 gallons a minute. The flow was measured by weir.

In 1916 a 2-inch air line extended to a depth of 430 feet and an auxiliary air line extended to a depth of near 215 feet. The discharge line was 5½ inches in diameter at the top. At that time this well furnished the entire supply which was estimated at 250,000 gallons a day.

Water from the well 1861 feet deep had a mineral content of 707, a total hardness of 304, and a content of iron of 0.5 parts per million, as shown by the analysis of sample number 36061, collected on November 30, 1916.

Analysis of Sample Number 36061 from City Well 1861 Feet Deep.

Determinations Made.	Parts per million.
Silica SiO_2	6.6
Iron Fe	0.5
Alumina Al_2O_3	1.9
Calcium Ca	12.7
Magnesium Mg	29.6
Ammonium NH_4	0.3
Potassium K	15.4
Sodium Na	134.1
Sulfate SO_4	163.0
Nitrite NO_2	0.1
Chloride Cl	96.0
Nitrate NO_3	3.0
Alkalinity Methyl Orange	286.
Residue	699.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	4.9	.29
Potassium Nitrite KNO_2	0.2	.01
Potassium Chloride KCl	25.5	1.49
Sodium Chloride NaCl	138.4	8.07
Sodium Sulfate Na_2SO_4	241.2	14.07
Sodium Carbonate Na_2CO_3	3.2	.19
Ammonium Carbonate $(NH_4)_2CO_3$	0.8	.05
Magnesium Carbonate $MgCO_3$	102.5	5.98
Calcium Carbonate $CaCO_3$	181.9	10.61
Silica SiO_2	6.6	.38
Iron Oxide Fe_2O_3	0.7	.04
Alumina Al_2O_3	1.9	.11
Total	707.8	41.29

SYCAMORE (3602). Sycamore is located in the northeastern part of De Kalb County near the south branch of Kishwaukee River, a tributary of Rock River. A public water supply was installed by the city about 1890. Water from wells into sand and gravel flowed into a collecting reservoir from which it was pumped into the distribution system. Later the city contracted with a private company to supply water from wells at a light plant owned by the company. The wells and equipment are now owned by the Public Service Company of Northern Illinois. The distribution system is owned and maintained by the city. Water is pumped directly from the wells into the distribution system to which an elevated steel tank of 175,000 gallons capacity is connected. The amount of water pumped from each well is registered by meter.

Ten hundred and twenty-three service connections were in use in 1922. The minimum charge is $1.25 for three months. The rate for the first 700 cubic feet is 30 cents and the lowest rate, for water in excess of 16,100 cubic feet, is 7½ cents. Additional charge is made if payment is not prompt and an additional charge of 25 cents is made when the city owns the meter.

Water is secured from three wells, (data on a well drilled in 1924 not included). Two wells are located about 15 feet apart near the center of the city east of the main street, half a block south of the court-house square. They were drilled by the J. P. Miller Artesian Well Company of Chicago. The tops of the wells are about 865 feet above sea level. One well was drilled in 1903. It is 902 feet deep and 8 inches in diameter at the bottom. It is cased with 12-inch pipe at the top. Sandy limestone was noted at a depth of 592 feet and sandstone below a depth of 625 feet. The other one was drilled about 15 feet south of the older well in 1907. It is 904 feet deep. The well was cased with 10-inch pipe to a depth of 244 feet and with 8-inch pipe between depths of 178 and 254 feet. It is 8 inches in diameter at the bottom.

The north well is equipped with a Downie double-acting deep-well pump which is driven by a 30-horsepower electric motor. The cylinder is 7¾ inches in diameter and the stroke is 18 inches. The capacity of the pump is about 190 gallons a minute. It was not operating at the time of visit on April 20, 1922. The amount of water pumped from this well in one year, to April 1, 1922, was 13,200,000 gallons. The south well is equipped with a double-acting steam-head deep-well pump with 7½-inch cylinder and 36-inch stroke. As operated the discharge is usually from 60 to 70 gallons a minute. The amount of water pumped from this well in one year, to April 1, 1922, was 5,800,000 gallons. The cylinder of one pump is at a depth of 125 feet and the water level when pumping is drawn to a depth of 100 feet. The cylinder in the other well is at a depth of 160 feet and the water level when pumping is drawn to a depth of 140 feet. The depth to water when not pumping, when measured in 1920, was 47 feet in one well and 56 feet in the other well.

A well was drilled in 1914 by the W. L. Thorne Company of Des Plaines. It is located in the northern part of the city on the south side of the Chicago Great Western Railroad, close to the old wells into sand and gravel. The well is 12 inches in diameter at the top and 10 inches in diameter at the bottom. An abstract of a record of material penetrated as given by the State Geological Survey Division is as follows:

	Thickness in feet.	Depth in feet.
Glacial till	150	150
Limestone, Galena-Platteville	385	535
Sandstone, St. Peter	280	815
Limestone, Prairie du Chien	187	1002

The well is equipped with a Glendora deep-well pump which is belted to a 40-horsepower electric motor. The cylinder is at a depth of 112 feet. The yield at time of visit on April 20, 1922, was 225 gallons a minute. The well had yielded as much as 600 gallons a minute. With a discharge of more than 400 gallons a minute shale was drawn into the well. The amount of water pumped from this well during one year, to April 1, 1922, was 96,000,000 gallons. The water level in 1922 was at a depth of 14 feet when not pumping and at a depth of about 70 feet when pumping at a rate of 260 gallons a minute.

A slight odor of hydogen sulphide was noted near the south well near the center of the city. The temperature of the water was 52 degrees Fahrenheit. The water had a mineral content of 367, a total hardness of 330, and a content of iron of 0.4 parts per million as shown by the analysis of sample number 47402, collected on April 20, 1922, when the pump was operating continuously and the discharge was from 45 to 65 gallons a minute.

Analysis of Sample Number 47402 from South Well.

Determinations Made.

	Parts per million.
Iron Fe	0.4
ManganeseMn	0.0
Silica SiO_2	17.0
Nonvolatile	1.6
Alumina Al_2O_3	2.8
Calcium Ca	65.1
Magnesium Mg	40.7
Ammonium NH_4	0.5
Sodium Na	10.5
Potassium K	2.5
Sulfate SO_4	31.4
Nitrate NO_3	0.1
Chloride Cl	5.0
Alkalinity Methyl Orange	189.6
Residue	353.

Hypothetical Combinations.

	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	0.2	0.01
Potassium Chloride KCl	4.6	0.27
Sodium Chloride NaCl	4.6	0.27
Sodium Sulphate Na_2SO_4	26.6	1.55
Ammonium Sulfate $(NH_4)_2SO_4$	1.7	0.10
Magnesium Sulfate $MgSO_4$	15.2	.89
Magnesium Carbonate $MgCO_3$	130.5	7.58
Calcium Carbonate $CaCO_3$	162.4	9.46
Silica SiO_2	17.0	0.99
Nonvolatile	1.6	0.10
Iron Oxide Fe_2O_3	0.6	0.03
Alumina Al_2O_3	2.8	0.16
Total	367.8	21.41

The temperature of water from the well 1001 feet deep in the northern part of the city was 51 degrees Fahrenheit. The water had a mineral content of 333, a total hardness of 285, and a content of iron of 0.8 parts per million as shown by the analysis of sample number 47401, collected on April 20, 1922, when the pump was operated 21 hours a day and discharged 225 gallons a minute.

Analysis of Sample Number 47401 from the City Well in the Northern Part of the City.

Determinations Made.	Parts per million.
Iron Fe	0.8
Manganese Mn	0.0
Silica SiO_2	20.2
Nonvolatile	1.1
Alumina Al_2O_3	1.7
Calcium Ca	63.1
Magnesium Mg	30.9
Ammonium NH_4	0.4
Sodium Na	15.6
Potassium K	3.0
Sulfate SO_4	2.8
Nitrate NO_3	0.2
Chloride Cl	2.0
Alkalinity Methyl Orange	322.
Residue	341.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	0.3	.02
Potassium Chloride KCl	4.2	.24
Potassium Sulphate K_2SO_4	1.6	.09
Sodium Sulfate Na_2SO_4	2.8	.16
Sodium Carbonate Na_2CO_3	34.0	1.99
Ammonium Carbonate $(NH_4)_2CO_3$	1.1	.06
Magnesium Carbonate $MgCO_3$	107.1	6.26
Calcium Carbonate $CaCO_3$	157.7	9.22
Silica SiO_2	20.2	1.18
Nonvolatile	1.1	.06
Iron Oxide Fe_2O_3	1.2	.07
Alumina Al_2O_3	1.7	.10
Total	333.0	19.45

TAMPICO (778). Tampico is located in the southeastern part of Whiteside County on the drainage area of Five Mile Creek, a tributary of Rock River. A public water supply was installed by the village in 1912. Water is drawn from wells by suction and is discharged into the distribution system to which an elevated steel tank of 40,000 gallons capacity is connected. Water is drawn from wells on the north side of the pumping station by a Fairbanks-Morse duplex pump which is driven by a 12-horsepower gas engine. Water is drawn from wells to the south of the station by a Goulds 7 by 8-inch double-acting triplex pump which is driven by a 15-horsepower electric motor. Eighty service connections were in use in 1925. The meter rate is 35 cents per 1000 gallons with a minimum charge of $2.25 every three months. Bills are not subject to discount.

Water is secured from wells about 25 feet deep into sand and gravel. They are located about three blocks from the center of the village. The elevation of the ground surface at the wells is about 545 feet above sea level. Until 1917 water was secured from three 4-inch wells located about 10 feet apart on the north side of the station. Each was equipped with a number 8 Cook screen 6 feet long. In 1917 a casing of one well was broken. A pit was then dug at the same location and four 2-inch wells were driven in the bottom of the pit. These wells north of the station are now seldom used.

In 1919 three pits were dug to the south of the pumping station, about 15 feet apart, and four 2-inch wells were driven in each

pit. Each well is equipped with a screen 5 feet long. The wells were installed by Fred Howland of Tampico. The casings are pulled each year and the screens are cleaned or replaced. These twelve wells furnish nearly the entire supply. The triplex pump was operated about one hour a day in 1924 at 54 revolutions a minute, a displacement of 432 gallons a minute. The pump is reported to discharge at practically full capacity.

The water had a mineral content of 387, a total hardness of 329, and a content of iron of 0.2 parts per million as shown by the analysis of sample number 52287, collected on September 1,1924.

Analysis of Sample Number 52287 from the Village Supply.

Determinations Made.	Parts per million.
Iron Fe	0.2
Manganese Mn	0.0
Silica SiO_2	12.5
Nonvolatile	2.8
Alumina Al_2O_3	0.9
Calcium Ca	60.5
Magnesium Mg	43.4
Ammonia NH_4	0.1
Potassium K	2.4
Sodium Na	9.9
Sulfate SO_4	95.5
Nitrate NO_3	9.7
Chloride Cl	10.0
Alkalinity	
Phenolphthalein	0
Methyl Orange	228.
Residue	379.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	6.3	0.37
Sodium Nitrate $NaNO_3$	8.1	0.47
Sodium Chloride NaCl	16.5	0.96
Sodium Sulfate Na_2SO_4	4.0	0.23
Ammonium Sulfate $(NH_4)_2SO_4$	0.4	0.02
Magnesium Sulfate $MgSO_4$	115.8	6.76
Magnesium Carbonate $MgCO_3$	68.9	4.02
Calcium Carbonate $CaCO_3$	151.0	8.82
Iron Oxide Fe_2O_3	0.3	0.02
Alumina Al_2O_3	0.9	0.05
Silica SiO_2	12.5	0.73
Nonvolatile	2.8	0.16
Total	387.5	22.61

TAYLORVILLE (5806). Taylorville is located in the central part of Christian County on the drainage area of Sangamon River, a tributary of Illinois River. Industrial plants in the city using large quantities of water have private water supplies from wells of about the same depth as the city wells.

A public water supply was installed by the city about 1888. Water was secured from a dug well. The supply proved inadequate and other wells have been drilled near the original well. Water from the wells is discharged into a concrete reservoir 18 feet in diameter and 30 feet deep. Water is pumped from the reservoir into, the mains by either of two Fairbanks-Morse single-stage centrifugal pumps, each of 500 gallons a minute capacity. Each pump is driven by a 50-horsepower electric motor. Current is generated at the pumping station. About 1800 service connections were in use in 1925. The rate for water is 40 cents per 1000 gallons for

the first 10,000 gallons, 35 cents per 1000 gallons for the next 10,000 gallons, and 20 cents per 1000 gallons for all over 20,000 gallons. The minimum charge is $2.00 every three months.

Water is secured from wells located near the corner of Cherokee and Vine Streets, a few blocks east of the public square.

Water was first secured from a dug well. The supply was inadequate and two wells were drilled in the bottom of the dug well. Later this well was abandoned.

From 1912 until 1923 water was secured from eight wells which were drilled in 1911 and 1912. They were 8 inches in diameter and 92 feet deep. The bottoms were in sand and gravel. Each well was equipped with a screen 14 or 16 feet long. Each well was equipped with a single-acting steam-head deep-well pump. The depth to water was given as 25 feet in 1913 and about 48 feet in 1923.

Water is now secured from two wells which were drilled for the city in 1923 by the Sickle Water Production Company of Aurora. They are 105 feet apart. The tops of the wells are about 610 feet above sea level. The wells penetrate 17 feet of clay and 82 feet of sand and gravel which is coarsest in the lower part. They pass through the sand and gravel into blue clay. The wells are 18 inches in diameters and 100 feet deep. A screen 22 feet long is placed in the bottom of each well. Each well is equipped with a centrifugal pump with the bowls at a depth of 50 feet and with 20 feet of suction pipe attached below the bowls. The yield of one of the wells (the south well), during a test after it was completed when no other well pumps were operated, was 800 gallons a minute at the start of the test and 300 gallons a minute at the end of the test. The water level before pumping was at a depth of 35 feet. One well pump is operated during the day time and the other during the night. In April, 1925, the average amount of water pumped was estimated at 350,000 gallons a day. On April 8, 1925, the water level in the south well, when the pump in the north well had been operating for 5½ hours, was 34 feet below the ground surface.

A sample of water, number 53562, collected at a tap in the pumping station on April 7, 1925, had a mineral content of 733, a total hardness of 550, and a conténts of iron of 1.9 parts per million as shown by the analysis.

A sample collected in 1919 from the wells then in use was of similar quality. The temperature of water discharged from a well on April 8, 1925, was 54 degrees Fahrenheit. The water forms a hard scale in boilers and heating coils. Coils last about one year.

Water used in boilers at the pumping station was treated with boiler compound and sludge was blown off frequently. The iron causes some staining of plumbing fixtures and laundry fabrics. From 150 to 200 meters are repaired annually.

Analysis of Sample Number 53562 from the City Supply.

Determinations Made.

	Parts per million.
Iron Fe	1.9
Manganese Mn	0.1
Silica SiO_2	20.8
Nonvolatile	0.3
Alumina Al_2O_3	3.7
Calcium Ca	137.8
Magnesium Mg	49.8
Ammonia NH_4	0.1
Potassium K	2.9
Sodium Na	30.9
Sulfate SO_4	259.0
Nitrate NO_3	19.5
Chloride Cl	34.0
Alkalinity	
Phenolphthalein	0
Methyl Orange	278.
Residue	790.

Hypothetical Combinations.

	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	7.5	.44
Sodium Nitrate $NaNO_3$	20.3	1.19
Sodium Chloride NaCl.	56.1	3.29
Sodium Sulfate Na_2SO_4	10.2	.60
Ammonium Sulfate $(NH_4)_2SO_4$	0.5	.03
Magnesium Sulfate $MgSO_4$	246.7	14.41
Calcium Sulfate $CaSO_4$	77.6	4.55
Calcium Carbonate $CaCO_3$	287.1	16.77
Iron Oxide Fe_2O_3	2.8	.15
Alumina Al_2O_3	3.7	.22
Silica SiO_2	20.8	1.22
Nonvolatile	0.3	.02
Total	733.6	42.89

THOMSON (495). Thomson is located in the southwestern part of Carroll County on low flat land, about three miles from Mississippi River. Surface soil is underlaid by fine sand. Private wells are generally from 30 to 32 feet deep.

A public water supply was installed by the village in 1903. Water was secured from a well into sand. Another well has been drilled and the original well has been abandoned. Water is pumped from the well directly into the distribution system by a Fairbanks-Morse triplex pump driven by belt from a 10-horsepower electric motor. An elevated wooden tank 16 feet in diameter and 14 feet high is connected to the system. Electric power is purchased from the Peoples Gas and Electric Company of Savanna.

Eighty service connections were in use in 1924. The amount of water pumped during 1923 averaged about 15,000 gallons a day. Service connections are not metered.

Water for the public supply is secured from a well into sand and gravel. It is located on Market Street about 100 feet east of the Chicago Burlington and Quincy Railroad. The well was drilled in 1918 by Mr. Warfield of Savanna. It is 8 inches in diameter and 40 feet deep. A screen ten feet long is placed in the bottom. Water is pumped from the well by a 5 by 8-inch

triplex pump which is operated at a speed of 48 strokes a minute, a displacement of 98 gallons a minute. The pump was operated from two and one-half to three hours a day in 1924.

The water had a mineral content of 197 and a total hardness of 132 as shown by the analysis of sample number 40032, collected on August 20, 1918.

Analysis of Sample Number 40032 from the Village Supply.

Determinations Made.	Parts per million.
Iron Fe	Trace
Manganese Mn	0.0
Silica SiO_2	24.4
Alumina Al_2O_3	0.8
Calcium Ca	31.1
Magnesium Mg	13.2
Ammonium NH_4	0.5
Sodium Na	9.5
Sulfate SO_4	26.1
Nitrate NO_3	35.4
Chloride Cl	8.0
Alkalinity Methyl Orange	86.
Residue	239.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Sodium Nitrate $NaNO_3$	34.9	2.03
Ammonium Nitrate $(NH_4)_2NO_3$	2.1	.12
Magnesium Chloride $MgCl_2$	32.4	1.88
Magnesium Sulfate $MgSO_4$	7.5	.43
Magnesium Carbonate $MgCO_3$	9.6	0.55
Calcium Carbonate $CaCO_3$	77.7	4.51
Magnesium Nitrate $MgNO_3$	8.1	.47
Manganese Carbonate $MnCO_3$	0.1	.01
Alumina Al_2O_3	0.8	.05
Silica SiO_2	24.4	1.42
Total	197.6	11.47

Well screens clog and are replaced or cleaned every year.

TINLEY PARK (493). Tinley Park is located in the southern part of Cook County. A public water supply was installed by the village in 1915. Water is pumped from a well directly into the distribution system and an elevated tank connected to the system by a Keystone Driller Company deep-well pump which is driven through gears by a 15-horsepower electric motor. Power is purchased from the Public Service Company of Northern Illinois. Ninety service connections were in use in December, 1923. The services are not metered.

Water for the public supply is secured from a well into St. Peter sandstone. It was drilled by Mr. Palmer of Blue Island in 1914. The well is 12 inches in diameter at the top, 6 inches in diameter at the bottom, and 915 feet deep. It is said to have yielded 250 gallons a minute for three hours during a test in 1914. It is equipped with a Keystone Driller Company two-stroke deep-well pump with 7¾-inch cylinder and 18-inch stroke. The cylinder is placed at a depth of 60 feet and 6 feet of suction pipe is attached to the bottom. The pump is operated at 35 revolutions a minute, a displacement of 250 gallons a minute. In 1923 the pump was operated for about two hours in the morning and two hours in the

afternoon. The depth to water when not pumping was said to be 12 feet in 1918 and 16 feet in 1924.

The water had a mineral content of 512, a total hardness of 442, and a content of iron of 0.4 parts per million as shown by the analysis of sample number 50664, collected on December 4, 1923, at the pumping station.

Analysis of Sample Number 50664 from the Village Supply.

Determinations Made.	Parts per million.
Iron Fe	0.4
Manganese Mn	0.0
Silica SiO_2	15.8
Nonvolatile	3.3
Alumina Al_2O_3	1.2
Calcium Ca	105.6
Magnesium Mg	43.6
Ammonia NH_4	0.2
Sodium Na	17.7
Potassium K	6.8
Sulfate SO_4	59.2
Nitrate NO_3	1.4
Chloride Cl	4.0
Alkalinity	
Phenolphthalein	0
Methyl Orange	420.
Residue	511.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	2.3	.13
Potassium Chloride KCl	8.4	.49
Potassium Sulfate K_2SO_4	3.4	.20
Sodium Sulfate Na_2SO_4	54.6	3.19
Ammonium Sulfate $(NH_4)_2SO_4$	0.9	.05
Magnesium Sulfate $MgSO_4$	24.7	1.44
Magnesium Carbonate $MgCO_3$	133.6	7.80
Calcium Carbonate $CaCO_3$	263.6	15.29
Iron Oxide Fe_2O_3	0.6	.03
Alumina Al_2O_3	1.2	.07
Silica SiO_2	15.8	.92
Nonvolatile	3.3	.19
Total	512.4	29.80

Analyses made at the well in 1918 showed the presence of 0.9 parts of iron, 6.4 parts of carbon dioxide, and 0.03 parts of hydrogen sulphide per million. Plumbing fixtures and laundry are stained by iron in the water.

TISKILWA (915). Tiskilwa is located in the southern part of Bureau County on the drainage area of Big Bureau Creek, a tributary of Illinois River. The Chicago, Rock Island and Pacific Railway installed a water supply for the use of the company and later when not used by the company the supply was used by the village. Water was secured from an impounding reservoir of 25,000 gallons capacity formed by building a concrete dam across a small ravine located about one mile southeast of the center of the village. The flow from several springs and from a few acres of land was caught in the reservoir.

Improvements in the water supply were made in 1911. The flow of the springs, measured by W. S. Shields in the summer of 1911, was 45,200 gallons a day. A concrete retaining wall about 150 feet long, extending to a stratum of impervious clay at a depth of from six to eleven feet, was built to separate water from the

springs supply from the surface water which flowed into the impounding reservoir. Water from the springs now flows to two concrete reservoirs, each of 30,000 gallons capacity, and from the reservoirs it flows through a pipe line to the village. The reservoirs are approximately 100 feet above the ground surface in the village and pumping is not necessary.

One hundred and ninety service connections were in use in 1925. The meter rate is $1.00 every three months and 25 cents per 1000 gallons.

A sample from the springs, number 38945, collected on February 11, 1918, had a mineral content of 323, a. total hardness of 277, and a content of iron of 0.2 parts per million as shown by the analysis.

Analysis of Sample Number 38945 from Village Springs.

Determinations Made.	Parts per million.
Iron Fe	0.2
Silica SiO_2	19.3
Alumina Al_2O_3	1.2
Calcium Ca	42.3
Magnesium Mg	41.7
Potassium K	0.9
Sodium Na	14.4
Sulfate SO_4	23.7
Nitrate NO_3	14.1
Chloride Cl	5.0
Alkalinity Methyl Orange	268.
Residue	330.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	2.3	0.13
Sodium Nitrate $NaNO_3$	17.4	1.01
Sodium Chloride NaCl	8.2	0.48
Sodium Sulfate Na_2SO_4	19.9	1.16
Magnesium Sulfate $MgSO_4$	12.8	0.75
Magnesium Carbonate $MgCO_3$	135.6	7.91
Calcium Carbonate $CaCO_3$	105.9	6.18
Iron Carbonate $FeCO_3$	0.4	0.02
Manganese Carbonate $MnCO_3$	0.0	0.00
Alumina Al_2O_3	1.2	0.07
Silica SiO_2	19.3	1.13
Total	323.0	18.84

Samples collected in 1911 from two of the springs contained considerable nitrate, 30 parts in one sample and 66 parts in another.

TOLONO (693). Tolono is located in the southern part of Champaign County on the drainage area of Embarrass River, a tributary of Wabash River. Water is obtained at some residences from dug wells extending to blue clay at a depth of about 12 feet. A few drilled wells more than 100 feet deep are in use at residences but water from a public supply is in general use.

A public water supply was installed by the village about 1895. The installation included two wells, a pumping station and pump equipment, a distribution system, and an elevated wooden tank connected to the system. One of the original wells has been abandoned and another well has been drilled. An oil engine has been installed to replace steam engines formerly in use and the original tank was replaced in 1912 by another wooden tank of 69,000 gallons capacity.

Water for the public supply is obtained from two wells into sand and gravel. One of these wells is one of the two original wells. It is 145 feet deep. In the bottom is a number 60 Cook screen 12 feet long. The well is equipped with a Cook single-acting deep-well pump with a 5½-inch cylinder placed at a depth of 120 feet. The stroke is 18 inches. This well is used only at times when repairing equipment of the other well. In November, 1923, it was in use and the pump was driven by belt from a gasoline traction engine. It operated 24 strokes a minute, a displacement of 44 gallons a minute. The actual discharge was probably considerably less as gas was discharged and gas could be ignited by holding matches close to valve stems on the discharge line. The gas is encountered at a depth of about 103 feet. The discharge of gas from the other well, drilled when the water works was installed, was so great that the well was abandoned. Gas from this well is used to heat the carburetor on the oil engine. The abandoned well is 17 feet distant from the old well in use.

The well generally used was drilled in 1914. It is located 37 feet north and east from the old well which is used occasionally. This well is 8 inches in diameter and 157 feet deep. Water is secured from a stratum of black sand between depths of 151 and 156 feet, a stratum below that from which water is secured in the well 145 feet deep. The well is equipped with a number 60 Cook screen twelve feet long. A 5¾-inch single-acting cylinder is placed at a depth of 120 feet. The pump is operated with 24-inch stroke at a speed of 28 or 30 strokes a minute, a displacement of 80 gallons a minute. The pump is probably operated with little slip at times but at other times gas is discharged. In 1923, the time the pump was operated was estimated at about ten hours a day.

Analysis of Sample Number 42010 from Village Well 157 Feet Deep.

Determinations Made.

	Parts per million.
Iron Fe	2.8
Silica SiO_2	20.5
Nonvolatile	2.7
Alumina Al_2O_3	3.4
Calcium Ca	88.6
Magnesium Mg	34.0
Ammonium NH_4	13.1
Potassium K } Sodium Na }	119.3
Nitrate NO_3	1.4
Chloride Cl	6.0
Alkalinity Methyl Orange	624.
Residue	678.

Hypothetical Combinations.

	Parts per million.	Grains per gallon.
Sodium Nitrate $NaNO_3$	1.9	.11
Sodium Chloride NaCl	9.9	.58
Sodium Carbonate Na_2CO_3	264.4	15.46
Ammonium Carbonate $(NH_4)_2CO_3$	35.0	2.04
Magnesium Carbonate $MgCO_3$	117.6	6.88
Calcium Carbonate $CaCO_3$	221.2	12.94
Iron Oxide Fe_2O_4	4.0	.23
Silica SiO_2	20.5	1.20
Alumina Al_2O_3	3.4	.19
Nonvolatile	2.7	1.60
Total	680.6	39.79

Water from the deeper well, the well generally used, had a mineral content of 680, a total hardness of 360, and a content of iron of 2.8 parts per million as shown by the analysis of sample number 42010, collected on October 28, 1919.

TOLUCA (2503). Toluca is located in the southeastern part of Marshall County on the drainage area of Crow Creek, a tributary of Illinois River. A public water supply was installed by the city in 1908. Water was pumped from a well into the distribution system and an elevated steel tank of 40,000 gallons capacity connected to the system, by a deep-well pump which was driven by an electric motor. In 1921 the well was equipped with an air lift; a concrete reservoir, into which water from the air lift is discharged, was built; and a centrifugal pump was installed to pump water from the reservoir. Air is supplied by a Sullivan 9 by 8-inch compressor which is driven by belt from a 20-horsepower electric motor at a rate of 205 revolutions a minute. The reservoir is 48 feet 4 inches by 28 feet 4 inches by 9 feet deep. The pump is a Dayton-Dowd two-stage centrifugal and is driven by a 10-horsepower electric motor. The discharge of this pump at time of measurement was 145 gallons a minute. More than 400 service connections were in use in 1924. Water is sold at a rate of 40 cents per 1000 gallons without discount.

The public water supply is secured from a well 2000 feet deep It was drilled by the J. P. Miller Artesian Well Company of Chicago. It is located in Cedar Street north of Railroad Street. The elevation at the top of the well is about 705 feet above sea level.

The material penetrated by the upper part of the well was principally limestone and shale. A “first vein” of salt water was noted below shale in limestone between depths of 615 and 628 feet. A “second vein” of salt water was noted between depths of 915 and 1095 feet, evidently in sand as sand was noted at 935 feet and shale at 1118 feet. Sandstone (St. Peter) was noted at 1705 feet depth. The well was cased with 76 feet of 12-inch pipe, with 250 feet of 10-inch pipe with the bottom at a depth of 310 feet; with 295 feet of 8-inch pipe with the bottom at a depth of 592 feet, and 261 feet of 6-inch pipe with the bottom at a depth of 848 feet. Records indicate that 6-inch pipe was then placed lower, that the upper part of it was taken out and that 8-inch pipe was placed on the 6-inch pipe up to 139 feet below the ground surface. The well was 6 inches in diameter at the bottom. When 1820 feet deep water stood 125 feet below the surface and when completed

it stood 165 feet below the surface. The well is equipped with an air lift with 1¼-inch air pipe and 3-inch discharge pipe to a depth of about 300 feet.

On June 17, 1924, the air lift was operated for six hours, then remained idle for three hours and was again started. The discharge for one hour, beginning one hour thirty minutes after the second start, was at a rate of 81 gallons a minute. The depth to water was 147 feet 4 inches before starting the air lift, 172 feet 2 inches after operating for 13 minutes and 173 feet 6 inches after operating for one hour. The air pressure as shown by gauge was 90 pounds at the start. One half hour later the pressure was 84 pounds and remained constant during the next two hours pumping. The depth to water when not pumping was reported to be 135 feet in 1913 and 138 feet in 1917.

From April 6, 1923, to November 12, 1923, as near as can be computed the air lift operated 12 hours 45 minutes a day and the amount of water pumped averaged 62,000 gallons a day.

The water had a mineral content of 1763, a total hardness of 218, and a content of iron of 0.4 parts per million as shown by the analysis of sample number 51662, collected on June 17, 1924, from a tap at the pumping station.

Analysis of Sample Number 51662 from the City Supply.

Determinations Made.

	Parts per million.
Iron Fe	0.4
Manganese Mn	0.0
Silica SiO_2	16.4
Nonvolatile	1.6
Alumina Al_2O_3	2.6
Calcium Ca	51.6
Magnesium Mg	21.7
Ammonium NH_4	4.1
Sodium Na	505.6
Potassium K	95.4
Sulfate SO_4	203.2
Nitrate NO_3	4.1
Chloride Cl	750.0
Alkalinity	
Phenolphthalein	0
Methyl Orange	268.
Residue	1806.

Hypothetical Combinations.

	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	6.7	.39
Potassium Chloride KCl	177.0	10.34
Sodium Chloride NaCl	1097.0	64.00
Sodium Sulfate Na_2SO_4	229.3	13.40
Ammonium Sulfate $(NH)_2SO_4$	15.0	0.88
Magnesium Sulfate $MgSO_4$	46.8	2.73
Magnesium Carbonate $MgCO_3$	42.2	2.46
Calcium. Carbonate $CaCO_3$	128.7	7.52
Iron Oxide Fe_2O_3	0.6	.04
Alumina Al_2O_3	2.6	.15
Silica SiO_2	16.4	.96
Nonvolatile	1.6	.09
Total	1763.9	102.96

TOULON (1235). Toulon is located in Stark County on the drainage area of Spoon River, a tributary of Illinois River. A public water supply was installed by the city in 1911. Water is pumped from a well into a collecting reservoir by a deep-well

pump which is driven through gears by a 15-horsepower electric motor. Water is pumped from the reservoir into the distribution system by an American two-stage centrifugal pump which is direct connected to a 30-horsepower electric motor. An elevated steel tank of 50,000 gallons capacity is connected to the distribution system. The collecting reservoir is 27 feet in diameter and 12 feet deep. Electric current is purchased from the Public Service Company of Northern Illinois.

About 300 service connections were in use in 1921 and all were metered. The water consumption averaged near 50,000 gallons a day. Meter rates per 1000 gallons are 45 cents for 6000 gallons or less and 30 cents for additional water.

Analysis of Sample Number 44134 from the City Supply.

Determinations Made.	Parts per million.
Iron Fe	0.2
Manganese Mn	0.0
Silica SiO_2	8.2
Nonvolatile	0.4
Alumina Al_2O_3	2.9
Calcium Ca	34.6
Magnesium Mg	18.0
Ammonium NH_4	3.1
Potassium K	34.1
Sodium Na	314.9
Sulfate SO_4	320.1
Nitrate NO_3	1.4
Chloride Cl	240.0
Alkalinity	
Phenolphthalein	0
Methyl Orange	248.
Residue	1132.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	2.3	.14
Potassium Chloride KCl	63.3	3.70
Sodium Chloride NaCl	345.9	20.23
Sodium Sulfate Na_2SO_4	473.0	27.66
Sodium Carbonate Na_2CO_3	59.3	3.47
Ammonium Carbonate $(NH_4)_2CO_3$	8.2	.48
Magnesium Carbonate $MgCO_3$	62.2	3.63
Calcium Carbonate $CaCO_3$	86.4	5.05
Silica SiO_2	8.2	.48
Nonvolatile	0.4	.02
Iron Oxide Fe_2O_3	0.3	.02
Alumina Al_2O_3	2.9	.17
Total	1112.4	66.04

Water for the public supply is obtained from a well drilled in 1911. It is located near the center of the city. It is 10 inches in diameter to a depth of 201 feet, 8 inches in diameter between depths of 201 and 385 feet, and 6 inches in diameter below a depth of 385 feet to the bottom at a depth of 1445 feet. The lower 100 feet is in St. Peter sandstone. The top of the well is about 750 feet above sea level. The well is equipped with an American double-acting deep-well pump with a 5¾-inch cylinder and 36-inch stroke. The cylinder was placed at a depth of about 240 feet and has been raised to a depth of near 180 feet. The pump was operated 22 revolutions a minute in 1921 and filled the reservoir at a rate of two feet in an hour, a rate of 143 gallons a minute. It was operated an average of 5½ hours a day. The depth to water when not pumping was reported to be 90 feet in 1913. It was reported to be 180

feet in 1920 but this is probably in error as the depth to the pump cylinder was given as about 180 feet in 1921.

The water had a mineral content of 1112, a total hardness of 160, and a content of iron of 0.2 parts per million as shown by the analysis of sample number 44134, collected on November 3, 1920.

TREMONT (976). Tremont is located in the central part of Tazewell County on the drainage area of Mackinaw River, a tributary of Illinois River. Many gas wells have been drilled in the village but few are now in use. Near the business district these wells are from 95 to 105 feet deep.

A public water supply was installed by the village in 1911. A well was drilled at the rear of the village hall, to a depth of 150 feet, without encountering a water bearing stratum. A lot was then purchased on which a 2-inch well was in use and the village drilled a well on this lot. This well furnished the entire public water supply until 1923 when another well was drilled.

Water is secured from two wells, each equipped with a deep-well pump which is driven by a 10-horsepower electric motor. The pumps discharge into the distribution system and an elevated tank 18 feet in diameter and 26 feet high. Electric power is purchased from the Illinois Power and Light Comporation. One hundred and thirty service connections were in use in 1924 and all were metered. The minimum charge is $1.20 a month and the meter rate is 40 cents per 1000 gallons.

The public water supply is secured from two wells located in the southern part of the village on Washington Street west of Sampson Street. The well drilled in 1911 is 8 inches in diameter and 132 feet deep. Water is obtained from sand and gravel and the well is equipped with a screen 10 feet long of which the upper four feet is soldered shut as it is above the water bearing stratum. The well is equipped with a Luitwieler deep-well pump with a 5¾-inch cylinder and 15-inch stroke. The cylinder is placed close to the top of the screen. When the pump was installed it was operated 32 revolutions a minute. The speed was later reduced to 24 revolutions a minute and the pump operated satisfactorily with a discharge of about 70 gallons a minute. In October, 1922, the pump was operated 15 hours a day and it was difficult to supply demands. The pump displacement was more than 55,000 gallons a day but it is probable that the amount of water pumped was very much less. In 1923 this well pump was operated 18 revolutions a minute, a displacement of 58 gallons a minute. The depth to water when

not pumping was reported to be 92 feet below the ground surface in 1914 and 6 or 7 feet above the bottom of the well in 1922.

In 1922 a test well was drilled east of the well in use, to a depth of 250 feet. Below a depth of 132 feet it was in shale.

In 1923 a well was drilled 31 feet east of the old well. It was drilled by Mike Ebert of Washington. It is 8 inches in diameter and 135 feet deep. The lower 10 feet is in water bearing sand and gravel and a screen 10 feet long is placed in this stratum. The well is equipped with a Cook double-stroke deep-well pump with a 5¾-inch cylinder placed close to the bottom of the well. The pump was operated in 1924 with 18-inch stroke at 12 revolutions a minute.

Both pumps are operated at a time. It is estimated that during the first half of 1924 the pumps were operated an average of 3½ hours a day and the amount of water pumped, if the slip was 15 per cent, averaged about 19,700 gallons a day.

The temperature of water from the west well, after the pump had operated for four hours, on June 20, 1924, was 54 degrees Fahrenheit. A sample of water, number 51681, collected from a tap in the pumping station on that date, after the pumps had operated continuously for four hours, had a mineral content of 442, a total hardness of 316, and a content of iron of 2.4 parts per million as shown by the analysis.

Analysis of Sample Number 51681 from the Village Supply.

Determinations Made.

	Parts per million.
Iron Fe	2.4
Manganese Mn	0.0
Silica SiO_2	20.1
Nonvolatile	1.4
Alumina Al_2O_3	1.7
Calcium Ca	77.4
Magnesium Mg	30.0
Ammonium NH_4	5.6
Sodium Na	3.1
Potassium K	6.5
Sulfate SO_4	3.9
Nitrate NO_3	0.4
Chloride Cl	4.0
Alkalinity	
Phenolphthalein	0
Methyl Orange	416.
Residue	447.0

Hypothetical Combinations.

	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	0.5	.03
Potassium Chloride KCl	8.4	.49
Potassium Sulfate K_2SO_4	4.1	.24
Sodium Carbonate Na_2CO_3	88.4	5.16
Sodium Sulfate Na_2SO_4	2.4	.14
Ammonium Carbonate $(NH_4)_2CO_3$	15.1	.88
Magnesium Carbonate $MgCO_3$	104.0	6.08
Calcium Carbonate $CaCO_3$	193.0	11.26
Iron Oxide Fe_2O_3	3.4	.20
Alumina Al_2O_3	1.7	.10
Silica SiO_2	20.1	1.17
Nonvolatile	1.4	.08
Total	442.5	25.83

TRENTON (1200). Trenton is located in the western part of Clinton County on the drainage area of Kaskaskia River, a tributary of Mississippi River. Many wells from 20 to 30 feet deep are in

use at residences and nine wells have been drilled into sandstone.

A public water supply was installed by the city in 1909. Water is pumped from three wells into a collecting reservoir 100 feet long, 50 feet wide, and 12 feet deep. The wells were first equipped with air lifts but these were replaced by deep-well pumps in order to draw water to a lower level and secure a greater supply. Two well pumps usually used are each driven by a 3-horsepower electric motor. One well is equipped with a steam-head pump. Water is pumped from the reservoir into the distribution system and an elevated tank of 50,000 gallons capacity which is connected to the system, by an American centrifugal pump of from 400 to 450 gallons a minute capacity. The pump is driven by a 25-horsepower electric motor. The tank is supported on a tower 100 feet high.

One hundred service connections were in use in 1923 and all were metered. The rate for water is 35 cents a month for 500 gallons or less and 50 cents per 1000 gallons for additional water. Bills are not subject to cash discount.

Eighteen test holes have been drilled into a bed of gravel east of the city. The water level was at a depth of from 15 to 18 feet and was said not to be lowered by bailing.

One well was in use at an electric plant before the water works was installed. First a well 60 feet deep was dug in the bottom of a cistern 15 feet deep. Later an 8-inch well was drilled in the bottom of the dug well to a total depth of 235 feet. Holes were then made in the 8-inch casing in order to allow water from the dug well to enter the drilled well. The dug well has now been filled. This well was used principally to supply water at the light plant and pumping station. It is equipped with a steam-head pump and in 1923 was seldom used.

Water for the public supply is secured from three wells which were drilled in 1909. The wells are in sandstone below a depth of about 140 feet and each is about 240 feet deep. Each well is cased with 10-inch pipe to the sand stone and is 8 inches in diameter in the sandstone, All three wells were equipped with air lifts which were used for about two years. One well, now equipped with a steam-head pump, is seldom used. Two of the wells are equipped with Goulds single-acting deep-well pumps with 2¾-inch cylinders placed close to the bottoms of the wells. In 1923 one pump was operated with 12-inch stroke at 19 strokes a minute and the other was operated with 16-inch stroke at 19 strokes a minute. The pumps were operated continuously and the discharge from the two wells was estimated at 17,000 gallons a day. The water level when not pumping for three or four hours was at a depth of 140 feet

and when pumping it was drawn down to, or nearly to, the bottoms of the wells as the pumps could not be operated at much greater displacement without drawing air.

The water had a mineral content of 1100, a total hardness of 70, and a content of iron of 0.8 parts per million as shown by the analysis of sample number 49982, collected on August 23, 1923.

Analysis of Sample Number 49982 from the City Supply.

Determinations Made.	Parts per million.
Iron Fe	0.8
Manganese Mn	0.0
Silica SiO_2	9.1
Nonvolatile	1.4
Alumina Al_2O_3	1.6
Calcium Ca	15.0
Magnesium Mg	8.0
Ammonia NH_4	0.1
Sodium Na	402.0
Potassium K	25.1
Sulfate SO_4	26.3
Nitrate NO_3	3.2
Chloride Cl	260.0
Alkalinity Methyl Orange	582
Residue	1050

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	5.1	0.29
Potassium Chloride KCl	44.0	2.57
Sodium Chloride NaCl	394.1	23.01
Sodium Sulfate Na_2SO_4	38.8	2.26
Sodium Carbonate Na_2CO_3	540.1	31.54
Ammonium Carbonate $(NH_4)_2CO_3$	0.2	0.01
Magnesium Carbonate $MgCO_3$	27.6	1.61
Calcium Carbonate $CaCO_3$	37.4	2.18
Iron Oxide Fe_2O_3	1.1	0.06
Alumina Al_2O_3	1.6	0.09
Silica SiO_2	9.1	0.53
Nonvolatile	1.4	0.08
Total	1100.5	64.23

Soft sludge is formed in a feed water heater in use at the electric plant. The water causes some corrosion and there is some leakage through the fronts of the boilers. Frequent blowing off of boilers is necessary.

TUSCOLA (2564). Tuscola is located in the northwestern part of Douglas County on the drainage area of Embarrass River, a tributary of Wabash River. A public water supply was installed by a private company in 1899. The plant is now operated by the Central Illinois Public Service Company. Water was first secured from a well. Other wells were drilled later and a supply from an impounding reservoir was developed. Since 1916 the supply has been secured from two wells which were drilled in that year. They are equipped with deep-well pumps which discharge directly into the distribution system. Water in excess of demands is discharged through a relief valve into two reservoirs located at the company's plant in the city. One reservoir is 26 feet in diameter and 30 feet deep and the other is 16 feet in diameter and 30 feet deep. The total capacity is 150,000 gallons. When demands exceed the yield of the wells, water is pumped from the reservoirs into the mains by either of two Smith-Vaile 7 by 12 by 7 by 12-inch compound duplex

steam pumps. One well pump is geared to a 15-horsepower electric motor and the other is geared to a 10-horsepower electric motor. The water consumption in 1919 was about 125,000 gallons a day. The rate for three months for 2000 gallons of water or less was 45 cents per 1000 gallons and the lowest rate, for water in excess of 10,000 gallons, was 20 cents per 1000 gallons.

Water for the public supply was first secured from a well 3017 feet deep which was drilled in 1897. A record of material penetrated in the upper part of the well, as given by J. L. Reat, is as follows:

Strata	Thickness in feet.	Depth in feet
Soil and blue clay	20	20
Blue clay	12	32
Blue and yellow clay	148	180
Shale and limestone	189	369
Sandstone, shale, etc	83	452
Soapstone, brown shale	155	607
Sandstone, quartz	173	780
Slate, shale	220	1000
Quartz, white sandstone	400	1400
Blue rock	200	1600
Shale, limestone	420	2020

The quartz and white sandstone include the Galena-Platteville and St. Peter formation.

The well was said to have been cased to a depth of about 1500 feet. Water from this well furnished the entire supply until 1904 and furnished part of the supply until 1916. The depth to water in 1898 was reported to be 28 feet. In 1914 when the well was equipped with a steam-head deep-well pump with the cylinder placed 325 feet below the ground surface the discharge was said to be about 50 gallons a minute.

Analysis of Sample Number 2931 from Well 3017 Feet Deep.

Determinations Made.	Parts per million.
Potassium K	9.1
Sodium Na	337.9
Ammonium NH_4	5.4
Magnesium Mg	13.2
Calcium Ca	33.7
Ferrous Fe	1.6
Aluminum Al	1.1
Silica Si	5.0
Nitrate NO_3	1.3
Chloride Cl	76.0
Sulphate SO_4	1.1
Residue	954.4

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	2.2	.13
Potassium Chloride KCl	15.3	.89
Sodium Chloride NaCl	113.3	6.70
Sodium Sulfate Na_2SO_4	1.3	.07
Sodium Carbonate Na_2CO_3	670.8	39.12
Ammonium Carbonate NH_4CO_3	14.4	.84
Magnesium Carbonate $MgCO_3$	47.8	2.79
Calcium Carbonate $CaCO_3$	84.0	4.90
Ferrous Carbonate $FeCO_3$	2.9	.17
Alumina Al_2O_3	1.7	.01
Silica SiO_2	10.5	.61
Total	964.2	56.23

Water from this well had a mineral content of 964, a total hardness of 138, and a content of iron of 1.6 parts per million as

shown by the analysis of sample number 2931, collected on November 10, 1898.

The water contained considerable hydrogen sulphide and the supply was not generally used.

Two wells were drilled in 1912. One was 10 inches in diameter and 830 feet deep. To a depth of 767 feet the material penetrated was principally shale. Sandstone was noted between depths of 225 and 245 feet; broken sandstone and shale, dry hole, between depths of 307 and 357 feet; and limestone between depths of 630 and 634 feet. A record of the lower part of the well as given by the water company is as follows:

	Depth in feet.		
Limestone, hard	767	to	777
Limestone and 2 feet of water bearing sand..	777	to	783
Encountering white sand rock 4 feet thick.	783	to	788
White limestone, water bearing, water raised to within 70 feet of the surface..	788	to	789
White limestone, without water.	789	to	808
Bailed and yielded not over 15 gallons a minute.	808	to	830

The well was equipped with a deep-well pump with a cylinder at a depth of 525 feet and yielded 10 gallons a minute. The yield was not sufficient to warrant using the well. Water from this well had a mineral content of 769 and a total hardness of 56 parts per million.

The other well drilled in 1912 was 10 inches in diameter and 230 feet deep. The yield was small and the well was soon abandoned. A sample of water collected in 1912 had a mineral content of 726 and a total hardness of 196 parts per million.

A surface water supply was developed in 1904 and furnished part of the supply until 1916. Water was secured from a stream near the southwestern limits of the city about 600 feet distant from the pumping station. The tributary drainage area was three or four square miles. A 4-inch drain tile was laid about two feet below the bed of the stream. Water flowed from the stream into the tile and through the tile into an intake well from which it was pumped.

Water for the public supply is now secured from two wells into sandstone, located near the eastern limits of the city. They were drilled by Meister Brothers of Tuscola in 1916. Well number 1 is 287 feet deep and is cased with 8-inch pipe to a depth of 118 feet. It is equipped with a Deane single-acting deep-well pump with a 5¾-inch cylinder and 24-inch stroke. In 1918 the inlet to the pump was at a depth of 1.75 feet. The pump was operated 26 strokes a minute and discharged 69 gallons a minute.

Well number 2 is about 135 feet north of well number one. It is 300 feet deep and an 8-inch casing extends to a depth of 127 feet.

The well is equipped with a Luitwieler deep-well pump with a 4¾-inch cylinder and 15-inch stroke. In 1918 the intake to the pump was at a depth of 135 feet. The pump was operated 43 strokes per minute and discharged 72 gallons a minute.

Measurements to water level were made in June, 1918, in a well located 22 feet west of well number 2. This well had been abandoned because it was crooked. When the pump in well number 1 had operated for many hours and the pump in well number 2 was idle, the depth to water was 82.2 feet. When the pump in well number 2 was operated for 24 minutes the water level dropped to a depth of 93.8 feet.

Water from the well 300 feet deep had a mineral content of 398, a total hardness of 231, and a content of iron of 0.5 parts per million as shown by the analysis of sample number 39632, collected on June 25, 1918.

Analysis of Sample Number 39632 from Well Number 2.

Determinations Made.	Parts per million.
Iron Fe	0.5
Manganese Mn	0.0
Silica SiO_2	11.1
Nonvolatile	1.3
Alumina Al_2O_3	1.0
Calcium Ca	51.3
Magnesium Mg	25.2
Ammonium NH_4	1.8
Potassium K, Sodium Na	65.4
Sulfate SO_4	3.0
Nitrate NO_3	1.4
Chloride Cl	15.0
Alkalinity Methyl Orange	344.
Residue	405.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Sodium Nitrate $NaNO_3$	2.0	.12
Sodium Chloride NaCl	24.7	1.44
Sodium Sulfate Na_2SO_4	43.8	2.55
Sodium Carbonate Na_2CO_3	94.1	5.49
Ammonium Carbonate $(NH_4)_2CO_3$	4.9	.29
Magnesium Carbonate $MgCO_3$	87 .1	5.08
Calcium Carbonate $CaCO_3$	128 .0	7.46
Iron Oxide Fe_2O_3	0.7	.04
Alumina Al_2O_3	1.0	.06
Silica SiO_2	11.1	.64
Nonvolatile	1.3	.08
Total	398.7	23.25

Water from the wells contains hydrogen sulphide. Water from well number 1 contained 0.22 parts and the water from well number 2 contained 0.68 parts per million when tested on March 2, 1920. An odor in the water is probably due in large part to putrifaction of bacteria, especially of sulphur bearing forms.

UNION (399). Union is located in the southwestern part of McHenry County on the drainage area of Kishwaukee River, a tributary of Rock River. In the northern part of the village water is generally secured from wells about 20 feet deep into a stratum of sand and gravel. To the south this stratum of sand and gravel is not encountered and wells are drilled into rock which is entered

at a depth of about 125 feet. One well at the plant of Libby, McNeil and Libby is 1365 feet deep. Equipped with an air lift with an air pipe to a depth of about 300 feet the well yielded 170 gallons a minute in 1919 when the air lift was operated eight hours a day. A well at the plant of the Casein Manufacturing Company near the northwestern limits of the village is into sand and gravel at a depth of 70 feet.

A public water supply was installed by the village in 1912. Water is pumped from a well into the distribution system and a steel pressure tank connected to the system, by a pump driven through gears by a 15-horsepower gas engine. The tank is 8 feet in diameter and 36 feet long. Gas to operate the engine is supplied by the Western United Gas and Electric Company. Thirty service connections were in use in 1919. A minimum charge of $5.00 a year entitled a consumer to use 20,000 gallons of water. The rate was 20 cents per 1000 gallons for the next 20,000 gallons, 15 cents per 1000 gallons for the next 30,000 gallons, and 10 cents per 1000 gallons for the next 30,000 gallons.

Water for the public supply is obtained from a well into sand and gravel. It is located in the northeastern part of the village. It is 10 feet in diameter and 16 feet deep. It is walled with brick laid in cement mortar and covered a few inches above the ground surface with a concrete cover. Below a few feet of top soil the well is in sand. The average amount of water pumped was estimated in 1919 at from 10,000 to 20,000 gallons a day. The water level varied. At times it was not more than six feet below the ground surface and at other times it had been as much as twelve feet below the surface.

Analysis of Sample Number 40951 from the Village Supply.

Determinations Made.

	Parts per million.
Alumina Al_2O_3	31.0
Silica SiO_2	13.0
Nonvolatile	6.0
Calcium Ca	104.0
Magnesium Mg	45.3
Ammonium NH_4	0.8
Potassium K, Sodium Na	8.1
Sulfate SO_4	120.0
Nitrate NO_3	2.1
Chloride Cl	64.0
Alkalinity Methyl Orange	248.
Residue	532.

Hypothetical Combinations.

	Parts per million.	Grains per gallon.
Sodium Nitrate $NaNO_3$	2.9	0.17
Sodium Chloride NaCl	18.5	1.09
Ammonium Chloride NH_4Cl	2.5	0.14
Magnesium Chloride $MgCl_2$	68.6	4.04
Magnesium Sulfate $MgSO_4$	137.2	7.99
Magnesium Sulfate $MgSO_4$	137.2	7.99
Calcium Carbonate $CaCO_3$	259.5	15.18
Alumina Al_2O_3	31.0	1.81
Silica SiO_2	13.0	0.76
Nonvolatile	6.0	0.35
Total	553.9	32.39

Water from the public supply had a mineral content of 553 and a total hardness of 445 parts per million as shown by the analysis of sample number 40951, collected on April 18, 1919.

Water from the public supply is used in boilers at a flour mill. Boiler compound is added and the boilers are cleaned every two weeks.

URBANA. See Champaign and Urbana.

UTICA. See North Utica.

VILLA GROVE (2493). Villa Grove is located in the northern part of Douglas County on the drainage area of Embarrass River, a tributary of Wabash River. Some private wells in the city and vicinity are into a stratum of sand at a depth of about 30 feet. Others are into a stratum of sand at a depth of about 80 feet and a few have been drilled into a stratum of sand which overlies shale at a depth of about 230 feet. The Chicago and Eastern Illinois Railroad has developed a surface water supply on Embarrass River from which they secure part of their supply.

A public water supply was installed by the village in 1915. Water is pumped from two wells directly into the distribution system and an elevated steel tank connected to the system, by deep-well pumps. One pump is driven by belt from a 15-horsepower electric motor and the other is driven by a 20-horsepower electric motor. A gas engine is also available to furnish power. The elevated tank is 26 feet in diameter and has a capacity of 75,000 gallons. The top is 139 feet above the ground surface. Electric current is purchased from the Central Illinois Public Service Company.

Three hundred and fifty service connections were in use in 1923 and about four hundred were in use in 1925. The rates for water for one month are 75 cents for 2000 gallons or fraction thereof, 30 cents per 1000 gallons for the next 2000 gallons, 25 cents per 1000 gallons for the next 6000 gallons, and 15 cents per 1000 gallons for all water in excess of 10,000 gallons.

Water for the public supply is secured from two wells. One well is 629 feet deep. It was drilled by Omer Kersey in 1914-1915. It is located at the side of the village hall. The ground surface at the well is about 646 feet above sea level. The well is cased with 12-inch pipe to a depth of 240 feet, with 10-inch pipe below the

12-inch, and with 8-inch pipe from the ground surface to a depth of 622 feet. The well was tested when drilled to a depth of 252 feet. A strainer was placed in a stratum of sand above hard shale at a depth of 230 feet. Pumping for four hours at a rate of 10 gallons a minute lowered the water level from a depth of 6 feet below the ground surface to the pump cylinder at a depth of 90 feet. The well is equipped with a Keystone Driller Company two-stroke deep-well pump with a 5¾-inch cylinder and 18-inch stroke. The cylinder is attached to 142 feet of 6-inch galvanized wrought iron drop pipe and 20 feet of suction pipe is placed below the cylinder. The pump discharge in 1923, as nearly as could be determined by computations from water levels in the elevated tank, was 100 gallons a minute. The total amount of water pumped was estimated at 75,000 gallons a day during the summer and 50,000 gallons a day during the winter. The water level in the well is reported to have been at a depth of 78 feet before pumping in 1915 and at a depth of 90 feet in 1923 when the pump had been idle for 10 or 12 hours.

The other well was drilled by the Ohio Drilling Company of Massillon, Ohio, in 1924. It is located about 200 feet southeast of the older well. A record of material penetrated as given by Holbrook, Warren, and Van Praag is as follows:

Black loam	6 feet
White clay and gravel	19 feet
Dark clay	25 feet
Brown shale	48 feet
Dark sand (some water)	10 feet
Clay	5 feet
Gravel (some water)	7 feet
Clay	64 feet
Brown shale	24 feet
Green sand	24 feet
Gray shale	23 feet
Slate	98 feet
Hard shell	5 feet
Slate	85 feet
Sand shell—(salty water)	4 feet
Slate	83 feet
Dark brown shale	35 feet
Gray slate	22 feet
Hard black formation	18 feet
White sand	5 feet
Water sand	10 feet
Hard gray sand (struck water)	3 feet
Brown sand	4 feet
Total depth	627 feet

The well is cased to a depth of 263 feet with 12-inch wrought iron casing and below the 12-inch to a depth of 590 feet with 10-inch wrought iron casing. The well is 10 inches in diameter to the bottom. The depth to water when the well was completed was 90

feet. A 6-inch cylinder was installed at a depth of 100 feet and the well is said to have been tested by pumping for 8 hours at a rate of 300 gallons a minute.

The well is equipped with a Goulds double-stroke deep-well pump with a 7¾-inch cylinder attached to 100 feet of drop pipe and with 20 feet of suction pipe below the cylinder. The pump is operated with 24-inch stroke and the discharge is estimated at 160 gallons a minute. In the spring of 1925 this pump was used one day each week.

The water had a mineral content of 462 and a total hardness of 232 parts per million as shown by the analysis of sample number 49988, collected on August 24, 1923.

Analysis of Sample Number 49988 from the City Supply.

Determinations Made.	Parts per million.
Iron Fe	0.0
Manganese Mn.	0.0
Silica SiO_2	7.9
Nonvolatile	1.2
Alumina Al_2O_3	2.0
Calcium Ca	51.3
Magnesium Mg	25.4
Ammonia NH_4	0.5
Sodium Na	87.5
Potassium K	10.8
Sulfate SO_4	10.9
Nitrate NO_3	2.1
Chloride Cl	54.0
Alkalinity	
Phenolphthalein	0
Methyl Orange	360.
Residue	422.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	3.4	0.20
Potassium Chloride KCl	18.0	1.05
Sodium Chloride NaCl	74.9	4.37
Sodium Sulfate $NaSO_4$	16.1	0.94
Sodium Carbonate Na_2CO_3	121.7	7.11
Ammonium Carbonate $(NH_4)_2CO_3$	1.3	0.07
Magnesium Carbonate $MgCO_3$	88 .0	5.14
Calcium Carbonate $CaCO_3$	128.1	7.48
Alumina Al_2O_3	2.0	0.11
Silica SiO_2	7.9	0.46
Nonvolatile	1.2	0.07
Total	462.6	27.00

The water contains hydrogen sulphide which imparts an unpleasant taste and odor. A wrought iron drop-pipe placed in the older well in 1915 was replaced in 1923. The bottom lengths which may have been under water at all times were in good condition. A sample of water collected from the sand stratum above shale when the yield of that stratum was tested was not so hard as the supply now obtained, but contained more of the sodium compounds. It had a mineral content of 986 and a total hardness of 150.

VILLA PARK (854). Villa Park is located in the eastern part of DuPage County on the drainage area of Salt Creek, a tributary of Des Plaines River. Two water supplies to furnish water for domestic purposes were installed by private companies interested in developing the village. In 1924 the village started to install a municipally owned supply.

A small area in the northern part of the village is supplied with water from a well 125 feet deep. The well is equipped with a deep-well pump which discharges directly into the distribution system and an elevated wooden tank connected to the system. The pump is driven by a 2-horsepower electric motor.

The water supply system for the southern and main part of the village is owned by the DuPage County Water Works Company. Water from deep wells is discharged directly into the distribution system and an elevated wooden tank 18 feet in diameter and 16 feet high which is connected to the system. Each pump is driven by an electric motor. Four hundred service connections were in use at the end of 1923. The charge for water was $3.00 for three months use.

Water for the village supply, excepting for a small area in the northern part of the village, is secured from three wells located near the corner of West Park Boulevard and Ardmore Avenue. The well first drilled is said to be 150 feet deep and cased to rock at a depth of 58 feet. It is equipped with a Goulds single-acting pump.

A well was drilled for the water company in 1918 by Mr. Eckert of Elmhurst. It is 39 feet south of the old well. It is 8 inches in diameter and 285 feet deep and is cased to rock. It is equipped with a Goulds single-acting pump of about 90 gallons a minute capacity.

Analysis of Sample Number 43320 from Well 285 Feet Deep.

Determinations Made.	Parts per million.
Potassium K } Sodium Na }	24.3
Ammonium NH_4	0.6
Magnesium Mg	25.6
Calcium Ca	93.7
Iron Fe	0.4
Aluminum AlO_3	0.3
Nitrite NO_2	0.0
Nitrate NO_3	0.3
Chloride Cl	3.0
Sulfate SO_4	48.5
Silica SiO_2	10.4
Nonvolatile	1.4
Alkalinity Methyl Orange	320.
Residue	413 .0

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Sodium Nitrate $NaNO_3$	0.48	.03
Sodium Chloride NaCl	4.94	.29
Sodium Sulfate Na_2SO_4	68.34	3.99
Ammonium Sulfate $(NH_4)_2SO_4$	2.26	.13
Magnesium Sulfate $MgSO_3$	5.60	.32
Magnesium Carbonate $MgCO_3$	84.83	4.96
Calcium Carbonate $CaCO_3$	234.06	13.69
Iron Oxide Fe_2O_3	0.57	.03
Alumina Al_2O_3	0.33	.02
Silica SiO_2	10.40	.61
Nonvolatile	1.40	.08
Total	413.21	24.15

The third well was drilled by J. D. Palmer of Chicago in 1923. This well is 251 feet deep and is cased with 12-inch pipe to limestone at a depth of 58 feet. The well is equipped with an American

double-stroke deep-well pump of 185 gallons a minute capacity. The cylinder is placed at a depth of about 70 feet and no suction pipe is attached. The water level when not pumping is at a depth of 35 or 40 feet.

Water from the well 285 feet deep had a mineral content of 413, a total hardness of 340, and a content of iron of 0.4 parts per million as shown by the analysis of sample number 43320, collected on June 23, 1920.

A sample of water collected in 1920 from the well which supplies water to the northern part of the village was of similar quality.

Two wells were drilled for the village in 1924 by the J. P. Miller Artesian Well Company of Chicago. They are located at the southwest Corner of Ardmore Avenue and St. Charles road. Data is from Suhr and Berryman. The well first drilled is 401 feet deep and is cased with 12-inch genuine wrought iron pipe to limestone at a depth of 76 feet. Below the limestone, which extends to a depth of 256 feet, about 60 feet of casing was placed in shale. When the well was 200 feet deep it yielded 60 gallons a minute. When it was completed the depth to water when not pumping was 30 feet and the yield during an 18 hour test was 200 gallons a minute with a lowering of the water level to a depth of 76 feet below the ground surface.

The second well was drilled at a distance of about 65 feet from the other. It is 12 inches in diameter and 200 feet deep. It is cased with 12-inch wrought iron pipe to limestone. This well yielded 250 gallons a minute and the water level was drawn down to a depth of 67 feet below the ground surface.

VIOLA (668). Viola is located in the eastern part of Mercer County on the watershed between Edwards River and Poke Creek, two streams tributary to Mississippi River. A public water supply was installed by the village in 1916. Water is pumped from a well into the distribution system and an elevated steel tank connected to the system by a deep-well pump which is driven through gears by a 10-horsepower electric motor. The elevated tank has a capacity of 60,000 gallons. The operation of the motor is automatically controlled by the height of water in the tank. Thirty-eight service connections were in use in March, 1919. All were metered and meters were owned by the village. The rate for water is 35 cents per 1000 gallons with a minimum charge of 50 cents every three months, in addition to a charge of 25 cents for a meter.

Water for the public supply is secured from a well 1281 feet

deep. It is located near the center of the village. A plat showing material penetrated was furnished by C. E. Horton. Material with thicknesses given or scaled from the plat are as follows:

Material.	Thickness in feet.	Depth in feet.
Surface soil	15	15
Sand	27	42
Blue mud and fine sand	58	100
Shale	15	115
Limestone	15	130
Shale and limestone	10	140
Sandy shale	5	145
Blue slate	37	182
Black slate	18	200
White shale and limestone	25	225
Black shale	20	245
Shale	5	250
Limestone and shale	50	300
Limestone	40	340
Shale	4	344
Limestone	106	450
Limestone and shale	90	540
Limestone	110	650
Shale	75	725
Shale and limestone, Maquoketa	50	775
Brown limestone, Maquoketa	50	825
Brown shale	25	850
Brown limestone, Galena-Platteville	306	1156
Sandstone, St. Peter	125	1281

Analysis of Sample Number 39812 from the Village Supply.

Determinations Made.

	Parts per million.
Iron Fe	1.1
Manganese Mn	0.0
Silica SiO_2	16.0
Nonvolatile	1.6
Aluminium Al	0.8
Calcium Ca	48.7
Magnesium Mg	25.7
Ammonium NH_4	1.5
Sodium Na	327.5
Sulfate SO_4	297.3
Nitrate NO_3	1.4
Chloride Cl	273.0
Alkalinity Methyl Orange	237.5
Residue	1128.6

Hypothetical Combinations.

	Parts per million.	Grains per gallon.
Sodium Nitrate $NaNO_3$	1.9	.12
Sodium Chloride NaCl	450.0	26.25
Sodium Sulfate Na_2SO_4	439.2	25.62
Sodium Carbonate Na_2CO_3	16.5	.96
Ammonium Carbonate $(NH_4)_2CO_3$	4.3	.25
Magnesium Carbonate $MgCO_3$	88.9	5.19
Calcium Carbonate $CaCO_3$	121.7	7.10
Iron Carbonate $FeCO_3$	2.2	.13
Alumina Al_2O_3	1.4	0.08
Silica SiO_2	16.0	.93
Nonvolatile	1.6	.09
Total	1143.8	66.72.

The well is cased with 10-inch pipe to a depth of 398 feet and with 8-inch pipe between depths of 368 and 1058 feet. It is 8 inches in diameter below the casing to a depth of 1156 feet and 6 inches in diameter below that depth. The water level when the well was completed was at a depth of 175 feet. The well was pumped for 10 hours at a rate of from 160 to 180 gallons a minute without drawing the water level down to the pump cylinder which was at a depth of 225 feet. The well is equipped with a Cook double-

stroke deep-well pump with a 5¼-inch cylinder and 18-inch stroke. The cylinder is placed at a depth of 200 feet. The pump was operated in 1919 at 24 revolutions a minute, a displacement of 84 gallons a minute. When installed it delivered 71 gallons a minute. The amount of water pumped was estimated in 1919 at an average of 4000 gallons a day.

The water had a mineral content of 1143, a total hardness of 227, and a content of iron of 1.1 parts per million as shown by the analysis of sample number 39,812, collected on July 24, 1918.

WALNUT (771). Walnut is located in the northern part of Bureau County on the drainage area of Green River, a tributary of Rock River. In 1916 more than half the residents were using water from private wells for drinking. Many of the wells were from 35 feet to 45 feet deep into gravel which is entered a few feet below the ground surface.

A public water supply was installed by the village in 1896. Water was pumped from the well into the distribution system and a steel pressure tank connected to the system, by a deep-well pump which was driven by a gas engine. Extensive improvements were made about 1910. Another well was drilled, a wooden tank 24 feet in diameter and 24 feet high on a steel tower 85 feet high was installed close to the well and connected to the mains, and the use of the steel pressure tank was discontinued. A 32-horsepower gas engine was installed to replace a smaller engine. The well drilled in 1910 has been abandoned and another well has been drilled. The two wells in use are each equipped with deep-well pumps which are driven by belts from a shaft. The meter rate for water is 30 cents per 1000 gallons with a minimum charge of $6.00 per year.

Water for the public supply is secured from two wells located in the northern part of the village. Each well is 6 inches in diameter and 230 feet deep. Water is secured from sand and gravel. A screen 20 feet long is placed in the bottom of each well. Each well is equipped with a deep-well pump. The discharge from the two wells in 1916 was said to be 3000 gallons an hour and the pumps were operated from 4½ to 5 hours a day.

An 8-inch well was drilled in 1910 and was equipped with a coarse screen. A fine screen was placed inside the coarse screen and the well was abandoned due to clogging with fine sand between the screens.

The water had a mineral content of 339, a total hardness of 290, and a content of iron of 5.0 parts per million as shown by the analysis of sample number 35616, collected on October 21, 1916.

Analysis of Sample Number 35616 from the Village Supply.

Determinations Made.

	Parts per million.
Silica SiO_2	23.7
Iron Fe	5.0
Alumina Al_2O_3	1.2
Calcium Ca	67.1
Magnesium Mg	29.7
Ammonium NH_4	0.8
Sodium Na	13.0
Potassium K	1.9
Sulfate SO_4	1.8
Nitrate NO_3	1.1
Nitrite NO_2	0.0
Chloride Cl	2.0
Alkalinity Methyl Orange	312.
Residue	345.

Hypothetical Combinations.

	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	1.8	.10
Potassium Chloride KCl	2.3	.13
Sodium Chloride NaCl	1.3	.07
Sodium Sulfate Na_2SO_4	2.7	.16
Sodium Carbonate Na_2CO_3	26.7	1.56
Ammonium Sulfate $(NH_4)_2SO_4$	2.1	.12
Magnesium Carbonate $MgCO_3$	102.8	5.99
Calcium Carbonate $CaCO_3$	167.5	9.77
Iron Oxide Fe_2O_3	7.1	.41
Alumina Al_2O_3	1.2	.07
Silica SiO_2	23.7	1.38
Total	339.2	19.76

WARREN (1253). Warren is located in the northeastern part of Joe Daviess County. A public water supply was installed by the village in 1895. The installation included a well, a steam-head deep-well pump, a distribution system, an elevated tank, and a steam boiler. Another well has been drilled and other improvements have been made. One well was equipped with a deep-well pump driven by a 25-horsepower electric motor but in 1919 it was proposed to change back to a steam-head pump. Nearly all residences are supplied with water from the public supply. Part of the services are metered.

Water from the public supply is secured from two wells located 20 feet apart near the center of the village. They were drilled by the J. P. Miller Artesian Well Company of Chicago. The elevation of the tops of the wells is about 1005 feet above sea level. Records of the drillers show that one well was drilled in 1895 to a depth of 875 feet. Limestone was entered at a depth of 15 feet. The well was cased into limestone with 14-inch pipe and to a depth of 200 feet with 181 feet of 10-inch pipe. The diameter is 6 inches at the bottom. The well was tested when about 600 feet deep and yielded 90 gallons a minute. The other well was drilled in 1901. It is 697 feet deep. It is 10 inches in diameter to a depth of 200 feet and $5\frac{5}{8}$ inches in diameter at the bottom. One hundred and four feet of $5\frac{5}{8}$-inch casing is placed with the bottom at a depth of 646 feet. The depth to water when measured in one of the wells in

1917 was 45 feet. One well is equipped with a single-acting steam-head deep-well pump with a 7¾-inch water cylinder and 36-inch stroke. The cylinder is wedged in the well at a depth of 165 feet. In the spring of 1919 at the time of a fire the pump was operated at a speed of 25 strokes a minute and it is said that the pump did not draw air. The other well is equipped with a single-acting deep-well pump with a 6¾-inch cylinder and 36-inch stroke. The cylinder is wedged in the casing at a depth of 165 feet.

In 1919, the date for which data of equipment is given, the pumps were usually operated at from 16 to 17 strokes a minute, a displacement of 210 gallons a minute, for about 6 hours a day.

The village clerk reports conditions were practically the same in January, 1925, excepting that two steam boilers were then in use.

The water had a mineral content of 443 and a total hardness of 360 parts per million, and contained no iron as shown by analysis of sample number 53172, collected on February 3, 1925.

Analysis of Sample Number 53172 from the Village Supply.

Determinations Made.

	Parts per million.
Iron Fe	0.0
Manganese Mn	0.0
Silica SiO_2	13.2
Nonvolatile	0.6
Alumina Al_2O_3	1.0
Calcium Ca	59.6
Magnesium Mg	51.5
Ammonia NH_4	0.0
Sodium Na	30.8
Potassium K	1.5
Sulfate SO_4	60.5
Nitrate NO_3	1.2
Chloride Cl	20.0
Alkalinity	
Phenolphthalein	0
Methyl Orange	350.
Residue	375.

Hypothetical Combinations.

	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	2.0	.12
Potassium Chloride KCl	1.3	.08
Sodium Chloride NaCl	31.9	1.86
Sodium Sulfate Na_2SO_4	56.5	3.31
Magnesium Sulfate $MgSO_4$	27.9	1.63
Magnesium Carbonate $MgCO_3$	159.1	9.29
Calcium Carbonate $CaCO_3$	148.8	8.67
Alumina Al_2O_3	1.0	.06
Silica SiO_2	13.2	.77
Nonvolatile	0.6	.03
Total	442.3	25.82

WASHINGTON (1643). Washington is located in the north-eastern part of Tazewell County about eight miles east of Illinois River. A public water supply was installed by the city about 1888. The installation included a well, a steam pump, an elevated tank, and a distribution system of wooden mains. A few years later another well was installed. Each well is now equipped with a deep-well pump driven by a 15-horsepower electric motor. A gas engine is available to drive one of the pumps. In emergency, water from

a well 180 feet deep can be supplied by the Dickenson Canning Company. In 1922 the last of the wooden mains were replaced with cast iron.

Five hundred service connections were reported in use in 1924. The meter rate for quantities less than 150,000 gallons in six months is 35 cents per 1,000 gallons and for additional water it is 30 cents per 1,000 gallons.

Water for the public supply is secured from two wells into sand and gravel, located near the center of the village. The tops of the wells are about 765 feet above sea level. The older well is located in the public park. This well was in use for several years before the public supply was installed. It was dug and cased with brick to a depth of 60 feet and was drilled to a total depth of 90 feet. In 1921 the well was dug to a depth of 90 feet and the lower part was cased with steel. The lower 12 feet of the steel casing has half-inch holes bored in it. The well is equipped with a Goulds deep-well pump with a 7¾-inch cylinder and 18-inch stroke. The pump is operated 28 strokes a minute.

When the well was dug to a depth of 90 feet in 1921 it was tested by pumping for 24 hours. Pumping for five hours at a rate of 270 gallons a minute lowered the water level from a depth of 40 feet below the ground surface to a depth of 52 feet below the ground surface where it remained throughout the remainder of the test. On June 19, 1924, when the pump was operated a short time and then not operated for one hour the water level was at a depth of 40 feet below the ground surface. Pumping for one hour at a rate of about 108 gallons a minute then lowered the water level four feet. The test was repeated by stopping for an hour and again pumping for an hour and the water levels were about three inches lower than during corresponding periods of the first test.

The average amount of water pumped during the year to May 1924, is estimated at about 50,000 gallons a day.

The other well is located about 300 feet southeast of the older well. It is 8 inches in diameter and 80 feet or 90 feet deep. A number 25 Cook screen is placed in the bottom. The well is equipped with a Cook single-acting deep-well pump with a 5¾-inch cylinder attached to 70 feet of drop pipe and 10 feet of suction pipe attached below the cylinder.

The water had a mineral content of 382, a total hardness of 329, and a content of iron of 0.8 parts per million as shown by the analysis of sample number 51671, collected at the pumping station on June 19, 1924.

Analysis of Sample Number 51671 from City Well in Park.

Determinations Made.	Parts per million.
Iron Fe	0.8
Manganese Mn	0.0
Silica SiO_2	19.7
Nonvolatile	2.2
Alumina Al_2O_3	2.7
Calcium Ca	89.5
Magnesium Mg	25.7
Ammonium NH_4	3.6
Sodium Na	8.9
Potassium K	2.4
Sulfate SO_4	18.9
Nitrate NO_3	2.7
Chloride Cl	8.0
Alkalinity Methyl Orange	338.
Residue	368.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	4.3	.25
Potassium Chloride KCl	1.4	.08
Sodium Chloride NaCl	12.1	.71
Sodium Sulfate Na_2SO_4	12.9	.75
Ammonium Sulfate $(NH_4)_2SO_4$	13.2	.77
Magnesium Sulfate $MgSO_4$	0.7	.04
Magnesium Carbonate $MgCO_3$	88.4	5.16
Calcium Carbonate $CaCO_3$	223.4	13.05
Iron Oxide Fe_2O_3	1.1	.06
Alumina Al_2O_3	2.7	.16
Silica SiO_2	19.7	1.15
Nonvolatile	2.2	.13
Total	382.1	22.31

WATERMAN (401). Waterman is located in the southern part of DeKalb County on the drainage area of Somonauk Creek, a tributary of Fox River. A public water supply installed by private interests was in use for about ten years. The installation included a small well 100 feet or more in depth, a well pump driven by a gasoline engine, a distribution system serving about twenty houses, and a small elevated wooden tank.

A public water supply was installed by the village in 1906. Water is pumped from a well directly into the distribution system and an elevated steel tank connected to the system, by a pump which is driven by a 7½-horsepower electric motor. Electric current is purchased from the Northern Illinois Utilities Company. A gasoline engine, formerly in regular service to drive the pump and a dynamo, can be used in emergency. One hundred and twenty-five service connections were in use in 1922 and all were metered. The rate for six months for the first 10,000 gallons of water used is 50 cents per 1000 gallons and the lowest rate, for water used in excess of 50,000 gallons, is 30 cents per 1000 gallons. The minimum charge is $2.50.

Water for the public supply is secured from a well located in the southwestern part of the village. It was drilled by F. F. Morse of Waterman. The elevation at the top is about 820 feet above sea level. The well is 6 inches in diameter and 72 feet deep. A screen is placed in gravel in the bottom of the well. The well is equipped with a single-acting deep-well pump with a 4¼-inch cylinder and 24-inch stroke. The pump was operated 37 revolutions per minute in 1922, a displacement of 54 gallons a minute, and

the discharge was thought to be about 40 gallons a minute. During the year 1921 the pump was operated an average of from 3 to 3½ hours a day. The water level has changed very little and was about 11 feet below the ground surface when not pumping in 1922. The pump cylinder was at a depth of about 40 feet. The pump was operated continuously 18 hours a day for about two weeks in 1914, while the interior of the elevated tank was painted. An overflow was provided through a fire hose. At that time the pump was driven by gas engine and operated at a little lower speed than it is driven by the electric motor.

The water had a mineral content of 373, a total hardness of 360, and a content of iron of 1.0 parts per million as shown by the analysis of sample number 33,294, collected on March 28, 1916.

Analysis of Sample Number 33294 form the Village Supply.

Determinations Made.	Parts Per million.
Potassium K	0.5
Sodium Na	6.7
Ammonium NH_4	0.5
Magnesium Mg	58.0
Calcium Ca	48.7
Iron Fe	1.0
Alumina Al_2O_3	3.6
Silica SiO_2	11.1
Nitrate NO_3	1.4
Chloride Cl	5.0
Sulfate SO_4	35.1
Alkalinity Methyl Orange	338.
Residue	372.

	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	1.3	.08
Sodium Nitrate $NaNO_3$	0.8	.05
Sodium Chloride NaCl	8.3	.42
Sodium Sulfate Na_2SO_4	9.9	.57
Ammonium Sulfate $(NH_4)_2SO_4$	1.8	.10
Magnesium Sulfate $MgSO_4$	33.9	1.98
Magnesium Carbonate $MgCO_3$	177.4	10.36
Calcium Carbonate $CaCO_3$	121.5	7.08
Iron Oxide Fe_2O_3	1.4	.08
Alumina Al_2O_3	3.6	.22
Silica SiO_2	11.1	.65
Undetermined	2.4	.13
Total	373.4	21.72

The iron content is sufficient to cause staining of plumbing fixtures and laundry.

WATSEKA (2817). Watseka is located in the central part of Iroquois County on the drainage area of Iroquois River, a tributary of Kankakee River. Many private wells from 100 to 150 feet deep had a natural flow some years ago. With the installation of additional wells and increased pumping from wells the water level was lowered and wells on the higher land ceased to flow.

A public water supply was installed by the village about 1892. Water from wells is pumped directly into the distribution system and a standpipe 12 feet in diameter and 100 feet high which is connected to the system. The floor of the pumping station is twelve feet below the ground surface. A steam pump was first used. A Goulds 8 by 10-inch single-acting triplex pump driven by belt

from a 20-horsepower electric motor is now generally used. A Goulds 9 by 12-inch single-acting pump driven by belt from a 30-horsepower electric motor was installed in 1924 for use in emergency.

About 730 service connections were in use at the end of the year 1924. The rate for use at residences is 30 cents per 1000 gallons with a minimum charge of $3.00 every six months.

Water is secured from two wells into sand and gravel, each 150 feet deep. They are located about 20 feet apart on the east side of Second Street between Walnut and Cherry Streets. The ground surface at the wells is about 630 feet above sea level. One well is cased with 6-inch pipe. The other one is cased with 6-inch pipe to a depth of 125 feet and with 4-inch pipe below that depth. Water from a water-bearing stratum at a depth of 125 feet and from a stratum at a depth of 150 feet enters the wells through small holes drilled in the casings. Water is drawn from the wells by pumps placed in a pit 20 feet deep. A pump is usually operated at a displacement of 90 gallons a minute. During repairs on the pump in 1917, water raised above the bottom of the pit. During repairs in 1924 the water level was at all times below the bottom of the pit. The water level in the village wells may have been lowered by pumping from a well installed in 1924 at an ice plant a block distant from the village wells.

The water had a mineral content of 343, a total hardness of 156, and a content of iron of 1.6 parts per million as shown by the analysis of sample number 38928, collected on February 6, 1918.

Analysis of Sample Number 38928 from the Village Supply.

Determinations Made.

	Parts per million.
Potassium K	2.6
Sodium Na	73.8
Ammonium NH_4	3.1
Magnesium Mg	14.8
Calcium Ca	38.1
Iron Fe	1.6
Alumina Al_2O_3	1.6
Chloride Cl	8.0
Sulfate SO_4	9.6
Silica SiO_2	5.4
Manganese Mn	0.0
Alkalinity Methyl Orange	292
Residue	345

Hypothetical Combinations.

	Parts per million.	Grains per gallon.
Potassium Chloride KCl	4.2	.24
Sodium Chloride NaCl	9.2	.54
Sodium Sulfate Na_2SO_4	14.2	.83
Sodium Carbonate Na_2CO_3	151.2	8.82
Ammonium Carbonate $(NH_4)_2CO_3$	8.3	.48
Magnesium Carbonate $MgCO_3$	51.3	2.99
Calcium Carbonate $CaCO_3$	95.2	5.55
Iron Carbonate Fe_2O_3	3.3	.19
Alumina Al_2O_3	1.6	.09
Silica SiO_2	5.4	.31
Total	343.9	20.04

WAUCONDA (399). Wauconda is located on the shore of a small lake in the southwestern part of Lake County. A public water supply was installed by the village in 1920. Water is pumped

from a well into two steel pressure tanks and the distribution system, by a Goulds 6 by S-inch triplex pump which is located in a pit 30 feet deep. The pump is driven by belt from an oil engine. (A 15-horsepower electric motor was to be installed in 1923). The tanks are 8 feet in diameter and 30 feet long. Eighty-five service connections were in use in 1923. The rate for water for six months is 30 cents per 1000 gallons for the first 10,000 gallons, 20 cents per 1000 gallons for the next 90,000 gallons, and 15 cents per 1000 gallons for water in excess of 100,000 gallons.

Water for the public supply is secured from a well drilled by A. B. Bell of St. Charles in 1920. It is cased with 10-inch pipe and is 132 feet deep from the ground surface. Water is secured from sand and gravel. The water level is said to be from eight to ten feet below the pump pit when not pumping and to be lowered but little by pumping. A 4-inch suction pipe connected to the pump extends to a depth of 20 feet. The pump was operated in 1923 at a speed of 38 strokes a minute, a displacement of 110 gallons a minute. In the spring of 1923 it operated a total of from two to three hours a day.

The water had a mineral content of 443, a total hardness of 302, and a content of iron of 0.8 parts per million as shown by the analysis of sample number 49672, collected at a tap on the system on June 29, 1923.

Analysis of Sample Number 49672 from the Village Supply.

Determinations Made.

	Parts per million.
Iron Fe	0.8
Manganese Mn	0.0
Silica SiO_2	31.4
Nonvolatile	1.0
Alumina Al_2O_3	0.4
Calcium Ca	42.8
Magnesium Mg	47.6
Ammonium NH_4	0.1
Sodium Na	49.7
Potassium K	7.4
Sulfate SO_4	21.3
Nitrate NO_3	1.2
Chloride Cl	8.0
Alkalinity	
Phenolphthalein	0
Methyl Orange	392.
Residue	420.

Hypothetical Combinations.

	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	2.0	0.11
Potassium Chloride, KCl	12.6	0.73
Sodium Chloride NaCl	3.3	0.19
Sodium Sulfate Na_2SO_4	31.5	1.84
Sodium Carbonate Na_2CO_3	88.1	5.14
Ammonium Carbonate $(NH_4)_2CO_3$	0.2	0.01
Magnesium Carbonate $MgCO_3$	164.9	9.63
Calcium Carbonate $CaCO_3$	107.0	6.25
Iron Oxide Fe_2O_3	1.1	0.06
Alumina Al_2O_3	0.4	0.02
Silica SiO_2	31.4	1.83
Nonvolatile	1.0	0.06
Total	443.5	25.87

WAYNESVILLE (592). Waynesville is located in the northwestern part of Dewitt County on the drainage area of Sangamon River, a tributary of Illinois River. Private wells in use in the

village are from ten to twenty feet deep. A public water supply was installed by the village in 1895. Water is pumped from two wells into the distribution system and an elevated steel tank connected to the system, by steam-head deep-well pumps. Steam is supplied by two 75-horsepower boilers. The capacity of the tank is 48,000 gallons. One hundred and twenty-nine service connections were in use in 1919 and all were metered. The rate for water is $1.00 for the first 300 cubic feet and 30 cents for each additional 100 cubic feet.

Water for the public supply is obtained from two wells drilled in 1895. The wells are 6 inches in diameter and 116 feet deep. An approximate record of material penetrated as given by L. M. Gamby, Superintendent of Water Works, is as follows:

Soil	5 feet
Sand and gravel	20 feet
Clay	75 to 85 feet
Hardpan	4 feet
White sand and gravel	3 feet

The wells are equipped with deep-well pumps with the cylinders placed at a depth of 102 feet. At the speed generally operated in 1919 the total displacement of the two pumps was said to be about 110 gallons a minute. They were operated about 18 hours a day in the summer. The amount pumped was estimated at about 23,000 gallons a day. The water level in one well when pumping from the other well was at depths of from 40 to 45 feet when measured prior to 1919.

The water had a mineral content of 569, a total hardness of 450, and a content of iron of 1.8 parts per million as shown by the analysis of sample number 41607, collected on August 18, 1919.

Analysis of Sample Number 41607 from the Village Supply.

Determinations Made.

	Parts per million.
Potassium K } Sodium Na }	48.2
Ammonium NH_4	4.0
Magnesium Mg	48.8
Calcium Ca	100.0
Iron Fe_2O_3	2.6
Alumina Al_2O_3	1.7
Nitrite NO_2	0.0
Nitrate NO_3	0.7
Chloride Cl	6.0
Sulfate SO_4	0.4
Silica SiO_2	18.8
Nonvolatile	0.9
Alkalinity Methyl Orange	560.
Residue	573.

Hypothetical Combinations.

	Parts per million.	Grains per gallon.
Sodium Nitrate $NaNO_3$	0.9	.05
Sodium Chloride NaCl	0.9	.58
Sodium Sulfate Na_2SO_4	0.1	.00
Sodium Carbonate Na_2CO_3	101.4	5.93
Ammonium Carbonate $(NH)_2CO_3$	13.7	.80
Magnesium Carbonate $MgCO_3$	169.0	9.89
Calcium Carbonate $CaCO_3$	249.8	14.60
Iron Oxide Fe_2O_3	2.6	.15
Alumina Al_2O_3	1.7	.10
Silica SiO_2	18.8	1.10
Nonvolatile	0.9	.05
Total	568.8	33.25

WELDON (573). Weldon is located in the southeastern part of DeWitt County on the drainage area of Sangamon River. A privately owned public water supply was installed in 1897. The water works and an electric light plant were purchased by the village in 1904. Water is now secured from a drilled well equipped with a pump driven by a 15-horsepower electric motor. The pump discharges directly into the distribution system to which an elevated wooden tank of 17,000 gallons capacity is connected.

Fifty service connections were in use in 1924 and the average consumption was estimated at 5000 gallons a day. Meter rates for three months are 35 cents per 1000 gallons for the first 3000 gallons, 30 cents per 1000 gallons for the next 3000 gallons, 25 cents per 1000 gallons for the next 4000 gallons, and 20 cents per 1000 gallons for all over 10,000 gallons. The minimum charge is $1.25 and bills are not subject to discount.

A well which supplied water for an elevator was used as a source of supply for five or six years when the water works was installed. A well was then dug on Oak Street on the south side of the Illinois Central Railroad, to supply water for the water works and an electric light plant. The well was dug 10 feet in diameter to a depth of 42 feet and three wells were drilled in the bottom of the dug well. One well to a depth of 89 feet was thought to supply a considerable part of the water. Water was pumped from the well by a steam pump which was placed in a pit 12 feet deep. When not pumping water stood about 23 feet below the ground surface and when pumping it was drawn down about 11 feet, when, with increasing yield and decreasing pump discharge, the water level remained about constant. In 1922 the well caved in and the village was without a public water supply.

A well was drilled at the side of the old well in 1922 by E. H. Johnson and Son of Bloomington. A record of material penetrated as given by the drillers is as follows:

Soil and yellow clay	to	18 feet
Blue clay	to	33 feet
Streak of sand, very little		
Blue clay	to	67 feet
Black drift, 2 feet, a little water		
Green blue clay	to	72 feet
Hard blue clay	to	99 feet
Streak of sand and water (2 inches)		
Hard blue clay	to	139 feet
Blue gumbo	to	145 feet
Black drift	to	152 feet
Green clay	to	158 feet
Vein of water and fine sand (2 inches)		
Soft blue clay mixed with gravel	to	164 feet

Hardpan, 14 inches		
Hard blue clay	to	173 feet
Soft blue clay	to	241 feet
Brown drift, 2 feet		
Streak of green clay	to	260 feet
Streak of sand and water		
Blue clay	to	281 feet
Brown drift	to	289 feet
Sand and little water streak		
Green clay	to	298 feet
Soapstone	to	314 feet
Brown shale	to	378 feet

Little water was secured and a well was then drilled on the north side of the railroad tracks east of Chestnut Street. A record of material penetrated is as follows:

Soil and yellow clay	to	8 feet
Streak of red sand and dirt	to	10 feet
Soft blue clay	to	70 feet
Hard blue clay	to	155 feet
Streak of water broke in here when we were 17 feet past it		
Mixed blue clay	to	167 feet
Hard blue clay	to	173 feet

When the well was at a depth of 173 feet a sample of sand bailed from the well was collected. The sand was said to be running into the hole from above. All of the sand passed through a number 14 sieve, four-fifths passed through a number 28 sieve, one-half passed through a number 35 sieve, and one-fifth passed through a number 48 sieve. (Sieve number gives approximate number of meshes to inch.) The well was abandoned at 177 feet 8 inches.

A well from which the public water supply is now secured was drilled by Ned Ross of Bloomington in 1923. The well is located on the north side of the railroad tracks on the west side of Oak Street, west of the post office which is on the corner. It is 8 inches in diameter and 165 feet deep. In the upper part some thin veins of fine sand were encountered. The bottom is in a stratum of sand which is at least 10 feet thick. The sand is very much coarser than sand encountered in the hole drilled east of Chestnut Street in 1922. A Cook screen 12 feet long was purchased to install in the bottom of the well. On account of the coarseness of the sand, openings in the screen were cut to larger size with a hack saw. On parts of the screen every opening was sawed and on other parts about every other opening was sawed. The well is equipped with a Trahern deep-well pump manufactured by the George D. Roper Corporation of Rockford, Illinois. The pump cylinder is attached to a 6-inch drop pipe at a depth of 147 feet and has 14 feet of 4-inch suction pipe attached. When the pump was installed it operated with 30-inch stroke at a speed of 32 strokes a minute and was run for 8 hours. No difference in discharge was noted with

long continued pumping and but little fine sand was discharged. The pump is now operated with 20-inch stroke at a speed of 24 strokes a minute, a displacement, if the pump is single acting, of 54 gallons a minute. The water level when not pumping in 1923 was at a depth of about 40 feet.

The water had a mineral content of 440, a total hardness of 247, and a content of iron of 2.0 parts per million as shown by the analysis of sample number 52264, collected on August 29,1924.

Analysis of Sample Number 52264 from the Village Supply.

Determinations Made.

	Parts per million.
Iron Fe	2.0
Manganese Mn	0.0
Silica SiO_2	20.3
Nonvolatile	1.6
Alumina Al_2O_3	6.4
Calcium Ca	57.8
Magnesium Mg	25.0
Ammonia NH_4	1.3
Sodium Na	73.3
Sulfate SO_4	0.0
Nitrate NO_3	1.6
Chloride Cl	5.0
Alkalinity	
Phenolphthalein	0
Methyl Orange	432.
Residue	469.

Hypothetical Combinations.

	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	2.5	0.15
Potassium Chloride KCl	5.8	0.34
Sodium Chloride NaCl	3.7	0.22
Sodium Carbonate Na_2CO_3	165.5	9.66
Ammonium Carbonate $(NH_4)_2CO_3$	3.6	0.21
Magnesium Carbonate $MgCO_3$	86.6	5.06
Calcium Carbonate $CaCO_3$	142.2	8.30
Iron Oxide Fe_2O_3	2.0	0.11
Alumina Al_2O_3	6.4	0.37
Silica SiO_2	20.3	1.18
Nonvolatile	1.6	0.09
Total	440.2	25.69

WENONA (1203). Wenona is located on the eastern part of Marshall County on the drainage area of Sandy Creek, a tributary of Illinois River. A public water supply was installed by the city in 1895. Water is pumped from a well into a collecting reservoir and from the reservoir into the distribution system and an elevated tank connected to the system. A steam pump formerly used in the well has been replaced by a pump driven by a 10-horsepower electric motor and a steam pump used to pump from the reservoir has been replaced by a Platt Iron Works 8 by 8-inch triplex pump which is driven at a speed of 60 revolutions a minute by belt from a 25-horsepower electric motor. Power for pumping is supplied by the Wenona Light and Power Company. The company was for a time paid 8 cents per 1000 gallons for pumping water and a meter was installed at the pumping station. This meter has been removed. Water is supplied to consumers in Wenona and in the village of East Wenona which is located in LaSalle County east of and adjoining Wenona. The total number of consumers in 1922 was 260 which is a few less than were reported in 1916. The rates for three

months per 1000 gallons are 40 cents for the first 10,000 gallons, 30 cents for the next 20,000 gallons, 20 cents for the next 20,000 gallons, and 15 cents for water in excess of 50,000 gallons, with a minimum charge of $1.50.

Water for the public supply is secured from a well 1857 feet deep which is located near the center of the city. The elevation at the top of the well is about 692 feet above sea level. A record of material penetrated, on file with the State Geological Survey Division, is as follows:

	Thickness in feet.	Depth in feet.
Through coal measures to "Trenton" rock		643
"Trenton" rock	101	744
White shale	179	923
Limestone	139	1062
Shale	33	1095
Limestone	65	1170
Clay and shale	164	1354
Real Trenton rock	116	1470

The total depth is said to be 1857 feet and officials of the city some years ago stated that the lower 57 feet of the well was in St. Peter sandstone. The well is cased with 12-inch pipe to a depth of 110 feet and with 9-inch pipe to a depth of 496 feet. Below the casing the well is 6 inches in diameter to a depth of 1114 feet and 4 inches in diameter below that depth. The well is equipped with a Keystone Driller Company double-stroke deep-well pump with a 5¾-inch cyinder and 24-inch stroke. The cylinder is at a depth of about 250 feet and has 20 feet of suction pipe attached. In 1922 the pump was operated at a speed of 30 revolutions a minute. The discharge was 115 gallons a minute with new leathers and 100 gallons a minute after leathers were a few weeks old. The capacity of the pump has not been changed much with changes in the plant and the cylinder has for many years been at about the same depth. The depth to water was reported to be 125 feet in 1896 and on December 19, 1916, when not pumping it was 152 feet. The amount of water pumped during the year to June, 1916, averaged 59,000 gallons a day. During the summer of that year the pump was operated continuously to supply this amount of water. A pump cylinder had been lowered in the well and may have been causing some decrease in yield. This cylinder and another lowered later were removed in 1920. The depth to water when not pumping in that year, probably after a long shut down during repairs, was reported to be 127 feet 6 inches. The pump discharge in October, 1922, was about 100 gallons a minute and during a test in November it was 102 gallons a minute. The depth to water when the pump was not operated for five hours

was 156 feet. Pumping for one hour forty-five minutes, after the pump had been idle during the night, lowered the water level to a depth of 246 feet and pumping for three hours more lowered the water level 18 inches further. The total amount of water pumped in 1922 was probably less than in 1916, due to installation of additional meters and slight reduction in the number of service connections in use.

The water had a mineral content of 1421, a total hardness of 265, and a content of iron of 0.4 parts per million as shown by the analysis of sample number 48458, collected on October 16, 1922.

Analysis of Sample Number 48458 from the City Supply.

Determinations Made.	Parts per million.
Iron Fe	0.4
Manganese Mn	0.0
Silica SiO_2	14.4
Nonvolatile	0.8
Alumina Al_2O_3	1.0
Calcium Ca	62.8
Magnesium Mg	26.4
Ammonium NH_4	1.5
Sodium Na	389.8
Potassium K	70.0
Sulfate SO_4	175.9
Nitrate NO_3	1.4
Chloride Cl	458.0
Alkalinity	
Phenolphthalein	0
Methyl Orange	390.0
Residue	145.4

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	2.3	0.13
Potassium Chloride KCl	123.2	7.20
Sodium Chloride NaCl	651.9	38.00
Sodium Sulfate Na_2SO_4	259.7	15.17
Sodium Carbonate Na_2CO_3	116.6	6.81
Ammonium Carbonate $(NH_4)_2CO_3$	4.1	0.24
Calcium Carbonate $CaCO_3$	156.9	9.16
Magnesium Carbonate $MgCO_3$	91.3	5.34
Silica SiO_2	14.4	0.84
Nonvolatile	0.8	0.05
Iron Oxide Fe_2O_3	0.6	0.04
Alumina Al_2O_3	1.0	0.06
Total	1421.9	83.04

WEST BROOKLYN (190). West Brooklyn is located in the southwestern part of Lee County on the drainage area of Green River, a tributary of Rock River. A few private dug wells from 20 to 25 feet deep are in use in the village.

A public water supply was installed by the village in 1897-1898. The installation included a well, a deep-well pump driven by a gas engine, three blocks of water mains, and a steel pressure tank connected to the mains. The original well has been abandoned and another well has been drilled and equipped with a deep-well pump, an electric motor has been installed to drive the pump, and mains have been extended. A connection has been made so that water can be supplied from a well at an elevator in the western part of the village. Small pipe, mostly three-quarter inch, have been laid in residence streets at the expense of individuals desiring water. Fifty-five service connections were in use in 1916 and fifty-six were in use

in 1918. The consumption, estimated in May 1918 from meter readings available, averaged 30 gallons per service per day.

The well formerly used to supply water for the village was drilled by Ulrick Brothers of Lee Center in 1897-1898. The well was cased with 5-inch pipe to a depth of about 280 feet, where fine sand was encountered, and with 3½-inch pipe below that depth. The well was 385 feet deep and the bottom was in gravel. When attempting to repair the well in 1913 pump rods were broken, leaving the pump in the well, and the well was abandoned. The village was without water for about a month. The depth to water in the well was reported to be 150 feet in 1916.

A well which had furnished water for an elevator before the village supply was installed was put in service in 1913 to supply the village. This well is 3 inches in diameter and 375 feet deep. It furnished all water used by the village until 1917 and was furnishing part of the supply in 1918.

Analysis of Sample Number 39450 from the Village Well.

Determinations Made.	Parts per million.
Sodium Na	33.1
Ammonium NH_4	1.3
Magnesium Mg	26.5
Calcium Ca	74.7
Iron Fe	2.2
Aluminum Al_2O_3	0.6
Nitrate NO_3	0.4
Chloride Cl	2.0
Sulfate SO_4	0.0
Residue	385.0
Silica SiO_2	23.5
Nonvolatile	0.9
Manganese Mn	0.2
Alkalinity Methyl Orange	342.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Sodium Nitrate $NaNO_3$	0.5	.03
Sodium Chloride NaCl	2.5	0.15
Sodium Carbonate $NaCO_3$	73.8	4.30
Ammonium Carbonate $(NH_4)_2CO_3$	3.9	.23
Magnesium Carbonate $MgCO_3$	91.8	5.35
Calcium Carbonate $CaCO_3$	186.5	10.88
Iron Carbonate $FeCO_3$	4.4	.26
Alumina Al_2O_3	0.6	.03
Silica SiO_2	23.5	1.37
Nonvolatile	0.9	.05
Total	388.4	22.65

The well which now furnishes a large part of the village supply was drilled by Fredendall and Morey of Aurora in 1915-1916. This well is located three feet from the old well which was abandoned. It is cased with 8-inch pipe to a depth of 290 feet where fine sand was encountered and with 6-inch pipe below that depth. The well is 358 feet deep and the bottom is in sand and gravel. The well is equipped with an American double-acting deep-well pump with a 5¾-inch cylinder and 24-inch stroke. The depth to water when not pumping in 1918 was said to be 217 feet. The pump was operated at a speed of 20 revolutions a minute, a displacement of 90 gallons a minute, and the water level was quickly drawn down to the pump cylinder which was at a depth of 270 feet. It is said

that when the pump was installed it was operated for 24 hours at a speed of 12 revolutions a minute, a displacement of 55 gallons a minute, and apparently delivered nearly the full capacity of the pump. At the time of visit on May 8, 1918, this pump had operated for many hours and the yield had been small. The pump was stopped and water was then pumped from the well at the elevator.

Water from the village well had a mineral content of 388, a total hardness of 295, and a content of iron of 2.2 parts per million as shown by the analysis of sample number 39450, collected on May 8, 1918.

The water stains plumbing fixtures.

WEST CHICAGO (2594). West Chicago is located in the western part of Du Page County on the drainage area of Du Page River, a tributary of Des Plaines River. Some wells have been dug into a thin stratum of sand at a depth of 15 feet. A greater yield of water is obtained in gravel at greater depths. Several wells in the city have been drilled into rock which is entered at a depth of about 90 feet. The deepest well drilled is owned by the Chicago and Northwestern Railroad. This well was drilled to a depth of 2081 feet and the lower part was in Cambrian sandstone.

A public water supply was installed by the city in 1896. Water was pumped from a well into a collecting reservoir by a steam-head deep-well pump and was pumped from the reservoir into the distribution system by a steam pump. A stand pipe was connected to the distribution system. Another well was drilled later and was equipped with a steam-head pump and another high service pump was installed to pump from the reservoir.

The installation of new equipment at the station was completed in 1924. All pumps are now driven by electric motors and two gas engines have been installed for use in emergency. Water is pumped from the reservoir into the mains by any of three two-stage American centrifugal pumps. Two of the pumps have capacities of 450 gallons a minute each and each is driven by a 20-horsepower electric motor with automatic control. One is set at a low pressure so as to come into service at time of fire or emergency. The other pump has a capacity of 1200 gallons a minute. It is driven by either a 100-horsepower electric motor or a 150-horsepower gas engine.

Six hundred and fifty service connections were in use in 1922 and the water consumption was estimated at 425,000 gallons a day. Seven hundred and eighty services were in use in 1925. The water

consumption decreased from 15,000,000 gallons in February, 1924, to 4,500,000 gallons in February, 1925. The decrease was due in part to the development of a private supply by the Chicago and Northwestern Railroad. The charge for water for domestic purposes was 25 cents per 1000 gallons, with a minimum charge of $1.25 for three months which allowed the use of 3000 gallons. The Chicago and Northwestern Railroad, which used large quantities of water, and schools were allowed a rate of 15 cents per 1000 gallons.

Water for the public supply is secured from two wells located 41 feet apart near the center of the city. Information is from F. E. Schacht, Superintendent of Water Works.

One well, number one, is 775 feet deep. It was drilled by the J. P. Miller Artesian Well Company of Chicago in 1896. It is cased with 12-inch pipe to rock which is entered at a depth of 98 feet and is 8 inches in diameter in rock. The drillers noted shale at a depth of 359 feet, hard rock at a depth of 725 feet and hard sandstone (St. Peter sandstone) at a depth of 735 feet. The well was equipped with a steam-head deep-well pump with a 7¾-inch Erb cylinder and 36-inch stroke. The cylinder was placed at a depth of about 90 feet. During a test in 1922, when the pump had been in almost continuous service, it delivered 265 gallons a minute for one hour. The well is now equipped with an American 12-inch four-stage deep-well turbine of 450 gallons a minute capacity. It is driven by an electric motor equipped with automatic control.

The other well, number 2, was drilled in 1908. It is 322 feet deep. It is cased with a 12-inch wrought iron pipe to limestone which was entered at a depth of 89 feet and is 8 inches in diameter in limestone. This well is equipped with a steam-head deep-well pump with a 7¾-inch water cylinder and 36-inch stroke. The cylinder is placed at a depth of 85 feet. In the spring of 1922 this pump was operated about four hours a day and the pump in the other well was operated almost continuously. During a test the pump in the older well was shut down and this pump delivered 165 gallons a minute. This well is now equipped with a double-stroke deep-well pump of 175 gallons a minute capacity which is driven by an electric motor. The depth to water in the well or wells was reported to be forty-four feet in 1897, forty-seven feet in 1904, fifty feet in 1915, seventy feet in 1920, and seventy-six feet in 1925. When the pump in well number two is operated the water level in well number one is lowered two feet. When the pump in number one well is operated the lowering of water level must be considerable

as a difference in the action of the pump in well number two can be noted.

Water from the well 775 feet deep which furnishes a large part of the public supply had a mineral content of 371, a total hardness of 340, and a content of iron of 1.2 parts per million as shown by the analysis of sample number 47369, collected on April 17, 1922.

Analysis of Sample Number 47369 from City Well 775 Feet Deep.

Determinations Made.	Parts per million.
Iron Fe	1.2
Manganese Mn	0.0
Silica SiO_2	17.1
Nonvolatile	2.0
Alumina Al_2O_3	1.1
Calcium Ca	66.8
Magnesium Mg	41.9
Ammonium NH_4	0.5
Sodium Na	4.9
Sulfate SO_4	76.0
Nitrate NO_3	0.2
Chloride Cl	8.0
Alkalinity Methyl Orange	286.
Residue	399.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Sodium Nitrate $NaNO_3$	0.2	.01
Sodium Chloride NaCl	12.3	.72
Ammonium Chloride NH_4Cl	0.2	.01
Ammonium Sulfate $(NH_4)_2SO_4$	1.4	.08
Magnesium Sulfate $MgSO_4$	77.8	4.65
Magnesium Carbonate $MgCO_3$	90.6	5.30
Calcium Carbonate $CaCO_3$	166.8	9.75
Alumina Al_2O_3	1.1	.07
Iron Oxide Fe_2O_3	1.8	.11
Silica SiO_2	17.1	1.00
Nonvolatile	2.0	.12
Total	371.3	21.82

The temperature of water from this well, taken on April 17, 1922, was 51 degrees Fahrenheit. A sample of water collected in 1914 from the well 322 feet deep was of similar quality. It had a mineral content of 408, a total hardness of 320, and a content of iron of 0.8 parts per million. The water used in boilers at the pumping station is first heated and treated with a boiler compound.

WEST DUNDEE (1587). West Dundee is located on the west side of Fox River in the northeastern part of Kane County. A public water supply was installed by the village in 1895. Water is collected from springs on a hillside east of Fox River and flows to a reservoir of 500,000 gallons capacity, from which it flows through a 10-inch pipe line to the pumping station on the west bank of the river. The reservoir can be by-passed. The fall from the springs to the pumping station is about 35 feet. Water is pumped by an hydralic ram and two 8 by 8-inch single-acting triplex pumps. Each pump is driven at a speed of 50 revolutions a minute by a gas engine. The ram pumps about 70 gallons a minute. It is operated at nearly all times when no other pump is running and is shut down whenever another pump is running. Four hundred and forty-one consumers were supplied with water in January, 1925. Fifteen or

twenty residences were not connected.

Water for the public supply is obtained from springs on a hillside in East Dundee, east of Pox River. In the original installation about 400 feet of collecting tile was laid with open joints at a depth of 15 or 20 feet. Water from these tile discharged into a gallery 40 feet long and 5 feet wide and flowed through sand in the bottom of the gallery into a pipe line leading to the reservoir and pumping station. The yield was small in 1922 and additional springs were developed. About 500 feet of tile was laid at a depth of from four to eight feet. This line of tile and the line from the old supply discharge into a manhole from which a pipe line is laid to the reservoir. An overflow pipe is provided at the manhole. On June 27, 1923, when part of the yield of the springs flowed through the overflow pipe, at the manhole, the quantity flowing into the reservoir was measured and estimating a leakage of 30 gallons a minute through the ram this flow into the reservoir was 240 gallons a minute. When pumping with one pump with a displacement of 260 gallons a minute, part of the supply from the springs usually overflows to waste.

A sample of water, number 53075, collected on January 14, 1925, at the overflow from the manhole at the source of supply, had a mineral content of 389, a total hardness of 325, and a content of iron of 0.3 parts per million as shown by the analysis.

A sample, number 37355, collected on June 19, 1917, was similar. It had a mineral content of 355, a total hardness. of 318, and a content of iron of 0.1 parts per million.

Analysis of Sample Number 53075 Collected at Overflow from Springs.

Determinations Made.	Parts per million.
Iron Fe	0.3
Manganese Mn	0.0
Silica SiO_2	17.8
Nonvolatile	0.7
Calcium Ca	72.8
Magnesium Mg	34.9
Alumina Al_2O_3	6.0
Sodium Na	9.4
Potassium K	4.8
Sulfate SO_4	49.4
Nitrate NO_3	23.0
Chloride Cl	10.0
Alkalinity	
Phenolphthalein	0
Methyl Orange	252.
Residue	394.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	12.3	.72
Sodium Nitrate $NaNO_3$	21.2	1.24
Sodium Chloride NaCl	9.3	.54
Magnesium Chloride $MgCl_2$	5.9	.35
Magnesium Sulfate MgSO	61.8	3.62
Magnesium Carbonate $MgCO_3$	72.4	4.24
Calcium Carbonate $CaCO_3$	181.9	10.64
Iron Oxide Fe_2O_3	0.4	.02
Alumina Al_2O_3	6.0	.35
Silica SiO_2	17.8	1.04
Nonvolatile	0.7	.04
Tota	389.7	22.80

WEST FRANKFORT (8478). West Frankfort is located in the southern part of Franklin County on the drainage area of Big Muddy River, a tributary of Mississippi River. A public water supply was installed by the city in 1916-1917. Water was, for about three years, secured from two wells. The wells were then abandoned and water from the Middle Fork of Big Muddy River is now pumped into the mains.

The two wells were drilled by the Layne and Bowler Company in 1916. They were located 350 feet apart on bottom lands near the south bank of Middle Fork of Big Muddy River, north of the city.

Well number one was 62 feet deep. It penetrated 35 feet of clay, 8 feet of clay and fine sand, and 19 feet of fine sand. The bottom was on rock. The well was drilled 24 inches in diameter. It was equipped with an 18-inch shutter screen 20 feet long and 18-inch casing above the screen. The space outside the screen and casing was filled with gravel. Well number two was similar but the screen was 12 inches in diameter. Each well was equipped with a Layne pump which discharged into a reservoir located at some distance from the wells at the side of the pumping station near the northern limits of the city. The two wells yielded 300,000 gallons a day when first installed. In 1918 city officials stated that with continued pumping the yield had increased and was more than 325,000 gallons a day. Later the yield decreased to a very small amount and the wells were abandoned. Whether or not the decrease in yield was due to clogging of the screens with sand or with sand and iron, could not be ascertained.

Analysis of Sample Number 39452 from City Well Number 2.

Determinations Made.	Parts per million.
Iron Fe	6.8
Manganese Mn	0.8
Silica SiO_2	22.5
Calcium Ca	158.2
Magnesium Mg	49.6
Aluminum Al	4.4
Sodium Na	171.0
Sulfate SO_4	67.8
Nitrate NO_3	3.5
Ammonium NH_4	3.1
Chloride Cl	290.0
Alkalinity Methyl Orange	456.
Residue	1105.
Nonvolatile	2.7

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Sodium Nitrate $NaNO_3$	4.8	.28
Sodium Chloride NaCl	431.6	25.16
Ammonium Chloride NH_4Cl	9.2	.54
Magnesium Chloride $MgCl_2$	22.3	1.30
Magnesium Sulfate $MgSO_4$	85.0	4.96
Magnesium Carbonate $MgCO_3$	136.8	7.98
Calcium Carbonate $CaCO_3$	394.5	23.00
Iron Carbonate $FeCO_3$	14.1	.82
Manganese Carbonate $MnCO_3$	1.7	.10
Alumina Al_2O_3	8.2	.47
Silica SiO_2	22.5	1.31
Nonvolatile	2.7	.16
Total	1133.4	66.08

The water had a mineral content of 1133, a total hardness of 600, and a content of iron of 6.8 parts per million as shown by the analysis of sample number 39452, collected at the pumping station on May 7, 1918, when well number two only was operating.

WESTERN SPRINGS (1258). Western Springs is located in the western part of Cook County on the drainage area of Des Plaines River, a tributary of Illinois River. A public water supply was installed by the village about 1895. Water was secured from springs in a low swampy area near the southwestern limits of the village. In 1914 a deep well was drilled on low land near the springs. Water for the public supply was secured from this well until 1924. In 1924 another well was drilled nearer the center of the city and a new pumping station was built. Water is pumped from the well into the distribution system to which an elevated steel tank of 160,000 gallons capacity is connected, by a Layne pump which is driven by a 35-horsepower electric motor. The quantity of water pumped is measured by a meter at the station. Electric power is supplied by the Public Service Company of Northern Illinois. Four hundred and twenty-five service connections were in use in 1924 and all were metered. The rate is 30 cents per 1000 gallons with a minimum charge of $3.00 every three months and a cash discount of $0.25 if paid promptly.

The well which furnished the public water supply from 1914 until 1924 was 2046 feet deep. The top was 648 feet above sea level. A record of material penetrated by the well, as on record in the village, with part of the classifications given by the State Geological Survey Division is as follows:

	Thickness in feet.	Depth in feet.
Peat, marl and clay	36	36
Gravel	28	64
Broken stone, Silurian system all or chiefly Niagaran	9	73
Limestone, Silurian system	287	360
Shale, Richmond	114	474
Limestone, Galena-Platteville	316	790
Sandstone, St. Peter	446	1236
Red marl, Prairie du Chien	8	1244
Limestone, Prairie du Chien	93	1337
Sandstone, Mazomanie-Dresbach, Cambrian system	153	1490
Brown limestone, Eau Claire, Cambrian system	20	1510
Gray limestone and shale, Eau Claire, Cambrian system	255	1765
Sandstone, Mt. Simon, Cambrian system	235	2000
Red sandstone, Mt. Simon, Cambrian system	46	2046

Information is available from records of the Water and Light Committee of the village and letters of C. B. Williams.

The well was cased with casing of large diameter to rock and

wrought iron casing of smaller diameter was placed from the ground surface to a depth of 1765 feet to exclude water from above that depth. The casing was sealed to the surrounding rock at a depth of 1338 feet, the top of the Mazomanie sandstone, and at a depth of 1765 feet. When a depth of 1340 feet was reached, before sealing the casing to rock at a depth of 1338 feet, water stood at a depth of 15 feet. When a depth of 1765 feet was reached and the well was cased 1338 feet, the water level stood 95 feet below the ground surface before pumping and was lowered 40 feet when pumping at a rate of from 125 to 140 gallons a minute. When the well was completed and cased to 1765 feet to shut out water from above Mt. Simon sandstone, the yield was 110 gallons a minute with a draw down of 150 feet. Water was pumped from inside the

---

Analysis of Samples from

Date Collected	March 18, 1914
Depth of well	17652 feet
Sample number	27280

	Parts per million.
Iron Fe	2.2
Manganese Mn	.....
Silica SiO_2	.....
Alumina Al_2O_3	.....
Calcium Ca	.....
Magnesium Mg	52.6
Ammonium NH_4	.....
Sodium Na	.....
Potassium K	.....
Sulfate SO_4	283.6
Nitrate NO_3	0.5
Nitrite NO_2	0.12
Chloride Cl	8.0
Alkalinity Methyl Orange	368.
Residue	817

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	.....	.....
Sodium Nitrate $NaNO_3$	0.7	.04
Sodium Chloride NaCl	13.2	.77
Sodium Sulfate Na_2SO_4	93.4	5.45
Ammonium Sulfate $(NH_4)_2SO_4$	.....	.....
Magnesium Sulfate $MgSO_4$	259.2	15.12
Magnesium Carbonate $MgCO_3$	....	.....
Calcium Sulfate $CaSO_4$	19.0	1.11
Calcium Carbonate $CaCO_3$	368.0	21.46
Iron Carbonate $FeCO_3$	4.6	.27
Undetermined	37.9	2.21
Alumina Al_2O_3	.....	.....
Silica SiO_2	.....	.....
Tota	796.0	46.43

casing by a deep,-well pump and water was drawn from outside the casing, from inside the large casing extending to rock, by suction from a steam pump. In recent years, before the well was abandoned, the water level was lowered six feet when pumping 600 gallons a minute and the water stood at about the same elevation as it did before sealing out water from the upper strata in 1914, fifteen feet below the ground surface. It is probable that the casing excluded water from the upper strata for a short time only, as the depth to water in October, 1914, was given as 15 feet.

Samples of water were collected from the well during drilling. Sample number 27280 was collected when the well was 1765 feet deep. Samples collected at less depth did not differ greatly in quality from this sample.

Deep Well at Western Springs.

April 19, 1914 2046 feet 27379		June 9, 1915 2046 feet 30698		June 9, 1915 from outside casing 30699	
Parts per million.		Parts per million.		Parts per million.	
1.0		5.6		4.8	
.....		0.0		0.0	
.....		9.2		4.4	
.....		8.0		1.6	
.....		215.5		213.0	
31.1		79.6		81.9	
.....		1.0		0.8	
.....		21.4		21.1	
.....		0.5		0.6	
131.6		476.2		483.7	
0		0.7		1.1	
0		.....		.....	
250		7.0		8.0	
330		380.		388.	
932		1175.		1150.	
Parts per million.	Grains per gallon.	Parts per million.	Grains per gallon	Parts per million.	Grains per gallon.
.....	.....	1.1	:06	1.6	.09
.....	.....	.....	.....	.....	.....
412.5	24.06	11.6	.68	13.2	.77
151.8	8.85	51.8	3.02	49.3	2.87
....	.....	3.7	.22	2.9	.17
36.0	2.10	393.5	22.95	404.8	23.61
82.3	4.80	.....	.....	.....	.....
....	.....	176.6	10.30	177.8	10.37
230.0	13.42	415.6	24.24	400.9	23.40
2.0	.12	11.0	.64	9.6	.56
17.4	.99	.....	.....	.....	....
.....	.....	8.0	.47	1.6	.09
.....	.....	9.2	.54	4.4	.26
932.0	54.34	1082.1	63.12	1066.1	62.19

Water secured from the Mt. Simon sandstone differed greatly from water secured in the upper part of the well as shown by the analysis of sample number 27379, collected on April 15, 1914, after the well was completed and casing was sealed at a depth of 1765 feet.

A sample of water, number 30699, collected on June 9, 1915, from outside the inner casing, was of practically the same quality as sample number 30698 collected at the same time from inside the casing, as is shown by the two analyses. It is probable that nearly all water secured from the well, excepting shortly after the well was completed and casing was first sealed, was from Niagaran limestone, with possibly some water from the drift above. This is shown by water levels as well as by these analysis.

Water for the public supply is now secured from a well on Wolf road on the south side of the Chicago, Burlington and Quincy Railroad tracks. The well was drilled in 1924 by S. B. Geiger of Chicago. The elevation at the top is about 675 feet above sea level. The well is 385 feet deep. It is cased with 16-inch pipe 20 feet into rock to a depth of 60 feet. The well is equipped with a Layne 16-inch 5-stage pump with the bottom of the tail pipe at a depth of 74 feet. The yield in October, 1924, was 500 gallons a minute. The total amount of water pumped was about 175,000 gallons a day. The water level was at a depth of 40 feet when not pumping and was lowered to a depth of 51 feet when pumping.

Analysis of Sample Number 52738 from the Village Well 385 Feet Deep.

Determinations Made.

	Parts per million.
Iron Fe	3.0
Manganese Mn	0.0
Silica SiO_2	15.3
Nonvolatile	2.0
Alumina Al_2O_3	0.2
Calcium Ca	200.0
Magnesium Mg	85.6
Ammonia NH_4	0.3
Sodium Na	22.0
Potassium K	6.1
Sulfate SO_4	458.2
Nitrate NO_3	0.2
Chloride Cl	8.0
Alkalinity	
Phenolphthalein	0
Methyl Orange	386.
Residue	1041.

Hypothetical Combinations.

	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	0.3	0.02
Potassium Chloride KCl	11.4	0.66
Sodium Chloride NaCl	4.3	0.25
Sodium Sulfate Na_2SO_4	62.8	3.67
Ammonium Sulfate $(NH_4)_2SO_4$	1.2	0.07
Magnesium Sulfate $MgSO_4$	423.0	24.70
Calcium Sulfate $CaSO_4$	109.0	0.64
Calcium Carbonate $CaCO_3$	419.3	24.49
Iron Oxide Fe_2O_3	4.3	0.25
Alumina Al_2O_3	0.2	0.01
Silica SiO_2	15.3	0.89
Nonvolatile	2.0	0.11
Total	1053.1	55.76

Water from the well 385 feet deep now in use had a mineral content of 1053, a total hardness of 850, and a content of iron of 3.0 parts per million as shown by the analysis of sample number 52738, collected in October, 1924.

WESTFIELD (933). Westfield is located in the northwestern part of Clark County on the drainage area of Embarrass River, a tributary of Wabash River. A public water supply was installed by the village in 1913. Water was pumped from a well into the distribution system, to which a 60,000 gallon elevated steel tank was connected, by a deep-well pump driven by a 7½-horsepower electric motor. The supply was increased in 1919 by installing another well. Water flows from this well into a reservoir built at the top of the well and is pumped from the reservoir into the mains by a centrifugal pump which is driven by a 20-horsepower electric motor. Electric current is purchased from the Central Illinois Public Service Company. One hundred service connections were in use in 1923 and all were metered. The only consumer using large quantities of water is the Westfield Railroad. The rates for a month are 50 cents per 1000 gallons for the first 20,000 gallons and 35 cents per 1000 gallons for additional water with a minimum charge of $1.00. Bills are not subject to cash discount.

Water for the public supply is secured from two wells. One well was installed in 1913. It is located on the east side of Washington Street one block north of Main Street. It is 8 inches in diameter and 158 feet deep and is cased to sandstone which is entered at a depth of about 40 feet. The well is equipped with an American double-acting deep-well pump with a 3½-inch (3¼?) cylinder and 23-inch stroke. The cylinder is placed 12 feet above the bottom of the well. In 1919, when this well furnished the entire supply, the pump was operated for about two hours and then remained idle for one or two hours. The yield when pumping was estimated at nine gallons a minute and the total amount of water supplied was estimated at from 6000 to 8000 gallons a day. In 1923 the pump was operated about four hours a day at a speed of 12 strokes a minute. The depth to water when not pumping was said to be 45 feet in 1919 and it was 60 feet in 1921 when leathers were replaced and the pump was idle for some time.

The other well was installed in 1919. It is located about three-fourths of a mile north of the village. At the top is a reservoir 19½ feet in diameter and 19 feet deep. In the bottom of this

reservoir is a well 10 feet in diameter to a depth of 31 feet below the ground surface and in the bottom of the dug well are two drilled wells, one extending to a depth of 140 feet below the ground surface and the other, to the east, to a depth of 72 feet. The deep hole is cased with 10-inch, 8-inch, and 6-inch pipe. It is said that it yields no water. The east hole is cased with 8-inch pipe and a 10-inch casing which extended from the ground surface to a depth of 30 feet was cut off about 20 feet below the ground surface. The bottom of the dug well is in a stratum of sand 4 feet thick. The flow into the well on November 27, 1923, when the water level was drawn down to a depth of 20 feet and the pump was then stopped, was eight or nine gallons a minute as determined by measuring the rate of rise of the water level. The total yield of the well was close to 8,500 gallons a day.

A sample of water, number 50627, was collected on November 27, 1923, from the well installed in 1919. It had a mineral content of 378, a total hardness of 218, and a content of iron of 2.0 parts per million as shown by the analysis.

Analysis of Sample Number 50627 from the Village Well Installed in 1919.

Determinations Made.	Parts per million.
Iron Fe	2.0
Manganese Mn	0.0
Silica SiO_2	16.7
Nonvolatile	3.3
Alumina Al_2O_3	1.6
Calcium Ca	50.0
Magnesium Mg	22.7
Sodium Na	51.5
Ammonia NH_4	5.7
Potassium K	6.1
Sulfate SO_4	8.0
Nitrate NO_3	2.8
Chloride Cl	8.0
Alkalinity	
Phenolphthalein	0
Methyl Orange	340.
Residue	386.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	4.6	.27
Potassium Chloride KCl	8.2	.48
Sodium Chloride NaCl	6.8	.39
Sodium Sulfate Na_2SO_4	11.6	.67
Sodium Carbonate Na_2CO_3	104.0	6.07
Ammonium Carbonate $(NH_4)_2CO_3$	15.1	.88
Magnesium Carbonate $MgCO_3$	78.4	4.58
Calcium Carbonate $CaCO_3$	124.8	7.30
Iron Oxide Fe_2O_3	2.9	.17
Silica SiO_2	16.7	.98
Alumina Al_2O_3	1.6	.10
Nonvolatile	3.3	.19
Total	378.0	22.08

The iron in the water stains plumbing fixtures and laundry. It is necessary to repair about four meters every year due to clogging.

WHEATON (4137). Wheaton is located in the central part of Du Page County on the drainage area of Du Page River, a tributary of Des Plaines River. A public water supply was installed by the city about 1890. Water was pumped from two wells into the distri-

bution system by a steam pump which was placed in a pit. A standpipe 14 feet in diameter and 120 feet high was connected to the system. Extensive improvements were made in 1911 and in 1916. Water is now pumped from the wells into a concrete reservoir of 100,000 gallons capacity by either of two centrifugal pumps which are placed in a shaft between the wells. Water is pumped from the reservoir into the distribution system by either of two American 2-stage centrifugal pumps, one of 500 gallons a minute capacity and the other of 750 gallons a minute capacity. The smaller of these two pumps and one of the two well pumps are driven by belt from a Nash 8 by 12-inch three-cylinder 60-horsepower gas engine. The other pressure pump and well pump are driven by a Nash 10 by 12-inch three-cylinder 105-horsepower gas engine. Each engine is supplied with gas from a suction gas producer in which pea size hard coal is used. With each unit there is a gas scrubber filled with stone. An air compressor supplies air at 200 pounds pressure to start the engines. The amount of water pumped is registered by meter at the pumping station and during the summer of 1917 it averaged near 400,000 gallons a day. An elevated steel tank of 200,000 gallons capacity is connected to the distribution system. The old standpipe was removed in 1914. Water is sold at a rate of 15 cents per 100 cubic feet, with a minimum charge of $1.00 for three months. For large quantities of water a reduction is made but nearly all water is sold at the rates given.

Water is obtained from two wells located about 20 feet apart. Each well is 10 inches in diameter and 175 feet deep. They penetrate about 110 feet of drift and 65 feet of Niagaran limestone. Conditions are favorable for large yields as the limestone contains fissures and is overlaid with drift containing considerable gravel. Between the wells is a shaft 5 feet in diameter and 34 feet deep below the floor of the basement which was the floor of the original station. Connections are made to the wells through tunnels and water is pumped by either of two American centrifugal pumps, each of 750 gallons a minute capacity, which are placed in the shaft. In the summer of 1917 the amount of water pumped averaged near 400,000 gallons a day. The water level was drawn down by pumping to a depth of 66 feet below the ground surface.

The water had a mineral content of 351, a total hardness of 275, and a content of iron of 0.1 parts per million as shown by the analysis of sample number 39427, collected on May 3, 1918.

Analysis of Sample Number 39427 from the City Supply.

Determinations Made.	Parts per million.
Iron Fe	0.1
Manganese Mn	0.0
Silica SiO_2	17.9
Nonvolatile	1.4
Alumina Al_2O_3	0.9
Calcium Ca	56.4
Magnesium Mg_4	32.5
Ammonium NH_4	0.2
Potassium K	2.1
Sodium Na	22.5
Sulfate SO_4	50.2
Nitrate NO_3	1.4
Chloride Cl	2.0
Alkalinity Methyl Orange	262.
Residue	375.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	2.3	0.13
Potassium Chloride KCl	2.4	0.14
Sodium Chloride NaCl	1.5	0.09
Sodium Sulfate Na_2SO_4	68.2	3.98
Ammonium Sulfate $(NH_4)_2SO_4$	1.0	0.06
Magnesium Sulfate $MgSO_4$	4.5	0.26
Magnesium Carbonate $MgCO_3$	109.4	6.38
Calcium Carbonate $CaCO_3$	141.6	8.26
Iron Carbonate $FeCO_3$	0.2	0.01
Alumina Al_2O_3	0.9	0.05
Silica SiO_2	17.9	1.04
Nonvolatile	1.4	0.08
Total	351.3	20.48

Samples collected in 1911 and 1914 were similar.

WILMINGTON (1384). Wilmington is located in the southwestern part of Will County on Kankakee River. Until recently all water used at residences was secured from private wells. Many of these were dug wells from 15 to 30 feet deep and others were drilled into rock which is 50 feet or less below the ground surface.

A public water supply was installed by the city about 1892. Water was pumped directly from Kankakee River and was used principally for sprinkling and for extinguishing fires. All parts of the water works formerly in use, excepting the distribution system, were abandoned in 1918 after the completion of a system which is now in use. Water is pumped from a well into a concrete reservoir by air lift. The reservoir is 50 feet long, 28 feet wide and 11 feet deep. It is built around the top of the well. Air is supplied by an Ingersoll-Rand 10 and 6½ by 10-inch two-stage air compressor which is driven at a speed of 300 revolutions a minute by belt from a 38-horsepower electric motor. Water is pumped from the reservoir into the distribution system and an elevated steel tank, by a Cameron centrifugal pump which is driven by a 20-horsepower electric motor.

Water for the public supply is obtained from a well 710 feet deep. The elevation at the top of the well is about 540 feet above sea level. The well was drilled by J. W. Hensley and Company of Indianapolis, Indiana, in 1917. It is cased into limestone with 21 feet of 12-inch pipe and cement is placed outside of this pipe. Below the 12-inch casing is 189 feet of 10-inch casing. The well is reported

to be in St. Peter sandstone between depths of 520 and 690 feet. The well is equipped with an air lift. The water level when the well was completed was 17 feet below the ground surface. The yield when it was equipped was 250 gallons a minute. Conditions were reported to be the same in 1923.

The water had a mineral content of 1110 and a total hardness of 420 as shown by the analysis of sample number 43291, collected on June 21, 1920.

Analysis of Sample Number 43291 from the City Supply.

Determinations Made.

	Parts per million.
Iron Fe	trace
Silica SiO_2	8.0
Nonvolatile	not determined
Alumina Al_2O_3	0.4
Calcium Ca	103.5
Magnesium Mg	39.2
Sodium Na } Potassium K	241.6
Ammonia NH_4	0.0
Sulfate So_4	286.1
Nitrate NO_3	5.3
Nitrite NO_2	0.0
Chloride Cl	275.0
Alkalinity Methyl Orange	242.0
Residue	1167.

Hypothetical Combinations.

	Parts per million.	Grains per gallon.
Sodium Nitrate $NaNO_3$	7.3	.43
Sodium Chloride NaCl	453.3	26.50
Sodium Sulfate Na_2SO_4	187.5	10.96
Ammonium Sulfate $(NH_4)_2SO_4$	0.1	.01
Magnesium Sulfate $MgSO_4$	193.7	11.33
Calcium Sulfate $CaSO_4$	6.1	.36
Calcium Carbonate $CaCO_3$	253.9	14.84
Alumina Al_2O_3	0.4	.02
Silica SiO_2	8.0	.47
Total	1110.3	64.92

WINCHESTER (1540). Winchester is located in the central part of Scott County, about eight miles east of Illinois River. Private wells in use at residences in the village are generally from 20 to 40 feet deep. When a mine shaft was sunk about one mile north of the city, to a depth of 101 feet, a hole was bored in the bottom of the shaft to a total depth of 272 feet. Very little water was secured. A well drilled in the northeastern part of the city to a depth of 500 feet yielded very little water and was never used.

A public water supply was installed by the city in 1914. The supply is from two wells located south of the city. A pump house with the floor seven feet below the ground surface is built over each well. Each well is equipped with a Luitwieler deep-well pump driven through gears by a 5-horsepower electric motor. Water is discharged into a pipe line leading to the city. An elevated steel tank of 80,000 gallons capacity is connected to the distribution system. One hundred and forty-seven service connections were in use in 1918 and the amount of water pumped was estimated at 35,000 gallons a day.

Before the installation of the public water supply information was secured in regard to several possible sources of supply. White Oak Spring is located in the northwest quarter of Section 9 on the bank of Little Sandy Creek, about three miles south and half a mile east of the center of the city. Two measurements of flow were made in September, 1909, and it is said that the flow was 600,000 gallons a day. Approximate measurement made late in August or early in September, 1913, indicated a yield of between 600,000 and 700,000 gallons a day. Sample number 25485 was collected from the spring on June 23, 1913.

Analysis of Sample Number 25485 from White Oak Spring.

Determinations Made.	Parts per million.
Potassium K	1.5
Sodium Na	12.8
Magnesium Mg	24.7
Calcium Ca	85.6
Alumina Al_2O_3	1.7
Nitrate NO_3	8.3
Chloride Cl	6.0
Sulfate SO_4	57.6
Silica SiO_2	11.9
Nonvolatile	1.7
Iron	0.1
Alkalinity Methyl Orange	244.
Residue	414.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	3.9	.23
Sodium Nitrate $NaNO_3$	8.1	.47
Sodium Chloride NaCl	9.9	.58
Sodium Sulfate Na_2SO_4	22.5	1.31
Magnesium Sulfate $MgSO_4$	53.2	3.10
Magnesium Carbonate $MgCO_3$	48.1	2.81
Calcium Carbonate $CaCO_3$	213.7	12.46
Iron Carbonate $FeCO_3$	0.3	.02
Alumina Al_2O_3	1.7	.10
Silica SiO_2	11.9	.69
Nonvolatile	1.7	.10
Total	375.0	21.87

In 1914 a well was drilled on the Perkins farm about 1½ miles south of the center of the city, near the bank of Big Sandy Creek. The well penetrated about ten feet of soil and clay and below the clay, sand and gravel with some stones as large as two inches in diameter. The well was 28 feet deep. Construction was similar to that of wells drilled later that year from which the public supply is now obtained. The water level before pumping was at a depth of nine feet. The well was equipped with a deep-well pump with the cylinder about six feet above the bottom of the well. The pump was operated from May 23 to May 25, a total of about 55 hours and the discharge, measured by weir, was 55 gallons a minute. The water level in an observation well 19 feet deep, located 200 feet from the well tested, was lowered three feet during this test. A partial analysis of a sample of water collected during the last day of the test showed a mineral content of 518, a total hardness of 456, and a content of iron of 15.0 parts per million. The iron content was very high and another source of supply was developed.

Water for the public supply is secured from two wells, each 42 feet deep, located about 100 feet apart on low land in the valley of Big Sandy Creek, on the Grout farm in the northwest corner of section 4, about 1½ miles south and half a mile east of the center of the city. The lower 13 feet of the wells is in sand and gravel. In constructing a well an 8-inch Johnson screen 13 feet long attached to an 8-inch casing was placed inside a 12-inch casing. The space around the 8-inch pipe and screen was filled with gravel and the 12-inch casing was then withdrawn. When the wells were completed they were tested and each yielded 50 gallons a minute. The entire distribution system and the elevated tank were once filled by pumping continuously from one well.

Water from the public supply had a mineral content of 313, a total hardness of 285, and a content of iron of 2.0 parts per million as shown by the analysis of sample number 39811, collected on July 23, 1918.

Analysis of Sample Number 39811 from the City Supply.

Determinations Made.	Parts per million.
Sodium Na	13.5
Ammonium NH_4	0.0
Magnesium Mg	29.3
Calcium Ca	65.6
Iron Fe	2.0
Alumina Al_2O_3	0.1
Nitrate NO_3	1.1
Chloride Cl	5.0
Sulfate SO_4	2.1
Carbonate CO_3	178.2
Residue	304.0
Silica SiO_2	8.6
Manganese Mn	trace
Nonvolatile	0.0
Alkalinity	
Methyl Orange	297.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Sodium Nitrate $NaNO_3$	14.5	.84
Sodium Chloride NaCl	8.2	.48
Sodium Sulfate Na_2SO_4	0.3	.02
Sodium Carbonate Na_2CO_3	12.2	.71
Ammonium Carbonate $(NH_4)_2CO_3$	0.1	.01
Calcium Carbonate $CaCO_3$	163.8	8.51
Iron Carbonate Fe_2CO_3	4.0	.23
Alumina Al_2O_3	0.1	.06
Silica SiO_2	8.6	.50
Magnesium Carbonate $MgCO_3$	101.3	5.87
Total	313.0	17.23

WINDSOR (484). Windsor is located in the eastern part of Mercer County on the drainage areas of Edwards River and Pope Creek, tributaries of Mississippi River. Wells at residences are nearly all into sand and gravel. One stratum of sand and gravel lies at a depth of about 30 feet and another at a depth of from 70 to 90 feet.

The installation of a public water supply by the village was started in 1924. Water is to be pumped from a well directly into the distribution system and an elevated steel tank of 40,000 gallons

capacity which is connected to the system, by a deep-well pump. The pump will be driven by a 15-horsepower electric motor.

A well 545 feet deep was drilled by the Sewell Well Company of St. Louis in 1924. The ground surface at the top of the well is about 800 feet above sea level. Between depths of 400 and 462 feet the drillers recorded limestone and below a depth of 462 feet material was recorded as sandstone. Possibly some of the lower material should be classed as dolomite. No water was encountered below sand and gravel until a depth of 462 feet was reached. The flow increased and drilling was stopped at a depth of 545 feet. The well is cased from the ground surface with 144 feet of 10-inch pipe of which 66 feet is wrought iron and from the ground surface with 402 feet of Byers 8-inch wrought iron pipe weighing 24 pounds per foot. When the well was completed water stood at a depth of 236 feet. In April, 1924, before a test, it was measured 228 feet. The well was tested on April 9 and 10, 1924, with a deep-well pump which was operated from the well rig. The cylinder was at a depth of 257 feet and 22 feet of suction pipe was attached. The well was pumped 22 hours. During the first hour the rate of pumping averaged near 100 gallons a minute and after that it averaged near 85 gallons a minute. No air was drawn into the cylinder. The pump was operated at very high speed and the test was ended by a broken rod.

The water had a mineral content of 821, a total hardness of 121, and a content of iron of 0.2 parts per million as shown by the analysis of sample number 51236 collected on April 10, 1924, after pumping continuously for 15 hours.

Analysis of Sample Number 51236 from the Village Well.

Determinations Made.

	Parts per million.
Iron Fe	0.2
Manganese Mn	0.0
Silica SiO_2	22.2
Nonvolatile	4.8
Alumina Al_2O_3	3.4
Calcium Ca	26.0
Magnesium Mg	13.7
Ammonia NH_4	2.3
Sodium Na	246.1
Potassium K	13.2
Sulfate SO_4	174.4
Nitrate NO_3	0.2
Chloride Cl	103.
Alkalinity	
Phenolphthalein	0
Methyl Orange	360.
Residue	804.

Hypothetical Combinations.

	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	2.8	0.16
Potassium Chloride KCl	23.1	1.35
Sodium Chloride NaCl	151.7	8.86
Sodium Sulfate Na_2SO_4	257.7	15.05
Sodium Carbonate Na_2CO_3	237.3	13.86
Ammonium Carbonate $(NH_4)_2CO_3$	6.0	0.35
Magnesium Carbonate $MgCO_3$	47.3	2.76
Calcium Carbonate $CaCO_3$	64.9	3.79
Iron Oxide Fe_2O_3	0.3	0.02
Alumina Al_2O_3	3.4	0.20
Silica SiO_2	22.2	1.30
Nonvolatile	4.8	0.28
Total	821.5	47.98

An odor of hydrogen sulphide could be detected while pumping.

WINSLOW (371). Winslow is located in the northwestern part of Stephenson County on the drainage area of Pecatonica River, a tributary of Rock River. A public water supply was installed by the village in 1916. Water is pumped from a well into the distribution system by a Goulds 6½ by 8-inch single-acting triplex pump which is driven by belt from a 16-horsepower gas engine. An elevated steel tank of 40,000 gallons capacity, located on high ground in the village, is connected to the distribution system.

Water for the public supply is secured from a well located in an abandoned stone quarry near the center of the village. The well is 8 inches in diameter and 200 feet deep. The upper 40 feet is in limstone and the lower 160 feet is in St. Peter sandstone. Through the limestone the well was drilled 10 inches in diameter and was cased with 8-inch pipe and cement was placed outside the pipe. The top of the casing is connected to the suction line from the pump. In 1917 the pump was operated at about 58 revolutions a minute, a displacement of 200 gallons a minute. A vacuum gauge on an air chamber at the top of the well, when read on May 10, 1917, indicated a depth to water of 16 feet when not pumping and a lowering of the water level of two feet when pumping for two or three hours.

The water had a mineral content of 324 and total hardness of 296 parts per million as shown by the analysis of sample number 40031, collected on August 22, 1918.

Analysis of Sample Number 40031 from the Village Supply.

Determinations Made.

	Parts per million.
Sodium Na	7.2
Ammonium NH_4	0.1
Magnesium Mg	21.4
Calcium Ca	83.4
Iron Fe	0.0
Alumina Al_2O_3	0.1
Nitrate NO_3	9.7
Chloride Cl	4.0
Sulfate SO_4	12.7
Silica SiO_2	15.0
Manganese Mn	0.0
Nonvolatile	0.0
Alkalinity Methyl Orange	275.
Residue	315.

Hypothetical Combinations.

	Parts per million.	Grains per gallon.
Sodium Nitrate $NaNO_3$	13.4	.78
Sodium Chloride NaCl	6.6	.38
Sodium Sulfate Na_2SO_4	3.3	.19
Ammonium Sulfate $(NH_4)_2SO_4$	0.2	.01
Magnesium Sulfate $MgSO_4$	13.1	.76
Magnesium Carbonate $MgCO_3$	64.5	3.70
Calcium Carbonate $CaCO_3$	208.2	12.06
Alumina Al_2O_2	0.1	.01
Silica SiO_2	15.0	.87
Total	324.4	18.76

WINTHROP HARBOR (473). Winthrop Harbor is located in the northeastern part of Lake County about a mile distant from Lake Michigan. Water for a public supply is pumped from a well directly into the distribution system by a deep-well pump which is driven by belt from a 5-horsepower electric motor. A steel pressure tank 5 feet in diameter and 16 feet long and a steel tank on a tower 100 feet high are connected to the distribution system. Electric current is supplied by the Public Service Company of Northern Illinois. Water consumers are charged $1.00 a month.

A well drilled in 1908 has been abandoned. It is 200 feet deep and is cased with 3-inch pipe to rock. The well flowed when it was drilled. The depth to water was 12 feet in 1912 and 22 feet in 1922.

Analysis of Sample Number 48670 from the Village Supply.

Determinations Made.

	Parts per million.
Iron Fe	0.6
Manganese Mn	0.0
Silica SiO_2	15.8
Nonvolatile	1.5
Alumina Al_2O_3	0.7
Calcium Ca	22.0
Magnesium Mg	14.0
Ammonia NH_4	0.3
Sodium Na	47.6
Potassium K	3.4
Sulfates SO_4	51.7
Nitrates NO_3	3.1
Chloride Cl	5.0
Alkalinity	
Methyl Orange	156.
Phenolphthalein	0.
Residue	262.

Hypothetical Combinations.

	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	4.0	.23
Potassium Chloride KCl	3.4	.20
Sodium Chloride NaCl	5.6	.33
Sodium Sulfate Na_2SO_4	76.3	4.46
Sodium Carbonate Na_2CO_3	47.6	2.78
Ammonium Carbonate $(NH_4)_2CO_3$	0.8	.05
Magnesium Carbonate $MgCO_3$	48.6	2.84
Calcium Carbonate $CaCO_3$	54.7	3.20
Silica SiO_2	15.8	.92
Nonvolatile	1.5	.09
Iron Oxide Fe_2O_3	0.8	.05
Alumina Al_2O_3	0.7	.04
Total	259.8	15.19

Water is now secured from a well which is located 19 feet distant from the abandoned well. It was drilled in 1912. It is 159 feet deep and is cased with 6-inch pipe to rock which is at a depth of 90 feet. The well is equipped with a Goulds single-acting deep-well pump with a 4¾-inch cylinder placed at a depth of 63 feet. The pump is operated with 20-inch stroke at a speed of 24 strokes a minute, a displacement of 37 gallons a minute. In 1922 the pump was operated from six to eight hours a day. Pumping from this well on November 16, 1922, after the pump had been idle for one hour, lowered the water level in the abandoned well, 19 feet distant, 14.5 feet in one hour and 15.5 feet in two hours to a depth of 38 feet. The pump was then stopped and the water level raised 13 feet in ten minutes and a total of 15.5 feet in forty minutes when it was at a depth of 22.5 feet, the same as at the beginning of

the test. In April, 1925, it was reported the pump was operated twenty hours a day.

The water had a mineral content of 259, a total hardness of 112, and a content of iron of 0.6 parts per million as shown by the analysis of sample number 48670, collected on November 16, 1922.

WITT (2443). Witt is located in the northeastern part of Montgomery County on the drainage area of Shoal Creek, a tributary of Kaskaskia River. Private wells obtain a supply of water above rock which is reached at a depth of from 10 to 20 feet. Two mine shafts have been sunk in the city, one near the northern limits and the other near the southern limits. Excepting for a small amount of water above rock, little or no water was encountered.

A public water supply was installed by the city in 1921. Water is pumped from two wells into the distribution system by either of two centrifugal pumps, each driven by a 30-horsepower electric motor. The pumping station which encloses the tops of the wells is 25 feet in diameter and the floor is 12 feet below the ground surface. A concrete elevated tank 20 feet in diameter and 30 feet high, located about three blocks from the center of the city, is connected to the distribution system. Fifty service connections were in use in 1923 and all were metered. The rate for 10,000 gallons of water or less used in three months is 50 cents per 1000 gallons with a minimum charge of 50 cents a month and the rate for the next 15,000 gallons is 30 cents per 1000 gallons. Large quantities are sold at lower rates but no consumer uses very large quantities. Bills are not subject to discount.

Water for the public supply is secured from two wells located about 14 feet apart, about 1¼ miles east and ½ mile north of the center of the city near the southwestern corner of section 33, on bottom lands of East Fork of Shoal Creek. The wells are 10 inches in diameter and 39 feet deep. The upper 14 feet is in soil and clay and the lower 25 feet is in sand and gravel. A screen 15 feet long is placed in the bottom of each well. Pumping from both wells with both pumps the elevated tank has been filled in two hours and fifteen minutes. It was computed that each well supplied 260 gallons a minute.

Several test wells were drilled before the water works were installed. One of these, on the site of the wells now used, was 6 inches in diameter and 39 feet deep. The well was equipped with a number 20 Cook screen 6 feet long. A centrifugal pump was in-

stalled with a suction pipe extending to a depth of 30 feet. The well was pumped almost continuously from the morning of May 26, 1918, to May 31, 1918. The rate of pumping was measured early in the morning on May 31 and was 70 gallons a minute. The depth to water was 14 feet in the well, 8 feet in a test hole driven to the sand stratum at a distance of 9 feet from the well, and 7 feet 3 inches in a test hole drilled to the sand stratum at a distance of 20 feet from the well. After a shut down of 20 minutes the pump was again started and the yield was 100 gallons a minute. Pumping for one hour the yield decreased to 80 gallons a minute and the water level in the well was at a depth of 15 feet. When not pumping the water level was from 5 to 6 feet below the ground surface.

A sample of water, number 39546, collected from the test well on May 31, 1918, after long continued pumping at a rate of 70 gallons a minute, had a mineral content of 441, a total hardness of 294, and a content of iron of 3.2 parts per million as shown by the analysis.

Analysis of Sample Number 39546 from City Test Well.

Determinations Made.	Parts per million.
Potassium K } Sodium Na }	47.0
Ammonium NH_4	0.3
Magnesium Mg	25.6
Calcium Ca	75.6
Iron Fe	3.2
Alumina Al_2O_3	6.1
Nitrate NO_3	1.4
Chloride Cl	29.0
Sulfate SO_4	33.1
Residue	442.9
Silica SiO_2	25.8
Nonvolatile	1.5
Manganese Mn	0.0
Alkalinity Methyl Orange	308.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Sodium Nitrate $NaNO_3$	2.0	.12
Sodium Chloride NaCl	47.8	2.79
Sodium Sulfate Na_2SO_4	48.9	2.85
Sodium Carbonate Na_2CO_3	27.3	1.59
Ammonium Carbonate $(NH_4)_2CO_3$	0.4	.02
Magnesium Carbonate $MgCO_3$	88.6	5.17
Calcium Carbonate $CaCO_3$	188.5	10.99
Iron Carbonate $FeCO_3$	6.6	.38
Alumina Al_2O_3	6.1	.36
Silica SiO_2	25.8	.50
Nonvolatile	1.5	.09
Total	443.5	25.86

The content of iron is sufficient to cause staining of plumbing fixtures.

WOOD RIVER (3476). Wood River is located in the western part of Madison County, about one mile distant from Mississippi River. A large refinery of the Standard Oil Company is located here. A water distribution system was installed in 1912 and since that time water for the public supply has been purchased from the Standard Oil Company.

Water is secured from wells into sand and gravel, located at the company's plant on bottom lands of Mississippi River. The amount of water furnished to the village is a very small part of the water pumped from the wells. The wells are in sand below a depth of about 12 feet. On account of clogging of screens new wells have been drilled about every four years.

Before 1912 eight-inch wells were in use and during a test one well yielded 845 gallons a minute.

When the public water supply was installed in 1912 the supply was from fifteen 12-inch wells, each from 90 to 95 feet deep. A Johnson screen 20 feet long was placed in the bottom of each well. The wells were located from 35 to 100 feet apart. Each well was equipped with an air lift. The total amount of water supplied at the time was about 8,000,000 gallons a day. The water level was reported to be from 26 to 37 feet below the ground surface.

Nine 16-inch wells, each about 110 feet deep, were in use in 1916. Each well was equipped with a deep-well centrifugal pump. The yield of one well was estimated to be close to 1,000,000 gallons a day. The depth to water was about 26 feet when not pumping and 40 feet when pumping.

Nearly all wells in use in 1918 were 20 inches in diameter and about 110 feet deep. During a test one well yielded 2,100 gallons a minute.

Part of the supply in 1923 was from thirteen 24-inch wells, each about 112 feet deep. In the bottom of each well was 30 feet of number 30, eighteen-inch, Johnson screen. The yield of each well was estimated at about 2000 gallons a minute.

The channel of Wood River which formerly flowed near the Standard Oil Company was diverted many years ago. In 1922 the company dredged out the old channel from Mississippi River to their plant, to a depth of 30 feet. In August, 1923, more than half of the water supply was secured from this channel and on completion of a new pumping station nearly all water used at their plant was to be taken from this channel.

A sample of water, number 49979, collected from the well supply on August 22, 1923, had a mineral content of 362, a total hardness of 258, and a content of iron of 0.4 parts per million as shown by the analysis.

This sample of water, compared to samples collected in 1912 and 1917, contained much more chlorides, sulfates, and nitrates. The sample collected in 1912 contained 4 parts chloride, 33.9 parts sulfate, and 1.8 parts nitrate.

Analysis of Sample Number 49979 from Wells 112 Feet Deep.

Determinations Made.	Parts per million.
Iron Fe	0.4
Manganese Mn	0.2
Silica SiO_2	23.5
Nonvolatile	0.7
Alumina Al_2O_3	0.4
Calcium Ca	70.6
Magnesium Mg	19.9
Ammonia NH_4	0.0
Sodium Na	17.9
Potassium K	1.3
Sulfate SO_4	84.4
Nitrate NO_3	26.6
Chloride Cl	19.0
Alkalinity	
Phenolphthalein	0
Methyl Orange	176.
Residue	327.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	3.5	0.20
Sodium Nitrate $NaNO_3$	33.5	1.95
Sodium Chloride NaCl	22.5	1.31
Magnesium Chloride $MgCl_2$	7.2	0.42
Magnesium Sulfate $MgSO_4$	89.2	5.22
Calcium Sulfate $CaCO_3$	18.5	1.08
Calcium Carbonate $CaCO_3$	162.8	9.51
Iron Oxide Fe_2O_3	0.6	0.03
Alumina Al_2O_3	0.4	0.02
Manganese Oxide MnO	0.2	0.01
Silica SiO_2	23.5	1.37
Nonvolatile	0.7	0.04
Total	362.6	21.16

WOODHULL (700). Woodhull is located in the southwestern part of Henry County on high land between Edwards River and Pope Creek, tributaries of Illinois River. A few private wells in use in 1916 were from 25 to 40 feet deep.

A public water supply was installed by the village in 1902. Water was pumped from a well directly into the distribution system and an elevated wooden tank of 68,000 gallons capacity, by a steam-head deep-well pump. A concrete reservoir 40 feet in diameter, of 94,000 gallons capacity, has been built near the well. Water is now pumped from the well into the reservoir by a deep-well pump which is driven by a 15-horsepower electric motor. Water is pumped from the reservoir into the mains and elevated tank by a McGowan 7 by 10-inch triplex pump which is driven by a 7½-horsepower electric motor. A 35-horsepower gas engine is used to furnish power to drive both pumps in case of emergency. One hundred and ninety-eight service connections were in use in 1916.

Water is obtained from a well 1394 feet deep, located near the southern limits of the village. It was drilled by the J. P. Miller Artesian Well Company in 1902. A record of material penetrated as given by the drillers with classification of the lower strata by the State Geological Survey Division is as follows:

	Thickness in feet.	Depth in feet.
Drift and shale	160	160
Fire clay and shale	250	410
Limestone	121	531
Shale	69	600

	Thickness in feet	Depth in feet.
Limestone	225	825
Shale, Maquoketa	185	1010
Limestone, Galena-Platteville	280	1290
Sandstone, St. Peter	104	1394

The well was cased with 10-inch pipe to a depth of 183 feet and with 250 feet of 6¼-inch casing with the bottom at a depth of 531? feet. It is 6 inches in diameter at the bottom. The well is equipped with a deep-well pump with the cylinder placed 267 feet below the ground surface. The depth to water when not pumping was reported to be 120 feet in 1903 and 200 feet in 1916.

The water had a mineral content of 928, a total hardness of 168, and a content of iron of 0.6 parts per million as shown by the analysis of sample number 35467, collected on October 9, 1916, at the discharge from the well.

Analysis of Sample Number 35467 from the Village Supply.

Determinations Made.	Parts per million.	Hypothetical Combinations.	Parts per million.	Grains per gallon.
Silica SiO_2	12.2	Potassium Nitrate KNO_3	2.3	.13
Iron Fe	0.6	Potassium Chloride KCl	25.3	1.47
Alumina Al_2O_3	2.7	Sodium Chloride NaCl	247.0	14.40
Magnesium Mg	15.2	Sodium Sulfate Na_2SO_4	406.9	23.74
Calcium Ca	42.3	Sodium Carbonate Na_2CO_3	69.2	4.03
Ammonium NH_4	1.5	Ammonium Carbonate $(NH_4)_2CO_3$	4.0	.23
Sodium Na	259.2	Magnesium Carbonate $MgCO_3$	52.6	3.06
Potassium K	14.2	Calcium Carbonate $CaCO_3$	105.8	6.16
Sulfate SO_4	275.0	Iron Oxide Fe_2O_3	0.9	.05
Nitrate NO_3	1.4	Alumina Al_2O_3	2.7	.16
Chloride Cl	162.0	Silica SiO_2	12.2	.69
Alkalinity Methyl Orange	264.	Total	928.9	54.12
Residue	946.			

WOODSTOCK (5523). Woodstock is located in the central part of McHenry County on the watershed between Fox River and Rock River. A public water supply was installed by the city in 1894. Water was secured from a well into rock. The original well and four other wells which were drilled later have been abandoned. Water is now secured from two wells into sand and gravel. Each well is equipped with a 15-inch 6-stage Layne pump driven by a 50-horsepower vertical shaft electric motor. These pumps discharge into either of two reservoirs which have a total capacity of 200,000 gallons. Water is pumped from the reservoirs by either of two pumps, one a 5-inch Worthington centrifugal of 1500 gallons a minute capacity direct connected to a steam turbine and the other a Knowles 18 by 10 by 12-inch Underwriters steam pump of 1000

gallons a minute capacity. Steam for the pumping station and a municipal power plant located adjacent to the station is supplied by three fire-tube boilers of 150-horsepower each. A standpipe 16 feet in diameter and 80 feet high is connected to the distribution system. Twelve hundred service connections were in use in 1922. Meter rates were $1.50 for the first 5000 gallons or less, 24 cents per 1000 gallons for the next 4000 gallons, and 18 cents per 1000 gallons for all over 9000 gallons.

The first well drilled was drilled by the J. P. Miller Artesian Well Company of Chicago in 1894 and was 1014 feet deep. It was cased with 12-inch pipe to a depth of 183 feet, with 8-inch pipe between depths of 163 and 212 feet, with 6¼-inch pipe between depths of 200 and 350 feet, and 5-inch pipe in caving material (depth not given). The well is 5 inches in diameter at the bottom.

A well drilled to a depth of 956 feet in 1899-1900 was drilled to a total depth of 2072 feet in 1908. A record of material as given by the J. P. Miller Artesian Well Company, drillers, with part of the classifications given by the State Geological Survey Division, is as follows:

	Thickness in feet.	Depth in feet.
Soil, clay, sand, and gravel	209	209
Limestone, Silurian system	66	275
Shale, Richmond	34	309
Limestone, "caves" Richmond	81	390
Shale, Richmond	30	420
Limestone, Galena-Platteville	335	755
Sandy limestone	41	796
Sandstone, hard, St. Peter	139	935
Marl, red, Prairie du Chien	62	997
Sandy limestone, Prairie du Chien	207	1204
Marl and sandstone, Prairie du Chien	48	1252
Limestone and shale, Prairie du Chien	70	1322
Sandstone, Prairie du Chien	74	1396
Limestone, Prairie du Chien	181	1577
Limestone and sandstone, Prairie du Chien	9	1586
Limestone, Prairie du Chien	17	1603
Sandstone, red, Mazomanie, Cambrian system	207	1810
Sandstone, hard, Dresbach, Cambrian system	203	2013
Sandy shale, Eau Claire, Cambrian system	9	2022
Sandstone, hard, Eau Claire, Cambrian system	17	2039
Limestone, Eau Claire, Cambrian system	33	2072
Sandstone, Eau Claire, Cambrian system	7	2079

The well was cased with 209 feet of 10-inch pipe and with 8-inch pipe to a depth of 250 feet. It was 8 inches in diameter to a depth of 320 feet where casing was placed. Below a depth of 327 feet the well was 7 inches in diameter to a depth of 983 feet where 5 3/16-inch casing was placed in the marl. The well was 5 1/8 inches in diameter at the bottom.

A third deep well was drilled by the Miller Company in 1908. It was cased from the surface with 209 feet of 10-inch pipe, with 8¼-inch pipe in rock to a depth of 253 feet, with 63 feet of 7-inch pipe with the bottom at a depth of 327 feet, and with 5 3/16-inch inserted joint casing between depths of 912 and 972 feet. The well was 5 inches in diameter at the bottom. These three wells were located near the center of the city near the corner of Norway and First Streets. The total yield was given in 1914 as 500,000 gallons a day, evidently a rate and not a total amount of water.

Two wells into sand were drilled on the north side of McHenry Avenue east of the city in 1912 and furnished part of the public supply for several years. The wells were 10 inches in diameter and 85 feet deep and were equipped with Cook screens 18 fet long. The capacity of the wells was given in 1914 at 500,000 gallons a day.

Water for the public supply is now obtained from two wells into sand and gravel, located 160 feet apart close to the original well which was drilled in 1894. The wells were drilled by the Layne and Bowler Company in 1920-1921. The elevation of the ground surface at the wells is 915 feet above sea level. One well, to the north, is 196 feet deep. A record of material penetrated, given by the drillers, is as follows:

Sand and gravel mixed with clay	20 feet
Sand and boulders mixed with clay	20 feet
Sand and clay	30 feet
Hard sand and clay	8 feet
Coarse sand and clay	22 feet
Sand and gravel	35 feet
Coarse sand to boulders	15 feet
Gumbo	7 feet
Gravel and boulders	35 feet
Boulders	4 feet

In the bottom of the well is 48 feet 5 inches of 13-inch, 6 gauge, 6-opening screen. Twenty-five feet of 24-inch, 6-gauge, 6-opening screen is placed with the bottom at a depth of 135 feet 10 inches and 5 feet of similar screen is placed with the bottom at a depth of 100 feet 10 inches. The well was drilled 30 inches in diameter and the space outside the screens and casing was filled with gravel. A print furnished by the company gives static water level at a depth of 49 feet 6 inches and a draw down of 38 feet with a discharge of 900 gallons a minute.

Pumping from this well for two hours on November 7, 1922, lowered the water level in the old well 2070 feet deep, which is 40 feet distant, from a depth of 73 feet where it stood when not pumping for two hours, to a depth of 82 feet 3 inches. During the

same test the water level in the old well 1190 feet deep, which is 60 feet distant, was lowered from a depth of 72 feet to a depth of 80 feet 3 inches.

Well number 2 is similar to well number 1. It is 206 feet 9 inches in depth. In the bottom is 39 feet of 13-inch screen and between depths of 107 feet 8 inches and 166 feet 3 inches are three sections of 24-inch screen with a total length of 29 feet 4 inches. The yield, apparently for test when completed, is given as 900 gallons a minute with a drawn down of 34 feet 6 inches.

The total amount of water pumped from the two wells in 1922 was probably near 650,000 gallons a day.

The water had a mineral content of 368, a total hardness of 355, and a content of iron of 1.6 parts per million as shown by the analysis of sample number 48599, collected on November 7, 1922.

Analysis of Sample Number 48599 from City Well 196 Feet Deep.

Determinations Made.	Parts per million.
Iron Fe	1.6
Silica SiO_2	12.5
Nonvolatile	1.0
Alumina Al_2O_3	0.1
Calcium Ca	74.4
Magnesium Mg	41.3
Ammonium NH_4	2.3
Sodium Na	5.4
Potassium K	1.9
Sulfate SO_4	0.0
Nitrate NO_3	1.2
Chloride Cl	3.0
Alkalinity Methyl Orange	362.
Residue	390.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	2.0	.12
Potassium Chloride KCl	2.2	.13
Sodium Chloride NaCl	3.8	.22
Sodium Carbonate Na_2CO_3	9.6	.56
Ammonium Carbonate $(NH_4)_2CO_3$	6.1	.36
Magnesium Carbonate $MgCO_3$	142.8	8.34
Calcium Carbonate $CaCO_3$	185.7	10.85
Silica SiO_2	12.5	.73
Nonvolatile	1.0	.06
Iron Oxide Fe_2O_3	2.3	.13
Alumina Al_2O_3	0.1	.01
Total	368.1	21.38

The temperature of water discharged from well number 1 in November 1922 was 51 degrees. Water used in boilers at the pumping station is treated with boiler compound. Feed water heaters are flushed three times a day and boilers are flushed every three weeks.

WYANET (825). Wyanet is located in the central part of Bureau County on the drainage area of Big Bureau Creek, a tributary of Illinois River. Private wells in use are into sand and gravel. Most wells are from 25 to 75 feet deep and a few are from 150 to 230 feet deep.

A public water supply was installed by the village in 1916-1917. Water is pumped from a well into the distribution system by a Keystone Driller Company pump which is driven by belt from a

15-horsepower electric motor. An elevated steel tank of 40,000 gallons capacity is connected to the system. Electric current is supplied by the Spring Valleg Electric Company. Forty-five service connections were in use in August, 1922, and many others were to be installed. Consumers pay $2.00 per quarter for 1800 gallons or less of water and 35 cents per 1000 gallons for additional water. Bills are not subject to cash discount.

Water for the public water supply is obtained from a well drilled by Hawkins and Olds in 1916. The elevation at the top of the well is between 655 and 660 feet above sea level. A record of material penetrated, as furnished by the village, is as follows:

Loam	1 foot
Clay	39 feet
Sand	20 feet
Gravel	10 feet
Rock	30 feet
Gravel	30 feet
Rock	30 feet
Clay and rock	20 feet
Gravel	20 feet
Water bearing sand	28 feet

The well is said to have been drilled in 27½ hours which indicates that material classified as rock was not very hard. The well is cased with 8-inch wrought iron pipe and a Johnson screen 10 feet long is placed in the bottom. The water level when the well was completed was at a depth of 90 feet. The well is equipped with a deep-well pump with a 5¾-inch cylinder placed at a depth of 150 feet. The pump is operated with 36-inch stroke. When the pump was installed it was operated for four hours at a speed of 42 strokes a minute and the discharge, measured by weir, was 175 gallons a minute. On the following day the pump was operated for nine hours at a speed of 32 strokes a minute and the discharge was 120 gallons a minute. In 1922 the pump was operated at 32 strokes a minute for from two to three hours a day. When concrete roads were built near the village the pump was operated five or six hours continuously every day. In April, 1925, it was reported that water was pumped at a rate of 130 gallons a minute, that about 15,000 gallons was pumped daily, and that the depth to water was 83 feet.

Water from the public supply had a mineral content of 455, a total hardness of 374, and a content of iron of 4.5 parts per million as shown by the analysis of sample number 48009, collected on August 2, 1922.

The temperature of water when discharged from the well on August 3, 1922, was 53 degrees Fahrenheit.

Analysis of Sample Number 48009 from the Village Supply.

Determinations Made.	Parts per million.
Iron Fe	4.5
Manganese Mn	0.5
Silica SiO_2	24.9
Nonvolatile	0.6
Alumina Al_2O_3	1.9
Calcium Ca	91.4
Magnesium Mg	35.5
Ammonium NH_4	3.1
Sodium Na	23.9
Potassium K	3.6
Sulfate SO_4	0.0
Nitrate NO_3	0.9
Chloride Cl	5.0
Alkalinity Methyl Orange	426.0
Residue	471.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	1.4	.08
Potassium Chloride KCl	5.7	.34
Sodium Chloride NaCl	3.7	.22
Sodium Carbonate Na_2CO_3	51.7	3.02
Ammonium Carbonate $(NH_4)_2CO_3$	8.2	.48
Magnesium Carbonate $MgCO_3$	122.9	7.19
Calcium Carbonate $CaCO_3$	228.1	13.35
Silica SiO_2	24.9	1.45
Nonvolatile	0.6	.03
Iron Oxide Fe_2O_3	6.4	.37
Alumina Al_2O_3	1.9	.11
Total	455.5	26.64

WYOMING (1376). Wyoming is located in the central part of Stark County on the drainage area of Spoon River, a tributary of Illinois River. Many private dug wells about 30 feet deep into sand have been in use but most people now use water from a public supply.

A public water supply was installed by the village in 1902. Water is pumped from a well into a collecting reservoir 40 feet in diameter by a deep-well pump and is pumped from the reservoir into the distribution system and an elevated steel tank connected to the system, by an 8 by 10-inch triplex pump. Power is furnished by a 45-horsepower gas engine. The elevated tank is 12 feet in diameter and 40 feet high and is supported on a brick tower 60 feet high. An air lift was first installed and has been replaced by the deep-well pump. Three hundred and seventy-five service connections were in use in 1920. Rates for water vary from 35 cents to 20 cents per 1000 gallons depending upon the quantity of water used and the minimum charge is $2.10 for three months.

Water for the public supply is secured from a well drilled by Mr. Dean of Galva. The well is 1557 feet deep. It is 12 inches in diameter to a depth of 242 feet, 9 inches in diameter between depths of 242 and 765 feet, and 8 inches in diameter below a depth of 765 feet. It is cased to a depth of 1197 feet. The lower 50 feet is in St. Peter sandstone. When the well was completed water stood at a depth of 85 feet. The well was tested by pumping for 10 hours at a rate of 200 gallons a minute. The well is equipped with an American double-stroke deep-well pump. The pump is operated

with 24-inch stroke at a speed of from 22 to 25 revolutions a minute. The discharge, when the pump is in good condition, is said to be 200 gallons a minute. In June, 1919, the pump cylinder, which had been at a depth of 100 feet, was lowered to a depth of 130 feet. Twenty feet of suction pipe is attached to the cylinder. The water level, when the pump was idle for half a day at the time the cylinder was lowered, was at a depth of 117 feet. The pump was operated for from 3 to 3½ hours a day in 1920.

The water had a mineral content of 966, a total hardness of 149, and a content of iron of 0.1 parts per million as shown by the analysis of sample number 44135, collected on November 3, 1920.

Analysis of Sample Number 44135 from the Village Supply.

Determinations Made.

	Parts per million.
Iron Fe	0.1
Silica SiO_2	8.4
Alumina Al_2O_3	1.2
Calcium Ca	37.3
Magnesium Mg	13.6
Ammonium NH_4	3.1
Sodium Na, Potassium K	297.8
Sulfate SO_4	233.1
Nitrate NO_3	2.8
Nitrite NO_2	0.0
Chloride Cl	215.0
Alkalinity Methyl Orange	280.
Residue	1016.0
Nonvolatile	0.8

Hypothetical Combinations.

	Parts per million.	Grains per gallon.
Sodium Nitrate $NaNO_3$	3.9	.23
Sodium Chloride NaCl	354.3	20.72
Sodium Sulfate Na_2SO_4	344.6	20.16
Sodium Carbonate Na_2CO_3	104.1	6.09
Ammonium Carbonate $(NH_4)_2CO_3$	8.2	.48
Magnesium Carbonate $MgCO_3$	47.2	2.76
Calcium Carbonate $CaCO_3$	93.1	5.45
Alumina Al_2O_3	1.2	.07
Iron Oxide Fe_2O_3	0.1	.01
Silica SiO_2	8.4	.49
Nonvolatile	0.8	.05
Total	966.2	56.51

A sample collected in 1912 was similar. The mineral content was 970, the total hardness 164, and the content of iron 0.1 parts per million. Some water meters had been in use for twelve years in 1920 and little trouble was reported due to corrosion.

YORKVILLE (441). Yorkville is located in the northern part of Kendall County on the southeast bank of Fox River, a tributary of Illinois River. A public water supply was installed by the village in 1886. A spring house or collecting reservoir 70 feet square was built on a hillside about one and a half mile east of the village to collect water from springs. Water flowed from the reservoir through a 6-inch wooden pipe line to the village. The pressure furnished was small, the pipe line leaked considerably after twenty years use, and repairs were expensive on account of the pipe line being at considerable depth in places. In 1909 extensive improvements were made. Another spring house was built at the side

of the old spring house, a vertical shaft centrifugal pump driven by a 7½-horsepower electric motor was installed to pump from the spring house to a reservoir which was built on the hillside at a higher elevation than the springs, and a cast iron pipe line was laid to the village.

Water from springs was collected by lines of tile laid about 3 feet below the ground surface. Below loam and peat, from 12 to 18 inches deep, was considerable gravel. Water was discharged from the tile into the collecting reservoir. The water consumption in 1917 was estimated at about 24,000 gallons a day.

A sample of water, number 38013, was collected from one of the lines of tile at the point of discharge into the collecting reservoir on September 10, 1917. The water had a mineral content of 381, a total hardness of 310, and a content of iron of 0.1 parts per million as shown by the analysis.

Analysis of Sample Number 38013 from Village Springs.

Determinations Made.	Parts per million.
Iron Fe	0.1
Silica SiO_2	7.2
Nonvolatile	0.5
Alumina Al_2O_3	18.4
Calcium Ca	78.3
Magnesium Mg	27.9
Sodium Na	10.0
Potassium K	0.7
Sulfate SO_4	79.2
Nitrate NO_3	15.9
Chloride Cl	6.0
Alkalinity Methyl Orange	266.
Residue	38.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	1.9	.11
Sodium Nitrate $NaNO_3$	20.2	1.18
Sodium Chloride NaCl.	9.9	.58
Sodium Sulfate Na_2SO_4	1.9	.11
Magnesium Sulfate $MgSO_4$	97.7	5.70
Magnesium Carbonate $MgCO_3$	28.1	1.64
Calcium Carbonate $CaCO_3$	195.5	11.37
Iron Oxide Fe_2O_3	0.2	.01
Alumina Al_2O_3	18.4	1.07
Silica SiO_2	7.2	.42
Nonvolatile	0.5	.03
Total	381.5	22.22

Water for the public supply is now secured from a well 590 feet deep which was drilled in 1923. An abstract of a record of material penetrated, on file with the State Geological Survey Division, is as follows:

	Thickness in feet.	Depth in feet.
Drift	10	10
Shale	70	80
Limestone, Galena-Platteville	330	410
Sandstone, St. Peter	180	590

The well is 8 inches in diameter to a depth of 125 feet and 6 inches in diameter below that depth. When completed the flow from the well was 18 gallons a minute. A deep-well pump was installed for a test and 75 gallons of water a minute was pumped.

A sample of water, number 50892, collected from this well on

January 26, 1924, had a mineral content of 269, a total hardness of 239, and a content of iron of 0.6 parts per million as shown by the analysis.

Analysis of Sample Number 50892 from Village Well 590 Feet Deep.

Determinations Made.	Parts per million.
Iron Fe	0.6
Manganese Mn	0.0
Silica SiO_2	12.9
Nonvolatile	1.8
Alumina Al_2O_3	0.0
Calcium Ca	51.0
Magnesium Mg	27.1
Ammonia NH_4	0.9
Sodium Na	3.6
Potassium K	3.6
Sulfate SO_4	37.0
Nitrate NO_3	1.9
Chloride Cl	6.0
Alkalinity	
Phenolphthalein	0
Methyl Orange	210.

Hypothetical Combinations.	Parts per million.	Grains per gallon.
Potassium Nitrate KNO_3	3.3	.19
Potassium Chloride KCl	4.6	.27
Sodium Chloride NaCl	6.3	.37
Sodium Sulfate Na_2SO_4	3.5	.20
Ammonium Sulfate $(NH_4)_2SO_4$	3.3	.19
Magnesium Sulfate $MgSO_4$	40.4	2.36
Calcium Carbonate $CaCO_3$	127.3	7.44
Magnesium Carbonate $MgCO_3$	65.4	3.82
Iron Oxide Fe_2O_3	0.9	.05
Silica SiO_2	12.9	.75
Nonvolatile	1.8	.11
Total	269.7	15.75

MUNICIPALITIES WHICH USE SURFACE WATERS FOR PUBLIC WATER SUPPLIES.

Municipalities which use surface waters for public water supplies are listed below for convenience and are shown on the map on the insert facing page 6 or on the map on page 8. Information in regard to surface water supplies will be given in a bulletin to be published later.

Municipality	Source of Supply
Alton	Mississippi River
Astoria	Stream
Avon	Pond
Belleville	From East St. Louis—Mississippi River
Benton	Stream
Berwyn	From Chicago—Lake Michigan
Blue Island	From Chicago—Lake Michigan
Breese	Shoal Creek
Brooklyn	From East St. Louis—Mississippi River
Burnham	From Chicago—Lake Michigan
Burr Oak	From Chicago—Lake Michigan
Cairo	Ohio River
Calumet City	From Chicago—Lake Michigan
Carlinville	Macoupin Creek
Carlyle	Kaskaskia River
Carmi	Little Wabash River
Central City	From Centralia—Martin's Branch
Centralia	Martin's Branch
Charleston	Embarrass River
Chester	Mississippi River
Chicago	Lake Michigan
Christopher	Stream
Cicero	From Chicago—Lake Michigan
Dallas City	Mississippi River
Danville	North Fork Vermilion River
Decatur	Sangamon River
Deerfield	From Highland Park—Lake Michigan
Dolton	From Chicago—Lake Michigan
East St. Louis	Mississippi River
Effingham	Little Wabash River

Municipality	Source of Supply
Eldorado	Wolf Creek
Evanston	Lake Michigan
Fairfield	Stream
Freeburg	Stream
Gillespie	Rocky Branch
Glencoe	From Winnetka—Lake Michigan
Granite City	Mississippi River
Grayville	Wabash River
Greenup	Embarrass River
Hamilton	Mississippi River
Harrisburg	Middle Fork of Saline River
Harvey	Part from Chicago—Lake Michigan
Herrin	Stream
Highland Park	Lake Michigan
Highwood	From Highland Park—Lake Michigan
Hillsboro	Middle Fork of Shoal Creek
Jacksonville	South Branch Mauvaise Terre Creek
Johnston City	Stream
Kankakee	Kankakee River
Kenilworth	Lake Michigan
Kincaid	Pond
Lake Forest	Lake Michigan
Litchfield	Stream
London Mills	Spoon River
Louisville	Little Wabash River
McLeansboro	Stream
Macomb	Crooked Creek
Madison	From East St. Louis—Mississippi River
Marion	Stream
Mattoon	Little Wabash River
Moline	Mississippi River
Mount Carmel	Wabash River
Mount Greenwood	From Chicago—Lake Michigan
Mount Olive	Stream
Mount Vernon	Casey Fork
Murphysboro	Big Muddy River
National City	From East St. Louis—Mississippi River
Nauvoo	Mississippi River
New Athens	Kaskaskia River
Newton	Embarrass River
Niles	From Chicago—Lake Michigan

Municipality	Source of Supply
Niles Center	From Chicago—Lake Michigan
Oak Park	From Chicago—Lake Michigan
Olney	Stream
Pana	Beck's Creek
Paris	Sugar Creek
Park Ridge	From Chicago—Lake Michigan
Pinckneyville	Stream
Pittsfield	Stream
Pontiac	Vermilion River
Quincy	Mississippi River
Riverdale	From Chicago—Lake Michigan
Rock Island	Mississippi River
St. Elmo	Sugar Creek
Salem	Stream
South Jacksonville	From Jacksonville—Stream
Sparta	Stream
Staunton	Stream
Streator	Vermilion River
Vandalia	Kaskaskia River
Venice	From East St. Louis—Mississippi River
Warsaw	Mississippi River
Waterloo	Stream
Waukegan	Lake Michigan
West Frankfort	Middle Fork Big Muddy River
White Hall	Stream
Wilmette	From Evanston—Lake Michigan
Winnetka	Lake Michigan
Zeigler	Big Muddy River