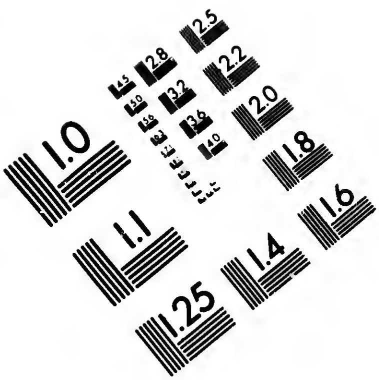


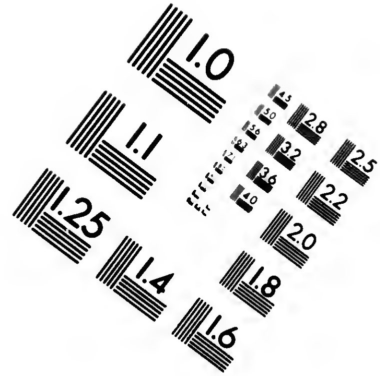
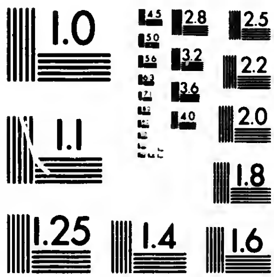
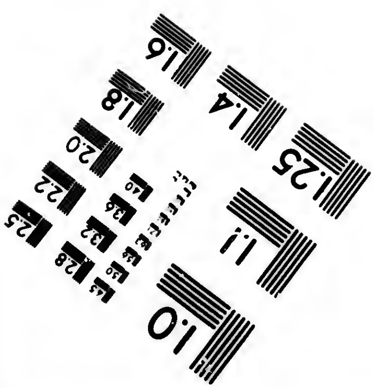
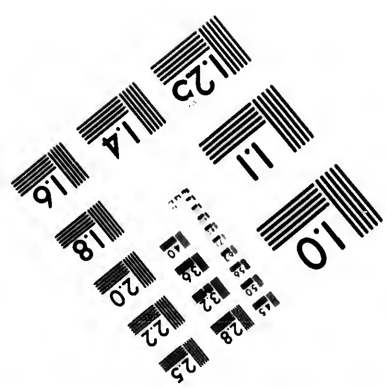


IMAGE EVALUATION TEST TARGET (MT-3)







Hering, Rudolf.

REPORT

ON THE

EXTENSION

OF THE

WATER SUPPLY

AND ON THE

DISPOSAL OF THE SEWAGE

OF THE

CITY OF TORONTO.

BY

RUDOLF HERING AND SAMUEL M. GRAY,

Consulting Engineers.

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MAYOR'S MESSAGE.

MAYOR'S OFFICE, February 25th, 1889.

GENTLEMEN OF THE COUNCIL,—I beg to lay before you the report of Messrs. Rudolph Hering and Samuel W. Gray, who were appointed by Council on the adoption of the Report of the Sub-Committee, submitted to Council September 24th, 1888, as follows:

"Your Sub-Committee being authorized to report to Council, therefore recommend that Messrs. Rudolph Hering and Samuel W. Gray, be invited to visit the City at once and report their conclusions as to the best means to be adopted to increase the water supply and to dispose of the sewage."

I trust that the recommendations and conclusions of the experts will meet with the approval of Council.

Respectfully submitted,

E. F. CLARKE.

To His Worship, Mayor E F. Clarke, and the City Council of Toronto, Ont.:

GENTLEMEN,—In accordance with your request contained in Report 31, of the Executive Committee, dated September 24, 1888, and adopted by the Council on the same day, to visit your City and to report our conclusions as to the best means for increasing the water supply and disposing of the sewage, we respectfully present the following report and maps:

We met in Toronto, October 2nd, and again November 7th, spending each time a week in examining the ground and in acquainting ourselves with the general conditions and data governing the above stated problem. Since our first visit we have been together at numerous times to discuss the questions involved and to reach what we believe to be their best solutions.

Before entering upon the subject we wish to thank your City officials, particularly Mr. Chas. Sproatt, Mr. William Hamilton, Mr. A. Macdougall and their respective assistants, Mr. Rust and Mr. McMinn, and also to express our indebtedness to Prof. Galbraith and Kivas Tully, Esq , for the kind attention received, and for supplying us with information which enabled us to thoroughly understand the various aspects of the problem and to formulate our recommendations.

We shall first briefly state the general conclusions arrived at and subsequently present the data and reasons which led to them.

I.—*General Conclusions.*

The question of water supply and sewage disposal has engaged the attention of the citizens of Toronto since the days when the steadily increasing amount of sewage began to pollute the harbor and endanger the healthfulness of the water for a domestic supply. The first radical move was made by laying a main across the harbor to the Island. It was hoped to obtain thereby not only pure water, but also clear water at such times when storms cause it to be riley near the shore. The first idea of drawing the supply from filter galleries did not prove a success, because a good deal of water was found to come from the stagnant pools on the Island. A crib was therefore located nearly 2,000 feet from shore and the intake pipe extended thereto, furnishing since then an excellent quality of water, except when it is riley after storms. The availability of other sources of supply and the inevitable increase of pollution of the harbor, have caused you to investigate the relation of these two questions and to seek for the best solution of the joint problem. You have had a study made of the merits of delivering water to the City by gravity from the Ridge Lakes, and for discharging the sewage into the lake near the mouth of the River Don. You have now requested us to inquire also into the feasibility of obtaining water from Lake Simcoe and from other points in Lake Ontario than the one now used, and in conjunction therewith to examine the merits of purifying the sewage, instead of discharging foul water into any part of the lake, and to suggest what we believe to be the proper way of disposing of it. We have given these matters the most careful consideration, weighing the merits both from a sanitary and a financial point of view, and briefly sum up our conclusions as follows:

We cannot endorse the project of taking the supply from the Ridge Lakes, because the water would be found greatly inferior in quality to that which your citizens are now accustomed to use.

Neither can we endorse the project of bringing water from Lake Simcoe through a conduit nearly 50 miles in length. While the water is much better than that in the Ridge Lakes, it is less good than that of Lake Ontario. The expense of the conduit likewise places it at a great disadvantage as against continuing to use the present source.

Without hesitation, we therefore advise you to adhere to Lake Ontario, not only as the best source, but also as the one from which you can at all times have an unlimited supply at the least expense.

The disposal of the sewage, which naturally seeks the lake, becomes therefore of prime importance. We have examined the merits of purifying the sewage by the irrigation of tracts of land, both east and west of the City, or by filtering it through the most porous parts of such tracts. In both instances we have been met by the necessity for large expenditures not only in taking the sewage to the ground, but in lifting it over a hundred feet, and then to conduct a business enterprise of farming as well as a sanitary work. The excessive cost alone would in our judgment decide against this project.

We have further examined into the merits of allowing the sewage to enter Lake Ontario, either in its natural condition or after it has been chemically or mechanically clarified. We have considered the lake currents, the results of diffusion of sewage and river water at other large lake cities, the effects of a discharge in winter and of the gradual self-purification of polluted water. Our conclusions point clearly to the fact that for many years to come no objection can arise and no pollution will be observed, if the sewage outfall is placed as proposed, six and one-half miles from the present water intake.

We considered, however, the cost of separating the two points still further, namely, by taking the water near Victoria Park and discharging the sewage near Mimico, and *vice versa*, as it is clear that the greater their distance the longer would the scheme remain a safe one. But, in both cases, we were confronted, on the one hand, with a much larger expenditure at the outset and great inconvenience from loss of time by so radical a re-modelling of the present works, and on the other, with the fact that the scheme which we recommend, will later, if it is found to be necessary, admit of satisfactory extension at a less expense than if much more costly works are undertaken at present.

We therefore advise discharging the sewage near Victoria Park, after collecting it by intercepting sewers, as indicated on the accompanying map and substantially as proposed by the City Engineer.

We recommend adhering to the present water intake, and, if it is desired to reduce the riley condition of the water, which is not unhealthy but unpleasant, and the expense is not found too great, we advise an extension of the intake further into the lake. As the present conduit was last summer taxed to its utmost delivering capacity, we advise the immediate laying of a second one, in order to avoid the inconvenience of a short supply during the coming season, and that the introduction of meters be encouraged to reduce the waste of water. We recommend that the high service be increased at the present station by the erection of additional pumping plant; and finally, that several new mains be laid through the heart of the City to maintain a more regular pressure during sudden drafts of large quantities of water.

For the data which justify these conclusions, for further details and estimates of costs, we refer to the following more extended statements:

II.—*Extension of the Water Supply.*

Toronto is a growing City of about 166,000 inhabitants, situated on the north shore of Lake Ontario, some thirty miles east of the westerly end of the Lake. In front of the City and about 10,000 feet from the shore is an Island about 12,000 feet long. Its eastern end terminates near an extensive marsh opposite the mouth of the River Don, and its western end turns northerly and approaches the main land near the Queen's Wharf. This Island therefore encloses a safe and convenient harbor for the City.

At present Toronto is supplied with water from Lake Ontario, drawn at a crib nearly 2,000 feet from the southern or outer shore of the Island and brought to the main land by a conduit, extending across the Island and the harbor, to a pumping station, having three engines with capacities of four, eight and ten million gallons per twenty-four hours.

The conduit beginning at the crib is six feet in diameter for a length of 2,357 feet, then it is four feet in diameter for a length of 6,007 feet, and for the remainder of the distance, which is about 4,600 feet, its diameter is three feet. A careful calculation has shown us that the latter part of the compound conduit is capable under favorable conditions of supplying about fifteen million gallons per twenty-four hours. As an examination, which was made for us of the grillage over the intake of the crib, showed it to be entirely free from obstructions, and as the water level in the pump-well has been lowered as far as it was expedient, we believe that the conduit has been used to its utmost capacity.

The water is pumped directly into the mains from which it is drawn by the consumers, and the surplus finds its way to Rosehill Reservoir, situated 216 feet above the Lake, and containing, when full, about forty million gallons of water.

The maximum daily consumption in the entire City is estimated at fourteen million gallons, and is therefore almost equal to the maximum delivering capacity of the present conduit, which in view of the rapid growth of the City indicates an urgent necessity for an immediate increase of the supply.

A high service reservoir of 500,000 gallons capacity, and situated about 3,000 feet west of Rosehill Reservoir, and about 260 feet above the level of the Lake, has the water re-pumped to it from the low service mains by an engine capable of delivering 500,000 gallons per twenty-four hours. The present daily consumption in the high service district is about 488,000 gallons; but many of the more elevated parts cannot be supplied with water on account of the lack of pumping capacity, which causes much annoyance to the people inhabiting them.

We have then three important questions presented to us:

1st. What is the most efficient and economical plan for supplying the City with pure water in the future?

2nd. What shall be done to immediately increase the general supply?

3rd. What is the best method of increasing the high service supply?

The available sources for a future water supply are Lake Ontario, Lake Simcoe and the so called Ridge Lakes, a number of small lakes or ponds situated at Oak Ridge, about twenty miles north of the City, at an elevation of from 727 feet to 760 feet above the Lake.

We visited several of the Ridge Lakes; examined their surroundings and the nature and extend of their water shed. They have before been considered as a source of supply for the City.*

From the reports then made, as well as from our own examinations, we are satisfied that neither the quantity of available water, its quality, nor the cost of storage and of bringing it to the City, warrants us in recommending the selection of this source.

We also examined into the merits of the Lake Simcoe project. This lake lies about fifty miles north of the City at an elevation of about 475 feet above Lake Ontario, and covers an area of about 400 square miles. During our visit we inspected the lake and both shores of its southern end or Cook's Bay from a steam tug, and also drove over some of the surrounding country and acquainted ourselves with the most available route along which to bring the water to the City.

* See Reports of the Superintendent of the Toronto Water Works for 1886 and 1887.

There can be no doubt that this lake offers an ample supply, and from the analyses made by Dr. Ellis,* we can assume that the water is also suitable in quality, if taken from a point sufficiently distant from the discharge of the marsh water at its southern end; although we must add that its taste is inferior to that of Lake Ontario water, and that it is chemically less pure, containing a greater proportion of organic matter, which is probably of vegetable origin.

We have appended a sketch map of the territory between Lake Simcoe and Toronto, showing the most favorable general location for a conduit, and a profile of the same, from which we could make an estimate of the least probable cost.†

The third source of supply considered by us was Lake Ontario. This lake of course offers an abundant supply, and the quality of its water is all that can be desired, which fact is apparent not only from the chemical analyses made by Dr. Ellis, but also from the favor which it meets from its consumers. In order to preserve this quality, however, the water intake must be protected from pollution, caused by the flood discharges of the Don and Humber Rivers and by the sewage and surface water of the City. We must therefore carefully examine into the available points from which to draw a supply.

Mimico, over six miles west of the City, has been mentioned as a favorable point. But the excessive cost of this scheme, the necessity of having a very long line of force main through uninhabited territory, besides a conduit sufficiently long to reach deep water for a crib, and the increase of pressure and therefore of waste and inconvenience in the lower part of the City, renders this location inadvisable. An intake has also been suggested opposite Dufferin street. Being exposed both to the currents from the harbor and to the flood water from the Humber River, and possessing no economical advantages, we cannot recommend this location.

Victoria Park, about six miles east of the City, has likewise been mentioned as a locality opposite to which the water might be drawn. We have called this Scheme A. For reasons hereafter to be stated, the littoral drift along the shore is westward, and therefore an intake east of the City could be nearer the shore and still be less exposed to pollution from the same, than if located west of the City.

A fourth point from which water may be taken is the one used at present outside of the harbor and south of the Island. The advantage of this location lies in its proximity to the City and yet in being sufficiently protected by the Island from the effects of pollution from the surface waters of the City and of the two rivers. We have called this Scheme B.

As the intakes of Schemes A and B can both be guarded against sewage pollution, the question of preference resolves itself largely into one of comparative cost, to which we have therefore given a careful consideration.

In Appendix A, which contains the estimates of cost, it will be found that Scheme B is the less expensive one by $189,491 for present needs, $660,991 for future needs.

* See Reports of the Superintendent of the Toronto Water Works for 1886 and 1887.
† See Appendix A.

In making all the estimates we have discriminated between the present and future needs, meaning by the latter when Toronto has a population of 500,000 inhabitants. Inasmuch as the prospects are favorable for a rapid growth, and as it would be unwise to adopt a scheme which at any time would have to be abandoned on account of expense, we considered that an assumption of half a million people, or three times the present population, was fully warranted.

According to the appended estimates, a supply of water for present needs from Lake Simcoe would cost, at a low figure, about $6,600,000. A supply from Lake Ontario with additional reservoir would cost $485,300, or without such reservoir $376,050, making a difference in first cost of over six million dollars in favor of Lake Ontario. For future needs a supply from Lake Simcoe would cost at least $7,711,325, and one from Lake Ontario with reservoir $870,550, and without reservoir $744,050, making a difference in first cost, again in favor of Lake Ontario, of $6,840,775, and $6.967,275 respectively. At 4% the annual cost of the Lake Simcoe scheme amounts to about $308,000, while the annual cost of pumping, which now requires the expenditure of little over one-third of this amount, would for a population of half a million probably still be under the above figure.

As the quality of water is likewise favorable to that of Lake Ontario, we unhesitatingly recommend this as the source from which the City should take its supply in the future as well as at present.

In estimating the cost of a supply from Lake Ontario, two schemes were considered, one being for a new and large reservoir upon Wells' Hill, which has recently been suggested, and the other for duplicate pumping machinery without the aid of this reservoir, in order to discover their relative cost.

While we realize the value of a reservoir in connection with a water supply, rendering it more convenient and slightly more economical to operate the system and to preserve constant pressure; and while we are mindful of the use of a storage reservoir at times when the lake water is riley or turbid by reason of storms or winds; yet we do not feel that these advantages would compensate for a large additional cost of the reservoir project above one which depends upon pumping alone. On the other hand we do not wish to ignore the tendency of large quantities of stored water to deteriorate during the hot and dusty summer months, unless a considerable circulation could be maintained by pumping the supply into the reservoir through an independent main pipe, and distributing the water by another main.

From the estimates of cost in Appendix A it will be seen that for Scheme B and for present needs the cost of the reservoir plan is $485,300, while that for the pumping plan is $376,05C, making a difference in favor of the latter of $109,250. For future needs this difference is $126,500. We do not consider that the advantages gained by the proposed new reservoir over those already received from the present low and high service reservoirs, warrant this additional expense and therefore recommend that additional pumping machinery be provided instead, to meet the emergencies liable to occur as done in other lake cities, notably in Chicago, where no artificial reservoirs exist.

In order to provide for immediate needs, we recommend that a conduit not less than four feet in diameter be laid from a new well to be built at the present pumping station, across the harbor to the shore crib, and there be connected with the present six foot conduit leading to the intake. When this proposed pipe is laid, then the capacity of both together will be nearly forty million gallons per twenty-four hours, the demand for nearly 500,000 persons. The laying of this conduit need not consume much time and will furnish immediate relief.

Thereafter we recommend the erection of an additional pumping station with pumps, etc., near the present one on land now owned by the City. We cannot advise moving the pumping station to the Island, as we not only consider a location several miles from the centre of distribution an economical disadvantage but also the fact that the high pressure, which would have to be borne by the pipes laid across the harbor, might cause considerable leakage at the joints, the location of which would be difficult to discover and to repair.

As the quantity of water drawn at the present crib increases, the velocity through the screen will become greater. To avoid the danger of becoming clogged by weeds and other matter a second crib should in time be built, to increase the area through which the water can enter.

In making the estimates for the purpose of comparison, no cost for high service was included for the reservoir plan, because most if not all of the area could be supplied from the new reservoir, without any addition to the present high service plant. But without the reservoir additional pumps will be needed, and taking account of the fact that the consumption per head will be less than in the low service, we recommend the erection of a two million and a three million gallon pumping engine and the necessary changes and enlargement of the buildings to accommodate the same.

We do not consider it entirely safe to be without duplicate machinery, and therefore suggest the above sizes, which will prevent a deficiency of pumping capacity to supply the district should one of the engines break down. The estimate in Appendix A shows the probable cost of the additional plant.

We do not consider that the position of the high service pumping station should be at the lake. The expense of a special pumping main and the heavy strain upon the engines, make it preferable to continue to draw from the low service mains about 160 feet above the lake, as you are doing now.

On account of the present high pressure along the streets near the lake, ranging from 75 to 85 lbs., it has been proposed not to operate the works under the pressure from Rose Hill reservoir, except at the time of a fire. We do not think this would be a wise course to adopt, since the plumbing appliances are fully adjusted to this pressure. The advantage gained would be to slightly reduce the lift of the pumps and to save a small amount of water in the consumption, but we believe this would be outweighed by the inconveniences due to a sudden increase of pressure after fire alarms, and particularly by having less circulation in the reservoir and therefore at times an unnecessary depreciation in the quality of the water.

Before leaving the question of water supply we have yet to mention a few points to which our attention was called. First, with regard to the laying of new mains. In determining the proper sizes of water pipes it should be borne in mind that the larger sizes should be laid to and in the districts which will consume the greatest amount of water, as this will secure the greatest pressure where it is most needed, for instance, in the large business centres where among other uses elevator and fire-supply are principal factors. It is of particularly great importance to so proportion the sizes that the pressure can be maintained during heavy drafts for fire purposes. As the pipes are often laid before the territory is fully developed, it is not always easy to correctly foresee future requirements. It is much less difficult to see what is needed when the territory is built up, and it is then often necessary to lay additional mains to meet the demands of certain districts which may have been found to lack a sufficient supply. In doing this it is necessary to have a knowledge not only of the location of all existing sewers, water, gas, and steam pipes, etc., but to anticipate as far as possible all future demands for space in these streets.

From the study which we have given this matter we are of the opinion tha it would be well to lay an additional main east and west in the vicinity of Queen or Adelaide streets, and another one north and south in the vicinity of York or Yonge streets. There need be no difficulty in determining upon the most desirable one of these streets, in either of which a marked advantage would be gained. Our attention was also called to the presumably high water consumption, the maximum of which is upwards of ninety imperial gallons to the person per twenty-four hours. It is probable that much of this amount is due to waste. But in just what manner it occurs we are not able to say, as it can only be determined by a careful inspection of all fixtures. This requires much time, as it should be made at different periods and under different circumstances. A careful, faithful, and continued inspection, coupled with a stringent enforcement of the rules regulating the plumbing, would doubtless result in materially decreasing the waste.

The use of meters, however, would probably be the most effective method of accomplishing this end. With metered water the taker is himself responsible for all waste and leaks that occur on his premises, and he is quite apt to prevent them. Without the meter the City assumes the loss, and it is not uncommon for the consumer to be quite indifferent regarding the condition of his fixtures so long as they cause him no inconvenience. These should be so carefully inspected, and the rules requiring the taker to keep them in repair so well enforced, that it will not be easy, if paying by fixture rates, to obtain water at a less cost than if supplied through meters. If any difference is to be made in the cost it should be in favor of the person paying by meter, because he assumes the risk of all leakage on his premises. In the cities and towns where a comparatively large number of meters are in use, the consumption per head is much smaller than in places using but few meters.

III.—*Disposal of the Sewage.*

The City of Toronto has a tolerably complete system of sewers for collecting both sewage and rain-water and discharging them into the harbor in front of the

City. We understand that it has been well built, and that it is generally in good condition. In the streets running south towards the lake the sewers are kept well cleaned by storms, but on the east and west streets they have gradients too flat to secure thorough self-cleansing, and therefore require more or less artificial flushing. We made no general examination of the present sewers to see if they have sufficient capacity, proper grade and shape for the duty they are expected to perform, as this question had no bearing upon the one before us.

The sewage is delivered into the slips or docks, and in some cases at the pier heads. The heavier matter is deposited as sludge and the lighter matter drifts away. The absence of any strong current facilitates the settling of such matter and examinations made at our request show a considerable accumulation even one thousand feet from shore. The gases resulting from its decomposition and escaping at the water surface are very offensive in summer, while in winter they tend to pollute the ice which is cut in the harbor for domestic consumption.

It is evident, therefore, that the sewage should be prevented from discharging into the harbor, and that intercepting sewers should be built to carry it to a more distant outfall, the location of which depends upon the method adopted for finally disposing of the sewage.

There are but two methods available for this purpose, viz., land treatment and a discharge into the lake, with or without a previous artificial purification. Land treatment means irrigation or filtration. By the former we understand the use of only so much sewage per acre of ground as will benefit the crops to be grown thereon; by the latter, the application of as much sewage as the soil will purify, irrespective of farming interests. Both have been more or less successfully carried out at a number of places in England and on the continent of Europe. Also in Pullman, Ill., the operation is conducted with good results, although much of the crude sewege is allowed to pass into Lake Calumet whenever the crops would be injured by it. If such a relief cannot be allowed, a much larger amount of land must be available.

Taking the most suitable territory which we could find within several miles east and west of the City, we were convinced that without injuring the crops. one acre could not receive daily more than an average of 5,000 to 8,000 imperial gallons of sewage, and perhaps less. With the present water consumption per capita, this means about 5,000 acres of sandy soil for 500,000 persons. The income from this land would not pay a fair interest on the cost price which its proximity to the City would demand, not to speak of the expense of providing sewers to convey the sewage to the farm and of pumping it to its elevated location not less than 120 feet above the lake. For a population of 500,000 with 40,000,000 imperial gallons of sewage per day, the annual cost of pumping would hardly be less than $100,000 which, capitalized at a rate as high as four per cent., would alone represent $2,500,000.

If filtration is resorted to not more than 20,000 imperial gallons could be purified per acre under the most favorable conditions, which represents at least 2,000 acres of land for the above assumed population, with less income from the crops and the same cost for pumping.

The expense of land treatment, therefore, even if sufficient territory of a proper kind could be found, which is perhaps doubtful, and the great responsibility of conducting so large a farm on behalf of the City, for the double purpose of preventing a nuisance and of securing a return from the sale of crops, seem to us conclusive facts for rejecting such a method of disposing of your sewage.

The other possible way of disposal is by letting it flow into the lake. If it is previously purified by chemical or mechanical treatment, a much nearer outfall to the City is permissible than if discharged in its crude state.

The cost of erecting the necessary plant, together with the capitalized cost of treatment according to any of the several available processes, may be roughly estimated to be $2,200,000 for a population of 200,000 persons and $5,000,000 for 500,000. For a much smaller sum the sewage can be carried a long distance from the City, and the necessity of subjecting it to treatment can thus be obviated.

Our attention has been specially called to the method of deodorizing sewage with porous carbon, as proposed by Mr. F. S. Miller, and which was recently tested in the basement of the City Hall. The sewage of the Jarvis street sewer was led successively through several tanks and made to pass through numerous layers of carbon, sand, gravel and coke, coming out of the last tank quite clear and odorless. The ability to purify sewage by means of such materials is well known, and also the fact that to remain efficient they each require frequent cleansing and in the case of the carbon also renewing. We do not venture, however, to estimate in detail the cost of thus deodorizing even 15 million gallons per day, which is probably the amount discharged into the harbor at present. Besides intercepting sewers you would be obliged to have large areas of tanks and to pump most of the sewage in order to gain the head necessary for the filtration. Then would have to be added the cost of treatment, exchanging and cleansing the filter beds, which must not be under-valued.

Finally, we understand it is proposed to dry the sludge by artificial heat, to powder it in a mill and then to sell it as manure. We are convinced that the income from the latter source will fall far short of the expectations as the fertilizing value of city sewage is found to be very slight. The enhanced income from sewage farms is due almost wholly to the benefit derived from irrigation *per se*, and which is the case in Pullman, the fields occasionally require additional manuring to raise the more profitable crops. The expense alone of preparing the sludge as proposed would be much greater than the real value of the finished product.

While we are inclined to the belief that at some future day, perhaps when the City contains 500,000 inhabitants, some form of purification may be advisable for perhaps a part of the City's sewage, we are of the opinion that at present, provided a proper place is selected, the less expensive method of a direct discharge of the crude sewage will be quite satisfactory, leaving the question of adding purification works to the requirements of a somewhat distant future.

The available localities for a sewage discharge depend upon the points from where the water supply is drawn, which, as we advised above, should be taken from Lake Ontario. The fact of drinking water coming from the same lake into which we discharge sewage should not necessarily disturb us, any more than breathing the same air into which we continually exhale the discarded gases and other effete matter from our lungs.

The objection to such pollution is mainly one of degree. If we have a high degree of dilution, in the first case with pure water and in the second with pure air, we have yet to discover the slightest evidence that any harm has resulted. The gradual self-purification of polluted water and air by means of oxidation, through the excess of oxygen contained in the diluting medium, is an established fact, and is nature's method of correcting what would otherwise be a serious evil. For our purpose it is a question of degree ot dilution, and in both cases we have enough experience to approximately indicate safe limits.

The regular and constant current of rivers enables us to fix this limit with greater exactness than when the sewage is discharged into a large body ot water, such as Lake Ontario, in which the currents move in almost any direction or sometimes are quite imperceptible. Still, it is not difficult to reach some conclusions in this case.

If the sewage is discharged into the lake in deep water near the bottom, we are safe in concluding that the *sludge, i.e.*, the heavier matter, will very soon settle and no longer be contained in the water a few thousand feet, perhaps a mile, distant. At long intervals dredging can easily and cheaply remove any large accumulation at the outfall. The lighter and fatty ingredients of the sewage, and those which are held up by attached bubbles of gas, rise to the surface and are moved along by the current, thus constituting the chief danger. Both in rising and subsequently in their horizontal movement they are separated and dispersed along the cycloidal paths travelled by particles of flowing water. One cubic foot of sewage discharged into a current of 100 cubic feet of water per second, would gradually become diffused throughout this quantity and diluted a hundred times. While becoming more and more exposed to purification by the oxygen in the water, the deleterious matter would gradually be reduced to a point beyond detection. The higher temperature of sewage as compared with lake water will not, we think, be an important factor in dispersion, because the flow for several thousand feet in a submerged steel pipe will tend to equalize the temperature and materially reduce that of the sewage before its discharge.

Nothing but actual tests, however, will tell us how rapidly diffusion and oxidation take place and therefore how far apart we should have the sewage outfall and water intake. The season was unfavorable to making many experiments in this direction. But from general experience gained upon the lakes and elsewhere, together with the results of a few recent local observations, we believe to be justified in drawing some conclusions.

Under the instructions of Mr. Sproatt, a few float experiments were made in the lake, in front of the City, from Sept. 25th to Oct. 19th, 1884, by Mr. C. H.

Rust, Assistant.* Mr. A. Macdougall made about 100 similar experiments near Victoria Park, extending over 22 days in May, and 13 days in June, 1886, and also some on Oct. 22nd and 30th in 1888.**

All these observations in one respect confirm those made in other localities, namely, that the lake currents are caused by the winds. They change direction as the wind changes. Their velocity, which probably never exceeds the rate of 100 feet per minute, usually increases slightly towards the surface, though after a sudden shifting of the wind the upper and lower parts of the current have sometimes opposite directions.

The littoral drift moves in the direction of the longest wave fetch of the lake, which at Toronto is westerly,† and for this reason we observe along the beach near the City the accumulation of sand to be on the eastern side of the groynes, which has caused some to believe that the prevailing currents were westerly. The float observations made in the lakes do not indicate any marked difference in the frequency of the currents in one direction or in the other. Nor is it of much value for our purpose to know this difference. The fact that they move both east and west is enough to indicate that the sewage should be discharged sufficiently far away so that the unfavorable current, if only occurring once a year, will not cause the water near the intake for the City's supply to be polluted.

Flood discharges of the rivers entering the lakes at Chicago, Cleveland and Milwaukee, have in no case been traced more than five miles from the mouths of the respective rivers. Within this distance the large quantities of muddy water (in the Chicago River amounting to several thousand cubic feet per second) become so thoroughly dispersed in the lake that they are lost to observation. When we consider the average discharge of less than one hundred cubic feet per second, which would represent the sewage from half a million people, we can safely conclude that at a distance of five miles this quantity would even be more thoroughly dispersed, and in fact, entirely lost.

The westerly movement of the littoral drift, the discharge of the river Don westward into the Harbor, and of the muddy water of the Humber into the Bay near the western end of the City, seem to indicate that, other things equal, the sewage is best discharged in that direction, say half way between Lighthouse Point and Mimico, while ten miles or more to the east opposite the bluff projecting into the lake near Victoria Park, is the best locality from which to supply the City with water. We notice that such a plan was suggested, before the less expensive location of the present intake at the Island had been adopted. We have made an estimate of such a project and find that it would cost about $1,930,850 (see estimates of cost in Appendix A)

To reverse the points by discharging the sewage near Victoria Park, and taking the water opposite Mimico, would likewise without question prevent a sewage pollution of the supply. This scheme, due to the many miles of watermains, the increased cost of pumping on account of the great distance and the

* See Appendix F of Report on Main Sewage System, presented to Council, Sept. 2nd, 1886.

** See Appendix B to this Report.

† See Report on the Preservation and Improvement of Toronto Harbor, by Sanford Fleming, C.E., 1850.

resulting high pressure in the lower parts of the western end of the City, clearly show it to be much more expensive and less desirable than the previously mentioned one and it was therefore not further considered by us.

But, with a sewage discharge near Victoria Park, several thousand feet from shore, it is possible to draw the water from the present intake opposite the Island and to allow a distance for dispersion of sewage of about six and one-half miles. The total cost of disposing of it in this way is estimated at $1,471,048, which makes this project nearly half a million dollars less expensive than the other one, and has a further advantage in greatly facilitating an immediate increase of the present supply, as mentioned above.

We have no fear that by the westerly movement of the littoral drift the sludge will be carried far towards the Island, before the bed of the lake will show its entire disappearance. Nor, if the sewage is passed through a strainer, having an inch mesh, do we think that objectionable floating matter will be found stranded along the near shore. The proposed improvement of the eastern entrance to the harbor and the proposed outlet of the river Don at the eastern end of Ashbridge's Bay will aid in dispersing the sewage matter by deflecting or breaking the current when it moves towards the Island.

The intake being in deep water near the bottom where the current is slight, is a further protection, because whatever matter might accidentally have drifted to so great a distance, would most probably be near the surface and not in the more quiet current near the bottom.

As already stated, however, we are willing to admit the possible advisability of clarifying at least some of the sewage in the future, when the City has trebled its present population. Whatever is herein recommended will not interfere with ultimately adding works for this purpose, but will really form a necessary part thereof.

For the above reasons we believe that it is safe to locate the sewage outfall opposite Victoria Park, in thirty feet of water, at least two thousand feet from shore, and being also the most economical project, we believe it to be the proper one for the City to adopt. This outfall was suggested in the City Engineer's Report of November, 1886.

We have next to consider the means of getting the sewage to this outfall. It would be very expensive and quite unnecessary. to carry to it the entire contents of the sewers which receive the water of the heaviest storms. After the first flush from a rain, most of the filthy matter is stirred up and washed out of the sewer, and the subsequent flow is so much less objectionable in quality, that there would be no objection in allowing most of it to run into the harbor. The ordinary flow of sewage together with the water from a slight rainfall, should therefore be intercepted and the excess during heavy rains be allowed to continue its present and natural course.

Various lines have been proposed for such intercepting sewers. In a report made to the chairman and members of the Committee on Works, March 1886, Mr. Sproatt, City Engineer, recommended one along Nassau and Gerrard streets, from Bathurst street to the river Don, and one along Front street from the Garrison Creek to the same river, connecting with the above at Gerrard street bridge; also a sewer from St. Paul's Ward and Rosedale to the river, connecting at the same point. Thence the main outfall sewer was to extend along the most practical line to opposite Victoria Park. At the junction of the intercepting sewers a pumping station was located, where the sewage from the Front street sewer could be lifted to the elevation of the Gerrard street sewer and thence discharged by gravity. The estimated cost of this system was $1,418,355 with an annual expense for pumping of $43,145.

On account of the large annual expenditure which would immediately follow the execution of this project, Mr. Sproatt suggested another one, embodying an intercepting sewer on the line of Queen Street from Garrison Creek to Woodbine Avenue, and thence to the outfall, diminishing the area from which the sewage would require pumping. A second intercepting sewer was located on Front Street and its sewage raised into the upper one by pumps situated near the east side of the Don and Eastern Avenue. The estimated cost of this system was $1,443,483 with an annual expense for pumping of $25,800. Our own study into the possible locations for these intercepting sewers led us to lines which partly agree with those recommended by Mr. Sproatt. We started with the principle that the high level sewer should intercept the greatest practicable area that could economically be drained to the proposed outfall by gravity. East of the Don we were satisfied that Queen Street was too far south and therefore too low to allow the sewage a free flow at all times at a desirable depth below the street. A line further north seemed much better, crossing the river on the line of Mark street. Thence westward, we selected what appears to us the lowest line at which the sewage from the main sewers can be collected. As indicated on the accompanying map, it makes a number of bends or turns, but if made with large radii, we do not consider this a disadvantage.

The sewage below this line must be intercepted by another sewer which we have placed on Front street, and, to distinguish it from the other, called it the low level intercepting sewer. From the Union Station eastward it may, on a close examination, be found more economical to place it on Esplanade street. Not knowing the character of the excavation to be met we preferred te estimate upon a line on Front street.

The high level sewer suggested by us will, we think, relieve the harbor of so great an amount of sewage that the low level sewer and the pumping station may not be required for several years. Rights of way and the necessary property should, however, be secured as soon as practicable. Our estimate of cost (see Appendix A) for the high level sewer is $1,059,312, and for the low level sewer, including pumping station, $411,736, or the total cost, $1,471,048. The annual expense of pumping we estimate at about $8,000, as follows:

Coal	$2,500
Oil and waste	200
Salaries	4,700
Sundries	600
	$8,000

In order to enable us to estimate the cost of purification and to properly proportion the sizes of the intercepting sewers, Mr. Sproatt, at our request, kindly made some gaugings of the actual flow in two districts representing different densities of population. He selected the Yonge Street and Brock street sewers near their outfalls and found the following result, the gallons being Imperial:

YONGE STREET DISTRICT.

Area, 370 acres. Population, 18,500.
Discharge of sewage per head per day, 108 gallons.
Minimum flow, from 12 to 5.30 a.m., 13.9 gallons.
Maximum flow, at 11.20 a.m., 31 8 gallons.
Average flow, computed, 23.1 gallons.
Rate of maximum flow, 148 gallons per head per day.
Rate of maximum flow, at the same rate for 500,000 persons, 137.5 cubic feet per second.

BROCK STREET DISTRICT.

Area, 380 acres. Population, 13,300.
Discharge of sewage per head per day, 74 gallons.
Minimum flow, from 12.30 to 6 a.m., 7.99 gallons.
Maximum flow, 9 to 10 a m., 14.10 gallons.
Average flow, computed, 11.4 gallons.
Rate of maximum flow, 92 gallons per head per day.
Rate of maximum flow, at same rate for 500,000 persons, 86.4 cubic feet per second.

We assumed that for a population of half a million there would be as many as three districts such as Yonge street to one such as Brock street. The maximum flow per second for the whole City would therefore be

$$\frac{86.4 + (137.5 \times 3)}{4} = 124.7 \text{ cubic feet.}$$

We arrived at about the same conclusion by separately estimating the future density of population per acre for the different districts, varying from thirty persons in the suburbs to seventy persons in the central part of the City, and assuming an average of ninety gallons of sewage per day per head of population, including the ground water, and one-half of this quantity to flow off in eight hours. The resulting figures are given in the table of estimates for the intercepting sewers, in Appendix A under the heading, Required Capacity.

These maximum quantities were supposed to half fill the sewers, allowing sufficient space, when running full, for an additional flow equal to the water of a rain 0.6 of an inch in twenty-four hours, supposing one-half of the amount to reach the sewers.

The shape of the smaller sizes we have supposed to be that of a four-center ellipse, which gives both height for convenience of entry and a sufficient concentration of the ordinary flow.

The grades of the intercepting sewers were assumed by us at 8 inches per 1,000 feet for the high level sewer from Sherbourne Street to the outfall, and at 12 inches per 1,000 feet for the remaining distance, and also for the entire low level sewer on account of its smaller capacity We have assumed the elevation of the invert at the shore near Victoria Park as 41 feet above datum, which during the years of average high lake level, will still give a sufficient head to maintain the proposed grade.

The velocities per second range from nearly 3 feet to 4 feet 8 inches when running half full, which is sufficient to keep the sewers in a fair condition. In the higher parts of the low level intercepting sewer there will be a very small amount of sewage and therefore a greatly reduced velocity. It will be well to connect its upper end with Garrison Creek sewer, so that a larger flow can be introduced for flushing purposes whenever it is deemed desirable.

The manner in which each one of the present sewers ought to be intercepted will differ almost in every case and will require special study to regulate the proper quantities which are to be removed by the overflow.

The two siphons passing under the River Don should be laid straight from shore to shore between two wells, constructed so that if necessary they can be pumped out and examined. At the western well, to which the siphon pipes should incline, provision must be made for removing deposit and floating matter. With these precautions they will operate quite satisfactorily.

Near the outfall we would recommend the erection of a building with arrangements for screening the sewage before it is discharged into the lake, in order to prevent the escape of a large amount of objectionable matter which might otherwise drift towards the shores.

Very respectfully,

RUDOLPH HERING,

SAMUEL M. GRAY,

Consulting Engineers.

New York, February 15th, 1889.

APPENDIX A.

. TIMATES OF COST.—EXTENSION OF THE WATER SUPPLY.

(a). *Water from Lake Simcoe.*

107,000 feet of brick conduit, 6 feet in diameter, at $25.50	$2,728,500 00
53,000 feet of tunnel, 6 feet in diameter, at $39	2,067,000 00
Two lines of 48in. cast-iron pipe, each 85,000 feet long, at $11	1,870,000 00
Crib at lake, connections with Reservoir, overflows, etc.	40,000 00
Total, exclusive of land damages	$6,705,500 00
Add 15% for contingencies, engineering and superintendence	1,005,825 00
Sum total	$7,711,325 00

(b.) *Water from Lak. Ontario.*

SCHEME A.—INTAKE NEAR VICTORIA PARK, RESERVOIR PROJECT.

Present needs:	
Estimated cost of pumping scheme, see below	$411,775 00
" " reservoir " "	175,000 00
Total	$586,775 00
Add 15% for contingencies, engineering and superintendence	88,016 00
Sum total	$674,791 00
Future needs:	
Estimated cost of pumping scheme, see below	$1,086,775 00
" " reservoir " "	305,000 00
Total	$1,391,775 00
Deduct $60,000 for engines not required	60,000 00
Total cost	$1,331,775 00
Add fifteen per cent. for contingencies, engineering and superintendence	199,766 00
Sum total	$1,531,541 00

SCHEME A.—INTAKE NEAR VICTORIA PARK, PUMPING PROJECT.

Present Needs:	
30,500 feet of 36 inch main, at $8.55	$260,775 00
One 8 million gallon pump	50,000 00
Buildings	50,000 00
Conduit, 2,000 feet, at $18	36,000 00
Crib	15,000 00
Total	$411,775 00
Add 15% for contingencies, engineering and superintendence	61,766 00
Sum total	$473,541 00

Future Needs :

Engine house and foundations	$100,000 00
Moving engines No. 2 and 3 from present house	25,000 00
One 8 million gallon engine	50,000 00
Conduit	50,000 00
Pipes and connections	15,000 00
Crib	15,000 00
Main pipes, 30,000 feet, at $14	420,000 00
Add for present needs, as above	411,775 00
Total	$1,086,775 00
Add 15% for contingencies, engineering and superintendence	163,016 00
Sum total	$1,249,791 00

SCHEME B.—ADHERING TO PRESENT INTAKE, RESERVOIR PROJECT.

Present Needs:

Land, 30 acres, at $1,500	$ 45,000 00
4,000 feet of 36 inch pumping main, Hammond Street to Reservoir, at $10	40,000 00
Gate house	10,000 00
40 million gallon reservoir	80,000 00
Sum	$175,000 00
Increasing capacity of pumping works, see below	247,000 00
Total	$422,000 00
Add 15% for contingencies, engineering and superintendence	63,300 00
Sum total	$485,300 00

Future needs:

For Reservoir as above	$175,000 00
Increasing its capacity to hold 100 million gallons	90,000 00
4,000 feet of 36 inch pumping main, Hammond Street to Reservoir, at $10	40,000 00
Sum	$305,000 00
Pumping plant for future needs ($512,000) less $60,000 for engines not required, see below	452,000 00
Total	$757,000 00
Add 15% for contingencies, engineering and superintendence	113,550 00
Sum total	$870,550 00

SCHEME B.—ADHERING TO PRESENT INTAKE, PUMPING PROJECT.

Present Needs:	
10,600 feet of 48 inch conduit to the Island	$200,000 00
Well at engine house	8,000 00
Connections at engine house	4,000 00
Connections with 6 foot pipe, etc	15,000 00
Dredging	20,000 00
Total	$247,000 00
Add 15% for contingencies, engineering and superintendence	37,050 00
Sum total	$284,050 00
Future Needs:	
For present needs, as above	$247,000 00
Two 8 million gallon pumping engines	90,000 00
One 10 million gallon pumping engine	55,000 00
Engine and boiler house	95,000 00
Wharf and grading	15,000 00
Enlarging crib	10,000 00
Total	$512,000 00
Add 15% for contingencies, engineering and superintendence	76,800 00
Sum total	$588,800 00

ADDITIONAL HIGH SERVICE SUPPLY FOR PUMPING PROJECT.

Present Needs:	
One 2 and one 3 million gallon pumping engines	$60,000 00
Enlarging engine house, etc	15,000 00
Connections, etc	5,000 00
Total	$80,000 00
Add 15% for contingencies, engineering and superintendence	12,000 00
Sum total	$92,000 00
Future Needs:	
For present needs, as above	$80,000 00
One 4 million gallon pumping engine	35,000 00
Engine house, etc	15,000 00
Connections	5,000 00
Total	$135,000 00
Add 15 per cent. for contingencies, engineering and superintendence	20,250 00
Sum total	$155,250 00

RECAPITULATION OF ESTIMATES FOR EXTENSION OF WATER SUPPLY.

Comparison of Reservoir and Pumping Projects.

SCHEME A.

Present Needs:		
Reservoir		$674,791 00
Pumping, low service	$ 473,541 00	
Pumping, high service	92,000 00	565,541 00
Difference in favor of pumping		$109,250 00
Future Needs:		
Reservoir		$1,531,541 00
Pumping, low service	1,249,791 00	
Pumping, high service	155,250 00	1,405,041 00
Difference in favor of pumping		$126,500 00

SCHEME B.

Present Needs:		
Reservoir		$485,300 00
Pumping, low service	284,050 00	
Pumping, high service	92,000 00	376,050 00
Difference in favor of pumping		$109,250 0
Future Needs:		
Reservoir		870,550 00
Pumping, low service	588,800 00	
Pumping, high service	155,250 00	744,050 00
Difference in favor of pumping		$126,500 00

Comparison of Schemes A. and B.

Present Needs:

Reservoir.

Scheme A	$674,791 00
Scheme B	485,300 00
Difference in favor of Scheme B	$189,491 00

Pumping.

Scheme A	$565,541 00
Scheme B	376,050 00
Difference in favor of Scheme B	$189,491 00

Future Needs:

Reservoir.

Scheme A	$1,531,541 00
Scheme B	870,550 00
Difference in favor of Scheme B	$660,991 00

Pumping.

Scheme A	$1,405,041 00
Scheme B	744,050 00
Difference in favor of Scheme B	$660,991 00

DISPOSAL OF THE SEWAGE.

SCHEME A. OUTFALL HALF WAY BETWEEN LIGHT HOUSE POINT AND MIMICO.

Low level intercepting sewer from Woodbine Avenue to Garrison Creek	$420,000 00
High level intercepting sewer between Pape Avenue and Huxley Street	310,000 00
From Garrison to Dufferin Street	125,000 00
Connections	30,000 00
River Don crossing	30,000 00
Outfall pipe, crib, etc	600,000 00
Land damages for above	100,000 00
Int. sewer from St. Paul's Ward and Rosedale, see below	40,000 00
Garrison Creek int. sewer, see below	24,000 00
	$1,679,000 00
15% for contingencies, engineering, and superintendence	251,850 00
	$1,930,850 00

Scheme B.—Outfall Opposite Victoria Park.

High Level Intercepting Sewer.

STREET.	Drainage area. Acres.	Requir'd capacity Cub. ft. per sec.	Grade per 100 feet.	Size of sewer.	Cost. $ c.
Huxley st., Spencer to Dufferin	652	8.99	.1	24 x 36	3,150 00
Dufferin st., Huxley to line Asylum Wall	652	8.99	.1	24 x 36	6,300 00
Line of Asylum Wall, Dufferin to Strachan Av.	1,230	15.51	.1	30 x 45	24,900 00
Defoe st., Strachan av. to Niagara	1,331	16.77	.1	34 x 51	6,400 00
Defoe st., Niagara to Bathurst...	3,455	42.34	.1	5 ft. 0 in.	15,300 00
Adelaide st., Bathurst to Spadina	3,620	44.82	.1	5 3	20,000 00
Adelaide st., Spadina to Simcoe	3,955	49.60	.1	5 6	25,750 00
Adelaide st., Simcoe to York....	4,403	56.34	.1	5 8	7,500 00
York st., Adelaide to Richmond	4,403	56.34	.1	5 8	5,123 00
Richmond st., York to Yonge...	4,403	56.34	.1	5 8	16,500 00
Richmond st., Yonge to Church.	4,907	63.04	.1	5 10	10,125 00
Church st., Richmond to Queen.	4,907	63.04	.1	5 10	3,375 00
Queen st., Church to Jarvis......	5,164	66.88	.1	6 0	7,875 00
Queen st., Jarvis to Sherbourne.	5,362	69.88	.1	6 6	11,500 00
Sherbourne st., Queen to Sydenham	5,362	69.88	.067	6 8	6,000 00
Sydenham st., Sherbourne to Sackville	5,682	73.88	.067	6 8	26,875 00
Sackville st., Sydenham to Wilton ave	5,682	73.88	.067	6 8	11,430 00
Wilton ave., Sackville to River st.	5,882	75.88	.067	7 0	17,888 00
River st., Wilton ave to Mark st.	6,818	83.88	.067	7 0	3,600 00
*Mark st., River to Munroe	6,818	83.88	.067	7 0	9,375 00
Outfall sewer, Munroe to Pape av	7,654	94.36	.067	7 0	53,300 00
" " Pape av. to Lake Ontario	10,346	125.00	.067	8 0	301,875 00
Total	....	....	....	....	594,141 00

* Not including siphon.

Siphon across River Don.

Two lines each 600 feet 48 inch cast iron pipe laid...	$23,000 00	
Two wells	16,000 00	
Buildings	6,000 00	
		$45,000 00

Outfall Pipe.

One line steel pipe, 6 feet in diameter, 2,000 feet into lake	$63,000 00	
Crib, laying, etc	40,000 00	
		103,000 00

Connections with present sewers, overflows, etc.	$30,000 00
Crossing creeks, Small's pond, etc.	10,000 00
Land damages	75,000 00

Intercepting sewer from St. Paul's Ward and Rosedale:

8,000ft.,	2ft. x 3ft.,	at $3.00,	$24,000 00	
4,000ft.,	2ft. 4in. x 3ft. 6in.,	at 4.00,	16,000 00	$40,000 00

Garrison Creek Sewer:

4,000ft., 3ft. x 4ft. 6in at $6.00	24,000 00
	$921,141 00
15% for contingencies, engineering and superintendence	138,171 00
Total cost of high level sewer	$1,059,312 00

Low Level Intercepting Sewer.

STREETS.	Drainage area. Acres.	Requir'd capacity Cub. ft. per sec.	Grade per 100 feet.	Size of Sewer.	Cost. $ c.
Front st., Wellington to Bathurst	158	2.37	0.1	20 x 30	4,191 00
" Bathurst to Spadina	"	"	0.1	20 x 30	6,908 00
" Spadina to Simcoe	"	"	0.1	20 x 30	8,635 00
" Simcoe to Bay	237	3.65	0.1	22 x 33	5,966 00
" Bay to Yonge	297	4.65	0.1	24 x 36	2,732 00
" Yonge to Church	321	5.13	0.1	26 x 39	6,292 00
" Church to Jarvis	361	5.86	0.1	26 x 39	4,589 00
" Jarvis to Sherbourne	391	6.36	0.1	28 x 42	7,227 00
" Sherbourne to Berkeley	427	7.03	0.1	28 x 42	7,623 00
" Berkeley to Parliament	467	7.75	0.1	28 x 42	3,049 00
" Parliament to Cherry	487	8.11	0.1	30 x 45	10,711 00
* " Cherry to River Don	547	10.21	0.1	32 x 48	18,755 00
Eastern Av. Pumping Station to River Don	750	12.00	0.1	32 x 48	37,697 00
Queen St. Pumping Station to Woodbine	327	3.40	0.1	20 x 30	34,056 00
Total					158,431 00

* Not including siphon.

Siphon across River Don.

Two lines each 600 feet of 24 inch cast iron pipe laid	$7,300 00	
Two wells	13,000 00	
Buildings	5,300 00	
Total		$25,600 00

Pumping Station near Queen and Pape Ave.

Two 3-million gallon pumps	$75,000 00	
Engine and Boiler House	20,000 00	
Wells, Screens, etc	16,000 00	
Two lines each 1700 feet of 24 inch cast iron pipe laid	18,000 00	
		129,000 00
Connections with present sewers, overflows, etc		20,000 00
Land damages		25,000 00
Total		$358,031 00
Add 15 per cent for contingencies, engineering and superintendence		53,705 00
Total cost of low level sewer		$411,736 00

RECAPITULATION.

Scheme A		$1,930,850 00
Scheme B, High level Int. Sewer	$1,059,312 00	
Low level Int. Sewer	411,736 00	1,471,048 00
Difference in favor of Scheme B		$459,802 00

FINAL RECAPITULATION

SHOWING THE DIFFERENCE OF COST IN FAVOR OF ADHERING TO THE PRESENT WATER INTAKE AND DISCHARGING THE SEWAGE OPPOSITE VICTORIA PARK. (SCHEME B.)

Present Needs:	
Water Supply	$189,491 00
Sewerage	459,802 00
Total difference in favor of B	$649,293 00
Future Needs:	
Water Supply	$660,991 00
Sewerage	459,802 00
Total difference in favor of B	$1,120,793 00

APPENDIX B.

TABULATED STATEMENT OF CURRENT OBSERVATIONS MADE DURING THE MONTH OF MAY, 1886, IN THE HARBOR, ON THE SOUTH SIDE OF THE ISLAND, AND BETWEEN THE EAST GAP AND VICTORIA PARK.

(1 float plotted) 1 10 m. 5 15

May	28th	5 N. W.	13 S.	6 S. W.	10	0	N. E.	0.50	2.00	"	near intake crib. (Grounded.)
					8	0	N. E.	0.60	2.00	"	W. Water Works buoy. (Grounded.)
					8	0	N. E.	1.75	6.30	"	½ mile south of Lighthouse.
					22	0	N. E.	0.60	4.15	"	¾ do.
					6	0	N. E.	0.75	3.00	"	S. E. side of Island.
					20	0	N. E.	2.25	7.10	"	1 mile S. East Gap.
May	31st	10 S. W.	29 S.	2 S.	20	0	E.	0.75	6.20	"	off Kew.
					10	0	W. by S.	0.25	6.00	"	at East Gap. (Grounded.)
					8	0	{ N. E. / S. W.	0.15 / 0.25	6.45 / 3.30 }	"	inshore S. side Island, near Lighthouse.
					20	0	E.	0.40	1.20	"	Water Works east buoy.

TORONTO, 12TH JUNE, 1886.

(Signed) ALAN MACDOUGAL.

APPENDIX B.

TABULATED STATEMENT OF CURRENT OBSERVATIONS MADE DURING THE MONTH OF MAY, 1886, IN THE HARBOR, ON THE SOUTH SIDE OF THE ISLAND, AND BETWEEN THE EAST GAP AND VICTORIA PARK.

Month.	Date.	Mean Velocity and Direction of Wind. 7 A.M.	3 P.M.	11 P.M.	Depth of Float.	Direction taken by Float.	Distance Traversed in Miles.	Time in Hours and Mins.	Location and Remarks.
May	5th	9 W.	8 W.	4 W.					Began work, in harbor, with surface floats. All influenced by the wind.
May	6th	Calm.	6 S. E.	5 S. W.	10 ft.	N. E. & E.	0.39	3.00	3 buoys near East Gap. (Grounded.)
					7	E.	0.81	4.00	3 spars 1 surface Queen's Wharf. Picked up in the docks.
May	7th	12 N.	8 S. E.	4 E.	11	N. W.	0.75	5.00	Off the Fort. Anchored at night.
May	8th	6 N.	12 N.	6 N. W.	11	S. E.	0.40	4.00	do. The same buoy.
					10	E. by S.	0.75	4.00	do. Another float. Anchored at night.
May	14th	3 N. E.	4 N. E.	2 E.	Surface.	N. W.	0.80	1.25	Mouth of Humber. (Grounded.)
					8 ft.	N. W.	0.50	6.00	
May	17th	7 N. W.	10 S. W.	4 S. W.	7	N. E.	2.00	6.00	Started off East Gap.
					8	E. by N.	2.00	6.30	" Kew.
					20	N. E.	0.75	1.30	" Victoria Park.
May	18th	4 S. W.	8 E.	Calm.	8	W.	1.60	6.30	" Victoria Park. (Grounded.)
					6	W.	0.75	3.00	" Woodbine.
					8	N. E.	0.85	3.00	" East Gap in a.m.
					8	N. by E.	0.25	3.00	" " p.m.
					8	W.	0 25	3.00	" " p.m.
					20 ft. & Surface.	N. E.	0 30	3.30	Woodbine. Floats kept close together.
May	19th	1 S.	8 S. E.	5 S. W.	8ft. 0in.	N. E.	0.75	6.30	Started west side of Island south of High Park.
					8 0	N. W.	0.25	2.00	" " "
					8 0	E.	1.75	6.00	" " "
					8 0	S. S. W.	0.57	4.20	" off Humber.
					8 0	S. S. W.	0.37	5.00	" "
May	20th	4 S.	22 N. E.	15 N. W.	8 0	S. E.	1.60	5.00	" in harbor off Queen's Wharf.
					8 0	S. by E.	1.10	6.00	" Yonge Street.
					8 0	S. E.	0.85	8.00	" "
					6 0	S. E.	2.25	9.00	" Church Street. Ran out E. Gap.
					10 0	E. by S.	1.25	4.00	" Victoria Park.
					8 0	E.	0.65	3.00	
					8 0	S. E.	0.75	1.50	
					20 0	E.	2.50	8.00	" East Gap.
					20 0	E.			" at Victoria Park. Picked up on 21st about 6 miles East of Victoria Park.
May	21st	4 E.	6 S. E.	6 N. E.	8 0	W. by S.	0.18	4.00	Started at intake crib.
					20 0	N.	0.23	4.30	" 1 mile south of East Gap.
						E.	0.23	2.00	
					20 0	S. E.	0.12	3.30	" 1½ do. do.
						N. E.	1.10	3.00	
May	22d	3 W.	7 N. W.	7 N. W.	6 0	N. N. E.	0.55	4.30	" 1 mile east of Gap.
						S. S. W.	0.94	1.30	
					22 0	S. W.	0.20	2.10	" Victoria Park.
						S by E.	0.48	2.10	
					8 0	N. W.	0.50	4.30	" Woodbine. (Grounded.)
May	24th	16 N. W.	9 S. W.	8 N. W.					Queen's Birthday.
May	25th	22 N.	28 N. W.	12 W.	8 0	S. E.	0.33	2.00	Started at west W. W. Buoy.
						S.	0.60	3.00	
					8 0	S.	1.00	1.50	" near intake crib.
					8 0	S. to S. E.	1.60	2.00	" back of Hanlan's Hotel.
						W. by S.	0.27	3.30	
					6 0	S.	0.40	4.00	" S. side of Island, line of Yonge Street produced.
						S. E.	1.32		
					20 0	W. by N.	0.60	5.00	" 1½ miles south of East Gap.
May	26th	9 N. W.	26 W.	5 S. W.	8 0				" off Victoria Park in shoal water. These floats went eastward, but in consequence of the long and small angles taken to fix them, their location cannot be accurately determined. in. dec. H. Min. (1 float plotted) 1 10 in. 3 15
May	28th	5 N. W.	13 S.	6 S. W.	10 0	N. E.	0.50	2.00	" near intake crib. (Grounded.)
					8 0	N. E.	0.60	2.00	" W. Water Works buoy. (Grounded.)
					8 0	N. E.	1.75	6.30	" ½ mile south of Lighthouse.
					22 0	N. E.	0.60	4.15	" ¾ do.
					6 0	N. E.	0.75	3.00	" S. E. side of Island.
					20 0	N. E.	2.25	7.10	" 1 mile S. East Gap.
May	31st	10 S. W.	29 S.	2 S.	20 0	E.	0.75	6.20	" off Kew.
					10 0	W. by S.	0.25	6.00	" at East Gap. (Grounded.)
					8 0	N. E.	0.15	6.45	" inshore S. side Island, near Lighthouse.
						S. W.	0.25	3.30	
					20 0	E.	0.40	1.20	" Water Works east buoy.

TORONTO, 12TH JUNE, 1886. (Signed) ALAN MACDOUGAL.

APPENDIX B.

TABULATED STATEMENT OF CURRENT OBSERVATIONS MADE FROM THE 1ST TO THE 18TH OF JUNE, 1886, IN THE HARBOR, ON THE SOUTH SIDE OF THE ISLAND, AND BETWEEN THE EAST GAP AND VICTORIA PARK.

					[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Grounded off Woodbine.
					8	0	N.E.	0.72	5	00	Of Vic. Park mouth of sewer in shore.
					40	0					Off mouth of sewer in 42 ft. of water. (Grounded.)
June	11th	12 N.	8 S.	6 N.W.	20	0	S.	0.25	5	25	Off E. Gap.
					10	0	N.E.	1.60	6	00	do.
					30	0	S.W.	0.15	4	00	do. Line of Leslie Street. (Grounded).
					30	0	S.	0.08	3	30	do. do. do.
					30	0	S.	0.13	6	00	Off Woodbine.
					6	0	N.	0.18	5	00	Off East Gap. (Grounded.)
					8	0	N.W.	0.21	2	00	Off Kew.
June	17th	2 N.	12 S.	30 N.W.	20	0	S.W.	1.90	About 48 hours.		Put in June 15th near East Gap, picked up off S. side of Island.
					40	0	S.W.	3.28	do.		Put in June 15th, South of Woodbine, picked up 2 miles S. of East Gap.
					20	0	S.W.	0.60	3	45	Put in 2 miles S of Island.

TORONTO, 22ND JUNE, 1886.

(Signed) ALAN MACDOUGAL.

APPENDIX B.

TABULATED STATEMENT OF CURRENT OBSERVATIONS MADE FROM THE 1st TO THE 18th OF JUNE, 1886, IN THE HARBOR, ON THE SOUTH SIDE OF THE ISLAND, AND BETWEEN THE EAST GAP AND VICTORIA PARK.

Month.	Date.	Mean Velocity and Direction of Wind.			Depth of Float.	Direction taken by Float.	Distance traversed in Miles.	Time in Hours & Mins.		Location and Remarks.
		7 A.M.	3 P.M.	11 P.M.						
June	1st	10 N.	9 N.	8 S.	12ft. 0in.	W. by S.	0.40	5	30	South side of Island (in line Jarvis Street), grounded.
					8 0	do.	2.10	5	00	South side of Island (in line Jarvis Street), grounded.
					12 0	do.	0.93	5	45	South side of Island (line of Yonge Street).
					6 0	W. by S. then N.W.	2.90	6	30	South side of Island (line of Yonge Street), followed South side of Island and picked up in Bay opposite Exhibition Buildings.
					20 0	E.	0.05	1	00	Harbour Commissioners' spar buoy W. side Island. (Grounded.)
						N.W.	1.00	4	20	The same buoy lifted and refloated.
June	2nd	3 E.	4 S.	12 N.W.	10 0	W.	1.52	4	10	S. of Island near Water Works crib.
					10 0	W.	1.22	4	00	
					15 0	W.N.W.	0.63	4	00	Harbour Commissioners' buoy.
					10 0	W. by N.	0.48	4	10	East Gap.
June	3rd	11 W.	15 N.W.	10 W.	11 0	N.	0.55	3	5	Off Ashbridge Bay (line of Leslie Street).
					9 0	E.	0.82	3	40	
					9 0	E.	1.52	7	00	Near E. Gap.
					9 0	E.	1.52	4	25	At mouth of sewer, shoal water.
					24 0	N.E.	0.78	5	5	Off mouth of sewer, deep water.
June	4th	2 W.	15 S.	5 S.	8 0	W.	0.05	4	00	Ashbridge Bay (off Lake Street) shoal water, grounded.
					8 0	N.E.	0.72	4	00	Near E. Gap. (Grounded.)
					15 0	N.	0.25	4	00	do. do
					10 0	N.	0.26	4	00	do. do. (old boiler).
					24 0	N.N.W.	0.93	5	50	S. W. corner of Island.
					24 0	S. by W.	0.25	5	35	do. do.
					10 0	E.	0.30	5	00	Off Fort.
June	5th	3 E.	28 W.	12 N.W.	10 0	S.W.	0.88	3	40	Near E. Gap (old boiler.) (Grounded.)
					10 0	S.E.	0.89	2	30	Off E. Gap.
					6 0	N.E.	0.80	2	30	do. (Grounded.)
					10 0	W.	1.60	7	45	Off E. Gap.
					8 0	N.	0.32	2	20	Off Ashbridge's Bay. (Grounded.)
					10 0	N.	0.25	2	20	do do.
					40 0	N.W.	0.20	5	35	S. of Island.
					20 0	N.W.	1.05	6	00	do.
					8 0	N.W.	1.92	6	00	do.
June	8th	10 W.	8 S.	4 W.	10 0	E.	0.62	5	50	Off E. end Queen's Wharf (took Windmill Line).
					10 0	N.E.	0.70	5	30	Off E. end Queen's Wharf (picked up end Water Works wharf).
					10 0	N.E.	0.70	5	30	do. do. do.
					6 0	N. by E.	0.45	5	00	Off Hanlan's.
					10 0	E. then N.E.	0.62	3	10	S. of G.T.R. station near R.C.Y.C. house.
					10 0	E.	0.10	2	40	E. Gap. (Grounded.)
					6 0	S.E.	0.42	4	00	E. Gap.
					25 0	N.W.	0.10	2	00	E. Gap. (Grounded.)
					8 0	N.W.	0.57	2	40	E. Gap off Ward's. (Grounded.)
June	9th	1 N.	6 S.	3 E.	8 0	W.	0.60	2	00	Off West end Queen's Wharf. (Grounded.)
					10 0	W.	0.30	2	00	do. do. do.
					8 0	W.	0.60	5	00	S. of Old Fort.
					6 0	W.	0.60	5	00	E. Gap.
					8 0	W.	0.40	5	00	do.
					12 0	S.W.	0.32	5	00	S. of E. Gap.
					10 0	N.W.	1.00	Out all night.		S. of G.T.R. station. (Grounded.)
June	10th	4 N.W	3 S.	12 N.W.	6 0	W.	0.60	8	15	Inside of E Gap. Harbor buoy.
					6 0	S.E.	0.70	8	00	Outside do. do.
					20 0	N.	0.12	4	30	do. do. (Grounded.)
					20 0			5	00	Off Woodbine (picked up in fog near Victoria Park).
					10 0	E.	0.15	5	00	Grounded off Woodbine.
					8 0	N.E.	0.72	5	00	Of Vic. Park mouth of sewer in shore.
					40 0					Off mouth of sewer in 42 ft. of water. (Grounded.)
June	11th	12 N.	8 S.	6 N.W.	20 0	S.	0.25	5	25	Off E. Gap.
					10 0	N.E.	1.60	6	00	do.
					30 0	S.W.	0.15	4	00	do. Line of Leslie Street. (Grounded).
					30 0	S.	0.08	3	30	do. do. do.
					30 0	S.	0.13	6	00	Off Woodbine.
					6 0	N.	0.18	5	00	Off East Gap. (Grounded.)
					8 0	N.W.	0.21	2	00	Off Kew.
June	17th	2 N.	12 S.	30 N.W.	20 0	S.W.	1.90	About 48 hours.		Put in June 15th near East Gap, picked up off S. side of Island.
					40 0	S.W.	3.28	do.		Put in June 15th, South of Woodbine, picked up 2 miles S. of East Gap.
					20 0	S.W.	0.60	3	45	Put in 2 miles S of Island.

TORONTO, 22nd JUNE, 1886.

(Signed) ALAN MACDOUGAL.

TABULATED STATEMENT OF CURRENT OBSERVATIONS OFF VICTORIA PARK, MADE OCTOBER 22ND AND OCTOBER 30TH, 1888, WITH FLOATS, BY MR. ALAN MACDOUGALL.

DATE.	WIND.	DEPTH SUBMERGED	TIME LAID.	TIME PICKED UP.	DRIFT.
Oct. 22nd.	Light easterly.	30 ft.	11.00 A.M.	2.40 P.M.	½ mile east.
do	do.	50 ft.	10.30 A.M.	3.00 P.M.	¾ mile east.
Oct. 30th.	Very light west.	Surface.	11.40 A.M.	1.45 P.M.	¾ mile east.
do	do.	50 ft.	12.00	2.45 P.M.	¾ mile east.
do	do.	70 ft.	12.10 P.M.	3.10 P.M.	½ mile east.
do	do.	100 ft.	12.15 P.M.	3.15 P.M.	200 yds. west.

REMARKS.—The floats were made of wooden frame, cross shaped with arms 4 feet by 15 inches deep, covered with canvas.