TORONTO WATER WORKS

REPORT

ON PROPOSED

ENLARGEMENT AND IMPROVEMENTS

BY

E. H. KEATING

CITY ENGINEER

TORONTO:

THE CARSWELL CO. LTD., CITY PRINTERS, 22, 24 ADELAIDE STREET EAST.

30TH OCTOBER, 1893.

REPORT ON PROPOSED NEW CONDUIT AND IMPROVEMENTS IN SUPPLY.

CITY ENGINEER'S OFFICE,
Toronto, June 11th, 1894.

To the Chairman and Members of the Committee on Works:

GENTLEMEN,—The following letter was received from the Committee on the 8th March last:

E. H. Keating, Esq.,
City Engineer, Toronto.

DEAR SIR,—At the meeting of the Committee yesterday the report presented by you and the Medical Health Officer was under consideration. Several of the members of the Committee were strongly of the opinion that a cast iron 6-ft. pipe across the bay would answer all the purposes required for the obtaining of a pure supply of water. The Committee desire that you will report:

1. On the cost of the 6-foot cast iron pipe from the intake to the well.

2. On the cost of a 6-foot cast iron pipe from Hanlan's Crib to the well.

3. The cost of a 6-foot steel pipe over the same sections.

4. The cost of the tunnel scheme as proposed, with an extension of pipe to the intake.

Yours truly,

ARTHUR H. CLARKE,
Secretary Committee on Works.

In order that the matter may be clearly understood, I append hereto a copy of the letter referred to, from the Medical Health Officer and myself, and in compliance with the request of the Committee the estimates asked for are given below. I may state that in preparing these estimates provision has been made for the increased expenditure which will be necessary in order to meet the requirements of the Harbour Board for anchorage, so that the conduit may safely be emptied for the purpose of examination and for sufficient covering to avoid the liability of the conduit being damaged by vessels. One item which will add very largely to the cost of laying any new conduit across the harbour is that of rock excavation under water, of which it is estimated that there will be about 4,700 cubic yards. The following are the estimates for which the Committee have asked:

1. The estimated cost of a 6-foot cast iron pipe from a new intake to the pumping well is	$560,000 00
2. The estimated cost of a 6-foot cast iron pipe from Hanlan's Crib to the pumping well is	240,000 00
3. The estimated cost of a 6-foot steel pipe over the same sections is as follows:	
For 6-foot steel pipe from a new intake in the lake to the pumping well	518,000 00
And from Hanlan's Crib to pumping well	237,000 00
4. The estimated cost of the tunnel scheme, as previously recommended, with an extension of pipe to the new intake, is	525,000 00

It must be clearly understood that any scheme involving a new conduit from the pumping station to Hanlan's Point or Hanlan's Crib will be incomplete in itself, and that further expenditures are necessary owing to the insufficient depth at which the existing 5-foot steel pipe has been laid through "the cut" across Toronto Island. The top of this pipe at one point lies at the level of low water in the lake, and for several hundreds of feet it is only six inches below the same level. It will therefore be seen that unless this defect is remedied, or some means are adopted towards augmenting the supply, the City is liable to be short of water at times when Lake Ontario may approach its lowest level, or if the consumption of water should increase. This pipe cannot now, while it is in use, be lowered without running the risk of damaging it seriously, and as the whole water supply of the City is at present drawn through it, a break would result in the serious contamination of the supply both by large quantities of sand and bay water. It appears, therefore, almost superfluous to emphasize the importance of providing, with the least possible delay, some means not only of conveying the lake water securely and uncontaminated across Toronto harbor, but also of insuring a full supply, which, under existing circumstances, cannot be relied upon at times when the lake may happen to fall to a low level.

Respectfully submitted,

E. H. KEATING,
City Engineer.

WATER WORKS IMPROVEMENT AND PROPOSED TUNNEL.

Referring to the communication from the Committee of the 19th June last, having reference to my letter to His Worship the Mayor of the 6th June, 1895, action upon which was deferred in order that a report might be submitted dealing with the whole matter, I have the honor to report as follows:

Proposed Tunnel and New Steel Conduit.

The borings across the harbor having been completed, and all necessary information with reference to the material to be passed through having been obtained, I have had the accompanying plan prepared showing the best position for the tunnel, which would commence at a point on the Water Works property about 60 feet south of the existing Pumping Station, where a 10-ft. shaft would be sunk to a depth of 138 feet 3 inches below zero level of the Lake. The tunnel would then be constructed at a similar level in a southerly direction under the harbor for a distance of 5,820 feet to a point near Mugg's Landing, where the terminal or inlet shaft would be sunk, to which a new steel conduit would be connected at a depth of about 12 feet below zero level.

It is proposed to make the tunnel 6 feet 6 inches in width by 6 feet 6 inches in height, the cross-section resembling a horseshoe, as will be seen by reference to the plan. It is also proposed to sink a shaft from the surface down to the tunnel at a point in the Bay 3,100 feet from the Pumping Station shaft, or nearly midway between the inlet or terminal shaft and the Pumping Station shaft, with the object of facilitating the work and shortening the time of construction.

The result of the borings shows that shale rock will be struck at the Pumping Station shaft at a depth of about 16 feet below the surface of the ground, at a depth of 42 feet below zero level at the centre shaft, and at a depth of 65 feet below zero at the inlet shaft. The whole length of the tunnel will be through shale rock, and it has been placed at such a depth as to avoid, as far as possible, any water bearing seams which are found to exist in some places at higher levels. All the water bearing seams crossed in the boring operations were found to contain mineral water, showing that they have no connection with the Bay.

The shafts where they pass through sand and for a short distance into the rock are proposed to be constructed of cast iron or steel. Through the rock they will be lined with brick and concrete, and the tunnel is proposed to be lined in the same manner. Sumps will also be provided at the bottom of each shaft, so as to admit of the tunnel being emptied at any time, and the drainage of the tunnel is provided for by constructing a channel at a sufficient gradient along the bottom, having a fall towards each shaft.

It is also proposed, in connection with this work, to lay an entirely new steel conduit pipe, 6 feet in diameter, from the inlet shaft at Mugg's Landing to the north end of the existing 6-ft. steel conduit at the bell-buoy crib, to which it will be securely and tightly connected. The southern end of this conduit, from the

connecting crib on the Island to the bell-buoy crib, will replace the existing 6-ft. wooden conduit, to which special attention has been previously drawn, and for which an appropriation of $75,000 was recently asked. This portion of the new intake pipe should be the first part of the work done, as it is necessary in order to get rid of the sand which at present is causing so much inconvenience and expense. It is proposed to lay the new steel conduit on a descending gradient from the Lake shore to the inlet shaft, and at a sufficient depth to provide for the delivery of over 40,000,000 gallons of water at the Pumping Station, the tunnel being designed to deliver about 75,000,000 gallons, with the pumping wells drawn down to 9 feet. Provision will be made at the inlet shaft for an additional 6-ft. steel pipe being connected therewith at any future time when the demand for water may exceed the capacity of the proposed new steel conduit. Provision will also be made for emptying and examining the new steel conduit between the Lake shore and the inlet shaft. Southwardly from the Lake shore, it is not practicable to make this provision without going to very considerable and unnecessary expense. It is intended that the new steel conduit shall be covered and the filling carried up to the general level of the Island, so as to prevent any possibility of its being damaged or of its rising when it may be necessary to empty it for the purpose of examination.

It is also proposed to lay a new 5-ft. steel connecting pipe from the new steel conduit, at a point near the inlet shaft to the existing 5-ft. steel conduit at a point nearly opposite Heber's landing, the object being to enable the supply to the City to be maintained through the existing conduits across the harbor at any time when it may be deemed advisable to pump out or examine the tunnel.

The estimated cost of the whole of the above works, which include the tunnel and shafts, the new 6-ft. steel conduit from the inlet shaft to the bell-buoy crib, the necessary connections from the discharge shaft to the pumping wells, the special 5-ft. connection between the new conduit and the present 5-ft. pipe, the necessary valves, cribs and manholes and all other work in connection with this undertaking, is $540,000, which is $15,000 above the original estimate, when it was contemplated to construct the tunnel via Hanlan's Point. This difference in cost is due chiefly to the increased length of the tunnel under the new scheme and the additional shaft in the Bay.

In preparing this estimate the prices paid for similar work in New York, Chicago, Milwaukee and Rochester have been referred to, and it is thought that ample allowance has been made to cover all contingencies.

E. H. KEATING,
City Engineer.

September 6th, 1895.

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30TH OCTOBER, 1893.

CITY ENGINEER'S REPORT ON PROPOSED ENLARGEMENT AND IMPROVEMENTS IN THE TORONTO WATER WORKS.

CITY ENGINEER'S OFFICE,
Toronto, October 30th, 1893.

To the Chairman and Members of the Committee on Works:

GENTLEMEN,—On the 30th January last, the Water Works Committee was abolished, and the management of the works was transferred to this Department.

The Minute of Council bearing upon this subject contains, among other things, the following instructions, viz.:

"It is further recommended that the City Engineer be instructed to make a thorough inspection of the Water Works system and machinery, and report at the earliest moment needed additions, alterations, etc., and the cost thereof, or any portion thereof, as he may deem necessary, for the purpose of placing the amount in the estimates for the year."

At the time these instructions were issued the affairs of the Water Works Department were known to be in a bad condition. The conduit, which was intended to convey the water from Lake Ontario to the Main Pumping Station, had only a few weeks previously met with a disastrous accident. Long sections had risen to the surface and broken in several places, while portions still remained projecting above and embedded in the ice in Blockhouse Bay and Toronto Harbor. The lake water being thus cut off, the entire water supply of the city was being drawn directly from the sewage polluted harbor, and as a natural consequence sickness was prevalent throughout the City, typhoid fever threatened to become epidemic, and a general state of alarm and uneasiness existed among the citizens.

Under these circumstances, I considered my first and most imperative duty was to devote special attention to repairing and replacing the damaged conduit and to search out the weakest and most dangerous points in the system, with the view to effecting a remedy and restoring confidence in the safety of the water supply for ordinary use, if possible. This, I think, has now been partially accomplished, and it is my only excuse for the delay which has occurred in presenting this report.

I have already made several reports and recommendations, the carrying into effect of which will be to increase the pumping capacity and to improve the character of the works; but as most of these recommendations have already been adopted and funds provided, it is unnecessary that I should refer to them here.

I find, however, that the impression appears to be general among the aldermen that I am expected to enquire into and report upon the whole question of our future water supply.

The only instructions I have on this subject are contained in a resolution of Council passed on the 13th February last, of which the following is a copy, viz.:

"Ald. Davies moves that the City Engineer, while considering the question of our future water supply, be instructed to report as to the advisability of securing a pure supply of water by gravitation from Scarboro Heights, and also as to the cost of removing the pumping plant to the lake front at that point, with the necessary mains to connect with the present system."

The consideration of the question of the future water supply of the city involves a study of the various projects which have at different times been brought forward, each of which has its advocates and most of which have recently been discussed to some extent either in the papers or at public meetings.

Two or three offers, I understand, have been made by different persons or syndicates to supply water to the city for a stipulated price per 1,000 gallons, delivered either into the existing mains, at some defined point, or into Rose Hill Reservoir, or a new reservoir to be hereafter constructed; but I have no positive or official knowledge regarding the details of these proposals, as they were not submitted to me.

I may, however, say with regard to all proposals of this kind, that in my opinion, the public interests demand that the control of the entire water supply of the city, in all its bearings and details, should be vested in, retained and jealously guarded by the municipal authorities.

The following is a list of the various schemes proposed, so far as they have come under my notice:

1. From Lake Ontario, in the vicinity of Scarboro.
2. From Lake Ontario, in the vicinity of Mimico.
3. From the Oak Ridge Lakes and the Rivers Don and Rouge (by gravity).
4. From Lake Simcoe.
5. From wells sunk in the gravel beds north of the city.
6. From springs and artesian wells in the Township of Erin.
7. From the vicinity of the present intake.

In order to dispose of the matter, as far as I am concerned, I propose briefly to refer to each of these projects, which I will take seriatim:

I.—From Lake Ontario, in the Vicinity of Scarboro.

This scheme would involve laying at least one new large main about 6½ miles in length to connect with the existing system; the construction of new wharves and buildings at Scarboro; moving the present high duty pumping plant to that point, and probably the erection of an additional ten-million gallon engine, besides involving a new and large intake pipe or conduit, which would require to be over two miles in length, if it is desired to draw the water from the same depth as at the present intake, which is seventy-five feet below the surface. In preparing the estimates, however, I have provided for the intake to be placed at a depth of only sixty feet, which would probably be sufficient. By this means the lake conduit could be shortened to 9,000 feet. At present prices $1,000,000 is a moderate estimate for completing this scheme on the above basis, so as simply to connect with the existing system and allowing for the new main to be forty-two inches in diameter, which is as small as it should be.

If a hundred million gallon reservoir at Scarboro is to be added—as apparently required under Ald. Davies' resolution—in order "to obtain a supply by gravity from that point," the above estimate would have to be very largely increased. The amount of this increase I am not at present in a position to state, because I am not in possession of sufficient information regarding the topography of the country, the most suitable site for the reservoir, and the character of the sub-soil, to warrant my making any estimate. It was my intention to have these matters thoroughly looked into, but the appropriation at my disposal was not sufficient to cover the cost of the investigations necessary. I may say, however, that Messrs. Hering & Gray, who in 1889 investigated and reported upon a scheme for obtaining the water supply from the vicinity of Victoria Park, estimated the cost of a 100-million gallon reservoir on Wells' Hill (with the necessary connections) at $305,000, and it is not likely that a similar reservoir at Scarboro would cost less.

Under existing conditions I do not think it advisable to draw the water supply of the City from the vicinity of Scarboro or Victoria Park for the following chief reasons, viz.:

1. The exposed position and unsuitable character of the shore for the establishment of a pumping station and wharves.

2. The great length to which it would be necessary to lay the suction pipe or conduit in the lake, in order to reach a suitable depth.

3. The turbid character of the water in the spring, which is reported on good authority to extend southwardly into the lake two miles.

4. The risk and uncertainty of being able to construct a tight reservoir, within a reasonable cost, in the sandy and gravelly soil on the heights in that vicinity, in the event of such a reservoir being needed.

I might also remark that this scheme, if adopted, would not be likely to prove satisfactory unless a new reservoir, having a capacity of at least one hundred million gallons, is constructed at Wells' Hill, or somewhere in that neighborhood, and that there does not at present seem to be any great advantage to be gained by pumping the water into a reservoir at Scarboro.

II.—From Lake Ontario, in the Vicinity of Mimico.

I am not aware of this scheme ever having been thoroughly investigated and recommended by any water works engineer.

My investigations have been confined to a partial inspection of the shore and lake in the early spring and a drive over the country along or near the probable route of the rising main.

The prospect did not appear sufficiently inviting to justify much further attention to this project. The water for a long distance from the shore (probably from two to three miles) appeared to be riled and dirty. From this I should infer that the shallow water extends out quite as far, if not further, than off Scarboro, and that the lake conduit would consequently have to be a very long one. The length of main required would be considerably greater than the main from Scarboro; a new and large reservoir at or about Wells' Hill would also be needed, and the required crossing at the River Humber would be likely to prove a costly feature.

While I have made no estimate of the costs of this scheme, I think it probable that it would largely exceed the Scarboro project, and that it is less favorable in other respects. I therefore do not advise its adoption.

III.—From the Oak Ridge Lakes and the Rivers Don and Rouge (by Gravity).

This project was reported upon in 1887 by Messrs. McAlpine & Tully, who strongly advocated its adoption.

In a comparison of costs with pumping water from Lake Ontario, they show an enormous annual saving in its favor.

Taking daily supplies of twelve, twenty, thirty and fifty millions of gallons as bases for their calculations, they give the following results:

Daily Supply.	Total Cost of Works.	Annual Cost (by Gravity).	Annual Cost (by Pumping).	Annual Saving Effected by Adoption of Gravity Scheme.
Gallons.	$	$	$	$
12,000,000	310,102	32,404	83,120	50,716
20,000,000	490,700	44,628	161,787	117,159
30,000,000	873,000	65,012	227,320	162,308
50,000,000	1,380,330	95,213	376,387	281,174

With regard to these figures I have only to say that in my opinion they will not stand close scrutiny. The cost of construction of the gravity works appears to have been underestimated, while the cost of pumping, under ordinary conditions, has clearly been overstated. Persons desirous of enquiring more fully into these matters are referred to the report itself and to the appendix attached to this report.

The report states that "when the demand for water shall have reached thirty millions of gallons a day, the annual saving by the gravity plan would be $162,308, and for fifty millions, $281,174, sufficient in each case to repay the whole cost of the gravity works in less than six years."

The concluding paragraph is, however, the most important one to be found in the whole report. It is as follows:

"In conclusion, we have to state that our preliminary examinations have shown that an abundant supply of pure and wholesome water for any possible future demand can be obtained from the districts herein described; that it can be delivered at the same or considerably greater elevation than the Rosehill Reservoir, at a cost, the annual interest of which, including the expense of management and renewals, will be so much less than the expense of furnishing an equal quantity by pumping, that the saving in considerably less than ten years will be equal to the whole cost of the proposed gravity works."

After a careful perusal of the report and a partial inspection of the district under consideration, I regret that I feel compelled to differ and entirely dissent from the views, estimates and conclusions arrived at by the engineers who prepared the report.

Chemical analyses and ordinary observation show that the water supply from a large part of the district is impure and unfit for domestic consumption, and in my opinion it cannot be purified and utilized without entailing enormous and unjustifiable expense, far beyond the estimates. I do not believe that the scheme, if carried into effect, would prove satisfactory, and I advise its rejection.

IV.—From Lake Simcoe.

This scheme having been pretty thoroughly looked into in past years and specially reported upon by Messrs. Hering & Gray in 1889, and by a Committee of the City Council in 1891, I did not feel myself justified in incurring any expense in undertaking further detailed investigations. I have, therefore, after examining the different reports, confined myself to a visit to the locality, a sail over a portion of the lake and a cursory examination of the points from which it has been proposed to draw the supply.

Messrs. Hering & Gray estimated the cost of the completed scheme to be "at least $7,711,325," exclusive of land damages. What the additional costs of these damages would be is an unknown quantity.

There are many advocates for this project, some of whom, I believe, claim that the cost has been greatly overestimated, and that there are ways and means by which the estimates may be reduced. I have not attempted to examine critically into these differences, not only because such an examination would involve an expenditure which I had no means of meeting, but because the engineers who made the surveys and estimates are competent experts in whom every confidence can be placed.

Without going further into the matter, it is sufficient to know that the pipe line is about forty-six miles in length, and that ten miles of tunnelling are required, in order to conclude that the cost must necessarily be enormous, and that, even supposing the estimates can be largely reduced, the project, for the present and under existing circumstances, is impracticable.

I should, perhaps, add that the chemical analysis of Lake Simcoe water shows it to be greatly inferior to that of Lake Ontario, so that, even assuming that an economical scheme for bringing Lake Simcoe water to the City could be devised, it would still be inadvisable to adopt it when a better and purer supply lies at our doors.

V.—From Wells Sunk in the Gravel Beds North of the City.

I understand that there are two rival companies interested in this project, but as their proposals are not in my possession I am unable to refer to them. I may, however, say that I visited North Toronto in company with some of the projectors in April last, with a view to gaining some knowledge of this source of supply.

I was shown the North Toronto pumping station, and an excavation in the gravel about a quarter of a mile distant therefrom, from which a small stream of water was flowing.

The North Toronto pumping station is supplied from a well adjoining, about 18 feet in diameter and 24 feet in depth, the normal depth of water in the well being about eight feet. The total daily consumption was stated by the engineer in charge to be about 8,000 gallons. This quantity of water is raised in abou two and a half-hours, and lowers the water in the well about four feet.

There is no other water visible except what I have mentioned above. The theory of the promoters is that there is an immense undergrcund flow from Lake Simcoe through the gravelly subsoil, and that it can be advantageously tapped by means of driven wells in the vicinity referred to, and thence drawn off by gravity to the City after being raised by pumps to the surface.

I am not in a position to deny the existence of the underground river, but considering the expense that would be involved in making satisfactory tests, the uncertainty as to the supply in any large quantity holding out, and the extreme improbability of being able to obtain anything approaching the required quantity of water from this source, coupled with the fact that it would still require to be pumped, I think I am justified in concluding that the outlook does not seem sufficiently encouraging to warrant further consideration of this project.

Since writing the above, I have ascertained that there is now very little water in the well referred to, and that it can be pumped dry in about ten minutes.

VI.—From Springs and Artesian Wells in the Township of Erin.

This locality was visited early in April. Its height above Lake Ontario is about 1,000 feet, and its distance from the centre of the city in a direct line is about 36 miles. Three or four flowing springs of exceptionally clear and sparkling water were pointed out. It was subsequently learned that this water is as exceptionally hard as it is bright. Mr. Vanderlip, who first called attention to this source of supply, also pointed out the locality of a bore-hole in the same vicinity, which had been sunk in prospecting for oil some years previously. He stated that no oil was discovered, but that at a depth of 80 or 90 feet the boring tool suddenly dropped about eight feet, and that water immediately rushed to the surface. The bore-hole is not now accessible, as it has long since been filled in and ploughed over, and nothing is to be seen except a puddle of water in a field to mark the spot.

The prospects of obtaining a considerable quantity of water from this locality appear greatly better than at North Toronto, but if it should prove to be as hard as that flowing from the springs in the same locality (which seems probable) it would be unfit for general use.

Under such circumstances, and considering the enormous expense which would have to be incurred in bringing the water so great a distance, I fear the project cannot be seriously entertained.

VII.—From the Vicinity of the Present Intake.

After looking into all the possible sources of supply—so far as they are known to me—the conclusion I have reached is that Lake Ontario can be relied upon

to furnish better water than can be obtained from any other quarter within reach, and that it is the proper reservoir from which to draw the supply.

I am also of opinion that the position of the present intake was wisely selected, and that the future water supply can be obtained from the same vicinity, not only to best advantage, but that the difficulties and expense which would be involved in making any radical change are so great that it would be unwise to go elsewhere.

The question of the disposal of City sewage naturally presents itself in connection with any scheme for drawing the water supply from Lake Ontario.

While it cannot be denied that all fæcal matters ought properly to be returned to the earth from which they have their origin, and that, theoretically, it is wrong in principle and dangerous to discharge sewage into the same body of water from which water may be drawn for domestic use, yet it is well, and in fact we are forced to look at this question from a practical standpoint.

This leads to the enquiry as to how far and to what extent injurious effects are to be feared from a continuance of the practice, assuming of course that ordinary safeguards are adopted.

If we take a hasty glance at our own case as it has existed ever since the foundation of the City, we find that Toronto, up to the present time, has continued to pour its crude sewage into the bay in front of its own doors, and for a long period pumped its drinking water directly from the same bay. We find to-day that the bulk of the sewage of 200,000 people is discharged into the same water from which the domestic supply is drawn, and within a radius of three miles from the Water Works intake, and yet chemical and bacteriological tests show that the water at the intake is practically pure and wholesome. The health of the City also corroborates the correctness of these tests.

If we look a little further, the case appears still more striking when we consider the millions of human beings residing on the shores of the great lakes and on the rivers emptying therein, all of whom pour their sewage and waste products into the same waters, which receive also the drainage from hundreds of thousands of acres of cultivated lands with all the accompanying impurities from freshly manured fields, barn yards, privies and millions of cattle.

The inference to be drawn is that all such foul matters, within certain limitations, decompose and undergo a process of self-purification after being discharged into a large body of fresh water, and that beyond a certain distance from the point of pollution, no injurious effects are to be traced or feared. What that precise distance is has never been definitely or satisfactorily determined so as to admit of direct calculation or the application of any standard rule. Each separate case requires special investigation and careful study, as local conditions must of necessity be considered.

Among the most recent investigations on this subject with which I am acquainted are those which were carried on in the town of Zurich, in Switzerland, containing, with its suburbs, about 100,000 inhabitants. The average delivery of sewage from the town is stated to be 4,400,000 gallons, and the maximum 11,000,000 gallons per day. This sewage is discharged into the River Limmet, which is about 98 feet in width and 6½ feet in depth, with an average

daily flow of about 2,000,000,000 gallons, and a mean velocity of about four miles per hour. The conclusions arrived at in this case were as follows :

"1. "That 96 per cent. of the precipitation takes place within 0.3 mile below the sewage outfall.

2. "That within six miles of the sewage outfall the number of bacteria falls to the number immediately above that point.

3. "That the greater the volume and velocity of the river, the slower is the rate of self-purification.

4. "That so far as concerns the sewage, the rate of self-purification is not influenced by meterological changes.

5. "That under the conditions described, and provided there are no intermediate sources of pollution, a river such as the Limmet, flowing at the mean velocity of about four miles per hour, will purify itself within a distance of about sixteen miles from the point of pollution."

I have dwelt rather fully upon this subject, in order to show that providing the city sewage is discharged into the lake at a sufficient distance from the Water Works intake, no injurious effects need be anticipated. What the safe distance is remains a matter for further investigation, and it is a question which must before long receive attention if the city continues to increase in population, as it undoubtedly will.

At the present time the water supply is drawn from Lake Ontario, at the bell-buoy crib, at a depth of twenty-one feet below zero level of the lake; the renovation of the 6-ft. steel pipe extension to a depth of seventy-five feet not being yet quite completed. The water flows through 2,357 feet of wooden conduit six feet in internal diameter to the shore crib on Toronto Island. Thence the water is conducted through a 5-ft. steel conduit to Hanlan's crib, a distance of 6,027 feet, and thence through a double line of pipes across the harbor, a distance of about 4,600 feet, to the Pumping Station, one pipe being of steel four feet in diameter, and the other cast iron, three feet in diameter.

The 6-ft. wooden conduit is partially filled with sand, but whether the sand finds its way through defective joints in this wooden conduit or not is at present uncertain. It is a difficult matter to determine beyond doubt what is the actual condition of this conduit, as the water supply cannot be shut off for a sufficient length of time to admit of examination.

The 5-ft. steel pipe also contains sand in some places, and it has, unfortunately, been laid so irregularly and at so high a level that it cannot be relied upon to furnish all the water required in the City at times when the lake may fall more than one foot below zero level, which sometimes happens.

The 4-ft. steel pipe across the harbor cannot safely be relied upon, owing to to its liability to damage by reason of its shallowness in some places, and also by reason of its exposed position in the bott m of the harbor across the ship channel, where it lies unprotected.

* Minutes of Proceedings of the Institute of Civil Engineers, Vol. CXI.

The 3-ft. cast iron pipe across the harbor is believed to be in perfect condition, but it is too small of itself to deliver all the water required in case of damage to the 4-ft. pipe.

Under these circumstances it becomes necessary to devise means whereby these defects may be overcome and the required water supply delivered at the Pumping Station with reasonable assurance that it will not suddenly be cut off, diminished or polluted, by reason of the lake falling to a low level or from accidents which are liable to happen at any moment.

Different methods have been proposed with the view to remedying these defects and lessening the risks, either partially or wholly, and others have suggested themselves after a study of the questions involved.

The following is a list of all these proposals and suggestions:

1. A new steel conduit across the Harbor.

2. A tunnel under the Harbor and Island and into the lake to a new inlet.

3. Pipes laid in a tunnel under the Harbor.

4. An auxiliary pumping station on the Island and forcing the water through the present conduits across the harbor to the pump-well.

5. Transferring the Main Pumping Station to the Island, and pumping the water through either the present conduits or through new pipes laid across the harbor.

6. The same as the above, only that the force main or mains should be carried across the western entrance to the harbor on a bridge.

7. A tunnel under the harbor and a new conduit across the Island.

I will briefly refer to each of these projects in the order in which they are given:

(1) A new steel conduit across the harbor would be largely open to the same objections as apply to the existing pipe, and does not wholly meet the case.

(2) A tunnel under the harbor and Island, carried out into the lake to a new inlet in deep water, would undoubtedly be an effective remedy, if practicable; but before any opinion could be formed on this subject, a complete set of borings would have to be made, and the investigations would prove tedious and expensive. The project would also be a very costly one, and need scarcely be considered when the same objects can be attained for far less money, as it is unnecessary to tunnel under the Island and risky to attempt tunnelling out into the lake anywhere in the vicinity of Toronto Island.

(3) Pipes laid in a tunnel under the harbor would also be an effective remedy, so far as danger from pollution by bay water is concerned, but the plan would prove an exceedingly expensive one, and does not meet all the requirements of the case.

(4) The idea of providing an auxiliary pumping plant on the Island was, I understand, first proposed in 1887 by Elias Rogers, Esq., who was then an Alder-

man. The scheme was investigated, reported upon and recommended by Messrs. Geo. C. Robb and John Galt in the same year, the sole object, apparently, being to provide some "temporary expedient" for increasing the water supply "until such time as a general and permanent system may be devised and carried out." The plan contemplated the erection of a tank or stand pipe at the Island crib and raising the water by means of a centrifugal pump, so as to create "an artificial head" of about twenty feet above the level of the lake at that point, with a view to forcing 22,000,000 gallons of water into the pump-well through the old wooden 4-ft. pipe in Blockhouse Bay and the 3-ft. iron pipe in the harbor, as these pipes were found to be inadequate. The estimated cost was stated to be $29,000; but the cost of operation is not given.

At the time the above report was made, the present 5-ft. and 4-ft. steel pipes from the Island crib to the City had not been laid, so that the necessity for such an auxiliary pumping plant for the purpose of increasing the supply no longer exists.

The scheme has, however, recently been revived, with the view not to increasing the delivery of the pipes, but to prevent the influx of polluted bay water in case of the pipes being leaky.

In regard to this scheme, I may say in the first place that the estimates of 1887 would be quite inadequate to cover the cost of the enlarged pumping plant which would now be needed, if a sufficient and constant head is always to be maintained to force the whole water supply through the existing conduits under pressure, and the annual cost of maintenance would be very considerable.

In the second place, a complicated state of affairs would be set up which might at any moment lead to disastrous results by the flooding of the engine houses at the Main Pumping Station. This is a danger which does not appear to have been considered in the original scheme, and to obviate which would involve considerable additional expense.

In the third place, I may say that the principle is wrong, and if carried out it would not, in my opinion, prove beneficial or satisfactory. Should leaks at any time be found to exist in the conduit through which the water was being forced, it would result in the waste of large quantities of fuel in pumping lake water into the bay and harbor. Common prudence and economy would require that the leaks should be found and stopped with the least practicable delay, so that after this remedy (which is necessary in any case) had been applied, there would be no further use for the auxiliary pumping station. The proposal, therefore, appears to me to be an absurd one.

(5) The scheme of transferring the Main Pumping Station to Toronto Island and pumping the supply through either the present conduits or through new pipes to be laid across the harbor, is open to the grave objection that in the event of serious leakage, a break, or accident to the force main under water, the entire water supply to the City might be suddenly cut off, and considerable time would necessarily be consumed in ascertaining exactly where the defects existed and in effecting repairs. This sole objection is too serious to warrant the adoption of any such scheme.

(6) The alternative project of placing the Main Pumping Station on the Island and carrying duplicate force mains across the western entrance on a bridge, at or near the Queen's wharf, might be seriously considered if the construction of a bridge of moderate height across the ship channel would be allowed. Such a bridge would undoubtedly be of very great service to the residents and to visitors of the Island, in addition to its affording the means of supporting the force mains and of rendering them easily accessible at all times. The centre span of the bridge would require to be about 400 feet in length across the channel, with long approaches both north and south.

The Harbor Commissioners have been communicated with on the subject. They will not sanction a pier in the centre of the channel, and they require clear head-room above the water level of 150 feet. This latter requirement renders the scheme impracticable, not only on account of the enormous expense of the structure that would be required, but also on account of the excessively heavy gradients that would be involved, which would render the bridge unserviceable for traffic.

(7) A tunnel under the harbor, coupled with a new conduit across Toronto Island and into the lake to a new intake, appears to me to be the best solution of the problem. It is also one of the cheapest and safest plans of any so far proposed, and I recommend its adoption. In my opinion it is unsafe to rely upon the existing conduits, for reasons which I have already explained, and *I advise that no time be lost in starting the works*, the construction of which will probably take two years.

Borings have been made at the Water Works wharf and at Hanlan's Point, for the purpose of ascertaining the nature of the material to be encountered. Shale rock was found at a depth of 13 feet below lake level (zero) at the pumping station, and at 55½ feet in depth at Hanlan's Point. The rock generally is firm and solid, but is of such a nature that the tunnel would require to be lined throughout its whole length, which is a little over a mile. A few small water-bearing seams were encountered in boring through the upper layers of the rock, and more borings are required before the courses of these seams can be traced with any certainty and the best level for the tunnel determined. If, however, it is kept down about 130 feet below the surface of the harbor, the borings so far taken indicate that no water will be encountered at that depth to hinder the vigorous prosecution of the work.

My estimate of the works which are necessary in order to complete this project in a proper manner is as follows (exclusive of land damages):

Tunnel, 6-ft. 6-in. in internal diameter, 5,500 feet in length, lined with brickwork, including necessary shaft at each end	$250,000 00
Screen chamber, valve house and connections at Main Pumping Station	20,000 00
New 5-ft. steel pipe, 900 feet in length, connecting existing 5-ft. pipe in Blockhouse Bay with southern end of tunnel, including specials and connections	19,000 00

New 6-ft. steel pipe, 2,400 feet in length (to replace existing wooden pipe), between shore crib and bell-buoy crib, including connections and anchorage	*60,000 00
Valve house and settling chamber at south end of tunnel	18,000 00
New 6-ft. steel conduit, 7,000 feet in length, across Toronto Island from south end of tunnel and into Lake Ontario, including new intake, valve house and settling chamber	158,000 00
	$525,000 00

In this estimate the tunnel is designed of ample capacity to deliver at the Pumping Station 75,000,000 gallons per day, so that no enlargement or duplication will be necessary until the City has trebled its present population. Provision is also made for a duplicate 6-ft. steel conduit across the Island in order to avoid any tearing down or expensive alterations when such an addition becomes necessary.

In addition to the project I have recommended and outlined above, further works are required in connection with the system of distribution.

I have already recommended that a new 24-in. main should be laid along Front Street, from Simcoe to Sherbourne Street, for the double purpose of relieving the pumps and force mains to some extent and of affording better protection against fire in the heart of the City than can now be obtained. I beg to renew this recommendation.

I also recommend that a new 36-in. force main be laid from the intersection of Bathurst and College Streets, up Bathurst Street, along Dupont, McPherson and Yonge Streets, and thence into Rose Hill Reservoir, as shown on the accompanying plan. The object of this additional main is that it will not only greatly improve the system for fire protection and general service, but that it will be a safeguard against accidents at the Main Pumping Station and will lessen the risk of breakage and damage to the existing force mains, especially to those on Front Street and across the railway properties. It will also afford the means of maintaining the best possible pressure on the mains at times when it may be necessary to stop all pumping operations which sometimes cannot be avoided.

I also recommend that the 30-in. main on Wellington Street be extended eastwardly from John Street to Simcoe Street, for the purpose of improving the circulation and rendering the system more complete and secure against accidents.

I also recommend that a new 12-in. main be laid on Avenue Road, from Davenport Road to Bloor Street, for the purpose of improving the supply in the high service district.

The following is the estimate of the entire works herein recommended :

* This expenditure may possibly be saved for a time, if, on further investigation, the existing 6-ft. wooden conduit should be found suitable to be retained.

Total cost of tunnel scheme as outlined above	$525,000
16,000 ft. of 36-in. force main, from intersection of Bathurst and College Streets to Rose Hill Reservoir, including valves and specials, etc.	135,500
1,000 ft. of 30-in. pipe on Wellington Street, from John to Simcoe Street, including valves, etc.	8,000
24-in. main on Front Street, from Simcoe to Sherbourne Street, including valves and specials, etc.	36,000
12-in. main on Avenue Road, from Davenport Road to Bloor Street	5,500
Total	$710,000

In addition to the above there are minor improvements and alterations which will be required from time to time, but they are not deemed of sufficient importance to call for special reference in this report. I may, however, say that the district on the east side of the River Don, lying to the north of Gerrard Street, will before very long require attention. It lies at a high elevation, and is supplied off the low service system, which is scarcely adequate, under existing arrangements, to afford an effective fire protection service.

Attached hereto is a map showing in outline the improvements I have proposed and recommended, and also an appendix giving the cost of pumping under varying conditions, and other information of interest.

I have the honor to be, Gentlemen,

Your obedient servant,

E. H. KEATING,

City Engineer.

APPENDIX.

(*For explanatory notes see page 21.*)

SCHEDULE No. 1.

First Cost of Construction of Conduits, Pumping Engines, etc. (exclusive of distribution), Toronto Water Works, and Annual Charges thereon, as at 31st December, 1892.

WORK.	Cost.	Interest Annually.	Sinking F'd per annum.	Total annual ch'ge.
	$ c.	$ c.	$ c.	$ c.
Works under commission, including wooden and iron conduits, Nos. 1 & 2 pumping engines and buildings, filtering basin and all work between connecting crib and engine house.....	506,802 27	30,408 13	6,410 49	36,818 62
Wooden intake pipe in lake.	46,344 38	2,317 21	697 54	3,014 75
No. 3 engine and appurtenances (including re-building	124,295 70	4,971 82	2,216 20	7,188 02
High level station (including new engines and buildings and connections)	66,839 24	2,339 36	1,294 76	3,634 12
New steel conduits and lake intake extension.....	189,085 71	6,617 99	3,662 84	10,280 83
Total (gross).....	933,367 29	46,654 51	14,281 83	60,936 34
Less cost of filtering basin and wooden conduit (both abandoned)	125,915 02	7,554 90	1,592 68	9,147 58
Total cost of works in use at end of 1892	807,452 27	39,099 61	12,689 15	51,788 76
Deduct depreciation of engines Nos. 1 and 2	101,874 82	6,112 48	1,288 60	7,401 08
	705,577 45	32,987 13	11,400 55	44,387 68
Deduct difference between cost of No. 3 engine and her value as compared with No. 4 engine.....	42,738 89	1,709 55	762 03	2,471 58
	662,838 56	31,277 58	10,638 52	41,915 10
Deduct 10 p.c. on remainder of plant for depreciation..	64,928 17	2,609 53	877 95	3,487 48
Estimated present value ..	597,910 39	28,668 05	9,760 57	38,428 62

SCHEDULE No 2.

Estimated Value of Conduits and Pumping Plant when Nos. 4 and 5 Engines are completed, and when two additional High Duty Engines are provided to replace Nos. 1 and 2, and also providing for increasing Conduit capacity for future needs.

WORK.	Value.	Interest on Value.	Sinking F'd for do.	Total annual ch'ge.
	$ c.	$ c.	$ c.	$ c.
Estimated present value, as per Schedule No. 1.....	597,910 39	28,668 05	9,760 57	38,428 62
*Estimated cost of Nos. 4 and 5 engines, connections and buildings, etc.	200,000 00	7,000 00	3,874 26	10,874 26
Total.....	797,910 39	35,668 05	13,634 83	49,302 88
Add cost of Nos. 6 and 7 engines, of like capacity as 4 and 5	200,000 00	7,000 00	3,874 26	10,874 26
	997,910 39	42,668 05	17,509 09	60,177 14
Add estimated cost for increasing conduit capacity for future needs	525,000 00	18,375 00	10,169 94	28,544 94
Total.....	1,522,910 39	61,043 05	27,679 03	88,722 08

*These engines were paid for out of current revenue, and not from debentures.

SCHEDULE No. 3.

Expenditure on Account of Pumping Stations, giving average cost of pumping 1,000 *gallons of water for the year* 1892.

Main Pumping Station (fuel, wages and general maintenance)	$103,202 91	
High Level Station (fuel, wages and general maintenance)	10,167 69	
		$113,370 60

	Gallons.
Quantity of water pumped (after allowing for slip)	7,001,674,226
" re-pumped at High Level Station	1,340,209,130
Cost on above basis of pumping per 1,000 gallons for both Stations	1.619c.
" " " at Main Pumping Station	1.474c.
" " " at High Level Station	0.758c.
Interest and sinking fund paid in 1892, as per Schedule No. 1	$60,936 34
Rate of do. per 1,000 gallons pumped	0.870c.

Cost of pumping per 1,000 gallons	1.619c.	
" interest and sinking fund per 1,000 gallons	.870c.	
Total cost of pumping	2.498c.	
Interest and sinking fund, if works that have been abandoned are deducted	$51,788 76	
Making cost of pumping	1.619c.	
" interest and sinking fund	.739c.	
Total cost per 1,000 gallons	2.358c.	
If further allowance is made for depreciated value of plant, the interest and sinking fund would be		$38,428 62
Making the cost of pumping per 1,000 gallons		1.619c.
Cost of interest and sinking fund per 1,000 gallons		.548c.
Total cost of pumping per 1,000 gallons		2.167c.

SCHEDULE No. 4.

Estimated Cost of pumping when Nos. 4 and 5 High Duty Engines are completed.

Capacity of engines	7,154,000,000 gallons net.	
Average of No. 4, since being put in commission	441 gallons per pound of coal,	
Coal required 8,111 $\frac{222}{2000}$, @ $4.50	$36,500 00	
Labor	20,567 75	
Repairs, lubricants, etc	10,000 00	
		$67,067 75
Interest and sinking fund on value of plant (Schedule No. 2)		49,302 88
		$116,370 63
Cost of fuel per 1,000 gallons	.510c.	
" labor, etc	.427c.	
" interest and sinking fund	.689c.	
Total cost per 1,000 gallons	1.626.	

SCHEDULE No. 5.

Estimated cost of pumping when consumption shall have reached 40,000,000 gallons per day and pumping capacity has been increased by the addition of two new high duty engines (6 and 7), and also including cost of increasing conduit capacity for future needs.

Capacity of engines, 14,308,000,000 gallons net (average of No. 4 forming basis of calculation for coal).

Coal required, 16,222 tons, at $4.50		$73,000 00
Labor		41,135 50
Repairs, lubricants, etc		20,000 00
		$134,135 50
Interest and Sinking Fund, as per Schedule 2		60,177 14
Total annual charge		$194,312 64

If provision is made for additional conduit, to increase daily capacity for future needs, the cost will be:

Coal, labor, repairs, etc., as above		$134,135 50
Interest and Sinking Fund, as above	$60,177 14	
" " on $525,000, as per Schedule No. 2	28,544 94	
		88,722 08
Total cost		$222,857 58
Cost per 1,000 gallons for labor		0.510c.
" " fuel		0.427
" " interest and sinking fund		0.620 .
Total estimated cost per 1,000 gallons		1.557c.

SCHEDULE No. 6.

Comparison of the actual payments which the City would have to make if one of the proposed offers to supply the City with water at 3c. per 1,000 gallons is accepted, and the estimated cost of pumping the same water, based upon the actual record of No. 4 engine:

By Pumping—

20,000,000 gallons daily = 7,154,000,000 yearly, after allowing for slip:

Cost of pumping, as per Schedule No. 4		$67,067 75
Interest and sinking fund upon total debt of works..	$266,000 00	
" " " cost of Engines Nos. 4 and 5	10,874 26	
		236,874 26
Maintenance of other branches of Department		80,000 00
		$383,942 01

By Private Supply—

7,154,000,000 gallons at 3c	$214,620 00	
Interest and sinking fund on debenture debt	226,000 00	
Cost of maintenance of remaining branches	80,000 00	
		520,620 00
Difference in favour of pumping		$136,677 99

Cost per 1,000 gallons by private supply	7.277c.
" " pumping	5.366
Difference in favor of pumping	1.911c. per 1,000 gals.

In other words:

Estimated revenue from water works 1893	$440,000 00
Cost if water supplied by private company	520,620 00
To be raised by taxation or by increased water rates	80,620 00

SCHEDULE No. 7.

Comparison of relative cost of water by pumping and private supply when consumption shall have reached 40,000,000 gallons per day and high duty pumping plant is provided as per Schedule No. 5.

By Pumping—

Cost of pumping as per Schedule No. 5	$134,135 00	
Interest and sinking fund on total debt	226,000 00	
Maintenance of remainder of works	80,000 00	
Interest and sinking fund on engines 4, 5, 6 and 7	21,748 52	
		461,884 02

By Private Supply—

14,308,000,000 gallons at 3c	429,240 00	
Interest and sinking fund on debt	226,000 00	
Maintenance of remaining branches	80,000 00	
		735,240 00
Annual difference in favor of pumping		$273,355 98

If a provision is made for additional conduit capacity to provide for future needs the cost will be:

By Pumping—

Annual cost as above	$461,884 02	
" of additional interest and sinking fund, as per Schedule No. 2	28,544 94	
		$490,428 96

By Private Supply—

Annual cost as above	735,240 00
Excess of cost by private supply	$244,811 04

SCHEDULE No. 8.

Comparative statement showing the actual cost of the City's water supply for 1892, *and what it would have been had the City been supplied for that year by private parties at* 3c. *per thousand gallons.*

Actual cost by Pumping—		
Cost of fuel, labor and general maintenance of the main pumping station	$103,202 91	
Ditto high level station	10,167 69	
	$113,370 60	
Maintenance of other branches of Department	66,845 19	
Interest and sinking fund upon total debenture debt for water works purposes	222,626 00	
		$402,841 79
Cost by Private Supply—		
7,001,674,226 gallons at 3c. per 1,000	$210,050 22	
Maintenance of branches of department other than main and high level stations	66,845 19	
Interest and sinking fund on total debenture debt for water works purposes	222,626 00	
		499,521 41
Excess of cost by private supply at 3c. per 1,000 gallons.		$96,679 62
Revenue and Expenditure:		
Revenue from water works for 1892		$449,252 78
Cost by pumping as above		402,841 79
Surplus of revenue over expenditure		$46,410 99
By Private Supply the result would have been :		
Revenue for the year		$449,252 78
Cost of water as above		499,521 41
Deficit, which would have been met by inoreased taxation or by increased water rates		$50,268 53

In the calculations for Schedules 6, 7 and 8 the cost of remodelling the present system in order to distribute the water from the north instead of from the south has not been taken into account.

Explanatory Notes.

Schedule No. 1 refers to the actual cost of the pumping plant, including the wharves, engine houses, pumping engines, and all plant south of the engine house, also the high level pumping station. The gross cost comprises the amount paid for the construction of these works (as per annual reports of the Commissioners and Water Works Department), the annual charge for interest and sinking fund thereon being also shown. The first deduction made from this amount is the cost of the filtering basin on the Island, and the four-foot wooden conduit between Hanlan's Point and the connecting crib on the Island, both of which have been abandoned. The result is the cost of the works actually in use on 31st December, 1892, and the annual charges thereon. Deductions are then made for depreciation of Nos. 1, 2 and 3 engines, being the difference between the actual cost thereof, as included in the gross cost, and their present value. This was arrived at as follows: No. 1 is valued at $7,000, being the amount the original builders of this engine offered to allow for the engine and boilers as part payment for another engine. The values of Nos. 2 and 3 are based upon their capacity and guaranteed duty as compared with No. 4 engine, which cost $54,408.

A deduction of 10 per cent. is next made for depreciation of the remainder of the plant. This is, I think, a small percentage for plant that has been in use on an average upwards of ten years.

Schedule No. 2 shows the various additions to be made to the total value of plant, as per No. 1, for new engines, also probable extensions required in the near future.

Schedule No. 3 gives the actual cost of pumping per 1,000 gallons with low duty engines, 1892; and Schedules Nos. 4 and 5 the cost of pumping 20 and 40 million gallons per day respectively with high duty engines of the same type as No. 4—the calculations being based upon the actual record of that engine for the eight months during which it has been in service—the annual charge for interest and sinking fund on cost of additional plant being also included. No. 3 Schedule is given for information and comparison, but cannot fairly be taken as a basis of calculation for the future, the record being made by low duty engines, which were also badly in need of repair.

Schedules Nos. 6, 7 and 8 are comparative, showing the relative cost between a water supply obtained by pumping and that purchased from private parties at 3 cents per 1,000 gallons, the first two schedules being calculated for a daily supply of 20 and 40 million gallons respectively. Schedule No. 8 shows what the City would have had to pay in 1892 for the water actually provided had it been supplied by a company at three cents per thousand gallons, and also gives the actual cost by the present system. From this statement it appears that had the water been supplied by private parties at the rate above named, instead of the current revenue being sufficient to meet the working expenses and give a surplus of $49,000, as was the case, there would have been a deficit of $50,000 on water works account, which would have had to be met by increased taxation or by an increase in the water rates.

In Schedules Nos. 4, 5, 6 and 7 no allowance has been made for repumping to the high level district, as the proportion of the total quantity which would require to be repumped is unknown. In 1892, however, the cost of the high level station was less than one-tenth of that of the main station, and the quantity of water repumped was less than one-fifth of the total supply.

Taking the relative cost of repumping at the high level station as one-tenth that at the main station, the cost per thousand gallons in Nos. 4 and 5 would be increased by 0.0937 cents. A like amount should also be added to the cost per thousand gallons by pumping in Schedules Nos. 6 and 7.

In calculating the annual cost of water by private supply for Schedules Nos. 6, 7 and 8 the large expense which would necessarily be incurred in remodelling the distribution owing to the alteration in the method of supply has not been taken into consideration.

CHAS. A. MATTHEWS,

Secretary Water Works Department.