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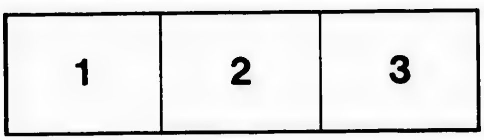
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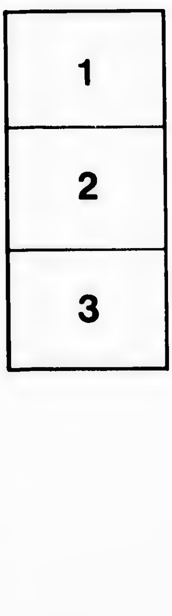
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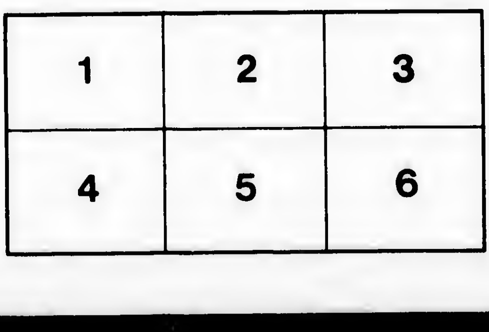
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REPORT

—TO THE—

CITY COUNCIL OF TORONTO

—ON THE—

Proposed Water Supply by Gravitation,

—FROM THE—

OAK RIDGE LAKES AND THE RIVERS DON AND ROUGE,

With Map, &c.,

—BY—

Messrs. William J. McAlpine and Kivas Tully,

CIVIL ENGINEERS.

TORONTO:
E. F. CLARKE, CORPORATION PRINTER, 33 AND 35 ADELAIDE STREET WEST,
1886.

WATER SUPPLY BY GRAVITATION.

MAYOR'S MESSAGE.

TORONTO, February 19th, 1887.

Gentlemen of the Council:

I beg to bring down the following papers as the Report of Messrs. McAlpine and Tully on obtaining a water supply by gravitation for the City of Toronto, and a letter from Kivas Tully, Esq., C.E., on the same point.

I would suggest that the Reports be printed with the accompanying map, for the information of the members, and would only call attention to the fact that, according to the Report, a supply of 20,000,000 gallons of water daily by gravitation can be procured from the head waters of the middle and west branches of the Don at a cost of less than $500,000.

This supply being by gravitation would, after the expense of construction once over, be free from the annual expense for maintenance to which we are now subject in our present system.

W. H. HOWLAND,
Mayor.

(LETTER FROM KIVAS TULLY, ESQ., C.E.)

TORONTO, February 18th, 1887.

His Worship W. H. Howland, Mayor, City Hall, Toronto.

SIR,—I have the honor to enclose the Report on the water supply to the City by gravitation from the Ridge Lakes and the Don and Rouge Rivers, as indicated on the accompanying map. Referring to my first communication on the subject, dated in April last, it was stated that "The annual sum of $70,000, the present cost of pumping from Lake Ontario by steam power, represents the interest of $1,750,000 capital at 4 per cent. It is therefore a proper question for the Council to consider whether, by the expenditure of the above amount in procuring a water supply by gravitation, this annually increasing expenditure could not be saved for the future, an additional pressure for fire purposes obtained, and water from an undoubted and reliable source provided." It was also recommended that "it might be advisable to procure an opinion from Mr. McAlpine, as he has had much experience in reporting on and constructing water works in the United States." As this was approved, a careful examination of the Ridge Lakes and the district north of the City was made by Mr. McAlpine with yourself and some members of the Water Works Committee, in June last. Since that time, information as to levels, etc., has been procured by an official of the Water Works, and after a long correspondence and consultation, the results, which are fully explained in the Report, will be found to justify my opinion and recommendation, and further to demonstrate the practicability of a water supply to the City by gravitation, combined with a large annual saving in the expenditure.

The water supply to Toronto was stated lately to be the purest in the world; if so, it is strange that this pure water cannot at all times be supplied to the citizens.

The Report of Professor Laint Carpenter, who was here in 1884 with the British Association, and who tested the water at various points in the Bay and Lake, states that the water at the bell buoy, outside the Island, the inlet of the water supply pipe, is "decidedly the best sample of all, but did not compare well with pure water. This is without doubt contaminated to a certain extent;" also, (3) "That the water as drawn from the bell buoy is by no means free from contamination from sewage and other organic impurities." His conclusions are (4) "That this water becomes mixed in its passage from the bell buoy to the pumping house with the bad water in the Bay, probably from leaks in the pipes, and in the well at the lake end of the wharf at the pumping house."

"A town may go on for some time drinking contaminated water with apparent freedom from illness, but this water is the breeding ground for many germs and microbes, and experience has shown that the intestinal discharges of one typhoid fever patient into such water is sufficient to poison a large water supply, so rapidly do the germs multiply under favorable conditions."

It may be urged that improvements have been made at the Water Works crib by lining it with iron, which I believe has been done since 1884, by which pollution from this source has been prevented ; but the leaks in the pipes across the Bay have apparently not been attended to as suggested, and the discolored state of the water after heavy gales indicates that the causes of pollution have not been altogether removed. The specimens of water which you procured last year, and which can still be seen in your office at the City Hall, show that there is a marked change between the lake water and that supplied to the City. I am constrained, therefore, to express the opinion, from practical experience and constant observation for over 40 years, that the citizens have *never* been supplied with pure water at all seasons of the year.

As the City of Rochester was supplied with water by steam power in the first instance, and afterwards by gravitation to increase the supply, both of which systems have been in operation for several years, I would strongly advise that you should personally, with some members and officials of the City Council, visit Rochester during the Spring, for the purpose of thoroughly examining and reporting on both systems, but particularly to ascertain whether the water obtained by gravitation has been pure, abundant, and suitable for domestic purposes.

I remain,

Your obedient servant,

KIVAS TULLY.

REPORT OF W. J. MCALPINE, C.E., AND KIVAS TULLY, C.E.

TORONTO, February 14th, 1887.

His Worship W. H. Howland, Mayor, and City Council, Toronto:

SIR,—On the 22nd of October last we presented to you a preliminary Report on the project of supplying the City with water from the ridge lakes, the eastern sources of the River Humber and the district south of the same, through which flow the Rivers Don and Rouge.

We now lay before you the results of our further examination of the subject, which show that an abundant supply of pure and wholesome water can be obtained from the sources mentioned and delivered in the City at a level of at least 220 feet above Lake Ontario, at a cost for an equal quantity the annual interest of which and that of the maintenance of the work will be less than one-half the present cost of supplying the City by pumping from Lake Ontario. Also, that the cost of increasing the quantity up to fifty millions, or any probable future demand, including the cost of maintenance and operating, will be much less than an equal quantity could be obtained by the increase of the pumping works and of their maintenance and operation. We understand that the chief object of the present examination is to determine whether the interests of the City will warrant the expense of a careful instrumental examination and estimate of the cost of the proposed works before any large expenditures are made for enlarging or improving the existing pumping works. The data in our possession, though sufficient for presenting the general features and approximately the cost of the "gravity plan," are not sufficient to determine the plans in such detail as are necessary to present absolutely accurate estimates of the cost, &c.

The instrumental examinations which we would suggest are as follows:

1st. A survey of the areas of the several water sheds of the branches of the Don, Rouge, and of each of the ridge lakes hereinafter referred to, and also the areas of each of the lake surfaces.

2nd. The selection of such storage reservoir sites on each of the streams as are necessary to carry out the plans hereinafter described, and the measurements to determine their capacities and the plans of the dams thereat.

3rd. The location of the several pipe lines from the lower reservoirs on each of the streams to the present City reservoir, or to such other distributing reservoir of greater elevation in or near the City.

4th. The establishment of self-registering rain gauges over the proposed water sheds, the records of which, though for a comparative short time, may be compared with those for the same period at the Toronto Observatory, and thus establish the ratio of precipitation between them so as to apply the valuable measurements of the latter for the last 45 years to the water sheds in question; also, to establish gauges on the Don and Rouge and measure the daily flow off, so as to compare their ratios with those of other districts of corresponding character; also, to have a weekly or monthly measurement of the elevation of the water on each of the lakes.

The general features of the proposed "gravity plan" are as follows:

1. To conduct the waters from the ridge lakes herein specified to the head waters of the Don in a canal and steel pipe.

2. To intercept the waters of the three branches of the Don and Rouge at an elevation of about 300 to 350 feet above the level of Lake Ontario and convey them to the City Water Works distributing reservoir in steel pipes.

3. To equalize the daily flow from the rivers specified by the construction of storage reservoirs in suitable places in the valleys, of sufficient capacity to receive and retain the excesses from the rainfall, &c., and discharging the same when the natural flow is less than the mean of the year from the absence of rain and other causes. The ridge lakes have sufficient capacity to retain as long as desired all of the water which runs into them, even from the greatest rains and melting snows, and it can be discharged therefrom as may be found advisable, and particularly during those summer months when the natural flow of the water in the rivers is at a minimum.

4. To thoroughly remove from the beds of the lakes to a reasonable depth, and from the land to be flooded at the storage reservoirs, all decayed and growing vegetable matter and other impurities; and,

5. To pass all the water through mechanical, and, if found necessary, chemical filters, before entering the conduit pipes.

THE SOURCES AND QUALITY OF THE WATER.

In the mixed population of a city there are always prejudices and fallacies in regard to this branch of the subject, which it is advisable to remove by a statement of the received opinions of the source of water and changes which it undergoes before it is used, and there are some general principles which may be applied to determine the quality of the water which any particular source will furnish. Many of these are but repetitions of what have been learned at school, but which have to some extent been forgotten by those engaged in active life. The parent source of all the fresh water on the earth is the ocean, and the atmosphere is the vehicle by which it is conveyed over and precipitated upon the land, from whence, after performing its various functions, it flows back to the sea, to be again exhaled and distributed over the land, and has thus incessantly circulated for ages.

The water which is precipitated upon the earth is in part absorbed by growing vegetation or by evaporation, and the remainder flows off through the superficial water courses to the brooks and rivers, and back to the ocean, or it penetrates the porous soil in drops, which unite together beneath the surface in threads, veins and strata, and descending until they meet some impenetrable stratum of earth or rock, over which they flow subterraneously and reappear on the river banks and other low places, in springs, and sometimes streams of considerable size.

Springs derive their supply from the aggregation of these rain drops, which have penetrated the porous soil; and wells are merely the interception of these underground threads and veins of water; while ponds and lakes are formed in depressed places by the same drops collecting in a mass over a substratum of soil or rock through which they cannot percolate, and then the water rises to the brim of the natural water-tight basin and flows over in a brook or river.

Water is never found in nature in a perfectly pure condition. In its vapory form it has a strong affinity for the other gaseous substances with which the air is charged from effete matter; and in its liquid form it is a solvent of many substances which it is brought into contact with upon and beneath the earth. Water is most pure when it is evaporated in mid-ocean, but as the vapory winds are driven over the land as before stated, it absorbs the gases which are encountered in the air, and when it falls to the earth and flows over or beneath it, it takes up in solution decaying vegetable and animal matter, earthy salts and other injurious substances.

Rainwater falling through a pure atmosphere—as outside of towns—upon a clean surface, is the purest form in which it can be found. That which falls upon a pure sandy soil, free from vegetation, is the next most pure. Vegetation and animal life while growing are absorbents of deleterious matter in the air and water, but in decaying give out that which is noxious to both. Surface water is therefore the least pure in the autumn, when vegetation begins to decay, and the most so in the winter and spring, when no decomposition occurs, or when vegetation is growing; while spring and well waters, which derive their principal impurities from earthy solutions, are nearly equally impure at all seasons of the year, according to the presence or absence of such solvent materials in the soil.

For drinking, water should be wholesome, clear, cool, and aerated: and for other domestic and manufacturing purposes, it must be soft and limpid.

For a public water supply, therefore, the water should be selected having the following characteristics in the highest degree possible, viz., first, purity; next, softness; and next, limpidity.

The late Mr. Soyer, the most eminent cook in the world, stated that there is a difference of one-half in the time required to cook vegetables and meats in hard instead of soft water, and adds that one-third of the tea used in London is wasted by the use of hard water. It has been ascertained that in the use of soap, the difference between hard and soft water is equal to one dollar per annum for each inhabitant.

The analyst has reported that the waters of the Ridge Lakes, as they are now found, are objectionable on account of the amount of vegetable matter present therein. The plans herewith presented contemplate the removal of all existing decayed or growing vegetable matter from the bed of the lakes to a depth of fifteen or twenty feet, and covering all of the surfaces, when the beds of the lakes are liable to grow vegetation, with coarse gravel. These measures will remove almost or nearly all of the vegetable contamination to the waters from these lakes. It is also proposed that the water from the lakes shall be conducted in open channels for considerable distances, and particularly down the channel of the upper part of the west branch of the River Don, where the fall is frequently considerable, which will produce much agitation. These exposures of the running waters to atmospheric influence will doubtless oxydize the impurities of all kinds which may happen to enter the waters.

It is also intended to have automatic reversible filters in one of the lower reservoirs on each of the rivers, which will remove any possible remainder of the impurities. In many cases the cost of filtering is expensive, but in the present one the power required to force the water through the filter will be without cost, and the previous action of the subsidence in the large reservoirs and aeration in the open channels will leave but little, if any, for the filters to perform, and their expense will be comparatively small. The water from these sources thus treated will undoubtedly be equal to that from Lake Ontario, with less degree of hardness, Bond Lake being only 6 degrees while Lake Ontario is 10. St. George's and Wilcock's, however, are harder than Lake Ontario, according to the analyst's Report. The water will be agreeably aerated by the rapids of the rivers, and in passing through the filters.

The supply from these lakes forms an admirable adjunct to the scheme, as the lakes will form a very large storage at small cost, sufficient to retain all the rain and snow without allowing any to run to waste, and also enough to hold over the surplus from one year of larger rainfall to another of lesser rainfall. If desired, nearly half of the water collected from the water sheds of the lakes may be retained, and let down for the supply of the City during the driest of the summer months, when the natural flow of the rivers is comparatively small. In this event, the expense of storing reservoirs on the latter may be considerably reduced. The computations of the quantity of water derivable from these lakes are based upon the precipitation at the Toronto Observatory.

The water sheds are nearly four hundred feet higher, which will doubtless increase the precipitation, besides which it forms the dividing crest between the Lakes Ontario and Simcoe, and intercepts the water-laden winds from both directions.

The supply from the lakes alone would be an average of eight-and-a-half millions of gallons a day for the whole year, and, if desired, by retaining the waters in the lakes, twelve or fifteen millions of gallons daily can be furnished to the City through the summer season from this source.

The areas of each of the lakes have been measured from the map, thereby correcting the statements of persons residing in the vicinity with whom we conversed when inspecting them in May last.

The following shows the areas and water sheds of the Lakes:

	AREA.	WATER SHED.
* Wilcocks and St. George	200 acres	1,800 acres.
Bond	75 "	800 "
McLeod	36 "	360 "
Ferguson	46 "	2,000 "
Bayle	45 "	540 "
† No. 3, 2 miles N.W. of Laskay	60 "	2,100 "
Total	462 acres	7,600 acres.

The cost of conducting the water from McLeod's Lake, which is 40 feet higher than Bond Lake, into the latter, would be about $10,000; but it has been ascertained that the waters from Bond Lake can be conducted to the outlet channel from Wilcock's Lake cheaper, but for greater safety we have used an area of 9½ square miles of water shed instead of 12 square miles, the area of 7,600 acres, nearly.

These lakes will receive and store the whole of the rain and snow fall annually, which averaged from 1841 to 1871 36.63 inches. The least quantity was in 1848, 26.80 inches, and the preceding year 36.94 inches. The mean of these two is 31.87 inches—that is, the storage capacity of the lakes is sufficient to carry over from preceding years the surpluses to supply the deficiency of such a low water yielding year as 1848, up to at least 31.87 inches, which is used in our calculation for the supply derivable from the lakes. As before stated, the computations are based on the records kept at the Toronto Observatory.

The following table shows the areas of the several water sheds, and the daily supply obtainable therefrom, with the specified storages

* Note.—Mr. St. George called these water sheds 4 square miles, 2,600 acres.

† Note.—The water from lake No. 3 can be conducted by a pipe to the main pipe near Laskay.—See map.

Sources.	Water Shed.	Millions of Gallons.					
	Square Miles.	Daily Supply.	Storage.	Daily Supply.	Storage.	Daily Supply.	Storage.
West branch of the Don.........	20	$6\frac{2}{3}$	228	$8\frac{2}{3}$	$494\frac{2}{3}$	10	628
Middle branch, nea Thornhill.	20	$6\frac{2}{3}$	228	$8\frac{2}{3}$	$494\frac{2}{3}$	10	628
East branch........................	10	$3\frac{1}{3}$	114	$4\frac{1}{2}$	$247\frac{2}{3}$	5	314
Six Ridge Lakes......	$9\frac{1}{2}$	$8\frac{1}{2}$	......	$8\frac{1}{2}$	......	$8\frac{1}{2}$	......
Upper Humber..........	$16\frac{1}{2}$	$5\frac{1}{2}$	188	$7\frac{1}{3}$	408	$8\frac{1}{4}$	518
Rouge, near Unionville..........	45	15	513	20	1113	$22\frac{1}{2}$	1413
East of the Rouge..........	30	10	342	$13\frac{2}{3}$	742	15	942
Totals..........................	151	$55\frac{2}{3}$	1613	$71\frac{1}{3}$	3500	$79\frac{1}{4}$	4443

That is, with small storage, all of the above mentioned sources will furnish a daily supply of $55\frac{2}{3}$ millions of gallons; with more storage, $71\frac{1}{3}$ millions of gallons daily; and with still more storage, $94\frac{1}{4}$ millions of gallons daily.

About one-third of the annual rainfall is evaporated while the water is flowing over the surface of the ground to reach the brooks, and from the surfaces of the water courses themselves. When the water is stored in large reservoirs, there is a further loss from evaporation. This loss, however, is but one per cent. of the rainfall; because the surface area of the required reservoirs is but 1-250th of the area of the water shed.

The loss of water absorbed by vegetation is relatively very small. These calculations show that a third of a million gallons of water daily can be obtained from each square mile of the water sheds in question, and a still larger supply if the storages be increased.

The following table shows the cost of obtaining certain specified daily supplies by selections from the above mentioned sources, with different amounts of storages. It also indicates the order of time in which the works for each additional supply should be constructed:

TORONTO WATER SUPPLY.

Revised calculations and estimates of cost.

	West branch of Don. First for $6\frac{2}{3}$ m. gallons daily.		Middle branch of Don. $6\frac{2}{3}$ m. gallons daily.		East branch of Don. $3\frac{1}{3}$ m. gallons daily.		Rouge. 15 m. gallons daily.	
	Quantities.	Cost.	Quantities.	Cost.	Quantities.	Cost.	Quantities.	Cost.
Storage reservoirs—minimum........	230 m. gal.	$39,100	230 m. gal.	$39,100	120 m. gal.	$24,000	510 m. gal.	$ 76,500
Conduit for maximum delivery—grading..........	....	30,000	....	39,000	....	39,000	....	90,000
Steel conduit pipe..........	....	66,000	....	120,000	....	72,000	....	240,000
Valves, culverts, &c.	....	10,000	....	12,000	....	12,000	....	15,000
Right of way..........	....	2,500	....	3,000	....	3,000	....	3,750
Extra at syphons	....	3,000	....	7,000	....	8,000	....	9,000
1st total cost from each source..........	....	$150,600	....	$220,100	....	$158,000	....	$434,250
With larger storage to give m. gallons daily..........	8·88 m. gal. daily.....		8·88 m. gal. daily.....		4·44 m. gal. daily.....		20 m. gal. daily.....	
Will add to the cost m. gal. storage.	270 m. gal.	40,500	270 m gal.	40,500	120 m. gal.	24,000	510 m. gal.	76,500
2nd total cost from each source..........	....	$ 91,100	....	$260,600	....	$182,000	....	$510,750
With maximum storage to give..........	10 m. gal. daily.....		10 m. gal. daily.....		5 m. gal. daily.....		$22\frac{1}{2}$ m. gal. daily.....	
Will again add to cost m. gal. storage	130 m. gal.	19,500	130 m. gal.	19,500	75 m. gal..	13,500	390 m. gal.	58,500
3rd total cost from each source	....	$210,600	....	$280,100	....	$195,500	....	$569,250

By the above tables a daily supply of $16\frac{2}{3}$ m. gallons can be had, with the maximum storage from the middle and west Don, for.............. $430,700 00.
" " " 15 m. gallons can be had from the Rouge, with minimum storage, for.............. 434,250 00.
" " " 20 m. gallons can be had from the middle and west Don, with maximum storage, for.............. 494,700 00.
" " " 20 m. gallons can be had from the Rouge, with larger storage, for.............. 510,750 00.

STATEMENT

Of the cost of supplying certain amounts from the above-mentioned sources and the lakes.

Total daily supply in million gals.	Having added daily.	From Source.	Adds to the cost.	Total Cost.
6·67 million.	....	From the west branch of the Don, minimum reservoirs..	....	$ 150,600 00
8·87 "	2·21 million.	" " with more storage	$ 40,500 00	191,100 00
10·00 "	1·12 "	" " with maximum storage	19,500 00	210,600 00
16·67 "	6·67 "	Adding for the middle branch of the Don, minimum storage	220,100 00	430,700 00
18·88 "	2·21 "	" " " with more storage	40,500 00	471,200 00
20·00 "	1·12 "	" " " maximum storage	19,500 00	490,700 00
28·50 "	8·50 "	By also adding from the lakes	280,000 00	770,700 00
31·83 "	3·33 "	By still further adding from east branch of Don, minimum storage	158,000 00	928,700 00
32·94 "	1·11 "	" " " " with more storage	24,000 00	952,700 00
33·50 "	0·56 "	" " " " maximum storage	13,500 00	966,200 00
48·50 "	15·00 "	By still further adding from the Rouge, with minimum storage	434,250 00	1,400,450 00
53·50 "	5·00 "	" " " more storage	76,500 00	1,476,950 00
56·00 "	2·50 "	" " " maximum storage	58,500 00	1,535,450 00

The following is the estimated cost of the six lakes (included above):

Purchase of the water and strips of land around same, bulk heads, regulating gates, outlets, &c., six lakes	$29,000 00
Cleaning out vegetation, &c., from lakes, covering soil, &c.. &c.	20,000 00
Connections—McLeod's to Bond Lake, Bond and Wilcox Lakes, &c.	20,000 00
Canal—Wilcox Lake to near Laskay, canals from lakes, &c.	74,000 00
Canal and brick pipe from the above to the head of Don, right of way for canals and pipes	62,000 00
Steel pipe from the Don to the City reservoir at Rose Hill	75,000 00
	$280,000 00

As the method of obtaining a much larger supply of available water than the minimum flow of any stream by the construction of large storage reservoirs is not probably familiar to many of the citizens, we have considered it advisable to refer to the experience of other cities on this continent, and to explain the subject fully. New York, Brooklyn, Boston, Providence, Albany, Troy, Rochester, and many other American cities, largely increase their supplies by storing reservoirs. Many of the canals and water powers in England, America and elsewhere have resorted to the same system. Its application to the water supply of Toronto is therefore no novel or untried experiment.

The effect of storing the flood-water of a running stream, so as to produce an equable regular flow largely beyond the minimum of the stream, is exhibited on a grand scale in the River St. Lawrence, where the flow is almost exactly alike throughout the year, there being only a slight difference in the flow off between the years of the greatest and least rain falls, even when the former is nearly double the latter. This equability of flow is effected by the immense areas of the great lakes, over which the heaviest rain storms produce but a comparatively thin layer of water.

The summit level of the Chenango Canal in the State of New York was wholly and most successfully supplied with water from storing reservoirs. This was fifty years ago. Some years later the Genessee Valley Canal was supplied in the same manner, and still later the Black River Canal. The long level of the Erie Canal enlarged depends upon storing reservoirs directly for its supply. Many other instances might be given of the frequent use and advantage of storing reservoirs, but the above may be considered sufficient to justify their use in the present instance.

The crest of the Oak Ridges north of Toronto runs parallel to the shore line of Lake Ontario, eighteen miles distant, the summit of the crest being from 750 to 850 feet above Lake Ontario, rising gradually towards the eastern boundary of the County of York, and the rivers run on the shortest line between the crest and the lake. The average slope of the surface of the land in the most direct line from the crest to the lake is one in 120 feet. The slopes of the upper parts of the rivers for the first three miles average one in 160 feet, being from one in 130, or perhaps less, to one in 200. For the next three miles the river slopes are from one in 250 to one in 400, being flatter near their mouths, but the average for their whole lengths is about one in 140. On a line parallel with the crest of the ridge and eight miles south of it, the surfaces of the rivers are from 270 to 320 feet above Lake Ontario. From the above data it will be perceived that the water shed north of Toronto and above the level of the Rosehill reservoir is most favorably situated for the proposed water supply by gravitation, the annual rain fall when collected in the several areas as before described, being more than sufficient for present wants and for many years in the future.

The positions of the lakes, which would be the summit sources of the water supply from the crest of the ridge, the directions of the rivers, and the areas of the several water sheds, are indicated on the maps which accompany this Report.

The quantity and cost of a gravitation supply having been determined by the above tables, it would be well to consider the quantity and cost of the water at present supplied to the City by the three large pumps with a daily maximum capacity of 24,000,000 gallons, two of which are kept constantly running to maintain the supply. By reference to the Annual Report of the Superintendent of the City Water Works for 1885, it will be observed at page 9 that the cost of maintenance in 1884 was $69,355.64, and the gallons pumped 3,645,-422,082 ; in 1885 the cost was $65,082.39, and the gallons pumped 3,-537,482,598. The average consumption of water per day being 9,675,-493 gallons. The Superintendent also states that the daily "average for the months of January and February was 11,327,000 gallons, while that of the month of June was only 8,995,972 ; showing conclusively that at this time the difference must have been run to waste in order to keep the pipes, &c., from freezing, while in the very hot, dry weather, the difference is what is used in the lawns and streets. If this wastefulness is permitted to go unchecked, the people of Toronto must be prepared for another large expenditure for pumping power, reservoir, &c." The cost of pumping 1,000 gallons in 1884 and 1885 is 1·904, and 1·840 respectively. A new conduit pipe across the Bay and a new reservoir are recommended, the cost of which has since been estimated by the Superintendent at $781,000. The quantity of water pumped in 1886 is stated to be 4,323,774,305 gallons, or 11,818,559 gallons per day, showing a marked annual increase. Under these circumstances, the daily supply for 1887 cannot be calculated at less than 12,000,000 gallons, and taking the population at 120,000, the consumption per head would be 100 gallons per day, a liberal supply.

In reference to the new conduit the Superintendent states: "The growth of the City has been so rapid, however, and the prospect of its still greater growth is so very encouraging, that in a very short time it will be necessary to provide for the increasing consumption by laying another pipe across the Bay." In respect to the new reservoir it is stated: "At certain times, as in the spring and fall, the lake for some distance beyond our inlet is discolored by storms, freshets, etc., and although containing nothing deleterious, clear water would be preferable. The new reservoir, besides holding an extra supply in case of accident, could be used partly as a settling basin, so that when the lake was muddy the City could be supplied from here with clear water." With reference to the increasing consumption of water in cities on this continent, it may be useful for comparison to give the following figures which have been taken from "Fanning's Hydraulic Engineering."

							1874	1884
Boston	average	daily	supply	in gallons	per head		60	110
Brooklyn	"	"	"	"	"		58	63
Buffalo	"	"	"	"	"		60	151
Chicago	"	"	"	"	"		84	145
Cincinnati	"	"	"	"	"		45	76
Cleveland	"	"	"	"	"		45	88
Deiroit	"	"	"	"	"		87	120
Jersey City	"	"	"	"	"		86	136
Louisville	"	"	"	"	"		24	64
Philadelphia	"	"	"	"	"		58	81
Washington	"	"	"	"	"		138	165
Montreal	"	"	"	"	"		66	88

The average daily consumption of the above eleven American cities and Montreal is 107¼ gallons per head of population for 1884.

The following extracts from a work recently published on "The Separate System of Sewage," by Cady Stanley and G. S. Pierson, C.E., in reference to the increasing consumption of water are also useful: "It is also true that the per capita consumption and waste of water has been gradually increasing up to the present time, and is likely to reach still higher figures. This increased demand for water has been met by pumping engines of much higher duty, and by improvements in water works generally, which enable them to furnish water to the consumer at lower and lower rates per gallon, commensurate with increased economy secured. This in turn encourages the use of water from the public mains for motive power, as the running of elevators, motors, etc., and for the thousand and one purposes of light manufacturing, requiring the use of power, always ready and costing nothing when not wanted. The application of water under pressure as a motive power to work of this class is apparently in its infancy, and is destined within the probable life of sewage systems now contemplated to considerably augment their flow. Rapid as has been the development of water supply systems in the United States, their capacity has barely kept up with the demands of the people."

"In American cities having well arranged and maintained systems of water supply, and furnishing good, wholesome water for domestic use, and clean soft water adapted to the uses of the arts and for mechanical purposes, the average consumption is found to be approximately as follows:

Domestic use	20	gallons	per head.
Stables	3	"	"
Manufacturing	5 to 15	"	"
Fountains	3 to 10	"	"
Waste in winter	10	"	"
Flushing and leakage	5 to 15	"	"
Total	46 to 73	gallons.	

By the above estimate for average consumption, it will be perceived that the total supply is computed at from 46 to 73 gallons per head for all purposes, but the average per head in Toronto appears from reports to be from 65 to 100 gallons. Taking the latter, 100 gallons, as the basis, the total average quantity to be supplied to the City would not be less at the present time than 12 millions of gallons per day, the estimated population being 120,000, and the annual cost by the present pumping works would be about $70,000 for operating the pumping works. The average daily consumption for two weeks ending January 15th, 1887, was reported lately to be 14,283,343 gallons. This is of course exceptional owing to the waste of water at this season. According to the recent statistics above quoted, it appears that the per capita consumption and waste of water increases in a greater proportion than the increase of population. It will therefore be necessary to provide for at least 20 millions of gallons per day, and if the water becomes extensively used for power in the City, the demand will, perhaps, ultimately reach thirty millions. By the construction of the necessary works for diverting the waters of the west, middle, and east branches of the River Don, which would supply 25 millions of gallons per day to the Rosehill reservoir, the cost as before stated would be as follows:

West branch of the Don, maximum supply....	$210,600 00
Middle " " "	280,100 00
East " " "	195,500 00
Total cost........................	$686,200 00

By the further expenditure of $280,000 the supply from the lakes could be increased 8½ millions, and by still further adding the maximum supply from the River Rouge, 22½ millions daily, the total supply could be increased to 56 millions of gallons daily, at a total cost of $1,535,450, as per statements.

The water shed of the west, middle, and east branches of the River Don for the supply of 25 millions of gallons daily, as indicated on the acompanying map, is 50 square miles, and the river flow from the middle and east branches, as before computed, can be diverted to a reservoir below Thornhill, from which it would be conveyed in a steel pipe to the Rosehill reservoir.

These waters may be discharged through a fountain in the centre of the Rosehill reservoir, thereby ensuring aeration and further oxydation, an arrangement which has been successfully and ornamentally carried out at the lowest reservoir at the Rochester water works.

By means of a branch pipe connecting the gravitation supply pipe with the present main water works pipe on the line of Yonge Street, the pressure for fire purposes can be increased at least 25 lb. additional to the square inch, an important improvement for fire purposes, which has also been successfully carried out at Rochester.

It will be observed that the plans herein presented will permit of successive enlargements from time to time, to meet the future demands for water by the City, and do not, as is usual in similar cases, require a large present expenditure to meet the demands of a distant future.

Exception has been taken to the sources from which the water supply by gravitation can be obtained, and that the pollution from farm yards, farm houses, outbuildings, villages and graveyards north of Toronto would render the water unfit for use, and that the water would not compare in purity with that now supplied to the City. The answer to the above is that if the water supply from the north of Toronto is objectionable on account of the supposed pollution from the above mentioned causes, how much more objectionable must the water of Lake Ontario be, which is the natural reservoir of 400,000 square miles of farming and other lands, and into which the pollutions of cities like Chicago, Milwaukee, Detroit, Cleveland, Buffalo, London, Hamilton, Guelph, Toronto and other cities, villages, &c., with a population of at least two millions, have their only outlet? That the water of Lake Ontario is not polluted, the analyses made at different times fully prove, at least it is not supposed to be objectionable.

The temperature of the water from deep-seated springs is that of the earth at such a depth, which is about the mean temperature of the place for the year. At the point of issue the temperature of spring water changes a little with that of the season. Spring water is usually charged with air, and this with its low temperature in summer and high in winter, renders it grateful to the taste.

Water running through streams is self-purified. All the impure matter is oxydized by its contact with the atmosphere, and when it is collected into the reservoir, and becomes quiescent, the operation of purification goes on always All the matter that it hitherto contained which is heavier than the water goes to the bottom, and that which is lighter than the water rises to the top, is exposed to the air, becomes volatilized, and is carried away by the wind.

Hence the best mode of purifying the water is a reservoir, and a natural lake, of which the Engineer's reservoir is merely an imitation. Water from land used for agricultural purposes is not objectionable. In no part of the world has water from farming lands been found to be defiled. In fact, good earth is of itself a purifier of water, as instanced in earth closets.

As before mentioned, in addition to its purity, the water which can be supplied by gravitation to the City will be found suitable for domestic use on account of its softness as compared with the water at present supplied from Lake Ontario, a matter of the utmost importance to the citizens.

COMPARISONS OF COST.

Comparative cost of supplying 12, 20, 30 and 50 millions of gallons of water daily by pumping from Lake Ontario, and by gravity from the district north of Toronto:

First—For 12 million gallons daily. By pumping. Assuming that the capacity of the present works, viz., the supply pipe from the lake, engines, pumps and boilers, houses, &c., including the necessary duplicate pumping engines and force mains to the reservoir, is equal to the supply of 12 million gallons daily, and taking the present annual cost of operating at $70.000. To this must be added an annual charge for a renewal fund to replace the engines, pumps, boilers, supply and force mains, the life of which, as above stated, may be taken at 30 years. The annual charge to provide for the renewals will not be less than $13,120, making a total of.................... $83,120 00

The works for delivering the same quantity by gravity will cost $310,102, the annual interest on which at 4 per cent. is........................	$12,404 00	
The annual cost of management and charge for renewal fund is equal to..........	20,000 00	32,404 00
Annual saving in the cost of supplying 12 million gallons daily by gravity.........................		$50,716 00

The cost of repairs, labor and supervision of the City pipes and reservoirs, being common to each plan, is omitted.

Second—For a daily supply of 20 million gallons:

By pumping—The Superintendent reports that the cost of adding to the present works, two 8 million gallon engines, pumps, boilers, houses, supply pipes, force mains, reservoirs, &c., $781,000, including land, &c., $19,000, will be $800,000, and if the same are located at Scarboro the cost will be $511,500, to which must be added the value of the land and right of way, making, say $550,000. The annual interest on the latter sum at 4 per cent. is............ $22,000 00

The annual expense of operating the present Works, and renewals as above..........................		83,120 00
The same for one 8 m. engine...........	$46,667 00	
Charge for renewals, engine pipes, &c......	10,000 00	56,667 00
Annual charge for pumping 20 million gallons daily.....		$161,787 00
The cost of gravity works of capacity to supply 20 million gallons daily will be $490,700. The annual interest on which at 4 per cent. is.......	$19,628 00	
The annual cost of management and renewal fund is.....................	25,000 00	44,628 00
Showing an annual saving for 20 million gallons by gravity of................................		$117,159 00

Third—For a daily supply of 30 million gallons:

By pumping—The cost of a 10 million gallon engine and duplicate, with boilers, &c., will be $120,000. The annual interest on which, $4,800, with charge for renewals, $2,400....... $ 7,200 00
The annual expense of operating the 10 million engine. 58,333 00
The same for the 20 million gallon supply, as before... 161,787 00

The annual charge for supplying 30 million by pumping.		$227,320 00
The annual interest on the cost of gravity works to supply 30 million gallons daily ($873,000) would be.................	$35,012 00	
The annual cost of management and charge for renewals......................	30,000 00	65,012 00
Showing an annual saving for 30 million gallons by gravity of....................................		$162,308 00

Fourth—For a daily supply of 50 million gallons:

By pumping—Two engines, &c., with duplicates, each of 10 million capacity, will cost $280,000; the engine, boiler house, &c., the additional supply pipe, force, and connecting main, &c., will cost $260,000, making $540,000.

The annual interest, $21,600, and charge for renewals, $10,800..		$ 32,400 00
The annual cost of operating two engines of 10 million gallons..		116,667 00
Add the annual expense of 30 millions as before.......		227,320 00
The annual charge of supplying 50 million gallons by pumping..		$376,387 00
The annual interest on the cost of gravity works for supplying 50 million gallons ($1,380,330) at 4 per cent............	$55,213 00	
The annual cost of management and charge for renewals.....................	40,000 00	95,213 00
Showing an annual saving in supplying 50 million gallons by gravity of..........................		$281,174 00

The above comparisons show that without allowing anything for the interest on the cost of the existing pumping works, the annual expense of operating them, including the proper annual charge for a fund for renewing the engines, pumps, boilers, supply and force mains once in thirty years, will exceed the interest on the cost of gravity works to supply an equal quantity of water, including also the proper charge for their renewal fund, by $50,716 per year, which saving in about six years would be equal to the whole cost of the said gravity works.

In like manner if the supply be increased to twenty millions of gallons a day, the interest on the cost of the additional pumping works (as made out by the Superintendent) with the annual charge for the renewal fund, and the cost of operating at the same rate, will exceed the interest and renewal charge for the gravity works to supply the same quantity by $117,159 per year, which saving in about four years would be equal to the whole cost of the gravity works.

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.

These comparisons are, however, not just towards the gravity plans, because they will deliver all of their water at least at the elevation of the Rosehill reservoir, and ten millions sixty feet feet higher, while the pumping engines deliver the water for consumption at perhaps an average of 80 to 100 feet below the level of the reservoir, and not more than one-fourth actually into the reservoir. The extra cost of pumping, say one-fourth of water, sixty feet higher than Rosehill, to compare with the gravity plan, would add about $19,000 a year and increase the annual saving to about $69,000.

If the gravity project shall receive the favorable consideration of the Municipal Government, we would recommend that the works necessary to bring in the water from the west branch of the Don (ten millions of gallons daily) shall be first commenced and built with as much alacrity as the case admits, so that it may meet the immediate demand for an increased supply, instead of increasing the pumping works. The expenditure will be $210,600, or about one-fourth of the sum estimated by the Superintendent for a supply of eight millions by pumping.

The necessary surveys and plans can be prepared in three months, and the works constructed in four to six months.

The lower storage reservoir, containing from 200 to 300 millions of gallons, would be 9½ miles from the Rosehill reservoir. The conduit pipe connecting them would have a capacity for delivering from five to ten thousand gallons per minute into the City distribution (equal to the capacity of twenty-five large steam fire engines). The necessity for another distribution reservoir within the City is not therefore imperative.

We would also recommend that the works to bring in the waters from the middle branch of the Don should be commenced at an early day and prosecuted more deliberately. They may be completed in one year, and when finished the pumping expenses may be discontinued, though it would be advisable to maintain them in working condition for several years, as they might prove serviceable in the event of a large conflagration. The further extension of the gravity works hereinbefore described may be built from time to time as the demand for water may determine.

It will be observed that in the Plans herein proposed the supply from each of the gravity sources will be entirely independent, so that the repairs may be made upon either one without diminishing the full supply to the City, as the quantity from the other sources may be increased for the time being until such repairs are made, and then the greater portion can be drawn from the repaired sources. In this manner the gravity works may be considered as duplicated by the existing pumping works up to the present capacity, and the latter may be made further useful in the event of a very large fire in the lower portions of the City, as before mentioned, which may demand for a short time an extraordinary quantity of water.

Ten millions of gallons of water in 24 hours with an average of 100 feet head is equal to 200 horse power. This quantity of water used in ten hours for small water engines at the rate of cost of running of five or ten steam horse power would be equal to $200,000 per annum.

If the water power was furnished by the City at one-fifth the cost of steam power, and there was a demand for the whole power, it would pay the City 20 per cent. on the cost of the gravity works.

The conduit pipes will generally follow the high ground, where they will be subject to very light water pressures, and therefore plate steel, coated with cement, is proposed to be used of the proper thickness to resist the pressure, and to allow for the corrosion of 30 to 50 years. Cast iron pipes must be made of a certain minimum thickness, which is necessarily far beyond that required for such low pressure of water.

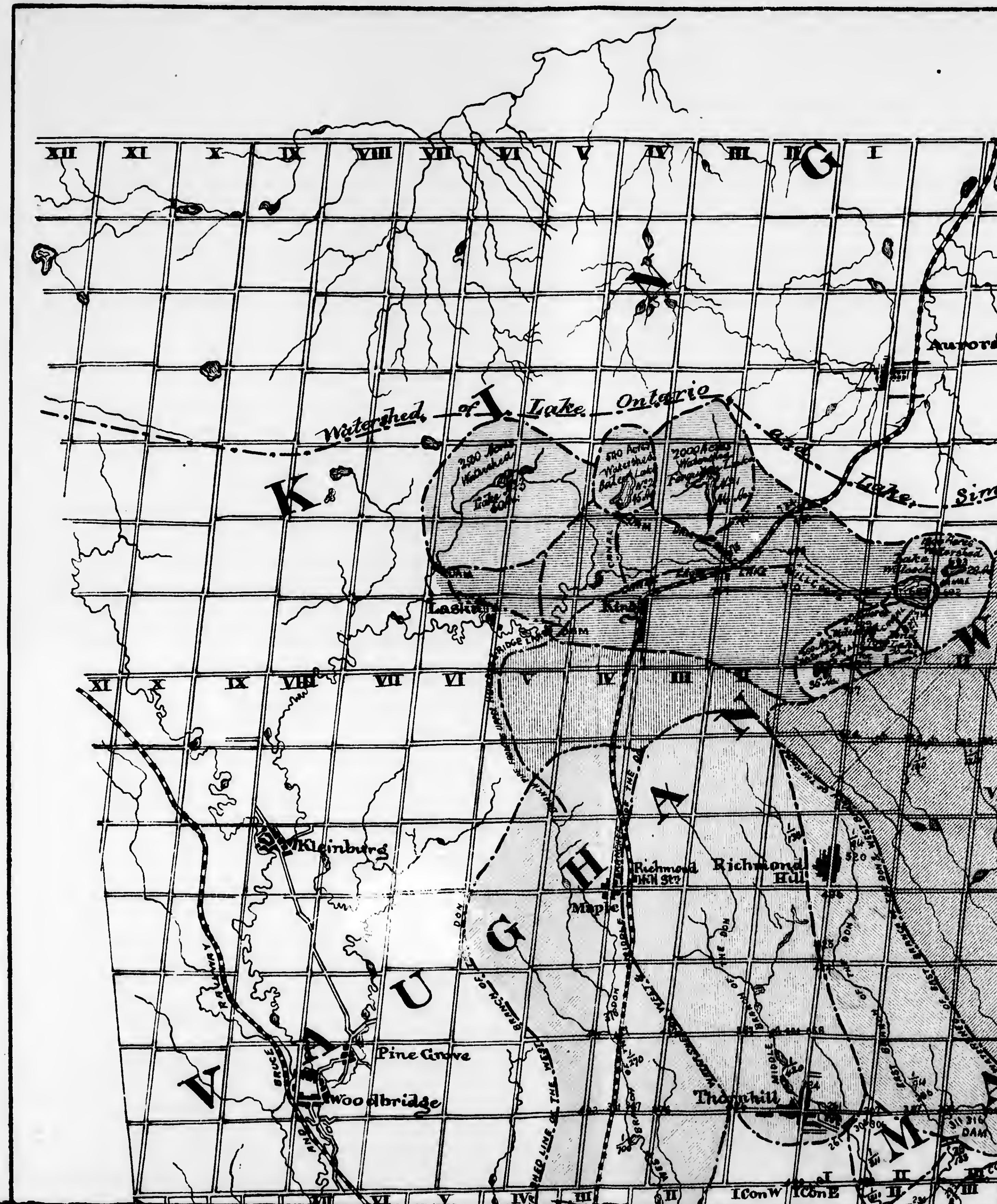
The steel pipes will be stiffened against collapsing when empty by circular fillets. The thickness of the syphon pipes across the valleys will of course be increased to meet the increased pressure.

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.

We have the honor to be,

Very respectfully,

WM. J. McALPINE.
KIVAS TULLY.



XII
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Aurora
Watershed of Lake Ontario and Lake Simcoe
K
King
Laskay
XI
X
IX
VIII
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Kleinburg
Richmond Hill Sta
Richmond Hill
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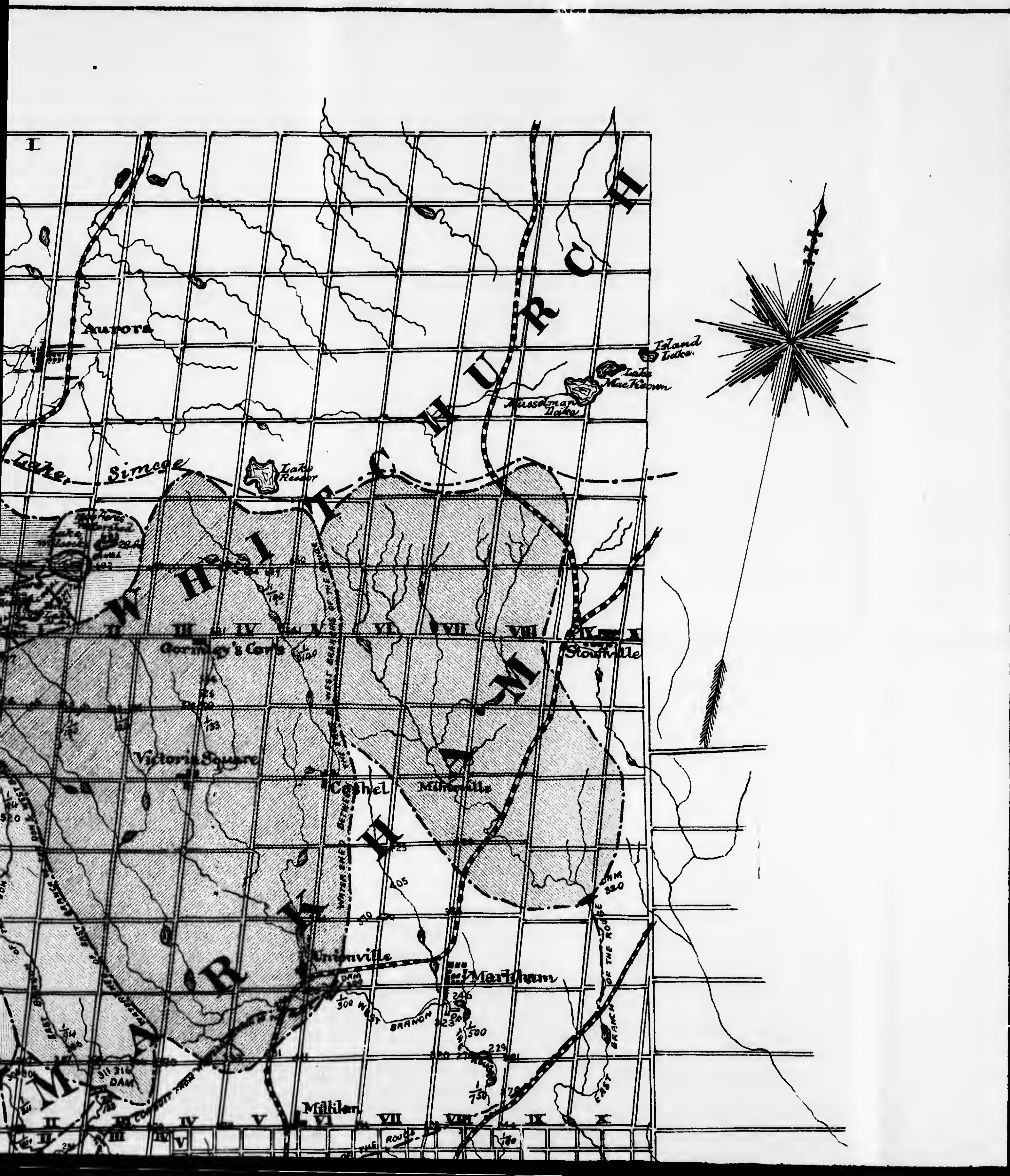
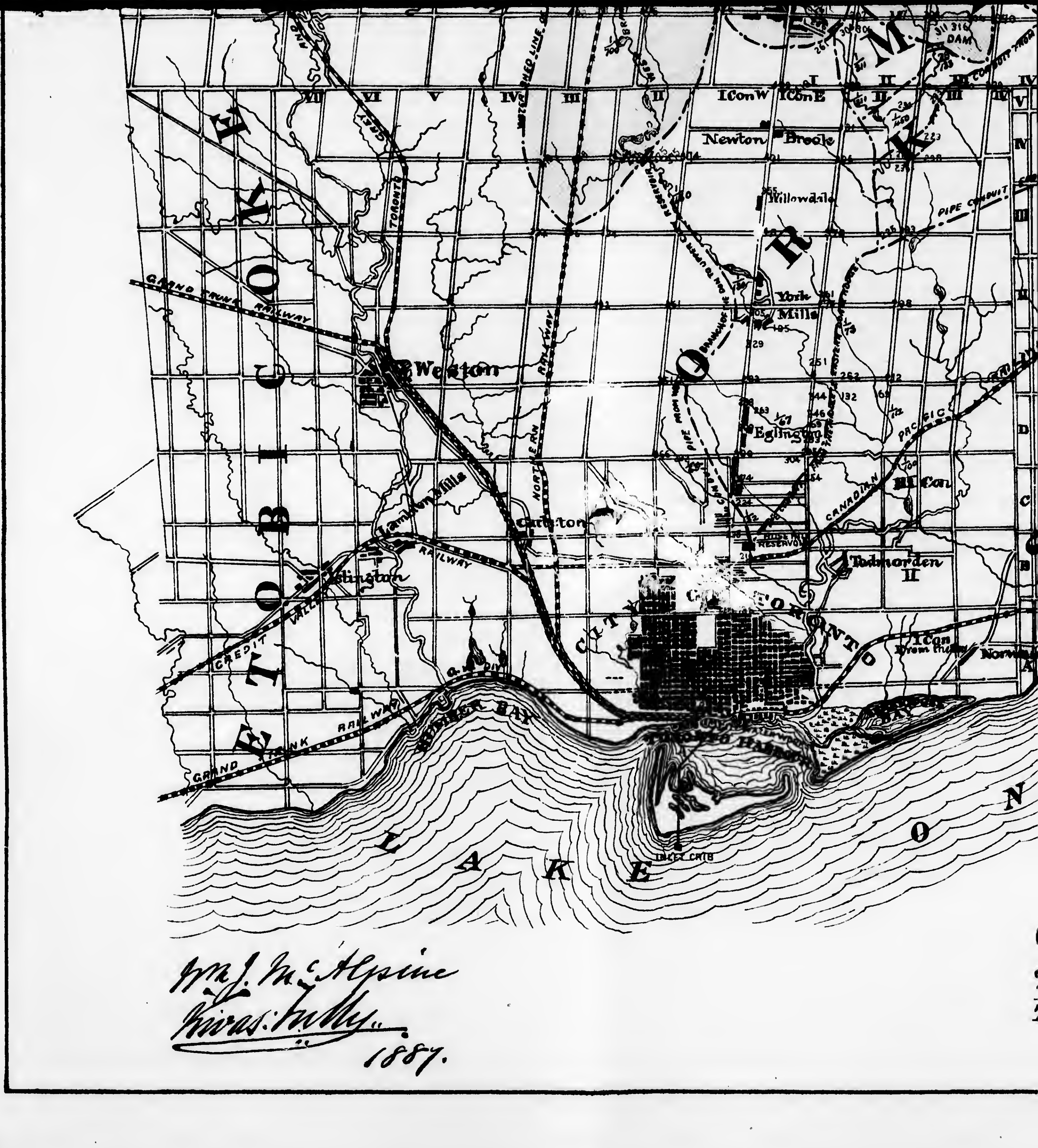
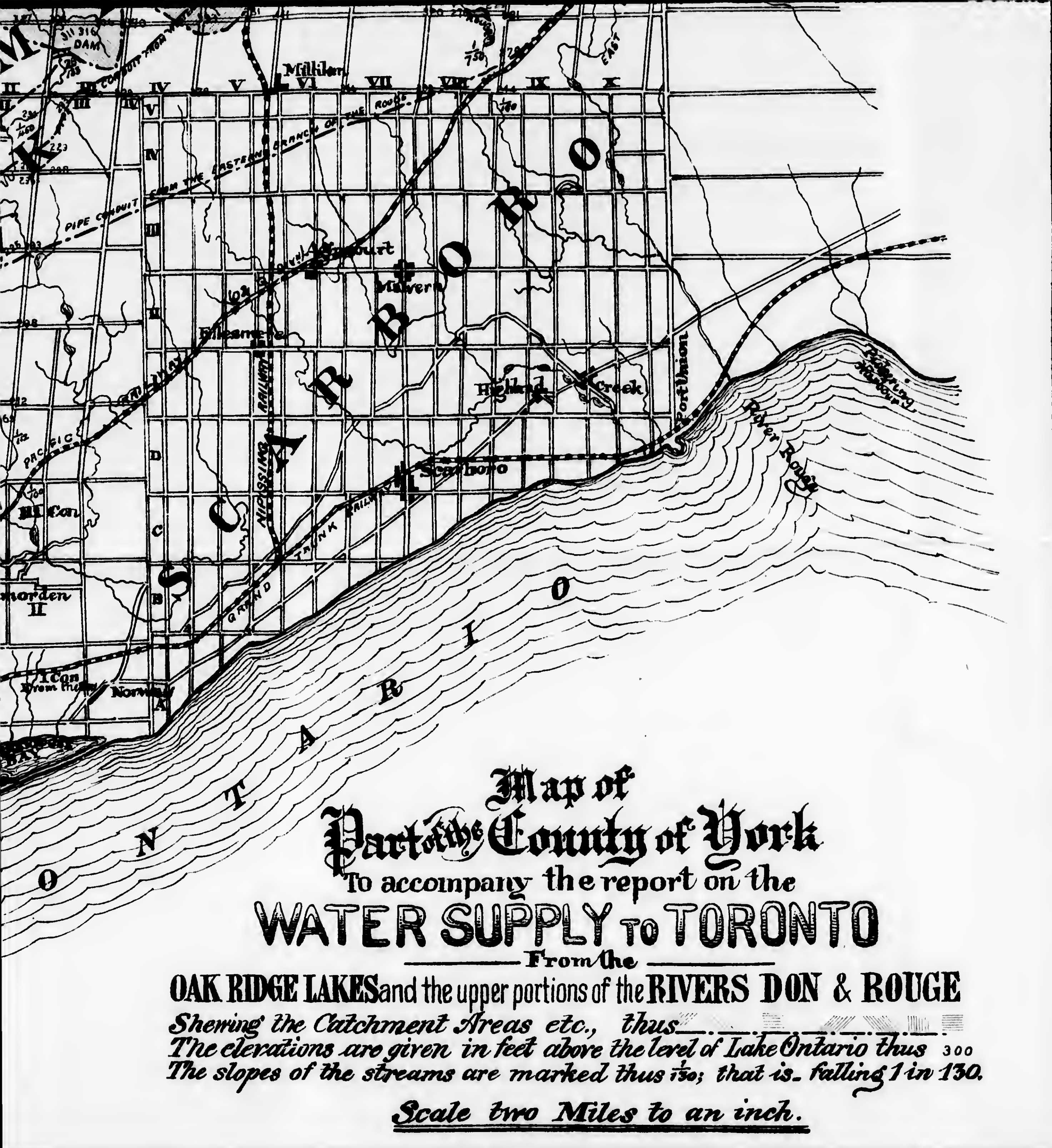


WHITCHURCH
MARKHAM
Aurora
Lake Simcoe
Island Lake
Lake MacKeown
Musselman Lake
Gormley's Cor's
Victoria Square
Cashel
Stouffville
Unionville
Markham
Milliken
WEST BRANCH
EAST BRANCH OF THE ROUGE
DAM



ETOBICOKE
YORK
Newton Brook
Willowdale
York Mills
Weston
Eglinton
Lambton Mills
Carlton
Islington
Todmorden
CITY OF TORONTO
GRAND TRUNK RAILWAY
CREDIT VALLEY RAILWAY
CANADIAN PACIFIC
NORTHERN RAILWAY
TORONTO
PIPE CONDUIT
HUMBER BAY
INLET CRIB
DAM
RESERVOIR
LAKE ONTARIO
IConW
IConE
Wm J. McAlpine
1887.



DAM
Milliken
I II III IV V VI VII VIII IX X
PIPE CONDUIT FROM THE EASTERN BRANCH OF THE ROUGE
SCARBORO
Agincourt
Malvern
Ellesmere
Highland Creek
Port Union
Pickering Harbour
River Rouge
Scarboro
NIPISSING RAILWAY
GRAND TRUNK RAILWAY
PACIFIC
Norway
ONTARIO
Map of
Part of the County of York
To accompany the report on the
WATER SUPPLY TO TORONTO
From the
OAK RIDGE LAKES and the upper portions of the RIVERS DON & ROUGE
Shewing the Catchment Areas etc., thus
The elevations are given in feet above the level of Lake Ontario thus 300
The slopes of the streams are marked thus 1/130; that is falling 1 in 130.
Scale two Miles to an inch.