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ON THE SANITARY CONDITION PAST AND PRESENT OF THE WATER SUPPLY OF BURLINGTON, VERMONT.

BY

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To the student of hygiene the sanitary history of the water supply of Burlington, Vermont, is peculiarly interesting and instructive. Burlington is the only city in New England which derives its water supply from the same lake into which it empties its sewage, although this arrangement for water supply and sewage disposal is common enough in other parts of the United States. It also affords a notable example of a community which has long used a suspected water without having suffered excessively from typhoid fever while yet exhibiting a condition of widespread and continued diarrhœal disturbance among its inhabitants; a condition which was apparently entirely due to consumption of impure water and has been apparently entirely corrected by simply increasing the distance between the sewer outfall and the water intake in the lake.

The location of Burlington is all that could be desired. Situated at the eastern extremity of Burlington Bay, on Lake Champlain, it occupies a very favorable sanitary position. The city is closely built over a small area only. For the most part it has an open suburban character and rests upon, or at the foot of, a hillside which rises rather abruptly from the lake and leads to an elevated and very extensive terrace or table-land stretching many miles to north and south, as well as eastward to the nearest hills—the higher ranges of the Green Mountains—some twelve miles away. Built thus upon the rather sharp declivity by which this broad terrace passes into the lake; with the Green Mountains on the east, and on the western horizon the sinuous line of the Adirondack peaks; while at its feet

the long lake reflects the shafts of sunlight and tempers the hot breaths of summer, the city has naturally a most fortunate situation. The climate, though cold in winter, is salubrious and the natural drainage excellent.*

Water in superabundance is at hand; and when, in 1866, the citizens determined to have an ample public water supply for fire and other purposes they naturally turned first of all for a source to Lake Champlain. Yet they did not finally decide to use the lake without due deliberation and careful inquiry.

"In 1866, when the matter of building our water works was under discussion, a gravity supply from Brown's River, in Jericho, was alluded to, and the matter was disposed of in the report in the following words: 'At no distance less than about eleven miles can we obtain a supply of water by gravitation from any place, and as this would involve an expense of about $500,000 such a mode of obtaining water at this time is out of the question.'"—(*Annual Report of the Water Commissioners of Burlington, Vt.*, for 1889, p. 95.) It was accordingly decided to abandon the idea of a gravity supply and to pump from the lake into the pipes, the surplus going to a reservoir at the top of the hill.

The water works were built in 1867, the intake being located on the lake front near the northern extremity of the docks. They appear to have given at first entire satisfaction. "At no time has the city water supply held so high a place in the public estimation."—(*Sixth Annual Report of the City of Burlington*, for 1870, p. 122.) As early as 1871, however, attention was drawn by the Health Officer (Dr. H. A. Crandall,) to the desirability of extending the intake further into the lake. "The prospect of increased sewerage, the increased shipping about the docks, the great amount of surface water flowing into the lake from our streets, besides other important reasons, influence me to recommend an extension of the pumping main at the

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*"Nature has done much to render Burlington both beautiful and healthful. It is unsurpassed among the places noted for the beauty of their location and their natural surroundings. Situated in the midst of mountain scenery, and bounded on the west by Lake Champlain, it possesses everything to contribute to good health. Opportunities for health-giving exercise abound, in walks, drives, mountain-climbing and yachting. * * * *

"The climate is not excelled for salubrity. While the vicinity of the lake modifies the extremes of temperature, both in winter and summer, the atmosphere is unusually bright and clear, and the proportion of sunshiny to cloudy days is about five to one in all seasons of the year."—(*Annual Report of the Health Officer—Dr. H. A. Crandall—for 1893.*)

pump house of the water works farther into the lake, say 300 feet or more, to deep and *pure* water."—(*Seventh Annual Report*, for 1871, p. 85.)

The occurrence of 5 deaths from dysentery and 3 from diarrhœa in 1870, and of 10 from dysentery in 1871, suggest that the "other important reasons" referred to by Dr. Crandall may have been the prevalence of diarrhœal disturbances. However this may be, the Health Officer for 1874 (Dr. A. P. Grinnell,) appears to refer to such a condition in his annual report for that year, and to have been moved to make an investigation. "It is generally believed that the water obtained from the lake is chemically pure and wholesome; but the prevalence of a certain class of disease whose origin could be traced to impure water or food has led me to make a more thorough investigation of the matter, and now I am able to place before the Board [the city council] the results of experiments, and the conclusions at which I have arrived, respecting the impurity of the water supplied to the people of this city."—(*Tenth Annual Report*, for 1874, p. 76.) The Health Officer then gives the results of chemical analysis of the water of the lake at the intake, one specimen having been collected from the surface and one from near the bottom, and continues: "The amount of organic matter found in either specimen is sufficient to warrant the statement that the water now supplied to the city contains impurities which are capable of generating diseases of a grave character. * * * * We can safely presume that the water consumed by the city is much of the time unfit for use. * * * * The necessity of supplying pure and wholesome water for purposes of drink and diet is apparent to everyone; but it is hardly possible to obtain such supplies from a point in the lake only *sixty feet* from the docks—the natural reservoirs for the excrementitious matter found in sewage." Dr. Grinnell also advised the extension of the intake pipe, "to or beyond the breakwater." (*loc. cit.*) This advice was repeated in the next Annual Report by the Health Officer for 1875 (Dr. C. P. Thayer.)

On the other hand, in the *Fourteenth Annual Report*, for 1878, p. 198, the Health Officer (Dr. H. H. Atwater) states: "In my observation of the diseases of this city and their causes during the period from the introduction of the public water supply to the present time, I have been unable to trace any distinct ill effects from the present source of supply. Typhoid fever, the disease which, of all others, we should

expect to result from sewage contamination of drinking water, is of infrequent occurrence in this community. There has been only one death from this disease during the last year, and this of a man over 70 years of age. Diarrhœa and dysentery occur here sporadically, and are not virulent, and prevail mostly during the summer months, so that they may be more reasonably attributable to the debilitating effects of heat, over-exertion and other causes, than to impure drinking water. * * * * Still, it seems to me that as the number of public sewers and the amount of sewage flowing directly into the lake yearly increases, it would be wise for the city to consider soon the propriety of obtaining the water at a greater distance from the shore."

In 1882, out of a total of 254, there were eight deaths from typhoid fever and eight from diarrhœa and dysentery, besides three from cholera morbus—a sum of diarrhœal disease which amounted to an epidemic.

In 1883 the Health Officer (Dr. John B. Wheeler) states: "First in the list of improvements, by which the public health would unquestionably be benefited, is the extension of the water main to some point outside the breakwater. * * * * It can hardly be doubted that much of the diarrhœal trouble so common in Burlington is due to the condition of the city's water supply. To extend the water main beyond the breakwater would be to take it beyond the reach of contamination and give our citizens a supply of pure water."—(*Nineteenth Annual Report*, for 1883, p. 88.)

Dr. Wheeler, as Health Officer, in the next annual report, says: "Some alarm was created, in the early summer, by the appearance of typhoid fever in the city. The alarm was owing not so much to the number of cases, which was not large, as to the existence of the disease, which is almost unknown in Burlington, except when an occasional case is imported. The number of fatal cases in 1884 was 10. * * * * The character of our water supply has been the subject of a good deal of discussion during the past year."—(*Twentieth Annual Report*, for 1884, pp. 55, 56.)

In 1885, the Mayor of Burlington, in his annual *Message*, said: "The subject of a supply of purer water for our city has been much discussed, and opinions are various among our citizens. * * * * Several analyses of water taken from different parts of the lake,—and from other waters than the lake,—have been made by compe-

tent chemists, and they indicate that we should not be materially benefited by changing the present source of supply. Whether analyses should be taken as conclusive evidence of fitness or unfitness of water for human use I am not prepared to say, but common sense would teach that, other conditions being equal, the greater the distance water is taken from a source of infection, the purer it will be." In the same report (*Twenty-first Annual Report*, for 1885) the Health Officer, Dr. J. H. Linsley, remarks: "The fact that no case of typhoid fever was reported to the Health Officer during the year refutes the possibility of the cause of the appearance of this disease in 1884, being in our water supply, as was at that time suggested."

During 1884 and 1885 numerous chemical analyses were made and in the Mayor's message, delivered on April 5, 1886, we find the following conclusion based upon them: "Some two years since the water committee were directed to examine into the subject of our water supply, and to report the result of their investigations to the board. They have just made their report, which contains the results of many analyses of water taken from various localities in the lake. The report imparts the gratifying assurance that the water at the point from which it is now pumped is as pure, if not purer, than at any other locality in the lake. There are some people who do not appreciate the value of the findings of the committee."—(*Twenty-second Annual Report*, for 1886, p. 13.) In the same *Report* (p. 74) the Health Officer (Dr. J. H. Linsley) remarks: "More or less discussion is constantly going on in regard to our present water supply, and many views are entertained as regards the comparative purity of the water used. I am unaware that the existence of any disease was ever traced to its impurity. But I think no one will deny that the surroundings of the suction-pipe, as at present situated, are not such as would tend to quiet the misgivings of anyone who is inclined to be skeptical in regard to the purity of the water at our present source of supply. I would respectfully recommend that when it is seen fit to extend the suction-pipe into the lake, such extension be made far enough to be beyond the *possible* contamination of the sewage from this city. Of course, the construction of the sewer in Battery street removes nearly all the sewage that formerly emptied into the lake at the foot of College street, to a point fully half a mile further south" Also, in the

same *Report* (p. 99), the superintendent of water works (Mr. F. H. Parker) states: "By a vote of the board of aldermen, May 17th, 1886, the city treasurer was authorized to borrow $24,000 * * * * for the purpose of * * * * and extending the suction-pipe to the pumps farther into the lake." * * * * "A city meeting was called, * * * * but the resolution authorizing the work was dismissed, and the improvements have not been carried out."

For 1888 we find in the report of the Health Officer (Dr. J. C. Rutherford) the following: "There was more sickness during the year just ended than for several years past. * * * * Different types of fever prevailed during the late summer and autumn, some of them taking a typhoidal form. The mortality from them, however, was very low. On December 24 I sent to the physicians of the city a circular letter requesting them to give me, to the best of their knowledge, the number of cases of fever they had attended during the past year. Nearly all replied, and although they said they had no record of their cases, the number they remembered was, in the aggregate, very large. They ascribed the cause of so much sickness to, First—the long-continued wet weather. Second—the sudden changes of temperature; and Third—the unwholesome condition of the aqueduct water. * * * *

"There have been reported to me twenty-six cases of typhoid fever. The source of only two could be traced from out of town; the rest, beyond any reasonable doubt, originated here. Many other cases were reported as typhoid, which, upon examination, I found to be of another type of fever. * * * *

"The water supply of the city has again become a prominent topic of conversation. Owing to the great amount of sickness during the summer and autumn, people have begun to question the purity of the aqueduct water."—(*Twenty-fourth Annual Report*, for 1888, pp. 74–77.) In the same document Mr. F. H. Crandall, who began his service as superintendent on April 25, 1888, (succeeding Mr. Parker, who became chairman of the newly-established water commission), in making his first report, says (p. 131): "The unusual amount of sickness in our city for some time past has again called public attention to the purity of our water supply. Various plans for its improvement have, for some time past, been under consideration, * * * * and investigations are now in progress as to the relative merits of different sources of supply."

The results of the "investigations" here referred to appeared in the next Report (*Twenty-fifth Annual Report of the City of Burlington, Vt.*, for 1889, pp. 95, 105, 113. See also *Twenty-third Annual Report of the Water Department, City of Burlington, Vt.*), and consisted mainly of a report of progress. The documents referred to are duplicates, and include statements from the commissioners and superintendent, and a lengthy and interesting summary of the situation from the chemical standpoint by Mr. Joseph L. Hills, chemist of the State Agricultural Experiment Station of Vermont. From Mr. Hills's report is taken the table of analyses given on the next page.

Mr. Hills himself added to this list twenty-three more chemical analyses, made at the Experiment Station between May and November, 1889, from the city service, various points in Lake Champlain, and several places from which it had been proposed to obtain a gravity supply.

From his several investigations Mr. Hills concluded that "The testimony of chemical analysis would appear to be, so far as one year's experience can indicate, that all the [proposed] sources of supply are of medium purity, except perhaps, Hinesburg Pond. * * * * The station chemists have not been able to detect evidences of sewage in samples from Mark's Bay or the pumping station (or indeed in a series of samples taken about one hundred yards away from the sewer mouth in the endeavor to trace the direction of sewage currents.) * * * * One of the most interesting points * * * * is that the water from the broad lake does not appear purer than that taken inshore. * * * * It does not appear settled that the extension of the suction-pipe will of necessity give our community a purer water supply."

Reviewing all the facts and data observed or collected up to this time, the superintendent (Mr. Crandall) wisely and truthfully remarked in his annual report for 1889, that they "afford a subject for careful thought and study, as well as a chance for interesting comparisons."

In 1890 the Health Officer (Dr. J. C. Rutherford) reported that "During the present winter there has been in the city a mild epidemic of diarrhœa, which some people supposed was caused by impure water. A meeting of the State Board of Health was called in this city, at which several of the prominent physicians gave their

CHEMICAL ANALYSES OF THE WATER SUPPLY, ETC., OF BURLINGTON, VERMONT, PREVIOUS TO MAY, 1889.

[COMPILED BY JOSEPH L. HILLS.] [Parts Per Million.]

Source of Sample.	Date.	Analysis By	Free Am.	Alb. Am.	Total Solids.	Fixed Solids.	Vol'tle Solids.	Chlorine.
Hydrant	1882	Mallet	0.035	0.14	70	20	50	0.7
Service Supply, Elmwood Avenue	Sept., 1884	Sabin	0.04	0.18	164	.....	.....	.....
Mouth of Suction Pipe, Pumping Station	"	Sabin	0.16	0.16	36	.....	.....	.....
" " " " "	"	Witthaus	0.052	0.13	72	.....	.....	2.1
" " " " "	March, 1885	Witthaus	0.034	0.10	89	.....	.....	1.1
" " " " "	"	W. R. Nichols	0.02	0.15	71	57	14	0.2
" " " " "	"	Seeley	.....	.....	60	41	19	.....
" " " " "	Jan. 8, 1889	Hills	0.03	0.18	88.5	54.5	34	1.7
Northwest corner of Breakwater, 10 feet deep	Sept., 1884	Sabin	0.06	0.114	119	.....	.....	.....
" " " " "	"	Witthaus	0.026	0.11	84	.....	.....	1.5
" " " " "	March, 1885	Witthaus	0.016	0.08	75	.....	.....	1.1
" " " " "	"	W. R. Nichols	trace	0.08	73	60	13	2.0
Foot of Bank Street	Jan. 8, 1889	Hills	0.02	0.19	86	49	37	1.4
Northwest corner of Breakwater, 26 feet deep	Sept., 1884	Witthaus	0.146	0.17	79	.....	.....	1.8
" " " " "	March, 1885	Witthaus	0.034	0.08	76	.....	.....	1.0
" " " " "	"	W. R. Nichols	trace	0.08	70	55	15	1.8
Marks' Bay, 58 feet deep	Sept., 1884	Sabin	0.048	0.10	107	.....	.....	.....
" " 62 " "	"	Witthaus	0.08	0.10	56	.....	.....	5.8
" "	March, 1885	Witthaus	0.034	0.05	66	.....	.....	0.9
" "	Jan. 8, 1889	Hills	0.03	0.16	80	45	35	2.9
Surface, midway Sewer mouth to South end Breakwater	Sept., 1884	Sabin	0.04	0 072	100	.....	.....	.....
" " " " " " " "	"	Witthaus	0.08	0.13	116	.....	.....	9.7
Three thousand feet west of Pumping Station	March, 1885	Seeley	.....	.....	69	52	17	.....
Rock Point	"	Seeley	.....		61	44	17	.....
Reservoir Water, 48 hours pumped	Sept., 1884	Sabin	0 093	0.168	129	.....	.....	.....
Reservoir Water, (*Old Reservoir*)	Dec. 29, 1888	Hills	0.03	0.16	80	45	35	2.9
Reservoir Water, (*New Reservoir*)	"	Hills	0 03	0.18	88.5	54.5	34	4.3
" " "	Feb. 12, 1889	Hills	0.04	0.14	.....	.....	.....	2.4
Hinesburg Pond	March, 1885	W. R. Nichols	0.06	0.20	63	50	13	2.6
" "	"	Seeley	.....	.....	53	33	20	.....
" "	Feb. 13, 1889	Hills	0.04	0.15	93	43	50	3.7

testimony, and the majority of them were of the opinion that the sickness was caused more by the variable weather than by the water. Anyone who doubts the purity of our water would be convinced that it is pure if he will take the trouble to visit the pumping station and the reservoirs." (*Twenty-sixth Annual Report* for 1890, p. 73.)

In spite of this "mild epidemic of diarrhœa," no death from this cause is reported for either 1890 or 1891. Two deaths were reported in 1890 from dysentery, one each from typhoid and continued, and two from typho-malarial fever.

The total mortality, the typhoid fever mortality, and the percentage which the latter was of the former, for the twenty-six years 1870–1895, are shown in the following table:

TYPHOID FEVER* MORTALITY IN BURLINGTON, VT.

(1870–1895.)

Year.	Total Mortality.	Typhoid Fever Mortality.	Mortality Percentage from Typhoid Fever.
1870	169	2	1.18
1871	146	6	4.10
1872	157	2	1.27
1873	228	..	....
1874	152	..	....
1875	145	..	....
1876	148	2	1.35
1877	202	4	1.98
1878	183	1	0.54
1879	228	2	0.87
1880	219	3	1.37
1881	226	2	0.88
1882	254	8	3.15
1883	242	1	0.41
1884	238	10	4.20
1885	266	1	0.37
1886	262	4	1.53
1887	286	4	1.05
1888	375	9	2.40
1889	248	8	3.14
1890	300	4	1.33
1891	272	4	1.47
1892	336	6	1.77
1893	306	10	3.26
1894	311	2	0.64
1895	311	1	0.32

*Including "typhoid," "continued," "slow," "enteric," "bilious," and "typho-malarial" fevers.

MORTALITY FROM TYPHOID FEVER PER 10,000 INHABITANTS IN CENSUS YEARS.

Year.	Population.	Deaths from Typhoid Fever.	Deaths from Typhoid Fever per 10,000 Inhabitants.
1870	14,387	2	1.3
1880	11,364	3	2.6
1890	14,590	4	2.7

The general situation when, in 1892, I was invited to make an investigation of the sanitary condition of the water supply appears, from what has thus far been brought together, to have been somewhat as follows:

First. It was widely held by physicians, and understood by the people, that diarrhœa was common among users of the water, especially those who had not become habituated to it, visitors to Burlington, if they drank the water, frequently suffering from some diarrhœal disturbance.

Second. The location of the intake of the water works was less than a mile from the outfall of the main sewer, and only a few rods from the docks.

Third. Typhoid fever, the ordinary measure of the sanitary condition of a water supply, was not then, and had seldom been, excessively prevalent in Burlington.

Fourth. Chemical analyses had indicated that the water supply of Burlington was at least the equal in purity of many well-known and excellent water supplies.

Fifth. Chemical analyses had failed to show any marked superiority in the water of the broad lake (the middle of Lake Champlain) to that at the intake, on the shore of Burlington Bay.

Sixth. Investigations had proved that it would be difficult, uncertain and costly, to procure a gravity supply from the mountains, because of their remoteness and for other reasons.

It is only fair to add that at the time of my own investigations and of making my report I was less familiar with some of these facts than I am now.

Previous to 1892 the sewer outfall had frequently attracted the attention of physicians and other citizens. When the water in the lake was low the sewage from the main sewer was not discharged

into the lake beneath the surface or even on the lake front, but ran in an open stream over flats laid bare by the receding waters of the lake and emptied into a small bay or basin connecting with the lake. The stench which at times arose from this torpid stream, from the flats and the bay, were highly obnoxious and objectionable, so that a demand had come, especially from the Board of Health and its efficient Health Officer, Dr. H. A. Crandall, for an improved outfall. Mr. F. P. Stearns, C. E., Engineer-in-Chief of the State Board of Health of Massachusetts was finally consulted, and advised an extension of the outfall to the main lake front with disposal there directly into the lake, and at a depth sufficient to be always below the surface.

I had already been making (in Boston) occasional bacterial analyses of the city water, the water of the lake, etc., for the water commissioners of Burlington, when, on June 20th, 1892, I was invited by them to visit the city and make a thorough investigation of the sanitary condition of its public water supply, present and prospective. I did as I was desired and subsequently presented a Report, of which the following is the principal portion:—

BOSTON, JUNE 30, 1892.

"*To the Board of Water Commissioners, Burlington, Vt.*

"GENTLEMEN:—I have the honor to submit to you a report upon my investigations, made at your request, concerning the sanitary condition of the Burlington water supply and the probable sanitary effect of certain proposed changes therein.

"I am informed that many of the physicians regard the water supply with suspicion, and I find that the successive Health Officers in their official reports have frequently referred to the water as more or less objectionable. I therefore undertook, first, to discover the actual effects of the water supply upon the health of the city.

"In order to do this in the case of a water supply suspected of sewage contamination it is customary to take as a measure the prevalence of diarrhœal diseases, and especially typhoid fever. I have therefore carefully studied the vital statistics of Burlington for the last twelve (12) years, comparing the mortality from typhoid fever with the total mortality and also with the number of inhabitants.

"The results show conclusively that the mortality from typhoid fever (and the same is true for diarrhœa and dysentery) has not been large in Burlington during the last twelve years. The average annual mortality from typhoid fever, from 1870 to 1891 in Burlington was 3.57 per 10,000 inhabitants."

I then went on to show that Burlington compared favorably in this respect with many cities having water supplies of undoubted purity, and stated that in respect to mortality from typhoid fever it had a better record than "many cities having water supplies of good reputation. This weighty fact alone justifies the conclusion that there is no positive evidence in the sanitary statistics of the city that the water supply is injurious to the public health. I may add by way of confirmation that during the last three years I have made repeatedly bacteriological analysis of the Burlington supply, and that I have found no satisfactory evidence of the presence of sewage in the drinking water.

"It is interesting and instructive to compare the history of typhoid fever in Burlington during the last six (6) years with that during the earlier half of the period under consideration, for in this way we may learn whether this disease is or is not increasing. If we do this we obtain the following results:—

TYPHOID FEVER* IN BURLINGTON, VT.

Six-year Periods.	Average Annual Death Rate from Typhoid Fever per 10,000 Inhabitants.	Average Annual Mortality Percentage from Typhoid Fever.
1880-1885	3.39	1.73
1886-1891	3.75	1.83

"These figures are certainly reassuring, and prove conclusively that there is no immediate reason for excessive anxiety or alarm for the sanitary condition of the water supply.

"It is, however, the opinion of many Burlington physicians, based upon their experience that the water supply is responsible for the occurrence from time to time of diarrhœal disturbances which, while

*Including "enteric," "slow," "continued," and "typho-malarial" fevers.

they very rarely result in death, serve to annoy and alarm the citizens. In the present state of our knowledge it is at present impossible to prove or to disprove this theory. The fact appears to be that such disturbances are common, and it is well known that the main sewer of the city empties into Lake Champlain, the source of the water supply, less than a mile from the intake. Whether there is anything more than coincidence in these facts it is impossible to say. In the present state of sanitary science, however, there can be no doubt whatever that the location of the intake of the water works, as near as it now is to the main sewer of the city, is highly objectionable if not positively dangerous. I can only regard it as a constant menace to the sanitary welfare of the city. It must be admitted as entirely possible that unpurified sewage driven by winds or carried by currents may be in the future, if it has not been in the past, conveyed more or less directly from the sewer outfall to the water intake.

"I have, therefore, at your request, considered the probable sanitary advantages of a removal of the intake of the water works to a point in the "broad lake" some three miles from its present position, and also those of a complete change from the lake to a mountain supply.

"In regard to the former—the broad-lake supply—I am of the opinion that it would be of very great advantage from a sanitary standpoint, inasmuch as it would so far remove the intake from the sewer outfall as to make it unlikely that raw sewage would ever pass from the latter to the former; while at the same time it would give more time for the purification *en route* of any sewage which might accidently so pass. Unless the city should become very much larger than it now is, the passage of sewage from the sewer outfall to an intake located, for example, on Apple-tree Reef, through the present sewer basin and the quiet waters of the bay, can only be regarded as a remote possibility.

"I may remark in passing that, in my judgment, one reason for the comparative immunity from epidemics of typhoid fever hitherto enjoyed by this city is that the sewage is held in a small bay for a longer or shorter time, according to circumstances, where it can to some extent become freed from the germs of disease.

"If Burlington could draw its water supply by gravity from mountain streams or storage reservoirs and secure abundant water

from an unpolluted watershed the danger of infection of the water supply would be done away. So far as I can judge, however, there are no streams of sufficient size and purity directly available. Storage would be an unavoidable necessity. But storage, while of great sanitary advantage so far as the germs of specific diseases are concerned, is apt to lead to disagreeable consequences in other directions. The water drawn from storage reservoirs is often more or less colored by peat, stumps, leaves, etc., and it not infrequently suffers fermentation with the development of organisms, acquiring thereby disagreeable and sometimes nauseous tastes and odors. If these compel the citizens to abandon its use and lead them to resort to polluted wells or other objectionable sources of supply, the sanitary consequences may be unfortunate. It will be seen, therefore, that while a mountain supply is in many respects highly desirable it is nevertheless true that its adoption in this case would be attended with the possibility of some undesirable consequences. It must be remembered that every new water supply depending upon the storage of surface water is an experiment. It cannot be undertaken without some risk of undesirable results.

"In fine, I am of the opinion that there is no positive evidence of any injurious characteristics in the present supply. But I believe, nevertheless, that in view of the common occurrence of diarrhœal disturbances reported by physicians, and on account of the menace to the public health involved in the present arrangement, some other source of supply should be found. I think that it would be of very great sanitary advantage to remove the intake as far as possible out into the broad lake. A mountain supply in storage reservoirs would afford complete relief from sewage contamination, but might involve serious troubles with microscopical organisms, tastes and odors.

"Respectfully submitted,

WILLIAM T. SEDGWICK."

This report was generally accepted as establishing the fact, that while there was no occasion for immediate alarm or excessive anxiety, it was imperative that steps should be taken, as soon as practicable, to improve the situation. The epidemics of 1882, 1884 and 1889 were not forgotten, and the figures submitted by me showed a perceptible, though slight, increase of typhoid fever and diarrhœal disturbance during the more recent six-year period. Accordingly,

after still further deliberation, it was decided to extend the intake-pipe some three miles from the sewer outfall into the lake to a point known as Apple-tree Reef, which had been found by repeated bacterial analyses to be a favorable one for the purpose. This extension, as has been fully described in the preceding paper by Mr. Crandall, was made in the summer of 1894. Its completion was undoubtedly hastened by the improved sewerage plan recommended by Mr. Stearns in 1892, and about to be carried out by the Sewer Commissioners, by virtue of which the main sewer outfall would be pushed outward to the lake front, the sewage discharged at all seasons beneath the surface of the lake. As soon as this improvement became assured, Mr. Crandall and the Water Commissioners, as well as the Board of Health, redoubled their activity in urging that the intake of the water supply should be removed further out into the lake, and all the more because the little bay in which at certain seasons the sewage fermented and doubtless worked itself to some extent free from disease germs, was now to be obliterated, so that fresh sewage might at times readily find access to the currents, if any, along the lake front, and at a point less than a mile from the intake of the water works.

I have lately had made by an assistant, Mr. S. C. Prescott, in the laboratory of the Vermont Agricultural Experiment Station—kindly placed at our disposal by Professor Jones, to whom our hearty thanks are due—a series of careful bacterial analyses of water taken from various points on the high service and the low; at the pumping station; from the pump well; and from the lake just outside—a point which corresponds to the old intake; from the lake front near the sewer outfall; and from the new intake on Apple-tree Reef. These show conclusively, both by comparison with analyses made before the extension of the intake and by comparison one with another, that the removal of the intake to a distant point in the lake has caused a marked bacterial improvement in the purity of the city water.

[These facts were then demonstrated to the audience by means of the stereopticon: actual plate "cultures" of equal amounts of water from different parts of the service, from the lake, the sewer outlet, the intake, pump well, etc., grown upon gelatin or agar and fixed by formaldehyde, being placed in the lantern and shown upon the screen. In this way a unique and striking demonstration was

afforded of—for example—the progressive and remarkable disappearance of bacteria from the sewer outlet, where they were abundant, to the old intake, where they were relatively few yet far more numerous than at the new intake or at any point in the service pipes.]

Chemical analyses, as far as they go, confirm the bacterial results, as may be seen from the following:—

Burlington, Vermont, September 4, 1895.

SANITARY WATER ANALYSIS.

(Parts in 100,000.)

	Residue on Evaporation.			Nitrogen.						Oxygen Consumed.	Chlorine.	Hardness.	Iron.	Microscopical Organisms in 100 Cubic Centimeters.		
				Albuminoid Ammonia.			Free Ammonia.	As Nitrites.	As Nitrates.							
	Total.	Loss on Ignition.	Fixed.	In Solution.	In Susp'nsion.	Total.								Diatoms.	Algae.	Blue-Green Algae.
Lake (old intake)	6.60	1.25	5.35	.0110	.0028	.0138	.0010	.0000	.0010	.2730	.14	4.2	.0060	3,550	1,400	200
Tap (city service)	6.20	1.05	5.15	.0072	.0048	.0120	.0000	.0000	.0100	.2496	.10	4.2	.0060	1,050	6,200	150

But there is yet another kind of evidence which witnesses still more eloquently to the improvement of the water supply. This is the testimony of the physicians of Burlington. As far as I have been able to communicate with them—and I have interviewed a number of the most prominent and representative—there is a surprising and remarkable unanimity of opinion among the local physicians to the effect that the peculiar diarrhœal disturbances which had so long prevailed in Burlington have, since the extension of the intake pipe, wholly ceased; and the physicians are enthusiastic in their recognition of the salutary change, which they attribute entirely to the improved water supply.

In view of all the evidence at hand—statistical, bacteriological, chemical and medical—I think we may safely conclude that the sanitary condition of the water supply of Burlington is now most excellent. If, however, in the future Burlington grows extensively and becomes a much larger city it will probably become necessary here, as in most large cities, to face once more the question of a pure

water supply. Special pains must also be taken to see to it that the intake pipe is kept intact and free from leakage. The unfortunate experiences of Toronto and of Buffalo with broken intake pipes afford ample warnings in this direction.

This is the first case within my own experience, now somewhat extensive, in which epidemic diarrhœa in a mild form has prevailed in a community for many years, having its ætiology in the consumption of impure water as has been proved by its apparent total disappearance on a change in the source of supply. The importance of the case in the history of water-borne diseases is manifest. It was complicated by the fact that typhoid fever, which is usually taken as a measure of the sanitary condition of a community, was here ordinarily by no means excessive, and that its occasional prevalence might easily have been due to some other cause than polluted water. The fact seems to be, however, that it was in truth really due to impure water, inasmuch as since the extension of the intake pipe in 1894 typhoid fever has practically disappeared. (See table, p. 175.)

It would seem fair to conclude, from the moderate occurrence of typhoid fever, while diarrhœa abounded, that germs of the latter disease, more hardy than those of the former, were frequently able to survive a journey from the sewer outfall to the water intake while those of typhoid fever, if present, usually perished. In future sanitarians will not be able by the test of typhoid fever alone to show that a water supply is above suspicion. A mild form of diarrhœa caused by polluted water may apparently prevail even in the absence of any constant or considerable excess of typhoid fever.