ILLINOIS

STATE WATER SURVEY

NO. 10

UNIVERSITY OF ILLINOIS BULLETIN

ISSUED WEEKLY

VOL. 10 JUNE 2, 1913 NO. 36

[Entered as second-class matter December 11, 1912, at the post office at Urbana, Illinois, under the Act of August 24, 1912.]

WATER SURVEY SERIES No. 10

CHEMICAL AND BIOLOGICAL SURVEY OF THE WATERS OF ILLINOIS

REPORT FOR YEAR ENDING DECEMBER 31, 1912

EDWARD BARTOW

DIRECTOR

PUBLISHED BY THE UNIVERSITY OF ILLINOIS

URBANA

CONTENTS

ILLUSTRATIONS

ORGANIZATION

EDMUND JANES JAMES, PH.D., LL.D .... President

STAFF 1912.

EDWARD BARTOW, PH.D. .... Director
PAUL HANSEN, B.S .... Engineer
SAMUEL WILSON PARR, M.S .... Consulting Chemist
ARTHUR NEWELL TALBOT, C.E .... Consulting Engineer
OTTO RAHN, PH.D .... Consulting Bacteriologist
WILFRED FRANCIS LANGELIER, M.S. .... .Inspector
HARRY PEACH CORSON, M.S. .... Chemist
WALTER GOTTFRID STROMQUIST, B.S. .... Assistant Engineer
RALPH HILSCHER, B.S .... Assistant Engineer
FRED WILBUR TANNER, B.S .... Assistant Bacteriologist
MILFORD EVERETT HINDS, B.S .... Assistant Chemist
EDWARD EMIL HOLLMAN, B.S .... Assistant Chemist
FLOYD WILLIAM MOHLMAN, B.S .... Assistant Chemist
HARRY FOSTER FERGUSON, B.S .... Engineering Assistant
CLARENCE SCHOLL .... Laboratory Assistant
CARMEN FLORENCE HARNACK .... Clerk
MARIE JESTER ....Stenographer
ELIZA PRESTELLA HART .... Stenographer
JANE BLANCHE MCMULLEN .... Stenographer

LETTER OF TRANSMITTAL

STATE WATER SURVEY.

UNIVERSITY OF ILLINOIS,
Urbana, Illinois, February 1, 1912.

EDMUND JANES JAMES, PH.D., LL.D.,
President University of Illinois.

SIR: Herewith I submit a report of the work of the State Water Survey for the year ending December 31, 1912, and request that it be printed as a bulletin of the University of Illinois, State Water Survey Series No. 10.

The report contains a summary of the work done by the laboratory and engineering divisions in accordance with the laws creating the State Water Survey and imposing upon it new and additional duties. (Laws of Illinois, 40th General Assembly 1897, 12; 47th General Assembly, 1911, 43. Bulletin University of Illinois, State Water Survey Series, 9, 7-8.) The report covers the first full year with the increased appropriation allowed by the 47th General Assembly. The special report by the engineering division shows the additional work accomplished and also confirms our belief that there would be a demand for the services of our engineering division.

Several other organizations whose work is related in some way to the work of the State Water Survey is briefly summarized in the report. There are several articles that describe special experimental work and special investigations.

Many cities have been visited during the year. The purpose of each visit, the observations made, and the recommendations, if any, are given.

Thanks are due to the regular staff for their interest in the work of the Survey and to Dr. L. L. Burgess, Mr. O. Kamm, Mr. H. L. Olin, and Mr. C. H. Spaulding, for assistance rendered in the preparation of special articles. Credit is given in appropriate places for the part each has taken.

Respectfully submitted,
EDWARD BARTOW,
Director.

GENERAL REPORT

GENERAL STATEMENT FOR THE YEAR ENDING DECEMBER 31, 1912.

During the year 1912 the laboratory and field work of the State Water Survey has been continued along the lines inaugurated in the latter part of 1911. In the latter part of 1911 there was a notable increase in the amount of work done by the Survey, owing to the appropriation of $15,000.00 per annum* by the Forty-seventh General Assembly for analytical and field work. The Legislature also made an appropriation of $7,500.00 per annum for scientific work connected with a study of the waters of the state.

The staff has been somewhat changed during the year. Owing to the retirement of Professor Thomas J. Burrill from the professorship of Botany and Bacteriology, Dr. Otto Rahn, Assistant Professor of Bacteriology, has been made Consulting Bacteriologist. Walter Bernreuter and Frank Curtis Gephart have resigned and the following have been appointed to the active staff-:

Assistant Bacteriologist, Fred Wilber Tanner, B.S. Wesleyan University, 1912.

Assistant Chemist, Milford Everett Hinds, B.S. Northwestern University, 1912.

Assistant Chemist, Edward Emil Hollman, B.S. University of Illinois, 1912.

Assistant Chemist, Floyd William Mohlman, B.S. University of Illinois, 1912.

Engineering Assistant, Harry Foster Ferguson, B. S. Massachusetts Institute of Technology, 1912; Engineer with Pennsylvania R. R., Fort Wayne, Ind., from June to October, 1912.

The Illinois State Water Survey was organized as a division of the Department of Chemistry. Instruction in Water Chemistry has, therefore, been given by members of the Water Survey staff. There is one course for undergraduates, Chemistry 10; one course for graduates, Chemistry 110, and both undergraduates and graduates are allowed to prepare theses on subjects connected with Water Chemistry. Several of the theses thus prepared have been of sufficient merit to warrant their publication in the bulletins of the State Water Survey and also in the scientific and technical press. The engineer has given a course of lectures on Water and Sewage Purification in the Engineering College.

*University of Illinois Bulletin State Water Survey Series *9*, **7.**

The following table shows the enrollment in Water Chemistry from 1905 to 1912, together with the number of members of the active staff:

Year—	Chem. 10	Chem. 110	Thesis	Total	Growth of Staff
1905-06	3	..	..	3	3
1906-07	6	1	1	8	3
1907-08	16	3	1	20	3
1908-09	9	5	4	18	3
1909-10	15	9	3	17	3
1910-11	11	7	2	20	3
1911-12	18	7	3	28	8

The notable increase in the staff during the year 1911-12 was due to the increased appropriations for field work and the establishment of an engineering division. Prior to the year 1905-6, the work of the Water Survey was carried on under the direction of Professor A. W. Palmer with two assistants. After 1905, the active staff has been, as shown in the table. The figures do not include the consulting staff, clerical help, laboratory assistants or field assistants employed to work during the summer vacations.

The Water Survey has always occupied quarters in the Chemistry Building, but at the present time, 1912, eight rooms in the Chemistry Building and two in the Engineering Building are in use. Plans are being prepared for an addition to the Chemistry Building. Quarters have been assigned to the Water Survey in the northeast part of the basement of the addition.

The work accomplished by the Survey has been described in nine bulletins. Until the fall of 1911 the work was practically all analytical. Little field work was done until additional funds became available in July, 1911. The appropriation made possible the establishment of an engineering division and the employment of field men to examine municipal water supplies, inspect water sheds and to make such field studies and to collect such samples of water as are necessary to promote the establishment and maintenance of pure and adequate supplies of water for domestic and manufacturing uses in each municipality. Sanitary analyses are made free of charge of water from municipal water supplies or from private wells collected according to the directions of the State Water Survey. Since the passage of the act authorizing analyses free of charge, the number of samples of water analyzed has greatly increased.

The most important analytical work which it has been possible to undertake is the systematic analyses of water from filtered surface supplies. Seventy-five per cent of the filter plants submit monthly samples for analysis. Samples of city water supplies are collected by the field men from each city visited and sanitary analyses and the complete analyses of mineral content of many such supplies are made.

During the year 1912 the number of towns visited by the engineers classified according to the purpose of the visit are as follows:

Inspection of existing public water supplies	60
Conferences concerning the installation and extension of public water supplies	1
Inspection of existing sewerage systems	25
Conferences concerning proposed sewerage systems	3
Special investigations such as surveys of watersheds	18

As a result of the above work reports have been submitted as follows:

Existing public water supplies	60
Proposed water supplies	19
Existing sewerage systems	11
Proposed sewerage systems	14

In connection with the reports on water supplies, a brief description has always been given of the sewerage conditions.

New Water Supplies. Previous investigations had shown that the typhoid fever death rate was greatest in parts of the state where there were fewest public water supplies. By conferences with the local authorities of 19 towns interest has been aroused and in some cases the State Water Survey is advising concerning plans for the installation or additions to water systems.

Filter Plants. Of the 61 water supplies obtained from surface water, only 17 used filtered water in 1910. Eleven additional plants have been or are being installed: Anna, Champaign, Evanston, Hamilton, Lawrenceville, McLeansboro, Mt. Carmel, Mt. Vernon, Pana and Warsaw. The State Water Survey has assisted by reviewing and reporting upon plans and when plants have been completed by directing efficient operation.

Sterilization. The treatment of the water with calcium hypochlorite, or bleaching powder, is a comparatively recent discovery. The first plant to use the chemical, in September, 1908, was the plant located at Union Stock Yards at Chicago. Tests of the efficiency of this plant were made at the laboratory of the State Water Survey and the use of the chemical was at once recommended to other plants. The first additional plant was installed at Lake Forest, November 5, 1908. The second at Kankakee, March 10, 1909. Since then, at least 20 plants have been installed. Practically all filter plants in the state now use the chemical as an adjunct to filtration and several plants which use unfiltered water are now using bleaching powder as a safeguard.

Control Laboratories. While the State Water Survey can make examinations of water at intervals for the various municipalities, daily control at the water works plant especially of surface supplies, is of far greater value. The first control laboratory installed upon the advice and under the direct supervision of the State Water Survey was at Kankakee, in 1907, and to date 15 laboratories have been installed. Seven of these have been established since September 1, 1911. Water works officials having laboratory facilities and laboratory control of their water are very enthusiastic.

TABLE I. SHOWING THE NUMBER OF WATER SAMPLES EXAMINED AT THE DIRECT REQUEST OF PRIVATE CITIZENS OR LOCAL HEALTH OFFICERS, ARRANGED BY YEARS AND ACCORDING TO THE NATURE OF THE SOURCE

SOURCES	October 1895, to Dec. 31 1896	YEARS																Total from each source
		1897	1898	1899	1900	1901	1902	1903	1904	1905	1906	1907	1908	1909	1910	1911	1912	
Surface waters, rivers, lakes and ponds..	69	72	102	54	59	61	97	75	80	107	304	336	356	372	428	196	393	3161
Springs	16	21	34	23	22	35	28	18	28	41	63	52	68	62	41	29	73	654
Cisterns.	12	19	17	7	7	3	10	6	7	5	13	29	28	31	21	25	27	267
Natural ice.	4	12	1	11	9	4	9	3	12	6	......	1	5	1	12	9	10	109
Artificial ice.	....	1	......	2	1	......	1	1	1	......	4	......	......	0	0	1	0	12
Water for artificial ice	3	......	......	3	......	1	1	......	5	2	1	......	1	2	0	2	0	21
Water for natural ice.	....	2	......	......	......	3	1	1	2	......	6	......	......	3	0	3	0	21
Mine water.	....	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	5	5
Shallow wells in rock.	28	16	8	22	12	22	10	17	25	25	19	45	32	53	43	29	31	437
Deep wells in rock	58	48	34	26	36	56	59	23	28	66	170	159	258	345	207	119	299	1791
Flowing wells in rock.	45	8	16	12	13	14	3	8	9	11	22	17	43	3	2	2	9	237
Shallow wells in drift.	500	245	168	243	274	209	243	245	270	292	142	514	683	614	344	256	436	5978
Deep wells in drift.	64	68	43	30	24	36	63	54	51	40	114	154	160	159	95	103	138	1396
Flowing wells in drift.	63	5	4	9	4	......	3	5	5	12	19	25	2	1	7	......	......	164
Sewage	37	......	21	25	10	......	1	7	2	6	5	33	46	5	1	1	6	206
Miscellaneous	....	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	53	53
Unknown.	....	......	......	......	......	......	......	......	......	......	......	......	......	......	......	20	30	50
Total samples from citizens	899	517	448	467	471	444	529	463	525	613	1182	1365	1682	1651	1201	795	1510	14562
Other samples	888	811	988	1579	1866	778	147	419	555	466	445	55	87	73	101	279	214	9751
Total for year	1787	1328	1436	2046	2337	1222	676	882	1080	1079	1627	1420	1769	1724	1302	1074	1724	24313
....	....	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......

Laboratory Report. From the time of its foundation, September, 1895, to December 31, 1912, the State Water Survey has received 24,313 samples of water (see table I). Of these 14,562 were sent by private citizens, health officers or water works officials. The remaining samples, with the exception of 2,800 collected in connection with investigations of the Chicago Drainage Canal, have been collected by the members of the staff, or under their direction for the study of special problems.

During the year 1912, 1,724 samples were received (see table II), 1,510 having been sent to the laboratory by health officers or private citizens.

The number received from such sources during 1912 was nearly double the number received during 1911, for the reason that during the former year, owing to decreased appropriations allowed by the Forty-Sixth General Assembly, it was impossible to make free of charge analyses for all who desired such work, and there was consequently a falling off in the number of analyses made, Even during the year 1912, the number of samples sent in has not reached the number sent in during 1908 and 1909, before a fee was charged. The number received during the last six months of 1912 (856) is, however, greatly in excess of those received during the first one-half of the year (654), and in all probability the year 1913 will show samples received greatly in excess of those in any previous year.

Scientific Investigations and Special Studies. In addition to the routine analytical work and routine inspections, the members of the Water Survey staff are occupied constantly with special problems relating to water and water supplies. In nearly every case, the problems are suggested by difficulties arising at various water works or sewage disposal systems throughout the state or by difficulties in the analytical methods which it is necessary to use. The regular staff is assisted in its work by instructors and students in the university. During 1912 such assistance was given by Dr. L. L. Burgess, Instructor in Chemistry; Mr. L. T. Fairhall, Mr. O. Kamm and Mr. H. L. Olin.

Effect of Chicago Sewage on the Illinois River. Work has been done in cooperation with the State Laboratory of Natural History to determine the effect of the sewage of the city of Chicago on the Illinois River with special reference to its action on fish life. Work has been done in cooperation with the Sanitary District of Chicago to study the physical and chemical condition of the river as affected by Chicago sewage and also to compare methods of determining dissolved oxygen. Description of the work is given elsewhere in this report.

Incrustation in Water Mains at Mt. Vernon, and Manganese in Illinois Water Supplies. These studies were undertaken primarily because of the serious incrustation in the water mains at Mt. Vernon. The incrustation consisting of oxides of iron and manganese was removed mechanically at an expense of $6,500.00. A plant to remove

TABLE II. SHOWING THE NUMBER OF WATER SAMPLES EXAMINED DURING THE YEAR EN`DING DECEMBER 31, 1912. ARRANGED BY MONTHS ACCORDING TO THE NATURE OF THE SOURCE.

SAMPLES BY REQUEST	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
Surface water, rivers, lakes and ponds	28	27	23	25	41	34	23	35	25	35	45	52	393
Springs	8	16	5	3	8	4	7	12	1	4	3	2	73
Cisterns	4	3	2	2	1	1	2	4	2	2	3	1	27
Natural ice	.....	8	.....	2	.....	.....	.....	.....	.....	.....	.....	.....	10
Shallow wells in rock	.....	.....	4	3	.....	1	2	2	7	5	6	1	31
Deep wells in rock	26	14	33	39	7	27	36	21	35	16	32	13	299
Flowing wells in rock	1	2	.....	.....	.....	4	.....		.....	2	.....	.....	9
Shallow wells in drift	12	18	17	43	29	28	49	56	50	59	39	36	436
Deep wells in drift	7	6	14	7	12	17	19	15	6	17	8	10	138
Sewage	.....	.....	.....	.....	2	.....	.....	1	.....	3	.....	.....	6
Distilled water	.....	.....	.....	.....	1	.....	.....	1	.....	.....	.....	.....	2
Mine water	.....	.....	.....		2	.....	.....	.....	.....	1	.....	2	5
Unknown	2	.....	2	3	3	1	7	3	3	1	4	1	30
Outside of State	4	.....	7	6	2	3	6	8	1	6	2	6	51
Total samples by request	92	94	107	133	108	120	151	158	130	151	142	124	1510
ANALYSES MADE ON THE INITIATIVE OF THE STATE WATER SURVEY.													
Surface water, rivers, lakes and ponds	14	5	.....	.....	22	4	4	8	3	14	7	1	82
Springs	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	2	.....	3
Natural ice	3	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	3
Deep wells in rock	3	1	.....	.....	.....	3	11	.....	.....	.....	15	3	36
Shallow wells in drift	.....	.....	.....	.....		.....	4	.....	6	12	10	9	41
Deep wells in drift	.....	1	5	.....	3	.....	9	3	.....	1	1	1	24
Sewage	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	18	19
Trade wastes	.....	.....	.....	.....	.....	.....	.....	.....	6	.....	.....	.....	6
Total on initiative of State Water Survey	20	7	5	.....	25	7	29	11	15	28	35	32	214
Total	112	101	112	133	133	127	180	169	145	179	177	156	1724

the iron and manganese before it enters the mains is being constructed. A full account of the work is given elsewhere in this report.

A New Method for the Determination of Potassium in Drinking Water. An adaptation of the Cobalti-Nitrite method, which promises to shorten the time of making the analysis and to eliminate the use of the expensive platinum chloride.

The experimental work which has been completed is fully described elsewhere in this bulletin.

Epidemics. It is not primarily a function of the State Water Survey to deal with epidemics. The State Board of Health and local health authorities have, however, called on the Survey to assist in checking epidemics of typhoid fever. The typhoid fever epidemics at Rockford, Evanston, Waukegan and Enfield were investigated in 1912. The primary function of the State Water Survey is in assisting and maintaining pure water throughout the state. Its recommendations, therefore, are for the prevention of epidemics rather than for their cure.

ASSOCIATIONS AND COMMISSIONS.

Special phases of Illinois water problems are of interest to several State, Interstate, National and International Associations and Commissions. These have been co-operating as far as possible in the study of water problems in order to prevent useless duplication of the work. The organizations interested are noted below, together with a brief statement concerning that part of their work during 1912, which concerned water supplies.

Illinois State Board of Health. (1877.) Water analyses for the State Board of Health have been made when requested. The care of the water supplies of the State has been given over to the State Water Survey.

State Laboratory of Natural History. (1884.) Professor S. A. Forbes, University of Illinois, Urbana, Director. The State Laboratory of Natural History is interested in the character of the streams of the state with respect to their effect on stream life. A special study is being made to determine the effect of Chicago sewage on the plankton and food fishes in the Illinois river. The chemical work has been done under the direction of the State Water Survey. An article in this report, entitled, "The Effect of Chicago Sewage on the Illinois River," is based on work done during 1911 and 1912.

Illinois Society of Engineers and Surveyors. (1885.) J. A. Harman, Consulting Engineer, Peoria, President; E. E. R. Tratman, Wheaton, Secretary-Treasurer. Water supply and sewage disposal problems form an important part of the work of the members of this organization. The 1912 proceedings contained six papers and reports relating to water and sewage problems. A brief review of these is given elsewhere.

Sanitary District of Chicago. (1890.) Thomas A. Smyth, President; George M. Wisner, Chief Engineer, Karpen Bldg., Chicago. The Sanitary District of Chicago has continued its investigations of sewage disposal for the City of Chicago during 1912. The State Water Survey and the Sanitary District continued their co-operation in making determinations of dissolved oxygen in the Illinois River. The results have been incorporated in the article entitled "The Effect of Chicago Sewage on the Illinois River."

Illinois State Geological Survey. (1905.) F. W. DeWolf, University of Illinois, Urbana, Director. The State Geological Survey has charge of drainage investigations and is interested in the character of the water obtained from deep wells and the horizons from which the water can be obtained.

Lake Michigan Water Commission. (1908.) Dr. G. B. Young, Health Commissioner, Chicago, President; Dr. Edward Bartow, Director State Water Survey, University of Illinois, Urbana, Secretary. The Lake Michigan Water Commission, which was established in 1908, has for its object the investigation of the sanitary conditions of Lake Michigan, with a view to conserving a supply of pure water for those cities and towns which depend on Lake Michigan for their source of supply. The members of the Commission are appointed by the governors of the states, and the mayors of several cities which border the lake. There are also representatives from the United States Army and the United States Public Health Service. No special appropriations are made for this commission. The members are, for the most part, officials connected with state, federal, or municipal bureaus. No meetings were held during 1912.

Lake Michigan Sanitary Association. (1908.) A. J. Horlick, Racine, Wisconsin, President; Wm. H. Humphrey, Association of Commerce, Chicago, Secretary. This association is composed of representatives of city councils, health departments and engineering departments of cities in the territory draining into Lake Michigan. It has for its object the protection of the water supplies.

Illinois Water Supply Association. (1909.) R. R. Parkin, Chief Engineer, Water Department, Elgin, President; Dr. Edward Bartow, Director State Water Survey, University of Illinois, Urbana, Secretary-Treasurer. The Illinois Water Supply Association is composed of persons interested in the waterworks and water supplies of Illinois. The annual meetings are held at the University of Illinois in February or March. Papers dealing with topics of interest to waterworks men are read. The program of the fourth meeting is published elsewhere in this report.

Rivers and Lakes Commission. (1909.) R. R. McCormick, First

National Bank Bldg., Chicago, Chairman; Robert Isham Randolph, First National Bank Bldg., Chicago, Secretary. An abstract of the publications of the Commission to the end of 1912 is given elsewhere in this report.

Great Lakes International Pure Water Association. (1911.) Dr. Chas. J. Hastings, Medical Health Officer, Toronto, Canada, President; Paul Hansen, Illinois State Water Survey, University of Illinois, Urbana, Secretary. At a meeting of representatives from various municipalities throughout the country held in Chicago, September 29, 1911, an association was formed of those interested in the character of the water of the Great Lakes. The 1912 meeting was held at Cleveland, October 23-4 with the National Association for the Prevention of the Pollution of Streams and Waterways. A number of interesting papers were presented, but have not been published by the association.

National Association for Preventing the Pollution of Rivers and Waterways. (1911.) Calvin W. Hendrick, American Bldg., Baltimore, Md., Chairman; H. de B. Parsons, 22 William St., New York City, Secretary. This association has for its object the prevention of excessive pollution of streams. An abstract of the papers presented at the meeting held in Cleveland October 23-4 is given elsewhere.

United States Geological Survey. George Otis Smith, Director, Washington, D. C. The survey has charge of stream measurements and other investigations of water resources of the country. Bulletins entitled "Water Supply Papers" are issued at frequent intervals.

Public Health Service. Dr. Rupert Blue, Surgeon-General, Washington, D. C. The Hygienic Laboratory of the Public Health Service has undertaken the investigation of the quality of interstate streams.

International Joint Commission of the United States and Canada. Th. Chase Casgrain, Chairman. To this commission has been referred the sanitary condition of the boundary waters between Canada and the United States. On December 17, 1912, a conference was held in Buffalo for the purpose of outlining the course to be pursued in investigating the pollution of boundary waters. The conference decided on certain fundamental conditions and adopted a resolution recommending that the commission secure a joint appropriation with which to carry out the preliminary work.

REPORT OF ASSOCIATIONS AND COMMISSIONS

ILLINOIS SOCIETY OF ENGINEERS AND SURVEYORS.

The Twenty-seventh Annual Report (1912) contains several papers and reports related to the water problems of Illinois. Their titles with brief abstracts are given below.

A Local Sewage Disposal Problem. F. L. Stone. A neglected septic tank at Wheaton was found to be giving little or no efficiency. The location of the tank at the present time is unfavorable and it is probable that later new works will be built upon a site about two miles distant. The recommendations were that for the present, sludge drying beds be constructed and also that the tank be remodelled to facilitate cleaning to enable it to furnish a better effluent.

A discussion of the paper by Langdon Pearse contains analytical data which shows clearly the inefficiency of the plant.

Sewage Disposal. Langdon Pearse. Experiments made in the Chicago Sanitary District laboratories indicate that a removal of 50 or 60% of the suspended matter results in increasing the stability of sewage to the extent of about 25%. The necessary degree of purification seems to be the most pressing problem at the present time.

Formulas for Flow in Sewers. G. C. Habermeyer. The author shows the relations between the various "run off" formulas used in the design of storm water sewer systems of the smaller cities.

Report of the Committee on Sewers. A review of the sewage work built or contracted for during 1911 is tabulated and brings to date a complete tabulation of Illinois sewerage statistics. A list of sewage purification plants in Illinois built or contracted for to date, is given.

The disposal of sewage in Lake Michigan along the North Shore has begun to be a menace to the water supply. In Lake County a proposition to found a sanitary district was defeated. In northern Cook County there are four citizens' organizations at work for sanitary interests. The desirability of having more data relating to storm "run off" from sewered areas is emphasized and the co-operation of engineers in collecting such data is solicited.

The tendencies in sewage purification methods, the attempt to standardize the various methods of analysis and reports, and the advocacy of laws regarding stream pollution are commended.

Report of the Committee on Waterworks. The organization and future plans of the various bodies whose duty it is to look after the water supply interests of the state are outlined. There are seven such bodies now in existence and the prospects are that much good will result.

All the organizations mentioned are included in the list published elsewhere in this report.

ILLINOIS WATER SUPPLY ASSOCIATION.

The Illinois Water Supply Association was organized in February, 1909. The constitution and the programs of previous meetings were published in Bulletins 8, pp. 24-9, and 9, pp. 43-5.

The fourth meeting was held at the University of Illinois, March 5 and 6, 1912. Officers for the year 1912-13 were elected as follows:

President, R. R. Parkin, Chief Engineer Water Department, Elgin.

First Vice-President, C. H. Cobb, Superintendent Water Works Co., Kankakee.

Second Vice-President, H. M. Ely, Superintendent Water Co., Danville.

Third Vice-President, W. J. Spaulding, Commissioner of Public Property, Springfield.

Secretary-Treasurer, Edward Bartow, Director State Water Survey, Urbana.

The following papers were read and published in the fourth volume of the proceedings of the association (1912):

President's Address, Owen T. Smith, Superintendent Freeport Water Company, Freeport.

A City Source of Supply, and Does the Water Meter Increase Revenue, Reduce Consumption and Satisfy the Consumer? R. R. Parkin, Chief Engineer Water Department, Elgin.

Effect of Installing Meters at Decatur, Harry Ruthrauff, Commissioner of Public Property, Decatur.

The New Work of the State Water Survey, Edward Bartow, Director Illinois State Water Survey, University of Illinois.

Method of Keeping Track of Examination and Flushing of Fire Hydrants, Dow R. Gwinn, Manager Water Company, Terre Haute, Ind.

The Limitation of Stream Pollution, Paul Hansen, Engineer Illinois State Water Survey, University of Illinois.

The Storage of Coal, S. W. Parr, Professor of Applied Chemistry, University of Illinois.

Nitrite Removal Test Applied to Montana Waters, W. M. Cobleigh, Professor of Chemistry, Montana State College, Bozeman, Montana.

The Necessity for Safe Water Supplies in the Control of Typhoid Fever, A. J. McLaughlin, Past Assistant Surgeon, Public Health and Marine Hospital Service, Washington, D. C.

Typhoid Fever and the Water Supply of Mattoon, R. A. Gabbert, President Chamber of Commerce, Mattoon.

Characteristics of Typhoid Fever Outbreaks, H. N. Parker, Bacteriologist, University of Illinois.

The Detailed Procedures to Be Followed in an Epidemiological Determination of the Origin of a Typhoid Outbreak, H. W. Hill, M. D., Director Division of Epidemiology, State Board of Health, Minneapolis, Minn.

Anchor Ice, Linden C. Trow, Chief Engineer Water Company, Lake Forest.

The Purchase of Coal on Specifications, Ward O. Collins, Vice-President Gulick-Henderson Company, Chicago.

Evanston's Experience with Hypochlorite, W. Lee Lewis, Ph.D., Instructor in Chemistry, Northwestern University, City Chemist of Evanston.

Hypochlorite Sterilization and Typhoid at Kansas City, Missouri, W. M. Cross, M. D., City Chemist, Kansas City, Mo.

Trials and Troubles of the Pumping Station and Their Remedy, M. M. Symons, Chief Engineer, Water Company, Danville.

Water Department Methods, W. J. Spaulding, Commissioner of Public Property, Springfield.

New Deep Rock Wells at Joliet, Ill., H. A. Stevens, City Engineer.

Sanitary Survey of the Mississippi River at Moline, Edward Bartow, Director Illinois State Water Survey, University of Illinois.

Color in Mississippi River at Saint Louis, W. F. Monfort, Chemist, Water Department, St. Louis, Mo.

Some Interesting Observations on the Disinfection of Lake Water with Calcium Hypochlorite, Dr. Arthur Lederer, Chemist and Bacteriologist, The Sanitary District of Chicago, and Frank Bachmann, Assistant Chemist, The Sanitary District of Chicago.

Incrustation in Water Mains at Mt. Vernon, Illinois, F. M. Sinsabaugh, Manager Citizens' Gas, Electric & Heating Company.

Composition of the Incrustation in the Mt. Vernon Water System, H. P. Corson, Chemist, State Water Survey, Urbana.

Illinois Legislation on Public Utilities Commission, Hon. William P. Holaday, Member 47th General Assembly, Danville.

Pumping by Steam and Electricity, E. MacDonald, Superintendent Water & Light Company, Lincoln.

The Installation and Successful Operation of a Million Gallon Gravity Filter Plant, John M. Keefer, Mayor, Macomb.

Further Tests on the Removal of Iron from a Drift Well Water, Arthur N. Talbot, Professor Municipal and Sanitary Engineering, University of Illinois.

Small Filter Plants, W. W. DeBerard, Western Editor, Engineering Record, Chicago.

The membership of the association is growing consistently. The 1912 roster included 183 active and 24 associate members. Membership is distributed among 22 states and territories. Copies of the proceedings are sent to members or may be obtained by purchase from the secretary. All persons interested in water supplies and water supply problems of Illinois are eligible to membership.

RIVERS AND LAKES COMMISSION.

To the end of 1912 the commission have published thirteen bulletins. The titles are as follows:

Bulletin No. 1, October 1, 1911.—"The Conservation of Water Power in the Des Plaines and Illinois Rivers and the Improvement of These Rivers for Navigation."

Bulletin No. 2, October 15, 1911.—"Prospectus of a Project for a Deep Waterway and the Conservation of a Natural Resource of the State of Illinois," prepared by Lyman E. Cooley.

Bulletin No. 3, March 25, 1912.—"The Uses of the Great Lakes," by Gardner S. Williams, M. A. S. C. E.; "Discussion on 'The Uses of the Great Lakes,'" by Robert R. McCormick, and the "Argument of Isham Randolph, M. A. S. C. E., Supporting the Plea of the Sanitary District of Chicago for the Right to Withdraw 10,000 Cubic Feet of Water Per Second From Lake Michigan."

Bulletin No. 4, April 1, 1912.—"Land Drainage in Illinois," by Robert Isham Randolph.

Bulletin No. 5, April 5, 1912.—"A Compilation of Money Spent by the Government on Various Harbors, Rivers and Canals, and the Riparian Property Holders Benefited," by George B. Hills, Junior Engineer.

Bulletin No. 6, April 3, 1912.—"Argument on Behalf of the State of Illinois Supporting the Prayer of the Sanitary District of Chicago for a Permit to Take 10,000 Cubic Feet of Water Per Second From Lake Michigan," presented to the Honorable Henry L. Stimson, Secretary of War, by Isham Randolph, C. E., under the authority of Governor Charles S. Deneen.

Bulletin No. 7, July 8, 1912.—"The 1912 Flood on the Lower Mississippi," by A. L. Dabney, Consulting Engineer, and "The 1912 Floods in the Ohio and Mississippi Rivers," by H. C. Frankenfield, in charge of the River and Flood Surveys of the United States Weather Bureau, Washington, D. C. Reprinted by courtesy of the *Engineering News*.

Bulletin No. 8, July 15, 1912.—"Proceedings of the Organization Meeting of the Association of Mississippi Valley States for River Control."

Bulletin No. 9, July 31, 1912.—"The Illinois Water Power Waterway." An attack by Ebin J. Ward and defense by Robert Isham Randolph.

Bulletin No. 10, December 1, 1912.—"The Illinois Waterway," A Guide for Navigators of Lake Michigan and the Mississippi River via the Chicago Sanitary and Ship Canal, the Illinois and Michigan Canal, and the Illinois River. Also an Alternate Route via the Illinois and Mississippi (Hennepin) Canal, by Robert Isham Randolph.

Bulletin No. 11, December 1, 1912.—"European Harbor Development," by Robert R. McCormick.

Bulletin No. 12, December 1, 1912.—"Practical Canal Building," by Robert R. McCormick.

Bulletin No. 13, December 15, 1912.—"The Illinois Waterway—A Review," by Isham Randolph.

An annual report, reviewing the work done by the commission since its organization in August, 1911, to the end of 1912, has also been published. Material and data consisting of county maps and atlases, river profiles, undeveloped water power, a gazetteer of streams, drainage areas, inventory of levee and drainage districts, inventory of water power, runoff and stream flow data, precipitation and evaporation records have been collected.

Complaints and hearings are recorded in the report. A complaint regarding the pollution of the Fox river relates closely to the Water Survey work and deserves mention here.

THE POLLUTION OF FOX RIVER.

A complaint entered by Edward F. Gorton and others, regarding the pollution of the Fox river, was given a hearing before the commission on June 15, 1911. A report by John W. Alvord, also one by the State Water Survey, were presented and formed additional evidence.

All of the testimony was to the effect that the river had already reached the limit of safe sewage burden, and that in its present condition constituted a nuisance and was a danger to public health in Fox river valley.

The testimony was in accord with the secretary's own views derived from a personal investigation, and his recommendations were that the commission so report its opinion.

NATIONAL ASSOCIATION FOR PREVENTING THE POLLUTION OF RIVERS AND WATERWAYS.

The 1912 meeting was held with The Great Lakes International Pure Water Association at Cleveland, October 23rd and 24th, 1913. A bulletin issued by the association contains three papers.

Report of Committee on Standards of Purity for Rivers and Waterways. The substance of the report may be summarized as follows: While recognizing that the pollution of many rivers and waterways is inevitable and absolute prevention of pollution is impossible, it is deemed imperatively necessary that some control of the discharge of waste matter into rivers and waterways be maintained in order that conditions prejudicial to the public health and comfort and damage to property may be kept at a minimum. The committee heartily endorses the movement that is being made to keep the pollution of streams within reasonable bounds and not to allow our rivers and waterways to become unduly soiled.

Some Opinions on the Limitation of Stream Pollution. By Paul Hansen. Two phases of the water pollution problem were discussed:

First. To what extent may waters be contaminated before they become unsuited as sources of purified domestic water supply?

Second. Are we warranted in demanding a high degree of purity in streams used extensively for recreation purposes but not for public water supplies?

A formula is proposed for the solution of the first problem, namely, that "the average dilution available of low water per unit of population multiplied by the time of flow of high water between sewer outlet and water works intake must not be less than a fixed quantity that may be termed a safety factor." Thus, if T = time in hours required for the passage of sewage from the sewer outlet to the water works intake at high water and D = dilution available during low water in cubic feet per second per 1,000 persons tributary to the sewers and S = the safety factor, then $T \times D = S$.

With regard to the second problem, the conclusion is-that there is an abundant justification for insisting on a high degree of purity in the case of streams which have value for recreation purposes.

A Sanitary Survey of Lake Michigan Along the Wisconsin Shore. M. P. Ravenel, M.D., and E. J. Tully. The Lake Michigan water is not at all times safe as a source of public water supplies. It is fallacious to consider that the discharge of sewage in any given direction from an intake will afford protection. The extension of intakes will not provide protection. Unpurified sewage should be kept out of the lake. The lake water should be filtered for use for water supplies.

THE VOLUMETRIC DETERMINATION OF POTASSIUM IN MINERAL WATERS

BY L. L. BURGESS AND OLIVER KAMM.

Quite recently a paper* was published in which we announced the discovery of a new compound in the cobaltinitrite series, containing both silver and potassium. The slight solubility of this substance made it an attractive one to study for the purpose of perfecting a procedure for the quantitative determination of potassium. Unfortunately, however, the composition of the precipitate is not constant, but varies slightly with the conditions under which it is precipitated. Results of unpublished analyses seem to show that no simple formula will be found to represent its composition; also, that no constant ratio exists between the quantities of silver and potassium in the compound. There is, however, a constant relation between the total silver plus potassium, expressed in gram atoms, and the total nitrite, expressed in gram equivalents, as is shown below. This fact makes it possible to use this precipitate for the quantitative estimation of potassium, since both the silver and the nitrite may readily be determined.

Gilbert† has shown that a somewhat similar constant relation between sodium plus potassium and nitrite exists in the sodium potassium cobaltinitrites obtained in the precipitation of potassium by means of sodium cobalti-nitrite (De Koninck's reagent). Because of the fact that no rapid method is available for the determination of sodium in the presence of potassium it is evident that any method which uses this precipitate can never give more than approximate results.

The present work was undertaken to determine whether the new silver potassium cobalti-nitrite could be employed as the basis for a rapid volumetric determination of potassium in mineral waters. The results will be compared with those obtained by careful analyses of the same waters by the chloro-platinate method. In order to make the test as rigid as possible waters differing greatly in mineral content have been selected.

It has already been shown‡ that the presence of moderate quantities of the alkaline earth metals and sodium do not interfere with the qualitative detection of potassium. To see if the presence of these metals has any effect on the quantitative determination the waters were analyzed for potassium, both in the presence of all the other dissolved

* Burgess & Kamm, J. Am. Chem. Soc. 34, 652. (1912)
† Gilbert, Inaugural Dissertation, Tübingen 1898.
‡ J. Am. Chem. Soc. 34, 652. (1912.)

materials and after a separation of the other metals by means of barium hydroxide and ammonium carbonate.

Relation Between Metals and Nitrite.

It has been stated that a constant relation exists between the total metals (silver plus potassium) and nitrite. Since the cobalt is in the cobaltic condition, part of the nitrite is oxidized by the cobalt during the titration with permanganate. Since, however, the ratio of cobalt to nitrite is also constant, there must exist a constant relation between the total metals and the nitrite determined by titration. This relation was obtained in the following manner:

Ten cubic centimeters of a standard potassium nitrate solution, containing 2.000 grams of potassium per liter, were measured out and diluted. Enough tenth normal silver nitrate was then added to make it approximately two one-hundredths normal in respect to silver, the final volume being 100 cubic centimeters. The potassium was precipitated with a concentrated solution of sodium cobalti-nitrite, and the analysis completed as described in the outlined method given below. The results are recorded in Table I.

TABLE I.

No.	K, gm.	cc. N/10 $KMnO_4$	cc. NaCNS .02534N	NO_2, gm.	Ag, gm.	Ratio (Ag+K):NO_2
1.	.0200	41.29	22.40	.09497	.06124	1:1.91
2.	.0200	39.69	21.00	.09129	.05742	1:1.90
3.	.0200	40.98	22.40	.09425	.06124	1:1.90
4.	.0200	39.63	21.00	.09115	.05742	1:1.90
5.	.0200	41.62	22.90	.09573	.06261	1:1.905

The above results show that the ratio given in the last column is constant, and may therefore be used as the basis for a quantitative method. This ratio [metal: nitrite = 1:1.90] was employed in all subsequent analyses, which were carried out according to the procedure given below. A glance at Table II will show that the concentration of potassium may be varied between wide limits without seriously influencing this ratio.

Method of Analysis.

The reagent used is an approximately 25% solution of sodium cobalti-nitrite, $Na_3Co(NO_2)_6$. It is prepared directly before using by dissolving the solid sodium salt* in water and filtering through a thick asbestos mat in order to separate any potassium present.

*The reagent, sodium cobalti-nitrite, may be obtained from various chemical houses if desired. It may be prepared as follows: 100 grams cobalt acetate $Co(C_2H_3O_2)_2 4H_2O$ and 250 grams of sodium nitrite are dissolved in about 600 cc. water. 100 cc. glacial acetic acid is then added, and, when thorough oxidation has taken place, the mixture is filtered to separate out as much of the insoluble potassium salt as possible. The tri-sodium salt is precipitated by the addition of several volumes of 95 per cent ethyl alcohol the voluminous precipitate being immediately filtered by suction upon a large Büchner funnel, a double filter paper

Precipitation is effected by adding the reagent slowly from a pipette with constant stirring, to a dilute neutral solution containing potassium. An excess of silver nitrate should be present. The concentration of the latter should not be greater than .02 normal, in order to prevent silver nitrite from being precipitated, the solubility of which is .027 mols per liter at 18° C. A relatively large excess of reagent is used so as to insure complete precipitation.*

The yellow silver potassium cobalti-nitrite comes down in a finely divided condition, but may be filtered on a Gooch after standing for a half hour, provided a thick triple mat of asbestos is used and not too strong suction is applied. Since the precipitate is colloidal in nature it should not be washed with pure water. Wash waters containing silver are unsuitable because of the difficulty in completely washing out the excess of silver from the precipitate before titration, while those containing potassium salts tend to replace silver. For these reasons we have selected a wash solution consisting of ice water, to which a few drops of acetic acid have been added. (Not more than one cubic centimeter of glacial acetic to one-half liter.) The precipitate is first washed until the wash water is colorless, and finally with about one hundred cubic centimeters additional. Because of the danger of having the colloidal substance pass through the filter, the latter should at no stage be permitted to drain completely.

The precipitate, together with the Gooch, is transferred to the casserole in which precipitation took place and oxidized with a hot standard solution of N/10 $KMnO_4$, the latter being diluted to any convenient volume. Titration is carried on in acid solution, about ten cubic centimeters of 1:5 sulphuric acid being added. The solution is heated to boiling, oxidation being complete after a few minutes. The excess of $KMnO_4$ is titrated off with an excess of standard oxalic acid and the solution titrated back to color with $KMnO_4$.

Following this determination of NO_2, the asbestos is filtered off upon a Gooch, washed, and reserved for repeated use. The silver in the filtrate is titrated with a standard NaCNS solution (approximately .02 N) using ferric alum as indicator. The latter titration should not take place in hot solution.

In the results recorded in this paper corrections have been ap-

being used. After drying on a clay plate for a day the reagent is ready to be bottled. Yield—about 120 grams, which is 75 per cent of theory. It has been customary in earlier work on this subject, to use the reagent without the precipitation with alcohol. Whether or not this procedure will have any effect upon a quantitative method, will be shown in our later work. All of the results recorded in this article were, however, obtained with the use of the pure reagent.

*The fact that the filtrate shows the reagent color is no satisfactory criterion of complete precipitation, because of the partial decomposition of the reagent into the cobaltous condition, in which state no insoluble potassium silver salt is formed. Precipitation should take place at room temperature (about 20° C.), because of the ease of decomposition of all cobalti-nitrites at a higher temperature.

plied both for the reducing power of the asbestos used as well as for the sulpho-cyanide end point. Such corrections amounted to about one-tenth of a cubic centimeter in each case.

Method of Calculation.

Since the relation of K plus Ag. to NO_2 titrated is a constant quantity we can, after having determined both Ag and NO_2, calculate the amount of potassium present, the ratio of metal to determined nitrite being taken as 1:1.90. Thus we can calculate the amount of nitrite equivalent to the silver titrated. Subtracting this value from the total nitrite titrated by $KMnO_4$, we obtain the amount of the latter equivalent to potassium. Potassium is calculated from the remaining nitrite, using the ratio 1K=1.90 NO_2. Factors may be used to simplify the calculations. It is suggested to anyone wishing to use this method extensively, that the nitrite factor (found to be 1.90 in our case) be re-determined. In this manner any error in preparing the standard solutions will be partly counterbalanced. Determination No. 14 (see Table II) will be recalculated here as an example. The following data is known:

1 c.c. N/10 $KMnO_4$ =.0023 gm NO_2
1 c.c. .02534N NaCNS=.002734 gm Ag=.002215 gm NO_2
1 gm. NO_2 = .4474 gm. K.

Example.

21.64 c.c. N/10 $KMnO_4$ = (21.64×.0023) =.04977 gm. NO_2
12.50 c.c. (.02534) NaCNS=(12.50×.002215) =.02769 gm. NO_2
Difference=.02208 gm. NO_2
.02208 × .4474=.00988 gm.=Wt. of K.

It is interesting to note that we could prepare a NaCNS solution of such a strength (exactly .0263 normal) that one cubic centimeter N/10 $KMnO_4$ would be equivalent to one cubic centimeter of NaCNS. The calculation will thus be greatly simplified; thus—(Vol. N/10 $KMnO_4$—Vol. NaCNS) (factor)=wt. K.

Known solutions containing varying amounts of potassium up to .04 gram were analyzed according to the procedure described above, the total volume at the time of precipitation being one hundred cubic centimeters in each case and the concentration of silver being approximately two one-hundredths normal. The results given in Table II show that the agreement between the calculated and determined values is satisfactory, and also that the ratio stated above holds over a considerable range. The larger differences obtained when dealing with the greatest quantity of potassium (.04 gm.) may be due to increased difficulty in washing, although a probable source of error is pointed out in the following paragraph.

TABLE II.

No.	K. present gms.	c.c. N/10KMnO$_4$	c.c. NaCNS .02534 N	K. found gms.	Error
6.	.0005	1.13	.65	.0005	.0000
7.	.0005	1.20	.82	.0004	—.0001
8.	.0010	2.37	1.53	.0009	—.0001
9.	.0010	1.75	.97	.00085	—.0001+
10.	.0020	5.08	3.30	.00195	—.0000+
11.	.0020	5.02	3.15	.0021	+.0001
12.	.0060	13.32	7.95	.0058	—.0002
13.	.0060	11.91	6.40	.0059	—.0001
14.	.0100	21.64	12.50	.0099	—.0001
15.	.0100	19.70	10.50	.00985	—.0001+
16.	.0140	28.91	15.90	.0140	.0000
17.	.0140	27.42	14.50	.0138	—.0002
18.	.0200	41.29	22.40	.0203	+.0003
19.	.0200	39.69	21.00	.0200	.0000
20.	.0400	72.20	35.10	.0395	—.0005
21.	.0400	77.98	39.40	.0412	+.0012

The amount of silver contained in the precipitate varies with the concentration of the silver in the solution in which precipitation takes place, a corresponding variation in the permanganate value being observed. This interesting fact may even be noticed in the results of Table I, in which case the silver value had been constant. The concentration of silver may be varied from .01 normal to almost .03 normal without impairing the accuracy of results by this method. However, because of the ease of adjusting the silver concentration to any approximate value we would recommend the use of a .02 normal solution.

Our work with low concentrations of silver has shown that, when dealing with small amounts of potassium (less than .01 gm. per 100 c.c.) no variation is noted. With greater concentrations of potassium, however, there is a slight tendency toward high results due to the carrying down of a trace of sodium. This can be prevented by using a larger concentration of silver, or by allowing the precipitate to stand for about an hour in the presence of a slight excess of silver, and thus replacing any trace of sodium carried down. This latter point should be borne in mind even when working with the proper concentrations; particularly so, when potassium is high. Under any conditions, it will be found desirable to precipitate not more than .02 gm. K in one hundred centimeters of .02 normal silver nitrate. The high result obtained in determination No. 21 (Table II) is thus readily explained, since the precipitate in this case was filtered immediately. Because of the large amount of potassium present the concentration of silver at the end of the precipitation was less than .01 normal.

The effect of the presence of varying quantities of sodium on the accuracy of the method was next studied. The results in Table III show that even when the ratio of potassium to sodium is one to five hundred no appreciable error is introduced.

TABLE III.

(SHOWING EFFECT OF PRESENCE OF SODIUM.)

No.	K present gms.	Na present gms.	c.c. KMnO$_4$ N/10	c.c. NaCNS .02534 N	K found gms.	Error
22.	.0020	.200	4.69	2.83	.0020	.0000
23.	.0020	1.000	4.26	2.45	.00195	—.00005
24.	.0200	.200	39.71	20.80	.02025	+.0002
25.	.0200	1.000	38.41	19.65	.0200	.0000

TABLE IV.

(SHOWING EFFECT OF PRESENCE OF Ca OR Mg.)

No.	K present gms.	Ca or Mg present gms.	c.c. $KMnO_4$ N/10	c.c. NaCNS .02534 N	K found gms.	Error
26.	.0020	.100 Mg	3.85	1.90	.0021	+.0001
27.	.0020	.100 Ca	4.05	2.15	.0021	.0000
28.	.0020	.500 Mg	3.85	2.00	.0020	.0000
29.	.0020	.500 Ca	4.42	2.50	.0020	.0000
30.	.0200	.500 Mg	38.62	19.60	.0203	+.0008
31.	.0200	.500 Ca	40.93	21.70	.0206	+.0006

That no interference need be feared when moderate quantities of the alkaline earth metals are present is shown by the results recorded in Table IV. The analyses were carried out in the presence of varying quantities of calcium and magnesium salts. No determinations were made in the presence of barium and strontium salts, but it is quite certain that they would not interfere unless present in large quantities, when a barium or a barium silver cobalti-nitrite* may be precipitated.

Analysis of Mineral Waters.

Eight waters were analyzed for complete mineral content by Mr. H. L. Olin, using the methods commonly employed in the laboratory of the State Water Survey. The results are contained in Table V.

TABLE V.

COMPLETE MINERAL ANALYSIS.

(Expressed in Milligrams per 1000 c.c.)

Lab. No.	23544	23545	23546	23553	23621	23622	23637	23652	23691
Alkalinity	386.	288.	250.	278.	256.	376.	264.	1172.	...
Residue at 180° C	942.	1111.	12567.	2090.	2338.	613.	3683.	5428.	...
Potassium	14.8	15.7	119.3	19.4	2.0	1.3	26.4	14.2	14.1
Sodium	276.6	313.3	3844.3	445.1	354.3	28.4	967.4	2121.4	...
Ammonium (NH_4)	1.0	1.0	3.6	1.0	2.5	.14	1.6	.9	...
Magnesium	14.4	28.8	131.5	56.2	102.4	30.5	74.1	14.5	...
Calcium	50.4	56.4	665.0	200.0	283.0	129.6	168.0	25.7	...
Iron and Aluminum	1.5	1.5	4.9	1.7	12.0	3.0	1.5	.6	...
Chlorine	325.	400.	6916.	1000.	750.	140.	840.	2560.	...
Sulphate	7.3	41.6	423.8	118.4	497.4	54.4	1363.	.0	...
Silica	10.6	8.8	9.4	10.4	20.0	1.4	12.0	10.0	...

It is evident that waters have been selected showing a wide variation in their mineral constituents. The results on the determination of potassium were performed either in duplicate or triplicate by each method. In the chloroplatinate method the precipitate was washed free from sodium with 80 per cent ethyl alcohol and then collected on a Gooch-Monroe crucible. Any insoluble impurity was corrected for by redissolving the precipitate in hot water and weighing the residue. The analyses by the cobaltinitrite method were made both with and without the separation of the other metals. The procedure is as follows: The combined chlorides of sodium and potassium are dissolved in about seventy-five cubic centimeters of water, the chlorine precipitated by adding an excess of silver nitrate, and the silver chloride filtered off. One cubic centimeter of the filtrate (drawn off with a pipette) may

*Burgess & Kamm. Loc. cit. pg. 658.

be titrated with the standard sulphocyanide solution in order to determine approximately its strength in respect to silver. Enough tenth normal silver nitrate is then added so as to obtain approximately a .02 N. silver solution in which to precipitate the potassium. The analysis is conducted as has been outlined above.

When it is desired to precipitate potassium from a mineral water without a previous separation of the other metals by the ammonium carbonate method, a convenient quantity of the water (usually 500 c. c.) is evaporated to a small volume in a casserole, the chlorine precipitated, and the determination completed in the usual manner.

It is necessary to allow the solution to cool to room temperature (20 to 25° C.) before precipitation, because of the increase in solubility of the precipitate at higher temperatures. The solution should be neutral, or acid with acetic acid. Results of these analyses are shown in Table VI.

TABLE VI.

POTASSIUM IN MINERAL WATERS.

Method:	*Platinic chloride*			*Cobaltinitrite* No separation of other metals			*Cobaltinitrite* Separation of metals		
	Milligrams per liter			Milligrams per liter			Milligrams per liter		
Lab. No.			Average			Average			Average
23544	15.0	14.6	14.8	14.7	14.9	14.8	14.8	15.8	15.3
23545	16.4	15.4	15.9	15.2	15.5	15.4	16.2	16.7	16.5
*23546	117.6	121.	119.3	119.8	117.5	118.7	124.	122.	123.
23553	19.4	19.4	19.4	20.3	20.0	20.2	21.7	21.9	21.8
23621	1.8	2.2	2.0	1.4	1.3	1.4	1.8	1.5	1.7
23622	1.1	1.4	1.3	.9	1.2	1.1	....	1.1	1.1
23637	26.2	26.5	26.4	26.3	26.2	26.3	26.0	26.4	26.2
*23652	15.0	13.4	14.2	12.0	11.0	11.5	12.6	13.0	12.8
23691	13.9	14.3	14.1	14.0	14.0	14.0	15.2	15.3	15.3
Uni. Supply	...	...	1.4	...	...	1.4	..	...	...

These results show excellent agreement and demonstrate that the new volumetric method is capable of giving results of a high degree of accuracy. The values obtained after the separation of the heavy metals are, in nearly every case, slightly higher than those obtained without such a separation. A careful examination of the chemicals used showed that they did not contain potassium. The reason for this increase has not been explained. In waters No. 23546 and 23652, because of the very large mineral content, only one hundred cubic centimeters were taken for analysis by the chloroplatinate method, and consequently the results contained in the table are ten times those actually determined and are correspondingly less exact. In the other cases, five hundred cubic centimeters were analyzed in each case. The results by the cobalti nitrite method were obtained from liter or half liter samples.

It was noticed that if the filtrate and washings from the chloroplatinate determinations were evaporated to dryness and the residue taken up with water, potassium could be detected in this solution. We therefore made the following series of analyses in which the potassium was determined by the usual procedure for the chloroplatinate method, but the filtrate and washings were collected, evaporated to dryness, the

*Only 100 c. c. portions of the water were here analyzed.

residue dissolved in water, the platinum precipitated and the potassium determined in the filtrate by the cobaltinitrite method. The results are given in Table VII. They show that the results by the chloroplatinate method are slightly low, but that the potassium is recovered completely from the filtrate. This is in agreement with the experience of the Bureau of Chemistry,* which recommends that a correction of +.0008 gm. KCl (equivalent to .0004 gm. K) be applied to determinations by this method.

TABLE VII.

No.	K present gms.	Na present gms.	K found as K_2PtCl_6	Error gms.	K found in filtrate cobaltinitrite method
1.	.0400	none	.0396	—.0004	.0007 gm.
2.	.0400	none	.0396	—.0004	.0006 gm.
3.	.0200	none	.0200	.0000	.0002 gm.
4.	.0400	.0400	.0397	—.0003	.0004 gm.
5.	.0400	.200	.0394	—.0006	.0005 gm.
6.	.0400	.200	.0394	—.0006	.0005gm.

Summary.

1. A new volumetric method for the determination of potassium in mineral waters, based on the insoluble silver potassium cobaltinitrites, has been described.

2. It was proven that sodium, calcium and magnesium salts do not interfere unless present in large quantities.

3. Nine mineral waters have been analyzed by this method and the results compared with those obtained by the standard method. Excellent agreement was obtained.

4. The slightly low results obtained with the chloroplatinate method were shown to be due to the solubility of the potassium chloroplatinate, since the potassium could be determined in the filtrate by means of the cobaltinitrite method.

*U. S. Dept. of Agr. Bull. No. 91, page 30. (1905). Mineral Waters of the U. S.

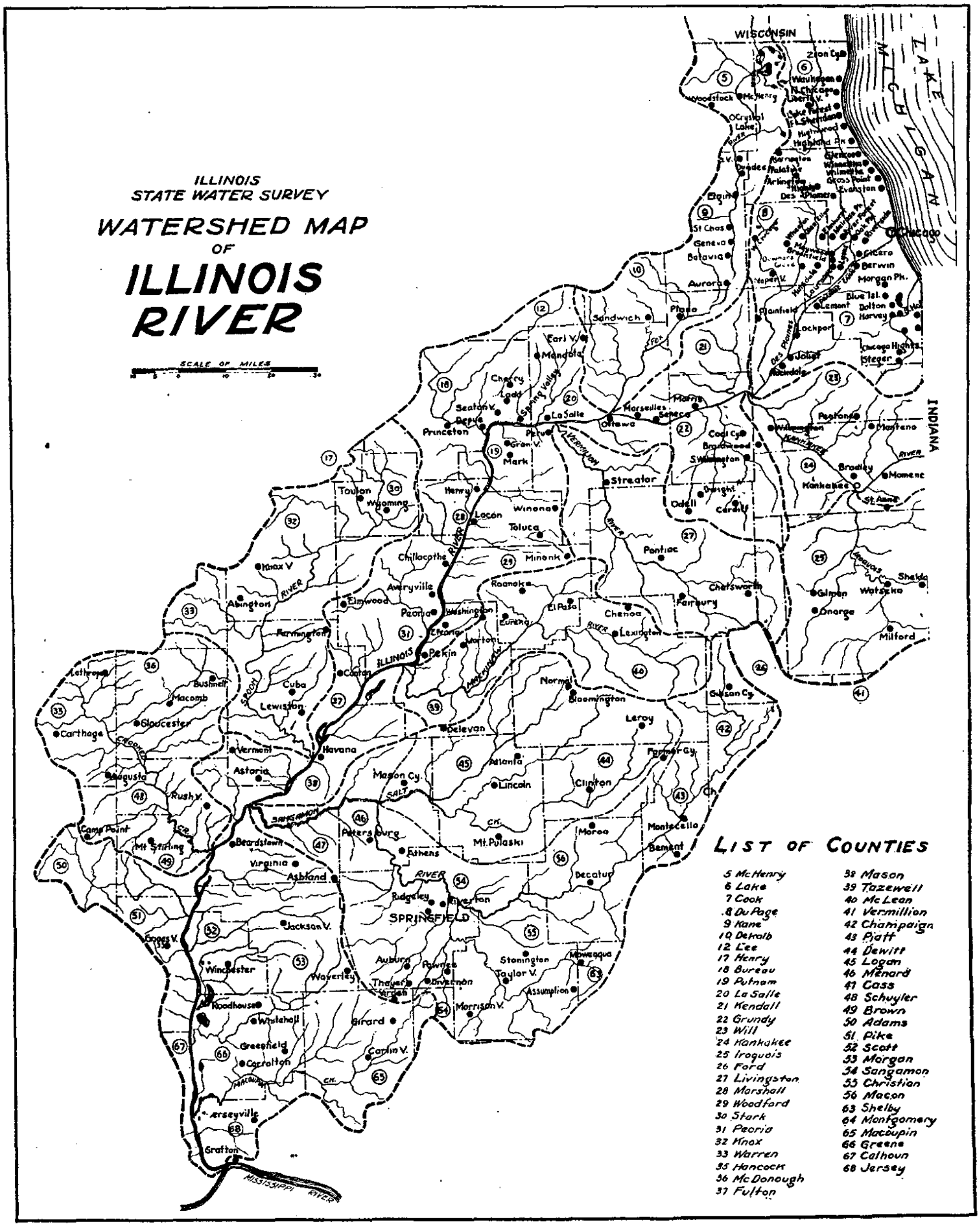
EFFECT OF CHICAGO SEWAGE ON THE ILLINOIS RIVER

The first board of Sewage Commissioners for the City of Chicago was established by an act of the Legislature in 1855. A plan formulated by this board, under the direction of Mr. E. S. Chesbrough as chief engineer, provided for the disposal of the sewage into Chicago river, Lake Michigan, and Illinois river. The sewage would reach Illinois river through the Illinois and Michigan canal, into which it was pumped. A pumping station was established at Bridgeport. It soon proved to be inadequate and, as early as 1865, work was commenced to deepen the canal to obtain a steady flow from Lake Michigan. In 1871 the first gravity flow was obtained through the Illinois and Michigan canal. In 1883 a second pumping station was established which continued in operation until the opening of the main drainage canal of the Sanitary District in 1900.

The Sanitary District of Chicago was organized after a great flood in 1885 which caused Des Plaines river to overflow to Ogden ditch into Chicago river and thereby sweep all the accumulated filth of the river into the lake, carrying it into the water intakes. A pure water commission, with Mr. Rudolph Hering as sanitary expert, recommended the construction of a canal from Chicago river to Des Plaines river that would be sufficient to take the greatest flood waters of Chicago river and also to prevent Des Plaines river from overflowing into Chicago river. The capacity of the canal should be 10,000 cubic feet of water per second, which Mr. Hering estimated would dilute the sewage of three million people and render it inoffensive. As a result of the recommendations, a dilution of 3.3 cubic feet per second for each one thousand people in the territory served by the canal was established by law as the legal dilution required.

At the present time (1912) the authorities of the Sanitary District estimate that between the years of 1920 and 1922 the population of the Sanitary District will have reached three million and, under the law, 10,000 cubic feet of water per second as a minimum will be required.* That raises the question as to whether this is sufficient water to properly dilute the sewage of so many people and the large quantity of manufacturing wastes that are discharged into different branches of Chicago river. It is also impossible to get a continuous flow of 10,000 cubic feet per second through the main channel until the Calumet-Sag canal reaching from Calumet river to the main channel is completed.

*Report on Sewage Disposal, The Sanitary District of Chicago, 1911, p. 37.


ILLINOIS
STATE WATER SURVEY
WATERSHED MAP
OF
ILLINOIS
RIVER
SCALE OF MILES
LIST OF COUNTIES
5 McHenry
6 Lake
7 Cook
8 Du Page
9 Kane
10 Dekalb
12 Lee
17 Henry
18 Bureau
19 Putnam
20 La Salle
21 Kendall
22 Grundy
23 Will
24 Kankakee
25 Iroquois
26 Ford
27 Livingston
28 Marshall
29 Woodford
30 Stark
31 Peoria
32 Knox
33 Warren
35 Hancock
36 McDonough
37 Fulton
38 Mason
39 Tazewell
40 McLean
41 Vermillion
42 Champaign
43 Piatt
44 Dewitt
45 Logan
46 Menard
47 Cass
48 Schuyler
49 Brown
50 Adams
51 Pike
52 Scott
53 Morgan
54 Sangamon
55 Christian
56 Macon
63 Shelby
64 Montgomery
65 Macoupin
66 Greene
67 Calhoun
68 Jersey
WISCONSIN
LAKE MICHIGAN
INDIANA
SPRINGFIELD
MISSISSIPPI RIVER

Since in eight or ten years the population of the district will equal the number for which the canal was designed, steps have already been taken by the Sanitary District to determine present conditions and to devise means of relieving by sewage purification, conditions which will necessarily arise in the near future. In the spring and summer of 1911 the Sanitary District, under the direction of the chief engineer, Mr. George M. Wisner, began a study of the condition of Illinois river. About the same time the attention of Professor S. A. Forbes, director of the Illinois Natural History Survey, was called to the lack of fish life in the river and he asked the cooperation of the Illinois State Water Survey in the study of the conditions. Mr. C. H. Spaulding, representing the State Water Survey, began a study of the chemical characteristics of the water. Mr. R. E. Richardson, representing the State Natural History Survey, began a study of the fish and the plankton. Mr. Richardson has continued his studies and the chemical work has been continued by W. F. Langelier, W. G. Stromquist and H. P. Corson, of the State Water Survey.

The pollution of water, by sewage, is best indicated by the amount of oxygen in solution. The amount of dissolved oxygen varies with the temperature.* In practice, there is a slight variation from the figures given for pure water due to changing temperature or to the presence of organisms which liberate oxygen. Frequently super-saturation is found in unpolluted waters. This may be due, either to a rise in temperature immediately before the sample was taken, or to the presence of oxygen forming organisms. The amount of oxygen present in Lake Michigan water and in Illinois river before the opening of the drainage canal was determined by Professor A. W. Palmer,† who states: "The variations in Lake Michigan water during the four years in which examinations were made were in general but slight and were occasioned chiefly by conditions which caused discharges from Chicago river and from those sewers which emptied directly into the lake, to pass farther out than usual. They are also in part due to storms which stir up the sediments near the shore and the cribs. The lake water was ordinarily fairly well charged with dissolved oxygen." This is shown on Diagram I, reproduced from the earlier bulletin.

A comparison of Mississippi river and the Illinois river at Grafton was also made, as is represented in curves on Diagram II, reproduced from the earlier bulletin. Professor Palmer further states: "From January 4th to June 27th, 1900, the percentage of saturation of the waters of the Illinois river range from 43 to 95.7, with 76.5 per cent as the average of 141 samples. A parallel series of samples from the Mississippi gave 55.8 per cent for the minimum, and 108.8 per cent for the maximum, with 82 per cent as the average of 120 samples. The waters of both the Illinois and Mississippi are frequently supersatu-

*Standard Methods of Water Analysis, 1912, 62.

†Chemical Survey of the Waters of Illinois, report for the years 1897-1902, 65—Plate xxxix.

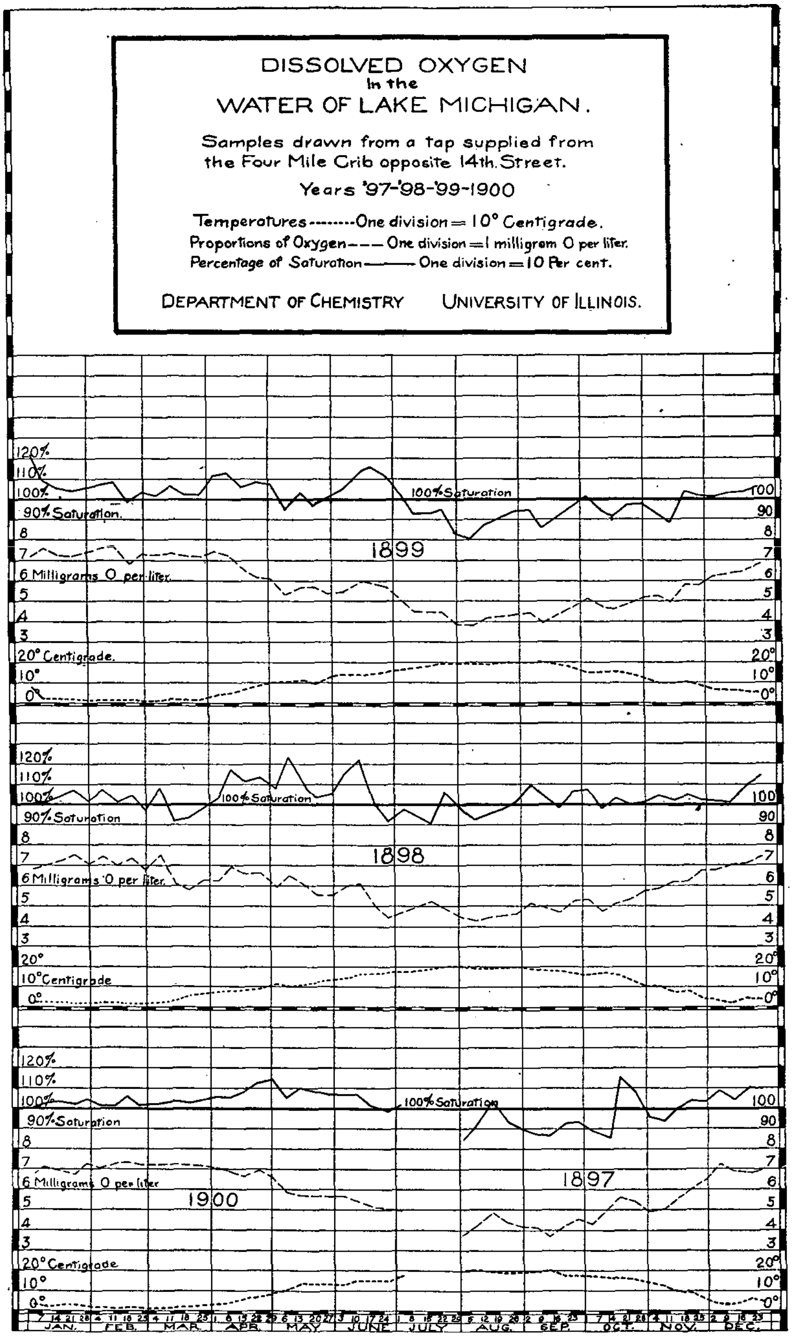

DISSOLVED OXYGEN
in the
WATER OF LAKE MICHIGAN.
Samples drawn from a tap supplied from
the Four Mile Crib opposite 14th. Street.
Years '97-'98-'99-1900
Temperatures ....One division = 10° Centigrade.
Proportions of Oxygen - - - One division = 1 milligram O per liter.
Percentage of Saturation ——— One division = 10 Per cent.
DEPARTMENT OF CHEMISTRY
UNIVERSITY OF ILLINOIS.
1899
1898
1900
1897
120%
110%
100%
100% Saturation
90% Saturation
6 Milligrams O per liter
20° Centigrade
10°
0°
JAN.
FEB.
MAR.
APR.
MAY
JUNE
JULY
AUG.
SEP.
OCT.
NOV.
DEC.

Diagram I.

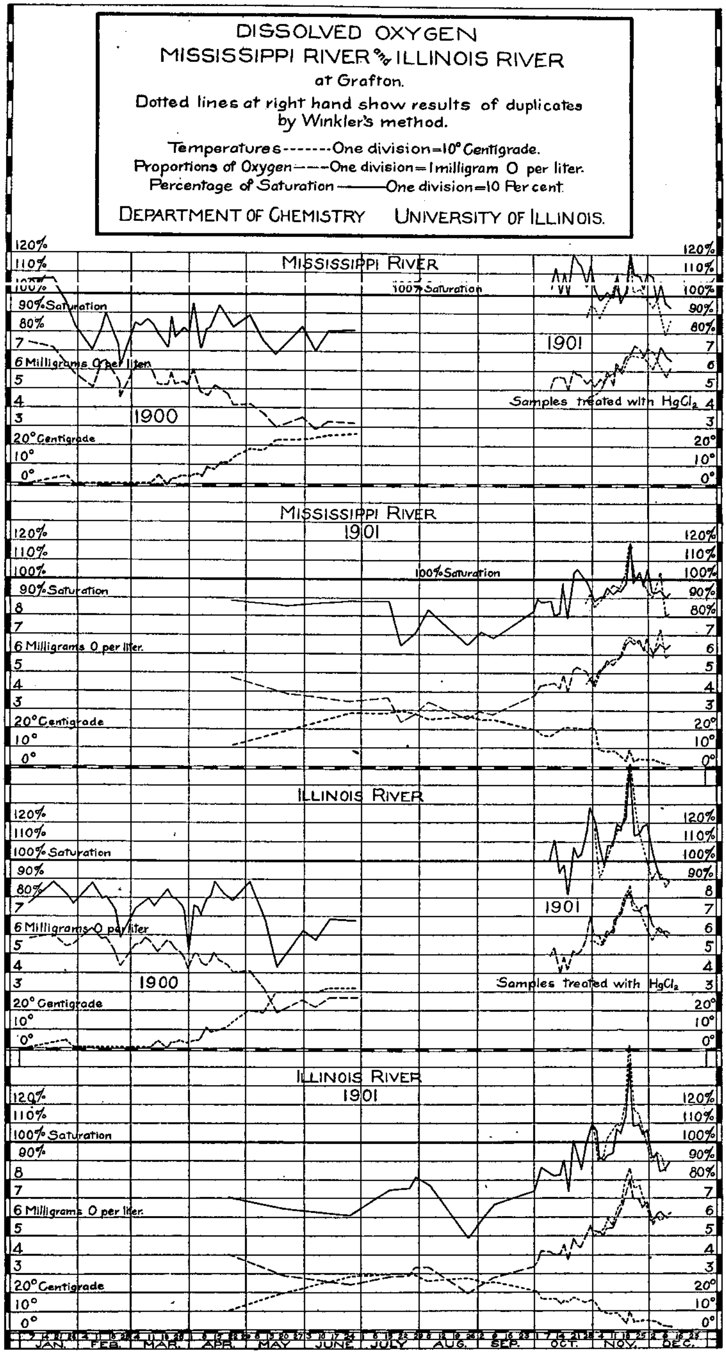

DISSOLVED OXYGEN
MISSISSIPPI RIVER and ILLINOIS RIVER
at Grafton.
Dotted lines at right hand show results of duplicates by Winkler's method.
Temperatures-------One division=10° Centigrade.
Proportions of Oxygen----One division=1 milligram O per liter.
Percentage of Saturation ——— One division=10 Per cent.
DEPARTMENT OF CHEMISTRY UNIVERSITY OF ILLINOIS.
MISSISSIPPI RIVER
1900
1901
Samples treated with $HgCl_2$
MISSISSIPPI RIVER 1901
ILLINOIS RIVER
1900
1901
Samples treated with $HgCl_2$
ILLINOIS RIVER 1901
100% Saturation
90% Saturation
6 Milligrams O per liter.
20° Centigrade
JAN. FEB. MAR. APR. MAY JUNE JULY AUG. SEP. OCT. NOV. DEC.

Diagram II.

rated with dissolved oxygen. Often both contain less than the saturation quantity. While the range is greater in the Illnois, the average is practically the same for both."

In determinations made in the laboratories of the State Water Survey, the method known as the Levy method* has been generally used. This method depends upon the oxidation of a solution of ferrous sulphate in an alkaline solution.

The results obtained are given in the table (pages 40-51), and shown in diagrams III and IV.

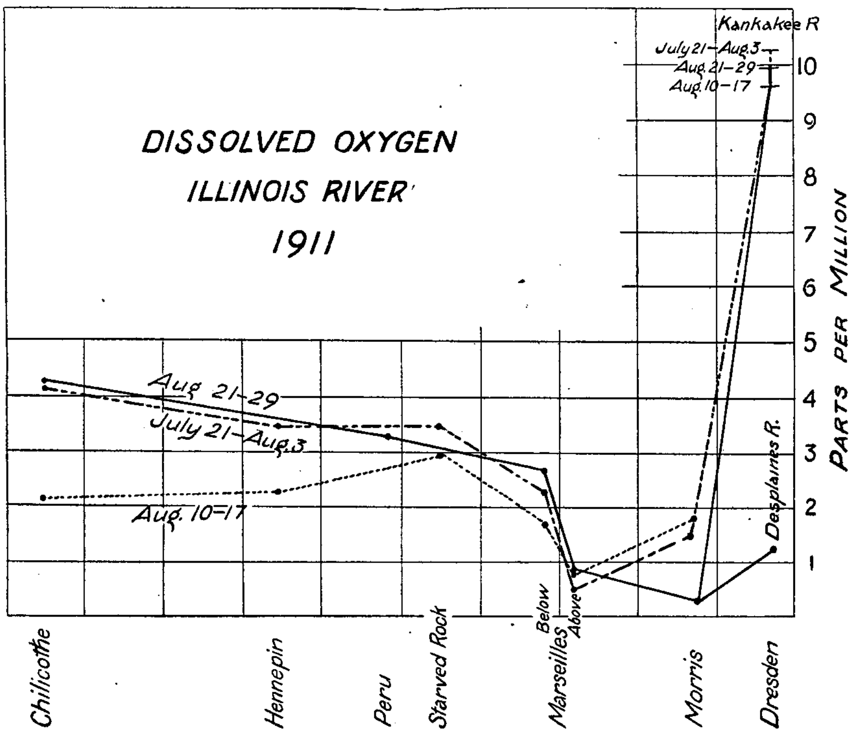


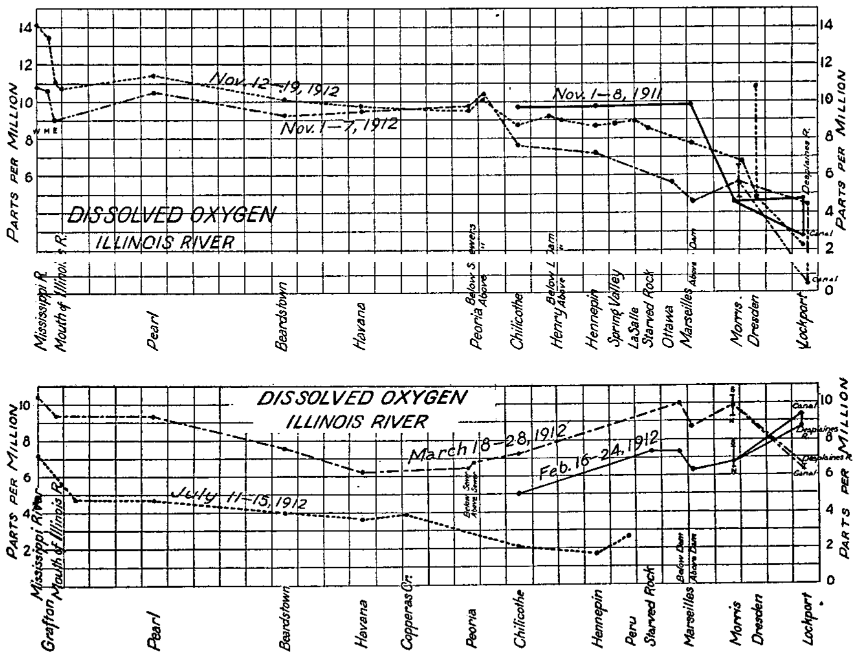
Diagram III.

The determinations made on the trip of July 11 to 15, 1912, show less than 3 parts per million of dissolved oxygen from La Salle to the beginning of Peoria Lake. The large amount of dissolved oxygen indicated between Hennepin and Henry is due to a sample taken from the mouth of Mud Lake and is not a thoroughly representative sample

*Ann. de L'Observatoire de Mont-Souris, 1883, et. Seq. Chem. Sur. of Waters of Ill., report for the years 1897-1902, 33.

of Illinois river water. Through Peoria Lake the amount of oxygen gradually increases to 8 parts per million. After receiving the sewage and manufacturing wastes of Peoria and Pekin there is a rapid decrease to below 2 parts per million, which again rises to 4½ parts per million below Beardstown and 7 parts per million at the mouth of Illinois river.

Results obtained on the trip of March 8 to 28, 1912, when the temperature of the water for the most part was near the freezing point, show larger amounts of oxygen. While the results are plotted as parts per million, the percentage of saturation is also greater than during



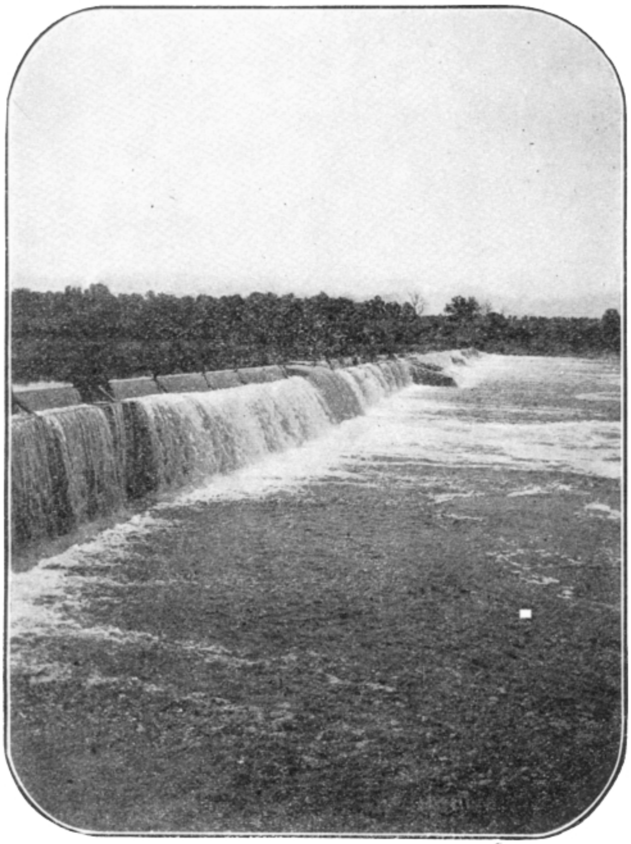
Diagrams IV and V.

the trip made in July. The most noticeable difference is the much greater amounts of oxygen at Morris, due probably to the slower oxidation at the low winter temperature. Tests made during July and August, 1911, over the stretch of the river from Morris to Chillicothe show a minimum of oxygen above the dam at Marseilles. After passing the dam there is a quick rise followed by a gradual increase as far as Chillicothe. Short trips during September and October, 1912, most of which cover the territory between Morris and Hennepin, show similar results, namely, increase in the oxygen after the passage over the dam, followed by slight increase farther down stream.

The results obtained by the Sanitary District and published in the report of their chief engineer, Mr. Wisner, are similar to those obtained by the State Water Survey.

The data obtained on two trips in November, 1912, show a gradual rise in dissolved oxygen content from Morris to Peoria, while the quantities from Peoria to Grafton varied but little.

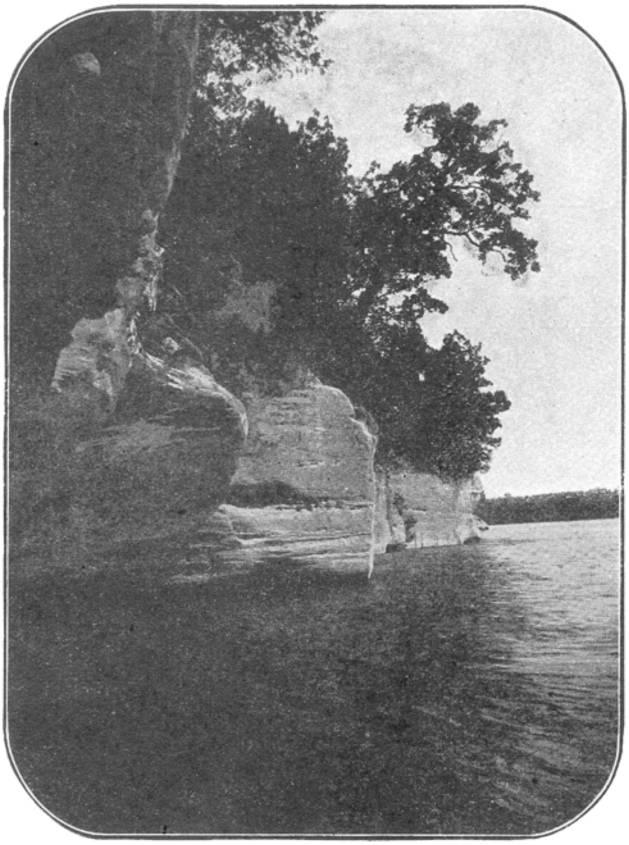
The mean temperature on the first trip, November 1 to 7, was



8.5° C., and on the second trip, November 12 to 19, was 6.3° C. The dissolved oxygen in parts per million averaged slightly lower in the first series than in the second, but as the temperatures were higher when the first series was made, the per cent saturation was about the same in both.

The effect of the Marseilles dam is not as marked in cold weather as it is during the summer months. The water above the dam contains much more oxygen in winter than in summer, for at low temperatures the decomposition is prolonged further down the river, consequently the water is not in condition to be greatly benefited by aeration over the dam.

The quantity of oxygen in Illinois river is larger in winter than



South Bank of Illinois River below Ottawa.

in summer, but the determinations made show it to be less than that in the Mississippi at Grafton.

The results thus far obtained show to some extent the effect of the Chicago sewage on Illinois river and the self-purification effected by the flow over dams and by sedimentation in Peoria Lake. Similar results have been obtained in other rivers, for example the Thames above, through, and below London; and by the Sudbury River in Massachusetts.*

Authorities differ as to the amount of oxygen required to support fish life. It is said that some fish require at least 2½ parts per million of dissolved oxygen. If this is so we would not expect fish at certain seasons above the Marseilles dam and at other seasons we might even expect to find them absent as far as Chillicothe. Professor Forbes' reports indicate an increase in the amount of fish-food and also an increase in the amount of fish below Peoria where dissolved oxygen below 3½ parts per million was not found. No fish are at present being taken from the river above Morris. They are still present in considerable quantities as far up as the Marseilles dam and in increased quantities on the lower stretches of the river. Some investigators claim that the toxins present in the water as a result of the decomposition of organic matter by bacteria are more dangerous to fish life than the lack of oxygen. There is certainly suggested a fertile field for further investigations.

*Sewage Disposal, Kinnicutt, Winslow and Pratt, pp. 24, 25.

TABLE OF DISSOLVED OXYGEN AND CARBON DIOXIDE, ILLINOIS RIVER AND RELATED WATERS, 1911 AND 1912

Water	Location	Date	Hour	Depth of Sample	Water Temp. C.	Water Temp. F.	Dissolved Oxygen, p.p.m.	Dissolved Oxygen, % sat'n.	Carbon Dioxide p.p.m.	Remarks
		1911								
Lake Mich	Chicago	July 18	12:00 m	3 ft	20.3	68.5	7.91	87.4	. . . .	39th St. pier
Lake Mich	Chicago	July 18	3:30 p	3 ft	21.4	70.5	9.25	103.6	. . . .	39th St. pier
Illinois R	Morris	July 22	10:00 a	5 ft	24.8	76.4	.30	3.4	. . . .	Midstream
Illinois R	Morris	July 22	1:30 p	5 ft	25.	77.	.26	3.1	. . . .	Midstream
Illinois R	Morris	July 22	4:00 p	5 ft	24.5	77.	.17	2.0	. . . .	Midstream
Illinois R	Morris	July 22	10:00 a	3 ft	24.5	77.	.04	0.5	. . . .	40 ft. from south bank
Illinois R	Morris	July 22	1:30 p	3 ft	25.	77.	.28	3.3	. . . .	40 ft. from south bank
Illinois R	Morris	July 22	4:00 p	3 ft	24.5	77.	.31	3.5	. . . .	40 ft. from south bank
Kankakee R	Dresden Hts	July 24	2:00 p	18 in	20.0	68.	9.91	107.9	. . . .	Midstream
Kankakee R	Dresden Hts	July 26	2:00 p	12 in	22.	72.	11.21	126.8	2.1	12ft. from east bank
Des Plaines R	Dresden Hts	July 27	10:00 a	5 in	20.	68.	1.25	13.6	12.8	At the dam
Des Plaines R	Dresden Hts	July 27	1:30 p	5 in	20.	68.	1.17	12.7	12.8	At the dam
Illinois R	Morris	July 28	7:30 a	5 in	20.	68.	1.24	13.5	8.2	Midstream
Illinois R	Morris	July 28	1:30 p	5 in	20.	68.	.91	9.9	14.1	Midstream
Illinois R	Marseilles	July 30	9:30 a	9 ft	21.	70.	.80	8.9	5.9	Midstream, above dam
Illinois R	Marseilles	July 30	9:30 a	18 in	21.	70.	.86	9.5	5.9	Midstream, above dam
Illinois R	Marseilles	July 31	10:00 a	18 in	21.6	71.2	2.64	29.9	5.8	¾ mile below dam; 8 ft. from shore
Illinois R	Peru	Aug. 2	8:30 a	18 in	21.9	71.8	3.20	36.	6.9	Above canal
Illinois R	Peru	Aug. 2	9:00 a	18 in	21.9	71.8	3.17	35.8	6.6	At bridge, south side
Illinois R	Peru	Aug. 2	1:30 p	18 in	22.	72.	3.51	39.6	. . . .	At bridge, south side
Illinois R	Chillicothe	Aug. 3	11:00 a	10.5 ft	24.4	76.8	4.29	50.4	5.9	¼ mile above landing
Illinois R	Chillicothe	Aug. 3	11:00 a	18 in	24.4	76.8	4.59	53.9	. . . .	¼ mile above landing
Illinois R	Chillicothe	Aug. 4	9:30 a	10.5 ft	24.4	76.8	3.71	43.6	6.	¼ mile above landing
Illinois R	Chillicothe	Aug. 4	9:30 a	18 in	24.5	77.	4.24	50.3	5.6	¼ mile above landing
Kankakee R	Dresden Hts	Aug. 10	10:30 a	18 in	26.	79.	8.67	105.9	.7	⅛ mile above mouth, 30 ft. from east bank
Kankakee R	Dresden Hts	Aug. 10	2:30 p	18 in	28.	83.	10.54	133.1	. . . .	Same location as above
Illinois R	Morris	Aug. 11	8:00 a	18 in	22.	72.	1.85	20.9	8.5	Midstream
Illinois R	Morris	Aug. 11	1:30 p	18 in	22.	72.	1.72	19.5	6.9	Midstream
Illinois R	Marseilles	Aug. 12	8:30 a	18 in	22.	72.	.98	11.	11.2	¼ mile above dam
Illinois R	Marseilles	Aug. 14	8:15 a	18 in	22.5	73.	.48	5.5	11.1	¼ mile above dam after heavy rain; river up 8 in.
Illinois R	Marseilles	Aug. 14	9:15 a	4 in	22.5	73.	1.65	18.9	8.7	¾ mile below dam; 3 ft. from bank
Illinois R	Starved Rock	Aug. 15	9:45 a	12 in	25.	77.	2.58	30.9	7.4	Near south side
Illinois R	Starved Rock	Aug. 15	1:00 p	12 in	25.	77.	2.62	31.4	. . . .	Near south side
Illinois R	Starved Rock	Aug. 15	10:45 a	12 in	25.	77.	3.18	38.	. . . .	Near north side
Illinois R	Starved Rock	Aug. 15	1:30 p	16 in	25.	77.	3.34	40.	7.3	Near north side
Illinois R	Hennepin	Aug. 16	9:30 a	18 in	25.5	78.	2.22	26.8	7.5	Midstream
Illinois R	Hennepin	Aug. 16	1:00 p	18 in	26.5	80.	2.27	28.	7.5	Midstream
Illinois R	Chillicothe	Aug. 17	9:00 a	18 in	26.	79.	2.33	28.4	6.7	Midstream
Illinois R	Chillicothe	Aug. 17	1:00 p	18 in	26.	79.	2.37	28.9	6.9	Midstream
Kankakee R	Dresden Hts	Aug. 21	10:30 a	18 in	23.	73.	8.47	97.6	. . . .	30 ft. from east bank
Kankakee R	Dresden Hts	Aug. 21	2:00 p	18 in	24.2	76.4	10.15	119.3	. . . .	30 ft. from east bank
Illinois R	Morris	Aug. 22	9:30 a	18 in	22.5	73.	13.7	15.7	6.7	Midstream

TABLE OF DISSOLVED OXYGEN AND CARBON DIOXIDE, ILLINOIS RIVER AND RELATED WATERS, 1911 AND 1912—Continued

Water	Location	Date	Hour	Depth of Sample	Water Temp. C.	Water Temp. F.	Dissolved Oxygen, p.p.m.	Dissolved Oxygen, % sat'n.	Carbon Dioxide, p.p.m.	Remarks
Illinois R......	Morris........	Aug. 23	8:00 a	18 in	22.6	73.2	1.47	17.	6.4	Midstream
Illinois R......	Marseilles.....	Aug. 24	8.15 a	18 in	21.7	71.4	.55	6.2	8.0	Midstream, above dam
Illinois R......	Marseilles.....	Aug. 25	12:15 p	18 in	21.	70.	.78	8.6	8.6	Midstream, above dam
Illinois R......	Marseilles.....	Aug. 24	9:00 a	9 in	21.5	71.	1.73	19.4	5.9	¾ mile below dam; 6 ft. from bank
Illinois R......	Marseilles.....	Aug. 25	1:00 p	9.in	21.2	70.4	2.80	31.	6.2	Below dam; 6 ft. from bank
Illinois R......	Starved Rock..	Aug. 26	9:15 a	9 in	21.	70.	3.07	34.	5.8	South side
Illinois R......	Starved Rock...	Aug. 26	10:30 a	12 in	21.5	71.	3.72	41.7	5.4	North side
Illinois R......	Starved Rock...	Aug. 26	12:30 p	12 in	22.	72.	3.87	43.8	5.5	North side
Illinois R......	Hennepin......	Aug. 28	9:30 a	18 in	22.	72.	3.28	37.1	6.4	Midstream
Illinois R......	Hennepin......	Aug. 28	2:00 p	18.in	23:2	74.4	3.62	41.7	6.0	Midstream
Illinois R......	Hennepin......	Aug. 28	9:45 a	18 in	22.	72.	3.50	39.8	6.4	50 ft. from east bank
Illinois R......	Hennepin......	Aug. 28	2:15 p	18 in	23.5	75.	3.50	40.7	6.8	50 ft. from east bank
Illinois R......	Chillicothe.....	Aug. 29	9:30 a	18 in	22.5	73.	3.95	45.1	6.3	Midstream
Illinois R......	Chillicothe.....	Aug. 29	3:00 p	18 in	22.8	73.6	4.28	49.4	6.1	Midstream
Illinois R......	Chillicothe.....	Aug. 29	12:00 m	18 in	....	....	4.60	....	4.9	East side of island
Illinois R......	Morris.......	Aug. 31	8:30 a	18 in	20.	68.	1.05	11.4	....	Midstream
Illinois R......	Morris.......	Aug. 31	1:30 p	18 in	22.	72.	1.18	13.3	7.4	Midstream
Illinois R......	Morris.......	Aug. 31	8:30 a	1 in	20.8	69.6	3.5	38.9	7.2	4 in. deep near shore; over Stigeoclonium
Illinois R......	Morris.......	Aug. 31	1:30 p	1 in	22.3	72.6	6.1	69.	4.2	4 in. deep near shore; over Stigeoclonium
Illinois R......	Marseilles.....	Sept. 1	8:30 a	18 in	21.	70.	.58	6.4	7.4	Above dam
Illinois R......	Marseilles.....	Sept. 1	9:15 a	6 in	21.2	70.4	5.90	65.4	5.8	⅛ mile below dam
Illinois R......	Ottawa.......	Sept. 2	11:30 a	6 in	23.	73.	4.75	54.8	....	Near south shore, above Fox; water 2 ft. deep
Illinois R......	Ottawa.......	Sept. 2	1:45 p	6 in	23.7	75.4	5.50	64.6	4.6	Near south shore, above Fox; water 2 ft. deep
Illinois R......	Ottawa.......	Sept. 2	2:45 p	6 in	23.8	75.6	5.82	68.4	4.2	Near south shore, above Fox; water 2 ft. deep
Illinois R......	Ottawa.......	Sept. 2	3:40 p	6 in	23.7	75.4	5.70	70.	4.35	Near south shore, above Fox; water 2 ft. deep
Illinois R......	Ottawa.......	Sept. 2	4:30 p	6 in	23.7	75.4	5.42	63.7	4.7	Near south shore, above Fox; water 2 ft. deep
Illinois R......	Ottawa.......	Sept. 2	5:30 p	6 in	23.7	75.4	4.87	56.9	5.5	Near south shore, above Fox; water 2 ft. deep
Illinois R......	Morris.......	Sept. 8	2:00 p	18 in	.....	....	.70	.....	....	Midstream
Illinois R......	Morris.......	Sept. 9	7:30 a	18 in	.....	....	.50	.....	....	Midstream
Illinois R......	Morris.......	Sept. 9	1:30 p	18 in	.....	....	.68	.....	....	Midstream
Illinois R......	Depue.......	Sept. 11	11:15 a	18 in	22.5	73.	2.65	30.3	7.16	Above outlet of lake
Depue L......	Depue.......	Sept. 11	2:00 p	18 in	24.8	77.6	12.92	155.	....	Middle of lake
Illinois R......	Morris.......	Sept. 13	7:30 a	18 in	20.8	69.6	2.03	21.4	....	Near south bank
Illinois R......	Morris.......	Sept. 13	11:00 a	18 in	21.2	70.4	.88	9.7	....	Near north bank
Ill. M.C.......	Morris.......	Sept. 12	5:00 p	18 in	.....	....	6.80	.....	....	
Drainage C....	Lockport.....	Nov .1	10:00 a	2 ft		50.	2.5 2.5	22.1 22.1		East bank of canal

TABLE OF DISSOLVED OXYGEN AND CARBON DIOXIDE, ILLINOIS RIVER AND RELATED WATERS, 1911 AND 1912—Continued

Water	Location	Date	Hour	Depth of Sample	Water Temp. C.	Water Temp. F.	Dissolved Oxygen, p.p.m.	Dissolved Oxygen, % sat'n.	Remarks
Des Plaines R. . . .	Lockport	Nov. 2	10:00 a	10 in		51.	5.2	46.	Near east bank; water 1 foot deep
							4.7	42.	
Illinois R.	Morris	Nov. 3	9:00 a	2 ft		41.	3.6	28.1	
							3.7	28.9	Midstream
Illinois R.	Morris	Nov. 3	2:00 p				5.5		
							5.6		Probably farther from north bank
Illinois R.	Morris	Nov. 3	9:00 a	2 ft			10.8	84.4	Near north bank
Illinois R.	Marseilles	Nov. 4	9:00 a	2 ft		43.	10.	80.6	Above dam
Illinois R.	Hennepin	Nov. 7	8:30 a	2 ft		46.	9.8	82.3	
							9.7	81.5	Midstream
Illinois R.	Chillicothe	Nov. 8	10:00 a	2 ft		45.	10.2	84.4	
							10.1	83.6	Midstream
Illinois R.	Morris	1912 Feb. 16	10:00 a		2.	35.6	7.2	51.9	South shore
			3:00 p		1.	33.8	7.6	53.2	
							7.5	52.5	
Illinois R.	Morris	Feb. 16	10:00 a	2 ft	2.	35.6	7.2	51.9	
			3:00 p		1.	33.8	6.9	48.3	Center of channel
							6.8	47.6	
Illinois R.	Morris	Feb. 16	10:00 a	8ft	2.	35.6	7.2	51.9	Center of channel
			3:00 p		1.	33.8	6.3	44.1	
Illinois R.	Morris	Feb. 16	10:00 a		2.	35.6	6.6	47.5	North shore
			3:00 p		1.	33.8	6.3	44.1	
Des Plaines R. . . .	Lockport	Feb. 17			1.5	34.7	8.6	61.2	
							8.9	63.3	
Drainage C.	Lockport				1.	33.8	9.4	65.8	
							9.2	64.4	
Kankakee R.		Feb. 19			.5	32.9	9.	62.	
							9.1	62.7	
Illinois R.	Marseilles	Feb. 20			3.	37.4	6.3	46.7	South shore, above dam
Illinois R.	Marseilles	Feb. 20			3.	37.4	5.9	43.7	Center of channel
Illinois R.	Marseilles	Feb. 22			.5	32.9	7.1	48.3	North shore
Illinois R.	Marseilles	Feb. 22			.5	32.9	7.3	49.6	Below dam
Illinois R.	Starved Rock . .	Feb. 23			.5	32.9	7.3	50.4	
Illinois R.	Chillicothe	Feb. 24			2.	35.6	5.	36.	
Des Plaines R. . . .	Lockport	Mar. 18			2.5	36.5	6.5	47.5	
Drainage C.	Lockport	Mar. 18			3.	37.4	6.3	46.7	
Illinois R.	Morris	Mar. 19			1.5	34.7	10.4	73.8	South shore
Illinois R.	Morris	Mar. 19			1.5	34.7	9.2	65.4	North shore
Illinois R.	Marseilles	Mar. 21			0.0	32.	8.8	59.8	Above dam
Illinois R.	Marseilles	Mar. 21			0.0	32.	10.	68.	Below dam
Illinois R.	Chillicothe	Mar. 22			0.0	32.	7.2	49.	
Illinois R.	Peoria	Mar. 23			0.0	32.	6.8	46.3	Above sewer outlet
Illinois R.	Peoria	Mar. 23			0.0	32.	6.5	44.2	Below sewer outlet

TABLE OF DISSOLVED OXYGEN AND CARBON DIOXIDE, ILLINOIS RIVER AND RELATED WATERS, 1911 AND 1912—Continued

Water	Location	Date	Hour	Depth of Sample	Water Temp. C.	Water Temp. F.	Dissolved Oxygen, p.p.m.	Dissolved Oxygen, % sat'n.	Remarks
Illinois R.	Havana	Mar. 25			2.	35.6	6.2	44.6	
Illinois R.	Beardstown	Mar. 26			1.5	34.7	7.7	54.7	
Illinois R.	Pearl	Mar. 27			2.	35.6	9.3	67.	
Illinois R.	Grafton	Mar. 28			3.	37.4	9.4	69.7	
Mississippi R.	Grafton	Mar. 28			3.	37.4	10.5	77.8	
Ill.-Miss. C.		July 11	8:00 a		25.	77.	4.3	51.2	At junction with Illinois River
Illinois R.	Peru	July 11			25.	77.	2.7	32.2	
Illinois R.	Spring Valley	July 11	9:00 a		25.	77.	2.		
							1.9	23.3	
Illinois R.	Marquette	July 11	9:30 a		25.	77.	1.4		
							1.6	17.9	
					25.	77.	1.4		Opposite Ill.-Miss. Canal
Illinois R.							1.5	17.3	
Ill.-Miss. Canal L. L.					28.	83.	5.2	65.7	
Illinois R.	Hennepin	July 11	10:45 a		25.	77.	1.8	21.5	
Illinois R.	Twin Sister Islands	July 11	11:15 a		26.	79	2.3		
							2.2	27.4	
Mud Lake		July 11			26.	79.	7.70	93.8	1,000 ft. from Ill. River
Illinois R.		July 11			26.	79.	7.80	94.8	Mouth of Mud Lake
Illinois R.		July 11			26.	79.	2.60	31.6	½ mile below Mud Lake
Illinois R.	Henry	July 11	12:30 p		26.	79.	2.1		Above dam
							2.5	28.	
Illinois R.	Henry	July 11			26.	79.	2.4	29.2	Below dam
Illinois R.	Lacon	July 11	2:00 p		28.	83.	2.1		
							2.3	27.8	
Illinois R.		July 11	2:30 p		28.	83.	2.7	34.1	Opposite Babb's Slough
Illinois R.	Chillicothe	July 11			28.	83.	2.5	31.6	East bank; cross section
Illinois R.	Chillicothe	July 11			28.	83.	2.7		Middle cross section
							3.	36.	
Illinois R.	Chillicothe	July 11			28.	83.	2.8	35.4	West bank; cross section
Illinois R.	Chillicothe	July 12	9:15 a		25.	77.	2.		
							2.1	23.9	
Illinois R.		July 12			25.	77.	1.9	22.7	Opposite entrance to Peoria Lake
Illinois R.		July 12	10:00 a		25.	77.	4.5	53.9	East bank, below Partridge Island.
Illinois R.		July 12			25.	77.	2.		Middle, below Partridge Island
							2.1	23.9	
Illinois R.		July 12	10:15 a		25.	77.	1.7	20.3	West bank, below Partridge Island
Illinois R.		July 12			25.	77.	3.2	38.2	Opposite Spring Bay
Illinois R.		July 12			25.	77.	5.3		
							5.4	62.	West bank, below Horse Haw Slough

TABLE OF DISSOLVED OXYGEN AND CARBON DIOXIDE, ILLINOIS RIVER AND RELATED WATERS, 1911 AND 1912—Continued

Water	Location	Date	Hour	Depth of Sample	Water Temp. C.	Water Temp. F.	Dissolved Oxygen, p.p.m.	Dissolved Oxygen, % sat'n.	Remarks
Illinois R		July 12			25.	77.	3.7	44.2	Middle, below Horse Haw Slough
Illinois R	Peoria Hts.	July 12	12:00 m		25.	77.	4.3		
							4.5	52.5	
Illinois R	Averyville.	July 12			26.	79.	6.9		East bank, cross section
							6.8	83.4	
Illinois R	Averyville.	July 12			26.	79.	5.3	64.5	Middle; cross section
Illinois R	Averyville.	July 12			26.	79.	5.9	71.8	West bank; cross section
Illinois R	Peoria.	July 12	3:00p		26.	79.	7.2		West bank, foot of Liberty St.
							7.0	86.4	
Illinois R	Peoria.	July 12			27.	81.	8.1		Middle, foot of Liberty St.
							7.8	98.6	
Illinois R	Wesley.	July 12			27.	81.	7.		
							6.7	85.	
Illinois R	Pekin.	July 12			27.	81.	5.4	67.	Below highway bridge
Illinois R	Pekin.	July 12			27.	81.	6.4	79.3	East bank; public landing
Illinois R	Pekin.	July 12			27.	81.	6.6		Below all distilleries
							6.5	81.2	
Illinois R	Pekin.	July 12			27.	81.	6.1	75.6	At point of dung discharge
Illinois R		July 12			27.	81.	5.6	69.4	Between Pekin and Mackinaw River
Illinois R		July 13	5:00 p		27.	81.	5.2	64.4	Above Mackinaw River
Illinois R		July 13			27.	81.	5.4	67.	Below Mackinaw River
Illinois R		July 13	7:45 a		26.	79.	5.3	64.5	Above Mackinaw River
Illinois R	Kingston Mines	July 13			26.	79.	4.1		Opposite the town
							4.6	52.3	
Illinois R		July 13				79.	3.6		At 141-mile Point
					26.		3.3	42.	
Illinois R	Copperas Creek	July 13				79.	3.8		Above dam
					26.		4.	47.4	
Illinois R	Copperas Creek	July 13			26.	79.	3.7	45.	Below the dam
Illinois R	Liverpool	July 13	10:15 a		27.	81.	3.6	44.6	
Illinois R		July 13			29.	85.	4.6		Above Spoon River
							4.9	61.1	
Spoon R.		July 13			28.	83.	5.7		At mouth
							5.6	71.3	
Illinois R		July 13			27.	81.	3.7	45.9	Below Spoon River
Illinois R	Havana.	July 13	11:30 a		27.	81.	3.6		Middle
							3.7	45.2	
Illinois R	Grand Island. .	July 13		6 ft	29.	85.	3.3	42.5	Above
Illinois R	Grand Island. .	July 13		2 ft	29.	81.	3.4		
							3.6	45.	Above
Illinois R	Grand Island. .	July 13			28.	83.	4.9		Below
							4.7	60.6	
Illinois R	Sharp's Lrdg.	July 13			27.	81.	4.7		
							4.4	56.4	
Illinois R		July 13			27.	81.	6.2		At Panther Slough
							5.9	76.2	
Illinois R		July 13			27.	81.	6.2		Below Island
							6.3	77.4	

TABLE OF DISSOLVED OXYGEN AND CARBON DIOXIDE, ILLINOIS RIVER AND RELATED WATERS, 1911 AND 1912—Continued

Water	Location	Date	Hour	Depth of Sample	Water Temp. C.	Water Temp. F.	Dissolved Oxygen, p.p.m.	Dissolved Oxygen, % sat'n.	Remarks
Illinois R............	Browning	July 13	4:30 p		27.	81.	3.8	47.1	
Illinois R............		July 13	5:00 p		27.	81.	3.7		Opposite Big Lake
							3.6	45.2	
Illinois R............	Beardstown....	July 13	5:30 p		29.	85.	3.7	47.6	West bank; cross section
Illinois R............	Beardstown....	July 13			28.	83.	4.8	50.6	Middle; cross section
Illinois R............	Beardstown....	July 13			28.	83.	5.3	67.	East bank; cross section
Illinois R............	Beardstown....	July 14	8:10 a		27.	81.	4.2	52.	One mile below
Illinois R............		July 14	8:45 a		27.	81.	3.8	47.1	One mile below Crooked Creek
Illinois R............	LaGrange	July 14			28.	83.	3.8		Above dam
							3.7	47.4	
Illinois R............	LaGrange	July 14	9:45 a		28.	83.	4.6		Below dam
							4.5	58.1	
Illinois R............	Meredosia	July 14	10:30 a		28.	83.	4.6		
							4.4	56.8	
Illinois R............	Naples	July 14	11:15 a		27.	81.	4.4	54.6	
Illinois R............	Valley City.....	July 14			27.	81.	4.7	58.3	
Illinois R	Florence	July 14	12:30 p		28.	83.	4.6		
							4.7	58.7	
Illinois R............	Bedford	July 14	1:15 p		29.	85.	4.6	59.2	
Illinois R............	Pearl	July 14			30.	86.	4.7		
							4.8	62.2	
Illinois R............	Kampsville	July 14	3:30 p		30.	86.	4.3	56.4	Above dam
Illinois R............	Kampsville.....	July 15	8:00 a		28.	83.	4.3	54.3	Above dam
Illinois R............	Kampsville.....	July 15	8:30 a		28.	83.	4.6	58.1	Below dam
					29.	85.	4.6		At head of Diamond Island
							4.7	59.8	
Illinois R............	Hardin	July 15	9:30 a		29.	85.	4.7	60.5	
Illinois R............		July 15	10:15 a		29.	85.	4.8		Above 12-mile Island
							4.7	60.5	
Mississippi R.....	Grafton...........	July 15	11:45 a		29.	85.	4.8		East bank; cross section
							4.9	62.4	
Mississippi R.....	Grafton...........	July 15			29.	85.	7.1		Middle; cross section
							7.2	92.	
Mississippi R.....	Grafton...........	July 15	12:00 m		29.	85.	7.6		West bank; cross section
							7.7	98.5	
Des Plaines R....	Lockport.........	Aug. 6	1:00 p	12 in	24.	76.	12.1	142.	Midstream; river very shallow
Drainage C	Lockport.........	Aug. 6	8:00 p		22.5	73.	.5	5.	South side
Kankakee R.......	Dresden Hts...	Aug. 7	10:00 a		21.5	71.	9.5	10.7	Cloudy; shore sample
Des Plaines R....	Dresden Hts...	Aug. 7	11:00 a		22.	72.	2.1	24.	Cloudy; shore sample
Illinois R............	Morris.............	Aug. 8	7:00 a		20.5	69.	4.5	50.	South side; 30 ft. from bank
Illinois R............	Morris	Aug. 8	8:00 a		21.5	71.	2.1	23.	Midstream
Illinois R............	Morris.............	Aug. 8	9:00 a		22.	72.	.8	9.	North side; 30 ft. from bank
Illinois R............	Marseilles.......	Aug. 8	2:00 p		23.5	75.	1.9	22.	Midstream; above dam
Illinois R............	Marseilles.......	Aug. 8	12:00 m		23.5	75.	4. 4	51.	Below dam
Illinois R............	Marseilles.......	Aug. 21	1:30 p		23.	73.	1.9	21.9	Midstream; above dam
							1.8	20.8	
Illinois R	Marseilles.......	Aug. 21	2:30 p		23.	73.	1.6	18.5	South side
							1.5	17.3	

TABLE OF DISSOLVED OXYGEN AND CARBON DIOXIDE, ILLINOIS RIVER AND RELATED WATERS, 1911 AND 1912—Continued

Water	Location	Date	Hour	Depth of Sample	Water Temp. C.	Water Temp. F.	Dissolved Oxygen, p.p.m.	Dissolved Oxygen, % sat'n.	Remarks
Illinois R.	Marseilles	Aug. 21			23.	73.	1.7 1.8	19.6 20.8	North side
Illinois R.	Marseilles	Aug. 21	4:30 p		23.	73.	2.9	33.5	Below dam
Illinois R.	Ottawa	Aug. 22	3:00 p		23.	73.	3.9 4.	45. 46.2	South side; above Fox River
Illinois R.	Ottawa	Aug. 22			23.	73.	3.4 3.3	39.2 38.1	North side
Illinois R.	Starved Rock	Aug. 22	10:00 a		23.	73.	3.5 3.4	40.4 39.2	North shore
Illinois R.	Starved Rock	Aug. 22 Aug. 22			23.	73.	3.7 3.6	42.7 41.5	South shore
Illinois R.	Hennepin	Sept. 6	11:00 a		26.	79.	2.4 2.2 2.3	29.3 26.8 28..	Midstream
Illinois R.	Starved Rock	Sept. 6	5:00 p		26.	79.	2.4 2.5	29.3 30.5	South shore
Illinois R.	Starved Rock	Sept. 6	5:30 p		26.	79.	2.7 2.6 2.8	32.9 31.7 34.1	North shore
Illinois R.	Chillicothe	Sept. 7	9:00 a		26.5	80.	2.7 2.6 2.7	33.3 32.1 33.3	Midstream
Des Plaines R.		Sept. 26	10:00 a		18.	65.	1.1 1.	11.6 10.4	Just above junction with Kankakee
Kankakee R.		Sept. 26	11:00 a		16.	61.	10.5 10.3	105.6 103.6	Just above junction with Des Plaines
Illinois R.	Morris	Sept. 27	10:00 a		17.	63.	1.8 1.7	18.4 17.4	Midstream
Illinois R.	Morris	Sept. 27	10:00 a		17.	63.	3.7 3.6	37.9 36.8	South side
Illinois R.	Morris	Sept. 27	10:30 a		17.	63.	1.8 1.7	18.4 17.4	North side
Illinois R.	Marseilles	Sept. 27	1:30 p		17.	63.	2.1 2.3	21.5 23.6	Above dam
Illinois R.	Marseilles	Sept. 27	3:00 p		17.	63.	*A*4.3 4.4 *B*3.8	44.1 45.1 39.	Below dam
Illinois R.	Starved Rock	Sept. 28	8:30 a		17.	63.	5.3 5.1	54.3 52.3	North shore
Illinois R.	Starved Rock	Sept. 28	8:00 a		16.	61.	4.8 4.6	48.3 46.3	South shore
Illinois R.	Marseilles	Oct. 11	10:30 a		16.	61.	1. .9	10.1 9.	Above dam; midstream
Illinois R.	Starved Rock	Oct. 11	2:30 p		16.	61.	3.5 3.4 3.6	35.2 34.2 36.2	South shore

(NOTE.—These samples below dam are very unsatisfactory, as they were taken from shore near algae.)

TABLE OF DISSOLVED OXYGEN AND CARBON DIOXIDE, ILLINOIS RIVER AND RELATED WATERS, 1911 AND 1912—Continued

Water	Location	Date	Hour	Depth of Sample	Water Temp. C.	Water Temp. F.	Dissolved Oxygen, p.p.m.	Dissolved Oxygen, % sat'n.	Remarks
Illinois R........	Starved Rock..	Oct. 11	3:00 p		16.	61.	4.8	48.2	North shore
							4.7	47.2	
Illinois R........	Hennepin......	Oct. 12	10:00 a		15.	59.	5.5	54.2	Midstream
							5.6	55.2	
Illinois R........	Chillicothe.....	Oct. 24	9:30 a		12.	54.	6.5	60.	Midstream
							6.4	59.1	
							6.3	58.2	
Illinois R........	Hennepin......	Oct. 24	4:30 p		12.	54.	6.3	58.2	Midstream
							6.5	60.	
							6.4	59.1	
Illinois R........	Chillicothe.....	Oct. 25	2:00 p		12.	54.	6.	55.4	Midstream
							6.2	58.2	
Illinois R........	Starved Rock..	Oct. 26	9:30 a		10.5	51.	6.1	54.5	North side
							6.2	55.4	
Illinois R........	Starved Rock..	Oct. 26	10:00 a		11.	52.	5.	45.1	South side
Drainage C......	Lockport......	Nov. 1	5:00 p		9.	49.	.4	3.5	9th St. bridge
Des Plaines R....	Lockport......	Nov. 1	5:30 p		9.	49.	4.5		
							4.6	38.8	9th St. bridge
Illinois R........	Morris........	Nov. 2	7:30 a		9.	49.	4.8	41.4	North side
Illinois R........	Morris........	Nov. 2			9.	49.	6.5	56.	South side
Illinois R........	Marseilles.....	Nov. 2	10:00 a		9.	49.	4.7		Above dam
							4.6	39.9	
Fox R..........	Ottawa........	Nov. 2	2:30 p		6.5	44.	10.8		
							11.1		
							11.	81.4	
Illinois R........	Ottawa........	Nov. 2	3:30 p		9.	49.	5.8		Above Fox River
							5.7	49.1	
Illinois R........	Hennepin......	Nov. 3	10:00 a		8.	47.	7.2		
							7.	60.1	
Illinois R........	Chillicothe.....	Nov. 3	2:30 p		8.	47.	7.6		
							7.8	64.8	
Illinois R........	Peoria........	Nov. 4	8:00 a		8.	47.	10.6		Above sewer outfalls
							10.3	88.3	
Illinois R........	Peoria........	Nov. 4	10:00 a		8.	47.	9.5		Below all distilleries and sewers
							9.6		
							9.7	80.8	
Illinois R........	Havana......	Nov. 4	2:00 p		8.	47.	9.7		
							9.6		
							9.4	80.8	
Illinois R........	Beardstown...	Nov. 5	9:30 a		8.	47.	9.5		
							9.1		
							9.4	78.5	
Illinois R........	Pearl........	Nov. 6	1:30 p		9.	49.	10.7		
							10.4	90.6	
Illinois R........	Grafton......	Nov. 7	11:00 a		9.	49.	9.		At mouth
							9.1	77.9	
Mississippi R....	Grafton......	Nov. 7	12:00 m		9.	49.	10.6		Above mouth of Illinois
							10.9	92.1	
Chicago R.......	Chicago......	Nov. 12	9:00 a		11.	52.	9.9		
							10.1	90.2	Halsted and 39th Sts.

TABLE OF DISSOLVED OXYGEN AND CARBON DIOXIDE, ILLINOIS RIVER AND RELATED WATERS 1911 AND 1912—Continued

Water	Location	Date	Hour	Depth of Sample	Water Temp. C.	Water Temp. F.	Dissolved Oxygen, p.p.m.	Dissolved Oxygen, % sat'n.	Remarks
Chicago R.	Chicago.	Nov. 12	9:30 a		11.	52.	9.7	87.5	"Forks," east and west forks of south arm of south branch of Chicago River
Chicago R.	Chicago.	Nov. 12	9:45 a		11.	52.	5.4	48.7	Bridgeport, south arm at junction with south branch of Chicago River.
Ogden Ditch.	Chicago.	Nov. 12	10:00 a		10.5	51.	8.9	79.5	At Western Avenue
	Chicago.	Nov. 12	11:30 a		10.	50.	8.8	75.9	South Branch at Loomis Street
	Chicago.	Nov. 12	12:00 m		9.5	50.	10.6	92.3	South branch at Van Buren St.
Lake Mich.	Chicago.	Nov. 12	12:30 p		9.	49.	12.4 12.1	105.2	Opposite U. S. Life Saving Station
	Chicago.	Nov. 12	1:00 p		10.3	50.6	6.7	59.9	North branch, Chicago Avenue
	Chicago.	Nov. 12	1:00 p		10.	50.	8.9	88.7	North branch, North Avenue
	Chicago.	Nov. 12	1:15 p		10.5	51.	10. 9.8	87.7	North branch, Diversey Blvd.
	Chicago.	Nov. 12	1:30 p		10.	50.	10.	87.1	North branch, ½ mile below Lawrence Avenue
Drainage C.	Chicago.	Nov. 13	12:00 m		11.	52.	7.	63.1	Kedzie Avenue
Drainage C.	Summit.	Nov. 13	1:00 p		10.	50.	7.	62.	Santa Fe bridge.
Drainage C.	Willow Springs	Nov. 13	1:30 p		10.	50.	5.	44.3	
Drainage C.	Lemont.	Nov. 13	2:00 p		10.	50.	3.1	27.4	
Drainage C.	Lockport.	Nov. 13	3:00 p		10.	50.	2.2	19.5	9th St. bridge
Drainage C.	Lockport.	Nov. 13	3:30 p		10:	50.	2.8	24.7	At locks
Illinois R.	Morris.	Nov. 14	7:30 a		8.	47.	6.5	54.6	North side
Illinois R.	Morris.	Nov. 14	7:30 a		8.	47.	6.8	57.2	Midstream
Illinois R.	Morris.	Nov. 14	7:30 a		8.	47.	8.7	73.1	South side
Mazon C.		Nov. 14	7:30 a		9.	49.	8.2	70.8	At mouth
Illinois R.		Nov. 14	8:00 a		8.5	48.	6.2	53.	Kinney's Island
Illinois R.		Nov. 14	8:00 a		8.5	48.	5.4	46.2	Perry's Island, north side
Illinois R.		Nov. 14	8:30 a		8.	47.	6.1	51.3	Perry's Island, midstream
Illinois R.		Nov. 14	8:30 a		8.	47.	9.5	80.	Perry's Island, south side
Au Sable C.		Nov. 14	9:00 a		5.5	42.	10.6	83.9	At mouth
Illinois R.		Nov. 14	9:30 a		7.	45.	4.5	36:9	At E. J. & E. R. R. bridge
Illinois R.	Dresden Hts. . . .	Nov. 14	11:00 a		7.	45.	4.6	37.7	North side
Illinois R.	Dresden Hts. . . .	Nov. 14	11:00 a		6.	43.	11.3	90.5	South side
Des Plaines R	Dresden Hts. . . .	Nov. 14	11:00 a		7.	45.	4.9	40.3	At mouth
Kankakee R.	Dresden Hts. . . .	Nov. 14	11:00 a		6.	43.	11. 10.8	87.2	At mouth
Illinois R.	Marseilles.	Nov. 14	4:00 p		8.	47.	7.7 8.	66.4	Above dam
Ill. and Mich. C. .	LaSalle.	Nov. 15	9:00 a		4.5	40.	11.6 11.5	77.1	Lowest lock
Ill. and Mich. C. .	LaSalle.	Nov. 15	9:15 a		4.5	40.	9.7	74.9	At mouth
Illinois R.	Starved Rock. . .	Nov. 15	9:30 a		5.5	42.	8.6	68.1	Above Vermilion River
Vermilion R.		Nov. 15	9:45 a		4.5	40.	12.5 12.7	97.1	At mouth
Illinois R.	LaSalle.	Nov. 15	10:00 a		5.5	42.	9. 8.9	70.7	Highway bridge, 1 mile below Vermilion River
Illinois R.	Peru.	Nov. 15	11:00 a		6.	43.	8.8 9.	71.3	

TABLE OF DISSOLVED OXYGEN AND CARBON DIOXIDE, ILLINOIS RIVER AND RELATED WATERS, 1911 AND 1912—Continued

Water	Location	Date	Hour	Depth of Sample	Water Temp. C.	Water Temp. F.	Dissolved Oxygen, p.p.m.	Dissolved Oxygen, % sat'n.	Remarks
Illinois R.	Spring valley. .	Nov. 15	11:30 a		6.	43.	9. 8.9	71.3	
Illinois R.	Marquette.	Nov. 15	12:15 p		6.	43.	9.1	72.8	
Hennepin C.		Nov. 15	12:45 p		7.	45.	13.1 13.	106.	At lowest lock
Illinois R.		Nov. 15	1:00 p		6.	43.	9. 8.9	71.3	At mouth of Hennepin Canal
Illinois R.	Hennepin.	Nov. 15	2:30 p		6.5	44.	8.7 8.8	70.7	
Illinois R.		Nov. 15	3:00 p		6.5	44.	8.5 8.7	69.9	Twin Sister Island
Mud Lake.		Nov. 15	3:30 p		5.5	42.	12.9	102.	1,000 ft. from Illinois River
Illinois R.		Nov. 15	3:30 p		6.5	44.	8.8 8.6	70.8	Opposite Mud Lake
Illinois R.	Henry.	Nov. 15	4:00 p		6.5	44.	8.9 9.1	73.3	Above dam
Illinois R.	Henry.	Nov. 15	4:00 p		7.	45.	9.1 9.2	64.7	Below dam
Illinois R.	Henry.	Nov. 16	10:00 a		5.5	42.	8.7	69.	Opposite wharf
Illinois R.	Lacon.	Nov. 16	11:15 a		5.5	42.	8.5	67.3	
Illinois R.	Lacon.	Nov. 16	12:00 m		6.5	44.	8.9	72.3	Opposite Babb's Slough
Illinois R.	Chillicothe. . . .	Nov. 16	1:15 p		6.5	44.	8.9 8.6	70.9	
Illinois R.	Peoria.	Nov. 16	1:30 p		6.5	44.	9.2 9.1	74.	North end of Peoria Lake
Peoria L.	Peoria.	Nov. 16	1:30 p		6.5	44.	9.2	74.8	Partridge Island, west side
Peoria L.	Peoria.	Nov. 16	1:45 p		6.5	44.	9.7 9.2	75.5	Partridge Island, middle
Peoria L.	Peoria.	Nov. 16	2:00 p		6.5	44.	10.2	82.9	Partridge Island, east side
Peoria L.	Peoria.	Nov. 16	2:30 p		6.5	44.	9.8 9.6	78.9	Opposite Spring Bay
Peoria L.	Peoria.	Nov. 16	3:00 p		7.	45.	9.9	81.1	Below Horsor Slough, west side
Peoria L.	Peoria.	Nov. 16	3:00 p		7.	45.	9.5	77.9	Below Horsor Slough, mid-stream
Peoria L.	Peoria.	Nov. 16	3:00 p		7.	45.	10.8	88.6	Below Horsor Slough, east side
Peoria L.	Peoria.	Nov. 16	3:30 p		7.	45.	9.7 9.9	80.3	Opposite Peoria Heights
Peoria L.	Averyville.	Nov. 16	3:45 p		6.	43.	9.9	79.3	West side
Peoria L.	Averyville.	Nov. 16	3:45 p		6.5	44.	10.4 10.1	83.	Midstream
Peoria L.	Averyville.	Nov. 16	3:45 p		6.	43.	11.	88.1	East side
Illinois R.	Peoria.	Nov. 16	4:00 p		6.	43.	10.6	84.1	At Liberty Street, near shore
Illinois R.	Peoria.	Nov. 16	4:00 p		6.	43.	10.3	82.5	At Liberty Street, midstream
Illinois R.	Peoria.	Nov. 17	8:45 a		6.	43.	9.3 9.8	76.	Below distilleries
Illinois R.	Pekin.	Nov. 17	9:30 a		6.	43.	9.6 9.8	77.7	
Illinois R.	Pekin.	Nov. 17	10:00 a		5.5	42.	9.7 9.6	76.	Below distilleries

TABLE OF DISSOLVED OXYGEN AND CARBON DIOXIDE, ILLINOIS RIVER AND RELATED WATERS, 1911 AND 1912—Continued

Water	Location	Date	Hour	Depth of Sample	Water Temp. C.	Water Temp. F.	Dissolved Oxygen, p.p.m.	Dissolved Oxygen, % sat'n.	Remarks
Illinois R.		Nov. 17	10:15 a		5.5	42.	9.7		Opposite Mackinaw River
							9.8	76.6	
Illinois R.	Kingston Mines	Nov. 17	10:30 a		5.5	42.	10.		
							9.8	78.5	
Illinois R.	Copperas C. . . .	Nov. 17	11:30 a		5.5	42.	10.1		Above dam
							10.	79.	
Illinois R.	Copperas C.	Nov. 17	11:30 a		5.8	42.6	10.1	80.9	Below dam
Illinois R.	Liverpool.	Nov. 17	12:30 p		5.8	42.6	9.6		
							9.9	77.7	
Spoon R.		Nov. 17	4:00 p		4.5	40.	12.		At mouth
							11.9	92.3	
Illinois R.	Havana.	Nov. 17	4:00 p		6.	43.	9.8		
							9.6	77.6	
Illinois R.		Nov. 18	9:45 a		5.	41.	10.1		Above Grand Island.
							9.8	77.3	
Illinois R.		Nov. 18	11:00 a		5.3	41.6	10.1	79.9	Below Grand Island
Illinois R.	Sharp's Lndg. . . .	Nov. 18	11:30 a		5.3	41.6	10.		
							9.9	78.4	
Illinois R.	Browning.	Nov. 18	12:30 p		5.5	42.	10.4	82.5	
Illinois R.	Beardstown.	Nov. 18	2:00 p		6.	43.	10.2		
							10.	80.9	
Crooked C.		Nov. 18	2:45 p		5.	41.	10.4	81.3	At mouth
Illinois R.		Nov. 18	3:00 p		5.8	42.6	10.7		Opposite Crooked Creek
							10.5	84.8	
Illinois R.	LaGrange.	Nov. 18	3:30 p		6.	43.	9.8		Above dam
							10.1	79.4	
Illinois R.	LaGrange.	Nov. 18	3:45 p		6.	43.	10.		Below dam
							10.3	81.8	
Illinois R.	Meredosia.	Nov. 19	7:15 a		5.	41.	10.8		
							10.7	83.5	
Illinois R.	Naples.	Nov. 19	7:45 a		5.	41.	10.9		
							11.	85.2	
Illinois R.	Valley City.	Nov. 19	8:30 a		5.5	42.	10.8		
							10.6	84.7	
Illinois R.	Florence.	Nov. 19	9:00 a		5.5	42.	10.7		
							10.5	84.1	
Illinois R.	Bedford.	Nov. 19	9:45 a		5.5	42.	10.9	86.2	
Illinois R.	Pearl.	Nov. 19	10:30 a		5.8	42.6	11.5	92.	
Illinois R.	Kampsville.	Nov. 19	1:00 p		6.	43.	11.1		Above dam
							11.2	88.9	
Illinois R.	Kampsville.	Nov. 19	1:15 p		6.	43.	10.8	86.5	Below dam
Illinois R.		Nov. 19	2:00 p		6.	43.	10.9		Head of Diamond Island
							10.6	85.7	
Illinois R.	Hardin.	Nov. 19	2:20 p		7.	45.	11.3		
							11.4	92.7	
Illinois R.		Nov. 19	3:10 p		6.8	44.6	10.9		Above Twelve Mile Island
							11.5	91.8	
Illinois R.		Nov. 19	4:30p		6.5	44.	10.8		At mouth
							10.7	87.	

TABLE OF DISSOLVED OXYGEN AND CARBON DIOXIDE, ILLINOIS RIVER AND RELATED WATERS, 1911 AND 1912—Continued.

Water	Location	Date	Hour	Depth of Sample	Water Temp. C.	Water Temp. F.	Dissolved Oxygen, p.p.m.	Dissolved Oxygen, % sat'n.	Remarks
Mississippi R. . .	Grafton.	Nov. 19	4:45 p		6.5	44.	13.4 13.8	112.	West side
Mississippi R. . .	Grafton.	Nov. 19	4:50 p		6.	43.	14.4 14.1	114.	Midstream
Mississippi R. . .	Grafton.	Nov. 19	5:00 p		6.5	44.	11. 10.9	88.2	East side

INCRUSTATION IN WATER MAINS AT MT. VERNON, ILL.*

In presenting this paper, it would be well first to give you a history of the water plant in Mt. Vernon, calling your attention to the fact that, in Southern Illinois, only surface water is available for city supplies. There are no springs, or water bearing strata of gravel, from which to obtain a supply. It is true that some towns in Southern Illinois have bored wells to a great depth, but they have not obtained water that is satisfactory for domestic and industrial use.

About twenty-three years ago a freight car manufacturing company moved its plant from Litchfield, Ill., to Mt. Vernon, installing its equipment in some buildings, belonging to the L. & N. Ry. situated in the heart of Mt. Vernon. These buildings had been abandoned by the L. & N. when it moved the division shops to McLeansboro.

The L. & N. Ry. had secured water by damming a small ravine west of town, the dam serving as a roadbed for the tracks. At this point was installed a small pumping station, pumping water along the right of way to the car shops, where a small water tank was erected. A tank was also placed near the passenger station, making two places for the engines to obtain water.

The Car Manufacturing Company soon found that the amount of water furnished by the small pond was inadequate; and as there was a larger ravine north of this pond, it purchased this ground and built a dam, forming a reservoir covering fifteen acres, and obtaining a supply from a much larger watershed. The pipe line from the reservoir is an eight inch line for 2100 feet, to a point near the L. & N. station. Here it was reduced to six inch, and continued on Broadway to Ninth street, which is the southeast corner of the public square, a distance of 3950 ft.

A number of the business men called on the president of the car company, and endeavored to have him place some fire plugs along the line, to give them some fire protection. As he did not care to enter into the water supply business further than for his own use, he proposed turning the proposition over to a company that they might form, then he would purchase water from them. A company was formed among the business men, and the mains were completed to the car

*A paper by F. M. Sinsabaugh, General Manager, Citizens Gas, Electric & Heating Co., read before the fourth meeting of the Illinois Water Supply Association March 5, 1912; Proc. Ill. W. S. Assn., 1912, 202. This paper is an introduction to a paper which deals with the composition of the incrustation, as determined in the laboratory of the State Water Survey.

works, and a few fire plugs installed. Business was solicited along the mains then in the ground.

The demand for water increased very rapidly, and the company officials used no discretion in their extension of the system, looking more to the present needs than to what they might expect in the future. In this manner they installed a great number of small mains, in most cases of wrought iron, which has a very short life.

It was not long before they found that there was not enough water in the pond to supply the needs of the town, so they installed a small auxiliary station on a little creek outside the city limits. This creek is considerably lower than the town, and they placed a low duty pump at this station, and ran a 6-inch line over to the reservoir. This 6 inch has since been replaced by a 12-inch line. Of course, the main supply was from the reservoir.

About this time the municipal ownership bug hit the city council, and it thought the city should own the water works. It made arrangements to buy the plant, together with a small electric light plant. The electric light plant was moved to the pumping station, and the machinery installed in the same building with the pumping outfit. In order to acquire this property and make some extensions, water fund certificates to the extent of some fifty thousand dollars were issued.

Municipal ownership was not as rosy as it had been pictured and when the first interest was due on these water certificates, there was no money to meet it, so the entire property fell into the hands of a party of bond brokers, who had underwritten the securities. The bond brokers assumed control, rebuilt the electric light plant, where the present plant now stands, and added thereto a gas works and hot water heating equipment.

The car manufacturing plant did a great amount of work and the town grew rapidly, gaining 50% in ten years. Necessarily the consumption of water grew greater each year, and again it was found that the supply was inadequate. There were times when the small creek and the ponds did not furnish an adequate supply, and in extremely dry weather they had to ship in water in tank cars. It is rather amusing to consider how they used to handle the situation. Water being so scarce they threatened to turn off all the residences and only supply the industrial plants, keeping a reserve for fire protection; but they made a proposition to all private consumers, that each one who would buy a tank car of water to be placed in the reservoir, could continue to receive water through the mains.

As the question of water supply had become so serious they employed engineers to ascertain where they could best locate a reservoir to increase the supply. They chose a position some four and a half miles north of town. They had to buy up some three hundred acres of land, where by damming up a large ravine they were enabled to impound something over three hundred million gallons. Up to the present time, this has been sufficient to supply all needs. During the summer and fall of 1911 the situation was getting a little shaky, and they have raised the spillway at the new reservoir and strengthened the dam, giving them some thirty or forty million gallons additional supply.

During the twenty or more years that this plant has been in operation there have been no steps taken to purify or filter the water, and an incrustation had formed in the pipes. The party of bond brokers who purchased this property met with reverses a few years ago and were unable to furnish the plant with the necessary funds to keep it in good working order. The property passed, therefore, into the hands of the present owners in December, 1910, when I assumed charge.

Soon after this a small fire occurred and we found that, with 100 pounds pressure at the pumping station, and two three-quarter inch fire nozzles, the fire department was unable to throw a stream into the second story of the building. I was very much surprised at this, and soon learned what was the trouble. The superintendent of the pipe lines, who had been with the company for some nine or ten years, informed me of the conditions of the mains.

Soon after this the National Water Main Cleaning Company were cleaning the mains in Centralia and, with the superintendent, I went to investigate the work and found wonderful results. I immediately made a contract with them to clean a main artery through the town to the car works, which would naturally be the oldest and dirtiest main in town. I might say that the car company had just completed a large plant for manufacturing steel cars, around which we had put twelve fire hydrants. They, knowing the condition of the mains, were very much exercised and were anxious to see the condition bettered, so that they would be assured ample fire protection.

Before cleaning the mains we made a test at the southeast corner of the square, which is about 4,000 feet from our pumping station. To the plug at this point we attached a two and a half-inch fire hose, with one and a quarter inch nozzle, and placed a gauge on the other outlet to the fire plug. With one hundred pounds pressure at the pumping station we were enabled to throw only a small stream for a distance of 68 feet. The pressure registered at the hydrant was 15 pounds.

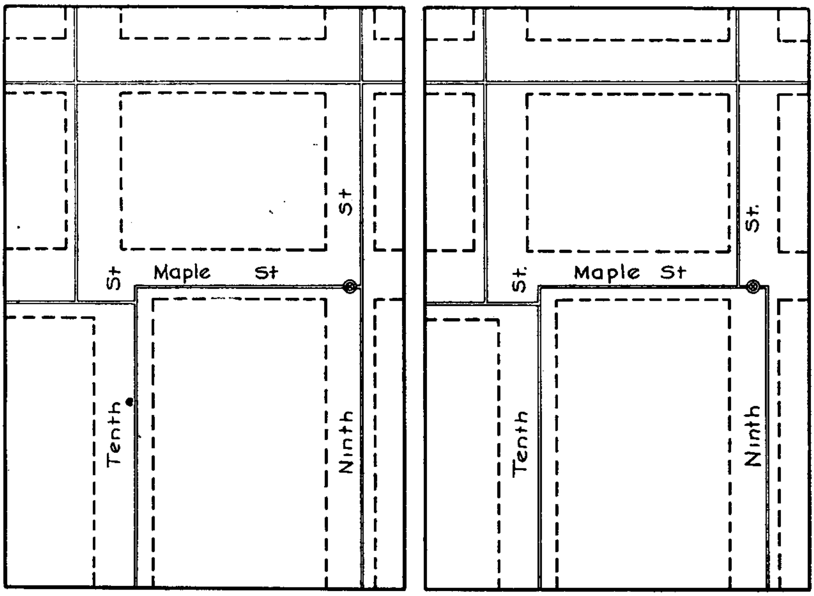
After we had cleaned four thousand feet of main we again made a test. The gauge at the fire plug registered 52 pounds, with the same pressure at the pumping station, i. e., 100 pounds, so you see we had a gain of 37 pounds.

The water was thrown 204 feet, compared with 68 feet before the cleaning.

We were so well satisfied with the work clone by this company that we made a contract with them to clean all our mains. When same was completed we found that we were able to reduce our domestic pressure from twenty to twenty-five pounds, and deliver water to patrons at a greater pressure than before. While the work cost us

$6,500 for cleaning 45,992 feet, we feel that the results have justified the expenditure.

It is interesting to note how the employes of the Water Main Cleaning Company go about this work. The first thing done is to close a valve feeding the main to be cleaned. Then they cut out a three foot section of the main just beyond the valve, into which they insert an instrument called the carrier, which is a rod about three feet long, to which is attached conical leathers with the apex away from the valve. These cones are made of ample area so as to completely cover any outlets to the main. To the carrier is attached a small wire cable. Then



Location of valve as shown on map of Mt. Vernon.

Actual location of valve.

Figure. Correction of the Map Showing Location of Valves, Mt. Vernon.

a temporary makeup is placed in the opening and the water is turned on. The pressure floats the carrier to the end of the section to be cleaned, carrying the small cable with it.

At the end they break out a section and make a temporary connection with a forty-five, which conveys the water to the surface, where it is carried off by the side gutters on the street. When the carrier reaches the other end of a section, it is detached and a larger cable is fastened to the small one. Then, with a windlass, the larger cable is pulled back to the point of beginning.

To the large cable is attached the cleaning tool, which consists of several sections with swivel joints, and a series of scratching and scraping arms. The section of the main first taken out is then leaded in permanently, and the water is turned on.

The cleaning tool is then drawn through by a wench, which requires four to six men to operate. As the cleaner is pulled along, the water behind it washes all the deposits out. It is amazing the amount that is taken out at each draw.

The length of sections cleaned varies from four to twelve hundred feet, according to the manner in which the mains are laid.

Not only does the cleaner remove the incrustation in the mains, but it will also find any obstruction, such as an accumulation of lead from a poorly poured joint. In our case they found a number of pump valves lodged in different places, and a number of pieces of wood, one of which was a 2x4 about six feet long, and another was a fence rail. These had either been maliciously inserted, or had been used by the workmen, when laying the pipes, for carrying same, and had been left in the pipe carelessly.

We were able to locate our valves correctly, and soon found out those that were not in perfect working order.

The figure will serve to demonstrate how easy it is to have the wrong location of your valves on the map. On the left of this figure you will see how the location was shown on our map; but upon cleaning the mains, we found it was located as shown on the right. This was not discovered until we had cleaned a considerable amount of mains in this territory. Had we known the exact location, it would not have been necessary for us to cut off as much of that part of the town as we did.

We find that there is no formation in the lead service pipe, but always find it in the iron service pipes; and where iron pipe was screwed into a brass fitting, there was always more incrustation than anywhere else.

OCCURRENCE OF MANGANESE IN THE WATER SUPPLY AND IN AN INCRUSTATION IN THE WATER MAINS AT MT. VERNON, ILL.*

In April, 1911, the attention of the State Water Survey was called to the conditions existing in the water system of Mt. Vernon, Ill. Incrustation had been gradually forming in the mains until the pressure in many parts of the system had become greatly reduced and in some cases complete stoppage had resulted. A paper by F. M. Sinsabaugh† explains the mechanical side of the problem and its solution by cleaning the mains. The chemical side of the problem, however, presents phases which are very interesting, and perhaps unusual, at least among the water problems of Illinois, in that manganese is present in quantity.

The occurrence of manganese in natural waters is rather uncommon. Many waters contain traces of the element, but large quantities are seldom found. Waters which contain manganese always contain iron. The so-called manganese waters invariably contain more iron than manganese. Waters containing iron or manganese possess many similar characteristics. Waters containing iron are usually clear and colorless when first drawn, but upon exposure to the air become turbid owing to the formation of a reddish-brown precipitate. They contain practically no dissolved oxygen when drawn, and the iron is present usually as ferrous bi-carbonate. Upon exposure to the oxygen of the air, however, the iron becomes oxidized, is thus rendered insoluble, and separates as the hydroxide. Waters containing much iron have a characteristic inky taste. Tea made with the water is black owing to the formation of iron tannates. White plumbing fixtures are stained brown, and linen washed with the water usually shows rust spots or becomes yellow. When soap is used with such waters, a brown scum, caused by the formation of insoluble iron soaps, floats on the surface.

Waters containing manganese possess similar characteristics, although owing to their comparative scarcity, their properties are not so generally understood as are those of waters containing iron. Precipitation of the hydrated oxide of manganese takes place when they are exposed to the air. Plumbing fixtures and linen are stained, but the color is a darker brown than that produced by iron alone.

The amount of manganese reported as occurring in natural waters

---

*Abstract of thesis prepared by H. P. Corson under the direction of Professor Edward Bartow, and submitted in partial fulfillment of the requirements for the degree of Master of Science in Chemistry.

†Proc. Ill. Water Supply Assn., 1912, 202-8. See also p. 52.

both in this country and in Europe is quite variable. W. P. Mason* reports 4.5 parts per million of manganese, and 11.3 parts per million of iron in a spring water at Excelsior Springs, Mo. In connection with this report he states that although manganese is reported in some sixty-two springs in the United States, in nearly half of these it is present only in traces, and only in seven instances does the amount equal or exceed the amount in Excelsior water.

The first case in America where manganese was found in sufficient quantity to cause trouble is mentioned by R. S. Weston.** In 1893 a well water supply used by a New England mill contained so much manganese that its use was discontinued.

E. V. Raumer† describes some incrustations containing manganese, deposited by manganese waters in Fürth. 43.85 per cent. Mn_3O_4 was found in one case in an incrustation from a water containing less than 2.8 parts per million of Mn_3O_4 or 2 parts per million of Mn. One water in the vicinity contained 8.6 parts per million Mn_3O_4, or 6.2 parts per million of Mn. Thread-like organisms resembling *Crenothrix* were found in the deposit, and these may have caused the precipitation.

E. H. S. Bailey‡ describes a brown deposit containing 45.2 per cent Mn_2O_3 in the service pipes of the city of Hutchinson, Ark. The water is from driven wells and contains 1.4 parts per million of Mn_2O_3 or 1.0 part per million of Mn. The author concludes that the deposit is caused "by a process of concentration in the pipes."

D. D. Jackson§ has found an organism depositing manganese, *Crenothrix manganifera,* in the filter galleries of the city supply of Newton, Mass., the water of which contains 1.4 parts per million of Mn. He describes three species of organisms which form deposits in water systems, *Crenothrix kühniana* depositing iron, *Crenothrix manganifera* depositing manganese and *Crenothrix ochracea* depositing alumina from waters containing these elements. Analyses of the incrustations deposited show that they consist of about one-third silica, one-third organic matter, and one-third the oxide of the particular metal which the organism deposits. The author states that *Crenothrix kühniana* is very common, that *Crenothrix ochracea* is rather uncommon, and that *Crenothrix manganifera* is very rare, because manganese seldom occurs in sufficient quantity in water to produce a noticeable growth. *Crenothrix kühniana* is identical with *Crenothrix polyspora,* (Cohn).

According to A. Beythien, H. Hempel and L. Kraft¶ the water for the city of Dresden is supplied from two sources, one containing 1.4 parts per million of manganese, and the other containing practically

*Chem. News, *61,* 123.
**Trans. Am. Soc. C. E., *64,* 175.
†Z. Anal. Chem., *42,* 590-602.
‡J. Am. Chem. Soc., *26,* 714.
§J. Soc. Chem. Ind., *21,* 681.
¶Z. Nahr. Genussm. *7,* 215.

none. Iron was present in both supplies. The portion of the system through which the manganese water flowed was incrusted by heavy *Crenothrix* growths, while the other parts of the system were free from them, showing that the growth of this organism was due to the manganese rather than to the iron content of the water. The incrustation contained about 50 per cent. Mn_3O_4 and 4.5 per cent. Fe_2O_3.

B. Schorler* and C. A. Neufeld† have discussed the relation of the iron and manganese organisms to each other, and the former concludes that they may be the same organism living in different environment.

Incrustations containing from .18 per cent. to 19.65 per cent. of manganese have been found by O. Materne‡ in the mains of the Vervies water system. The water contained a very small amount of iron, and only traces of manganese.

A classic example of injury to a water supply by a very high content of iron and manganese is the water calamity of Breslau in 1906.§ Breslau was formerly supplied with water from the river Oder, but in 1905 a supply from 313 wells driven to a depth of 30 to 40 ft. in the Oder valley was substituted. In March, 1906, the Oder overflowed its banks, and soon afterward the turbidity, odor, hardness, residue, manganese, and iron in the ground water supply increased enormously. The iron content increased to 440 parts per million and the manganese content to 220 parts per million. The filtered water from the Oder river was finally substituted for the ground water supply. Many explanations have been offered for this peculiar change in the quality of the water. Most authorities agree that it was caused by a process of oxidation and leaching of the soil. The soil contains a large amount of iron and manganese sulfides. The iron sulfide was oxidized to iron sulfate by the river water containing organic matter and bacteria. Iron sulfate was then leached through the soil to the water bearing strata, a part hydrolyzing with the formation of H_2SO_4 which dissolved and carried along the manganese. Extensive experiments for the removal of iron and manganese from the Breslau supply have been carried on by a number of investigators.

A manganese water at Björnstorp estate, Sweden, is described by M. Weibull.¶ Several waters from ponds and wells in the vicinity caused clogging of pipes and yellowing of fabrics laundered in them. Investigation showed that some of the waters contained as much as 6.3 parts per million of MnO, or 5 parts per million of Mn, causing precipitation of manganese upon exposure to the air. The rock formation in the vicinity is gneiss and diorite, the latter containing 8.2 per

*Centr. Bakt. Parasitenk, II, *12,* 681.

†Z. Nahr. Genussm. *7,* 215.

‡Bull. Soc. Chim. Belg., *18,* 363.

§Z. öffent. Chem. *12,* 121; *13,* 401; Z. Nahr. Genussm, *14,* 40; Z. prakt. Geol. *15,* 153; Chem. Ztg. *31,* 255; Trans. Am. Soc. C. E, *64,* 174.

¶J. Gasbel., *50,* 767.

cent MnO which probably accounts for the waters of the vicinity containing large amounts of manganese.

Arad, Hungary, has had flaky incrustations containing iron and manganese in its water mains. They are described by R. H. Hajek†, director, as containing 71.02 per cent. MnO_2 and 5.95 per cent. MnO. The precipitation was more pronounced on galvanized surfaces, such as strainers, while brass and copper surfaces were clean.

R. S. Weston‡ cites some twenty ground waters in this country and in Europe which contain manganese:

Locality—	Mn present (Parts per Million)
Arad, Hungary	Present
Babylon, N. Y	0.07
Bayshore, N. Y	0.37
Berlin, Germany	Present
Björnstorp, Sweden	3.4–53.4
Brunswick, Germany	Present
Breslau, Germany	Trace–110.
Calverton, N. Y	0.30
Halle, Germany	1.50
Hamburg, Hofbrünnen	0.45
Hanover, Germany	Present
Patchogue, N. Y	0.20
Reading, Mass	0.004–0.56
Stargard, Germany	Present
Stettin, Germany	5.22
Superior, Wis	0.12
Shrewsbury, Mass	0.10

An analysis made by Weston of the flaky deposit from the water at Brunswick, Germany, shows that of three samples examined, contents of 0.30 per cent. 1.24 per cent. and 7.15 per cent. of Mn were found. A large amount of iron was also found in each case.

The water supply of Khartoum*, Africa contains manganese according to W. Beam. The supply is from drilled wells which at first contained from traces to one part per million.

We have determined the amount of manganese in waters from the vicinity of Mt. Vernon, Ill. (A) and have also determined the composition of the incrustation which formed in the mains (B).

A. MANGANESE IN WATERS FROM MT. VERNON.

The waters described below are all from sources in the vicinity of the city of Mt. Vernon in Jefferson County, Ill.

The manganese was determined by the calorimetric ammonium persulfate method described by J. Rodenberg§ as follows: Boil a measured amount of the sample with dilute HNO_3. Precipitate chlorine

†Eng. Record, *56,* 507.
‡Trans. Am. Soc. C. E., *64,* 124.
*4th Report Wellcome Tropical Research Laboratories, Vol. B, 26.
§Chemisch Weekblad, *7,* 877.

with $AgNO_3$ and filter. A slight excess of $AgNO_3$ must be present in the filtrate to act as a catalytic agent for the subsequent oxidation. Add $(NH_4)_2S_2O_8$ to the filtrate and boil the solution. The manganese is thus oxidized to permanganate. Compare the color at once in Nessler tubes with varying amounts of a standard solution of manganous sulfate which has been treated in the same manner.

The largest amount of manganese was found in the Green Lawn Spring, corner of Sixth and Jordan streets. To show the character of the water the sanitary analysis and the analysis of the mineral content are given.

THE SANITARY ANALYSIS OF WATER FROM GREEN LAWN SPRINGS, MT. VERNON, ILLINOIS.

Laboratory No. 23146. Collected March 26, 1912.

Turbidity	50	Nitrogen as		Bacteria per c.c.	
Color	10	Free ammonia	1.166	Gelatine at 20°	38.
Odor	1E	Alb. ammonia	.064	Gas Formers:	
Residue on evaporation	1189.	Nitrites	.110	10. c.c.	1—
Chlorine in chlorides	32.	Nitrates	.000	1. c.c.	2—
Oxygen consumed	3.2	Acidity as $CaCO_3$	30.	0.1 c.c.	2—
				Indol	—

ANALYSIS OF THE MINERAL CONTENT.

Ions	Parts per Million	Hypothetical Combinations	Parts per Million	Grains per Gallon
Potassium, K	12.7	Potassium nitrate, KNO_3	Trace	Trace
Sodium, Na	122.6	Potassium chloride, KCl	24.2	1.41
Ammonium, NH_4	1.5	Sodium chloride, NaCl	33.8	1.97
Magnesium, Mg	50.9	Sodium sulfate, Na_2SO_4	337.0	19.65
Calcium, Ca	103.8	Ammonium sulfate, $(NH_4)_2SO_4$	5.5	.32
Iron, Fe	51.2	Magnesium sulfate, $MgSO_4$	251.6	14.67
Alumina, Al_2O_3	Trace	Calcium sulfate, $CaSO_4$	352.3	20.54
Manganese, Mn	*7.8*	Iron sulfate, $FeSO_4$	139.3	8.12
Nitrate, NO_3	Trace	*Manganous sulfate, $MnSO_4$*	*11.7*	*.68*
Chlorine, Cl	32.0	Alumina, Al_2O_3	Trace	Trace
Sulfate, SO_4	767.8	Silica, SiO_2	42.9	2.48
Silica, SiO_2	42.8	Bases	4.4	.25
Bases	4.4			
		Total	1202.6	70.09

The water was almost clear when first received at the laboratory, but a turbidity of 50 soon developed upon standing. The water contained no carbonates, all the iron and manganese being present as sulfates. The manganese content of 7.8 parts per million is one of the highest which has been reported for the mineral springs in this country.

The city supply of Mt. Vernon, Ill., contains manganese. The supply is obtained from two sources. Part of it is pumped into the mains from an artificial lake or reservoir. This lake is fed by natural springs. At times this source of supply is insufficient, and surface water from the Casey Fork is pumped into the artificial lake.

Analyses of the water from the city supply taken at three different times have been made.

THE SANITARY ANALYSIS OF WATER FROM THE CITY SUPPLY OF MT. VERNON, ILLINOIS

No. 21908 Collected April 12, 1911; No. 22994 Collected February 13, 1912; No. 23145 Collected March 26, 1912.

Serial No.	Appearance			Residue on Evaporation	Chlorine in Chlorides	Oxygen Consumed	Nitrogen as				Alkalinity	Bacteria per c.c.	Gas Formers		
							Ammonia								
	Turbidity	Color	Odor				Free	Albuminoid	Nitrites	Nitrates			10 c.c.	1 c.c.	0.1 c.c.
21908	120	0	1V	366	10.0	2.7	.124	.154	.090	4.71	20	2500	1 +	2—	2—
22994	12	30	2V	362	8.0	3.5	.014	.200	.003	.60	32	700	1 +	2 +	2—
23145	55	40	2M	267	5.0	1.3	.078	.106	.020	.68	18	640	1 +	2 +	2—

ANALYSIS OF THE MINERAL CONTENT.

Amounts are Stated in Parts per Million.

Ions—			
Laboratory No	21908	22994	23145
Date collected	April 12, 1911	Feb. 13, 1912	March 26, 1912
Potassium, K	5.2	4.8	5.3
Sodium, Na	32.4	27.0	13.2
Ammonium, NH_4	...	...	.1
Magnesium, Mg	26.6	27.6	17.0
Calcium, Ca	38.4	40.0	23.0
Iron, Fe	.80	.52	1.6
Manganese, Mn	*.64*	*.58*	*.70*
Alumina, Al_2O_3	2.2	2.0	.8
Nitrite, NO_2	...	...	.06
Nitrate, NO_3	2.1	2.8	3.0
Chlorine, Cl	10.0	8.0	5.0
Sulfate, SO_4	218.7	210.1	145.8
Silica, SiO_2	8.2	13.2	7.6
Bases	...	1.5	6.0

HYPOTHETICAL COMBINATIONS.

Amounts are Stated in Parts per Million.

	21908	22994	23145
Potassium nitrite, KNO_2	...	...	.1
Potassium nitrate, KNO_3	3.4	4.6	4.9
Potassium chloride, KCl	7.4	5.7	6.3
Sodium chloride, NaCl	10.7	8.7	3.3
Sodium sulfate, Na_2SO_4	86.9	72.8	36.7
Ammonium sulfate $(NH_4)_2SO_4$	...	...	.4
Magnesium sulfate, $MgSO_4$	131.5	136.4	84.0
Calcium sulfate, $CaSO_4$	78.1	73.8	74.7
Calcium carbonate, $CaCO_3$	38.4	45.7	5.0
Ferrous carbonate, $FeCO_3$	1.7	1.0	3.3
Manganous carbonate, $MnCO_3$	*1.3*	*1.2*	*1.4*
Alumina, Al_2O_3	2.2	2.0	.8
Silica, SiO_2	8.2	13.2	7.6
Bases	1.1	1.5	6.0
Total	370.9	366.6	234.5

HYPOTHETICAL COMBINATIONS.

Amounts are Stated in Grains per Gallon.

	21908	22994	23145
Potassium nitrite, KNO_2	...	...	.01
Potassium nitrate, KNO_3	.20	.27	.28
Potassium chloride, KCl	.43	.33	.36
Sodium chloride, NaCl	.62	.51	.19
Sodium sulfate, Na_2SO_4	5.07	4.24	2.14
Ammonium sulfate $(NH_4)_2SO_4$	...	...	.02
Magnesium sulfate, $MgSO_4$	7.67	7.96	4.90
Calcium sulfate, $CaSO_4$	4.56	4.30	4.35
Calcium carbonate, $CaCO_3$	2.24	2.65	.29
Ferrous carbonate, $FeCO_3$	.10	.06	.19
Manganous carbonate, $MnCO_3$	*.06*	*.07*	*.08*
Alumina, Al_2O_8	.13	.12	.05
Silica, SiO_2	.48	.77	.44
Bases	.06	.09	.34
Total	21.62	21.37	13.64

The chemical and bacteriological examinations show that the water should be purified before being used for drinking purposes. The turbidity, color, the number of bacteria and the gas formers being especially significant. The low alkalinity indicates the advisability of using lime or soda with mechanical filters. (A filter plant was constructed during the winter of 1912-13.)

These analyses show a content of from .5 to .7 parts per million of manganese. There is a wide variation in the mineral content of samples taken at different times. This is explained by the fact that the water from the two sources of supply differs in composition, the stream especially varying with the season. The sanitary character and the mineral content of the water from the reservoir and from the Casey Fork are shown in the analyses:

SANITARY ANALYSES OF THE WATER FROM THE RESERVOIR AT MT. VERNON, ILLINOIS

No. 22993 Collected Feb. 13, 1912; No. 23144 Collected March 26, 1912.

Serial No.	Appearance			Residue on Evaporation	Chlorine in Chlorides	Oxygen Consumed	Nitrogen as				Alkalinity	Bacteria per c.c.	Gas Formers		
	Turbidity	Color	Odor				Ammonia: Free	Ammonia: Albuminoid	Nitrites	Nitrates			10 c.c.	1 c.c.	0.1 c.c.
22993	12	30	2V	382	8.0	3.8	.012	.202	.004	.68	32.	375	1 +	2 +	1—1+
23144	60	70	1M	275	5.0	2.2	.078	.120	.015	.60	14.	620	1 +	2 +	2—

ANALYSIS OF THE MINERAL CONTENT OF THE WATER COLLECTED FROM RESERVOIR MARCH 26, 1912.

Ions	Parts per Million
Potassium, K	8.3
Sodium, Na	13.1
Ammonium, NH_4	.1
Magnesium, Mg	17.6
Calcium, Ca	23.3
Iron, Fe	1.6
Manganese, Mn	*1.15*
Alumina, Al_2O_3	1.0
Nitrate, NO_3	2.7
Chlorine, Cl	5.0
Sulfate, SO_4	130.8
Silica, SiO_2	7.0
Bases	3.8

Hypothetical Combinations	Parts per Million	Grains per Gallon
Potassium nitrate, KNO_3	4.4	.25
Potassium chloride, KCl	10.5	.61
Potassium sulfate, K_2SO_4	2.2	.12
Sodium sulfate, Na_2SO_4	40.4	2.35
Ammonium sulfate $(NH_4)_2SO_4$	.4	.02
Magnesium sulfate, $MgSO_4$	87.0	5.07
Calcium sulfate, $CaSO_4$	45.8	2.66
Calcium carbonate, $CaCO_3$	24.5	1.42
Ferrous carbonate, $FeCO_3$	3.3	1.19
Manganous carbonate, $MnCO_3$	*2.3*	*.13*
Alumina, Al_2O_3	1.0	.05
Silica, SiO_2	7.0	.40
Bases	3.8	.22
Total	235.6	18.49

SANITARY ANALYSIS OF THE WATER FROM THE CASEY FORK, MT. VERNON, ILLINOIS. COLLECTED MARCH 26, 1912.

Laboratory No.	23143
Turbidity	110.
Color	90.
Odor	1M.
Residue on Evaporation	375.
Suspended Solids	177.
Chlorine in Chlorides	3.0
Oxygen Consumed	5.7
Nitrogen as	
Free Ammonia	.100
Albuminoid Ammonia	.302
Nitrites	.018
Nitrates	1.36
Alkalinity	18.
Bacteria per c.c.	12,750
Gas Formers	
10 c.c.	1+
1 c.c.	2+
0.1 c.c.	1+1 —
Indol	+

ANALYSIS OF THE MINERAL CONTENT.

Ions	Parts per Million	Hypothetical Combinations	Parts per Million	Grains per Gallon
Potassium, K	7.6	Potassium nitrite, KNO_2	.2	.01
Sodium, Na	9.3	Potassium nitrate, KNO_3	9.8	.57
Ammonium, NH_4	.1	Potassium chloride, KCl	6.3	.36
Magnesium, Mg	10.0	Potassium sulfate, K_2SO_4	.9	.05
Calcium, Ca	13.2	Sodium sulfate, Na_2SO_4	28.7	1.67
Iron, Fe	.1	Ammonium sulfate, $(NH_4)_2SO_4$	.4	.02
Manganese, Mn	Trace	Magnesium sulfate, $MgSO_4$	49.4	2.87
Alumina, Al_2O_3	2.0	Calcium sulfate, $CaSO_4$	3.5	.20
Nitrite, NO_2	.1	Calcium carbonate, $CaCO_3$	30.5	1.77
Nitrate, NO_3	6.0	Ferrous carbonate, $FeCO_3$	.2	.01
Chlorine, Cl	3.0	*Manganese carbonate, $MnCO_3$*	*Trace*	*Trace*
Sulfate, SO_4	62.1	Alumina, Al_2O_3	2.0	.11
Silica, SiO_2	17.4	Silica, SiO_2	17.4	1.01
Bases	5.4	Bases	5.4	.31
		Total	154.7	8.96

An analysis of the water taken from the storage reservoir or artificial lake shows a high manganese content. The absence of manganese in the water from the Casey Fork which at times is pumped into this lake shows that the source of manganese is the springs which feed the lake.

B. INCRUSTATIONS CONTAINING MANGANESE.

In April, 1911, we received three pieces of ¾-inch pipe taken from different parts of the system. They had been in service for a considerable length of time and were partially filled with a dark brown, flaky incrustation. An analysis of this incrustation showed that in addition to the substances invariably found in such deposits, namely, silica, iron, aluminium, calcium and magnesium, these samples contained manganese in considerable quantity. They contained from 8 to 12 per cent of manganous oxide.

F. M. Sinsabaugh, General Manager Citizens Gas, Electric and Heating Company, sent us three additional samples in February, 1912, to be used for a confirmatory examination.

Sample No. 1 was collected from the mains. It was brittle and flaky in structure and of a light brown color.

Sample No. 2 was from a piece of ¾-inch service pipe which had been in service eighteen years, and was almost completely closed. The deposit was of a very dark brown color.

Sample No. 3 was also from a ¾-inch pipe which had been in service for eighteen years. The pipe was not only almost completely closed by incrustation, but was so corroded as to be almost completely eaten through in places.

These samples were ground, dried at 110°, and analyzed with the following results:

ANALYSES OF INCRUSTATION FROM WATER SYSTEM AT MT. VERNON, ILLINOIS.

	No. 1 From Mains Percentage	No. 2 From ¾" Service Percentage	No. 3 From ¾" Service Percentage
Silica, SiO_2	3.62	14.43	10.64
Ferric Oxide, Fe_2O_3	79.10	45.44	63.42
Alumina, Al_2O_3	2.19	5.41	3.44
Manganous Oxide, MnO	*Trace*	*11.31*	*5.50*
Calcium Oxide, CaO	Undetermined	3.97	1.77
Magnesium Oxide, MgO	Undetermined	1.95	.71
Loss on Ignition, Organic Matter, etc	15.31	17.22	14.65
Total	100.22	99.73	100.13

The significant features in these analyses are the amounts of manganese which the samples contain Strange to say, No. 1 contains only traces of manganese, while No. 2 and No. 3 contain 11.31% and 5.50% of manganese oxide respectively.

For the formation of the incrustation in the pipes the iron and the manganese in the mineral content of this water are the important factors. The amount of iron is from .6 to .8 parts per million, while that of manganese is .64 to .58 parts per million respectively. The amount of carbonate is very low.

In many cities in the state trouble has been caused by waters high in iron causing incrustation by precipitation of the iron. This is the first case, however, which we have found in this state, and one of the few places in the country where manganese has been found in incrustations.

Since this manganese bearing water has come to our attention, a number of other waters of the state similar in character, have been examined for the presence of manganese. Only traces have been found. We would appreciate it, if any of the water works men of the state who know of incrustation, would acquaint us with conditions and furnish samples for examination.

REPORT ON SANITARY SURVEY OF DES PLAINES RIVER ABOVE RIVERSIDE

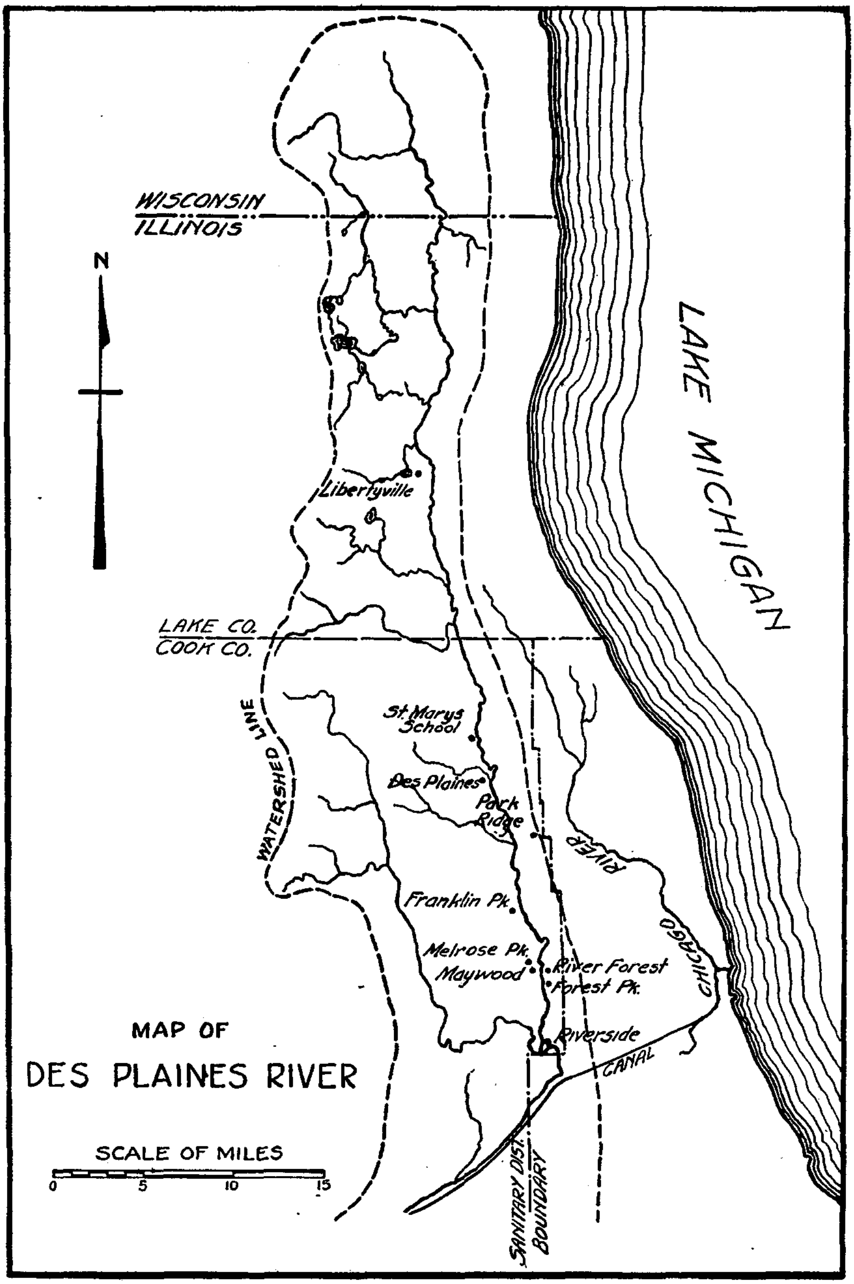
Several suits at law were recently filed against a number of villages which discharge their raw sewage into Des Plaines river. Injunctions were asked to restrain these villages from disposing of sewage in this manner, thereby creating nuisances and unsanitary conditions in the river. Urgent requests for advice, addressed to the State Water Survey by certain village officials led to an investigation of the condition of Des Plaines river during the latter part of June, 1912.

GENERAL DESCRIPTION OF WATERSHED.

Des Plaines river has its source in Racine County, Wis., about twenty miles beyond the northern boundary of Illinois. It flows southward nearly parallel to and about ten miles to the west of Lake Michigan, to a point west of Chicago and then takes a southwesterly course to the northeastern corner of Grundy county where it unites with Kankakee river to form the Illinois. The Des Plaines has a total length of approximately 180 miles and has a natural drainage area of about 1,390 square miles. At Lockport, about 35 miles above the junction with the Kankakee, in addition to the natural run-off of its own watershed, the stream receives the sewage from the Chicago Sanitary District mixed with diluting water pumped from Lake Michigan. This water is limited by law to a maximum of 3½ cu. ft. per second per 1,000 population contributing sewage.

This report considers that portion of the river above the village of Riverside, the point where the stream changes from its southerly course to a southwesterly course, about 70 miles above the junction with the Kankakee.

Between Riverside and Lockport the river is paralleled by the Chicago Drainage Canal carrying Chicago's sewage. Throughout this distance of about 35 miles there are no towns of importance on the stream. North of Riverside are rapidly growing communities consisting of a number of thriving cities and villages, essentially a part of Chicago. In the accompanying table are listed these cities and villages with their population and distances above Riverside. A map shows the watershed of the river and the location of the municipalities.



Map of Des Plaines River Watershed.

Municipality—	Miles from Riverside by water	1890	Census Population 1900	1910	Estimated Population, 1912
Riverside	0	...	1,551	1,702	1,732
Forest Park	3	...	4,085	6,594	7,095
Maywood	5	...	4,532	8,033	8,733
River Forest......	5	...	1,539	2,456	2,640
Melrose Park......	5½	...	2,592	4,805	5,249
Franklin Park.....	9	...	483	683	723
Park Ridge.......	15	987	1,340	2,009	2,143
Des Plaines.......	18	986	1,666	2,324	2,456
Libertyville	42	550	864	1,724	1,896
Total			18,652	30,331	32,668

During the ten years (1900-1910) there has been an increase of about 63 per cent in urban population along the portion of the stream under consideration. The most thickly settled district, responsible in the greatest degree for the present unsanitary conditions in the river, includes Forest Park, Maywood, River Forest and Melrose Park. This district has increased about 75 per cent in population during this period. The rural population has increased only slightly. In 1900 it averaged about 46 per square mile and in 1910 about 57.

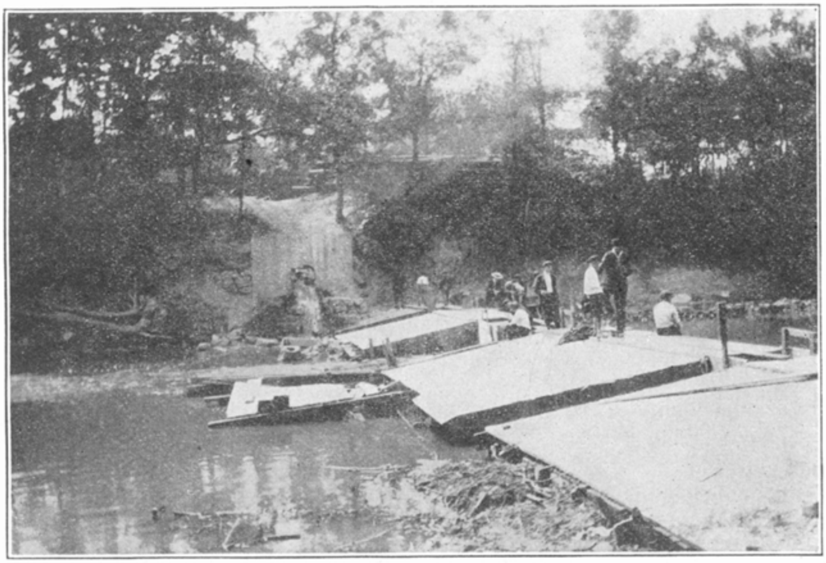
The watershed area of Des Plaines river above Riverside is about 500 square miles and has probably a total population of 55,000. As shown on the map, the boundary of the Sanitary District of Chicago nearly parallels the stream at a distance of from one to three miles to the east and extends as far north as Lake county. The boundary follows quite closely the divide between Des Plaines and Chicago river watersheds and all drainage east of this line is provided for by the sanitary district.

The land lying within the drainage area of Des Plaines river is, in general, quite flat. Elevations range from about 600 feet to about 800 feet above sea level, but with few exceptions, the slopes are very gradual. The river banks in Cook county are, as a rule, rather steep and rise from 10 to 20 feet above the bed of the stream. In some places, however, notably along the river for twenty miles or more in Lake county, the banks are poorly defined and the land for considerable distances on either side is more or less swampy. Marsh land is quite common in nearly all parts of Lake county, and to the west of the river are a number of small lakes which drain into a small tributary known as Mill creek. Lake county, nevertheless, is more rolling and averages higher in elevation than the land lying to the south.

The bed of the river has an elevation of approximately 670 feet at the boundary line between Illinois and Wisconsin, and at Riverside its elevation is about 590. This is a fall of 80 feet in about 64 miles, or an average of about 1¼ feet per mile. For the first 30 miles of this distance the average fall per mile is about 1 foot while for the remaining distance the fall is about 1½ feet per mile.

The drift over this watershed area is very deep, running from 50 to nearly 300 feet in thickness. It consists very largely of till. The surface soil is mostly a black loam, frequently clayey. Small pockets of sand and gravel are occasionally encountered, but, for the most part, the soil is of such a character that it washes away easily in the form of fine silt and produces extremely high turbidities in the streams. The bed of Des Plaines river is at all points muddy and insecure.

There are two dams built in the river, one at Maywood and one at Riverside. The purpose of the Maywood dam, a low wooden structure, is to hold back water to be used for cooling purposes at a plant of the Public Service Company of Northern Illinois. The Riverside dam, about 12 feet high and built of masonry, maintains a considerable depth of water for some distance above. This was built primarily to



Dam of Public Service Company at Maywood.

improve the river front within the village. An outlet sewer across the town provides means for allowing flushing water from the pond to enter the stream below the dam.

Records of gagings taken at Riverside by the Sanitary District show that at times of high water there is a flow in the stream as great as 11,670 cubic feet per second and that the minimum flow is zero. For two or three months during some years there is practically no flow. It was the assertion of every one questioned along the stream, that for a time during every summer, no current whatever is perceptible and that, except above the dams, the stream is impassable by small boats. The eight municipalities discharging sewage into the stream above Riverside have a total daily water consumption of about 2,000,000 gallons, an average of about 3.1 cu. ft. per second, which represents approximately the amount of sewage entering the stream during dry periods. The water is all obtained from deep wells and adds to the natural run-off of the watershed. At times, therefore, whatever flow there is in the stream is due almost entirely to the sewage discharged into it at various points.

SOURCES OF POLLUTION.

At the time this investigation was begun the stage of the stream was considerably above normal low water and there was a very per-

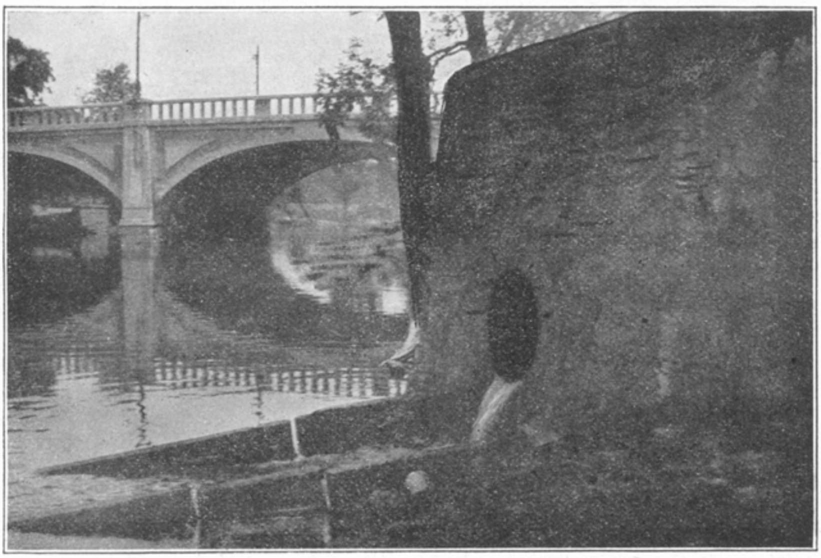
Dam at High Water, Riverside, Ill.

ceptible current. At the end of the two weeks over which the work extended, a fall of probably one foot had occurred at points which were out of range of impounding effect produced by the dams. The flow was very sluggish, but there was still considerable water falling over the dam at Riverside.

The sewage from a population of approximately 32,000 is now being discharged into DesPlaines river at 17 points above Riverside. This sewage comes from eight municipalities and one private institution. Individual considerations of these sources of pollution follow:

Forest Park: Population, 7,096. Total area, 1.85 square miles. Area outside cemeteries 1.1 square miles. This village has a system of combined sewers which serves the entire built-up portions and has one 66-inch outlet. The system receives the house drainage of practically every dwelling in the village and the sanitary sewage from "Forest Park," an amusement resort visited daily during the summer by large numbers of people from neighboring villages and Chicago.

The sewer outlet is at the abutment of a highway bridge on 12th street. It has its invert at El. 1.9 at the water's edge and at El. 7.3 about 100 feet back. (Datum, low water Des Plaines river about 25 feet above Lake Michigan.) When this outlet. was visited a slight current could be discerned in the middle of the river, but immediately below the outlet the sewage seemed to be held near shore. Septic action had begun and from the bridge above foul odors were very noticeable. There is one dwelling about 200 feet distant from the outlet on the opposite side of the river. Land to the south of the outlet on the same side of the river is quite low, not averaging more than five feet in elevation above low water in the river. On the opposite side the bank is quite steep and rises to a height of about 12 feet.



Central Sewer Outlet, River Forest.

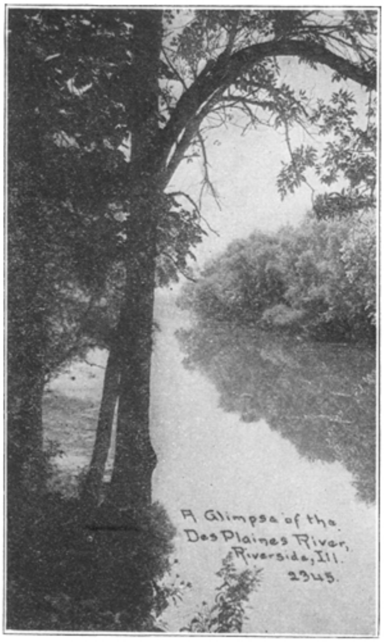
River Forest: Population, 2,640. Area, 1¼ square miles. River Forest is divided into three sewer districts by parallel lines running east and west. The southern district has an 18-inch tile outlet at El. 6.2 at Madison street about one mile above the Forest Park outlet. Further up stream at a distance of about half a mile is the outlet to the central district. This is a 30-inch concrete outfall at El. 4.5. About ¾ mile above this is a 24-inch outlet from the northern district at El. 4.8. These sewers are all built on the combined plan.

The outlets from the central and northern districts are situated above the dam at the Public Service Company's plant, that from the central district being only about 1,000 feet above.

The bank along the River Forest side of the stream is rather low, much of the land not being higher than El. 8.0.

Maywood: Population, 8,733. Area, 1.8 square miles. This village has been divided into seven sewer districts, of which six are now sewered on the combined plan while the seventh, except for a short

Sewer Outlet No. 4, Maywood.



A Glimpse of Des Plaines River.

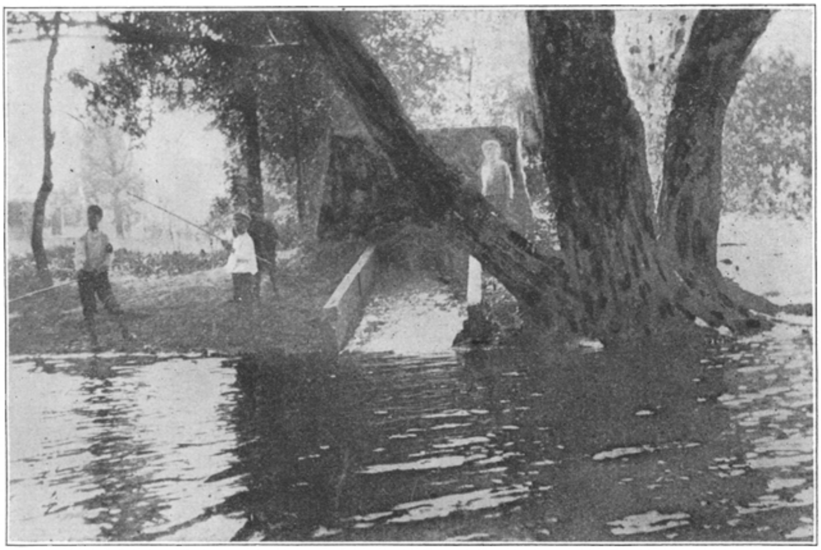
line connecting with district No. 6, is unsewered. The following table gives figures relative to these sewer districts and their outlets:

District Number	Area Acres	Size Outlet	Elev. Outlet	Dist. Outlet from Dam
1	90	18 in.	1.68	4,000 ft. above
2	100	30 in.	1.36	700 ft. above
3	100	24 in.	9.14	10 ft. below
4	220	30 in.	6.23	400 ft. below
5	300	42 in.	0.96	2,400 ft. below
6	120	27 in.	2.89	5,500 ft. below
7	250			

Melrose Park: Population, 5,249. Area, 0.97 squares miles. Melrose Park has outlets for its sewers at two points. One 33-inch line passes along the northern boundary of Maywood and discharges into the river at El. 6.55 about 5,000 feet above the Public Service Company's dam, the other a 51-inch line passing through Maywood along the C. & N. W. right-of-way discharges at El. 3.79 about 500 feet above the dam. Land around the upper outfall has a very gradual slope back from the river to an elevation of about 20 feet. Around the lower outfall the bank is quite steep and rises to a height of about 20 feet.

The village is very thoroughly served and practically all dwellings are connected. The smaller outlet serves an area of about 200 acres while the larger serves about 320 acres.

Franklin Park: Population, 723. Area, 1.7 square miles. The population of this village is very widely scattered. The sewerage sys-



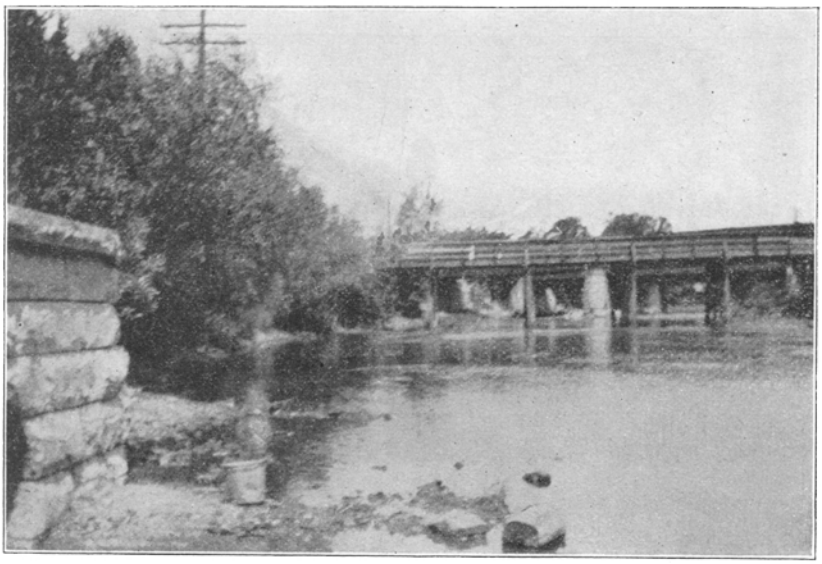
North Sewer Outlet, Melrose Park.

tem is comparatively new and incomplete and at present is said not to have more than 10 house connections. Connections, however, will increase rapidly in number.

There is one concrete main sewer 5 feet in diameter, discharging into the river just below the railroad bridge of the C., M. & St. P. The invert of this sewer is at an elevation of about a foot above water level at low stages of the river. The banks of the stream are quite steep in this locality and rise to heights of about 10 or 12 feet. Just below the outlet there is low lying ground which could be conveniently utilized for sewage treatment works.

Park Ridge: Population, 2,143. Area 2.0 square miles. The built-up portion of Park Ridge is very completely served by a system of combined sewers to which practically every dwelling is connected. There is at present a single 3-foot outlet to the river in the abutment of a highway bridge a mile west of town. This outlet has proved inadequate for removal of storm water and there is now under construction a 6-foot concrete overflow sewer, from the center of the city to the river, paralleling the old trunk line. These outlets are at an elevation of about 10 feet above the river bed.

The banks on the same side of the river as the outlets are quite steep and from 10 to 15 feet high. On the opposite side the land slopes up very gradually from the river. In constructing the new trunk sewer a large deposit of sand of very excellent quality was encountered



Sewer Outlet, Des Plaines.

near the point of discharge. This may be of value to the city in case treatment works should ever be built.

Des Plaines: Population, 2,456. Area, 1.7 square miles. About one square mile is at present built up and this area is well served by a system of combined sewers. Not all dwellings are connected with the sewers, but connections are being rapidly made. There is one point of discharge to the river, that being just below the C. & N. W. R. R. bridge near the center of town. There is a rather high steep bank on this side of the stream and a public highway is built on the top. On the opposite side the land rises quite gradually from the water's edge to a height of about eight feet above the river. This land is used as a camp meeting ground. The stream bed is very muddy. A large amount of water vegetation grows in the water along the banks. Foul odors are said to be very noticeable in the vicinity during the summer months.

St. Mary's Training School: This is a Catholic institution located near the west bank of the river about two miles north of Des Plaines at the Wisconsin Central R. R. station known as Feehanville. The population, made up very largely of children, numbers at present about 1,000 and is having a steady growth. Sewage from this institution is discharged into the river. The main sewer is a 14-inch pipe having its outlet at an elevation about 5 feet above mean low water in the stream. There is both low land and high land in the vicinity on which purification works might be built. The outlet is about 1,000 feet from the nearest highway and there are no houses in the vicinity. So far as could be learned, objectionable conditions are not produced in the river at this point.

Libertyville: Population, 1,896. Area, 1.8 square miles. An area of about one square mile is now built up and about 85 per cent. of this is well served by a system of sanitary sewers. There are no storm water sewers other than a few tile drains. The sanitary sewage is conducted to two septic tanks built on low ground in the east part of town, about 1,700 feet from the river. Each of these tanks is 56 feet long, 8 feet wide at the top, 6 feet wide at the bottom, 6 feet deep at the inlet and 7 feet deep at the outlet. These tanks are said to have given excellent results producing a uniformly clear effluent until the past spring when back water from the river flooded the tanks and stirred up the contents. The effluent at the time of the visit was quite satisfactory in appearance for such a method of treatment. There is considerable sand and gravel near these tanks which can be used for filtration when it becomes necessary to further purify the sewage. An order has recently been passed requiring all dwellings to be connected with the sewers wherever possible. This will, of course, result in a stronger sewage and it may be fairly anticipated that a corresponding deterioration in the septic tank effluent will follow.

Recapitulation: The villages of Franklin Park, Park Ridge, Des Plaines and Libertyville and the St. Mary's Training School are each located at a considerable distance from any other town and have, therefore, individual problems of sewerage and sewage disposal. All except Des Plaines and possibly Franklin Park are so situated with respect to the river as to have no vital concern in the quality of the river water since the stream is at a considerable distance from residences. Des Plaines does suffer from a local nuisance resulting from its present method of sewage disposal. At Franklin Park a number of dwellings front on the stream, but the volume of putrescible sewage is not yet sufficient to greatly affect the river and to result in a nuisance.

Maywood, Melrose Park, River Forest and Forest Park practically constitute one large town and the sewerage and sewage disposal problems of each are necessarily matters of concern to all. Data concerning the sewer outlets are given in the accompanying table. The River Forest and Forest Park outlets are on the east side of the river and all others are on the west side:

Name of Outlet—	Distance from Public Service Co.'s Dam	Elevation	Size	Area Served, Acres
Forest Park	9,500 ft. below	7.3	66 in.	700
River Forest—South	5,000 ft. below	5.2	18 in.	200
River Forest—Central	1,000 ft. above	4.5	30 in.	300
River Forest—North	5,000 ft. above	4.8	24 in.	500
Maywood—No. 6	5,500 ft. below	2.89	27 in.	120
Maywood—No. 5	2,400 ft. below	0.96	42 in.	300
Maywood—No. 4	400 ft. below	6.23	30 in.	220
Maywood—No. 3	10 ft. below	9.14	24 in.	100
Melrose—South	500 ft. above	3.79	51 in.	320
Maywood—No. 2	700 ft. above	1.36	30 in.	100
Maywood—No. 1	4,000 ft. above	1.68	18 in.	90
Melrose—North	5,000 ft. above	6.55	33 in.	200

CONDITION OF THE RIVER.

It will be noticed from the table that there are six outlets immediately above the dam of the Public Service Company and that these discharge the sewage from a built-up area of 1,510 acres, having a population of about 16,000. This dam is built of plank filled with broken brick as ballast and impounds water to a depth of about 4 feet. As there is practically no natural flow in the river during certain periods of the year it is only natural that large quantities of putrescible solids should collect on the river bed above this dam and convert the pond into a veritable septic tank. This has occurred for several summers past. Last summer the mayor of Maywood, with the local police force, visited the dam one night and chopped away a portion of the dam, thus emptying the foul water from the pond. The dam was immediately rebuilt by the service company and the Maywood authorities destroyed it a second time. An agreement was then made between the two contending parties whereby the company was permitted to build a dam with flood gates and the Maywood authorities were given the privilege of opening the flood gates at such times as they saw fit for the relief of obnoxious conditions. Such an arrangement, of course, cannot give adequate relief. After the dam was cut conditions were as bad, if not worse, than before, because the sludge on the river bed was not removed and parts of the bed were exposed to view and to the direct rays of the sun. There is no pollution from the plant of the service company itself. The damming of the water by them is done to obtain water for the condensers in the plant.

It is not only above this dam that the river is in bad condition, but if the dam were entirely removed conditions would probably be little improved. The water in the stream is not sufficient to furnish proper dilution for the sewage and furthermore there is not current enough to keep the solids in the sewage from settling on the river bed. The settling of solids occurs at the outlets below as well as above the dam. At the time of the investigation there was septic action with rank odors at the Maywood outlet No. 5, which is below the dam. The same condition was observed further down, at the Forest Park outlet. As already stated, the stage of the river was still somewhat above mean low water and even worse conditions are to be expected. Obnoxious conditions had not yet begun to occur above the dam.

With the present method of sewage disposal without treatment it would be necessary to have a minimum flow of fresh water in the river of about 125 cubic feet per second to obviate the occurrence of septic action. This statement is made on the basis of the generally accepted standard of 4 cubic feet per second of diluting water per 1,000 persons contributing sewage. As has already been stated the minimum flow in Des Plaines river at Riverside is zero.

The village of Maywood is the only one of these municipalities which has shown any inclination to improve conditions. The village authorities recently engaged engineers to investigate and make a preliminary report on the possibilities of remedying the situation. Surveys were made and the report states that it is wholly practicable to construct an intercepting sewer to conduct all Maywood and Melrose Park sewage to the present Maywood outlet No. 5. It would be practicable to connect the Forest Park and River Forest outlets with an intercepting sewer. The ideal procedure would, of course, be to sewer these several villages as one large town, which, in fact, they constitute, and treat the disposal problems of all as a single problem. There have been several meager attempts in the past to form a sanitary district and obtain legislation which would make it legal for these villages to work together in these matters, but nothing has resulted. The matter of becoming a part of the Chicago Sanitary District is not generally looked upon with favor as it is feared the benefits would be slow in coming and would not be in fair proportion to the additional Sanitary District taxes.

It has been suggested by some that works be installed for pumping water from Lake Michigan into the upper part of the river to provide sufficient diluting water at all seasons. The cost of such an undertaking would undoubtedly be out of all proportion to the benefits gained. It has been suggested that an impounding reservoir to collect water at flood times and to maintain a flow during dry seasons be built at some point in the upper part of the stream. It is questionable whether a place could be found where it would be practicable to build an impounding reservoir of very great capacity, because of the broad, flat character of the land through which the stream flows. It might, however, be practicable to build a number of small reservoirs on the tributaries of Des Plaines river in Lake county which flow through rather more rolling country than the main stream.

Equlalizing the flow in the stream probably would not, however, be a satisfactory solution of the sewage disposal problem in this community. Even though the flow in the stream were sufficiently increased to care for the sewage of the present population, it would be only a few years until the increase in population would make further remedies necessary. This is a rapidly growing district and primarily a community of homes. The Des Plaines is the only stream of water easily available to the people living in these west side suburbs, and this fact is making its banks more and more popular as picnic grounds, even though it falls short in many ways of being an ideal pleasure stream. Equalizing the flow in the stream would greatly improve it for recreative uses, and if this were accompanied by the elimination of the numerous foul and unsightly sewer outlets and the purification of the sewage before discharging it into the stream, the Des Plaines river would unquestionably be the source of much more pleasure than now and the discontent and disgust which has resulted from past conditions would be entirely removed.

SUMMARY.

During several months in the year Des Plaines river above Riverside has practically no natural flow, yet it is receiving approximately 2,000,000 gallons of sewage per day from the various communities.

At the present time the stream is excessively polluted and much complained of at and above Maywood. The condition requires immediate remedy.

The communities upon the watershed may be divided into two groups, one group comprising those which are isolated and must solve their sewage disposal problems independently, and the other comprising those communities located adjacent to each other and which may profitably work out a joint solution for their sewage disposal problems. In the first group are Franklin Park, Des Plaines, Libertyville and St. Mary's Training School. All of these communities are so far removed from each other that their problems are independent. In the other group belong Maywood, Melrose Park, River Forest and Forest Park. These four towns constitute virtually one community. The solution of their sewage disposal problem is a crying necessity and a combination of effort would undoubtedly render the solution more economical and effective.

It is especially important that all of the communities in the Des Plaines watershed realize that they have a sewage disposal problem to meet now or in the near future, and that it is highly desirable for them to at once make engineering studies for the purpose of determining what works are required to adequately dispose of the sewage. Such studies will serve as a basis for modifying or extending the sewerage systems and, for installing purification works at the proper time in the best and most economical manner.

RURAL WATER SUPPLIES*

The Census Bureau† defines urban population as that residing in cities and other incorporated places of 2,500 or more, and rural population as that residing outside of such incorporated places. The urban territory of the state of Illinois in 1910 contained 3,476,929 inhabitants, or 61 per cent. of the total population, while 2,161,662, or 38.3 per cent., lived in rural territory. Only six cities of over 2,500 inhabitants, with a combined population of 20,000, have no general water supplies. Of the cities containing less than 2,500 inhabitants, eighty-five have no general water-supplies, and hence must rely on wells or cisterns for their drinking waters. In cities having general water-supplies many people, either from necessity or preference, use shallow well water for drinking purposes. From necessity because the city mains are not extended to new sections, or because in old sections the houses are not connected with the mains; from preference because the city water furnished has unpleasant physical characteristics, like taste, color or turbidity, causing people to prefer the clear, shallow well water. We estimate that the number of people in cities using well water would be approximately the same as the number of people in the rural territory using general supplies. It would be reasonable, therefore, to estimate that a population equivalent to the rural population, or that 40 per cent. of the population of the state of Illinois, obtain their drinking water from wells.

In a great measure the relative use of shallow wells in different sections of the state is dependent upon the source and character of the municipal water-supplies. In the northern part of the state of Illinois the majority of the city water-supplies are obtained from deep rock wells. In the east central portion of the state the water-supplies are obtained from deep drift wells. In these sections it is a comparatively easy matter to obtain a satisfactory general water-supply, and therefore the number of shallow wells are reduced to a minimum. In the west central and southern parts of the state the general water-supplies are obtained from streams. This method of obtaining a water-supply is more expensive than the deep well method, since it requires the building of a dam and an impounding reservoir and in most cases the construction of a filter plant. For this reason 32 per cent. of the

*Read at the sixty-third annual meeting of the Illinois State Medical Society, at Peoria, May 22, 1913, Section on Public Health and Hygiene, by Edward Bartow.

†Thirteenth Census of the United States, 1910.

cities of more than 1,000 inhabitants in the southern part of the state have no general water-supply.

It is possible to have deep rock wells in the northern part of the state because the St. Peter and Potsdam sandstones, water-bearing strata which outcrop in the central and northern part of Wisconsin, dip to the southward, so that they are from a few hundred to two thousand feet below the surface in the northern third of Illinois, or rather north of a line drawn from Quincy to Chicago. Because the height above sea level in Illinois is less than in Wisconsin, wells which enter these two strata are free-flowing or can be easily pumped. Such wells furnish an ideal water for a municipal water-supply, and in many cases when the expense is not prohibitive, are used as a source of supply for the individual farms. In the water-bearing stratum the water is absolutely free from contamination. It is only necessary to take proper measures to prevent contamination during delivery to the consumer. Contamination may be caused by defective casing, a contaminated reservoir or from faulty connections with impure river supplies.

In the rock wells along or south of a line drawn from Quincy to Chicago there is a strong probability that the water will be very highly mineralized. It is, therefore, necessary in the central and southern parts of the state to obtain water-supplies from sources other than deep wells in rock. In the eastern part of the central area the glacial drift is deep enough and contains gravel coarse enough to furnish a satisfactory water-bearing stratum. We, therefore, find many of the cities in this area obtaining their water-supplies from wells from 100 to 200 feet in depth. These waters are also perfectly free from contamination in the water-bearing strata, and if properly cared for furnish a perfectly hygienic supply. Many farms in this area obtain at a comparatively small expense their water-supplies from the deep drift wells. Since this drift extends over most of the northern section of the state, it furnishes a satisfactory source of supply for the rural districts where the municipalities use the deeper well waters. Only 10 per cent. of the cities of 1,000 inhabitants or more in the northern part of the state are without municipal water-supplies.

In the western half of the central part of the state and in that part of the state south of a line drawn from St. Louis to Danville the drift is not deep enough to furnish sufficient reservoir capacity, and it is necessary to rely on surface waters for municipal supplies, and the shallow-dug wells for the rural supplies. Very few of the surface water-supplies in this section of the state have been filtered. The unfiltered water-supplies are not only unattractive for drinking, but they may be contaminated or even may be infected. Because of these unattractive municipal supplies a large majority of the citizens in the southern section use water from shallow wells. Under such conditions we expect a higher typhoid fever death-rate in the southern part of the state than in the east-central and northern parts.

A study of the statistics collected by the State Board of Health from 1904-1911* shows this to be the case. Dividing the state into two parts, fifty-one counties to the north and the same number to the south, we find in the northern part of the state but two counties with a typhoid fever death rate exceeding 30 per 100,000, and not one county with a typhoid fever death rate of 40 per 100,000. Sixteen of these northern counties had a rate below 10 per 100,000.

In the southern part of the state there were five counties with a typhoid fever rate of more than 40 per 100,000, and twelve more

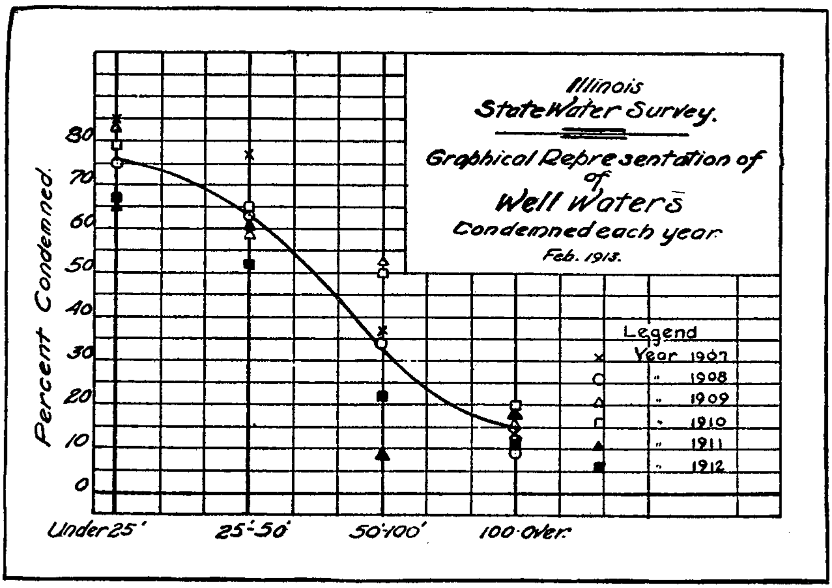


Diagram No. 1.

with a typhoid death rate of more than 30, and but one with a rate below 10 per 100,000. It is gratifying to note that the average for the eight years, 1904-11, is better than the average for the five years, 1904-8.

We have carefully classified all well waters sent to the Survey for examination during the years 1907-12. (See Table 1.) The waters received have been classified according to depth as follows: Less than 25 feet, 25-50 feet, 50-100 feet, over 100 feet, and unknown. The variation in the quality of each class from year to year is but slight. (See Diagram **1.**) The average number condemned decreases with

*Proceedings Illinois Water Supply Association, *2,* (1910) 151-164.

TABLE 1.—PURITY OF WELL WATERS, SHOWING PER CENT OF WELL WATERS CONDEMNED ANNUALLY BY THE WATER SURVEY. ARRANGED ACCORDING TO DEPTH OF WELL.

	1907	1908	1909	1910	1911	1912	Total
Less than twenty-five feet—							
No. examined	284	254	242	148	113	168	1,209
No. condemned	240	192	183	118	74	113	920
Per cent. condemned	85	75	75	79	65	67	76
Twenty five to fifty feet—							
No. examined	224	395	354	201	196	353	1,723
No. condemned	173	250	226	137	122	185	1,093
Per cent. condemned	77	63	63	65	62	52	63
Fifty to one hundred feet—							
No. examined	111	192	161	90	89	129	772
No. condemned	42	66	54	46	8	28	244
Per cent. condemned	37	34	53	51	9	22	32
Over one hundred feet—							
No. examined	161	312	376	205	171	339	1,564
No. condemned	22	31	62	43	30	49	237
Per cent. condemned	13	9	16	20	17	14	15
Unknown—							
No. examined	88	46	72	67	19	27	319
No. condemned	34	22	38	35	9	6	144
Per cent. condemned	38	47	52	52	47	22	45
Total—							
No. examined	868	1,199	1,205	711	588	1,016	5,587
No. condemned	511	561	563	379	243	381	2,638
Per cent. condemned	60	46	47	53	41	38	47

the depth of the well. The wells are condemned from the analysis considered in conjunction with the source of the water and the surroundings of the well. The condemnation is not because of the known presence of disease germs, but because of the presence of filth and, therefore, the possibility of infection. Of those wells less than 25 feet in depth, 76 per cent. were condemned; of those 25 to 50 feet, 63 per cent. were condemned; of those from 50 to 100 feet, 32 per cent. were condemned; of those over 100 feet in depth, only 15 per cent. were condemned; and many of the deepest were condemned because of the excess of the mineral content and not because of contamination. Of those of unknown origin, 45 per cent. were condemned. Of the well waters received during the six years, 47 per cent. were condemned. We note an improvement in the character of the waters received for analysis and a decrease in typhoid fever during the latter part of the five-year period.

Without doubt the above summary does not give the true idea of the actual condition of the well waters throughout the state as a whole. For as a matter of fact, a majority of the samples sent to the Water Survey for examination are sent because of typhoid fever cases in houses using the water. A truer estimate of the actual character of the well waters of the state can be obtained from a study of water

* University of Illinois Bulletin, Water Survey Series, No. 7, 78-97.

†These samples collected by the Survey should represent average conditions.

collected by representatives of the survey from typical wells.* A small number of samples collected by representatives of the Survey from farm wells in various parts of the state have been examined. While 73 per cent. of those less than 25 feet deep were condemned, only 54 per cent. of those from 25 to 50 feet, 13 per cent. of those from 50 to 100 feet, and none of those over 100 feet in depth, were condemned. Diagram 2 shows the character of samples analyzed by request of citizens to be worse than that of those analyzed on the initiative of the Water Survey.

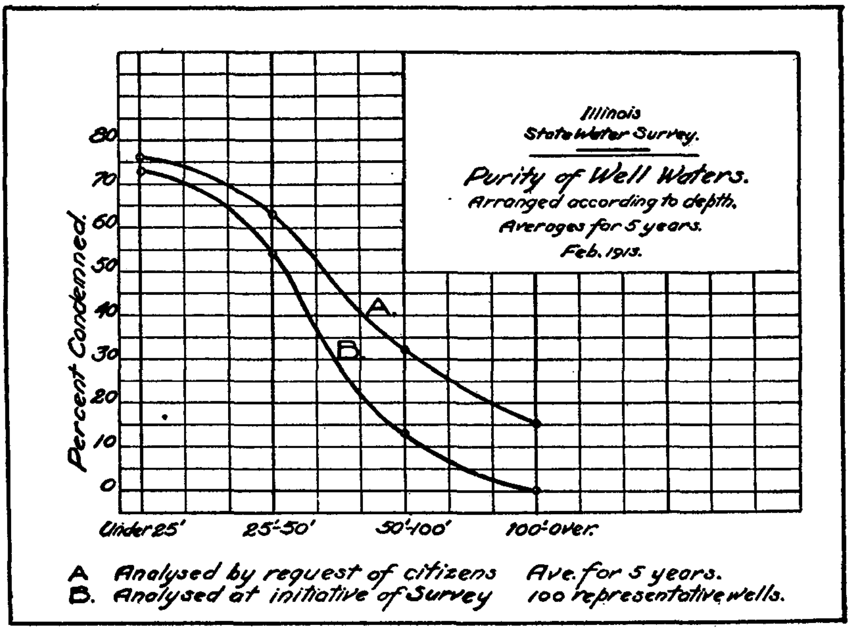


Diagram No. 2.

The results of the examination of the water from shallow wells showed three-fourths of them to be contaminated and, therefore, possibly dangerous. An ideal remedy would be to abolish all shallow-dug wells, but the ideal cannot be attained in this as in many other matters. As indicated in the discussion of the sources of water supplies in the state, it is impossible in some parts of the state to obtain a desirable water from deep wells so that the shallow well is a necessity.

TABLE 2.—FARM WELLS.†

	Less than 25 ft. deep.	25 ft. to 50 ft.	50 ft. to 100 ft.	More than 100 ft.	Total.
Number examined	15	41	15	29	100
Number condemned	11	22	2	0	35
Per cent condemned	73	54	13	0	35

Whenever the water-bearing stratum is porous enough to allow free flow, a driven or bored well less than 50 feet deep should furnish a satisfactory water. In many cases, however, the flow through the water-bearing stratum is so slow that it is necessary to make a reservoir into which the water may slowly percolate and from which it can be drawn as needed. Hence the shallow-dug well is a necessity. Granting that it is a necessity, great care must be taken to protect the water. The character of the strata which it penetrates must be taken into consideration. Strata of sand may serve as a filter to purify the water. Strata of clay or other material through which water flows in crevices or cracks may allow pollution to be carried considerable distances. Wells should be located on a higher level and at a distance from any cesspools, privies or barnyards. The immediate surroundings of the well must be carefully protected. Surface water should not be allowed to pass through the casing within at least four feet of the top. The cover should be tight, so that water from the pump may not flow back into the well carrying with it any dirt and filth from the well cover.

If typhoid fever does break out, we wish to emphasize the fact that about the last thing to do is to send water for examination. Typhoid fever infection has taken place from ten days to two weeks before the symptoms are recognized. There are other means of spreading typhoid fever, and even if the water were the means, during the time between infection and the outbeak of the disease the water in the well may have lost its infection. Rather should the patient be so cared for that he may not again infect the well or infect others by contact. The water may be analyzed, but it will require from one week to ten days to obtain the results of an analysis, and in the meantime infection may have spread through other means. It is the wisest course to protect all wells so that infection cannot enter, making the water safe at all times.

ENGINEERING REPORT

The work of the Engineering Department may be classified in four groups, as follows:

(1) Regulative;
(2) Special Investigations;
(3) Statistical;
(4) Educational.

Regulative: The regulative work of the department relates to the examination of plans and specifications for new projects. New projects may involve the installation of entire new water supplies or sewerage systems or may involve important modifications in existing water supplies or existing sewerage systems. It is of special importance that new water supply projects be investigated promptly in order that any unwise selection of a source of supply or method of treating a water for purification purposes may be brought to the attention of the local authorities. In the case of new sewerage systems, it is likewise important that the local authorities be advised with reference to the proper final disposal of sewage so that the surface water resources of the state may not be unduly jeopardized. Accordingly, the department has regarded the investigations of new projects as an immediate demand upon its attention.

To carry out this branch of the work of the department, all sources of information such as newspaper clippings, engineering periodicals, and so forth, are regularly reviewed to learn of new undertakings. When information is obtained of a project which seems to require the services of the Survey, a communication is sent to the local authorities requesting the submittal of plans and specifications before special assessments are spread. This often enables the Survey to secure the plans at a time when changes can be most readily made. Plans and specifications are then carefully reviewed and in practically all instances a representative of the engineering department visits the community in question for the purpose of making an examination on the ground. Upon the basis of the information thus acquired, a detailed report is prepared descriptive of the project and conveying approval or disapproval of the design and construction proposed. In actual practice it is rarely necessary to submit an outright disapproval and in most cases approval is given with certain conditions attached.

Very often the Survey is able to get in touch with local authorities before plans and specifications are prepared. In this event an endeavor is made to cooperate with the engineer employed and place before him various information which the Survey has at hand. This results in the production of plans and specifications which require but perfunctory review.

The State Water Survey does not attempt to act as consulting engineers, but strongly advocates the immediate employment of a competent consulting engineer by the local authorities. This leaves the State Water Survey in the attitude of an advisory Board of Review.

In the regulative work of the State Water Survey there might be some opportunity for duplication of the work of other state departments, such as the State Board of Health and the Rivers and Lakes Commission. Such duplication of effort, however, has been studiously avoided.

Following is a list of cities and villages that have been reported with reference to new projects. These include both water supply investigations and sewerage investigations:

*Albion**
Alton
Anna Insane Hospital
Arthur
Assumption
Barrington
Benton
Carlyle
Casey
Charleston
Chester
Columbia
Decatur
Deer Creek
Effingham
Eldorado
Evanston
Fairfield
Flora
Geneseo
Georgetown
Granite City
Hamilton
Harmon
Harrisburg
High Lake
Highland
Litchfield
Mattoon
Maywood
Melrose Park
Mounds
Mt. Vernon
New Athens
Palatine
Pana
Peoria Insane Hospital
Peoria Heights
Petersburg
Rankin
Rushville
Vandalia
Warsaw
Wheaton
Wilmington

Special Investigations: From time to time the State Water Survey is called upon to make special investigations which are not directly called for in its enabling act, but for which its equipment and staff happen to be well adapted. These requests for special investigations frequently come from other state departments and have included outbreaks of typhoid fever when such outbreaks have been suspected of being produced by polluted water supplies, nuisances caused by improper disposal of liquid wastes and objectionable methods of garbage reduction. Special investigations which have been conducted during 1912 are as follows

Enfield
Hillview
Stallings
Thawville

Statistical: To conduct the work of the engineering department of the State Water Survey in a manner that the services of the survey may be equitably distributed throughout the state and accomplish the

*Cities written in italics discussed in detail in this Bulletin. Others are discussed in Bulletin No. 9.

greatest good with the means at hand, it is necessary for the department to acquire a knowledge of water-supply conditions throughout the state. To accomplish this, representatives of the engineering department will visit all of the communities in the state which have public water supplies or sewerage systems for the purpose of securing detailed and accurate descriptions of these utilities. The work is being carried on as rapidly as possible, consistent with giving due attention to regulative work and special investigations.

Descriptions of public water supplies are embodied in reports which include recommendations for improvements where such seem desirable, and copies of these reports are transmitted to the local authorities for their information. The most valuable results of such reports relate to the discovery and elimination of possible sources of contamination of public water supplies which may endanger public health. A striking example of how insidious these dangers are is had in the city of Rockford, which obtains its water supply from deep rock wells. The general public had the greatest confidence in the purity of the supply and, as a matter of fact, the water in the deep-lying rock strata is absolutely pure from a sanitary standpoint. The method of handling the water, however, subjected it occasionally to grave contamination, which in the early part of 1912 resulted in a most disastrous epidemic of typhoid fever. It is to safeguard the cities against repetitions of such disasters that special cognizance is taken of the possibilities of contamination.

Of secondary importance, yet of great practical value to local authorities are recommendations made by the Survey with reference to the improvement of service and increasing economy of operation. These matters, however, have not been dealt with so exhaustively as has the general character and sanitary quality of water supplies. Improvement of service and economy of operation, however, constitute a broad field of profitable activity which the Survey will cover as soon as more pressing duties permit.

A list of cities visited with reference to existing water supplies is given as follows:

*Aledo**
Alton
Anna
Anna State Insane Hospital
Arcola
Arlington Heights
Aurora
Batavia
Benton
Bloomington
Cairo
Cambridge
Carlinville
Carlyle
Carthage
Centralia
Chatsworth
Chenoa
Chrisman
Clinton
Collinsville
Crystal Lake
Danville
Downers Grove
Du Quoin
Earlville
East Dundee
East St. Louis
Elgin
El Paso
Evanston
Fairbury
Farmer City
Forest Park
Fort Sheridan
Franklin Park
Freeport
Galesburg
Galva
Geneva
Gibson City
Glencoe
Grayville
Highland Park
Hillsboro
Hoopeston
Jacksonville

Kenilworth
Kewanee
Kirkwood
Knoxville
Lake Bluff
Lake Forest
Lawrenceville
Leroy
Libertyville
Lincoln
Litchfield
Macomb
Marion
Maroa
Maywood
McLeansboro
McHenry
Melrose Park
Menard State Hospital
Monmouth
Monticello
Mounds
Mt. Carmel
Mt. Olive
Mt. Vernon
Murphysboro
Nauvoo
Newton
Normal
North Chicago
Naval Training Station
Ottawa
Pana
Paris
Paxton
Pekin
Petersburg
Plano
Pontiac
Quincy
Rankin
Rantoul
River Forest
Rockford
Rock Island
Roodhouse
Rossville
Rushville
St. Charles
Sandwich
Silvis
Sparta
Springfield
Staunton
St. Elmo
Sterling
Streator
Tiskilwa
Vandalia
Waterloo
Watseka
Waukegan
Wilmette
West Dundee
Woodstock
Yorkville
Zion City

Educational: The educational work of the State Water Survey is certain to be productive of great public good, and is given greater effectiveness through the close relation between the survey and the University of Illinois. One form of this educational work is involved with the general activities of the survey and consists in discussing water supply and sewage disposal problems with various city officials having such matters under their supervision. Sometimes this work is broadened to the extent of addressing public meetings on requirements for adequate public water supplies and sewage disposal.

At the university the engineer of the survey lectures and has classes in Water Purification, Sewage Treatment and other sanitary engineering subjects, and in addition the reports of the survey furnish a fund of practical information for students.

*Cities written in italics discussed in detail in this Bulletin. Others are discussed in Bulletin No. 9.

WATER SUPPLY AND SEWERAGE INVESTIGATIONS

ALBION, PROPOSED WATER SUPPLY.—Visited September 4, 1912. A report descriptive of available sources of supply, together with general comments and recommendations for further procedure, was sent to the local authorities.

Albion is located in the center of Edwards county, of which it is the county seat, and is on the divide between Little Wabash river and Bonpas creek, two tributaries of Wabash river. The population is approximately 1,300.

Investigations showed that a ground water supply is practically out of the question for the reason that all of the ground waters in the vicinity are so highly mineralized as to be very objectionable.

Several possibilities for obtaining a water supply of surface origin exist, but owing to the fact that the town lies on a divide between two watersheds, rather remote from a stream of any size, the cost of developing a surface water supply will prove rather great. Bonpas creek seems to offer the most favorable opportunity for securing an adequate supply, but this creek does not approach nearer than four miles of the town. No data are available to indicate if there are suitable sites for impounding reservoirs on Bonpas creek, but the topography of the stream valley is such as to make it appear that a reservoir site of reasonably satisfactory character may be found. The cost of developing this source of supply would be quite large and probably beyond the present financial means of the community.

Another project that has been considered seriously is the use of the existing water supply of Grayville, about ten miles distant and to the southeastward. This project would involve the construction of an 8-inch pipe line approximately 10 miles in length, at a cost of from $60,000 to $80,000. In addition to this, Grayville would be obliged to materially increase its pumping capacity and install purification works capable of meeting the needs of the two communities.

Present information points to an independent water supply for Albion derived from Bonpas creek, as the most favorable proposition. A definite decision, however, cannot be reached until surveys have been made which will permit of reasonably accurate cost estimates for both projects. It was recommended that should the cost of each project prove to be approximately the same, preference be given to Grayville, inasmuch as this would permit the use of a larger central plant, thus effecting certain economies in operation and moreover the large size of purification works necessary for the combined supply of both towns would permit of the employment of a properly trained superintendent of filtration. Recommendation was also made that a competent consulting engineer be employed.

ALEDO, WATER SUPPLY.—Population is approximately 2,200. The public water supply derived from deep rock wells is of good quality from a sanitary point of view, but has an objectionably high mineral content and a disagreeable taste, due to the presence of salt. The residents of Aledo have become used to the peculiar taste of the water, and the water is in very general use for drinking and domestic purposes. Some private wells are still in use, but many of these have been abandoned as polluted upon the strength of analyses made in the laboratories of the State Water Survey. The water works seem to be substantially arranged and economically managed.

SEWERAGE SYSTEM.—Aledo has a very complete system of sanitary sewers. Owing to the absence in the vicinity of the village of a stream having a large volume of flow, it is necessary to treat the sewage, and this is accomplished by sedimentation in a two-story tank, followed by passage through percolating filters. The plant seems capable of giving acceptable results, provided it receives very close attention. At the present time the sewerage system and sewage purification works are under the general supervision of the superintendent of water works, who gives them such time as his numerous other duties permit. The sewage purification plant is, therefore, not receiving the attention which the most successful results would demand. At the time of the visit a portion of the siphonic apparatus was out of order so that sewage was not being properly applied to one of the three units. Due to the improper operation of the filters during cold weather, the walls surrounding the filters have been more or less damaged by frost action.

A competent laborer employed to assist the superintendent of water works in connection with his duties in caring for the sewerage system would be of advantage not only in securing the better operation of the purification works, but such employe would also be available for inspecting the installation of house connections with the sewerage system, cleaning the sewers and making minor repairs.

ALTON, EXISTING WATER WORKS.—Visited December 4, 1911, with the main object of assisting the Alton Water Company in equipping a laboratory for filter control and again on October 22, 1912, for the purpose of obtaining further descriptive matter. (See Bulletin No. 9.) These visits form the basis of a report, copy of which was sent to the water company. The State Board of Administration has determined to use the Alton city water for the new Insane Hospital to be located in the vicinity of Alton.

Water is drawn from Mississippi river at a distance of 200 feet from shore. The raw water is treated with lime and iron and hypochlorite. The filtered water, both in appearance and from a bacterial standpoint, is not always up to as high a standard as would be desirable. The most serious defect in the design of the filter plant is that the sewers carrying soiled wash water from filters pass through the clear water basin, where, on account of leaky joints, they may contaminate the water in the basin. Plans for extensive enlargements and improvements in the filter plant are under way.

ANNA INSANE HOSPITAL, PROPOSED WATER SUPPLY.—Visited January 9, 10 and 11, 1912. The character of this project was described somewhat in detail in Bulletin No. 9 and requires but slight supplementary comment. The visit above mentioned was made in company with the consulting engineer for the purpose of looking over available well locations and reservoir sites. It resulted in the adoption of a reservoir site about four miles to the west of the institution, suitable for impounding about 30,000,000 gallons of water. Subsequently a report was prepared by the consulting engineer, embodying a description of the project and this was submitted by the Board of Administration to the State Water Survey for review in April, 1912. The project as outlined was approved by the survey and thereupon plans and specifications were prepared. Owing to various difficulties, no contracts had been awarded by the end of the year, but construction will be gotten under way early in 1913.

ARCOLA, EXISTING PUBLIC WATER SUPPLY.—Visited December 3, 1912. This visit forms the basis of a descriptive report on the public water supply which was sent to the local authorities. It was found that the present water supply is very inadequate, and that the water works equipment is inefficient and in a more or less dilapidated condition. A proposal has been made to remedy by drilling new wells, each equipped with an electrically-driven deep-well centrifugal pump. The spring election will decide whether the city will or will not make the proposed improvements.

The State Water Survey suggested the feasibility of removing iron from the water by means of aeration and filtration, so that the supply will be more acceptable for general domestic purposes. Aeration and filtration would also eliminate past difficulty due to clogging of meters by sediment, and make it possible to again meter the house services. Greater protection of the water from contamination after it is drawn from the wells was also recommended.

Arcola has no sanitary sewer system and thus far the installation of one has not been agitated.

ARLINGTON HEIGHTS, SEWAGE TREATMENT WORKS.—Visited on July 24, 1912, for the purpose of inspecting sewerage and sewage purification works then under construction. The population of Arlington Heights at the present time is about 2,000. Growth is moderate, and it is not anticipated that within the next ten years the population will exceed 2,500. The community is almost wholly residential and has no industries of importance.

The sewerage system is on the combined plan and covers practically the entire community. Sewage treatment works are necessary for the reason that the only streams in the vicinity are very small and would be subject to gross contamination were the sewage from the town discharged directly into them. In order to collect the dry weather flow composed of sanitary sewage, three intercepting chambers have been constructed. The work of installing the sewers seems to have been well carried out, though, as will be noted later, there were at first certain defects connected with the design of the intercepting chambers.

The treatment works are located three-fourths of a mile to the eastward of the built-up portion of the city in an isolated locality and comprise a grit chamber, two settling tanks, a dosing chamber and six intermittent sand filters. They were presumably designed to care for a population load of about 2,000, for it may be reasonably anticipated that within the next ten or fifteen years 2,000 persons will be tributary to the sewerage system. Based on a population of 2,000, the normal dry weather flow may be taken as about 200,000 gallons per twenty-four hours. This will, of course, be increased materially during times of storm.

Grit Chamber: The grit chamber is 20 feet long, 10 feet wide and 3 feet deep to the flow line. It thus has a retention period of approximately thirty-two minutes based on the assumed nominal sewage flow. The velocity through the basin will be about .62 of a foot per minute. It may be expected, therefore, that the basin will act more as a sedimentation tank than as a grit chamber and will contain in addition to ordinary grit, sand, etc., a considerable quantity of organic matter.

Settling Tanks: There are two settling tanks, each 40 feet long and 7 feet in depth. One of them is 8 feet in width and the other 12 feet in width. The capacities are respectively 16,800 gallons and 25,200 gallons. The retention periods obtainable with these tanks operated singly and combined are two hours, three hours and five hours. The tanks are provided with means for removing a portion of the sludge while in operation. For a thorough cleaning, however. the tanks must be emptied. Both tanks and grit chamber are covered with concrete slab roofs for the purpose of rendering them less unsightly and preventing the dissemination of odors. No special arrangements are made for distributing the inflow evenly across the width of the tanks, though this will be partly accomplished by a hanging baffle placed a few feet from the inlet end. The outlet end, however, is provided with a series of openings for the purpose of drawing off the effluent evenly across the width of the tank. In addition to the hanging baffle near the entrance of each tank, there are two hanging baffles placed respectively near the middle and near the outlet end. The purpose of these is presumably to control the movement of the scum which may form.

Dosing Chamber: From the sedimentation tanks the sewage passes to a dosing chamber, which is located in the center of a group of six intermittent sand filters. This dosing chamber is hexagonal in plan and has a depth to the flow line of about 2 feet 9 inches. The total capacity is 7,710 gallons, which represents a retention of about 55 minutes' flow. The volume of sewage contained in the chamber is such that if spread out upon one of the filter beds it would cover it to a depth of about 2.7 inches. The chamber is equipped with six automatic, alternating discharge siphons of the Miller type. These siphons are adjusted to empty the chamber on the several beds automatically in rotation. Provision is also made for cutting out any one or more siphons for the purpose of cleaning or repairing filters without interfering with the operation of the remaining filters. The dosing chamber is covered with a neat superstructure which permits ready access to all of the syphonic devices.

Filter Beds: The filter beds have the forms of sectors of a circle, with the apex cut off. The six beds are grouped around the dosing chamber and form a complete circle. The filtering material consists of 27 inches of sand of a fair quality. The under drains consist of 6-inch lateral drain tile discharging into a central 10-inch drain tile, which in turn discharges at the center of the group of beds into a 12-inch main drain leading to the neighboring small stream. Sewage is distributed on the surface of the beds by means of systems of wooden troughs which have about fifteen points of outlet onto each filter. It was observed during the laying of the under drains that they were partly embedded in the mud underlying the sand, so that it is questionable if they are entirely effective.

The combined area of the beds is .574 acre, hence the population load based upon the assumption already given is 3,487 per acre, and the rate of treatment will be 348,700 gallons per acre per day. These rates are excessive and it cannot be anticipated that the plant will give good service unless the area of the sand beds is much increased. The difficulty will be all the greater in view of the thinness of the sand, which, as already noted, is only 27 inches. A more conservative practice would be to make the sand 36 inches in thickness and underlay this with gravel of graded size so as to cause an approximately uniform drainage into the under drains from all parts of the bed.

When the plant was first placed in service the filter beds were thrown out of commission immediately after the first storm, owing to the fact that the interceptors did not sufficiently limit the flow of sewage to the purification works. The beds were badly flooded, and moreover the sewage carried so much sediment that the surface of the sand became covered with a thick film of mud. The interceptors have since been modified and the beds were cleaned and again put in good shape. What subsequent experience has been, is not known.

Further studies of the operation of this plant are contemplated, as a number of points of interest may be determined as follows:

(1) The minimum amount of sewage that may, without detriment, be diverted for treatment when a combined system of sewers is used and where the only available outlet is a very small stream with practically no flow in dry weather.

(2) The suitability of this type of plant for treating combined sewage.

(3) The rates at which sewage may be successfully treated in ordinary practice on intermittent sand beds of the type adopted.

(4) The suitability of the frequent dosing of beds, which has been provided, namely, once about every six hours.

ARTHUR, PROPOSED WATER SUPPLY.—Visited December 4, 1912, upon learning that a new water supply was in progress of installation. Arthur has a population of approximately 1,200 and is primarily a farming center. The water works is being installed by the municipality at an approximate cost of $9,500, not including distribution system. The plans for the installation were prepared by the National Engineering Company of South Bend, Indiana. This company also has the contract for construction. The water is to be obtained from three wells sunk to a depth of 75 feet on a city lot about three blocks west of the center of the city and adjacent to the Pennsylvania railroad. Wells enter a water-bearing sand at a depth of approximately 35 feet, from which it is expected to obtain an adequate supply. Three wells will be placed in a group and will be drilled from the bottom of a collecting reservoir 20 feet in diameter and 25 feet deep. The pressure at which the water is encountered is sufficient to cause it to rise into this reservoir and stand within 5 or 6 feet of the surface when the pumps are not in operation.

Pumping equipment for the new installation comprises one single-acting triplex power pump with a capacity of about 360,000 gallons per day geared to a 20 H.P. gasoline engine. Space will be provided in the pumping station for an additional pumping unit. At the time of visit plans had not been prepared for a distribution system. Additional funds are required for its installation, though it is anticipated it will be completed about July 1, 1913. Connected with the distribution system will be an elevated steel tank with a total height of 110 feet and a capacity of 50,000 gallons.

BARRINGTON, PROPOSED SEWERAGE.—Visited on July 24, 1912, to inspect a proposed site for a proposed sewage treatment plant. Plans and specifications were later submitted and reported upon by letter to Mr. F. L. Stone, consulting engineer, of Chicago. The sewerage system is now being completed and will soon be placed in service.

BEMENT, EXISTING WATER WORKS.—Visited March 29, 1912. The information obtained was embodied in a descriptive report of the water works, copy of which was sent to the local authorities. Bement is a farming center and has a population in the neighborhood of 1,600. The water works were installed by the municipality in 1894 and the source of supply comprises three wells. Two of these wells are located near the center of the town within the pumping station building and are 6 inches in diameter and 137 feet and 140 feet in depth, respectively. The third well is one-third mile distant, is 8 inches in diameter and has a depth of 150 feet. The water is obtained from a sand and gravel stratum near the base of the heavy glacial drift deposits that cover this portion of the state. The water is pumped directly from the wells into a 40,000-gallon collecting reservoir and thence into the distribution system.

Each of the two wells at the pumping station is provided with a single-acting, deep-well steam pump, which lifts the water from the well and discharges it through a suitable pipe line into the collecting reservoir. The remaining well is about to be equipped with a motor-driven, double-acting pump. This well is owned by the electric lighting company. In 1910 a contract was awarded to the electric lighting company to pump water at 7 cents per 1,000 gallons, using its own well and pumping equipment in combination with the wells and pumping equipment belonging to the city. The water, as indicated by analyses, is of good quality from a sanitary point of view, but rather hard and contains considerable iron. A recommendation has been made by the State Water Survey that the city authorities consider the feasibility of installing a plant for removing the iron and possibly for softening the water. Water is pumped into the distribution system by a duplex steam pump having a nominal capacity of about 720,000 gallons per day.

BENTON, ADDITIONAL WATER SUPPLY.—Benton was visited in the later part of 1911 for the purpose of investigating a proposed additional water supply. A report was submitted which is summarized in Bulletin No. 9. On May 9, 1912, a second visit was made for the purpose of obtaining additional data and on the basis of this visit a supplementary report was prepared under date of July 10. At the present time there are two sources of supply, namely, the original supply obtained from a railroad borrow pit having a capacity of about 15,000,000 gallons and an impounding reservoir with a capacity of about 200,000,000 gallons. The latter is located on a small stream about four miles northward of the city.

The supply is adequate in quantity and though no analyses have been made, it appears to be comparatively soft. It is, however, turbid and subject to some contamination. Owing to its objectionable appearance, it is not generally used for domestic purposes. The State Water Survey has recommended the purification of the supply by filtration, but the water company feels that the expenditure necessary would not be a profitable one. Further advice received by the State Water Survey indicates that the water company will undertake a partial purification by coagulation and sedimentation, utilizing the old borrow pit as a sedimentation basin.

SEWAGE DISPOSAL.—Visited May 9, 1912. While this visit was made primarily in connection with the installation of an additional water supply, it was learned that the present method of disposing of the sewage from the city, namely, by direct discharge into several very small water courses, is giving rise to much difficulty. The riparian owners along one of these streams which flows in a northwesterly direction from the town have obtained an injunction restraining the city from making any more sewer connections while the contamination of the stream continues. It is not known what steps the city proposes to take to overcome this difficulty. The State Water Survey has offered its assistance to the city authorities, but thus far the offer has not been accepted.

BLOOMINGTON, EXISTING WATER WORKS.—Visited April 30, 1912. Results of this visit were embodied in a report which was sent to the superintendent of water works. Water is obtained from three wells in the valley of Sugar creek north of town. The supply is apparently sufficient in quantity to meet the needs of the city, and is of excellent quality from a sanitary point of view. The mineral content is high and includes a considerable quantity of iron which gives rise to more or less complaint. The city was advised in the report to improve the water by softening and removing the iron. The conditions at Bloomington are particularly favorable for the installation of a softening and iron removal plant. Many private shallow wells still in use throughout the city are seriously contaminated as is revealed by analyses. The State Water Survey urged the use of the public supply in preference to the use of private wells.

CAIRO, EXISTING WATER SUPPLY.—Visited January 11, 1912, and again on July 18, 1912. Samples of the city water were collected and analyzed in the laboratories of the State Water Survey. No report was prepared on these visits, but the installation of a hypochorite treatment plant, the remodelling of the filters, and other improvements were recommended.

CAMBRIDGE, EXISTING WATER SUPPLY.—Visited July 3, 1912, for the purpose of examining the existing water works. The data obtained form the basis of a report, a copy of which was sent to the local authorities. The supply, though highly mineralized, is of very good quality from a sanitary point of view. The water is almost universally used for drinking and domestic purposes. At the time of the visit, the single well in use was being pumped nearly to the limit of its capacity and the village feels the need of having an additional well both for the purpose of securing more water and to have the deep well pumping equipment in duplicate. A bond issue for installing an additional well met with defeat owing to a popular objection to a clause dealing with the manner of redeeming bonds. It was urged in the report that an additional well be installed just as soon as suitable arrangements could be made. The installation of a system of sanitary sewers was also recommended.

CARLINVILLE, EXISTING WATER SUPPLY.—Visited October 7, 1912. The results of this visit were embodied in a report which was sent to the water works authorities. Carlinville has a population of about 4,000 and aside from being the county seat, has important coal mining interests and is an agricultural center. The water works were installed in 1889 under the terms of a franchise granted to a local company. The franchise called for a water suitable at all times for domestic uses and in adequate quantity for fire protection. The company erected a pumping station and installed pressure filters at Macoupin Creek south of the city and supplied water until about 1907. The system was poorly constructed and the service proved generally unsatisfactory. Five years ago the water works changed hands, after which, with financial aid from the city, the distribution system was almost entirely replaced, the old pressure filters were abandoned in favor of gravity filters and the pumping equipment was improved. Macoupin Creek has an ample watershed so that with moderate storage afforded by a small dam, an ample supply of water is obtained. The service is generally regarded throughout the city as satisfactory and amicable relations now exist between the water company and the city officials.

The most important criticism which the State Water Survey has to offer in connection with the Carlinville water supply relates to the filter plant. This has certain defects which should be corrected in order to secure efficient operation. These defects relate to the preparation and application of chemicals, the sedimentation basin, interior arrangement of filter, methods of controlling rate of filtration and means for washing the filter units. These will be dealt with in the order above named.

Preparation and Application of Chemicals.—Chemicals are used only when the water is very turbid. It is impossible to secure best results by mechanical filtration without thorough coagulation at all times. The chemical feed is such that there is no assurance that the chemical is introduced into the suction of the pump at a uniform rate.

To remedy defects in connection with the preparation and application of the chemicals recommendation was made that the entire chemical preparation and feed equipment be remodelled along the lines shown by a sketch submitted. The sketch calls for tanks for the preparation and application of soda ash or lime and hypochlorite. Soda ash or lime is necessary to make up for deficiencies in alkalinity that sometimes occur in the raw water. The water should also be treated with hypochlorite as an additional safeguard and to insure a good bacterial removal.

Sedimentation Tank.—The sedimentation tank is not well placed with reference to the filter, yet it can be successfully utilized in its present position if certain other defects are remedied. The sedimentation tank is operated with a fluctuating head, so that at most times very much less than the full capacity of the tank is utilized. This defect can be readily remedied by providing an overflow weir near the top of the tank which will maintain a practically constant head of water. The utilization of the capacity of the tank may still further be promoted by rebaffling.

Filter:—The filter tank is of adequate size to meet present demands, but with materially increased consumption, it will be necessary to add an additional unit. It would be highly desirable to have the filter plant in two units under any circumstances in order that one unit may be shut down for repairs without depriving the city of filtered water. The filter is of the round tub type and rather shallower than ordinarily constructed. Filter tanks are generally built with a stave length of 8 feet, whereas this has a stave length of but 6½ feet. This is a defect which cannot be readily remedied, but with proper operation and other defects cared for, it is probable that the shallow depth of the filter tank will not seriously interfere with results obtainable.

The interior of the filter is not provided with overflow troughs which are necessary to admit the raw water to the filter without disturbance of the sand and also serve to carry off evenly from all parts of the filter the soiled wash water during washing. The expense of installing overflow troughs is not great and they should be provided.

No means are provided for regulating the rate of filtration and it appears that the rate of filtration is, as a matter of fact, rather variable. It was recommended that there should be placed upon the effluent pipe of the filter an automatic rate controller.

The filter is washed by water drawn directly from the mains leading to the city and inasmuch as the cleansing of the filter is accomplished by water alone, a rather high rate of application of the wash water is required. At least 18 inches vertical rise per minute should be obtainable. As a matter of fact, it is impossible to secure this amount of water for the reason that the loss of head that would occur in the 10 inch main leading to the standpipe in the city would be greater than the head actually pumped against by the pumping engines. Even with both pumping engines operating at full capacity and the standpipe full, it would be difficult to get a sufficiently high rate of application of the wash water. In actual practice washing is carried out at a very much lower rate than that above given and probably does not exceed 9 or 10 inches vertical rise per minute. To remedy this defect, the installation of a low lift wash water pump was recommended. A centrifugal pump with a capacity of at least 2,100 gallons per minute and taking its suction directly from the clear water basin, was suggested.

Analytical Control: It is doubtful whether the water company is in a position to maintain a laboratory at the filter plant which will enable the filter operator to maintain bacterial control over the operation of the filter, but it should be entirely feasible to make such simple determination as for turbidity, alkalinity, color, and possibly the number of bacteria, which if regularly carried out will serve as a valuable guide for the operation of the filter plant.

CARTHAGE, SEWAGE DISPOSAL.—Visited August 3, 1912, for the purpose of examining a sewage treatment plant recently completed by the city. Carthage has a population of approximately 2,400 and is quite thoroughly sewered by a system installed about fifteen years ago. It comprises sanitary sewers only, varying in diameter from 6 inches to 10 inches and having a total length of about 5½ miles. Due apparently to defects in construction, this system admits large quantities of water during periods of storm. The discharge of the sewage into a small water course tributary to Crooked creek has occasioned much annoyance on the part of riparian owners below. Because of threatened damage suits the city undertook to build sewage purification works last year. Mr. W. S. Shields, consulting engineer of Chicago, was first engaged to prepare plans and specifications and he recommended the construction of a plant comprising a sedimentation tank of the two-story type followed by secondary treatment on percolating filters. The cost of this installation appeared to the city authorities too large and so the project was abandoned in favor of a tank recommended by the Russell Sewage Disposal Company.

The tank as constructed is 80 feet in length, 40 feet in width, and 5 feet 4 inches deep to the flow line. It is divided into 32 compartments each 10 feet square. Sewage is introduced into one corner of the tank and passes from compartment to compartment in a zig-zag fashion. The passage from one compartment to another is formed by means of an inverted vitrified pipe trap, the object being to always maintain the openings well below the sewage level. The top of the tank is covered by a concrete slab construction and is made as air-tight as practicable. Entrance can be had only into the first four compartments, over which are placed manholes with sealed covers. The tank is provided with a bypass which permits sewage to flow directly to the creek, if for any reason clogging should occur within the interior of the tank and thus check the normal passage of the sewage. It is said that this bypass comes into play at the present time when the flow of the sewage in the sewers is swollen after storms. As nearly as can be estimated, the present sewage flow will probably be in the neighborhood of 80,000 gallons per 24 hours. Such being the case, the retention period in the tank would be in the neighborhood of 32 hours. It is probable, however, owing to the presence of considerable quantities of storm and ground waters in the sewers, that the period of retention at times is very much less than this, perhaps less than half the figure given.

The most serious objection to the tank is the inaccessibility of its interior. In time the chambers will undoubtedly become filled with sludge and there will be no means of entering them for cleaning purposes. It is a fallacy to suppose that any form of sewage tank can operate indefinitely without accumulating more or less sludge, even though only a few years ago, many extravagant claims were made for the sludge digesting ability of septic tanks. Another objection to the tank is that the retention period is so long and the conditions under which it operates are such that the effluent will always be so-called stale and devoid of oxygen. The device will, therefore, not prove valuable as a preliminary process for further treatment. With the tank in question, it is impossible to modify its operation, because of its peculiar construction, so that it may be made available for giving the sewage a preliminary treatment before passing it through filtration devices.

At the time of visit, the effluent was putrescible. Though comparatively clear, it had a slightly inky appearance and a very strong odor characteristic of strongly septicized sewage. It is manifest that even at the present time the effluent is not in a satisfactory condition to permit its discharge into the stream which receives it. As time goes on, the effluent will become even less favorable for discharge into the stream, for the reason that the accumulation of solids in the tank will begin to unload in the form of very fine black suspended matter in the effluent.

The local authorities were advised that unless the city of Carthage can make a satisfactory arrangement with injured riparian owners by the payment of damage claims, they should reconsider the matter of sewage disposal with a view to installing a more adequate plant.

CASEY, PROPOSED WATER SUPPLY.—Visited December 27, 1911, for the purpose of inquiring into the feasibility of obtaining a more adequate public water supply from wells. At the same time an examination was also made of the existing water supply. In order to obtain further data, a second visit was made on Feb. 1, 1912. The second visit was followed by more or less correspondence with local authorities. The results of all inquiries were embodied in a report under date of June 10, which was sent to the local authorities for their information.

Casey is a community with a population of about 3,000. During recent years the city has had a rapid growth owing to the development of numerous oil wells in the vicinity. The first steps toward the introduction of a public water supply were taken twenty years ago when a tract of forty acres in the southwestern part of the city was purchased and set aside for water works and park purposes. An earthen dam was built across a shallow ravine, thus forming an impounding reservoir about four acres in extent. The drainage area is very limited, but the supply is said to be largely replenished by springs in the bottom of the reservoir. In 1900 a small pumping station was erected on the bank of the reservoir, but was at first utilized to supply boiler water to the municipal electric lighting plant located near the center of the town. In 1909 the water works was elaborated to the extent of installing a new pumping equipment in connection with an electric lighting plant near the center of the town. There was added a power pump with a nominal capacity of about 500,000 gallons per 24 hours, an elevated tank with a capacity of 70,000 gallons and a few distribution mains. This equipment was intended primarily for fire protection and serves this purpose in a fairly satisfactory manner.

Because of the inadequacy of the supply and its poor quality it could not be used for domestic purposes and hence a number of public spirited citizens as well as the city officials are desirous of securing a new supply of assured good quality, ample in quantity and preferably obtained from wells.

There are a number of wells in and about Casey, but very few of them within a convenient distance yielding a sufficient quantity of water of satisfactory quality to constitute a source of public water supply. Various possibilities were pointed out, but the most favorable seemed to be certain water bearing strata reached by wells lying a short distance to the westward of the built-up portion. To exploit the various possibilities it was recommended that the city engage the services of a competent engineer well versed in the development of water supplies from ground water sources with instructions to make test borings and conduct pumping tests at such points as thorough investigations indicated to be most favorable.

In compliance with this recommendation the services of an engineer were secured and he prepared a report which was submitted to the State Water Survey on December 6, 1912. Unfortunately the engineer saw fit to pass over the well possibilities with very general comments based upon meager information. He then proceeded to recommend the development of a supply from the Embarrass river from 10 to 11 miles distant and at a cost wholly beyond the means of the city. The report was disapproved by the State Water Survey and comments thereon were sent to the local authorities with the advice that a thorough investigation into the feasibility of a well supply be undertaken.

Owing to change of administration, and various other factors, the effort to secure a new water supply for Casey has not been strongly pressed by the local authorities.

CENTRALIA, Existing Water Supply.—Visited March 21, 1912, and again on May 6th, for the purpose of obtaining a description of the public water supply. The results of these visits were embodied in a report, copy of which was sent to the water works committee of the council. It was learned that the main supply for the city is obtained from a large impounding reservoir 8 miles northeast of the city. The water from the reservoir is more or less turbid and during dry periods in the summer develops plant growths which impart tastes and odors to the water. The installation of a filtration plant as soon as funds could be made available was recommended to improve the physical characteristics of the water and remove whatever danger exists from pollution. The water is of a highly satisfactory quality from a mineral point of view, being very soft.

Sewage Disposal.—As a result of complaints made through L. H. Jonas, attorney-at-law, by riparian owners along a small stream which receives the sewage discharge from Centralia, that city was visited on September 2, for the purpose of investigating the matter. On the basis of this visit, a report was prepared, copies of which were sent to the attorney above mentioned and the city engineer.

The main outfall sewer from the city is 20 inches in diameter and and carries the sewage to a septic tank located about two miles southwest of the center of the town. The septic tank then comprised two compartments holding 30,000 gallons and 60,000 gallons respectively. The effluent from the tank is discharged directly into the small stream in question. The sewerage system which was installed in 1904 serves only the central portion of the city, but extensions are contemplated for the near future. Apparently there is considerable ground water and storm water leakage into the sewer system inasmuch as the outfall sewer at times flows full, representing a discharge of approximately 2,750,000 gallons per 24 hours. At this rate of flow there would be a retention period in the tanks of about ¾ of an hour to 1 hour and it is believed to vary from this to about 4 hours during periods of dry weather.

The stream which receives the tank effluent has but a small watershed and previous to the installation of the sewerage system had no flow during protracted dry periods. The stream was followed for a mile and a half below the discharge from the tanks and though it contained a natural flow fully equal to the quantity of the sewage flow, yet it presented an exceedingly offensive appearance accompanied by a foul odor throughout this distance. In addition to sewage, it is plain that the stream is also receiving the wastes from a gas factory which adds much to the objectionable appearance of the stream. It is claimed by the farmers that the deposition of tarry and slimy matter on the corn planted near the stream during periods of overflow causes the corn to decay. Hay from meadows which have been flooded by the sewage polluted waters is said to be damaged to such an extent that horses and cattle refuse to eat it.

It was suggested to the city authorities that the matter be adjusted by making arrangements for the installation of additional sewage treatment and the State Water Survey offered its services in reviewing plans for same. The city, however, attempted to remedy matters by merely doubling the capacity of the septic tanks, which subsequent inspection showed to be without material effect.

It is probable that the complainants will again threaten damage suits and that the city will be forced to provide some more satisfactory final disposal for its sewage.

CHARLESTON, Proposed Improved Water Supply.—Visited June 18, 1912, at the request of the Hon. T. T. Shoemaker, mayor, with reference to proposed purification works and other modifications in the water supply system. Charleston has a population of about 6,000 and is undergoing a rather slow, but steady growth. It is the county seat and is the location of a large state normal school. In addition it has considerable importance as a railroad center.

The water supply is drawn from Embarrass river at a point about two miles east of the city. The intake is a pool formed by a masonry dam 68 feet high located about two miles from the intake. The river flows through a narrow ravine about 100 feet in depth, but the gradient of the stream bed is rather flat, as indicated by the fact that the back water of the dam extends in an up-stream direction three or four miles. The bed of the stream is for the most part composed of rock or sandy deposits and rising from it are a number of springs. For this reason the water is fairly clear during dry weather, but following storms and heavy rainfalls it becomes excessively turbid and quite unfit for general domestic use.

The sanitary quality of the public water supply has never been open to serious question for the reason that the valley slopes are very steep and are practically uninhabited above the point of intake. No evidence is available to indicate that it has ever been the cause of disease. The local authorities, however, recognize that with an unprotected watershed the supply is not safe for general domestic consumption. The most serious point of possible pollution is the village of Oakland, twenty miles above. This community has a population of 1,200 and is contemplating the installation of a sewerage system.

The quantity of water used at Charleston could only be roughly estimated in the absence of regular pumping station records at from 800,000 to over 1,000,000 gallons per 24 hours. This is excessive, but is accounted for by the absence of meters on services and the fact that free water is supplied to the state normal school, where it is used very extravagantly.

The proposed improvements involve a filter plant but some consideration was given to remodelling the pumping station. The present pumping station is in an exceedingly dilapidated condition and very poorly arranged and the pumping equipment is in poor repair. It also constitutes a very serious fire risk, for all of the construction is of wood and poorly protected. However, only sufficient funds were made available to install a filter plant and an elevated tank.

The city entered into a contract with the Pittsburgh Filter Manufacturing Company for the design and construction of a filter plant of 1,000,000 gallons daily capacity. At the end of the year this plant was nearing completion. The local authorities failed to formally submit plans and specifications for the filter plant prior to the awarding of contracts, but the design and construction has thus far been carried out in accordance with recognized good practice.

COLLINSVILLE, EXISTING WATER SUPPLY.—Visited Feb. 5, 1912. Collinsville has a population of about 8,000 and occupies rather rolling country overlooking the American bottoms in the vicinity of East St. Louis. The public water supply was installed by the municipality in 1902. The supply is taken from four tubular wells in the American bottoms about one mile beyond the western boundary of the city and about 1,000 feet from the base of the neighboring bluffs. There are four wells placed at the corners of a square 100 feet on a side. The wells vary in depth from 70 feet to 90 feet and encounter water bearing sand and gravel at a depth of 15 feet at which level the ground water stands. The water is of very good quality from a sanitary point of view and the surroundings of the well are such that there is no likelihood of future contamination. On the other hand the water is rather hard and contains considerable quantities of iron. The public, however, seems to be quite well satisfied with the supply.

The pumping equipment is housed in a small brick building and comprises one compound duplex steam pump having a nominal capacity of 750,000 gallons per 24 hours and one triplex electrically driven power pump having a nominal capacity of 600,000 gallons per 24 hours. The water is pumped directly from the wells into the distribution system connected with the distribution system and near the center of the town and on the highest point of ground within the city is a steel stand pipe 120 feet in height.

SEWAGE DISPOSAL.—Visited on March 31, 1912, and again on November 6, 1912, for the purpose of making inquiry into difficulties in connection with the final disposal of city sewage. The sewerage system of the city is divided into three sewer districts, two of which are completely sewered and comprise about one-half the entire area of the city. Each of these districts has a separate outlet, and owing to local topography it is impracticable to so design the sewerage system that all of the sewage will be collected at a single outlet. The sewage from these two districts is passed through septic tanks and it is proposed to provide similar treatment for the third district. There were, however, objections by persons living in the vicinity of the proposed location of the tank for the third district, and the final solution of the difficulty has not been reached. The objection to the proposed tank arises from the fact that one of the existing tanks, namely, that for District No. 1, has been responsible for much nuisance in its vicinity.

The tank for sewer district No. 2 receives diluted sewage and the effluent is generally small in quantity and causes no pollution in the stream into which it is discharged. Part of the success of this method of disposing of the sewage must be attributed to the fact that the tank and the water course into which the effluent is discharged are remote from habitations.

The tank that receives the sewage from sewer district No. 1 has, as above noted, been the source of complaint. This tank is located within 500 feet of houses and the effluent is discharged into a stream which flows through pasture land. Moreover, sewage from sewer district No. 1 is rather concentrated, particularly during dry weather. Formerly the effluent from the tank passed over a series of steps for aeration purposes, and it is probable that this is the point from which the greater portion of the nuisance arose, for complaints have been greatly reduced by by-passing the aerator and conveying the effluent from the tank through a pipe line to a point one-fourth mile in a down-stream direction. This new arrangement, however, does not improve conditions in the creek and merely serves to transfer the nuisance to a point lower down the stream, where there are fewer objectors. The local authorities were advised that a still further improvement could be secured by modification in the mode of operating the tank. This recommendation involved the use of only a single compartment at a time, thereby rendering it possible to produce a fresher effluent. It was also pointed out that the two compartments of the tank could be alternated when the accumulation of sludge became troublesome and that the sludge be permitted to remain quiescent in the compartment not in use until thoroughly digested.

Emphasis was given to the fact that the ultimate solution to the sewage disposal problem at Collinsville must involve sewage treatment to an extent that will produce at least a nonputrescible effluent. Moreover the treatment works must be of a design that will not give rise to a nuisance in themselves. Inasmuch as the disposal of sewage from District No. 1 is the primary cause of complaint, purification of this sewage should be given first attention. The disposal of sewage from District No. 2 apparently at the present time gives no serious offense and hence treatment is not necessary. The sewage from District No. 3 in all probability will require but partial treatment at the present time in a two-story tank of the Emscher type, but it is essential that this tank be located somewhat remote from residential districts on land that will not be built up and furthermore the tank should be at a site where at some future date it may serve as a preliminary process to more complete treatment.

COLUMBIA, Proposed Water Supply.—Visited November 20, 1912, in response to a request from the mayor with reference to a proposed public water supply. Two possible sources of supply were under consideration by the local authorities, namely, tubular wells in the American bottoms, a mile or two to the northwest of the center of the city, and the so-called Hill spring, which issues from a hillside about three miles southeast of the city. With reference to the former there was no question as to the quantity of water available, but there was some danger of securing a water impregnated with iron, and, moreover, the cost of pumping would be a serious item, inasmuch as the town lies some 70 feet above the suggested location for the wells. The Hill spring yields a water of very good quality in all respects, but the quantity is somewhat deficient, as indicated by weir measurements. In view of the unfavorable aspects of the two sources above mentioned, it was recommended informally that a further search for a supply be made. This search is now under way, but up to date no definite results have been obtained.

DECATUR, EXISTING AND PROPOSED PURIFICATION WORKS.—Decatur was visited a number of times as follows: January 22 and 30, February 8, 9 and 28, and March 30, 1912. The results of the first of these visits were embodied in a lengthy report which gives a description of the existing water works, a detailed discussion of the operation of the filtration plant and concludes with certain recommendations. A summary of the report includes the following:

First: The Sangamon river is being polluted at points above the water works intake and steps should be taken for minimizing this pollution to an extent that will remove any unnecessary burden from the water purification works.

Second: In view of the age, bad state of repair, and obsoleteness of the existing filter plant, renewals or additions thereto are not warranted. Instead, there should be constructed at the earliest possible time a complete new water purification works at the site adjacent to the pumping station, such purification works to be of a design and construction that will conform to the latest developments in water purification practice.

Third: Pending the time when funds will be available for a new water purification plant, the existing plant may be slightly modified at nominal expense so as to be more reliable in producing a clear water.

Fourth: To insure the safety of the filtered water from a health point of view, filtration should be supplemented by treatment of the water with hypochlorite for the purpose of sterilization. There is already available complete equipment for carrying on this process and the cost of chemicals will be but nominal.

Fifth: In order to maintain a more complete control over the operation of the filter plant a small laboratory should be equipped, in accordance with the usual recommendations of the State Water

Survey for such laboratories. The cost of equipment for a laboratory will not be great and, further, all the apparatus may be readily transferred to the laboratory of the new purification works when same has been built.

Sixth: To permit a somewhat closer observation of the individual filters, the effluent pipe on each filter should be equipped with a tap for obtaining samples.

Seventh: Complete daily records pertaining to the operation of the filter plant should be regularly kept. These should include quantity of water filtered, quantity of wash water, quantity of alum used and the turbidity, color, alkalinity and number of bacteria in the raw and filtered water.

All of these recommendations, except the maintenance of complete analytical control over the operation of the plant, have been carried out or are in process of being carried out. The maintenance of complete analytical control has been found impracticable in the absence of a technically trained employe. The installation of a hypochlorite plant and the partial equipment of a laboratory was carried out under the supervision of representatives of the State Water Survey who visited Decatur from time to time. Filter operation records are now being kept on blank forms furnished by the State Water Survey.

On November 5, 1912, there was received from Mr. Wm. G. Clark, consulting engineer for the city, a report outlining in a preliminary way the design for a new filter plant. This report and plans were reviewed and certain general recommendations were made directly to the engineer. Detailed plans for the proposed new plant are now under way, and it is anticipated that contracts will be awarded during the early part of 1913.

SEWAGE DISPOSAL.—On October 15 and 16, 1912, Decatur was visited for the purpose of making inquiry into a difficulty arising from the discharge of sewage into the Sangamon river. On November 30 and on December 21 of the same year Decatur was again visited for the purpose of obtaining measurements of the sewage flow and various other data that would be of assistance to the State Water Survey in making recommendations with reference to a more adequate final disposal of sewage. Studies on the disposal of sewage for Decatur are now under way and a report will be prepared at some future date covering the stream pollution conditions on the entire Sangamon river watershed.

DEER CREEK, PROPOSED WATER SUPPLY.—Visited November 12, 1912. Deer Creek contemplates deriving its water supply from an existing well about 267 feet in depth and 6 inches in diameter, obtaining water presumably from rock strata. No reliable data relative to the formation penetrated could be obtained. It was not practicable to secure any plans illustrating the proposed mode of developing the water supply but in a general way it is intended to pump the water directly from the well into the distribution system by means of an electrically-operated deep well pump.

EFFINGHAM, Proposed Water Purification.—Visited June 19, 1912, for the purpose of inspecting proposed sites for water purification works. The Effingham water company desires as soon as it can make suitable arrangements for the extension of its franchise to install water purification works and several sites were inspected for the purpose of discussing informally with the water works authorities their relative merits. It was anticipated that plans and specifications would be submitted at an early date, but because of various delays in reaching an agreement relative to an extension of contract, these plans were not submitted during 1912.

Disposal of Wastes from Catsup Factory. --visited June 19, 1912, for the purpose of making inquiry relative to the treatment of wastes from the catsup factory of the Mullen-Blackledge-Nellis Company. The matter of disposing of wastes from the catsup factory first came to the attention of the State Water Survey in 1910 as a result of complaints made by a riparian owner on the stream below the factory. A number of samples of the stream water were analyzed in the laboratories of the State Water Survey and showed gross contamination.

In the absence of any adequate experiments on the treatment of wastes from catsup factories, it was not possible to give any definite advice in regard to their final disposal, but some form of sedimentation tank was suggested as a means for removing the grosser solids. To this end and before the visit above mentioned a tank of the Emscher type was drawn up and the design was based on some fragmentary data obtained from the New Jersey State Board of Health report for 1911. The plans did not prove satisfactory to the company because of the high cost and the fact that it did not represent a complete solution. The visit to Effingham was made for further investigation but resulted in no very definite conclusions. Recommendation was made, however, that for preventing the deposition of sludge in the stream and for keeping out unsightly floating particles, a hole be dug in the soil, perhaps 6 feet deep, 30 feet long and 10 feet wide to permit suspended matter to settle before the wastes enter the creek. It was believed that this would remove a large portion of the heavier than water solids and that the floating particles could be intercepted both by screens and hanging baffles, the latter to be used near the inlet and outlet ends. Odors from the fouling of such a basin were anticipated, but it was hoped that the odor would not be excessively bad. Sludge accumulation in the bottom of the excavation was to be distributed on land at the end of the operating season. Offers were made to study the proposition further, but as no more complaints have been received, it is presumed that the company has reached a satisfactory adjustment with the riparian owners in the down stream direction.

ELGIN INSANE HOSPITAL, **WATER** SUPPLY.—Visited January 20, 1912, at the request of the superintendent, Dr. R. T. Hinton, on account of a typhoid fever outbreak thought to be due to the water supply. Though the public water supply at the time was subject to some contamination, there was no evidence to indicate that it was the cause of the typhoid fever. On the other hand subsequent studies made by physicians at the hospital revealed the fact that typhoid fever was caused by a waitress in the dining room, who was a typhoid carrier.

The hospital has a total population including patients and employees of over 1,700. The water supply is drawn from two large dug wells in the gravel and sand deposits bordering the Fox river a short distance below the Elgin sewer outlet. One of these wells is 40 feet from the water's edge and at times of heavy pumping, the water level is drawn down below the water level in the river, consequently the water from the river has an opportunity to filter through the soil and enter the water supply perhaps without having been completely purified. There is evidence that the supply is thus contaminated by the persistent presence of a very few gas formers, though the total number of bacteria is generally low.

In light of the above the State Water Survey recommended that the well near the river be abandoned, preferably by filling in, and that new wells be sunk at least 100 feet and preferably 150 feet from the river bank and at a sufficient distance apart to prevent mutual interference during pumping. Because of inadequate data regarding the water bearing strata, definite recommendations could not be made regarding the kind and number of wells to be used, but methods of conducting tests for the purpose of determining these details were outlined.

EL PASO, **EXISTING WATER** SUPPLY.—Visited October 30, 1912, for the purpose of obtaining a general description of the public water supply. El Paso is a farming community with a population of about 1,500. The supply is obtained from a well 8 feet in diameter and 60 feet deep. Three tubular wells sunk in the bottom of this well penetrate to a depth of 120 feet. The principal water bearing stratum is encountered at a depth of 60 feet and consists of 14½ feet of clean gravel. The water is of good quality, from a sanitary point of view, and is comparatively soft for an Illinois ground water, having a total hardness in the form of carbonates of 336 parts per million and a total mineral content of 485 parts per million. There is sufficient iron, namely, 1.5 parts per million to cause considerable discoloration, but this does not seem to meet with popular disapproval.

The pumping equipment is housed in a small pumping station four blocks west of the center of town and comprises a single electrically driven triplex power pump having a nominal capacity of 325,000 gallons per 24 hours. The water is pumped directly from the well into the distribution system.

Connected with the distribution system is an elevated steel tank having a total height of 100 feet and a storage capacity of 112,000 gallons.

The distribution system comprises about 4½ miles of mains, varying in size from 4 inches to 8 inches, all of cast iron pipe. The original mains were of wooden pipe, but due to continual leakage and the rusting out of the iron bands holding the pipe together, wood was entirely abandoned after about 20 years of service.

No accurate data could be obtained regarding consumption, but the average daily consumption is roughly estimated at 80,000 gallons.

SEWERAGE SYSTEM.—Visited October 30, 1912, in connection with the water supply, at which time inquiries were made relative to the sewerage system. El Paso has no general system of sewers, but a number of private drains have been installed from time to time and have been extended without any comprehensive plan or supervision by the city. Four outlets to drains discharge directly into open fields south of the city and one drain discharges into a ditch along the Illinois Central Railroad and both cause unsightly conditions and objectionable odors.

EVANSTON, EXISTING WATER WORKS.—Visited November 23, 1911, for the purpose of addressing the local authorities relative to the necessity for purification of the public water supply. A later visit was made for the purpose of obtaining a description of the public water supply. This description has been embodied in a report.

Evanston obtains its water supply from Lake Michigan at a point about 3,000 feet from shore. The water is more or less subject to sewage contamination as is evidenced by a number of analyses and the prevalence of typhoid fever in the city. Typhoid reached epidemic proportions in the latter part of 1911, which greatly alarmed the residents, and gave rise to a vigorous movement looking toward the purification of the supply. Largely through the agency of the State Water Survey the authorities were induced to install as a temporary means for rendering the water safe, a chlorination plant, which has been in successful use since the early part of January, 1912.

FAIRFIELD, PROPOSED WATER SUPPLY.—Pursuant to an investigation made in 1911 (see bulletin No. 9) with reference to a proposed water supply, Fairfield was again visited on November 22, 1912.

At this time it had been definitely proposed to obtain a public water supply from drilled wells in the rock underlying the central portion of the town and on property now occupied by the municipal electric lighting plant. It was proposed to conduct pumping tests, but up to date these have not been carried out. Plans had been prepared and were reviewed by the State Water Survey. These plans were based on the assumption that the source of supply should prove adequate, which is a matter still doubtful. Otherwise the proposed installation seems quite satisfactory.

PROPOSED SEWERAGE.—Visited November 22, 1912. The sewerage system proposed is designed on the separate plan which permits the disposal of domestic sewage and wastes of a putrescible character separate from storm water drainage. This is a very desirable arrangement. The method proposed for final disposal of the sewage is discharge into Johnson creek after treatment in tanks. It is questionable if tank treatment is sufficient, for Johnson creek is a small stream and at times practically dry. However, as there are no houses in the immediate vicinity of the creek, pollution of its waters may not be objectionable and if necessary additional treatment devices may be added later. In line with this policy, recommendation was made that the elevation and location of the tanks be reconsidered with a view to securing if possible a gravity flow through the completed treatment works and with a view of having the plant sufficiently remote from present or future habitations to avoid any difficulty due to possible odors.

FARMER CITY, EXISTING WATER WORKS.—Visited March 27, 1912, for the purpose of obtaining a description of the public water supply. Results of the visit were embodied in a report which was submitted to the local authorities for their information. Farmer City is a farming community with a population of about 1,600.

The water supply was installed in 1891 by the municipality and is operated in connection with a municipal electric lighting plant. Water is obtained from two tubular wells 176 feet deep and 8 inches in diameter, reaching water-bearing sand and gravel strata in the deep glacial deposits which cover this region. The water rises in the wells to within 30 feet of the surface. The supply is of good quality from a sanitary point of view, though rather hard and contains enough iron to impart a marked color and turbidity. The quantity of water available seems ample to meet present requirements, which average about 90,000 gallons per day.

The pumping equipment comprises two single acting, deep well steam pumps each having a nominal capacity of 145,000 gallons per 24 hours. They discharge directly into the distribution system, which comprises about six miles of cast iron mains varying in size from 4 inches to 8 inches in diameter. Connected with the distribution system is an elevated tank 12 feet in diameter, 40 feet high and supported on a tower 75 feet in height. The capacity is 32,000 gallons.

SEWERAGE.—Opportunity was afforded by the above visit to consider certain defects in the sewerage system and to make recommendations for their correction. At present a combined system of sewers is being used with direct discharge into neighborng small water courses which gives rise to nuisances and renders the streams unfit for cattle watering. Complaints have been made and damage suits threatened, but as yet these have not been pressed.

FOREST PARK, Existing Water Work.—Visited June 18 and 19, and July 1, 1912, partly in connection with a sanitary survey of the upper Des Plaines river and also for the purpose of securing a description of the public water supply. Forest Park is a suburban community of Chicago and has a population of about 7,500.

The public water supply was installed in 1892 by the municipality, and is derived from two deep rock wells respectively 2,000 feet and 1,650 feet in depth near the center of the city and within 20 feet of each other. The shallower well varies in diameter from 10 inches at the top to 5 inches at the bottom. The other well varies from 14 inches at the top to 8 inches at the bottom. The former is pumped by means of air lift and the latter by means of a deep well impeller pump. Water rises to within 150 feet of the surface, which is materially lower than when the wells were first drilled. The water level is said to have fallen at the rate of 7 feet per annum during the past five years. The quality of the water meets with popular approval, but is rather hard. No analyses of the water have as yet been made in the laboratories of the State Water Survey.

The pumping equipment is housed in a brick pumping station near the center of the village. From the well, water is pumped by means of the pumping equipment already mentioned, into two collecting reservoirs having a combined capacity of 100,000 gallons. From the collecting reservoirs the water is pumped into the distribution system by three single stage 6-inch centrifugal pumps, each directly connected with an electric motor. Each pump is rated at about 150,000 gallons per 24 hours. The piping is so arranged that the pumps may be operated in series for the purpose of increasing the pressure during fires. Old steam pumping equipment is still in place and can be rendered available in the course of several days should necessity require. Connected with the main discharge from the several pumps and located in close proximity to the pumping station is an elevated steel tank supported upon a brick tower. The capacity of the tank is about 22,000 gallons.

The distribution system comprises about 11 miles of cast iron pipe varying in diameter from 4 inches to 12 inches. There exists a connection between the water works distribution system of River Forest and Forest Park so that either system may supply the other in case of necessity.

FORT SHERIDAN, Existing Water Supply.—Visited December 15, 1911. A descriptive report of the water supply with recommendations for improvements was submitted under date of March 13, 1912.

The water supply is obtained directly from the lake through an intake pipe which extends out 3,500 feet from the shore. The water is at times turbid and is recognized by the authorities at the post as dangerous to health. When the water is used in its raw state for drinking purposes it is claimed that diarrheal troubles prevail among the soldiers, but thus far there has been no typhoid fever at the post other than a few cases which are believed to have been infected elsewhere. To prevent disease the soldiers are required to drink only boiled water under penalty of court martial. This would seem to be a rather cumbersome arrangement, though it may work out successfully under strict military discipline.

Recommendations were made that a hypochlorite plant be installed at once to render the water safe and that this be followed as soon as practicable by the installation of a filter plant which would remove the objectionable turbidity.

SEWAGE DISPOSAL.—Visited December 15, 1911, at which time an inspection was made of a sewage treatment plant under construction. This plant is in a general way well arranged and should give efficient results if properly operated. During construction, however, certain structural difficulties developed, but these were subsequently overcome by suitable modifications of the design.

The method of conveying the sewage from the plant is an unusual one in that it is permitted to flow from the high land upon which the post is built down to the lake beach, involving a difference in level of about 80 feet, and then is pumped back to the high elevation again at a point some distance south of the post, where the treatment works were located.

FREEPORT, EXISTING WATER WORKS.—Visited July 19, 1912, for the purpose of making a general inspection of the water works preliminary to the installation of extensive improvements. The water supply of Freeport is derived from a group of 25 tubular wells, 40 to 45 feet in depth, and deriving their supply from the alluvial deposits of Pecatonica river. This supply is supplemented to some extent by a well 300 feet deep, deriving its supply from the St. Peters sandstone. The water contains considerable iron, which is removed before delivery to the consumers by precipitation with lime and filtration in mechanical filters.

The pumping equipment comprises one compound duplex pump with a capacity of 2,000,000 gallons per 24 hours for pumping the water from the wells to the iron removal plant; one compound duplex Holley-Gaskill type pump with a capacity of 3,000,000 gallons, and one simple duplex pump with a capacity of 750,000 gallons per 24 hours for delivering the treated water into the mains. The pumping station will be greatly improved and an additional low-lift pump of 2,000,000 gallons' capacity and a new high service pump of 4,000,000 gallons' capacity will be added. The iron removal plant, which has a nominal capacity of 2,000,000 gallons, will be enlarged, extensions will be made to the distribution system and reservoir capacity will be increased. Upon completion of the improvements a full description of the water works will be prepared.

GALESBURG, EXISTING WATER SUPPLY.—Visited on December 2 and 3, 1911, and again on April 30, 1912. A descriptive report with recommendations for improvements was submitted to the mayor and council.

At the time of visit, the water was pumped from two deep wells by means of compressed air and from six shallow wells by means of motor-driven impeller pumps. The water from the well pumps was received in a collecting cistern, from which it was pumped into a storage reservoir of 6,000,000 gallons' capacity by means of two steam pumps of the Holley-Gaskill type, each having a capacity of 1,000,000 gallons per 24 hours. These pumps were so arranged that they could also pump directly into the distribution system. Water was pumped from the reservoir into the distribution system by means of a cross compound crank and fly-wheel pumping engine with a capacity of 6,000,000 gallons per 24 hours.

The distribution system comprised about 100 miles of cast iron mains, ranging in size from 4 inches to 16 inches. Connected with the distribution system is a standpipe with a total capacity of 175,000 gallons, located on high land in the east part of the city.

It was pointed out to the local authorities that the greatest defects in the water works were the inadequate supply and uneconomical arrangement of the pumping equipment. The city has now employed a consulting engineer for the purpose of improving the water works and increasing the available supply.

SEWAGE DISPOSAL.—Visited December 2 and 3, 1911, and again on April 30, 1912, with primary reference to the public water supply; but inquiry was also made relative to the method of disposing of sewage. At the present time most of the sewage is discharged into a small stream flowing out of the city toward the westward. This stream is grossly polluted and has been the cause of complaint on the part of riparian owners in a down-stream direction. The city is from time to time threatened with lawsuits resulting from damage to property.

In the southeastern portion of the city is a subsidiary sewerage system recently installed with direct discharge into a small stream. The resulting foulness of this stream has given rise to various complaints and at the present time an injunction is in effect, which prevents the further discharge of sewage therein. The outcome of the difficulty is not known, nor is it known what steps the city proposes to take to raise the injunction and continue the use of the sewers. It was learned that engineering studies had already been made by a competent engineer looking toward the improvement of the sewerage system with special reference to the final disposal of the sewage, but recommendations resulting from these studies were never acted upon. Recommendation was made to the city authorities that the matter be reopened with a view to correcting present objectionable conditions.

GALVA, EXISTING WATER SUPPLY.—Visited July 2, 1912, Galva is an agricultural center, having a population of 2,500.

Water works were originally installed by the municipality in 1894. The original installation comprised one deep tubular well. A second well was installed in 1899, and a third well is now being contemplated. The two existing wells are respectively 1,500 feet and 1,535 feet in depth. Both vary in diameter from 12 inches at the top to 6 inches at the bottom. The water comes from the St. Peters sandstone. During the year 1910 complaints were made concerning the quality of the water and accordingly samples of the water were sent to the State Water Survey for examination. These showed evidence of contamination in well No. 2. To ascertain the cause of contamination, a cluster of electric lamps was lowered within the well and the condition of casing was examined with a field glass. At a depth of 110 feet a defective joint was found in the casing that permitted considerable quantities of water to enter. This defect was corrected and subsequent analyses showed the water to be of good quality. The leaky condition of the casing has been regarded as the cause of contamination, but it is questionable if polluted water could have entered at the depth indicated for the reason that the drift deposit in this vicinity is 30 feet to 60 feet deep and consists largely of clay. Though the water has a total mineral content of about 950 parts per million, the total hardness is only about 123 parts per million and is entirely composed of carbonates. There is a moderate quantity of iron, which causes some discoloration, but to this there is no serious objection.

Deep well pumps are used to discharge the water into two covered reservoirs with capacities of 96,000 and 100,000 gallons, respectively. From the reservoir the water is pumped by means of two steam pumps with capacities of 850,000 gallons and 1,000,000 gallons per 24 hours, respectively. The distribution system comprises about four miles of cast iron mains, varying in diameter from 4 inches to 8 inches. Connected with the distribution system and located near the pumping station is an elevated steel tank 11 feet in diameter, 55 feet in height and placed on a brick tower having a height of 60 feet. The capacity of this tank is 36,000 gallons.

SEWERAGE SYSTEM.—Visited July 2, 1912, for the purpose of inspecting a recently completed sewage treatment plant. Sanitary sewers were not built until 1911. Previous to that time some sewage was discharged into private drains in the southern part of the town and carried to a small stream. It proved necessary on account of local topography to build two separate systems, one having an outlet into a small stream to the north and the other having an outlet into a small stream to the south. The sewers range in size from 6 inches to 10 inches and are of vitrified pipe laid with cemented joints.

At the outfall of each system a sewage treatment plant is placed. The south side plant comprises a sedimentation tank and trickling filters, and has a nominal capacity of about 45,000 gallons per 24 hours. This gives a sedimentation period of eight hours and a rate of filtration of 2,000,000 gallons per acre per day. The north side plant comprises a grit chamber, a two-story sedimentation tank, dosing tank with automatic dosing apparatus, a trickling filter and sludge bed. The tank has a capacity of about 26,000 gallons per 24 hours, based upon a two-hour sedimentation period, and has a sludge capacity sufficient to hold about three months' accumulation. The trickling filter has a capacity, based upon a rate of filtration of 2,000,000 gallons per acre per day, of about 40,000 gallons.

The treatment works were badly neglected because no one has been designated to give systematic attention to their upkeep. The works to the south of the city are overgrown with weeds, show much surface clogging on the filters and create disagreeable odors in the vicinity. All of this notwithstanding the fact that there are as yet very few people tributary to the sewers.

To the northward the treatment works are in much better condition and yield an effluent that is apparently satisfactory. The sewage, however, is so weak that the tank effluent is found to be quite inoffensive.

The local authorities were urged to employ an intelligent laborer, whose sole duty would be to look after the sewage treatment plants and the sewerage system. It was pointed out that in connection with the sewerage system, his time could be profitably employed by making occasional inspections of the sewers to see that they are not clogged and by systematically flushing the sewers at dead ends. He also should be required to inspect the laying of all house connections in order to make sure that no down spout water or surface drainage is permitted to enter the sewerage system.

GENESEO, Existing Water Supply.—Visited July 6, 1912, for the purpose of securing a description of the public water supply. Data obtained were embodied in a report, copy of which was sent to the local authorities.

Geneseo has a population of about 3,000 and is primarily an agricultural center. The water works is municipally owned and has been in use for at least twenty years, but since its first installation important changes have been made. The first supply was from a 400-foot well near the center of the town. This was later replaced by a deep rock well, penetrating the Potsdam sandstone at a depth of 2,250 feet. Because of inadequate quantity and high mineralization this source of supply was given up in favor of a number of springs about two miles to the northward of the city and in the valley of Green river adjacent to the Hennepin canal. The Hennepin canal may be used as an emergency supply.

On an area of about 8 acres of land there are 11 springs from which the water is collected into a reservoir by means of a system of vitrified tile pipe. The reservoir has a capacity of 110,000 gallons. The quantity of water seems to be sufficient to meet present needs of the city, which average about 90,000 gallons per day.

The water is of good quality from a sanitary point of view, though there are slight possibilities of contamination owing to the inadequate protection of the tile pipe. The mineral content is also comparatively low, amounting to 350 to 375 parts per million.

Pumping equipment which is housed in a small brick pumping station comprises two power pumps driven by internal combustion engines. These pumps have nominal capacities of 600,000 gallons and 500,000 gallons per 24 hours, respectively.

The distribution system comprises about 8 1-3 miles of cast iron mains varying in size from 4 inches to 8 inches. Connected with the distribution system and located near the center of the town is an elevated steel tank with a total height of 100 feet and a capacity of 150,000 gallons.

Proposed Sewage Disposal.—At the request of the mayor and council, made through Mr. Henry Waterman, city attorney, Geneseo was visited on October 31, 1912, for the purpose of making a preliminary investigation relative to a suitable method of disposing of the city's sewage in an inoffensive manner. At present the sewage, including waste from a gas house and a creamery and at times wastes from a large pumpkin and corn canning works, are discharged into a very small stream known as Geneseo creek, which pursues a circuitous course, ultimately discharging into Green river to the northward.

As the sewage disposal problem of Geneseo is similar to that which confronts numerous small communities, the report in full will be published in Bulletin No. 11 (1913).

GEORGETOWN, Proposed Water Supply.—Visited November 28, 1911, and again on May 29, 1912, at the request of Mr. Wm. P. Holaday, member of a local committee appointed to investigate proposed water supply.

Recommendations had previously been made by the State Water Survey in favor of the installation of a public water supply for Georgetown, but large cost of such an improvement resulted in this recommendation being given but slight consideration. Two severe and disastrous fires occurring in the latter part of 1911, however, gave a renewed impetus to the desire to secure a public water supply.

Georgetown is a rapidly growing city with important mining interests and has at the present time in the neighborhood of 2,500 population. Two general sources of supply were considered in a broad way, namely, Little Vermilion river, and wells. The former project was not deemed feasible except as a last resort, for a number of reasons, including among others, the difficulty of securing a suitable dam and reservoir site and the necessity of filtering the water in order to render it safe and free from turbidity. Possibilities of securing a water from wells were considered, and the most promising seemed to be wells in the western part of the village, penetrating a water bearing stratum at a depth of about 25 feet. The water bearing stratum consists of fine sand and gravel overlaid by clay and normally the water is under artesian pressure sufficient to cause it to flow at elevations a few feet above the surface of the ground. Plans had been prepared for the development of this supply on the basis of what appeared to be insufficient knowledge regarding the source of supply and a recommendation was made by the State Water Survey that the project be halted until the availability of a sufficient quantity of water could be denfiitely ascertained by means of suitable tests.

For various reasons it proved impracticable to finance a municipally constructed and owned water works and at the end of the year nothing definite had been accomplished.

GIBSON CITY, EXISTING WATER SUPPLY.—Visited March 26, 1912, for the purpose of obtaining a description of the existing water works. The results were embodied in a report, copy of which was sent to the local authorities.

Gibson City is a town of about 2,100 and is primarily a farming center. The principal industry is a large canning factory. The public water supply was installed in 1895 by the municipality and is derived from three tubular wells about 55 feet in depth. Ordinarily water is pumped directly from the wells into the distribution system by means of a duplex pump having a nominal capacity of 500,000 gallons per day. This pump may also discharge into a collecting reservoir, near the pumping station, having a capacity of 115,000 gallons. The water in this reservoir is held in reserve for fire protection purposes. An additional duplex steam pump having a nominal capacity of 1,000,000 gallons per 24 hours takes its suction from the reservoir and is held in reserve for fire emergency.

The distribution system includes 5 miles of cast iron mains varying from 4 inches to 6 inches in diameter. Connected with the distribution system is an elevated steel tank having a storage capacity of 45,000 gallons.

The water is of good quality from a sanitary point of view and is well protected against the possibility of surface contamination. Sufficient iron is present to discolor the water at times, but this does not seem to give rise to popular complaint. The hardness is moderate for Illinois ground waters.

GRAYVILLE, EXISTING WATER SUPPLY.—Visited September 3, 1912, in connection with a project to utilize the Grayville water supply to serve the nearby village of Albion. The present population of Grayville is about 2,000. The town is primarily an agricultural community, but has some lumber interests. The public water supply was built in 1895. The project was started by the municipality, but owing to difficulties in raising funds necessary to complete the construction, the project was taken hold of by a corporation formed for the purpose. The works were completed and operated for 10 years thereafter by this concern, at which time the property reverted to the city.

The supply is taken directly from Wabash river at a point where it is subject to sewage contamination from a number of towns in an upstream direction. The nearest and most important in this connection is Mt. Carmel, which is 24 miles distant. The water is also at times excessively turbid and but little used for general domestic purposes.

The pumping station is located on the bank of the river immediately below the mouth of Bonpas creek. The pumping machinery consists of one compound duplex steam pump having a nominal capacity of 1,000,000 gallons per 24 hours. Thus there is no duplicate equipment in case of breakdown. There are about five miles of cast iron mains, varying in size from 4 inches to 8 inches in diameter. Connected with the distribution system and on a high point of land is a steel standpipe 10 feet in diameter and 65 feet high, thus having a total capacity of 65,000 gallons.

Filtration of the water supply has been considered from time to time, but has never had sufficient popular support to render the project a reality. It may also be noted that a number of more or less contaminated wells are used for domestic purposes.

GREENUP, EXISTING WATER SUPPLY.—Visited January 31, 1912, for the purpose of obtaining a general description of the public water supply. A copy of the report based on the data obtained was sent to the local authorities for their information.

The population of Greenup is about 1,400 and a substantial growth in the near future is anticipated. The water supply was first installed by the municipality in 1897 and no important changes have been made in the system up to date. The source of supply, namely, the Embarrass river, is unsatisfactory and the mechanical equipment is uneconomical. A remodeling of the water works is contemplated, but definite plans have not as yet been developed. The Embarrass river is subject to more or less contamination from towns above; the nearest city is Charleston, 25 miles distant, in an upstream direction. The water during dry periods is clear and reasonably satisfactory. but after storms or periods of large rainfall it is excessively turbid and quite unsatisfactory. The pumping equipment, which is housed in a small brick building on the bank of the river in the eastern part of the town, consists of a power pump with a nominal capacity of about 300,000 gallons per 24 hours, and is driven by a gasoline engine. The equipment is not in duplicate.

The distribution system comprises about 2½ miles of cast iron pipe, varying in diameter from 4 inches to 8 inches. Connected with the distribution system and placed near the highest part of the village is an elevated steel tank 90 feet in total height and having a capacity of 35,000 gallons.

HAMILTON, PROPOSED WATER SUPPLY.—On June 3, 1912, there were received from Mr. L. P. Wolff, consulting engineer of St. Paul, Minnesota, plans and specifications for a proposed water works system and a sewerage system for the city of Hamilton. In anticipation of receipt of these plans, Hamilton had been visited on May 4, 1912. On the basis of the data locally obtained and of a review of plans and specifications, a report was prepared which was submitted to the consulting engineer and local authorities for their information.

Hamilton has a present population of about 1,650, but a rapid increase in the size of the community is expected owing to the presence of the plant of the Mississippi Power Company.

The proposed water supply is to be taken from Mississippi river, above the dam of the power company. It will flow through a mechanical rapid sand filter plant and then be pumped to the city through a suitable distribution system. Purification works will comprise two sedimentation basins, chemical preparation and feed devices 3½ million gallon filter units (only two to be equipped as a first installation) and a clear water basin. The immediate installation will, therefore, have a nominal capacity of 1,000,000 gallons. Adjoining the filter plant will be a small pumping station, housing two electrically-driven power pumps having nominal capacities of 450,000 gallons and 900,000 gallons per 24 hours, respectively. The power will be obtained from the Mississippi Power Company. The filter plant in general is well designed and if placed under proper management will undoubtedly produce excellent results. There were, however, a number of details relating to the plant in connection with which slight improvements were possible, and such improvements were recommended to the consideration of the consulting engineer. The water works were placed under construction and will be completed some time during the year 1913.

PROPOSED SEWERAGE.—The sewerage system will be built strictly upon the separate plan, and is so designed that it may ultimately be extended to all parts of the corporation and possibly to future additions thereto. The portion planned for immediate construction is estimated to cost $20,000 and will include 19,355 feet of vitrified sewer pipe, varying in size from 8 inches to 15 inches in diameter. All of the sewage will be conducted to a single outlet at the foot of Main street, where the sewage will be discharged into the so-called Hamilton slough. The plans and specifications call for standard construction. Manholes will be provided at intervals not exceeding 600 feet. Flush tanks will be placed at all dead ends and pipe will be laid with cemented joints.

Attention was called to the necessity of preparing specifications governing the installation of house connections, as this is necessary to prevent surcharging the sewers with storm water and large quantities of ground water which are often admitted through house connections.

The discharge of sewage into Hamilton slough may give rise to some difficulty, owing to the small quantity of water flowing through this small side channel of Mississippi river. It is believed, however, that the discharge of water from the power company's dam will greatly increase the flow through the slough and thus provide ample dilution. Should difficulty be encountered it will be quite practicable at a future date to extend this sewer to the main channel of the Mississippi. No treatment of sewage for Hamilton will be necessary because of the enormous dilution available in Mississippi river.

HARMON, Proposed Public Water Supply.—Visited July 8, 1912, at the request of the city council for the purpose of conferring with that body relative to the best method for securing the installation of a public water supply. Samples were obtained for analysis and the mechanical features of the proposed works were discussed. It is understood that the water works have since been completed, but as no plans and specifications were submitted for review and as no subsequent visits have been made, the character of the installation is not known.

HARRISBURG, Public Water Supply.—For a number of years the public water supply of Harrisburg has been unsatisfactory, owing to a high degree of turbidity and more or less contamination. In compliance with a popular movement to secure an improved water supply for Harrisburg, the People's Light and Water Company have undertaken to install purification works. To insure the public that plans for the proposed purification works are satisfactory, the company has offered to have them reviewed and reported upon by the State Water Survey as a disinterested party, the report to be made public through the Commercial Club of Harrisburg.

The matter has now been before the State Water Survey since October, 1911. On October 24 and 25, 1911, Harrisburg was visited for the purpose of securing a general description of the water works, with special reference to the treatment of the water. During the latter part of October a preliminary set of plans was submitted for review by Mr. J. R. Cravath, consulting engineer. Under date of November 8, 1911, the State Water Survey submitted to Mr. Cravath a preliminary report containing certain criticisms of the plans. On November

15, 1911, Harrisbuig was again visited for the purpose of making further inspections. This was followed by a conference in Chicago on November 22, attended by representatives of the State Water Survey and Messrs. Cravath, W. W. DeBerard and T. C. Phillips, representing the water company. At this conference various items of the report submitted on November 18 were taken up. Nothing further was accomplished until July 14, 1912, when revised plans were received by the State Water Survey and these were reported upon on August 2, 1912. On August 16, 1912, a second conference was held in Chicago, attended by a. representative of the Water Survey and Messrs. J. R. Cravath and W. W. DeBerard, representing the water company. On October 17, 1912, a third set of plans for the water purification works was received and these formed the basis of a report submitted October 31, which carried a definite approval of these plans, though making certain recommendations for improvements. The matter of improving the water supply again went into abeyance, owing to negotiations for the sale of the water works, and nothing further was accomplished during the year.

HARVARD, Sewage Treatment Works.—Visited July 25, 1912, when a brief inspection of the sewage treatment works was made. Data obtained were embodied in a preliminary report containing certain criticisms and recommendations and this report was transmitted to the local authorities for their information.

Harvard has a population of about 3,000 and is well sewered by a separate system. Owing to the fact that the only water course available for receiving the sewage passes through farm lands used for pasturage purposes and near dwellings located on these farm lands, it became necessary to treat the sewage. The treatment works as installed, comprise two sedimentation tanks, a dosing chamber containing automatic siphonic dosing apparatus and 6 intermittent sand filters. Based upon a nominal capacity of the plant for treating the sewage from 2,000 persons, representing approximately 200,000 gallons of sewage per 24 hours, the sedimentation tanks have a retention period of about 10.3 hours, The dosing chamber has a capacity capable of covering each filter bed to a depth of about 2½ inches. The filter area comprises a total of somewhat over ½ acre, so that on the basis of the above assumed nominal capacity, the filtration would be at a rate of about 400,000 gallons per acre, which is quite excessive.

Such meager data as could be obtained regarding the flow of sewage indicated volumes of from 140,000 gallons per day to 250,000 gallons per day. Thus, it would appear that the plant is being utilized far beyond its capacity, 'and this is further evidenced by excessive odors in the vicinity of the plant and by prolonged clogging of the filter beds. Clogging often necessitates throwing filters out of commission and permitting the putrescible tank effluent to flow directly into the stream. This has given rise to complaint from time to time.

The following recommendations were embodied in the summary of the report:

(1) Records should be maintained of the volume of sewage flow. This may be most effectively and conveniently accomplished by means of a recording gage placed over the dosing chamber.

(2) The discharge of crude or settled sewage into the creek should be avoided by throwing but one filter bed out of service at one time. This may readily be accomplished by proper manipulation of the automatic dosing apparatus, instructions for which are in the hands of the local authorities. The filter beds will give best results if each bed is given a resting period of one week in every six weeks. There would thus be one bed out of service at all times.

(3) In order to make available as much filter area as possible, the distribution system should be simplified. A suggested simplification is an arrangement whereby the sewage will be discharged at not over four points on each bed, each point of discharge to be in the center of an approximately equal area.

HARVEY, Investigation of Nuisance.—On November 29, 1912, there was received by the State Board of Health a communication from A. M. Lambert, secretary of the Civic Affairs Committee of Harvey, requesting abatement of the discharge of sewage into the so-called Halsted street ditch in that city by certain persons living just across the street in the village of Phoenix. This matter was referred for investigation to the State Water Survey, and on December 7th a visit was made to Harvey and the accompanying information obtained through the assistance of Mr. Lambert.

Harvey is a city of about 8,000 people, situated on the Illinois Central railroad about 14 miles south of Central Station, Chicago. It is primarily a manufacturing town, although it also has a number of attractive residences and is, on the whole, a fairly well developed and up-to-date community. There is a complete system of sewers, draining northward to Little Calumet river. A public water supply, obtained from deep rock wells, is very generally used. Harvey's factories employ several thousand men, mainly skilled labor. A large percentage of these men do not live in Harvey, but in neighboring towns and Chicago.

Just to the east of Harvey is the village of Phoenix, the dividing line between these two municipalities being the center line of Halsted street. Phoenix was incorporated only three or four years ago, and now has a population of nearly 1,000, of which practically all are Polish people. The town is growing rapidly in population, as it is said property is comparatively cheap and taxes are low. Public improvements comprise a few sidewalks and graded streets. There are no sewers and there is no public water supply except the Harvey supply, on which there are a few services in Halsted street. Most of the drinking water is obtained from private wells about 25 feet deep, dug in clay. Many of these are said to be poorly protected from surface wash and carelessly made. The majority of people living in Phoenix are said to be very slovenly and unsanitary in their modes of living, and to any one visiting the town the absence of civic pride is obvious.

The seat of the complaint is a ditch on the Harvey side of Halsted street, part of which drains northward to the river, the other part draining southward to a drainage ditch and thence eastward to the river. This entire territory is very flat and low, and was originally subject to overflow, but by the installation of the Harvey sewerage system and digging of drainage ditches, both on the south and west, the old difficulty has been largely done away with. Slopes, however, are very gradual and any water reaching the Halsted street ditch is liable to stand stagnant for days.

On the east side of the street, in Phoenix, and within a distance of two blocks, are about ten or twelve saloons, from which foul drainage enters the Halsted ditch. This drainage gives rise to a bad smelling and unsightly nuisance, vigorously complained of in Harvey. From each of nearly all these saloons a pipe has been laid across the street to the ditch. The material discharged through these pipes consists mainly of waste from the saloons, floor washings, and cellar drainage. There is no sanitary plumbing in any of the saloons and consequently there are no closet connections. The ditch itself contains considerable rubbish of various kinds, including some garbage. At one street intersection another-ditch or gutter from the Phoenix side connects with the large Halsted street ditch, and it is alleged this also at times receives foul wastes from a number of dwellings and a saloon. The Halsted street ditch was visited after a series of rainy days and it had, of course, received some flushings, so that no serious nuisance prevailed. Also it was observed that a number of the ends of tile drains had very recently been covered with dirt, as if to hide them. This may be attributable to the fact that word had gotten out that a request for an inspection by state health authorities had been sent from Harvey.

Complaints regarding the pollution of Halsted street ditch have been made numerous times in the past several years to both the Harvey and Phoenix officials, and each time the matter has been discussed. referred to a committee and eventually dropped. On one occasion Harvey officials covered the ends of all drains where they discharge into the ditch, but in a few days they were reopened by people from the Phoenix side. The most influential citizens of Phoenix are the saloon keepers, and they are opposed to spending money for sewers, being content to discharge their wastes into this ditch or their back yards. The stench arising from this locality is said to be almost unbearable at times, and, from the general appearance of things, it is easily believable that such may be the case.

The plea made by Phoenix is that the village is too poor to pay for a sewerage system, but no estimates of cost of such a system have been made, hence such plea is made without basis in fact. This village could be comparatively cheaply sewered, as there is a convenient outlet in the Little Calumet on the north edge of town, and it is not believed the burden would be in any way severe if a period of years were allowed for payment of bonds and assessments were justly spread.

Communications urging the installation of sewers in Phoenix were sent to local authorities.

HERRIN, PROPOSED PUBLIC WATER SUPPLY.—Visited November 7, 1912, for the purpose of obtaining information relative to a recently completed public water works and a proposed sewerage system. Information obtained was embodied in a report, copy of which was sent to the local authorities. Herrin has a population of approximately 7,000, and owing to important coal mining interests the growth of the city is apt to increase rapidly.

The water supply is obtained from an impounding reservoir with a storage capacity of somewhat over 48,000,000 gallons and having a tributary watershed of about 4.7 square miles. The present reservoir will be capable of furnishing in dry years such as 1908 about 400,000 gallons per 24 hours continuously. This is a rather limited supply for a population of 7,000. Though the tributary watershed will permit of a somewhat larger storage, it is questionable if the local topography will lend itself economically and satisfactorily to a larger impounding reservoir.

The watershed is devoted entirely to farming and the possibilities of contamination of the water are not great, nevertheless, they are sufficiently important to be carefully considered. The most serious contamination comes from a number of farm houses on the watershed, which contamination could, in large measure, be eliminated by suitable regulations properly enforced through frequent inspections. In all probability, however, it will be found impracticable in connection with so small a supply to adequately protect the watershed and, therefore, the water should be purified. There is an additional reason for purification in the fact that the water at times contains high turbidities and considerable color.

There is no definite intention of installing purification works, but the authorities were advised to at least treat the water with hypochlorite of calcium to render it safe for domestic purposes. With complete purification, the water would be of exceptionally good quality inasmuch as it is very soft.

PROPOSED SEWERAGE.—The general plans for the sewerage system are representative of correct practice. In view of the fact that there is no large stream in the immediate vicinity of Herrin, in which to dispose of the sewage by dilution, it is proposed to construct the system on the separate plan and to treat the sanitary wastes. The contracts to be immediately awarded will comprise the sanitary sewers only, but it is anticipated that with the installation of street paving, storm sewers will be added as needed.

The only feature regarding the sewerage system to which criticism may be offered is the method of finally disposing of the sewage. It is proposed to carry the main outfall sewer to a point on a small stream to the northwestward. This stream has a watershed of only a few square miles and after flowing a distance of several miles discharges into Big Muddy river. In the locality where the outfall sewer terminates, the stream spreads out into marshy land, subject at times to long periods of inundation. It is proposed before discharging the sewage into the stream to pass it through a septic tank, the design of which had not been determined at the time of the inspection. Such a tank would yield a putrescible effluent which, if spread out in a marsh, would surely give rise to nuisance. It was suggested that the difficulty might be overcome by improving the channel of the stream from the tanks to Big Muddy river. Also the consideration of other forms of tanks was recommended. By the end of 1912 nothing definite had been accomplished toward the construction of the sewerage system.

HIGHLAND, Proposed New Water Supply.—Visited February 6, 1912. The results of the visit were embodied in a report, copy of which was sent to the local authorities.

Highland has a population of about 3,000 and is principally important as a farming center. The most important industries are a brewery and a condensed milk factory. There are but few municipal improvements. The brewery and the condensed milk factory have secured a water supply by creating an impounding reservoir of 50,000,000 gallons and by utilizing two small natural ponds. It has been proposed to use this reservoir and these ponds as a source of water supply for the municipality.

The report calls attention to the desirability of securing a well supply, if practicable, and suggests further investigations. The matter of installing a public supply, however, was dropped for the remainder of the year.

HIGHLAND PARK, Existing Water Supply.—Visited December 14, 1911, in connection with a general sanitary survey of the north shore of Lake Michigan. On the basis of data obtained, a report was prepared descriptive of the water works with certain recommendations for improvement and this was submitted to the local authorities for their information.

Highland Park is a residential town and a suburb of Chicago with a population of about 4,500. The water works were installed in 1893 and have always been owned and operated by the city. The supply is obtained from Lake Michigan through a 20-inch intake, extending a distance of 3,650 feet into the lake. An old intake, 16 inches in diameter and 2,000 feet long, is still serviceable, but is used for emergency only, as in case of anchor ice trouble. The supply, which averages about 700,000 gallons daily, is pumped into the distribution system by means of two duplex pumps, each having a nominal capacity of 1,500,000 gallons per 24 hours, and one cross compound duplex crank and fly-wheel pump having a nominal capacity of 3,000,000 gallons per 24 hours. The distribution system comprises about 31 miles of mains, varying in size from 4 inches in diameter to 12 inches in diameter. The unusual length of mains is necessitated by the very large house lots. Connected with the distribution system is a steel standpipe, 100 feet in height, near the center of the town.

The water supply is frequently of unsatisfactory physical quality, due to turbidity, and is subject to contamination not only from the outfall sewers of neighboring towns, but also from outfall sewers of Highland Park itself. Recommendations were made for ultimately filtering the water and immediate treatment with hypochlorite of calcium was urged for rendering the water safe, pending the time when filters may be installed.

HILLSBORO, Proposed Water Supply.—Visited June 20, 1912. Hillsboro has a population of about 6,000, but owing to the presence of large zinc smelting works a rapid increase in the population is expected. The present water supply is obtained from a small reservoir in the southern part of the town, which is rather grossly contaminated by sewage and other wastes. Moreover, the supply is altogether inadequate for the present needs of the city.

Various projects have been considered, among others a deep drilled well, which furnished large volumes of water under artesian pressure. The water, however, was rather highly mineralized and the project was abandoned, at least pending a search for a satisfactory supply from some other source. There are in the vicinity of Hillsboro a number of ravines which may be utilized as impounding reservoirs, and search for a new supply on the part of the State Water Survey was confined to an examination of these. The greatest difficulty in determining upon the necessary yield of a source of supply was to ascertain the probable future population to be served. Estimates based on available information indicated that the population in 1932 that would use the water supply (and this includes some neighboring communities) would be about 15,000, and that 30 years later a population of 30,000 may be anticipated. It was, therefore, deemed desirable to develop a supply in such a manner that it would be capable of yielding an average of 2,000,000 gallons per day with a possible ultimate development which would secure a yield of about 3,500,000 gallons. The only streams in the vicinity that seemed capable of meeting these demands were the Middle Fork of Shoal creek and Long Branch creek. The former was preferred on account of its greater ultimate possibilities and smaller liability to future contamination. The expense involved in such a project is so great, however, that the present financial condition of the community will not permit of its being carried out. Accordingly, inquiry is still under way, looking toward the development of a supply that may be met by the financial resources of the community.

Pending the installation of an improved water supply, emergency measures were necessary to meet immediate demands. For this reason a contract was awarded to the local electric power company to install a pumping equipment, drawing its supply from the Middle Fork of Shoal creek. This stream has a flow throughout the year that will meet ordinary present requirements of the city.

HOOPESTON, EXISTING PUBLIC WATER SUPPLY.—Visited February 6, 1912, for the purpose of securing a description of the public water supply. Data obtained during this visit were embodied in a report wich was sent to the local authorities for their information.

Hoopeston has a populaion of about 5,000 and is principally devoted to farming interests. Among its industries are two canning factories for corn and beans and two factories for the manufacture of canning machinery and tin cans.

The water works were installed by the municipality in 1888. The supply is obtained from three deep wells, two of which are 8 inches in diameter and one of which is 10 inches in diameter. All of the wells are located within a radius of about 15 feet inside of the pumping station. The first two wells were sunk as a part of the original installation and the last was installed in 1906. The two original wells are each 360 feet in depth and the new well is 118 feet in depth. The formation penetrated throughout could not be ascertained, but it was learned that the glacial drift is approximately 300 feet thick and has a 20-foot bed of water-bearing sand and gravel encountered at about 100 feet. Presumably the wells obtain most of their supply at this level. The water level in the wells rises to within 21 feet of the surface when the pumps are idle. Water from the wells is pumped into two collecting reservoirs with capacities of 37,000 gallons and 103,000 gallons, respectively, thus making a total capacity of 140,000 gallons.

The water has a total hardness of about 230 parts per million, all of which is in the form of carbonates of calcium and magnesium. It also contains a slight amount of iron, which imparts a moderate color and turbidity. It is said the water has a severe corrosive action on iron and steel, which is particularly noticeable in the casings of the wells, which must be renewed at comparatively frequent intervals. The analyses of the water made in the laboratories of the State Water Survey show a rather high bacterial content, which suggests the possibility of contamination through defective casings.

The. pumping equipment, which is housed in a brick structure, comprises the following:

(1) Two steam-head deep well pumps on the two old wells and one air-lift equipment on the new well, all used for pumping water from the wells into the collecting reservoirs.

(2) Two compound duplex steam pumps, each having a nominal capacity of 1,500,000 gallons, used for pumping from the collecting reservoirs into the distribution system.

The extent of the distribution system could not be ascertained, owing to the absence of all records, but it covers the town apparently in a fairly satisfactory manner and the pipe varies in size from 4 inches in diameter to 8 inches in diameter. Connected with the distribution system is a standpipe, the size and capacity of which are not known.

SEWERAGE SYSTEM.—Visited February 6, 1912, primarily with reference to securing a description of the public water supply, at which time it was learned that a sewerage system was nearing completion. This system is built strictly on the separate plan and has an outlet into a small water course south of the corporation. The sewage is to be passed through a septic tank, with the expectation that it will sufficiently purify the wastes to prevent them from creating nuisance in the small water course which receives them. The local authorities were advised that the septic tanks would not prove efficacious, especially in view of the fact that the sewage contains large quantities of wastes from a canning factory. The authorities were advised that at a future date the survey would again inspect the sewerage system with a view to ascertaining the adequacy of the method of final disposal.

JACKSONVILLE, EXISTING WATER SUPPLY.—Visited April 30, 1912, May 4, 1912, and again on July 23, 1912. These visits were made at the suggestion of interested citizens, some of the local officials and representatives of the Jacksonville Water Company, in the hope that the State Water Survey might be of assistance in securing a working agreement between the water company and the city by the removal of certain difficulties which had arisen as a result of the failure of the company to meet the terms of its contract.

The Jacksonville Water Company had a contract with the city to furnish water within a certain specified time, the water to be obtained from a group of tubular wells in the bottom lands of Illinois river about 18 miles distant from the city. Because of difficulties with its pumping machinery and the failure of its main pipe line, which was constructed of thin, spiral, riveted pipe, 20 inches in diameter, the company was unable to deliver the water in the appointed time and in the volume agreed upon. The city, therefore, abrogated the contract, whereupon the company brought suit to enforce the city to accept the terms of its contract on the grounds that it was able to meet its obligations, and that the city had no right to take full advantage of a technicality.

Meanwhile the city had sought a new supply to supplement the old and inadequate supply, derived partly from an impounding reservoir and partly from deep wells yielding a highly mineralized water.

This new municipal supply comprised a series of tubular wells in the northeast part of the city and in the valley of Mauvaisterre creek. These wells and their equipment also proved more or less defective and were regarded, perhaps without sufficient basis in fact, as incapable of yielding a water of good sanitary quality on account of their proximity to Mauvaisterre creek at a point below the entrance of a large portion of the sewage from the city.

The final result of the negotiations was a formal agreement on the part of the company with the city to furnish the city with water, pending the results of the litigation, charging the city a sum agreed upon for the actual quantity of water furnished; the city to retain possession of its system of mains, the old pumping station and of other water works equipment. Upon the termination of the litigation, a new agreement might, if both parties were agreeable, be entered into.

Accordingly the water company proceeded to place its plant in order with a view to delivering water to the city, but unfortunately the pipe line was in such bad repair, due to corrosive action of a waste material from a coal mine in which a portion of the pipe line is embedded, that the company was unable to meet its agreement and the whole matter was thrown back into a state where satisfactory arrangements between the water company and the city officials seems impossible.

KEWANEE, EXISTING WATER SUPPLY.—Visited October 31, 1912, for the purpose of obtaining a general description of the public water supply.

Kewanee has an estimated population at the present time of 13,000 to 14,000, a large increase over the 1910 census figure, due to the incorporation of a number of outlying communities. Kewanee is primarily a manufacturing community and has large manufacturing concerns devoted to the manufacture of brass and iron goods and machinery.

The water works were first installed in 1884, at which time water was taken from a shallow well obtaining its supply from gravel beds near Crystal lake. In 1887 and 1888 the original supply was replaced by three deep tubular wells sunk to St. Peters sandstone. In 1905 an additional well was sunk and improvements made in the pumping equipment. In 1908 a new pumping station was built, together with two additional wells, near the center of the city, but up to date this pumping station has never been used, nor have the new wells been equipped with pumps.

The old plant is some distance from the city and is costly to maintain and the supply is limited, so that improvements are greatly needed. The city has now, however, employed competent consulting engineers who are at present at work on equipping the new pumping station near the center of the city so that it may give satisfactory and efficient service. These improvements comprise in a general way (1) the drilling of an additional well at the new station, making three in all; (2) purchase of three electrically-driven deep well pumps; (3) the construction of a 1,000,000-gallon collecting storage reservoir and a 200,000-gallon elevated tank; (4) the prevention of water waste by the universal installation of meters and the maintenance of complete pumping station records; (5) the use of the original shallow well, as has hitherto been the practice, for sprinkling purposes after being equipped with new pumping machinery; (6) the old pumping station to be overhauled and maintained in readiness for use in emergency. Upon completion of the new improvements, Kewanee will again be visited for the purpose of securing a complete descriptive report.

KIRKWOOD, EXISTING WATER SUPPLY.—Visited May 2, 1912, for the purpose of securing a description of the public water works. Data obtained were embodied in a report, copy of which was sent to the local authorities. Kirkwood is a small community, having a population of about 1,000, with very little tendency to increase in size. In fact, the census figures show a slight decrease in population.

Water works were installed in 1894, at which time a well 216 feet deep was drilled about one block from the center of the town. As this well did not yield a sufficient quantity of water, it became necessary in 1907 to drill a new well 127 feet deep in the western portion of the town and a small pumping station was constructed over it. This well apparently derives its water supply from rock strata at considerable depth. Very little data are available relative to the water-bearing strata. Upon the test of this well, it yielded approximately 50,000 gallons per 24 hours.

The water has only a moderate mineral content, practically all of which is in the form of carbonates. There is present, however, a sufficient quantity of iron to impart a marked turbidity and color. From a sanitary point of view, the water is quite satisfactory and seems to meet with general popular satisfaction.

The pumping equipment comprises one steam-head deep well pump of unknown capacity, which pumps directly from the wells into the distribution system. The old original well is maintained in service as an emergency supply and is pumped by means of a windmill when the wind happens to be blowing.

The distribution system comprises about 1.2 miles of cast iron pipe, varying from 4 inches to 8 inches in diameter. Connected with the distribution system is a standpipe 10 feet in diameter and 100 feet in height, thus having a total capacity of 60,000 gallons.

KNOXVILLE, EXISTING WATER SUPPLY.—Visited December 24, 1911, and July 1, 1912. These visits were made at the request of the local authorities, who desired to ascertain the cause and remedy for the discoloration of the water. The results of these two visits were embodied in a report, copies of which were sent to the local authorities.

Knoxville has a population of about 2,000. The water works were installed in 1896 and have always been owned and operated by the city. Water is obtained from a deep rock well located on a city lot about three blocks from the center of the town. The well is 1,350 feet deep and passes through about 20 feet of drift and a number of alternating layers of coal, shale, and limestone, ultimately penetrating 170 feet of St. Peter sandstone, from which the supply is principally derived. The diameter of the well varies from 8 inches at the top to 6 inches at the bottom. The water stands within 140 feet of the surface. A test of the well indicated a yield of about 216,000 gallons per 24 hours with a lowering of about 70 feet. The present average daily consumption is in the neighborhood of 40,000 gallons.

The first pumping equipment comprised a steam-driven deep well pump. This was replaced by air lift in 1903, and the air lift was in turn replaced in May, 1911, by a motor-driven deep well pump. Water is pumped from the well into a covered collecting reservoir having a capacity of about 50,000 gallons. From here the water is pumped into the distribution system by means of a duplex steam pump, having a capacity of about 300,000 gallons per 24 hours.

The distribution system comprises about 4.1 miles of cast iron mains, varying in size from 4 inches to 10 inches. Connected with the distribution system is an elevated steel tank, 11 feet in diameter by 50 feet high, and supported on a brick tower 50 feet in height. The total capacity is thus 34,000 gallons.

Analyses indicate the public water supply to be of good quality, from a sanitary point of view, but it contains over 1,000 parts of mineral solids, most of which is in the form of chlorides and sulphates of sodium. There is also present about 230 parts of calcium hardness and about 30 parts of sulphate hardness. The analyses show a variable quantity of iron, varying from 0.6 part per million to as much as 5 parts per million. It is probable that the variations in the iron are as much due to the removal thereof in the collecting reservoir as to variations in actual content.

The principal complaints made against the water relate to the color which it contains, which color stains plumbing fixtures and fabrics in the laundry. Occasionally complaint was made against turbidity and sometimes against tastes and odor. No localization of the complaints could be observed, but they seemed to come from people living along live mains and dead ends alike. The complaints are more or less intermittent and have been made only since the replacement of the air-lift equipment by a deep well pump in 1911. A single sample of water taken following the first visit threw no light on the cause of the trouble for the reason that the iron content appeared to be rather low, namely, 0.6 part per million. Accordingly, during the second visit a sample of water was collected for complete mineral analysis five minutes after and another one and one-half hours after starting the deep well pump. In addition to this, eight samples were collected for partial mineral analysis, including iron, at eight different points on the distribution system.

The two analyses of water taken at the pumping station showed an enormous difference in the iron and alumina content. The first sample taken five minutes after the pumps were started contained 87.2 parts per million of iron and 16 parts per million of alumina. In the second sample the iron content was but 0.5 part per million and the alumina 3.5 parts per million. The remainder of the two mineral analyses are very close in agreement, though a slight variation may be observed noticeably in the calcium content, which was 58.4 and 67.8 in the first and second samples, respectively. These analyses point very strongly to the conclusion that the iron content is increased by the solvent action of the water on the casing of the well during periods that the water is not being pumped. The increase in the alumina content cannot be explained on the same basis. It may be, however, that some water enters through defective points in the casing carrying in quantities of clay containing alumina. No opportunity was had for making an extensive examination of the casing, but it is claimed that a recent inspection made with the assistance of electric lamps lowered into the casing showed no marked defects.

Even assuming that the excessive iron content is imparted to the water by contact with the casing, it may not appear clear why this quantity of water should affect the whole supply. The following consideration may throw some light upon this. The well being a deep one, has a storage capacity of approximately 2,000 gallons, or 4 per cent of the capacity of the receiving reservoir, which latter has a storage capacity equal to the aproximate daily consumption. If 2,000 gallons of water containing 87.2 parts per million of iron is added to 48,000 gallons of water containing 0.5 part per million of iron, the mixture will contain approximately 4 parts per million, which quantity is excessive and capable of causing trouble in the mains. The water as delivered to the consumers contains, as a matter of fact, less than this quantity of iron for the reason that some precipitation takes place, due to more or less aeration and sedimentation after the water is delivered into the reservoir. This aeration is apparently not sufficient to remove a very large percentage of the iron at all times, and hence complaints due to colored water. That complaints were less vigorous previous to the introduction of the deep well pump, is no doubt due to the fact that the air lift previously in use more effectively aerated the water and freed it of carbonic acid, so that the precipitation of iron was more prompt and more complete in the collecting reservoir.

The local authorities were advised to install, at small expense, an aerating device, whereby the water may be thoroughly aerated in passing from the deep well into the collecting reservoir. Further, it was recommended that provision be made for pumping the water to waste for a short period after the pumps are placed in operation, so as to get rid of the water with the large iron content. As a further means of securing clear water, if preceding suggestions do not prove sufficient, it was recommended that the service pumps be not placed in operation until the iron content of the water in the collecting reservoir had had an opportunity to precipitate and settle out.

Another phenomenon has been observed in connection with the water supply of Knoxville, namely, that the water first drawn from the well by means of the deep well pump shows the presence of a marked black precipitate. This, however, has never given any trouble by entering the mains. The black precipitate is probably due to manganese, but there is no analytical evidence on this point, inasmuch as no determinations were made for manganese.

LA GRANGE, Recently Completed Sewage Treatment Works.—On July 14, 1912, a brief inspection of the recently completed sewage treatment works at LaGrange was made.

LaGrange has a present population of about 5,500. The growth of the community is moderate. The population ten years hence will be in the vicinity of 7,000.

The sewers of LaGrange are on the combined plan. Hitherto the dry weather flow has been intercepted, passed through septic tanks and finally discharged into Salt creek. Salt creek became so contaminated that further treatment was considered necessary. Accordingly, there was built on the banks of Salt creek and about 6,000 feet distant from the existing main outlet, a purification plant, comprising .344 acre of sprinkling filters, 6 feet in total depth. A 15-inch sewer was also constructed for conveying the effluent from the existing septic tanks to the new treatment works. The effluent from one of these tanks must be raised to a higher level, and hence a small pumping station was installed.

The 15-inch sanitary outfall sewer was built in conjunction with a 72-foot storm-water conduit. The sewer, which is of vitrified pipe, laid with open joints, is embedded in the side wall of the storm-water conduit, which latter is made of extra thickness for the purpose. The space between the interiors of the sewer and the storm-water conduit is only a matter of about 6 inches. Due to defects in construction, all of the sewage flowing in the sewer found its way into the conduit. Various means were resorted to for the purpose of repairing the leaks, but so far without entire success. It thus happens that though the sprinkling filter plant has been built for over a year, it has not yet treated any sewage. What the ultimate solution of the difficulty will be is not known, but the leaks in the sanitary sewer show a tendency to become slowly stopped.

The sprinkling filter plant is of good design and the construction works seem in every way to be satisfactory. It may be noted that owing to its remote location, lack of care, and, the depredations of small boys, the sprinkling nozzles are, for the most part, in bad shape.

It is assumed that the plant is designed for treating the sewage from a population of about 5,000, in which event the population load will be in the vicinity of 14,500 per acre. In all probability, this population load will not be reached for a periol of ten years or more. The present population load, based upon an estimated population tributary to the sewers of 4,000, is in the neighborhood of 11,600 per acre. This latter figure is none too small for a plant of this character, and if the higher population loads are to be reached, very careful supervision of the plant will be necessary.

The details of the design are shown upon plans filed in the office of the State Water Survey. In general, it may be stated that the sprinkling filter comprises a concrete basin with impervious floor, 190 feet long by 83 feet wide, inside dimensions, filled with broken stone to a depth of 6 feet. The broken stone is underlaid by a system of underdrains, consisting of notched 6-inch half tile, laid in straight transverse rows, 12 inches, center to center. The drains slope toward the longitudinal center of the filters and discharge into a longitudinal main drain, which in turn leads through suitable connections to Salt creek. The outer ends of the lateral underdrains penetrate the side walls of the filter bed, so that they may be flushed out by means of a hose and nozzle.

The sewage is distributed to all parts of the filter by means of 5-inch tile distributing laterals, embedded in concrete and placed 12 feet 9 inches, center to center, and extending transversely across the bed. At intervals of 12 feet 9 inches along these distributors are placed vertical risers 2½ inches in diameter and made of fiber. These risers extend a few inches above the surface of the broken stone composing the filtering material and are capped with six-lobed sprinkling nozzles of the Taylor type.

The flow of sewage on to the filters is controlled by two dosing chambers, automatically discharged by means of alternating siphons. Each dosing chamber is tributary to one-half of the filter bed. These chambers are of such size that each will hold about thirty minutes' flow of sewage, and are so shaped that the sprinkling nozzles will discharge approximately the same quantity of sewage on each unit of filter area. The operation of the filters will thus be intermittent, but the period between doses will be so short as to prevent the drying out of the bed.

Further studies of the LaGrange sewage treatment plant are contemplated with a view to ascertaining the feasibility of using purification works of this type for small communities.

LAKE BLUFF, Proposed Improvement in Public Water Supply.—Visited December 19, 1911, and again on January 27, 1912, at the request of the local authorities for the purpose of making inquiries relative to modifications in the public water works that would give a more satisfactory supply as to mineral content and give better service for fire protection. The supply is obtained from two wells, respectively 300 feet in depth and 700 feet in depth. The water is excessively mineralized and is inadequate in quantity to meet the present needs. Two possibilities for securing an improved supply were pointed out, namely, (1) by connecting with the mains of the Lake Forest water works, and (2) by improving existing wells or drilling new wells. Certain objections were pointed out in connection with the character of the Lake Forest water supply and emphasis was placed on the possibility of securing a satisfactory ground water at great depth from the Potsdam sandstone. The village finally decided in favor of deepening one of the existing wells.

Shortly before the dates above given, the wooden elevated tank connected with the distribution system failed and the city officials were informally advised with reference to the relative merits of replacing this tank with another elevated tank and with air pressure tanks at the surface level. The officials finally decided in favor of a new wooden elevated tank.

LEROY, Existing Water Supply.—Visited March 27, 1912, for the purpose of obtaining a description of the public water supply, which was embodied in the form of a report, copy of which was sent to local authorities.

Leroy has a population of about 2,000 and is primarily a farming community. It contains as an important industry, however, a canning factory which employs 250 people in season.

The public water supply was installed by the municipality in 1895, and aside from the addition of electricity as a source of power and the installation of one new well, no important changes have been made since then. The original source of supply comprises two tubular wells about one block from the center of the city. These are 87 feet in depth and cased with 8-inch pipe. The new well, located on the same lot with the old ones, is 90 feet in depth and is cased with 12-inch pipe. The wells apparently derive their supply from sand and gravel deposits in the drift, which in this locality has a total depth of about 200 feet. The water-bearing strata are encountered at depths of from 75 feet to 100 feet. The yield of the wells is not known, but the average daily consumption at times reaches 100,000 gallons, which the wells can meet readily.

The supply is of good quality, from a sanitary point of view, but is rather highly mineralized, containing a total residue of about 500 parts per million. The hardness, which is in the neighborhood of 400 parts per million, is all in the form of carbonates of calcium and magnesium, principally the former. The most serious objection to the public water supply is its iron content, which is in the neighborhood of one part per million. This causes a heavy red sediment, particularly at dead ends, and gives rise to much complaint, owing to characteristic iron stain.

The pumping equipment is housed in a small building built over the two original wells. The wells are each equipped with an electrically-driven deep well pump. A gasoline engine, which constituted part of the original installation, is maintained in reserve in case of breakdown.

The distribution system comprises about 3½ miles of cast iron pipe, varying in size from 4 inches to 6 inches in diameter. Connected with the distribution system is a steel standpipe, 12 feet in diameter and 100 feet in height, thus giving it a total capacity of about 80,000 gallons.

LIBERTYVILLE, Existing Water Supply.—Visited June 21, 1912, in connection with a sanitary survey of Upper Des Plaines river. Data obtained during this visit were embodied in a descriptive report, copy of which was sent to the local authorities. Libertyville has a population of about 2,000, shows a steady growth, and will probably develop as a suburb of the city of Chicago. It also has some industrial interests, notably a macaroni factory, a wire fencing factory and a woolen industry. The public water supply was installed in 1905. There has been practically no change in the original installations, other than the extension of mains.

The supply is derived from three tubular wells in the east part of town. One well is 170 feet deep and 4 inches in diameter. The other two are 180 feet deep and 6 inches and 8 inches in diameter, respectively. These wells extend in a row along an east and west line, the first two being 50 feet apart and the last two 100 feet apart. Water is encountered under pressure within the drift and the pressure is sufficient to cause the water to rise above the surface of the ground in quantities sufficient except during periods of high consumption to meet the present demands of the village. Two of the wells are equipped with air lift, but the use thereof was necessary only once during the past year. Connections are made with a collecting reservoir holding 70,000 gallons, which serves to store the water delivered by the wells. The wells and reservoir are amply protected against surface contamination. The present consumption of water is about 55,000 gallons per day.

Though no analyses have been made of the public supply, it is known to be rather hard, but otherwise has no objectionable qualities.

The pumping equipment is housed in a small brick building placed over one of the wells. All power is furnished by a 40 horse-power gasoline engine. This is directly connected to a Gould power pump, which takes its suction from the reservoir and pumps directly into the distribution system. A small air compressor belt, driven by the gasoline engine, furnishes the necessary air supply to the air lift.

The distribution system comprises about 6½ miles of cast iron pipe, ranging in size from 4 inches to 8 inches. Connected with the distribution system is an elevated steel tank, 150 feet in total height, having a capacity of 65,000 gallons.

SEWERAGE.—The industries produce moderate quantities of wastes which at present add materially to the sewage from the village. A system of sanitary sewers which serves approximately 85 per cent of the built-up portion of the town is in use at Libertyville, and the sewage, after passing through two septic tanks in the eastern part of the town, discharges into a ditch which is already much polluted by wastes from the several industries and a laundry. From the tanks the combined wastes flow a distance of about 1,700 feet to Des Plaines river. The tanks are substantially constructed and based on a sewage flow of 150,000 gallons per day, about normal for a town of this size, they have a retention period of about 5½ hours. While the sewerage system covers about 85 per cent. of the town, only a small percentage of the population is tributary thereto. Hence the tanks have not been worked beyond their capacity and the effluent, owing to large dilution of the sewage with ground water, has not been offensive. Recently there has been passed a village ordinance requiring connection of all houses with sewers where sewers are accessible. As a result of this ordinance, a great increase in the sewage flow may be anticipated.

The local authorities were advised that a more extensive system of treatment would probably be necessary in the near future in order to protect Des Plaines river against undue contamination.

LINCOLN, EXISTING WATER SUPPLY.—Lincoln was visited March 21, 1912, at the request of the water works authorities for the purpose of investigating an alleged danger to the public water supply, due to improper disposal of the city's sewage. Copy of the report, which is given practically in full, as follows, was sent to the local authorities for their information.

Lincoln is in the center of Logan county, of which it is the county seat. The population of Lincoln in 1910 was about 11,000. The area within the corporation limits is about 4½ square miles. The topography in and about the city is rather flat, but in the vicinity of neighboring water courses the topography may be described as rolling to mildly hilly. The main drainage of the built-up portions of the city is toward the southwestward, into a small, dry-weather stream flowing approximately parallel to and immediately south of the tracks of the Chicago & Alton railroad. This stream ultimately discharges into Salt creek about one mile southwest of the city. A small portion of the northern part of the town drains into a small, dry-weather water course, tributary to Kickapoo creek, which in turn is tributary to Salt creek, several miles to the westward of the city.

The surface covering within the city of Lincoln consists of a rather heavy layer of compact clay, perhaps 50 to 60 feet in depth, in the higher portions of the town. Underneath this lies a heavy stratum of water-bearing gravel which yields an abundant supply to numerous private wells still retained in use throughout the city The wells would, no doubt, yield a wholesome water if amply protected against the entrance of contamination from the top, but most of them are not so protected. In the stream valleys, notably in the valley of Salt creek, the gravel deposits are laid bare by erosion and are now being extensively quarried for use in roadmaking, for concrete and other purposes.

Each year there occur in Lincoln a number of cases of typhoid fever. The exact number cannot be ascertained owing to the absence of accurately kept vital statistics. Nevertheless the cases are sufficiently numerous to create some alarm. The presence of typhoid is attributed primarily to the use of private wells, also to the existence of many improperly constructed privies and to some extent to milk and other causes. The public water supply has, in recent years, been absolved from any bearing upon the typhoid situation, since it is obtained within the gravel deposits along Salt creek, and is believed to be free from present contamination. Furthermore, many analyses made in the laboratories of the Illinois State Water Survey have revealed the absence in the existing supply of those constituents indicative of contamination. On the other hand, there can be no question that the public supply in the past has been subject to pollution and it may again be contaminated in the future, as will be seen from the following discussion.

The first supply was obtained from a large shallow well excavated in the gravel deposits of Salt creek in 1884. This well soon proved to be incapable of yielding a sufficient quantity of water, and so a direct intake from Salt Creek was installed and for a number of years thereafter was generally used. Several years later an attempt was made to increase the ground water supply by the installation of another shallow well near the first, but the depth of this new well was so shallow and it was placed in such close proximity to the existing well that it failed to give any material relief. Following this a number of attempts were made to obtain additional quantities of water from tubular wells and tile collecting drains without success. In 1902 the water works were taken over by the present owners and vigorous efforts were put forth to increase the supply and improve the quality by making it unnecessary to use the polluted creek water at any time. The program for improving the water supply was very much interfered with by extraordinary difficulty in securing sufficient land, but the land was finally obtained in the early part of 1911. Steps had already been taken to increase the supply by the installation of an additional circular well 12 feet in diameter near the existing old wells, and recently a very large so-called infiltration gallery was built on the opposite side of the creek. The infiltration gallery alone seems capable of affording an ample supply of pure water for the city. All of the water from the wells and galleries passes to the pumping station through a 14-inch cast iron suction pipe with bell and spigot leaded joints. This suction pipe is approximately 1,500 feet in length from the pumps to the 12-foot well, which serves as a suction well, and the pipe lies about 5 feet below the surface of the ground. The fact that the pump suctions are connected directly with this pipe causes it to be under a negative pressure. Should the pipe break there would be a tendency for the surrounding ground water or water standing upon the surface of the ground to enter. So far as known the suction is in sound condition at the present time, but being under the ground and often below the level of ground water, a break may occur long before it is discovered.

The small, dry-weather stream which flows on the south side and parallel to the tracks of the Chicago & Alton railroad passes between the railroad and the pumping station and at the pumping station it has been arched over at the water company's expense. Into this water course as already noted, is discharged the bulk of the sewage from the city, which in times of low water causes the stream to be very foul and malodorous. During high water, though the nuisance does not exist because of the greater dilution of the sewage, the stream overtops its banks and floods a large area completely surrounding the pumping station. It thus happens that during periods of high water there is standing above the suction pipe a body of water badly polluted with sewage. In case of accident to the suction, this badly polluted water might readily find a channel through the shallow covering of earth into the suction line and thus pollute the entire city water supply. Such an occurrence may create, and in all probability would create a disastrous epidemic of typhoid or other intestinal diseases.

In view of the above outlined facts there can be no question but that a new mode of sewage disposal is necessary for all sewage reaching the southern sewer outlet. Ditching the small water course into which the sewage is discharged has been suggested. This can undoubtedly be accomplished in such a manner as to prevent sewage from passing over the suction pipe. On the other hand, a ditch is very apt to get out of repair especially during flood seasons, and in order to keep the channel open frequent redredging and weed cutting is necessary. Further, digging a ditch would not do away with the present nuisance conditions which obtain during dry periods, and it is now generally recognized that municipalities have no legal or moral right to pollute a stream to an extent that will render it offensive. The logical solution of the problem would, therefore, seem to be the extension of the sewer outfall into Salt creek at a point well below the water works plant so as to guard against polluted back water standing over the suction pipe.

During the visit on which this report is based but little definite information could be obtained regarding the sewerage system, but in a general way it may be said that no steps should be taken toward the construction of an expensive outfall sewer until a comprehensive study of the sewerage system has been made with reference to future requirements. That is to say, the sewerage system for the entire city should be considered as a unit and the outfall or outfalls, if more than one is deemed necessary, must be planned in such a way that all of the sewage from the city will be conducted to a point or points where it may be inoffensively disposed of by suitable purification devices. It is probable that for another decade the sewage flow from Lincoln will not be so great, but that it can be inoffensively disposed of by direct discharge into Salt creek or by discharge after the coarser or more unsightly floating and suspended matters have been removed, but the future necessity of purifying the sewage must not be lost sight of, for it is certain to be demanded by riparian owners as Lincoln becomes a larger city and the surrounding country becomes more populous.

The city authorities were advised to employ competent engineers with instructions to review the sewerage situation in Lincoln for the purpose of devising a comprehensive plan which will provide for a more satisfactory final disposal of the city sewage at once, and which will serve as a basis for all future extensions to the sewerage system during the life of works existing and works to be immediately constructed.

LITCHFIELD, EXISTING WATER SUPPLY.—Visited December 2, 1911, May 9, 1912, and November 22, 1912, for the purpose of securing a general description of the public water supply and advising the local authorities relative to securing a more adequate and satisfactory source of supply.

Litchfield has a population of about 6,000 and owing to numerous iron working industries and neighboring coal mines, it is probable that the community will experience a healthy growth. The water works were installed in 1873 with bonds issued by the municipality. The original source of supply was an impounding reservoir to the south of the city. The bonds were later declared illegal in view of the fact that their issuance had not been submitted to a vote of the people and they were accordingly never paid, the bond holders suffering a total loss.

For eighteen years the city operated the water works, but at a considerable financial loss. In 1891 the Litchfield Water Company was reorganized, and took over the water works on a lease for a term of 20 years. Shortly afterwards the water company increased the available supply by building a pumping station on the banks of Shoal creek about 2½ miles east of the city. The company has also made a few changes in the old pumping station and added materially to the distribution system.

The old reservoir is formed by an earthen dam across a ravine. The reservoir when full has a water surface of approximately 20 acres and a storage capacity of about 40,000,000 gallons. The original capacity was materially greater than this, but the bottom of the reservoir has been filled in to a depth of many feet with sediment. The tributary watershed is very limited, amounting to something over 2 square miles in all, so that it cannot furnish an adequate supply, taking into consideration future growth even with additional storage capacity, which may be had by constructing a second dam at a point below the existing dam. Moreover the drainage area tributary to the reservoir extends into the built-up portion of the city and receives much objectionable surface drainage as well as quantities of sewage from private sewer installations. Shoal creek has assisted materially in meeting the needs of the city, but even this stream during periods of very dry weather has no flow. It is now necessary to increase the available supply and some preliminary investigations have been made with this in view. The most favorable project would seem to be a large impounding reservoir in the valley of a small water course to the eastward of the city. Tributary drainage area is but little over two square miles and, therefore, not adequate to meet all requirements, but it would be readily feasible to augment the supply by pumping water from Shoal creek at favorable times. The capacity of the reservoir that could be constructed would be in the neighborhood of about 200,000,000 gallons.

The present consumption of water is rather high owing to the heavy use of water by the industrial concerns, the absence of meters and general waste. The average daily consumption is probably in the neighborhood of 1,250,000 gallons. The exact figures cannot be ascertained owing to the absence of pumping records. The water is wholly unsatisfactory in quality inasmuch as it contains at all times a peculiar heavy black sediment and is known to be objectionably contaminated. In point of hardness and mineral content it is reasonably satisfactory.

The pumping equipment comprises two compound duplex steam pumps each having a nominal capacity of 1,750,000 gallons, one of which is located at the old pumping station on the banks of the old reservoir and the other on the banks of the Shoal creek pumping station.

The distribution system comprises about 10 miles of cast iron pipe varying in size from 4 inches to 10 inches. The system is very imperfect and gives very poor fire protection within certain areas. There is no reservoir connected with the distribution system for equalization of pressure and supply.

MARION, EXISTING WATER SUPPLY.—Visited May 10, 1912, for the purpose of securing a general description of the public water supply. Visited again on July 20, 1912, and November 6, 1912, for the purpose of making inquiry into an apparent contamination of the source of supply.

Marion has a population of about 7,500. It lies in an important coal mining region, which industry is its main support. Future growth of the city is likely to be rapid.

The water works were installed by the Marion Light, Power & Water Company in connection with an electric light plant in 1904.

The water is obtained from 7 tubular wells penetrating rock. Of these wells, 5 are 700 feet in depth with 6-inch casings, one is 700 feet with a 10-inch casing and one is 800 feet with a 10-inch casing. All casings extend to limestone bed rock, which is 50 feet below the surface. Within the rock, all of the wells have a diameter of but 6 inches. When first installed, the group of wells is said to have yielded from 72,000 gallons to 86,000 gallons per 24 hours, but after being in service for a year only 36,000 to 43,000 gallons could be obtained from them. This quantity of water was not sufficient for the needs of the city and many efforts have been made on the part of the water company to increase the yield of the present wells by modifying the pumping equipment, but only with partial success. Recently several additional wells were drilled but proved to be practically dry holes, but further efforts will be made along this line.

An auxiliary supply is maintained in the form of a pond fed by surface streams. This pond lies in the midst of the group of wells and is formed in part by excavation and in part by embankment. The pond water is, however, only used in case of fire emergency and for sprinkling streets. No special effort is made to maintain the purity of the pond water and as a matter of fact it is apt to receive contamination from surface drainage within the thickly built-up portion of the city. It is also used as a pleasure lake and an adjunct to a summer park maintained by the water company.

The water yielded by the public supply wells is highly mineralized, containing over 1,200 parts per million of total mineral residue. Most of this is in the form of sodium chloride and sodium carbonate, there being about 400 parts per million of the former and 700 parts per million of the latter. The salts which produce hardness are very low, amounting to only about 17 parts per million. The water contains a considerable quantity of iron, which causes some staining, but has not been the cause of serious complaint. As indicated by a number of analyses made in the laboratories of the State Water Survey, the supply shows evidence of contamination both in the excessive number of bacteria and in the presence of gas formers. The contamination cannot be explained very satisfactorily, but the most probable cause would seem to be frequent handling of the pump rods, for repair and adjustment.

MAROA, EXISTING PUBLIC WATER SUPPLY.—Visited March 28, 1912, for the purpose of obtaining a general description of the public water supply. The information obtained was embodied in the form of a report, copy of which, together with an offer to assist the city further in connection with its water supply problems, was sent to the local authorities.

Maroa is a farming center and has a population of about 1,200. The water supply was installed in 1892 and no changes have been made since, other than the extension of the distribution system. The supply is obtained from three tubular wells 85 feet deep, two of which have 6-inch casings and one of which has an 8-inch casing. The supply is obtained from deep sand and gravel strata within the glacial drift and the water rises under slight pressure to within about 40 feet of the surface of the ground. Under ordinary conditions the large well is alone capable of meeting the demands of the city which amount to about 50,000 gallons per day on the average.

Water is pumped from the wells into a collecting reservoir of about 45,000 gallons capacity by means of steam head deep well pumps and from the reservoir is pumped by means of a compound duplex steam pump with a nominal capacity of 500,000 gallons into the distribution system.

The distribution system comprises about three miles of cast iron pipe varying in size from 4 inches to 8 inches in diameter. Connected with the distribution system and elevated upon an 80-foot tower is a 50,000 gallon steel tank.

The water is of good quality from a sanitary point of view and the supply is fairly well protected against the possibility of surface contamination. The mineral content of the water is in the neighborhood of about 400 parts per million which is not excessive. On the other hand there is sufficient iron to cause a marked turbidity and color which gives considerable trouble at 6 dead ends on the distribution system.

Recommendation was made that iron be removed in part by placing within the collecting reservoir some simple form of aerating device for precipitating the iron as ferric hydrate, the collecting reservoir to act as a sedimentation basin.

MATTOON, Existing Water Supply.—Visited December 9, 1912, for the purpose of obtaining a general description of the public water supply. Mattoon is an important farming, railroad, and manufacturing center with a population of approximately 14,000.

Water works were first installed in 1885 by the Mattoon Clear Water Company. The supply was taken from a series of wells 80 feet in depth and obtaining a supply of water from sand and gravel strata in the glacial drift. The original installation included but three wells, located near the pumping station in the southern part of the city. A number of additional wells were added from time to time as needed.

In 1904, 1905 and 1906 there was a serious shortage of water from the wells. This worked a material hardship on the industries, and particularly the railroads, and some of the latter threatened to remove their shops unless greater quantities of water could be made available. During the winter of 1906 and 1907 the Mattoon Water Works and Reservoir Company was organized with a capitalization of $100,000 for the purpose of financing the installation. Among the sources considered by this company were:

(1) Kaskaskia river;
(2) Riley creek;
(3) Little Wabash river;
(4) A combination of Little Wabash and a tile drainage supply from the so-called Kickapoo creek drainage area. The last mentioned was adopted because it involved smallest initial cost for construction purposes and lower operating expenses. The project was carried out under the supervision of A. N. Talbot as consulting engineer, and the new supply was placed in service in 1908. Having accomplished its purpose with the installation of the new supply, the Mattoon Water Works and Reservoir Company turned over its property to the city for a proper consideration and disbanded as a corporation. Since that time there has been much friction between the municipality and the old company arising primarily over the questionable right of the city, in view of its contract with this company, to sell water to private consumers. This culminated in securing an injunction against the city, preventing it from making service connections.

In September, 1912, the Clear Water Company sold out to the Central Illinois Public Service Company. Following this transaction, the city and the public service company entered into an agreement whereby the city may at any time within ten years purchase the plant for the sum of $30,000, plus the bonded indebtedness, a sum of $125,000, plus the cost of actual improvements made. The city also agreed not to lay any mains parallel to the mains of the water company or to take on any new consumers other than industrial users. This agreement has been in mutually satisfactory operation to date.

The municipal plant includes:

(1) An impounding reservoir, 150,000,000 gallons capacity, at a point on Little Wabash river about seven miles southwest of Mattoon, and above which there is a drainage area of about 20 square miles.

(2) A pumping station at the reservoir with two compound duplex steam pumps, having a nominal capacity of 1,000,000 gallons each.

(3) Rising main from the river pumping station of 12-inch cast iron pipe, 11,000 feet in length.

(4) A concrete receiving reservoir in the southern part of the city with a capacity of 1,300,000 gallons.

(5) An auxiliary supply from a system of farm drain tile, covering an area of 5 square miles of farm land and discharging into the receiving reservoir.

(6) A main pumping station adjacent to the receiving reservoir with two compound duplex steam pumps, having capacities of 1,000,000 gallons per 24 hours and 1,500,000 gallons per 24 hours, respectively.

(7) A distribution system, comprising 5 miles of cast iron mains, varying from 6 inches to 12 inches in diameter, which reaches the main industrial plants of the city.

The plant of the Illinois Public Service Company consists of the following:

(1) Twenty-six tubular wells, 16 of which are in regular service.

(2) A small collecting reservoir or suction pit 8 feet in diameter.

(3) A 5,000,000-gallon surface reservoir for storing well water against emergency.

(4) A pumping station, one triplex power pump of 750,000 gallons' daily capacity, two compound duplex steam pumps, each of 1,000,000 gallons' daily capacity; five steam head deep well pumps, each having a nominal capacity of about 50,000 gallons per 24 hours, and eight deep well power pumps, each having a nominal capacity of about 60,000 gallons per 24 hours.

(5) A distribution system, comprising about 15 miles of cast iron pipe varying in diameter from 4 inches to 12 inches.

The municipally-owned supply is of somewhat doubtful quality, from a sanitary point of view, owing to the opportunities for contamination of the reservoir supply and to some extent of the supply derived from the farm drain tile, but this water is used exclusively for industrial purposes, and in this connection it has the merit of having much lower mineral content than the supply of the Public Service Company. The latter, on the other hand, furnishes a water that is of good quality, from a sanitary point of view. It is not exceptionally highly mineralized for Illinois ground waters, but contains a sufficiently large quantity of iron to cause objectionable turbidity and discoloration at dead ends especially.

MAYWOOD, Existing Water Supply.—Visited during the latter part of 1912 in connection with a sanitary survey of Upper Des Plaines river. Advantage of the opportunity was taken to secure a general description of the water works.

Maywood is a suburban community of Chicago and has a population estimated at approximately 9,000. The water supply was installed in 1895 and is obtained from three deep rock wells, located at the corners of a triangle, having sides 30 feet in length. One of these wells is 2,200 feet in depth and the other two are 1,600 feet in depth. The water-bearing stratum is the St. Peter sandstone, encountered at a depth of 1,400 feet. When not being pumped, the water in the wells stands at about 90 feet below the surface, but during pumping with the present pumping equipment it is lowered to about 114 feet below the surface. The water level is steadily lowering. During the past five years the lowering has been at the rate of about 5 feet per year.

The water is raised from the wells by means of an air lift and discharged into a collecting reservoir with a capacity of about 22,000 gallons. From the reservoir the water is pumped into the distribution system by two compound duplex steam pumps, each having a capacity of about 850,000 gallons per 24 hours. The average daily pumpage is about 700,000 gallons.

The distribution system comprises about 27½ miles of cast iron pipe, varying in diameter from 4 inches to 12 inches. Connected with the distribution system is a steel standpipe 16 feet in diameter and 100 feet high. This is ordinarily shut off at times of fire and direct pumping is relied upon.

A number of analyses of the public supply have been made in the laboratories of the State Water Survey and it is generally of good quality from a sanitary point of view. During the year 1908 and 1909 some contamination was revealed by the analyses, but this has apparently been corrected by repairing the casings and making tight joints between the casings and bed rock. The water is not highly mineralized for a deep rock water. Moreover, only a part of this mineral content causes hardness. The water supply is free from iron and has otherwise excellent physical characteristics, and meets with general popular approval.

McLEANSBORO, EXISTING WATER SUPPLY.—Visited May 9, 1912, and December 13, 1912. On the former date a general description of the water works was obtained, which was embodied in a report under date of October 22, 1912. The latter visit was made for the purpose of examining the operation of a filter, which had not been efficient. Results of this visit were embodied in a report under date of February 20, 1913, copy of which was sent to the local authorities with recommendations for improvements, especially in the manner of applying the coagulant and hypochlorite to the raw water.

McLeansboro is primarily a mining town and agricultural center, but also has an importance as a railroad junction point. The population is in the neighborhood of 2,000, and the city is having but a slight growth. Sanitary conditions of the town are not of the best, as is evidenced by a rather high typhoid morbidity rate. The exact figures could not be ascertained, but are probably in the neighborhood of 50 per annum.

The public water supply consisted of two wells, 180 feet deep, together with a small pumping station and distribution system. The wells were located at the fair grounds about three-fourths of a mile southwest of the center of the town. Because of the limited yield of the wells, an auxiliary source of supply in the form of a pond in the western part of the town was utilized. Even with this reinforcement, the supply proved inadequate and a new source of supply was sought. In 1910 and 1911 an earthen dam was constructed across a small stream about one mile southwest of the center of the city. The reservoir is estimated to have a capacity of about 75,000,000 gallons. The tributary watershed could not be even approximately ascertained from available data. From the reservoir the water is conducted through an 8-inch- pipe to a pumpng station and filter. The filter is of the pressure type and consists of an 8-foot horizontal tank about 10 feet in length and having a nominal capacity of 250,000 gallons per 24 hours. The water is pumped directly through the filter and into the distribution system by means of an electrically-driven centrifugal pump with a capacity of about 300,000 gallons per 24 hours.

The distribution system comprises about 6 miles of cast iron pipe, varying in size from 4 inches to 8 inches in diameter. Connected with the distribution system is an elevated steel tank near the pumping station. This tank has a total capacity of 60,000 gallons and rests on a tower, whch gives it a total height of 122 feet.

The water from the reservoir is ordinarily turbid and is subject to more or less contamination from farm houses on the watershed, which are not in any way under the control of the water works authorities. In an effort to economize, the cheapest and simplest form of filter was purchased. Inasmuch as the water is pumped during only a few hours of the day, the filter is ordinarily operated at its normal rate of 250,000 gallons per 24 hours.

The coagulant is appled to the raw water at a point very near the filter. The method of applying the coagulant is by means of a so-called alum pot connected with the inlet pipe to the filters by two small pipes, one of which is used as an inlet and the other as an outlet. By adjusting valves on these pipes, a small stream of water, roughly proportional to the volume of water entering the filter, is caused to flow through crystallized alum placed in the pot. The pot is filled with alum at frequent intervals and an effort is made to keep it full at all times, so that the water passing out of the pot is practically a saturated solution. This device, as a matter of fact, works very unsatisfactorily, owing, partly no doubt, to the lack of uniformity of the application and partly to the fact that the alum is applied too close to the filter.

Though it is not practicable with pressure filters to secure good results, except under exceptional circumstances, it was felt that the results at McLeansboro could be greatly improved by applying the coagulant into the pipe line at a considerable distance from the filter and by improving the coagulant preparation and feed devices, so that it may be added at a perfectly uniform rate. Sketches were furnished to the local officials showing how this might be satisfactorily and economically accomplished. There was also recommended limited analytical control over the operation of the filter, and the use of hypochlorite as a sterilizing agent. These recommendations did not, however, meet with compliance on the part of the local authorities.

MELROSE PARK, EXISTING WATER SUPPLY.—Visited the latter part of June, 1912, in connection with a sanitary survey of Upper Des Plaines river. Advantage was taken of the opportunity to secure a general description of the public water supply. Melrose Park is primarily a residential suburb of Chicago and has a popula tion in the neighborhood of 5,000. The growth of the community is rapid.

Water works were first installed in 1898. The source of supply was a deep rock well, which has furnished the entire supply to date. An additional well is now being drilled. The existing well is 1,620 feet deep. It is 15 inches in diameter and terminates at the bottom in a rock bore 4 5/8 inches in diameter. A new well will have the same depth and approximately the same dimensions. The upper casing extend to bed rock, encountered at about 90 feet below the surface. Another casing is necessary at a depth of 1,100 feet on account of soft rock. Water is encountered at a depth of about 1,400 feet in the St. Peter sandstone. When not being pumped, the water in the well stands about 75 feet below the surface and is lowered to 85 feet or 90 feet during pumping. Originally the water stood at a depth of 30 feet below the surface or 45 feet above its present level. This represents a drop of about 3.2 feet per annum.

Water is raised from the well by means of an air lift and discharged into a concrete collecting reservoir with a capacity of about 175,000 gallons. From the collecting reservoir the water is pumped into the distribution system by two compound duplex steam pumps, having nominal capacities of 750,000 gallons and 1,500,000 gallons per 24 hours. The present available daily pumpage is in the neighborhood of 340,000 gallons, a large portion of which is used by the Chicago & North Western Railroad and a large iron works.

No analyses have as yet been made of the water from Melrose Park, but it has excellent physical characteristics and meets with general popular approval. The water also appears to be adequately protected against any form of contamination in the handling.

MONMOUTH, EXISTING WATER WORKS.—Visited May 1, 1912, for the purpose of securing a description of the public water supply and also investigating alleged improper sewage disposal. Monmouth is an important factory town and also a farming center, with a population of about 9,200. Water works were installed in 1886 and then the source consisted of a deep rock well, which furnished the entire supply. A second deep well was added in 1891, and a third in 1899. In 1900 still further improvements were made by connecting the wells to a circular shaft, so that all could be pumped by means of one deep well pump with steam end at the top of the shaft. The shaft is 10 feet in diameter and 185 feet in depth. At the 185-foot level tunnels were made to each of the wells. Within the shaft was placed a deep well pump. This installation remained in operation until 1906, when the deep well pump was replaced by air lift, owing to the frequent breaking of pump rods. At the same time one of the wells was abandoned.

Each well is 1,222 feet in depth and terminates in the St. Peter sandstone, which is the water-bearing stratum. The water rises to within about 85 feet of the surface, and severe pumping at a rate of 528,000 gallons per 24 hours will lower it to 210 feet below the surface. The air lift discharges the water from the wells into a brick, cement-lined collecting reservoir of 300,000 gallons' capacity. From the reservoir the water is pumped into the distribution system by two duplex steam pumps, each having a capacity of 2,000,000 gallons per 24 hours.

The distribution system consists of about 19½ miles of cast iron pipe, varying in size from 4 inches to 10 inches in diameter. Connected with the distribution system is an elevated tank with a total height of 126 feet and a capacity of 115,000 gallons. The tank is not used except in cases of breakdown of the pumps, inasmuch as it is considered an inconvenience to open and close the valve when extra pressure is required in case of fire.

The average daily consumption of water is in the neighborhood of 450,000 gallons, which is close to the limit of the yield of the two wells at present in use. The water is very highly mineralized, containing in the neighborhood of 1,800 parts per million of total solids. Most of this is in the form of sodium sulphate, and there are also considerable quantities of sodium chloride, magnesium and calcium carbonates. From a bacterial point of view, the water is of a very satisfactory quality, nor has it sufficient iron or magnesium to create objectionable turbidity or discoloration.

The supply seems to meet with general popular approval.

MONTICELLO, EXISTING WATER SUPPLY.—Visited March 30, 1912, for the purpose of securing a general description of the public water supply. Copy of a report based on the visit was sent to the local authorities for their information. Monticello is the county seat of Piatt county, and is situated near the center of that county on Sangamon river. Its present population is in the neighborhood of 2,000.

The public water supply was installed in 1892. The original source was one well, near the center of the town, but this has been supplemented by two additional wells. Practically the entire present pumping equipment has been installed since 1892.

All the wells are inside of the pumping station and located within an area of 25 feet square. One of the wells is 309 feet deep and has a 6-inch casing. The other two wells are 212 feet in depth and have casings 8 inches and 10 inches in diameter, respectively. The water rises within the wells to about 25 feet from the surface and the working barrels of the pumps are placed at a depth of 100 feet. The deepest well enters the rock for a few feet, thus indicating an extraordinary thickness of glacial drift in this vicinity. Nothing could be ascertained regarding the location of water-bearing strata, but it is assumed that the water is derived from one or more sand and gravel strata within the drift.

Each well is equipped with a double-acting deep well steam pump, which discharge ordinarily into a covered concrete collecting reservoir, having a capacity of 56,000 gallons. Piping arrangements are such, however, that the pumps on the two new wells may discharge directly into the distribution system, which is done in case of break-down or when the reservoir is being cleaned. Water is pumped from the collecting reservoir into the distribution system by means of a duplex steam pump, having a nominal capacity of 400,000 gallons per 24 hours.

The distribution system comprises 5 miles of cast iron pipe, varying in size from 4 inches to 6 inches. Connected with the distribution system is an elevated tank, 12 feet in diameter, 45 feet in height and mounted upon a brick tower 75 feet in height. The total height of the tank is thus 120 feet and storage capacity is 36,000 gallons.

The water is of very good quality, from a sanitary point of view, and is not excessively hard. The total solids (about 345 parts per million,) are practically all in the form of carbonate hardness. On the other hand, iron is present, which gives rise to more or less complaint. The wells and reservoirs are so protected that contamination of the supply in the handling is quite improbable. Recommendation was made to the local authorities that suitable works be installed for the removal of the iron.

MT. OLIVE, EXISTING WATER SUPPLY.—Visited May 14, 1912, for the purpose of obtaining a general description of the public water supply. Such description was embodied in the form of a report, together with some comments on a proposed sewerage system, and was sent to the local authorities for their information.

Mt. Olive is in the southwestern part of Macoupin county, on the watershed of Cahokia creek. The population at the present time is about 4,000. Mt. Olive is primarily important as a coal mining center, and the opening of new mines in the near future is expected to give an impetus to the city's growth.

Steps were taken toward the installation of a public water supply in 1895 by the formation of an impounding reservoir in a small ravine northwest of the town. It was not until ten years later, however, that sufficient funds were available to build a pumping station and lay distribution mains.

The reservoir is about 1½ miles distant from the center of the city, and is formed by an earthen dam, 40 feet in height and 400 feet long. The capacity of the reservoir is about 300,000,000 gallons and has a water surface of 43 acres. The tributary watershed is about 2,000 acres, all of which is in farm land. The property owned by the city, including the reservoir area, is about 80 acres. The supply of water seems to be quite adequate to meet present needs, but because of the limited watershed area it is probable that deficiency will occur should the city increase in size sufficiently to double its water consumption, which is now about 500,000 gallons per day.

While the quality of the water is endangered to some extent by surface drainage from the drainage area, it is endangered to a far greater extent by boating and fishing and by the proximity of a small clubhouse built on city land. The water is generally free from turbidity, which is quite uncommon among surface waters in Illinois, but it is subject to frequent disagreeable tastes and odors, due to the development of plant growths in the reservoir.

The pumping equipment is housed in a brick structure built on the south side of the reservoir, near the dam. The pumps are placed 10 feet below the overflow level in the reservoir and within a 20-foot circular pit. The equipment comprises two compound duplex pumps, each having a nominal capacity of 1,000,000 gallons per 24 hours. They pump from the reservoir into a 12-inch rising main, 1¾ miles long, to the center of the town. In addition to the rising main, there are 5 miles of distributing mains, all of cast iron pipe, varying in size from 4 inches to 8 inches in diameter. There is no storage available in connection with the distribution system.

MT. VERNON, EXISTING WATER SUPPLY.—Under date of October 1, 1912, there was sent to the State Water Survey for review a set of plans for water purification works to be installed by the Citizens' Gas, Electric and Heating Company. These plans were prepared by the Pittsburg Filter Manufacturing Company, with whom the above public service company had contracted for the installation of the plant. In anticipation of the receipt of these plans, Mt. Vernon was visited on March 20 and 27, 1912, and again on May 7, 1912, for the purpose of obtaining knowledge of local conditions. The results of the review of plans and visits were embodied in a report which was sent to the water company for its information, and which is presented in substance in the following.

The filter plant, as shown on plans, has a nominal capacity of 1,500,000 gallons per day and comprises a mixing chamber, a coagulating basin, three filter units, a plant for the preparation and application of chemicals, and a clear water basin. These several parts will be discussed in the order above given.

The raw water is received in a mixing chamber, placed at the inlet end of the coagulating basin. This chamber is 17 feet long, 9 feet wide and 12 feet deep. All of the details of this chamber are not given on the plans, but it will be baffled in a manner that will keep the water in gentle agitation for about 12 minutes after the chemicals have been added.

Provision is made for passing the water from the mixing chamber onto the filters without passing it through the coagulating basin. The by-pass will be used when the coagulating basin needs cleaning. It is anticipated that more or less sediment will accumulate in the mixing chamber, and in order that this may be drawn off, there is provided in the bottom of the mixing chamber a sump. Connected with a sump is a valve-controlled outlet, which leads to a sewer. Apparently it is intended to remove the sludge while the chamber is in operation, for the reason that no means are shown for by-passing. This is not a matter, however, that is likely to give any difficulty.

The coagulating and sedimentation basin is 87 feet long and 35 feet wide. A portion of this space, occupying one corner of the basin, is given up to the mixing chamber already described. The total capacity of the coagulating basin is thus about 260,000 gallons, which represents a period of approximately four hours' flow, based upon the nominal capacity of the plant. In a preliminary conference between the engineer for the company and representatives of the State Water Survey a greater period of sedimentition was recommended, namely, six hours, but it is believed that under the local conditions the lesser period will prove entirely satisfactory.

The local conditions have special reference to the possibility of effecting a preliminary sedimentation in the reservoir when the water from the creek carries excessively high turbidities or is otherwise difficult to treat.

The basin is divided into two compartments by a central longitudinal baffle, which forces the water to pass from the inlet (adjacent to the mixing chamber) to the farther end, thence back again on the opposite side of the baffle to the outlet. The floor of the basin is given a moderate slope toward the center. The drainage is further facilitated by a longitudinal center gutter, which has a bottom slope of 5 per cent. At the center of the basin, to which all slopes converge, is a sump, which is connected to the sewer by means of a 10-inch valve-controlled pipe.

For the purpose of distributing evenly the inflow into the coagulating basin across the width of the channel, there is provided a circular conduit, placed at the bottom and extending across the channel. This conduit is perforated with about 33 small openings equidistantly spaced.

The coagulated water, after having doubled the length of the basin, is removed by means of a so-called skimming trough. This is merely a trough extending across the width of the channel, near the surface, and into which the water falls in weir fashion. From the skimming trough the water is conducted to the filters through a suitable channel. In by-passing the coagulating basin the water is admitted to the skimming trough from the mixing chamber. Overflow into the sedimentation basin is prevented by maintaining the level of water in the mixing chamber at a lower elevation than will obtain under ordinary conditions of operation.

There are three filters, each 16 feet 6 inches by 11 feet, at the sand surface. There is thus an area for each filter of 181.5 square feet. Each filter has a nominal capacity of 500,000 gallons per 24 hours, but the area provided is sufficiently liberal to permit of a somewhat higher rate of filtration.

The design of the filters is characteristic of filters built by the Pittsburgh Filter Manufacturing Company. In this instance, however, agitation of the sand by means of compressed air will be omitted and instead there will be used a more rapid rate of washing with wash water. To permit of the use of large quantities of wash water without carrying off sand, the crests of the wash water troughs will be placed about two feet above the surface of the sand. Connected with each filter is an automatic rate controller of the submerged type, and an indicating loss of head gauge.

The filter plant is designed to operate with alum as a coagulant. Inasmuch as the alkalinity of the raw water is at times very low, it will be necessary to add an alkali, and for this purpose lime tanks have been provided. In order to make certain of the sanitary quality of the water, it is proposed to supplement filtration by means of sterilization with hypochlorite of calcium.

The chemical preparation and feed devices are not shown in detail, but in general they comprise rectangular concrete tanks in duplicate, except in the case of hypochlorite, for which only a single tank has been. provided. In the top of each tank is built a smaller tank, in which the chemicals will be dissolved. In order to maintain the chemicals of even strength, the lime tanks and the hypochlorite tank are provided with stirring devices. Such devices have not been provided for the alum, as it is believed that they are unnecsary to maintain the solution of uniform character. The application of the chemicals in each instance to the water is controlled by means of constant head orifice boxes.

The points of application of the chemicals are not shown upon the drawings, but the location of the chemical tanks is such that application of chemicals may be made into the raw, coagulated or filtered water, as may be deemed best. The lime and alum will, of course, be applied to the raw water at all times, but it may be found advisable to introduce the hypochlorite at one or more of the points above mentioned.

The clear water basin, which is located under the filters and pipe gallery, has a capacity of 75,000 gallons. Clear water storage is still further provided by a standpipe, which has a capacity of 150,000 gallons. The standpipe is so arranged that the entire contents thereof may be discharged into the clear well, when during fires it is desired to use directly pumping pressure in the distribution system. The total available clear water capacity is, therefore, 225,000 gallons, which is somewhat less than desirable, but ample for meeting immediate needs.

A superstructure of brick is provided and covers the filters, pipe gallery and the mixing chamber. A very commendable feature is the extension of the superstructure over the entire area of the filters, instead of merely over a portion thereof, as has been common practice. That portion of the superstructure which extends over the mixing chamber will afford a convenient space for the storage of chemicals.

The pipe gallery is made 15 feet wide, or considerably greater than is necessary for the piping, for the reason that it is proposed to use a portion of this gallery for a pump room. In it will be placed some high-pressure centrifugal pumps for fire service. The great width of the pipe gallery permits of ample space upon the operating floor for the location of the chemical preparation and feed devices, thus bringing them in plain view of the filter operator.

MURPHYSBORO, EXISITING WATER SUPPLY.—Visited May 7, 1912, and July 18, 1912. These visits formed the basis of two reports, the first of which is a descriptive report of the water works, containing general recommendations with reference to improvements, and the second is a report containing more specific recommendations for improvement. These reports were sent to the water company and also to the local authorities, with an urgent recommendation that the improvements be carried out in order that Murphysboro might have a clearer water supply and one that is good from a sanitary point of view.

Murphysboro is the county seat of Jackson county and is situated near the center of that county on Big Muddy river. The principal business interests are coal mining and shoe and brick manufacturing. The present population is estimated at about 8,000 and the city is experiencing a substantial growth.

The public water supply was originally installed in 1889 and 1890 by the Murphysboro Water Works, Electric and Gas Light Company, which is operating under a 60-year franchise to furnish the city with water "suitable for domestic purposes." The Big Muddy river constitutes the source of supply at a point above local pollution. The watershed area above this point is about 2,175 square miles. The natural flow in the stream is at all times sufficient to meet the requirements of Murphysboro. Pollution enters the river at various points above Murphysboro, the nearest and most serious of which is the pollution from Carbondale, a city of about 5,500 population, 20 miles distant along the course of the stream. Creosote wastes, which add greatly to the difficulty of treating the water at Murphysboro, also enter the stream at Carbondale. Mine drainage, entering at various points, greatly affects the character of the water in the stream. For example, a high acidity of the mining wastes often changes the reaction of the river water from alkali to acid.

Very imperfect records are kept at the water works, so that it is difficult to estimate the average daily quantity of water used. Such estimates as can be made indicate a consumption of about 2,000,000 gallons per 24 hours—an excessive quantity, due, no doubt, to wasteful use.

The water from Big Muddy river is passed through a mechanical filter plant, with a nominal capacity of 2,000,000 gallons per 24 hours. The design and construction of this plant are imperfect in many respects. The iron solution is made in a circular, wooden tank of about 500 gallons' capacity, with a continuous stream of water flowing through same. About every four hours a definite quantity of the chemical is thrown into the tank, and this is expected to produce a uniform solution for application to the raw water. As a matter of fact, the solution is very variable in strength and results in a very variable treatment of the water. The method of preparing the lime is similar and results in the variable application of this chemical. The chemicals enter the raw water at the inlet to the coagulating basin. This latter consists of a circular basin, 100 feet in diameter and 12 feet in depth, and has a nominal retention period based on a nominal capacity of the plant of 8.4 hours. This is a rather liberal period, but is at times insufficient to secure a complete reaction of the lime with the water. The efficiency of the basin could be much increased by modifying the baffling system, and sketches were prepared for the water company showing how this might be satisfactorily accomplished.

There are four mechanical filter units of the rectangular type and of reinforced concrete construction. Each unit has a nominal capacity of ½ million gallons per 24 hours. The filters are arranged two on either side of a central pipe gallery, and are housed under a very crude wooden superstructure, the latter in a poor state of repair. The filter beds were in an exceedingly bad condition, the sand being full of mud and the underdrain system apparently clogged, which condition seemed to have arisen from the fact that the filters were not being properly washed. The upward rise in wash water was only 3½ inches per minute, whereas a minimum of 9 inches is required. Air agitation is provided, but this is rather unevenly distributed, and a thorough overhauling of the air pipes is necessary. It is quite probable that nothing short of a thorough reconstruction of the filters will prove entirely satisfactory.

In the pipe gallery the piping arrangement is poor and inadequate, and the various parts exceedingly inaccesible. No means are provided for controlling the rate of filtration other than the hand-operated valves, and there is no loss of head gauges whereby the condition of the filters may be ascertained.

The plant is in such bad condition that it cannot furnish anywhere near its rated capacity, and it is, therefore, necessary to bypass a large quantity of the coagulated water into the clear water reservoir. The clear water reservoir has a capacity of about 350,000 gallons, or approximately four hours' retention period, on the basis of a consumption of 2,000,000 gallons per day.

Analyses made in the laboratories of the State Water Survey show that the filters have a very low bacterial efficiency and fail to remove in a satisfactory manner the turbidity and color of the water. Fortunately, the public supply is not considered drinkable by the people of Murphysboro and, therefore, is not used for this purpose to any great extent. There is no good reason why the filter plant cannot be placed on a thoroughly efficient basis by suitable modifications which should not prove excessively costly.

Water is pumped from the creek by means of a compound duplex pump, having a nominal capacity of 3,000,000 gallons per 24 hours, and is delivered into the coagulating basin. From the clear reservoir the filtered water is pumped and delivered into the distribution system by means of two compound duplex pumps having nominal capacities of 2,500,000 gallons and 1,500,000 gallons per 24 hours, respectively. Connected with the distribution system is an elevated tank, having a nominal capacity of 180,000 gallons and with a total height of 150 feet. This tank is located between the water works and the city and produces an average pressure in the city of about 45 pounds.

Notwithstanding the efforts of the State Water Survey to induce the water company to improve its equipment, nothing has been accomplished up to the present time.

NAUVOO, EXISTING WATER SUPPLY.—Visited May 12, 1912, for the purpose of securing a general description of the public water supply. A report, prepared on the basis of this visit, was sent to the local authorities for their information. Nauvoo is located on Mississippi river in Hancock county. The population is about 1,000 and shows a tendency to decrease rather than to increase. The town is primarily a farming center, though there are two important Catholic schools located there.

In 1907 a corporation was granted a franchise to construct a water works at an estimated cost of $150,000, which included a filtration plant to treat the water from Mississippi river. After about $30,000 had been spent on the improvement, including pumping stations and mains through the center of the town, difficulty arose between the city authorities and the water company which resulted in the refusal of the city to use the water, and at present the only water pumped is delivered to the two Catholic institutions in an unpurified condition.

The pumping equipment is housed in a small pumping station at the river's edge and comprises two gasoline-driven power pumps, having a nominal capacity, each, of about 200,000 gallons per 24 hours.

The distribution system comprises about 4½ miles of cast iron pipe, varying from 6 inches to 10 inches in diameter. The water is now being pumped into two wooden tanks with a combined capacity of about 6,500 gallons. These tanks are located on the roofs of the schools.

In view of the rather questionable quality of many private wells now in use in Nauvoo, the State Water Survey recommended the completion of the present water supply, including purification works, and offered its services in assisting to adjust matters between the city authorities and the water company.

NEW ATHENS, PROPOSED WATER SUPPLY.—Visited May 19 and 20, and February 5, 1912. On February 1, 1912, there was a conference with the consulting engineer of New Athens in the office of the State Water Survey. The results of this conference were embodied in a report, the substance of which is contained in the following:

New Athens is a small city, having a population of about 1,500, situated on the banks of Kaskaskia river, about 30 miles above its confluence with Mississippi river. The need of a public water supply has been strongly felt, primarily for fire protection. It was desired, of course, to use the supply for general domestic purposes, but it developed that there was no supply available that was adequate in quantity other than Kaskaskia river, which is known to be a more or less polluted stream. A number of searches were made for wells yielding a satisfactory water, but without success. As fire protection is the primary reason for installing a public supply, it is not proposed to treat the water for purification purposes, yet house connections will be permitted, though with the expectation that the water will not be used for either culinary or drinking purposes.

Plans and specifications for the proposed improvement are, in the main, well drawn and call for an equipment that will meet all of the ordinary demands of the fire insurance underwriters. A few minor recommendations for changes with reference to the intake and the pumping pit were made and embodied in revised plans. The original installation provides for only a single pumping engine, but this will be duplicated as funds become available. The design of the pumping station is rendered somewhat costly by the fact that the river at this point has a variation in level of over 30 feet. The pumps will be located in a dry pit, 11 feet in diameter and 35 feet in depth, and will be electrically driven, the electricity to be obtained from the local light plant.

The distribution system comprises about 4.3 miles of cast iron pipe, varying in size from 4 inches to 8 inches in diameter. Connected with the distribution system at a high point in the village is a 70,000-gallon elevated steel tank.

The local authorities were advised that notwithstanding the intention of using the proposed supply for fire protection only, it will be practically impossible to prevent persons from using the water for domestic purposes. In fact, a public water supply, after a short time, enters so completely into the general domestic economy that even those who purchase bottled water for drinking purposes will, in one way or another, get water from the public supply into their system. It was, therefore, strongly urged that the purification works be made a component part of the proposed new improvement. Because of lack of funds, the recommendation of the survey was not carried into effect.

NEWTON, EXISTING WATER SUPPLY.—Visited February 1, 1912, for the purpose of obtaining a description of the public water supply. A report embodying the results of the visit was sent to the local authorities for their information. Newton is situated on the Embarrass river, near the center of Jasper county, of which it is the county seat. The present population is about 2,200 and the future growth is likely to be moderate.

Water works were installed by the municipality in 1895 and no important modifications have been made in the system since that time. The water is pumped from the Embarrass river on the north side of the city and above local contamination. The area of the watershed above this point is about 1,100 square miles and the flow in the stream is always ample to meet the needs of the city. The river is subject to pollution principally from Greenup and Charleston, respectively 15 and 40 miles, in an up-stream direction. Much difficulty has been experienced in connection with the intake, owing to the entrance of sand with consequent injury to the pumps. The average daily consumption of water could not be ascertained exactly, but seems to be in the vicinity of 320,000 gallons.

The pumping equipment comprises: One duplex steam pump, having a nominal capacity of 500,000 gallons per 24 hours, and one compound duplex steam pump, having a nominal capacity of 750,000 gallons per 24 hours.

The distribution system comprises 3 miles of cast iron pipe, varying in diameter from 4 inches to 8 inches. Connected with the distribution system is an 80,000-gallon elevated tank with a total height of 110 feet and located in a high portion of the town.

The water, as furnished to consumers, is of very unsatisfactory quality. It is excessively turbid, high in bacteria, and generally shows the presence of gas formers. Consequently it is but little used for general domestic purposes. Nevertheless, it constitutes a menace to the public health. Moreover, many private wells of poor quality are in use in lieu of the public water supply. A strong recommendation was made by the State Water Survey that purification works be installed, but up to date this recommendation has not been acted upon.

NORMAL, EXISTING WATER SUPPLY.—Visited April 30, 1912, for the purpose of obtaining a general description of the public water supply. This description was embodied in a report, copy of which was sent to the local authorities. The city of Normal adjoins Bloomington on the north. It has a population of something over 4,000. It is primarily a residence city, and the Illinois Normal College is located within its borders. The water works were installed in 1898 and but few changes have been made since the first installation.

The present source of supply consists of two wells, each 180 feet in depth and 15 feet apart. One of these has a 10-inch casing and the other has an 8-inch casing. A third well is about to be installed, 185 feet in depth and 12 inches in diameter. At the bottom of each well is a Cook strainer, 8 inches in diameter and 20 feet long. The water is obtained from sand and gravel strata in the glacial drift, which at this point has a very great thickness. The water rises to within 90 feet of the surface and is under some pressure.

One of the wells was tested by the rather unique method of pumping water into it instead of out of it. It is found that this well could take water at the rate of about 500,000 gallons per day without filling up, and it was assumed that conversely the same amount could be taken out without materially lowering the water level. The truth of this assumption can only be ascertained by a pumping test conducted in an ordinary way, but the experiment does, however, indicate a considerable freedom of flow in the water-bearing stratum.

Water is pumped from the two existing wells by motor-driven deep well pumps, each having a nominal capacity of 175,000 gallons per 24 hours. The proposed new well is to be equipped with a motor-driven deep well turbine pump. The water from the well pumps is delivered into a concrete reservoir, having a nominal capacity of 13,000 gallons. This reservoir will be augmented in the near future by a new concrete reservoir, having a nominal capacity of 150,000 gallons. From the reservoir the water is pumped into the distribution system by a motor-driven triplex-power pump, having a nominal capacity of 500,000 gallons per 24 hours. This pump may also be driven by a gasoline engine, which is held in reserve for emergency. The pumping equipment, however, is not in duplicate.

The distribution system comprises about 12 miles of cast iron pipe, ranging in diameter from 4 inches to 12 inches. Connected with the distribution system is an elevated tank, 12 feet in diameter and 60 feet in height, having a capacity of 50,000 gallons. This rests upon a brick tower having a height of 80 feet. Thus the total height is 140 feet.

The water is of very good quality, from a sanitary point of view, and has only a moderate mineral content for deep drift wells. All of the hardness, amounting to about 200 parts per million, is in the form of carbonates. Though the water contains as much as one part of iron per million, the precipitation of iron in the mains has not given rise to complaints; in fact, the water is generally regarded as being of very excellent quality and superior to the water in the neighboring town of Bloomington.

PALATINE, PROPOSED SEWAGE TREATMENT.—Visited July 24, 1912, for the purpose of making an inspection of nuisance conditions alleged to result from the discharge of sewage from Palatine into a small water course. A brief report was based upon this visit and a copy was sent to the consulting engineer for the village. The report is in substance as follows:

Palatine has a population of 1,144. The growth is moderate, but there is a local feeling that with civic improvements now in contemplation the future growth will be more rapid.

The city at present has a sanitary sewerage system which serves practically all the built-up portion of the community. The number of persons tributary to the sewers is not known, but in all probability does not exceed 800. The sewage is carried through a main trunk sewer in a southwesterly direction and is discharged into a small stream flowing to the southward. This stream has a very meandering course, and passes through large, swampy areas. In summertime numerous stagnant pools form in the stream bed and these become very malodorous.

The problem of overcoming the present objectionable conditions is rendered somewhat difficult because the present sewer outfall is only 1 foot above ordinary low water in the stream, thus rendering it impracticable to install purification works without the necessity of pumping. It is possible that a sufficient fall may be secured by modifying the grade of the outfall sewer and straightening the channel of the stream so as to give it a more rapid fall and a deeper bed. Necessary surveys to ascertain the feasibility of these modifications have not as yet been made. It is questionable, however, if straightening of the creek can be accomplished, owing to objections on the part of riparian owners below.

The Central Engineering Bureau of Chicago has recommended the installation of sewage tanks of such design that at a later period secondary treatment devices may be added.

In all probability, a simple tank treatment will not suffice to do away entirely with present objectionable conditions, and this view must be somewhat emphasized in case it is found impracticable to straighten the course of the stream.

It is evidently the intention of Palatine to postpone the installation of purification works as long as possible. Litigation is now being carried on with reference to the matter, and a decision with regard to the immediate installation of purification works will rest upon the outcome of this litigation.

PANA, EXISTING WATER SUPPLY.—Visited December 1, 1911, for the purpose of obtaining a general descriptive report of the public water supply with special reference to a recently-developed surface supply, involving the use of a filtration plant. A second visit was made on July 15, 1912 to secure certain modifications in the filter plant, and, a preliminary test of the filter plant was conducted on July 31 to August 3, 1912. The results of these visits were embodied in two reports, copies of which were sent to the local authorities.

Pana is situated in the southeastern part of Christian county, on the watershed of Kaskaskia river. It is an important coal mining town and also a manufacturing center. The present population is in the neighborhood of 6,500, and future growth will probably be rapid.

The water works were first installed in 1894 by the municipality. The original source of supply was a group of four wells, approximately 80 feet in depth, sunk about one mile northwest of the business center of the town. Thirty-five feet of water-bearing sand was encountered at a depth of 15 feet below the surface.

The pumping equipment originally comprised Cook deep well pumps, which raised the water from the wells into a collecting reservoir of 66,000 gallons' capacity, and the water was repumped by means of a 1,000,000-gallon duplex steam pump from the reservoir into the distribution system. In 1900 the deep well pumps were abandoned in favor of air lift. Even with air lift, these wells failed to yield a sufficient quantity to meet the demands of the city, and in 1900 an additional group of wells was sunk about 1½ miles northeast of the town. At this plant deep well pumps are used for pumping the water from 7 tubular wells, about 55 feet in depth, into a collecting reservoir of 22,500 gallons' capacity, and the water is thence repumped by a duplex steam pump, having a nominal capacity of 1,000,000 gallons per 24 hours.

This second installation proved inadequate almost from the start and it became evident that an additional source of supply was necessary. It was decided to develop a surface supply about three miles to the east of Pana, but the old pumping station will be maintained in readiness for use in case of failure of the new supply.

The new supply is obtained from an impounding reservoir, formed by building a dam across Beck's creek, a small tributary to the Kaskaskia. The tributary drainage area is not known, and curiously enough, no surveys were made to ascertain this. A rough estimate, based on available imperfect maps, would indicate an area of about 5¼ square miles. The quantity of water impounded is, likewise, not precisely known, but it is probably in the neighborhood of 60,000,000 gallons.

This quantity of water must be relied upon to tide over prolonged dry periods, inasmuch as there is little or no natural stream flow in dry seasons. When the daily consumption in Pana shall have reached 1,000,000 gallons per day, which will be in the not distant future, there will be a supply available for only 60 days. In 1911 there was a period with practically no run-off in certain parts of the state for nearly six months. To meet immediate future demands, therefore, it will be necessary to secure an additional supply, and it is questionable if such a supply can be impounded along the same water course above the present reservoir. Even with complete storage of the run-off in dry years, the limited watershed available would yield only about 1,500,000 gallons per day.

At the reservoir is a small pumping station equipped with a motor-driven centrifugal pump, having a nominal capacity of 835,000 gallons per 24 hours, used for delivering water through a 10-inch cast iron main to a filter plant, which is located near the center of the town.

The filter plant is contained in a neat brick building and comprises two rectangular, concrete, mechanical gravity filters, each having a nominal capacity of 500,000 gallons per 24 hours. The filters are well designed, substantially constructed, and have the important accessories of loss of head gages and filter rate controllers. The filtering material, originally too fine, was later replaced with sand, having an effective size of 0.46 mm. and a uniformity coefficient of 1.47. Underneath the filter is a clear water reservoir, having a total capacity of 55,000 gallons, which is altogether too small. A capacity of at least 200,000 gallons should be provided. Alum is used as a coagulant and the solution is prepared in two rectangular, concrete tanks, each having a capacity of 315 gallons. The solution is delivered into the rising main from the impounding reservoir by means of a small, steam-driven solution pump of the boiler-feed type. It is the expectation that this pump can be operated at a sufficiently uniform rate to secure a practically uniform application of the chemical.

The most serious defect in the filter plant is the absence of coagulating basins or even a reaction chamber. This omission makes it practically impossible to secure an acceptable water when the raw water is in a turbid condition. Furthermore, it is impracticable to secure economical runs of the filters between washings. There are other minor defects, such as leakage of the solution tanks and the filters, and unevenness in the wash water troughs. These minor defects have all been corrected, it is understood.

The State Water Survey has made strong recommendations to the local authorities to install coagulating basins, and has also urged the use of hypochlorite of calcium as a sterilizing agent, but these recommendations have not as yet been adopted.

As a part of the new water works installation, there is included a new pumping station, housed in a very neat and substantial brick building near the filter plant. The pumping equipment comprises two compound duplex condensing steam pumps, each having a nominal capacity of 500,000 gallons per 24 hours. These pumps take their suction from the clear water reservoir of the filter plant and discharge directly into the distribution system.

The distribution system comprises about 5 miles of cast iron pipe varying in size from 4 inches to 12 inches in diameter. This does not include the rising main from the reservoir or a 6-inch main from the northeast pumping station. Connected with the distribution system and near the center of town is a standpipe 100 feet in height and having a total capacity of 250,000 gallons.

PARIS, EXISTING WATER SUPPLY.—Visited January 9, 1912, for the purpose of obtaining a description of the public water supply with special reference to the necessity of purification and augmentation of the supply. At the request of the local authorities, Paris was again visited December 13, 1912, for the purpose of presenting to the council the recommendations of the State Water Survey with reference to improvements in the water supply. Paris is situated in the southern part of Edgar county on the watershed of Sugar creek, a small tributary of the Wabash river. The present population is in the neighborhood of 8,000. Paris is an important manufacturing community and has agricultural and mining interests.

The water works were installed in connection with an electric lighting plant in the western part of the town about 20 years ago. The original supply was obtained from tubular wells, but soon proved inadequate. In 1896 Sugar creek was developed as a source of supply at a point about 1½ miles north of the public square. An impounding reservoir is formed by means of a masonry dam 20 feet high and 100 feet long. The reservoir covers an area of about 60 acres and has an approximate capacity of 100,000,000 gallons. The watershed tributary is rolling country and mostly devoted to farming and has an area of about 24 square miles. This area is adequate with sufficient storage to meet any probable future requirements of the town. The present storage is, however, insufficient, and within the last few years the city has experienced serious water shortages.

The supply is of very unsatisfactory quality due to excessive turbidity at times, due to the entrance of considerable pollution of a dangerous character from sources near the reservoir and due to tastes and odors resulting from the development of plant growth in the summer time. The last mentioned gives rise to most popular complaint and is especially objectionable during periods when the reservoir is drawn down below the crest of the dam.

The average daily consumption is somewhat above 1,000,000 gallons. Owing to the rapid growth of the city, consumption will be considerably in excess of the available supply within a comparatively few years.

The pumping station is located on the bank of the reservoir near the dam. The pumping equipment consists of one triple expansion duplex steam pump having a nominal capacity of 2,000,000 gallons per day. There is also a small simple duplex pump which is in so bad a state of repair that it is used only in case of emergency. The larger pump is also in a bad state of repair; but owing to the absence of duplicate machinery of adequate size, it cannot be thrown out of service for necessary overhauling. A new pumping installation comprising electrically driven centrifugal pumps is in contemplation.

The water is pumped directly into the distribution system, which consists of about 20 miles of cast iron pipe varying in size from 4 inches in diameter to 12 inches in diameter. Connected with the distribution system is a standpipe approximately 100 feet high and with a total capacity of 106.000 gallons.

The State Water Survey has made recommendations to the local authorities strongly urging the installation of water purification works, increase in the available supply, and the restriction of unnecessary waste. These improvements are now being actively agitated.

PAXTON, EXISTING WATER SUPPLY.—Visited March 25, 1912, for the purpose of obtaining a general description of the public water supply. This description was embodied in a report which was sent to the local authorities. Paxton is located in the southern part of Ford county, of which it is the county seat. It is primarily a farming center, though it has a few important industries. The present population is in the neighborhood of 3,000 and the growth of the town is very slow.

The water works were installed in 1887 and the supply was originally obtained from a single tubular well near the center of the town. This well was subsequently abandoned and three others have since been drilled. Until ten years ago steam power was used for pumping, at which time it was replaced with electricity. The wells range in depth from 142 feet to 148 feet and have casings 5 inches, 6 inches, and 8 inches in diameter respectively. The wells are placed in a row and are 18 feet apart. The three wells are said to have a combined yield upon test of 7,000 gallons per hour or 168,000 gallons per 24 hours. The present average daily consumption is 75,000 gallons, but at times the consumption runs as high as 140,000 gallons.

The water is of good quality from a sanitary point of view but is rather hard and contains enough iron to cause considerable discoloration. These objectionable characteristics have not, however, given rise to popular complaint. Recommendation was made by the State Water Survey that the iron be removed by the installation of a suitable iron removal plant.

Water is pumped from the wells by means of Cook deep well pumps and delivered into a collecting reservoir having a capacity of about 100,000 gallons. From the collecting reservoir the water is pumped into the distribution system by means of a triplex power pump having a nominal capacity of 600,000 gallons per 24 hours.

The distribution system comprises about 4 1-3 miles of cast iron pipe 4 inches and 6 inches in diameter. There is also about 3,000 feet of 3-inch wrought pipe. Connected with the distribution system is a wooden elevated tank with a capacity of 65,000 gallons placed upon a brick tower 80 feet in height.

PEORIA STATE HOSPITAL AT SOUTH BARTONVILLE, EXISTING WATER SUPPLY.—Visited Nov. 18 and 19, and Dec. 22, 1912, with reference to the proposed installation of an independent water supply for the Peoria State Hospital at South Bartonville. The hospital obtains its water supply from the Peoria water works, but there has been dissatisfaction of one sort or another especially with reference to the pressure at which the water is delivered and the Board of Administration was considering an independent supply. Before an opportunity had been afforded for securing necessary data, upon which to base a satisfactory report relative to an independent supply, the Board of Administration concluded a satisfactory arrangement with the Peoria Water Company for continuing the use of the present supply.

PEORIA HEIGHTS, PROPOSED WATER SUPPLY.—Visited December 16, 1911, and April 29, 1912, with reference to a proposed water supply. Peoria Heights, a suburb of Peoria is located in Peoria county about 5 miles north of the business center of Peoria. The population is about 600 and the village will probably experience a substantial growth.

Preliminary plans were prepared by Mr. C. H. Dunn, consulting engineer of Peoria, and comprise four alternatives, namely:

(1) Sinking of two deep wells near the Bartholomew Bros. automobile factory, where two deep wells are now in use for factory purposes.

(2) The use of an existing well at an abandoned factory.

(3) The purchase of water from the Peoria Water Company.

(4) The development of a well supply in the valley of the Illinois river in the vicinity of the Peoria Water Company's wells.

As a result of various considerations the last mentioned project has been decided upon as the most practicable.

Detailed plans have not been prepared or submitted, but the project will in all probability include an electrically operated pumping station near the wells in the river valley, a distribution system and an elevated tank at a high point in the village.

PEKIN, EXISTING WATER SUPPLY.—Visited January 23, 1912, for the purpose of making general inspection of the public water supply. Pekin is located on Illinois river on the western boundary of Tazewell county, of which it is the county seat. The population is estimated at 10,000 and the growth is comparatively rapid.

The water works were installed in 1886. Since this time no important changes have been made although additional wells and additional equipment in the pumping station have been installed. About 1.82 acres of land are owned by the water company in the heart of the city. The source of supply consists of a group of 19 tubular wells, 15 of which are located within a circular pit 25 feet deep, while the other four are located in a rectangular pump pit. The wells all penetrate throughout their entire depth sandy and gravelly deposits constituting the alluvial deposits of Illinois river. They vary in depth from 50 to 60 feet, which would give them a total depth from the surface of the ground of 75 feet to 85 feet. They vary in diameter from 4 inches to 8 inches, the greater number, however, being 8 inches. All are provided with Cook strainers or drive point strainers. The 14 wells in the well pit are connected directly with the pumps in the pump pit by means of a suction pipe in a horizontal tunnel 27 feet long. The surroundings of the wells are not all that can be desired. On two of the streets bordering the water works property are large city sewers and within several hundred feet of the wells are a number of dwelling houses which have outdoor privies.

Numerous analyses made of the water show that it is but moderately hard, free from any objectionable physical characteristics and very low in total bacterial content.

The water is pumped directly from the wells into the distribution system by two compound duplex condensing steam pumps each having a nominal capacity of 1,500,000 gallons per 24 hours and one simple duplex steam pump having a nominal capacity of 250,000 gallons per 24 hours.

The distribution system comprises about 26½ miles of pipe, 56 per cent of which is of cast iron pipe varying in diameter from 4 inches to 14 inches, while the remainder is of wrought pipe varying in size from 1 inch to 2 inches in diameter. Connected with the distribution system and located on the same lot with the wells and pumping station, is an elevated steel tank 20 feet in diameter and 56 feet in height placed upon a stone masonry tower 85 feet in height. The total height is thus 141 feet and the capacity of the tank is 131,700 gallons.

PETERSBURG, EXISTING WATER SUPPLY.—Visited November 1, 1912, with reference to possible contamination of the water supply and trouble with corrosion of meters. A report was prepared, copy of which was sent to the local authorities for their information. Petersburg is in the center of Menard county on the Sangamon river. The population is approximately 2,500 and the census figures indicate a slight decrease in the population over 1900.

The water works were installed in 1878, at which time the supply was derived from ten 4-inch tubular wells 60 feet in depth. After about 19 years of service, the casings had corroded to an extent that made it impossible to use the wells and the group of small wells was then replaced by one large well, from which the supply is now taken. This well is located on the river's bank about 200 feet from the water's edge, and in a built-up section of the town. The diameter is 25 feet and total depth 44 feet. The water-bearing stratum consists of sand and gravel which is first encountered 8 feet below the surface. The inside of the well is plastered so that all water must enter it from the bottom. The water level in the well is practically the same as the water level in the river and has a maximum variation between high and low water of about 25 feet.

Analyses of the water made in the laboratories of the State Water Survey indicated it to be of excellent quality from a sanitary point of view. It is moderately hard, and contains more or less iron, which imparts a turbidity. The iron content varies materially, so that the water is more objectionable at times than at others. Comparisons of analyses of river water and well water show that the two are not alike and that the well water is a characteristic ground water.

The pumping station, which is located near the well, contains one duplex steam pump having a nominal capacity of 600,000 gallons per 24 hours and two compound duplex steam pumps each having a nominal capacity of 1,000,000 gallons per 24 hours. The small pump is used exclusively for supplying river water to the railroad and for street sprinkling, this being considered more suitable for boiler purposes and more economical for street sprinkling.

The distribution system comprises about 5 miles of cast iron pipe varying in size from 4 inches to 10 inches in diameter. Connected with the distribution system is an elevated steel tank with a total capacity of 185,000 gallons. This tank is placed upon a 20-foot stone masonry tower located in the highest part of the city.

RANTOUL, EXISTING PUBLIC WATER SUPPLY.—Visited March 25,1912, for the purpose of obtaining a general description of the public water supply. Rantoul is located in the north part of Champaign county on the Vermilion watershed. The population is in the neighbodhood of 1,500 and the village is experiencing a substantial growth. The business of Rantoul is of an agricultural character.

Water works were installed some time during the '80's and comprised as an original installation a well pumped by a windmill, an elevated tank and a very limited distribution system. In 1895 the present system was built and replaced the original system.

The present supply is drawn from two wells both 10 inches in diameter and 120 feet deep. They penetrate for the most part a stiff blue clay until a sand and gravel water-bearing stratum is reached at great depth. The entire depth penetrated by the wells lies within the glacial drift, which has a great thickness in this vicinity. Each well is provided with a 16-foot Cook strainer.

The pumping equipment is operated in conjunction with the municipal electric lighting plant. Each well is equipped with a deep well steam head pump with a nominal capacity of about 150,000 gallons per 24 hours. These pumps pump directly from the wells and discharge into the distribution system.

The distribution system comprises about 6 miles of pipe ranging in diameter from 2 inches to 8 inches. Less than one mile of this is of cast iron pipe, the remainder is all of wrought pipe varying in diameter from 2 inches to 3 inches. Connected with the distribution system is a wooden equalizing tank with a capacity of 80,000 gallons which is placed upon a brick tower 90 feet in height.

The quality of the water is very good from a sanitary point of view, nor is it objectionable on account of its mineral characteristics. The total residue is only 331 parts per million, practically all of which is in the form of carbonates. The presence of iron imparts some color and turbidity to the water, which, however, has not given rise to much popular complaint.

RIVER FOREST, EXISTING WATER SUPPLY.—Visited the latter part of June, 1912 in connection with a sanitary survey of Upper Des Plaines river. Advantage was taken of the opportunity to secure a general description of the water works.

River Forest is bounded on the west by Des Plaines river, on the east by the village of Oak Park and Chicago, and on the south by the village of Forest Park. The community is essentially a residential suburb of Chicago. The population is estimated at about 3,000 and the growth is rapid.

The water works were installed by the municipality in 1893 and have ever since been owned and operated by the municipality. The supply is obtained from two tubular wells each 1,000 feet deep and about 200 feet apart near the center of the village. One of these is 12 inches in diameter and the other is 8 inches in diameter. Both are 6 inches in diameter near the bottom. The casings extend to rock which is encountered at a depth of 54 feet. Water is found in St. Peters sandstone at a depth of about 980 feet and again at 1,400 feet. The water rises to within 50 feet of the surface, but has a general tendency to recede. The rate of recession per annum could not be ascertained. The wells are capable of yielding with the present pumping equipment about 240,000 gallons per 24 hours, which meets present requirements. Water from the wells is pumped into two rectangular collecting reservoirs having capacities of 74,000 gallons and 150,000 gallons, respectively, or a total of 224,000 gallons.

The water is of excellent sanitary and physical quality, has only a moderate mineral content (total residue 473 parts per million) and meets with general popular satisfaction.

The pumping equipment is housed in a brick pumping station near the wells. Water is raised from the wells into the collecting reservoirs by means of an air lift equipment. From the reservoirs the water is pumped into the distribution system by two duplex steam pumps each having a nominal capacity of 750,000 gallons per 24 hours. There is also an electric pumping equipment for the same service, which is retained in reserve for fire emergency. This comprises four motor driven 3-inch centrifugal pumps so connected that they may be used in single or double stage. The distribution system comprises about 12 miles of cast iron pipe ranging in size from 4 inches to 12 inches in diameter. Connected with the distribution system is an elevated steel tank having a capacity of 54,000 gallons. This tank is 12 feet in diameter, 65 feet in height and is placed upon a brick tower which gives it a total height of 107 feet.

ROCKFORD, IMPROVEMENTS IN PUBLIC WATER SUPPLY.— Visited November 6, 1912, at the request of the superintendent of water works for the purpose of making an inspection of the recent improvements in the public water supply, carried out with a view to protecting the water from contamination, such as was responsible during the preceding February for a disastrous typhoid fever epidemic.

The water supply of Rockford at the time of the epidemic was obtained from 11 deep rock wells penetrating the St. Peters and Potsdam sandstone, all located near the center of the city and adjacent to Rock river on its west bank. A group of eight wells comprising four wells entering the St. Peters sandstone and four entering the Potsdam sandstone are joined together in what is known as a shaft and tunnel system. This system comprises a steel lined shaft about 10 feet in diameter and 100 feet deep, at the bottom of which are placed three centrifugal pumps for lifting the water from the wells into a collecting reservoir. The pumps are connected by means of rope drive to steam engines, located at the ground surface. The wells are connected with the pumps by means of pipe lines laid in tunnels at the level of the base of the shaft. These wells are all located on lots belonging to the water company, with the exception of so-called Potsdam No. 6, which is in an alley way. The three remaining wells are in Peach street. The wells are known as Potsdam wells Nos. 2, 3 and 5. Well No. 2 was held in reserve for fire emergency only and was pumped by means of an air lift into a brick chamber surrounding the top of the well, whence it flowed by gravity into the collecting reservoir or the pump pit. Wells Nos. 3 and 5 are equipped with motor-driven deep well impellor pumps and machinery, housed in an underground chamber.

The collecting reservoir is a rectangular structure of concrete about 18 feet in total depth and holds approximately 1,000,000 gallons of water. At the time of the epidemic the reservoir was filled from a connection with the distribution system, a very uneconomical arrangement. The water from the shaft and tunnel system was ordinarily pumped into a so-called pump pit and filter well. The latter constituted the source of supply in the early years of the water works, and admitted ground water from the gravel deposits bordering the river. The filter well was concreted on bottom and sides to make it available as a pump pit along with the regular pump pit, which latter is a narrow rectangular structure of stone masonry and too small to equalize the pulsations of the large pumps. Both of these structures, more particularly the filter well, still permit the entrance of quantities of ground water from near the surface, which is known to be more or less contaminated. Moreover the proximity of the filter well to the river (a distance of about 50 feet) makes it possible for the well to receive river water. There is also a direct river connection leading into the filter well which is ordinarily kept closed and presumably tight.

The epidemic followed a big fire at one of the furniture factories in Rockford. During the fire Peach street well No. 2 was placed in service and the collecting reservoir was drawn down to an unusual extent. The investigation revealed three possible explanations of the typhoid epidemic and a number of possibilities whereby the water supply might become contaminated. First: Peach street well No. 2, as before noted was pumped by air lift, the water being discharged into a brick chamber surrounding the top of the well. This brick chamber was covered over with a manhole flush with the surface of the street paving and it was readily possible for surface filth including typhoid germs to enter. Moreover near to the well is a large sewer, sewage from which may have entered the well through a defect in the well casing or through the brick wall of the chamber. Second: Very near the collecting reservoir are several privies, one of which was within 5 feet of the north wall. Naturally the ground water in the neighborhood of the privy would be more or less contaminated. Ordinarily the water level in the reservoir was maintained at a sufficient elevation to exclude ground water, but when drawn upon heavily, the pressure would be reversed and the ground water would tend to enter. An examination of the interior of the reservoir showed quite conclusively that fecal matter from the privy near the north wall actually did enter the reservoir. Third: Polluted river water may have entered the public water supply mains through factory fire protection systems. The water in these systems, which is derived from the river, was at the time of the epidemic separated from the public supply only by means of single check valves and it is readily possible that one or more of these check valves may have opened at the time of the fire.

Which of these three causes was the real cause of the epidemic, will probably never be absolutely known, though the distribution of the cases lends considerable weight to the last mentioned possible cause.

Other conditions that might have contributed to the pollution of the supply are the direct connection with the river; leaky condition of the gravity conduit conveying water from the Peach street wells to the pumping station and the pervious condition of the pump pit and collecting reservoir.

In view of the foregoing, unusual efforts were made on the part of the water works authorities to introduce such modifications as would exclude all possibility of the contamination of the public water supply, and these include the following:

(1) The abandonment of Well No. 2 in Peach street.

(2) The abandonment of the pump pit and so-called filter well, both of which are in a leaky condition and permit the ready entrance of polluted ground water from the surface strata of sand and gravel.

(3) The installation of a new reinforced concrete covered reservoir.

(4) Greater protection of water in the old reservoir against contamination.

(5) The repair of the Peach street conduit leading from wells 5 and 6 in Peach street.

(6) Improvement in the security of connections between city distributing mains and factory fire protection systems using river or other polluted water.

There is also under contract a new well to the Potsdam sandstone in a distant part of the city on the east side. This well, known as well No. 7, is surmounted by a small pumping station in which is housed a motor-driven deep-well pumping system, which discharges the water directly from the well into the distribution system at that point. This is the first of a so-called segregated system of wells which are to be installed at various points throughout the distribution system and provided with both automatic and remote control. The new well is expected to deliver over 1,000,00 gallons per day.

The improvements made and the vigilance maintained by the water works authorities especially with reference to fire connections should preclude the possibility of further contamination of the water supply.

ROSSVILLE, EXISTING WATER SUPPLY.—Visited February 7, 1912, for the purpose of securing a general descriptive report of the water supply. Copy of a report based on this visit was sent to the local authorities for their information.

Rossville is located on the North Fork of the Vermilion river in the northeast part of Vermilion county. The present population is in the neighborhood of 1,450 and the growth is practically at a standstill. Rossville is primarily a farming center, but has some coal mining interests. A large canning factory is also located in Rossville.

The water works were installed in 1904. The original supply consisted of three tubular wells 84 feet in depth. This supply proved insufficient and in 1910 two new wells were drilled and the present pumping station was built. The two new wells furnish at the present time the entire supply and are respectively 126 feet and 131 feet in depth and both are cased with 8-inch pipe. The water is encountered in sand and gravel deposits within the glacial drift near the bottoms of the wells. The water rises under pressure to within 65 feet of the surface.

The supply is of a very good quality from a sanitary point of view and is only moderately mineralized as compared with water from other deep drift wells. The total mineral content is about 400 parts per million, most all of which is in the form of carbonates. The water also contains something over 2 parts per million of iron, which produces color and turbidity, but this has not met with serious objection. With regard to the iron content, the present supply is inferior to the original supply.

Water is pumped directly from the wells into the distribution system by means of two deep well pumps each with a rated capacity of about 300,000 gallons per 24 hours. The distribution system comprises about 2 miles of mains mostly of 8-inch cast iron pipe, but with two short stretches of 6-inch pipe. This liberal provision was made so as to facilitate future extension. Connected with the distribution system is a standpipe, 10 feet in diameter and 85 feet in height, with a total capacity of 50,000 gallons.

SILVIS, EXISTING WATER SUPPLY.—Visited May 18, 1912, on account of an outbreak of typhoid fever. Investigation showed that the outbreak was due to milk and the infection was not general throughout the community. Silvis was again visited on July 5 for the purpose of securing a general description of the water works with special reference to the possibility of contamination and danger to health. The results of this inspection were embodied in a report, copy of which was sent to the local authorities. Silvis is located near Mississippi river in Rock Island county, and it may be classed as a suburb of Moline. The population of the village is in the neighborhood of 1,200 and is increasing rapidly.

The water works were built in 1910 and the supply was originally obtained from a shallow well in the gravel deposits of the bottom lands of the Mississippi river. The well is 28 feet deep and 15 feet in diameter and is lined with steel to its full depth. Water is obtained from a layer of sand and gravel. The water is of a very good quality from a sanitary point of view under ordinary circumstances, though there are possibilities of contamination which should be guarded against.

At the time of visit a deep well was being drilled and had then reached a depth of 1,600 feet. It was subsequently continued to a depth of 2,000 feet. The water within the well is under artesian pressure and flows from the top in volume, which seems ample to meet the present needs of the community. The new well is amply protected against contamination. The water, however, is very highly mineralized, the chief constituents being potassium and sodium chlorides, sulphates of sodium and magnesium, and calcium carbonate. From a mineral point of view, the new supply is thus inferior to the old supply.

The water is pumped from both wells directly into the distribution system by means of two electrically-driven two-stage centrifugal pumps, each of about 300,000 gallons capacity per day. The distribution system comprises about 3.6 miles of cast iron pipe varying in size from 6 inches to 12 inches in diameter. This unusually liberal size is in anticipation of a large future growth. Connected with the distribution system is a standpipe 112 feet in height and 21 feet in diameter with a total capacity of 350,000 gallons. The standpipe is placed on a high hill forming a side of the river valley.

STAUNTON, EXISTING WATER SUPPLY.—Visited May 15, 1912, for the purpose of securing a general description of the public water supply. This was embodied in a report, copy of which was sent to the local authorities for their information. Staunton is located in the extreme southeastern part of Macoupin county on the watershed of Cahokia creek. The population is in the neighborhood of 5,000 and growth is rapid. The principal industry at Staunton is coal mining and a large proportion of the population works in the mines.

The public water supply was installed in 1889. The source of supply is an impounding reservoir formed by a dam across a ravine about two miles north of the city. This reservoir is about 40 feet deep at the dam, but is quite shallow about the edges, especially at the upper end. Nothing definite could be learned regarding the capacity of the reservoir. It was merely known that the supply, as at present developed, is at times scarcely able to meet the requirements of the city. Some consideration has been given to increasing the supply by the construction of another dam across the same ravine in a down stream direction.

The watershed of the reservoir is made up almost entirely of farm land on which are a few houses. There are no habitations within ¼ mile of the reservoir with one exception. The reservoir is also entirely surrounded by timber land. In short, the supply is unusually free from contamination for a surface water. With but simple regulations rigidly enforced, the supply could be made satisfactory without purification. Two analyses have been made of the supply and these indicated the water to be quite safe. A rather high turbidity and color are objectionable features, but these are not seriously complained of by the general public.

The, water is pumped from the reservoir by an electrically driven impeller pump having a nominal capacity of about 700,000 gallons per 24 hours. There is held in reserve a duplex steam pump also having a nominal capacity of 700,000 gallons per 24 hours. The water is delivered under direct pressure with no reservoir of standpipe for relief. The distribution system comprises 7 miles of cast iron pipe varying in diameter from 4 inches to 8 inches.

ST. ELMO, EXISTING WATER SUPPLY.—Visited February 2, 1912, for the purpose of obtaining a general description of the public water supply. Such description was embodied in a report, copy of which was sent to the owner of the water works. St. Elmo is situated in the east part of Fayette county. The population is in the neighborhood of 1,300 and the growth seems to be at a standstill, due to the removal of the C. & E. I. shops, which were formerly located at this point.

The water works were installed in 1904 by P. M. Johnson, resident of that city. Shortly afterwards the system was sold to the city, the original owner taking a mortgage as security. The city, however, failed to meet its obligations and the property reverted to P. M. Johnson.

Sugar creek, a small tributary of Kaskaskia river, is the source of supply. The stream is impounded by means of an earthen dam with a concrete core, wall and spillway. The dam is about 200 feet long and 13 feet in total height.

The reservoir has an estimated capacity of about 11,000,000 gallons. The watershed area tributary to the reservoir is in the neighborhood of 3 square miles. It is evident from past experience that the reservoir is scarcely sufficient to meet all demands, but the capacity could readily be enlarged by building a new dam farther down stream.

The public supply is but little used for drinking purposes owing to its objectionable physical characteristics. An analysis indicates that for a surface water, the supply is reasonably free from contamination, yet the unprotected condition of the watershed renders the supply unsafe for humah consumption.

A small brick pumping station near the edge of the reservoir houses the pumping equipment which consists of one compound duplex steam pump with a nominal capacity of 350,000 gallons per 24 hours. This pump takes the water directly from the reservoir through an 8-inch intake pipe and discharges it into the distribution system under a pressure of 65 pounds.

An 8-inch rising main about one mile in length conveys the water to the town. Within the built-up portion of the town there are about two miles of distributing mains ranging in size from 4 to 8 inches. All mains are of cast iron pipe.

TISKILWA, EXISTING WATER SUPPLY.—Visited July 31, 1912, upon request of the local board of education for an investigation of the source of water supply used at the new township high school at that place. Opportunity was taken to make an inspection of the public water supply and prepare a descriptive report thereon, copy of which was sent to the local authorities.

Tiskilwa is situated in the southern part of Bureau county, on Big Bureau creek, and has a population of about 900. The growth of the town is practically at a standstill. It is primarily a farming center.

The present public water supply was installed a number of years ago, but has never been used for other than fire protection and sprinkling purposes. A few houses have connections and use the water for flushing closets and sprinkling lawns. The water is obtained from a small reservoir fed by springs and surface drainage, and is so situated that gravity flow to the village is available. The water is subject to gross contamination as a result of the use of the upper part of the reservoir as a hog wallow and the entrance of drainage from nearby habitations.

The village recently engaged the services of a consulting engineer, Mr. W. S. Shields, to advise it with respect to the improvement of a public water supply and he recommended as the cheapest and best way of securing a supply adequate to serve present needs the construction of a covered concrete reservoir of about 60,000 gallons' capacity for the purpose of collecting, by means of drain tile, the spring water that now enters the open reservoir. This improvement would cost but the small sum of $3,700. The popular desire is, however, to secure water from wells, even though this involves expensive pumping and, therefore, the project as recommended by the engineer has not been executed.

The distribution system, made up entirely of 4-inch pipe, consists of a single line, running northward from the reservoir a distance of approximately one mile.

WARSAW, Existing Water Supply.—Visited May 4, 1912, for the purpose of securing a general description of the water works, with special reference to the proposed installation of a filter plant. Warsaw is located on Mississippi river in Hancock county. The population is in the neighborhood of 2,500. Its proximity to the plant of the Mississippi Power Development Company will, it is believed, result in a rapid future growth.

The water works were installed in 1908 and are owned and operated by the municipality. The water is pumped from the Mississippi river directly into the distribution system without treatment. A purification plant is, however, nearing completion.

The pumping station is located on the river bank. The pumping equipment consists of two electrically-driven triplex power pumps, each having a capacity of 360,000 gallons per 24 hours. One of these will be used for pumping the water from the river into the coagulating basin of the filter plant and the other will be used to pump from the clear well into the distribution system.

The purification plant has a nominal capacity of 180,000 gallons per day and comprises coagulation with alum, sedimentation, treatment with hypochlorite and rapid filtration through sand. The sedimentation basin is of wooden construction, circular in plan, 22 feet in diameter and 10 feet deep to the overflow, and has a capacity of about 28,500 gallons, equivalent to 3.8 hours storage at the nominal rate of operation. There is a single wooden tub filter, 9 feet in diameter. This is provided with a loss-of-head gage and effluent controller and is washed with water, assisted by mechanical stirring arms. Built in an excavation beneath the sedimentation basin is the clear water well, constructed of concrete, 16 feet in diameter and 10 feet deep, with a capacity of about 15,000 gallons, equivalent to about 2 hours' storage. Chemical solutions are prepared in two circular, wooden tanks—one for alum and one for hypochlorite. Each of these is 3 feet in diameter and 3 feet deep, and holds about 155 gallons.

The distribution system comprises about 2.1 miles of cast iron pipe, 4 inches and 8 inches in diameter. Connected with the distribution system and located in the high part of the town is a standpipe, 12 feet in diameter and 80 feet in height, with a total capacity of 67,800 gallons.

SEWERAGE SYSTEM.—On November 15, 1912, plans and specifications were received from Mayor N. C. Eckbohm of Warsaw for a proposed system of sewers, prepared by Arthur M. Morgan, consulting engineer, of Chicago, Illinois. These plans were reviewed and a report, abstract of which follows, was submitted to the local authorities. The main portion of the city occupies comparatively level table land about 125 feet above the river. The steep slopes, extending from the table land down to the river, are also built upon. The proposed sewerage system about to be installed is laid out upon standard lines, and is to be built upon the separate plan. The system divides itself, according to local topographic and other features, into four districts, known respectively as the "Business District," "North Residential District," "South Residential District," and the "South Addition Residential District."

The total length of sewers is in the vicinity of 6½ miles. Manholes are liberally provided, there being about one to each 300-foot length of pipe. Many of these manholes are drop manholes, necessitated by the steep grades encountered in that portion of the city sloping down to the river. All permanent dead ends will be provided with flush tanks. The South Addition Residential District lies at a lower level than contiguous portions of the sewered area, and in order to divert the sewage from this district into the main sewerage system, it will be necessary to install a small sewage pumping station. This pumping station is to be built below the street level and will comprise an electrically-driven centrifugal pump in a 10-foot circular pump well. The storage available in this pump well will be about 3,000 gallons. The motor will be arranged to start and stop automatically as the reservoir becomes full or empty.

The system will have one main outlet about opposite the center. of the city into the Mississippi river. This will bring the sewer outlet about 2,200 feet below the water works intake, a distance sufficiently safe, as there is no likelihood of up-stream currents caused by eddies or wind action.

The final disposal of sewage requires no special consideration, for the reason that Warsaw is fortunate enough to be located upon a large stream, which will provide ample dilution for all sewage that may be discharged into it for many years to come. The most that the city may ever be called upon to do will be to partially treat the sewage to remove offensive solids and unsightly floating matter. For the present, it is only necessary that the outfall bulkhead be placed so that even at extreme low water the sewage will fall directly into the river and not be exposed in a foul stream upon the banks.

WATERLOO, Exisiting Water Supply.—Visited May 6, 1912, for the purpose of securing a general description of the water supply. This description was embodied in a report, copy of which was sent to the local authorities for their information.

Waterloo is the county seat of Monroe county and is located near Fountain creek. The population is in the neighborhood of 2,000 and growth is slight. The city is primarily a farming center, but is also supported by large flour mills and a milk condensery.

The water works system was installed about 16 years ago by the municipality. The supply is derived from an impounding reservoir, about 12 acres in area, and also from Fountain creek, about two miles southwest of town. The reservoir is formed by a dam built across a small ravine within 200 feet of Fountain creek. The capacity of the reservoir has never been measured, but a rough estimate places it at 40,000,000 gallons. The water entering the reservoir is principally derived from springs emerging from limestone rock and is supplemented by surface drainage from a small watershed, approximately one-half square mile in area. During dry periods water from Fountain creek is pumped into the reservoir. Three principal sources of contamination are: (1) A roadway, running along the north bank of the reservoir; (2) a residence within about 200 feet of the reservoir and on the south side thereof; and (3) picnickers and fishermen, who have free access to the reservoir and adjoining land.

Pollution from the roadway and the residence can be readily diverted by constructing ditches which will intercept all drainage and carry it below the dam. Picnicking on the grounds surrounding the reservoir and fishing within the reservoir should not be permitted under any circumstances.

The fact should not be overlooked that the springs emerge from a limestone formation, which, owing to its cavernous character, permits the passage of water for great distances without exerting a purifying effect, such as results in the slow percolation of water through gravel and sand deposits. That the water in the limestone may become polluted, is evidenced by the fact that abandoned wells within the town of Waterloo are frequently used as convenient means for getting rid of house sewage. Because of this danger, the water supply of Waterloo should be regularly analyzed in order that any contamination may be detected before it has an opportunity to result disastrously. The watershed of Fountain creek above the point of intake is wholly unprotected, and the water may be contaminated at any time in a great variety of ways. Hence this source of supply is an unsafe source. Should it be possible to adequately protect the water in the reservoir by constructing ditches and using the other precautionary measures above described, this supply should prove satisfactory without purification of any sort. The watershed of Fountain creek, however, cannot be adequately protected and, therefore, this water should be purified. It is scarcely practicable to construct an expensive filter plant for treating this water during the short periods when it is pumped into the reservoir, but it would be quite practicable to sterilize the water by means of bleach. This reagent should, under the circumstances, prove very effective, provided it is regularly and conscientiously applied whenever the Fountain creek water is used. The most convenient point of application undoubtedly would be in the suction line from Fountain creek, between the intake structure and the pumps.

At times much difficulty is encountered, due to the development in the reservoir of growths of plant life. These growths impart very disagreeable tastes and odors to the water, which are much complained of. Under the guidance of the State Water Survey, the reservoir is being treated from time to time with copper sulphate, and this seems to have eliminated the difficulty.

The pumping equipment comprises two compound duplex steam pumps, each having a nominal capacity of 500,000 gallons, and one compound duplex steam pump with a nominal capacity of 1,000,000 gallons per 24 hours.

The distribution system comprises about 1½ miles of 8-inch cast iron pipe, leading from the pumping station to the city, and within the city there are about 2 miles of cast iron pipe, varying in size from 4 inches to 6 inches. No storage is provided on the distribution system.

WATSEKA, Existing Water Supply.—Visited May 3, 1912, for the purpose of securing a general description of the public water supply. This description was embodied in a report, copy of which was sent to the local authorities for their information. Watseka is the county seat of Iroquois county, near the center of that county, on the watershed of Kankakee river. The population is about 2,500 and growth is very slight.

The water works were installed about 1892 by the municipality. Water has always been obtained from wells and pumped directly into the distribution system. There are two wells located near the center of town, each 150 feet in depth. One of these is cased with 6-inch pipe to a depth of 125 feet and the remainder of the depth is cased with- 4-inch pipe. The other well is cased with 6-inch pipe throughout the entire depth. The wells are presumably equipped with strainers at their lower ends. The supply is derived from sand land gravel strata within the drift. The water rises within the wells to about 10 feet below the surface of the ground. This is drawn about 10 feet under ordinary condition of pumping. The yield of the two wells with present pumping equipment is in the neighborhood of 300,000 gallons per 24 hours. Heavy pumping causes sand and gravel to be drawn from the wells.

The water is pumped by means of a single duplex steam pump, having a nominal capacity of 1,000,000 gallons per 24 hours. The pump draws directly from the wells and discharges into the distribution system.

The distribution system comprises about 5 miles of cast iron pipe, varying in size from 4 inches to 8 inches in diameter. Connected with the distribution system is a standpipe, 12 feet in diameter and 110 feet high, thus giving it a total capacity of 93,000 gallons.

The method of handling the water precludes the possibility of its becoming contaminated after being drawn from the wells, and as a matter of fact analyses show that the water is of excellent quality from a sanitary standpoint, nor is the water highly mineralized, as compared with many of the Illinois ground waters. The hardness is caused by carbonates alone, which amount to something over 300 parts per million.

WHEATON, SEWAGE PURIFICATION.—Visited October 17 and 18, 1912, with reference to proposed sewerage.

Wheaton is a community having a population of about 3,500. The town has a public water supply and a system of sewers, the latter serving about two-thirds of the population. The sewage is discharged into a small stream known as Spring brook, which at a distance of about 6 miles discharges into the west branch of the Dupage river. Spring brook has a watershed of only a few square miles and consequently has a very small flow. During dry periods in the summer the stream would normally be without flow, but the sewage discharged into it at the present time always causes it to have some flow. The land bordering Spring brook, especially within a distance of two miles below Wheaton, is especially desirable for residence purposes, and there at present exist a number of very fine summer residences and also two golf courses. At distances further down the stream the surrounding country is laid out in farms, but there are several farm houses sufficiently close to the stream so that sewage odors may reach them.

When the sewerage system was constructed in 1904, local authorities, realizing the possibility of nuisance resuling in Spring brook, constructed a septic tank in the hope that this would sufficiently purify the sewage. The tank, however, has been a disappointment. While it removes a considerable quantity of solid mater when operating under normal conditions, the effluent is still highly putrescible, and during dry periods causes a serious nuisance throughout the upper four miles of the brook. During the past three or four years very vigorous complaints have been made against this nuisance, more particularly by the two golf clubs above referred to, and by the residents along the ditch within a few miles below the septic tank discharge. During 1911 the services of Mr. F. L. Stone, of the Central Engineering Bureau, and Mr. Langdon Pearse, consulting engineer, of Chicago, were retained for the purpose of securing some advice as to how the difficulty might be overcome. Under date of November

14, 1911, these engineers submitted a report, copy of which is on file in the office of the State Water Survey. The conclusions of this report are as follows:

1. "A nuisance exists in the open ditch below the outfall of the storm drain.

2. "The present septic tank requires immediate cleaning, and is today a help only by retaining the fresh fecal matter.

3. "The most immediate way of alleviating the present nuisance is by a cut-off.

"For permanent improvement, the storm drain should be extended to the Aurora, Elgin & Chicago Railway and the ditch filled up. The grade of the open ditch below the A., E. & C. Ry. is more than double that from the present outlet to this point.

4. "Settling, even in Emscher tanks, is inadequate to remedy permanently the conditions existing at Wheaton—that is, the lack of any diluting water. Therefore, further purification will be required, preferably sprinkling filters."

The recommendations at the end of the conclusions are as follows:

1. "As a temporary measure to relieve the existing nuisance, we recommend the construction of the cut-off.

2. "In connection with the cut-off, sludge drying beds should be built at the present site. The tank should be carefully operated and frequently cleaned. We believe the operation and cleaning will be greatly facilitated by remodeling the existing tank.

3. "In providing the further purification required, we believe that consideration should be given to selecting a permanent site where a new settling tank, pumping station, sprinkling filter and secondary settling basin should be built.

4. "We recommend that consideration also be given to extending the present storm drain to the Aurora, Elgin & Chicago Railway bridge, thus abolishing the present open ditch and making a clean-cut lawn.

"The construction of the cut-off will facilitate the construction of this drain by removing the water from the ditch.

"We trust that this report places the matter before you in a manner to make our conclusions clear. Once the policy of your Board is settled concerning the location you can obtain, or prefer, for the site of your permanent plant, then we can advise more definitely and accurately on the costs. In our figures, no allowance has been made for right of way or land purchase. We have endeavored to provide for first-class designs in agreement with the best modern practice to produce an effluent as stable and of the degree of purity required under your conditions."

During the winter of 1911 land 1912 the matter of improving the method of disposing of the sewage from Wheaton was temporarily dropped. With the advent of the dry summer months of 1912, however, the agitation was again renewed and pressed so vigorously that the officials of Wheaton feel that immediate steps must now be taken for the purpose of remedying conditions. The authorities wish, however, to proceed cautiously and in a manner that will insure the ultimate solution of, the problem along the right lines. Accordingly, they arranged for a review of the situation by their consulting engineers, and at the suggestion of the consulting engineers, the State Water Survey was requested to examine into the situation. The authorities desired to have, if possible, a unanimous report from their own engineers and from the engineer of the State Water Survey.

On October 17, 1912, the engineer of the State Water Survey visited Wheaton and in company with Mr. F. L. Stone made a visual examination of Spring brook, from its junction with the West branch of the Dupage river in an up-stream direction to the point where the brook receives the effluent from the Wheaton septic tank. Following this a conference was had with Messrs. Stone and Pearse for the purpose of reaching some general conclusion as to the best method of improving existing conditions; On the evening of the same date the engineers met with the mayor and city council in the presence of a number of the complainants, who have property along Spring brook. The engineer of the State Water Survey presented verbally a report which represented the consensus of opinion of the three engineers, and is given, in substance, as follows:

For the purpose of doing away with the existing nuisance in Spring brook, three suggestions have been made. These may be enumerated as follows:

(1) Temporary relief by the remodeling of the existing septic tank, so as to make it conform as nearly as may be to the principle governing the operation of the Emscher tank and the construction of a pipe line for carrying the effluent to a point below the property of George Plamondon, a distance of about 8,000 feet in a down-stream direction.

(2) Permanent relief by the construction of a pipe line which will convey the effluent from the tank to the West branch of Dupage river.

(3) Permanent relief by conveying the sewage in a down-stream direction to a point where a suitable site may be found for sewage treatment works for treating the sewage in a manner that will render it entirely suitable for discharging into the stream during periods of low flow.

In connection with each of the above projects, it has been proposed to intercept the dry-weather flow from the storm-water sewers, inasmuch as this now contains putrescible wastes.

Project No. 1 seemed at first to be the most practicable and cheapest way of overcoming the present difficulty, though it was recognized that a nuisance would still exist in the lower reaches of the stream. The inspection of October 17 demonstrated conclusively that such a project would not prove an adequate solution, even as a temporary measure, for the reason that already the property owners below the point of the proposed discharge have been greatly inconvenienced by the pollution, both on account of odors and because the banks of the stream are extensively used for the pasturing of horses and cattle. The effect of the installation of the extension would merely be to transfer the nuisance in a more aggravated form to the lower reaches of the stream, and in all probability injunction proceedings would be initiated before the extension could be carried out. This project was, therefore, not recommended.

Project No. 2 has more merit than the first, inasmuch as the present small sewage flow from Wheaton could probably be discharged into the West branch of the Dupage river after sedimentation without producing objectionable odors, during a very large portion of the year at least. On the other hand, the West branch of the Dupage river is a very beautiful stream and as yet undefiled by sewage. Moreover, its banks are extensively used for pasture purposes. Wheaton is a rapidly growing community, and there can be no doubt but what in the course of a very few years the quantity of sewage produced in the town will be so great as to seriously pollute the water of the West branch of the Dupage river, and at such time further improvements will be necessary at great expense. Nor would it be in line with a broad and rational state policy to acquiesce in the discharge of a quantity of sewage into a stream which is almost certain to give rise to a nuisance and otherwise objectionable conditions in the course of a very few years. In view of the above considerations, this project was not recommended.

Project No. 3, namely, purification of the sewage at a suitable site, seemed the only adequate- one and this was recommended. It was pointed out, however, that there are no suitable sites within about 1.8 miles of the present septic tank. Below this point, however, there are a number of particularly favorable sites for purification works, and it was recommended that an option be obtained on a ten-acre tract.

The matter of selecting the type of treatment proved rather difficult, and in the light of then available data it was not possible to present a definite recommendation. On the other hand, it was agreed that a preliminary treatment, involving sedimentation in Emscher tanks, would be necessary, and that the present tanks should be abandoned, unless the outfall sewer involved the construction of an inverted siphon, under which conditions it might be necessary to clarify the sewage before its passage through the siphon.

Secondary treatment, it was pointed out, may be accomplished by the installation of sprinkling filters, contact beds, or intermittent sand filters. The first of these, while undoubtedly cheapest in first cost, will positively necessitate the pumping of the sewage, whereas, further data may demonstrate that contact beds and intermittent sand filters can be utilized without the necessity of pumping. The estimated cost of the sprinkling filters was something less than $30,000 without covering, and with covering $35,000. In view of the value of the land throughout the valley of Spring brook, together with its availability for residence purposes, it is believed that the sprinkling filters should be covered to prevent the dissemination of odors. In connection with the installation of sprinkling filters, it was pointed out that the effluent may not be in all respects satisfactory, owing to the extensive use of the banks of the stream for pasture purposes.

The contact beds were estimated to cost in the neighborhood of $45,000, though it is probable that they can be built somewhat cheaper than this. They offer no advantage over the sprinkling filters in so far as the effluent is concerned, and it is even probable that the effluent from single-contact beds would be somewhat inferior to that from the sprinkling filters. On the other hand, the contact beds are particularly well adapted to the prevention of the dissemination of odors, and it may be that the location of the site finally determined upon may cause this consideration to prevail.

Intermittent sand filters, it was estimated, could be built at about the same cost as the contact filters, namely, about $45,000. Such a plant would, have the special advantage of producing a highly purified effluent; one which would be perfectly clear and could not be objected to in any manner by riparian owners. Further, an intermittent sand filter plant is believed to offer fewer difficulties than any other type of plant in its operation, more particularly if comparatively unskilled labor must be used. While not as free from odors as well operated contact beds are, still the odor in the vicinity of intermittent sand filter beds, properly operated and not overworked, is very slight.

It was recognized that the problem before the city of Wheaton is a particularly difficult one, and in any event must involve a very burdensome expense, and for this reason it was felt that the cost factor should preponderate in reaching a final decision as to the best form of treatment to be installed. But aside from this, it was believed by the engineers that intermittent sand filtration should be given first consideration, location and size of site permitting.

With reference to the interception of dry-weather flow in the storm-water sewers, it was recommended that an effort first be made to cut out the putrescible wastes at the house connection. If this prove impracticable, it was recommended that the intercepted wastes be lifted into the sanitary outfall sewer by means of some form of air displacement pump, operated with air compressed at the municipal water works pumping station.

WINNETKA, EXISTING WATER SUPPLY.—Visited December 12, 1911, for the purpose of securing a general description of the public water supply, and again on September 27 and 28, 1912, for the purpose of conferring with the local authorities relative to suitable methods for treating the water to render it safe.

Winnetka is on the north shore of Lake Michigan, in Cook county, about 17 miles north of the center of Chicago. It is a high-class residential suburb of that city. The population at present is about 3,200 and the village is experiencing a substantial growth.

Water works were installed in 1893 and are owned and operated by the village. The neighboring village of 'Glencoe at the same time installed a distribution system of mains, which is connected with the distribution system of Winnetka, so that the former village receives its supply from the Winnetka pumping station. There are two intake pipes, the original being 12 inches' in diameter and extending from the pumping station in a southeasterly direction and at an angle of about 40 degrees with the shore line. This is used only for condensing water and in case of emergency. In 1910 a new intake pipe was laid, extending 3,000 feet into the lake and at right angles with the shore. This intake is of cast iron pipe, 20 inches in diameter. The outer end termintes in 27 feet of water and is provided with a strainer to prevent the entrance of large floating matter. At the shore end the intake discharges into a concrete well, 24 feet in diameter, with the bottom 27 feet below the lake level. Much difficulty is encountered on account of anchor and frazzle ice forming on the intake in winter time.

The pumping station, which is operated in conjunction with a municipal electric lighting plant, is a neat brick building and contains the following pumps: One tandem compound duplex steam pump with a nominal capacity of 2,000,000 gallons per 24 hours; one tandem compound duplex steam pump with a nominal capacity of 1,300,000 gallons per 24 hours; one simple duplex steam pump with a nominal capacity of 960,000 gallons per 24 hours. The last pump is o1d and seldom used.

The distribution system comprises about 21 miles of cast iron mains, varying in size from 4 inches to 12 inches. Connected with the distribution system and on the bluff overlooking the lake is a standpipe, 148 feet high having a total capacity of 55,000 gallons. This standpipe is encased in an architecturally attractive brick and stone tower.

A number of analyses made in the laboratory of the State Water Survey and covering the period from January, 1909, to July, 1910, show that the water at times is badly contaminated with matter of sewage origin. Analyses show also objectionable turbidities and color, but according to local testimony the occurrence of excessive turbidities is so infrequent that it does not give rise to complaint among consumers. The absence of object-ionable turbidities, such as are experienced at other points along the lake shore, are apparently due to the fortunate location of the intake over a hard bottom, which is not greatly stirred up by storms.

Realizing the necessity for a safer water supply, there has recently been installed a hypochlorite treatment plant, which seems to be in successful operation.

MISCELLANEOUS INVESTIGATIONS

ENFIELD, TYPHOID FEVER OUTBREAK.

Visited November 12 and 13, 1912, for the purpose of investigating the prevalence of typhoid fever. The results of the investigation were embodied in a report, copies of which were sent to the local authorities and the State Board of Health.

Enfield is a farming community with a population of about 900. There is neither a public water supply nor sewer system in the town. Each house has its own well or cistern, generally 10 to 15 feet deep. Often wells and cisterns are combined by permitting the roof drainage to discharge into a shallow-dug well. Wells are not made water-tight, are open at the top and the old-fashioned hand bucket has been replaced by pumps in only a few instances. Privies are poorly constructed and dilapidated, and do not average more than 50 feet distant from the wells.

There were in all 22 cases and four deaths between July 10 and September 30. Twelve were females and ten were males. The ages ranged from 5 to 67 years. Twelve of the cases were located in town in five families and did not appear to have any connection with the ten cases occurring on farms outside of town.

Of the town cases all were located in the northeast part at what is called the Junction. This section is not thickly populated, and nearly all houses have a chicken yard, cow stable or pig pen near by. The sanitary conditions in this neighborhood are extremely bad. It is the low part of the town and gets the drainage from the outhouses on the hillside. All the wells are open at the top and the privies are filthy. The families were told to disinfect the discharges from the patients, but this was never thoroughly done, and most of the time not at all. The well children continually came in contact with the sick and were thus directly exposed to infection, which accounts for the fact that 9 of the 12 cases were children.

Each family used water from its own well, and although analyses showed the wells to be contaminated, as would be expected, due to their construction and the location of the privies, it is hardly possible that the water started the disease, although it may have helped to spread it.

All the cases in town used milk from four different dealers and there were no cases in the dealers' families.

The first of the twelve town cases was a child in a family of six, which developed twenty-five days before any other cases. Evidence obtained threw no light on the cause of this case. No other members of the family were taken sick. Children from other families continually visited at the home of this first case and played with the children there and in this way the disease was probably spread.

The three cases that were not children belonged to the same family that maintained a general store in the neighborhood. The first of these cases did not develop until late in the outbreak, and may have been infected by contact with children coming to the store. The other two of these three cases developed twenty and twenty-five days after the first and were undoubtedly due to contact.

The cases located on farms outside of town were distributed among 6 families; 4 families had one case each and 2 families had three cases each. One case was located about three miles northwest of town, another case about four miles southwest of town, and the remainder to the southeast of town.

The two cases to the northwest and southwest of town, so far as is known, had come in contact with no other cases, and the infecting cause could not be ascertained.

The cases to the southeast of town were divided among four houses, which were quite widely separated, but a relation nevertheless existed among them. The first case in each household was a farmer, and these four farmers had been together shucking corn, and in all probability had a common source of infection. The later cases developing in the households were undoubtedly contact cases.

Although the cause or causes of the first cases at Enfield were uncertain, there is a great deal of evidence to show that the secondary cases resulted from the careless disposal of the patients' discharges and personal contact. About half of all the cases were secondary cases.

Recommendations were made for the improvement of sanitary conditions, in order to prevent further spread of the disease.

HILLVIEW, TYPHOID FEVER OUTBREAK.

Visited November 20, 1912, at the request of the State Board of Health for the purpose of investigating a typhoid fever outbreak. Reports embodying the information obtained and conclusions reached were sent to the local authorities and the State Board of Health.

Hillview is a small farming community, with a population of about 350. It has neither a public water supply nor sewerage system. Water is obtained from driven, bored or dug wells, from 20 feet to 30 feet deep, which often are situated dangerously close to privies, which are mostly of poor construction and in a dilapidated condition.

The typhoid outbreak comprised in all 14 cases. The first case occurred 35 days before any of the other cases, and no relation was found to exist between it and the succeeding cases. The other thirteen cases occurred within a period of 23 days, and in such rapid succession that only three would permit of being classed as secondary cases.

With the exception of two cases, the outbreak was confined to the eastern half of the village. One of the above two cases was located in the very northwestern part. The eastern section, in which the majority of cases occurred, is the most thickly settled part of the village.

Investigation showed that milk was not involved. Some of the cases used no milk, or only condensed milk, and there was no common milk supply among the others. Many families in which no cases occurred used milk from the same source as families having cases, and one family in which cases occurred kept its own cows and supplied families in which no cases developed.

No evidence secured pointed to water as a medium of infection. Two wells were more commonly used than others and local suspicion was attached to them, but investigation showed that a number of cases had not used water from either of these wells and, moreover, many people not taken sick had used the water freely. It is true that both wells were in bad condition; were shallow, and near privies, and one was entirely open at the top. Analyses showed the water to be contaminated, but the same would have been true of nearly all the wells in the village, for they all must receive more or less seepage from nearby filthy and badly-built privies. Though the wells at Hillview are potential sources of typhoid infection, the epidemiological evidence indicates that they were not the cause of the epidemic under consideration.

Fly infection may have played a part, for the prevailing unsanitary conditions would readily permit of such, but the bunching of the cases as regards time would indicate a more momentarily active infection than fly infection is likely to be.

Only two of the 14 cases were females, one of which was the early case apparently not connected with the outbreak, and the other occurred late in the outbreak and was most probably due to contact with an earlier case in the family. Of the twelve males, the ages ranged from 6 to 40 years; five attended school and the other seven were farmhands or laborers.

The fact that the majority of cases were males was very significant. It was further proof that milk, water, flies, and so forth, which ordinarily would affect males and females alike, were not the cause. Investigation showed that the only thing in common to all the males was a poolroom at the rear of a restaurant and store. The son of the proprietor was one of the early cases, and it has been learned that two other cases developed in the family since the investigation. The female case occurring late in the epidemic was a relative and frequent visitor of this family.

Although the evidence pointed toward the poolroom as the seat of infection, the real infecting cause at the poolroom was not definitely ascertainable. An out-of-town case that had just recovered visited Hillview previous to the outbreak and probably frequented the poolroom. This case was not in town during the investigation and detailed information could not, therefore, be obtained. The very early female case had visited at the home of this out-of-town case during the recovery of the latter and may have been infected there.

Recommendations were made for the improvement of sanitary conditions, in order to prevent further spread of the disease.

GARBAGE PLANT AT STALLINGS.

Visited July 16, 1912, upon request of the State Board of Health to investigate nuisances resulting from the operation of a garbage reduction works at Stallings, near Granite City. Again visited on September 13, 1912, to obtain further information. A report embodying the information obtained was sent to the State Board of Health.

The garbage reduction works belonged to the Great Western Chemical Corporation and had been completed about eight months previously for the purpose of disposing of the garbage collected in the city of St. Louis, Missouri.

This garbage, amounting to 100 to 150 tons per day, is disposed of by the so-called reduction process, the object of which is to recover from this material grease and fertilizer. The contract for doing this work is held by the Great Western Chemical Corporation, which, until about eight months ago, maintained works at St. Charles. Missouri. The odors from these works were so objectionable to the residents in the vicinity thereof that the corporation was obliged to seek a new location and chose Stallings, about six miles in a direct line northeast by east of the central portion of Granite City. The country roundabout Stalling is but sparsely inhabited at the present time, there being not over 25 or 30 scattered farm houses within a radius of two miles. The plant is located near the tracks of the Illinois Traction System, the Chicago, Peoria & St. Louis Railroad, the Toledo, St. Louis & Western Railroad, and the Illinois Central Railroad. The garbage is delivered to the plant over the tracks of the Illinois Traction System in steel tank cars, specially designed for the purpose.

The complaints made against the operation of the plant are of three classes, namely: First, odors due to the passage of garbage tank cars through Granite City and Madison; second, odors due to the processes carried on at the reduction works; and, third, gross contamination of surface waters in the vicinity, more particularly a portion of Long Lake.

ODORS DUE TO PASSAGE OF CARS THROUGH GRANITE CITY AND MADISON.

The tank cars used in transporting the garbage are of the most modern type and have been very successfully used in both Cleveland and Columbus, Ohio. Such a car consists of a semi-cylindrical steel tank, mounted upon suitable trucks and arranged to dump side-wise. The capacity of each car is about 40,000 pounds, or 20 tons, and 18 cars are in service. Extra precautions are taken to prevent odors by providing the tanks with steel-hinged covers, and by transporting the garbage only at night. Notwithstanding the use of the above good equipment and transportation of garbage at night, odors are distinctly perceptible by residents along the Illinois Traction System in Granite City and Madison, and these odors become particularly strong, when for any reason the cars are permitted to stand still upon the tracks. A short time before the visit of the representative the public was much aroused over the odors resulting from a wreck of several garbage cars. There seems to be no practicable way to eliminate entirely odors incident to the transportation of garbage, but if the garbage cars were hauled over a steam railroad, the rights of way of which are ordinarily considerably removed from habitations and city streets, there would be less likelihood of complaint than exists under present conditions with garbage being carried through the heart of residence sections. The most that can be recommended under the circumstances is that the cars be maintained scrupulously clean, and that a special effort be made to remove garbage adhering to the outside portions of the cars.

ODORS DUE TO OPERATION OF PLANT.

To understand the situation fully relative to the production of odors incident to the process of garbage reduction, as well as to the production of liquid wastes which may pollute neighboring water courses and ponds, some description of the garbage reduction process is necessary.

Various processes of garbage reduction are in use, all of which are more or less malodorous. Theoretically, it is possible to reduce garbage without the dissemination of bad odors, but in practice this has never yet been accomplished. Some processes using specially enclosed machinery, housed in substantially constructed buildings, provided with special ventilating systems, may be operated so as to minimize the aerial nuisance to a very great extent—that is to say, they may be operated without producing objectionable odors beyond a radius of about 1,000 feet. Such plants, however, are very expensive to construct, nor do they represent the most economical methods of operation. A company contracting to reduce garbage under the ordinary short-term municipal contract arrangement can rarely afford to make an investment which will enable them to build a plant of the most improved type. They are usually tempted to select the process requiring the lowest first cost for machinery and equipment, and to erect the most flimsy and makeshift buildings. These last remarks characterize the installation at Stallings, and perhaps in this case an additional incentive to the use of crude construction was given by the unfortunate experience, from the company's point of view, at St.

Charles. In other words, the company does not wish to put a large investment into a plant which it may be compelled to abandon.

The process utilized is no doubt an economical one, but it would be difficult to conceive of a process capable of producing more odors. The garbage is received at the plant in a so-called receiving house, which comprises a concrete water-tight bin of large proportions, into which the tank cars are dumped. The bin is covered by a rather flimsy steel superstructure. From the receiving house the garbage is conveyed to the drier house by means of a suitable scraper conveyor. As the garbage is removed from the receiving house a large quantity of liquid escapes. It is claimed that this liquid is caught in a sump and pumped to the dryers, but the process of drying this dirty water is certainly not an economical one, and it would not be strange if the operators of the plant would occasionally let this liquid run to waste. Being rather high in organic matter and of a highly putrescible nature, the access of this liquid into a neighboring stream or body of water would tend to pollute same to a high degree.

There are 14 dryers, each of which comprises a long steel cylinder with a furnace at one end and a smokestack at the other. The cylinders are 42 inches in diameter and 28 feet long, and are provided on the inside with flanges which serve as agitators for keeping the material stirred as it passes from one end to the other. The furnaces are of an ordinary type and burn coal. About 400 pounds of coal are required, it is said, to dry a ton of garbage. To insure a good draft and a sufficiently high temperature, a large rotary fan is used which forces air into the ash chambers below the fires. It is claimed that a temperature of about 1,500 degrees F. is obtained, but from the appearance of the garbage as it emerged from the dryers it is questionable whether this temperature exists anywhere else except in the combustion chambers of the furnaces. The garbage is introduced into the revolving cylinder at the furnace end of the steel cylinder and is permitted to fall out at the opposite end through suitable openings at the base of the stack. As it emerges the garbage has the appearance of having been fried. It is claimed that the moisture is reduced from about 75 per cent originally present to 15 per cent. Very little of the matter is completely disintegrated, and rags come through practically unscorched. Undoubtedly the worst odors emanating from the reduction plant escape through the stacks of the dryers, and the smoke and fumes are carried for great distances in whichever direction the wind may happen to be blowing.

In most reduction plants similar fumes are avoided by cooking the garbage in enclosed tanks, called digesters, for a period of 6 to 8 hours, after which the liquid is pressed out and the comparatively dry tankage can be further dried in a manner which will create comparatively slight odor. The digestion process, while it undoubtedly recovers a larger amount of salable material, is more complex and costly than that used in the present instance.

with positive ventilation, to minimize odors to an extent that would enable the plant to continue its operation in its present location without creating a serious nuisance beyond a radius of 1,000 feet. There is no question but that the reduction process can be carried on at a profit even with a more expensive process and the construction of more substantial buildings, provided the company has a sufficiently long-termed contract and can obtain the raw material without cost. Time and opportunity did not permit going into the financial condition of the company and the terms of its contract nor would it be wise to attempt this since in the end the company must itself determine whether it shall shut down its present plant or build a new plant capable of operating without excessive nuisance.

In case the company decides to continue operations at the present site, it must find some more satisfactory means for transporting garbage from St. Louis to the reduction works. There should be no objections to giving the company further opportunity to minimize these odors by more careful cleaning of its tank cars and by possible modification in their construction, but entirely satisfactory conditions will not be established until a new route for the transportation of garbage is secured.

With regard to the pollution of surface waters this can be effectively prevented by the evaporation of all liquid wastes except condenser water. The evaporation is best conducted in triple effect evaporators. The process of evaporation is not a paying one, but the expense involved is largely compensated for by the recovery in the form of a syrupy liquid of nitrogenous and other bodies which when mixed with the tankage materially increases its fertilizing value and hence its market price.

THAWVILLE, TYPHOID OUTBREAK.

Visited November 6, 1912, at the request of the village president, for the purpose of investigating the prevalence of typhoid fever. The results of the investigation were embodied in a report, copy of which was sent to the local authorities.

Thawville is a farming center with a population of about 350. There is neither a public water supply, nor sewerage system in the village. Water is obtained from dug wells 10 feet to 20 feet deep in the bottom of which tubular wells are sunk to a depth of 40 or 50 feet. Privies, many of which are poorly constructed and in a dilapidated condition, are located at an average distance of about 50 feet from the wells.

There were eleven cases in all and these arrange themselves according to location, into four distinct groups. Two of these groups comprise but one case each, one of the groups comprises three cases and the remaining group comprises six cases.

The occurrence of the cases in groups, together with other data regarding milk supply, water supply and so forth, indicate that milk and water were not factors.

The weight of evidence rather indicates that the secondary cases which comprise at least five cases, are the result of contact infection.

The sources of infection of the primary cases were not ascertainable with any degree of definiteness. The first case, one of the group of three, occurred some months before all of the other cases, namely, in March of the present year, whereas the other cases occurred during September and October. This first case was not definitely diagnosed to be typhoid, but had many of the typhoid symptoms. The second and ninth cases (referred to in the order of their going to bed) occurred in the same house as the first case and probably were infected by the first case.

Special significance attaches to this group of cases inasmuch as they all occurred among attendants in the post office and general store. There is a possibility that these persons may have contaminated letters or food and that this may have been the cause of the spread of the disease to the other cases. This belief is, however, supported only by very slight evidence, as follows:

Case No. 11 which was one of the isolated cases, and Case No. 3 which was the first of the group of six cases, at times went to the post office and the general store connected therewith. On the other hand Case No. 3 had been out of town previous to the incubation period of the disease and may well have contracted the infection elsewhere. Case No. 11 was a child who had not been out of town or far from home. This child, so far as could be ascertained, had visited none of the houses containing the other cases, but had come in contact with Cases 1, 2 and 9 at the post office.

Just how the cases in the two groups of more than one were infected, could, of course, not be ascertained, yet it is significant that in both these groups, the discharges from the patients were not properly disinfected, but were simply thrown into out-of-door privies which afford ready access to flies. Furthermore the wells from which the water supplies were obtained were inadequately protected against the entrance of surface contamination and it was readily possible for foul matter to enter through the loose boards which covered the tops. That the wells were grossly contaminated, was amply evidenced by the analyses made in the laboratory.

While, as generally obtains in the investigation of typhoid fever epidemics, more particularly in rural communities, it is not possible to point out definitely the exact source or sources of infection, yet it was plain that the sanitary conditions in Thawville, more particularly as these apply to the wells and privies, were exceedingly dangerous and favorable to the promotion of typhoid, once it gained a foothold.

Nor can the importance of the disinfection of the patients' discharges be too much emphasized and it should be the first duty of the physician and the public health officer to instruct the housewife or other person who may have the care of the patient, in thorough methods of disinfection. Ordinary bleaching powder is as effective a disinfectant as can be used, but it must be used liberally. It was often found that ridiculously small quantities were applied to the discharges, which was worse than no disinfectant at all, since it created a false sense of security.

The general sanitary conditions of the town may be greatly improved by the better protection of wells against surface contamination and by the reconstruction of privies in such a manner that fecal matter may not get onto or into the soil and so that flies may not have access thereto. Beyond this the community should consider the installation of a public water supply of assured good quality as soon as the growth of the village and the funds available will permit. Thawville is rather a small town to support a public water supply, yet there are instances of communities no larger, which have public water supplies in successful and economical operation. Following the introduction of a public water supply, there should be installed a proper system of sanitary sewers which will permit the introduction of indoor sanitary plumbing and open the way toward the abolition of the dangerous outdoor privy and cesspool.

INDEX