

University of Illinois
State Water Survey

Bulletin No. 3

UNIVERSITY OF ILLINOIS BULLETIN

VOL. 4.

OCTOBER 1, 1906.

No. 3

(ENTERED AT URBANA, ILLINOIS, AS SECOND-CLASS MATTER)

CHEMICAL AND BIOLOGICAL SURVEY OF THE WATERS OF ILLINOIS

REPORT FOR YEAR ENDING
AUGUST 31, 1906

By EDWARD BARTOW

WATER SURVEY SERIES No. 3

URBANA, ILLINOIS

PUBLISHED BY THE
UNIVERSITY



Illinois Printing Co., Danville, Ill.

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MABEL EUNICE BUSH *Clerk*

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*Began work January 1, 1906, under Co-operative agreement with State Board of Health.

†Assistant Hydrographer, United States Geological Survey. Began work July 1, 1906, under Illinois Co-operation.

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LETTER OF TRANSMITTAL.

STATE WATER SURVEY.

*University of Illinois,
Urbana, Illinois,*

October 1, 1906.

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 to August 31, 1906, with the request that it be printed as a Bulletin of the University of Illinois, State Water Survey Series, No. 3.

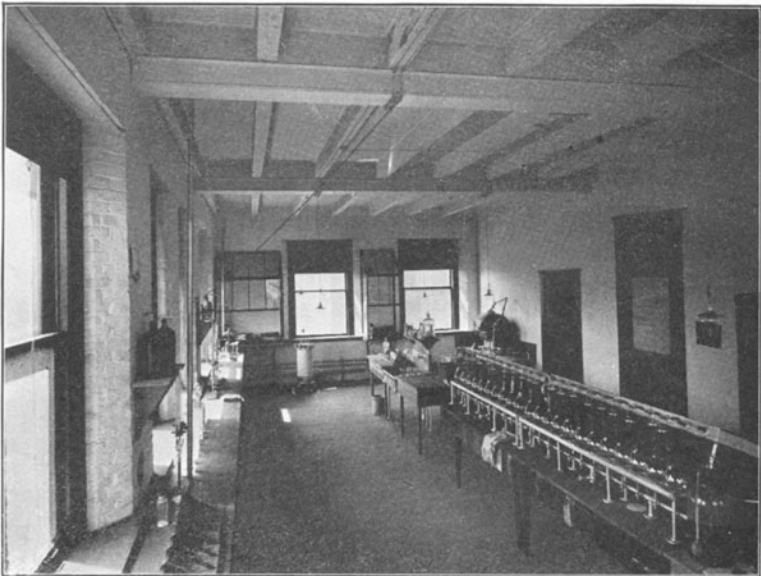
In the report is included a general description of the work of the Survey since its foundation in 1895, with a more detailed description of the work accomplished during the year ending August 31, 1906.

The development during the year to which we call attention, includes the establishment and equipment of a laboratory for the bacteriological examination of water; a coöperative agreement between the State Water Survey and the State Board of Health, which was consummated January 1, 1906; and a coöperative agreement between the State Water Survey, State Geological Survey, Engineering Experiment Station of the University of Illinois, and the Division of Hydrography of the United States Geological Survey, which was effective July 1, 1906, its object being to study problems of special interest to each party as shown in the contract printed in full in this report.

These coöperative agreements coalesce all the general water investigations of the State. This enlarging and intensifying of the work of the State Water Survey must lead to more efficient study of the water problems and valuable conclusions must follow.

Respectfully submitted,

EDWARD BARTOW,
Director.



LABORATORY FOR SANITARY CHEMICAL ANALYSIS, STATE WATER SURVEY

GENERAL STATEMENT FOR YEARS FROM 1895 TO 1906.

The State Water Survey of Illinois, founded in 1895, has for its object a chemical and biological survey of the waters of the State. The work was carried on under the direction of Professor Arthur William Palmer, Professor of Chemistry at the University of Illinois, until his death in February, 1904. He was succeeded by Professor Samuel Wilson Parr, Professor of Applied Chemistry at the University of Illinois, who had control of the work until the present Director took charge September 1, 1905.

From the time of its foundation until the first of January, 1906, especial attention was given to the sanitary-chemical examination of the water supplies of the State. Up to that time 13,873 samples had been received. Of these, 5,376 were sent in by private citizens or local health officers. During the years 1899 and 1900, 2,800 analyses were made for the Sanitary District of Chicago during the investigation of the effect of the Chicago Drainage Canal on the water of the Illinois River. These analyses were made under special arrangements with the Sanitary District of Chicago. Extra assistance was provided for the work. The remaining samples were collected by direct order of the State Water Survey for the purpose of carrying on special investigations. These investigations were chiefly local and include a series of analyses of test wells and the study of the effect of sewage from Champaign and Urbana on the Champaign branch of the Salt Fork of the Vermilion River.

During this period, 547 waters were examined to determine the chemical composition of the mineral residue. Most of these mineral analyses were made at the request of private citizens who desired to obtain data concerning the possible medicinal value, or concerning the effect of the waters on boilers, or concerning the availability for various manufacturing purposes. The results

of these analyses have been collected and are nearly ready for publication as Bulletin No. 4 of the State Water Survey.

From a scientific standpoint it is to be regretted that samples could not be collected systematically from various sections of the State by a representative of the Survey. Yet, a classification of the points from which these samples were received shows that sanitary analyses have been made of waters from 100 counties and 590 towns, and that waters for analysis of the mineral residue were received from 90 counties and 269 towns. This distribution shows the widespread demand for such work.

In the State of Illinois there are three general sources of water supply, rain water, surface water and ground water. Rain water is not used to a great extent for drinking purposes, the Survey having been called upon to analyze the water from only ninety-three cisterns.

Surface water furnishes drinking water to the majority of the people of the State because the cities are located on Lake Michigan or on some river from which a general water supply is obtained. Seven hundred and seventy-six analyses of such waters have been made.

Ground water signifies water obtained from springs or wells either in rock or drift. Because of the ease with which individual households can be supplied from such sources, springs and wells furnish the greatest number of water supplies.

In Table I the samples sent in by private citizens are classified according to the sources from which the waters were taken. Examination of Table I indicates a very gradual increase in the number of waters sent in yearly. That the increase was not greater was probably due to the limitations necessarily placed upon the Survey compelling it to refrain from too great publicity. On the whole it may be stated that a large amount of valuable data has been collected which will form the basis for a more systematic survey.

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	Oct., 1895, to Dec. 31, 1896	Y E A R S									Totals for each source
		1897	1898	1899	1900	1901	1902	1903	1904	1905	
Surface waters, rivers, lakes and ponds	69	72	102	54	59	61	97	75	80	107	776
Springs	16	21	34	23	22	35	28	18	28	41	266
Cisterns.	12	19	17	7	7	3	10	6	7	5	93
Natural ice	4	12	1	11	9	4	9	3	12	6	71
Artificial ice. . . . .	.....	1	.....	2	1	.....	1	1	1	0	7
Water for artificial ice.	3	.....	.....	3	.....	1	1	.....	5	2	15
Water for natural ice. . . . .	.....	2	.....	.....	.....	3	1	1	2	0	9
Shallow wells in rock.	28	16	8	22	12	22	10	17	25	25	185
Deep wells in rock	58	48	34	26	36	56	59	23	28	66	434
Flowing wells in rock.	45	8	16	12	13	14	3	8	9	11	139
Shallow wells in drift.	500	245	168	243	274	209	243	245	270	292	2,689
Flowing wells in drift.	63	5	4	9	4	.....	3	5	5	12	110
Deep wells in drift.	64	68	43	30	24	36	63	54	51	40	473
Sewage	37	.....	21	25	10	.....	1	7	2	6	109
Total samples from citizens..	899	517	448	467	471	444	529	463	525	613	5,376
Other samples	888	811	988	1,579	1,866	778	147	419	555	466	8,497
TOTAL FOR THE YEAR.	1,787	1,328	1,436	2,046	2,337	1,222	676	882	1,080	1,079	13,873

REPORT FOR YEARS 1895 TO 1906

SPECIAL REPORT FOR YEAR ENDING AUGUST 31, 1906.

During the year 1905 and 1906 the Survey has continued to analyze all samples of water sent in by citizens desiring to know its sanitary, medicinal or commercial value. It has been our aim to make sanitary examinations more complete. We have, therefore, added to the determinations made heretofore, that of alkalinity. This allows an estimate to be made of the relative value of waters to be used in the laundry or household. As an example of the significance of this determination, when the water is used for laundry or bathing purposes, it is stated that for every part per million of hardness, estimated in terms of calcium carbonate, six parts of soap are required before cleansing can be done. Or, a practical illustration is found in the experience of the city of Glasgow. In the amount of soap used since the introduction of the soft Loch Katrine water, this city saves annually, \$180,000. It can be readily seen what significance a hardness of 300 will have when compared with a hardness of 100.

The analytical methods in use in the laboratory conform very closely to those of the committee of the American Public Health Association, published in the First Supplement of the Journal of Infectious Diseases, May, 1905.

During the year the scope of the work has been increased by the equipment of a bacteriological laboratory. (See illustration opposite.) It is thoroughly equipped not only for the ordinary routine tests, but for the more accurate confirmatory tests, and for special investigations along the lines of water bacteriology. This laboratory now contains a refrigerator; an incubator for maintaining temperature at 20 degrees and one for 37½ degrees; three sterilizers, one for hot air, one for steam, and one for steam under pressure; and other necessary apparatus.

In Table II, the samples sent in to the Laboratory during the year ending August 31, 1906, are classified according to the sources from which the waters were taken. Comparing Tables I



BACTERIOLOGICAL LABORATORY, STATE WATER SURVEY.



LABORATORY FOR MINERAL WATER ANALYSIS, STATE WATER SURVEY.

TABLE II, SHOWING THE NUMBER OF WATER SAMPLES EXAMINED BY REQUEST DURING THE YEAR ENDING AUGUST 31, 1906,
ARRANGED BY MONTHS AND ACCORDING TO THE NATURE OF THE SOURCE.

SOURCES	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	TOTAL
Surface waters, rivers, lakes and ponds. . .	7	13	8	14	22	19	24	24	23	20	27	30	231
Springs	13	3	4	3	1	....	1	1	12	2	7	8	55
Cisterns . . . . .	....	2	1	1	....	2	1	1	....	2	....	2	12
Natural ice . . . . .	....	....	....	....	....	....	....	....	....	....	....	....	....
Artificial ice . . . . .	....	....	1	....	....	....	....	....	....	....	....	....	1
Water for artificial ice . . . . .	....	....	....	....	....	....	....	....	1	....	....	....	1
Water for natural ice . . . . .	....	....	....	....	....	....	....	....	....	....	....	....	....
Shallow wells in rock	1	2	....	....	....	....	1	....	1	1	....	....	6
Deep wells in rock	8	8	5	11	8	5	5	11	10	7	10	10	98
Flowing wells in rock	2	....	1	....	....	....	....	....	4	2	2	1	12
Shallow wells in drift	55	61	37	18	18	28	23	22	35	27	53	63	440
Flowing wells in drift . . . . .	....	1	1	....	....	....	....	....	1	....	1	....	4
Deep wells in drift	4	6	2	5	2	3	9	6	5	2	5	9	58
Sewage . . . . .	....	....	1	....	4	12	12	13	2	5	....	6	55
Total samples by request	90	96	61	52	55	69	76	78	94	68	105	129	973
Other samples	31	5	7	44	35	28	21	31	111	32	21	61	427
TOTAL FOR THE MONTH	121	101	68	96	90	97	97	109	205	100	126	190	1,400
Bacteriological analyses	14	12	12	55	55	66	64	62	148	70	79	88	725
Mineral analyses	2	14	7	3	2	11	15	22	22	27	23	39	187

and II, it is noticed that the total number of samples received from citizens during the year ending August 31, 1906, is 360 greater than has been received in any previous year, and that this increase is general in all the important classes of water.

We would call especial attention to the increase in the number of samples of surface waters, due to an effort on the part of the State Water Survey, to obtain periodical samples from municipal water works which obtain their water from such sources. The larger number of sewage samples examined during the year may also be accounted for because of the coöperative agreement with the State Board of Health, since these samples were for the most part collected by or under the direction of the Sanitary Engineer of the State Board of Health. It is noticeable also that the number of waters sent in decrease during the winter months. This is due to the fact that typhoid fever is more prevalent in the late summer and fall, and people fail to have the purity of their water supply determined unless illness suggests contamination. Much of the increase during the spring and early summer of this year is undoubtedly due to the publicity given to the work of the State Water Survey after the formation of the coöperative agreement with the State Board of Health.

The other samples examined have been collected for the study of special problems.

Ninety-eight of the samples analyzed during May and June were analyzed with the assistance of Messers. A. B. Cutler and D. B. A. Graham, in connection with their thesis work in the Department of Municipal and Sanitary Engineering. In their work they made a study of the relative efficiency of gravity and mechanical filters, analyzing the raw water and the effluent from their filters at frequent intervals.

Twenty-nine of the samples analyzed during August were collected for the study of the efficiency of the filters of the Danville Water Co., with a view to improving the quality of the water furnished to the city of Danville.

From December to August, two hundred and thirty-eight samples were collected by the Water Survey to study the efficiency of the Urbana and Champaign septic tanks and the effect of the effluent on the small stream into which they empty.

Twenty-one samples were sent in by the State Geological Survey from the East St. Louis district for examination of the mineral content according to coöperative agreement.

MUNICIPAL WATER SUPPLIES.

During the year there has been undertaken a systematic study of the municipal supplies of the State. Large cities like Chicago employ experts whose special duty it is to make regular examinations of the water supply. Smaller cities for financial reasons rarely employ such men regularly. Outside assistance is not called for until there is complaint, and usually the examinations are made at such rare intervals that they are valueless for comparative study. For the best results, it is our belief that periodical examinations should be made of all municipal water supplies. The city of Chicago makes daily analyses of the water obtained through each of the nine intakes through which the Lake Michigan water is drawn. This is done that warning may be given without delay should signs of pollution be detected.

If a large city considers daily examinations essential, the small city should have some regular attention paid to its supply. We consider it an important function of the State Water Survey to care for the municipal supplies of the State. Under present circumstances it would be impossible to make daily examination of many supplies, nor would it be advisable.

Water obtained from streams should be analyzed at frequent intervals, weekly if possible, monthly at least. Waters coming from shallow wells may be analyzed even less frequently. Waters from deep wells need not be analyzed more often than once a

year, unless the water is stored in reservoirs where there is a possibility of contamination.

An attempt has been made to collect data concerning the municipal water supplies of the State. This data together with analyses made of such waters, has been gathered to form Bulletin No. 5 which is to be issued soon. Letters and blanks have been sent to every city of more than 1,000 inhabitants. The data desired for each city or town is the following:

1. Population, and rate of increase.
2. On what branch of river system.
3. Chemical or physical character of the river water.
4. Ponds, lakes or reservoirs, and their character.
5. Ice industry.
6. Character of wells and springs.
7. Sewer system established.
8. The municipal water supply, when established.

Source of water, ownership, cost, changes since installation.

Description of reservoirs, pumping station, and pumps.

Daily consumption.

Character of the water, chemical and physical.

If treated, how, and at what cost.

If supply from wells, the geological strata, diameter and depth.

The annual cost of maintenance.

Our attempt has in general received the hearty coöperation of the water works and city officials. Many cities of the State have sent in samples for analysis and the following cities send regular monthly samples to our Laboratory: Danville, Decatur, Elgin, Evanston (weekly), Kankakee, Lake Forest, Moline, Quincy, Waukegan, and Winnetka. Owing to present conditions the Water Survey has not felt justified in consenting to make more frequent regular analyses.

By such analyses the State Water Survey should be of assistance to water works along the following lines:

1. It can test the purity of water delivered.
2. It can make comparative tests of the waters from several possible sources for cities intending to put in a new supply, or to extend an old one.
3. It can test the efficiency of filters by analyses of water before and after filtration.
4. It can determine the turbidity and mineral content of streams of the State, used for municipal supplies, in order to obtain data from which can be calculated the size and expense of filter plants or softening plants.
5. It can determine the mineral content of well water supplies, giving data concerning the character of the residue on evaporation and the proper means of softening.
6. It can determine the kind of algæ present, and render assistance toward its removal.

It is not possible for a representative of the Survey to visit all the municipal supplies of the State. Where visits have been made we have been cordially received and encouraged to believe that our work is appreciated. We have, however, visited the water works at:

Carbondale,	East St. Louis,	Lawrenceville,	Shelbyville,
Carlyle,	Elgin,	Moline,	Springfield
Carmi,	Evanston,	Murphysboro,	Streator,
Centralia,	Galesburg,	Ottawa,	Urbana,
Champaign,	Geneseo,	Peoria,	Waukegan.
Charleston,	Kankakee,	Quincy,	
Danville,	Lake Forest,	Rockford,	
Decatur,	La Salle,	Rock Island,	

COÖPERATION OF STATE WATER SURVEY AND STATE BOARD OF HEALTH.

In October, 1905, Mr. Jacob A. Harman, Sanitary Engineer of the State Board of Health, visited the Laboratory of the State Water Survey, and in conference with the Director, discussed the feasibility of coöperative work between the State Water Survey and the State Board of Health. Following this conference, at the direction of Dr. James A. Egan, Secretary of the State Board of Health, a second meeting was held on November 2, at which a suggested method for coöperation between the State Water Survey and the State Board of Health was outlined. A third conference followed in Springfield, November 20. As a result of these conferences an agreement for coöperative work was entered into between the State Water Survey and the State Board of Health. A copy of the proposed agreement as accepted by the State Board of Health and the Trustees of the University, follows:

COÖPERATION OF THE STATE WATER SURVEY AND THE STATE BOARD OF HEALTH.

For the purpose of coöperation we are dividing the water problems of the State into the following four sub-divisions:

1. Epidemics.
2. Sewage Purification.
3. Water Supplies.
4. Streams.

1. EPIDEMICS.—The epidemics that are carried by means of water are, cholera and typhoid fever. The first at the present time is so well under control that the possibilities of a cholera epidemic in an inland state are remote. Practically the only water-borne disease to be considered would, therefore, be typhoid fever. In this coöperative agreement it is the function of the State Board of Health to investigate places where the typhoid rate is high and it is the function of the State Water Survey to

analyze the samples collected by the Inspector of the State Board of Health and report on the same.

2. SEWAGE PURIFICATION.—For the second problem the oversight of sewage disposal is a function of the State Board of Health. Through its Inspectors it shall obtain the physical data and collect samples of sewage and effluent, which the State Water Survey shall analyze. In addition to inspection by the State Board of Health, the State Water Survey shall inspect plants where a special study is to be made. Either the State Board of Health or the State Water Survey shall make at least an annual inspection of all sewage works and sewage systems, public and institutional.

3. WATER SUPPLIES.—It is the primary function of the Water Survey to have the oversight of all the water supplies of the State. We may divide these into:

1. Municipal.
2. Institutional.
3. Individual.

1. Municipal.—Statistics should be obtained regarding the source and character of all city supplies. This may be done by first writing a letter to the mayor of each city or to the superintendent of water works, to obtain preliminary data to be followed as far as possible by inspection of the water supply by a representative of the State Water Survey or of the State Board of Health. Sanitary and economic analyses should be made at regular intervals of all supplies. The interval should be determined by each individual case. For example, streams vary more than wells, hence such supplies require more frequent examinations. A study should also be made of public or community wells. These are generally located on or near the street and the possibility of contamination is great.

2. Institutional.—In some cases the institutions receive their supply from the city in which they are located. Such supplies need no special attention. In cases where the institu-

tion has its private plant, arrangements should be made for periodic examination of its water supply.

3. Individual Wells.—The Water Survey has been making analyses for citizens of Illinois of wells and springs throughout the State. This should be continued and should be supplemented by the collection of water from wells in localities where no pollution is suspected, with the ultimate end of preparing a normal chlorine map of the State. This work must be accomplished by personal inspection of localities by a representative of the State Water Survey and personal collection of samples for shipment direct of the Laboratory.

4. STREAMS.—No special investigation of streams to be made under this agreement.

As a result of this agreement, Dr. W. G. Bain was chosen Bacteriologist to the State Water Survey and began work in the Laboratory at Urbana, January 1st, 1906. Under the general direction of Mr. Harman a series of tests of the septic tanks of Champaign and Urbana and Lake Forest have been carried on. Sewage and effluent have been collected from the sewage disposal works at Monmouth, South Bartonville, and Quincy. The detailed results of these examinations will be published in a Bulletin of the State Board of Health. As a result of these investigations, negotiations are now under way looking toward the control of the Urbana Septic Tank (see illustrations opposite) by the State Water Survey and the State Board of Health. It is proposed to run this septic tank in a way to attain its highest efficiency, with the hope of producing a model for other cities, institutions, or manufacturers who plan to install sewage disposal works. It is also hoped that this may lead to the foundation of a sewage experiment station, to be under the joint control of the State Water Survey, State Board of Health and the Department of Municipal and Sanitary Engineering of the University of Illinois. Such an experiment station has been founded at the Massachusetts Institute of Technology, and valuable results are



FIG. 4. SEPTIC TANK, URBANA, ILLINOIS, Exterior.

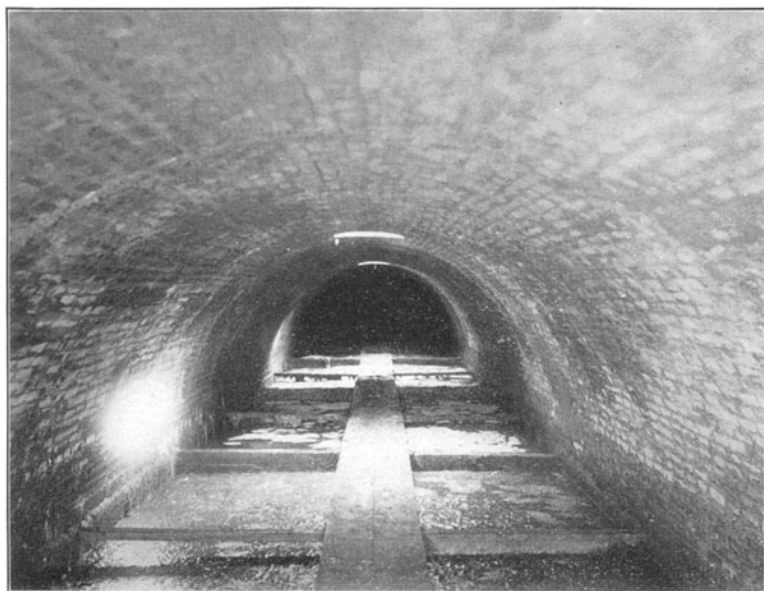


FIG. 5. SEPTIC TANK, URBANA, ILLINOIS, Interior.

being obtained. Our conditions differ, however, in the character of the sewage and in the character of the streams into which disposal works effluent is allowed to flow. We therefore believe that it will not only be profitable, but necessary for the State of Illinois to carry on experiments with sewage disposal. Many important cities of the State must obtain their water supply from surface waters, and such work will be of great value for the protection of the streams and lakes.

ILLINOIS COÖPERATION.

For a number of years it has been the policy of the United States Geological Survey to form coöperative agreements with state departments. The topographical maps of the United States are being prepared according to such agreements. Recently the Hydrographic Branch has inaugurated a similar policy. In general the United States Geological Survey assigns for coöperative work an amount of money equivalent to the amount that can be appropriated by the state departments for work of common interest. In Illinois the agreement for coöperative work was entered into by the State Water Survey, with the State Geological Survey, the Engineering Experiment Station of the University of Illinois, and the Hydrographic Branch of the United States Geological Survey. These departments are specially interested in the study of the mineral content of water from streams and other sources, with a view to their use for manufacturing purposes and their relations to the geological formations. The scope of the work undertaken for the fiscal year ending June 30, 1907, is shown in the contract which is copied in full.

THIS AGREEMENT, made and entered into this first day of July, 1906, between CHARLES D. WALCOTT, Director, for and on behalf of the UNITED STATES GEOLOGICAL SURVEY, of the First Part; EDWARD BARTOW, Director, for and on behalf of the STATE WATER SURVEY OF ILLINOIS, of the Second Part; L. P. BRECKENRIDGE, Director, for and on behalf of the ENGINEERING EXPERIMENT STATION OF ILLINOIS, of the Third Part; and H. FOSTER

BAIN, State Geologist, for and on behalf of the STATE GEOLOGICAL SURVEY OF ILLINOIS, of the Fourth Part.

WITNESSETH: It is hereby agreed that there shall be conducted in the State of Illinois a coöperative survey to determine as hereinafter provided, the character and applicability of the natural waters of said State, during a period of twelve months from July 1st, 1906, and that the parties hereunto subscribed shall contribute to the support of said survey as follows:

By the Party of the First Part.....	\$5,000
By the Party of the Second Part.....	3,200
By the Party of the Third Part.....	1,000
By the Party of the Fourth Part.....	1,000

TOTAL..... \$8,200

1. That all work performed under this coöperative agreement shall be confined to the determination of the mineral and organic constituents in the surface and ground waters of said State, their applicability for use for industrial and domestic purposes, and their pollution by sewage, together with certain experimental work: (a) upon the effectiveness of sewage purification plants now installed within the State; (b) upon the reaction of different types of water in the production of steam in boilers, with studies of boiler scale corrosion and foaming; (c) upon a comparative study of methods for the prevention of the growth of crenothrix and in addition thereto such special studies as may be determined upon by the Board of Control hereinafter designated.

2. That the work performed under this coöperative agreement shall be under the direction of a Board of Control composed of representatives designated by the parties hereunto and until further action by the parties shall be as follows:

For the Party of the First Part,	M. O. LEIGHTON;
For the Party of the Second Part,	EDWARD BARTOW;
For the Party of the Third Part,	L. P. BRECKENRIDGE, ARTHUR N. TALBOT, and SAMUEL W. PARR;

For the Party of the Fourth Part, H. FOSTER BAIN.

It is hereby understood and agreed that in case of a division of opinion in the Board of Control with reference to the disposition of any of the matters over which said Board is placed in control under the terms of this agreement, that each of the parties to this agreement, shall be entitled to but one vote.

3. That Edward Bartow is hereby designated as Administrative Director of the investigations provided under this agreement, and shall have in charge the approval of accounts for disbursement, and shall, with the approval and consent of the Board of Control, engage the services and fix the compensation of such

assistants as are required for the carrying on of the work herein provided, with the exception of those assistants especially appointed under this agreement.

4. That a member of the staff of the United States Geological Survey, duly classified by the United States Civil Service Commission, shall be designated to carry on a part of the work provided under this agreement, the nature of which shall be determined upon by the Board of Control, and that said official shall be paid the sum of Fourteen Hundred (\$1,400) dollars per year for such services.

5. That the Three Thousand dollars contributed by the Party of the First Part to the support of the work provided under this agreement shall be expended, so far as it is possible, for the salary of the member of the staff of the United States Geological Survey, and those of such other assistants as may be designated by the Board of Control, the total amount of such salaries not exceeding the contribution by the party of the First Part, and that all accounts be paid by the Party of the First part shall be prepared and audited in accordance with the rules and regulations of the United States Geological Survey and of the United States Treasury Department.

6. That Thirty-two Hundred dollars contributed by the Party of the Second Part and the One Thousand dollars contributed by the Party of the Third Part shall be expended for assistance, traveling expenses, clerical work, supplies and equipment, and such other incidental purchases and expenses as may be determined on by the Board of Control with the approval and consent of the representatives of said parties.

PROVISO: In view of the fact that the State Board of Health has furnished a Bacteriologist, at a salary of \$1,000 per year, whose services are available for the proposed coöperative investigation, and has agreed that the Sanitary Engineer of the State Board of Health will collect samples from Sewage Disposal Works, and that the Medical Inspector will collect water from suspected supplies, the contribution by the Party of the Second Part is made with the understanding that the Party of the Second Part shall be free to make for the State Board of Health, bacteriological and chemical examination of suspected water and of sewage, not to exceed 500 in number.

7. That the One Thousand dollars contributed by the Party of the Fourth Part shall be expended as follows: (1) Seven hundred dollars to be expended by and under the direction of said Party of the Fourth Part in conference with the administrative director of these investigations; of which Five hundred and fifty dollars shall be devoted to a study of the ground waters of the East St. Louis district, and one Hundred and fifty dollars to the collection and transportation of samples of well waters from selected points throughout the State, and to preliminary studies

of the water horizons of the State. (2) Three hundred dollars of the money contributed shall be expended by said administrative officer for salaries, chemicals, or incidental expenses of this investigation as he shall deem best.

8. That the Party of the Second Part shall provide a suitably equipped laboratory for chemical and bacteriological work, and that in case it shall be necessary to provide extra equipment for the purposes of the investigations herein specified, the cost of such additional equipment shall be paid from any moneys remaining in the fund not otherwise allotted.

9. That there shall be established along the rivers and at points designated by the Board of Control sampling stations from which there shall be sent daily samples to the laboratory of the State Water Survey at Urbana, such samples to be sent by mail in four-ounce bottles, under the authority of the Party of the First Part and with the franking privilege accorded to such Party by law. That these samples shall be stored for definite periods in such laboratory, and analyses of the composite from each sampling station shall be made at intervals to be determined by the Board of Control. That the determinations to be made upon such composite samples shall be determined by the Board of Control and when not otherwise specified shall be the following: Silica, iron, alumina, calcium, magnesium, sodium, potassium, sulphur trioxide, chlorine, carbon dioxide, turbidity (U. S. Geological Survey Standard), suspended matter, and dissolved solids ; such determinations to be expressed in parts per million and in ionic form.

10. That samples of ground waters from points designated by the Board of Control shall be sent to the above designated laboratory for mineral analysis, the determinations and expression of results to be the same as that described in the foregoing section of this agreement, and in addition thereto shall be made such other special determinations for defined purposes as may be agreed upon and directed by the Board of Control.

11. That there shall be carried on special experiments upon the effect of the various Illinois waters upon steam producing boilers which shall include a study of the types of such waters with reference to their reaction in boilers, the methods of analysis and the methods of installation of steam apparatus indicated by the various chemical processes revealed and also the corrosion caused by steam waters together with experiments to show the relation between the composition of the water and its tendency to corrode, foam or cause scale, and such other special work as may from time to time be directed by the Board of Control.

12. That samples shall be collected from the public water supplies of the state for the sanitary analysis, for the purpose of determining the potability of such supplies. Such analyses shall include the determination of bacteria and the presence or ab-

sence of *Bacillus coli communis*, according to standard methods promulgated by the American Public Health Association. That similar analyses shall be made of the river water at chosen distances below points of pollution to determine the persistence of contaminating matter, the specific determinations to be made in connection with these investigations to be based upon the special problem in each case and to be designated by the Board of Control. Such investigations shall be extended to private water supplies whenever in the opinion of the Board of Control such analyses are desirable. It is understood and agreed that the work indicated in this section shall apply both to surface and to ground waters.

13. That there shall be maintained a series of experiments upon the best methods of treating water supplies subject to pollution of various kinds and to the disorders due to microscopic organisms such as crenothrix, these investigations to be designated as "Experimental Work upon the Treatment of Water," and the extent of the work and the character of the tests shall be determined by the Board of Control.

14. That the provisional allotments for the various investigations herein provided shall be made according to the following schedule, it being understood and agreed that in case experience shall show that a change in such allotments will be of advantage to the work, such change may be made by the Board of Control:

Mineral Analyses :

Surface waters.....	\$1,830
Ground waters.....	1,300
Boiler waters.....	1,600

Sanitary Analyses:

Surface waters.....	1,000
Ground waters.....	900

Experimental Work upon Treatment

of Water.....	1,000
Incidentals and Equipment.....	570

TOTAL..... \$8,200

15. That in case it shall be found previous to the close of the term of this contract that the expenses incurred under this agreement will be greater than the total amount of the fund provided, retrenchment shall be made by suspension, according to the decision of the Board of Control.

16. That in case the expenses of the work outlined in this agreement should not be as great as the fund provided, adjustment shall be made in the last month of the term of the contract by paying salaries and expenses from the various allotments in such a way that the expenditures of each party hereunto subscribed shall be an equal proportion of the amount contributed by each to the fund.

17. And, be it understood and agreed that the original notes and records of the work performed under this contract shall be kept in the custody of the Administrative Director and copies thereof issued to the several parties to this agreement upon demand. That each of said parties shall have the right to use any part of the results as may be of value in its special line of work for purposes of publication, but that the publication of the results of the entire series of investigations as a whole shall be reserved to the Party of the First Part. In the publication of said reports by the Party of the First Part, the relationship of each party to the report shall be clearly stated, and each party shall be provided with an equitable number of copies thereof to be distributed according to the provisions of any statutes by which either party may be governed.

IN TESTIMONY WHEREOF, we have hereunto set our hands the date and year first written herein.

CHARLES D. WALCOTT,
Director U. S. Geological Survey,
for and on behalf of the Party
of the First Part.

EDWARD BARTOW,
Director State Water Survey of
Illinois, for and on behalf of
the Party of the Second Part.

L. P. BRECKENRIDGE,
Director Engineering Experiment
Station of the University of
Illinois, for and on behalf of
the Party of the Third Part.

H. FOSTER BAIN,
State Geologist, Illinois State Geo-
logical Survey, for and on
behalf of the Party. of the
Fourth Part.

As soon as the foregoing agreement was signed Mr. W. D. Collins, Assistant Hydrographer of the United States Geological Survey was assigned to work in Illinois. Messrs. W. F. Wheeler and A. W. Sellards were engaged for three months as Field Assistants of the United States Geological Survey and later Mr. P. C. Jeans was engaged for six weeks as Laboratory Assistant of the State Water Survey. In accordance with paragraph 3 of the agreement, Mr. Isaiah Bowman and Mr. Chester A. Reeds were assigned by the State Geological Survey to summer field

work in the East St. Louis Quadrangle. In connection with their study of the Quadrangle, twenty-four samples of water were sent in to the State Water Survey Laboratory, analyses of which were made by Mr. W. F. Wheeler.

Mr. Frank K. Ovitz has been engaged to make investigations on the action of water in boilers and will begin work in October under the direction of Professor S. W. Parr.

For the collection of daily samples of water, twenty-six stations were established in the State during the latter part of July. Samples have been shipped regularly since August first from the following places.

LOCATION.	STREAM.	LOCATION.	STREAM.
Carlyle.	Kaskaskia River.	Marion.	Reservoir.
Carmi.	Little Wabash River.	Menard.	Mississippi River.
Cartter.	Reservoir.	Moline.	Mississippi River.
Chandlerville . . .	Sangamon River.	Mounds.	Cache River.
Charleston	Embarass River.	Murphysboro . . .	Big Muddy River.
Cypress.	Reservoir.	Ottawa.	Fox River.
Danville.	Big Vermilion River.	Peoria.	Illinois River.
Decatur.	Sangamon River.	Quincy	Mississippi River.
Elgin.	Fox Rixer.	Rock Falls.	Rock River.
Joppa.	Reservoir.	Rockford.	Rock River.
Kampsville.	Illinois River.	Shelbyville.	Kaskaskia River.
Kankakee.	Kankakee River.	Springfield.	Sangamon River.
La Salle.	Illinois River.	Sterling.	Rock River.
Lawrenceville . . .	Embarass River.	Streator.	Vermilion River.

At the time of writing this report the analyses have been completed for waters sent in during the month of August. Reports have been mailed to those who have expressed a desire for them, and all reports can be obtained on request. As an example, we insert the results of the analyses of the Sangamon River Water at Springfield, made during the month of August.

REPORT OF ANALYSES OF SAMPLES OF SANGAMON RIVER WATER AT
 SPRINGFIELD, ILLINOIS, AUGUST 1 TO 30, 1906.

Average of three composite analyses of thirty daily samples.

IONS	Parts per Million	HYPOTHETICAL COMBINATIONS	Parts per Million	Grains per Gallon
Potassium K & sodium Na	15.0	Sodium nitrate NaNO ₃	5.6	.33
Magnesium Mg	18.9	Sodium chloride NaCl . .	2.6	.15
Calcium. . . . Ca	56.6	Sodium sulphate Na ₂ SO ₄	37.1	2.16
Iron Fe	.3	Sodium carbonate Na ₂ CO ₃	1.2	.07
Aluminum. Al	.3	Magnesium carbonate . . MgCO ₃	65.5	3.81
Nitrate NO ₃	4.1	Calcium carbonate . . . CaCO ₃	141.3	8.24
Chloride Cl	1.6	Iron carbonate FeCO ₃	.6	.03
Sulphate SO ₄	25.1	Alumina Al ₂ O ₃	.6	.03
Silica SiO ₂	22.0	Silica SiO ₂	22.0	1.28
		TOTAL.....	276.5	16.10

Analysis made by W. D. Collins, Assistant Hydrographer,
 U. S. G. S., under coöperative agreement between
 Illinois State Water Survey,
 Division of Hydrography, United States Geological Survey,
 Illinois State Geological Survey,
 Engineering Experiment Station, University of Illinois.

Inquiries regarding above analysis and requests for further
 reports should be addressed to the Director State Water Survey,
 University of Illinois, Urbana, Illinois.

It should be borne in mind by those living upon the streams
 examined at points other than the collecting stations, that the
 analysis represents the condition of the water for several miles
 above and below the point of collection. For example, the
 condition of the Fox River at St. Charles and Geneva will be
 similar to the condition of the Fox River at Elgin, and the condi-
 tion of the Rock River at Oregon and Dixon will be similar in
 character to the condition of the same river at Rockford or Rock
 Falls.

The examination of municipal water supplies provided for in this coöperative agreement is an enlargement of that already planned and previously mentioned in this report.

Complaint having reached the Water Survey concerning the pollution of Lake Michigan by the wastes from the Corn Products Refining Co.'s factory at Waukegan, it was decided to make a special investigation of the situation with a view to the abatement of the nuisance, if such should prove to be a fact. This work was placed in the hands of Mr. A. W. Sellards and Mr. J. M. Lindgren, under the general direction of the Board of Control. Samples of the wastes from various parts of the factory were collected and examined in the Laboratory of the State Water Survey. We are not yet ready to make definite report concerning the investigations. The preliminary results indicate the probability of the successful handling of the factory wastes.

During the summer several experiments of a research nature have been carried on, three of which have resulted in material worthy of note.

1. BACTERIA IN DEEP WATER-BEARING STRATA.—With a view to the determination of the kind of bacteria present in the deep ground waters of Central Illinois, bacteriological examination was made of the water from the wells of the Champaign and Urbana Water Company, and of the University of Illinois. Our experiments strongly indicate that the water as it exists in the water-bearing strata is sterile, bacteria found in the water as delivered from the pump doubtless being carried in by air.

2. METHOD FOR QUANTITATIVE BACTERIOLOGICAL EXAMINATION OF WATER IN THE FIELD.—Owing to the difficulties experienced with the transportation of water for bacteriological examination, and owing to the inconveniences of the present field outfits, a special slide cell was devised to take the place of the ordinary Petri dish. Comparative analyses by means of the ordinary Petri dish and of the newly devised slide cell were equally good, and would indicate the possibility of obtaining satisfactory

results with a much simpler field outfit and one much less bulky.

3. CHEMICAL EXAMINATION OF WATER BACTERIA.—We began by working on the supposition that a polluted water is dangerous because certain varieties of bacteria are present. Such bacteria have specific action upon the cell structure of the intestinal tract, and our idea was to obtain a medium simulating such cell composition and measure the action of the bacteria upon it. In other words an attempt was made to determine the probability of the presence of these pathogenic bacteria, by a study of the effect of the water to be tested on media of known composition. A medium was prepared which would furnish the food necessary for the growth of pathogenic germs. This medium was inoculated with waters known to be pure and with waters known to be polluted. A chemical examination was made of the medium after a period of incubation. Striking differences were noted: for example, a deep well water of known purity, though containing high free ammonia, when inoculated into the medium, showed practically no change in the character of the nitrogen content of the medium; but a surface water, known to be polluted, caused very marked differences in the character of the nitrogen content of the medium.

The results of these experiments will be published either in a special bulletin of the State Water Survey or in journals dealing with sanitary investigations.

LECTURES.

As an aid to class instruction, lantern slides have been prepared illustrating typical water supplies and sewage disposal works. These are not only available for class instruction, but can be used for public lectures. Three such lectures have already been given. One on "The Water Problems of Illinois," given before the University of Illinois Section of the American Chemical Society; one on "Municipal Water Supplies," before the First Annual Convention of the Mayors of Illinois, at Rock

Island; and one on "Methods of Sewage Disposal," before the citizens of Geneseo.

These talks have been prepared for the purpose of explaining to the general public methods for utilizing the available water in the State of Illinois, and for protecting it by the proper disposal of sewage.

RECOMMENDATIONS.

In the foregoing report an attempt has been made to show what the Water Survey is doing. That more should be done along present lines, and that the scope of the work should be increased is evident. We would suggest the following lines where expansion is necessary:

First, more sanitary analyses. With the publicity given the work of the Survey, the demand for sanitary analysis has increased so greatly that an additional assistant and additional equipment should be provided.

Second, personal inspection of water supplies. Some difficulty is experienced in obtaining samples of water from some supplies, often because the officials do not understand the purpose and character of the work of the Water Survey. A personal call is the most effective method for explaining the details of the work. Many officials are very much interested and wish to avail themselves of the assistance of the Survey. However, a personal conference with these men with a visit to the plant has been found to be of greatest value. One or more special inspectors should be engaged by the Water Survey, whose duty shall be to visit the water works plants. Only by this means can a systematic survey of the water supplies of the State be made. The work to be done by such inspectors can be realized if account is taken of the fact that there are 315 cities of the State containing 1,000 or more inhabitants. Our records show that 222 cities already have water supplies. At least two inspectors will be required to pay an annual visit to each of the water supplies

already in existence, and to visit the cities having no water supplies, and where a general supply should be installed, and where advice is needed.

Third, a sewage experiment station should be established. The presence at the University of a department of Municipal and Sanitary engineering, makes this the best place for the location of such a station. By the coöperative agreement with the State Board of Health, steps are being taken toward this end. The Water Survey and the Department of Municipal and Sanitary Engineering should each be able to detail a man to give his entire time to the study of sewage problems.

Fourth, the work under the Illinois coöperation with the United States Geological Survey, State Geological Survey and Engineering Experiment Station should be continued and expanded.

Fifth, problems of a scientific nature with practical application are awaiting solution. Some of the problems that have been called to the attention of the Water Survey during the past year may be mentioned, A method is needed for the satisfactory distinction between waters from various sources. The work on chemical examination of water bacteria was undertaken with this end in view. The results already obtained are very suggestive and it is a matter of regret that at present no provision can be made for its continuation. A method is needed for the satisfactory disposal of wastes from distilleries, starch factories, creameries, etc. The methods in use for water analysis and sewage disposal are not entirely satisfactory. Little attention can be given to improving methods when a great many routine analyses must be made. Help and equipment should be provided for more investigations of this character.

