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REPORT

ON

A PRELIMINARY SURVEY

FOR

THE WATER SUPPLY

OF

MONTREAL.

BY

THOS. C. KEEFER,

ENGINEER.

MONTREAL:

PRINTED BY JOHN LOVELL, AT HIS STEAM-PRINTING ESTABLISHMENT, ST. NICHOLAS STREET.

1852.

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PRELIMINARY REPORT.

To E. Atwater, Esquire,

Chairman, Water Committee, Corporation of Montreal.

Sir,

In compliance with your instructions of 15th June last, I have made the necessary Survey for ascertaining the practicability of bringing water from the head of the Lachine Rapids, for the purpose of affording—not only an ample supply for consumption, but also sufficient power to force this supply into the different wards of the City, and into suitable Reservoirs.

My instructions were directed towards this particular plan of supply—but as I have been requested to compare it with other proposed or possible ones, I will first allude to the subject of water supplies in general, and to the particular facilities available to Montreal, for securing an abundance of this invaluable element.

Three modes of water supply are usually open to the Engineer, the selection from which is to be determined by the positions of the city or town to be supplied.

The first is by "Gravitation,"—where water can be obtained at a high level, and be brought into the City in such manner as to supply its highest districts by its gravity alone. This is undoubtedly the best method, where sufficient head and volume of water are attainable at a justifiable outlay.

The second mode is,—by pumping from a river, springs, or wells, into reservoirs of sufficient height,—or without reservoirs, directly into consumption by the aid of stand pipes.

The third method—where no water presents itself within reach of the surface,—is by means of Artesian Wells, sunk until a subterraneous vein of water is intercepted and conducted to the surface, and if necessary, pumped into reservoirs or into the service pipes.

From the first mode of supply, the City of Montreal is precluded, except at a cost not justified by the circumstances. Situated upon an island, and surrounded by a plain but slightly elevated above tide water, no sufficient supply presents itself, at a high level, nearer than the mountains beyond New Glasgow, whose rain shed is into the Ottawa River. A sufficiently abundant and elevated supply could probably be obtained from this quarter by an aqueduct, as long and expensive as that of the Croton, approaching the City by the route of Isle Jesus, where no navigable channels intervene.

The necessary passage of the St. Lawrence forbids the idea of a supply from the south side of this river.

The geological features and rocky substrata underlying the city, hold out no hope of obtaining a supply, by means of Artesian Wells—even if other circumstances were to render such a course desirable.

But while you are by position restricted to the second mode of supply—Pumping—you have the satisfaction of knowing that this presents itself under the most favorable conditions. One of the largest and purest rivers in the world flows at the very feet of your city—affording not only an illimitable supply for consumption, but the cheapest power for elevating this supply into the highest parts of the city.

Unless a "Gravitation" supply be ample for all future wants, and sufficiently elevated to supply *every* house, it is more or less limited in its value. In most cities supplied by this means, the elevation is insufficient, either from the want of head pressure, or of *ground high enough* to place a reservoir upon; moreover, inasmuch as a fixed scale of dimensions must be assumed, there is no opportunity for enlargement with the increase of population,—the city must therefore, sooner or later, be put upon a short allowance, or else, a total reconstruction of the works becomes necessary. But, in the case of Montreal, the fountain head both for power and supply being inexhaustible, the works may be periodically enlarged by successive generations to meet their increasing wants, so long as the St. Lawrence flows toward the sea.

With respect to the scarcely less important question of *delivery*, the mountainous characteristics of Montreal not only afford peculiar advantages, by admitting of high reservoirs at the same cost as lower ones, but the mechanical mode of elevation to be employed will enable you to maintain reservoirs of different dimensions, if necessary, at different elevations; and from time to time, as the sides of the mountain become occupied with public or private buildings, the never ceasing power of the St. Lawrence will be available to afford to the remotest of these, bountiful supplies of this inestimable blessing.

In comparing the plan proposed for supplying the city, with other modifications of the same principle, I do not propose to institute a comparison between steam and water power, as I presume the experience of the Corporation is conclusive on this head. I would, however, observe first, that whatever objections there may be on the score of expense to the employment of steam, these are heightened in the present case by the necessity for importing fuel, and its consequent high price here. The consideration which, in my judgement, is conclusive upon this head, and which, in fact, is the leading principle of the proposed plan of supply is, that if it be necessary to go to the head of Lachine Rapids, to obtain a supply sufficiently pure for *consumption*, a slightly increased expenditure, while securing this supply, will bring in along with it, sufficient *power* to deliver that supply to our highest streets and tenements. That it *will be* necessary to go to these rapids for a pure and certain supply, when dealing with so grave and permanent a question as that of providing an important city, for all time, with one of the most indispensible elements to the health and comfort of its citizens,—I hope to shew.

It has been proposed to employ a water power from the Lachine Canal, and by means of it to force water from some contiguous part of the river into the Town; and I believe the idea has been entertained of taking the supply for consumption, as well as the water power, from the Canal.

The Lachine Canal is fed from the St. Lawrence through a basin cut off from the river by means of a long water tight pier—which basin receives and *retains* the drainage from the Village of Lachine, and also that of the constant succession of steamers and other craft which arrive and depart during the season of navigation. This canal is the common cess-pool for the offal of boats of every description passing through it. The soil, a clayey one, is constantly disturbed by the agitation produced by emptying the locks, or by the screws and paddles of passing steamers,—and, lastly, it lacks that uniform and vigorous current by means of which water relieves itself from all temporary impurities. The canal water might be filtered before going into consumption, could the popular repugnance to its antecedents be overcome, but there is, I conceive, a fatal objection to any scheme based upon employment of the facilities afforded by the Canal in any shape. In no matter should a city be more thoroughly independent than in its water supply; and it would be a sufficient reason for the City to discard all connection with the Canal, (in this matter,) from the simple fact that it can have no control over it.

It is the usual practice of the Board of Works to take the water out of the Canal, for purposes of repair, for a week or more in March or April; and when necessary it has been taken out for a month, in August—the business in this month being lightest—although this is precisely the period when the water consumption of the City would be heaviest. Besides this, the supply would be liable to interruption, without previous warning, at any moment,—from accident,—a breach in the embankment, or a gate knocked out by a steamer. Lastly, the Government lease only the *surplus* water, and when increasing trade multiplies the demand for lockages, all water tenants must give way to the navigation; so that it is very doubtful whether a lease could now be made at any one point, for the large amount of water power which it would be incumbent upon the City to secure.

But if, by employing large storing reservoirs, the uncertain *power* of the Canal, could be risqued—and assuming that canal water, filtered or otherwise, would be prescribed *for consumption*, it is necessary to determine the point on the St. Lawrence, from which the supplying is to be drawn; and which point must be within reach of a water power from the Canal—that is, at some place on the river bank *above* the canal entrance. The breadth of the shoal, extending out above and below Point St. Charles, is about half-a-mile, and a suction pipe of this length secured against the "grounding" and "grinding" of the ice, would be indispensible, in order to attain a point of sufficient purity, and depth enough to prevent its being choked by "anchor," or grounded "bordage" ice. The whole of this portion of the river is so shallow, that there would always be risque of having the supply suddenly cut off by the action of the Ice.

With respect to the purity of the water to be obtained above the Harbour, it may be stated that if any objections have been urged against the present point for taking water from the river, on account of its proximity to the sewage discharge of the City, these objections are by no means wholly removed by the above proposed new point of departure. At present the river front, between the mills and Point St. Charles, has few living occupants—but the drainage from the burial trenches of the victims of 1847, may be considered reason for condemning any point *below* the Emigrant Sheds. But we must look forward to the growth of the City south of the Canal, when the whole river bank, opposite Nuns' Island, will be peopled, and the sewage discharge become objectionable. The extreme shallowness of the water is the principal objection to any point of supply, from the immediate bank of the St. Lawrence, between Montreal Harbor and the head of the Lachine Rapids. In summer, the water exposed in shallow pools to the sun becomes heated, and from want of volume can be rendered impure, notwithstanding its current. In winter, not only will the irregular lodging of islands of ice render any point of supply uncertain, but the increased current along shore, caused by the ice dams on the shoals, disturbs the bed and banks so as to render the water positively turbid.

If it be desirable to obtain water from the river in the immediate neighborhood of the city—to be elevated either by steam, or by water power from the Canal, (if the latter can be applied)—it will be decidedly better to take it from the channel opposite St. Helens, than from any point above—making the suction pipe of sufficient length to extend beyond, and below the influence of the sewage discharge from the City.

For the foregoing reasons, I am of opinion that the plan of going to the head of the Lachine Rapids for water is the best one, under all the circumstances, which can be adopted for the supply of Montreal. It remains only to allude to its financial aspect.

It may be argued, that although the annual expenditure after completion will be much less, for the same quantity delivered, than the annual expense for a supply by the present mode, (steam-pumping) yet if the interest upon the capital to be invested in the new enterprise, exceeds, when added to the cost of management, the whole annual expenditure for pumping *the same supply*, by steam—the propriety of the new plan may be doubted. The determination of this depends upon the *quantity* to be supplied, and the *height* to which it is to be elevated: for while, with steam power, the cost increases almost in proportion to the quantity and height raised, this is not the case with water power, with which the most abundant supply may be provided at almost the same cost as the most limited one. And herein lies the advantage of a plan where the cost is one of preliminary outlay chiefly—as compared with one, in which every increased facility is burdened by a corresponding increase of cost. If the quantity required were fixed, and not to be increased,—and if the cost of procuring it were to be a permanent burden upon the present generation, there would be good reasons why a known annual cost, in steam power should be preferred to the investment of a large sum, and payment of interest thereon, in order to secure ultimate economy of management. It is, however, fairly to be assumed that such an enterprise as the water supply of a city, will be a self sustaining one;—and that, therefore, the burden of any investment, will be but temporary. And as the consumption will increase—not merely by the natural growth of the City, but *with the facilities for extending the supply*—it is evident that nothing but absolute poverty can justify the continued use of steam, where another power is within reach—which promises not only ultimate economy,—but (what is far more important) an extension of the consumption, and all the advantages which flow from it: which result will never take place if the use of steam be persisted in.

The uses of water are not confined to domestic purposes only; its abundance and cheapness give rise to manufactures, and thus become sources of immediate profit to the community. Secondly, by an overflowing amount and a sufficient head pressure on every street, the extinction of fires becomes certain and speedy; and this, by reducing insurance and giving increased security, attracts immigration and capital. Thirdly, with the intense heat of our summers, and the inordinate amount of dust generated, water should be used most unsparingly, not only for the comfort of the citizens but as a preservative of property. The damage done by dust to goods and furniture, at places and in seasons, where and when doors and windows must be left open,—cannot be ascertained,—but, could it be, it would be found to cover a large proportion of the interest upon the cost of works which would obviate the evil. Fourthly, In the supply of fountains:—in parks, public gardens, and pleasure grounds, abundance of water must be considered not merely as a luxury, and as purifying the air,—but as possessing a positive commercial value. Every object of interest and beauty about a city is an additional attraction to the tourist, and the seekers of pleasure or amusement—always the wealthier classes of society. Those who know how much our steamers, hotels, and carters, are dependent upon the annual stream of "pleasure travel," can best estimate the amount of money left by this class, and the relief thus afforded to the whole community. Indeed, if the positive *paying* character of the speculation were fully appreciated, much greater attention would be given to embellishing, by a sound taste and a little money, the many natural beauties possessed by Montreal.

DESCRIPTION OF THE PLAN.

It is proposed to take water out of the River St. Lawrence at a point about one mile above the head of the Lachine Rapids. The river here flows deep and strong within a few yards of the shore, and ranges but little between its extreme high and low water marks. At the point where the Aqueduct would commence the level of the river is thirty-seven feet above the summer level of Montreal Harbor.

The water is to be conducted in an open channel, four and three quarter miles in length, to the Lachine Canal at Gregory's. Here the wheels and pumps would be placed,—the waste water being discharged into the St. Pierre River, which has a fall of about 12 feet between this point and the St. Lawrence,—but being narrow and crooked, some clearing out and enlargement of its channel will be required. On account of the winter elevation of the St. Lawrence, it is proposed to keep the "tail race" from the water wheels, at least twenty feet above low water level of Montreal Harbor; this will leave a head and fall of at least sixteen feet at the pumps,—about one foot of fall being assigned to create a proper current in the Aqueduct.

From the Pumps at Gregory's, the water is to be forced through an iron main, 30 inches in diameter, laid under the Canal, turnpike, railway, and all the public streets, into a reservoir, at about the elevation of the residence of the Hon. Mr. Justice Smith, being about two hundred feet above the level of Montreal Harbor.

Having presented the general features of the plan, I proceed more particularly to the different heads.

The Aqueduct.—The dimensions proposed for the channel to conduct the water from the St. Lawrence above the Lachine Rapids, to the water wheels at Gregory's, are—twenty feet width on bottom, forty feet wide at the water surface, and eight feet depth of water. The wetted perimeter of the canal is to be faced with stone and gravel, and the profile of the bottom to have an inclination of about 2½ inches per mile. The capacity ensured by the above specifications is greater than would be required for passing the requisite quantity required by the wheels and pumps, but a considerable margin is provided to guard against a diminished flow in winter, when the ice will occupy a large per centage of the sectional area; and also to cover all losses from evaporation, leakage and filtration. The cost of an open channel does not increase proportionally with the sectional area; and, as great additional capacity is to be attained at slight increase of first cost, it is better to provide against any necessity for early enlargement,—as well as against the filling up of the channel by gradual depositions. Lastly, the volume of water thus secured is too great to be influenced by any ordinary impurities to which it will be exposed.

As some objections have been urged to an open conduit, I will mention them here.

The distinguishing feature of the present plan, as compared with Aqueducts generally, is, that it is proposed to conduct not only the quantity required for the consumption, but the very much larger volume which is needed to supply two hundred horse power under the given head. Now, the great advantage possessed by an open canal over every enclosed form of conduit, is, that it will deliver the greatest quantity *with the least loss of head*—a consideration of the first importance when a water power is in question. If iron mains or brick culverts of reasonable number or dimensions be substituted, nearly the whole available head and fall would be required to overcome the friction, and the water would be delivered at Gregory's robbed of all its value as a moving power. Brick culverts would be a very much cheaper form of conduit than iron pipes, for such a volume, bu. the full duty from these could not be exacted without the risk of their being blown up, as it would be necessary to place the entrance mouth of these culverts below the level of the ice, which arrangement would expose them to a considerable pressure at high water, particularly, if (as they should have) an efficient fall per mile be given to them. Iron mains, therefore, would be the safest,—but these should be of the largest possible dimensions to guard against friction, and possibly the effects of "anchor" ice, which, at several points on the St. Lawrence is known to float into the shallow mill races, or flumes, and permanently resist all attempts to drive the machinery. To pass the same volume of water as would flow through the open Aqueduct proposed, would require *more than a dozen* iron mains of the largest size, 5 feet diameter each, laid with an inclination of double the rate per mile of that of the open channel, while the cost of any *one* of these pipes would be at least *double* that of excavating the Aqueduct, and as much as the whole cost of the latter, including land damages, masonry, bridging, and lining with stone.

The Lachine Canal and water power thereon, are evidence of the perfect practicability of maintaining a full supply of water, by an open channel, during the severest winters.

The only objection, therefore, which can be urged against the open aqueduct, is, that the water will be exposed to impurities. We have alluded to the utter incapacity of pipes to convey a water power such as is required; if therefore the objection to the open canal, on the ground of its exposure, be sustained, it will obviously be sound policy to excavate an aqueduct for the *water power*, and lay a pipe within it for the *water supply*, as nearly the whole fall could be given to the pipe—which to pass 5,000,000 galls in 24 hours, would require a diameter over 30 inches and a fall of 10 feet in the whole distance. The cost of this pipe would be about the same as that of the excavated aqueduct.

The objections to an open canal, are reduced in the present case, by its secluded position. In the whole length of nearly five miles, it is crossed by but two public roads, norwithstanding its proximity to the city. By fencing in the route, and passing the highways by tight bridges, any interference must not only be premeditated, but upon such a trivial scale as would render harmless such useless and unprofitable mischief.

The New River—an artificial open channel 40 miles in length, and crossed by 200 bridges, has, for 240 years, furnished the principal supply of water to London. The Canal de l'Ourcq—24 leagues long—serves the same purpose to the City of Paris. Dublin and Greenock are likewise supplied by open aqueducts.

In the recent agitation for an improved water supply for London, two of the leading schemes proposed, contemplate open canals. The "Henly Scheme" embraces an open canal to carry 200 millions of gallons daily.

The "Maple-durham Scheme" proposes an open canal 4½ miles long, (about the same length of yours) for a part of the distance—thence, through three iron pipes of five feet diameter each.

The objections to open canals are :—

1st, Loss of water by evaporation, leakage, and filtration.

2nd, Exposure to breaches in the embankments, from long continued rains.

3rd, Exposure to impurities, either from wash and surface drainage—absorption of the earthy strata through which it passes—or from deleterious substances thrown in, ignorantly or maliciously.

In the present instance, the first objection disappears with the unlimited abundance of the fountain head; the second need not exist, inasmuch as the topography of the route admits of the whole line being "in excavation," avoiding embankments and their attendant risques.

With respect to the third—wash and surface drainage may be prevented by a thorough system of side ditches, and off-take drains, and by "sodding" the inner slope of the banks above water. By lining the sides and bottom of the Aqueduct with stone and gravel, no impurities will be absorbed—so that there only remains the single objection of exposure to impurities thrown in. The great volume of water is the best security against this remote contingency. Under any circumstances the Reservoirs and entrance to the Aqueduct cannot be covered, so that inspection and legislative aid must be relied on to protect the works from malicious injury.

On the other hand—the advantages of the open canal are:—

1st, It is much cheaper than any other conduit of the same capacity.

2nd, Water flowing freely in open channels, exposed to light and air, not only frees itself from impurities it may hold in suspension—but diminishes its hardness.

3rd, In this climate, for one-third of the year at least, an open aqueduct will be protected by a covering of ice, rendering it as secure as a covered one.

4th, It is susceptible of future enlargement.

From the position of this Aqueduct, and the highly favorable nature of the ground, it may be considered a practical extension of a branch of the St. Lawrence to the borders of the City at Gregory's,—where the water can be delivered in nearly as pure a state as when it leaves the river. The fears of injury to the water are rather imaginary than real, and may be disposed of altogether by the construction of large subsiding reservoirs at the pumps—for which purpose the surrounding ground is highly favorable. Many cities are supplied by water collected on gathering grounds under cultivation—by means of catch-water drains leading into storage reservoirs, where the water is purified by subsidence.

The Survey was directed principally to the plan of bringing the open Aqueduct as near the City as practicable—or until it would be intercepted by the Lachine Canal at Gregory's—the nearest point where a discharge for the water from the wheels could be readily secured. It is very desirable to shorten as much as possible the length of the "rising main" through which the water is to be forced—as this will be a saving in power, and a diminution of risk—particularly when that end of the main which is subject to the heaviest pressure is shortened. It would be more convenient to have the pumps and reservoirs at Gregory's than nearer the Rapids, as they would then be under the influence of the Police and City authorities:—also, if the Aqueduct be properly constructed, what may be termed the artificial works, requiring close attention, will hardly commence until we reach Gregory's.

A modification of this plan is, however, practicable—which possesses some advantages.

By placing the pumps near the Telegraph Mast, at the foot of the Lachine Rapids—the length of the open canal would be shortened nearly three miles—for which a corresponding length of rising main would be substituted. By this arrangement the cost of the Aqueduct, land damages, and bridges, would be reduced: and by placing the wheels nearer the river, the cost of the "tail race" would be diminished. If the water for consumption can be obtained from the river sufficiently clear at all seasons of the year to go into the pumps—an important reduction in the cost of the Aqueduct and protection of it from trespass will be effected—because in this case the canal will be cut for the water power only, and the expense of lining be evaded. This would also remove any objections on the score of exposure—which in this case is altogether avoided. There is, however, a question of back water on the wheels, from the lodging of ice on the shoals at the foot of the rapids—to be first determined, and it is also doubtful whether the supply can be taken from the river at this point. The adjoining ground is not so favorable for subsiding reservoirs as at Gregory's—and, lastly, the increased power required, and the increased risk of nearly three miles additional pipe under the highest pressure, are set offs against the greater economy and reduced exposure of this plan.

The selection between these two sites for the pumps will be determined by more extended surveys and estimates, and particularly by the relative land damages upon the two routes—and the question of right of way across the Aqueduct.

THE RESERVOIR.—Next to an abundant and constant supply of water, the most important consideration is the height to which it can, when required, be delivered, and the amount of head pressure which can be obtained. Irrespective of the necessity for supplying the highest dwellings or the upper stories of lofty buildings, the greater the pressure, within the limits of the strength of the service pipes, the better will be the distribution; and greater security against the ravages of fire is attained. In other cities, as New York and Boston, distributing reservoirs have been constructed at enormous cost, *above* the surface of the highest attainable ground; but here the proximity of the Mountain and its successive terraces, enable us to select any required height, at nearly the same cost, for the construction of our reservoir. A little more power and a little more pipe, provided for in the first outlay, and a high service is as easily secured as a low one.

The most ordinary pipes will bear a pressure with safety of 300 feet head of water. The pipes at present laid in the city, are all under 12 inches diameter, and capable of bearing a pressure of 450 feet and upwards;—the strength of metal in pipes of these dimensions being determined, not by the water pressure they are to sustain, but by what is requisite to make a good casting. They are in fact subject to strains from their position in the streets, which call for greater strength than what is required to resist the water pressure.

With an efficient head pressure great economy in the distribution is secured—a smaller sub-main or service pipe will supply the place of a larger one with a lower head. The "high service" remedies the common evil of a failure in the delivery at points most distant from the reservoir, and in the upper stories of buildings which may have a plentiful supply in the cellar. With a "low service",—while the city is drawing,—the water is not allowed time to ascend to the height due to the reservoir head—except at night. The remedies for this are—pipes of extravagant dimensions, or a reservoir sufficiently elevated above the point of delivery to feed the service pipes faster than the consumption,—and send on the surplus to the higher, or the more distant points.

But it is as a safe-guard against fire that the high service is to be chiefly commended. Too many towns are restricted to—or are content with,—a pressure sufficient only to fill the engine tanks—relying on manual labor to throw the water on the flames. This need not be the case with Montreal—for here the merchant may have his private hose on ever floor of his warehouse, and by simply turning a cock play upon a fire as soon as discovered.

In the important process of cleansing the streets the benefits of a heavy pressure are apparent, enabling you to *scour* instead of simply *wetting* them; and the greater the pressure—the greater number of square yards can be commanded from one plug.

Lastly,—The pipes in upper stories should be *constantly* full;—if alternately wet and dry from insufficient head, air is admitted and oxidation takes place—imparting deleterious properties to the water, injurious to health and destructive to the pipes.

As it is not practicable to place the pumps nearer the reservoir than Gregory's, (on account of the intervention of the Lachine Canal,) it was desirable to ascertain the nearest point to this possessing sufficient altitude, and suitable for a reservoir. A line was therefore run to the mountain, near the residence of the Hon. John Young. The distance to this point would be about one and a half miles,—but as a reservoir here would be too far from the City it was considered preferable to select a site near the M'Tavish property—this quarter affording ground of the required elevation nearer to the commercial heart of the City than any other point. The rising main is lengthened by this arrangement but the whole length of influent and effluent pipe is diminished, and —what is more important—the great body of the water in this main and in the reservoir, is laid nearer to its required destination.

The Pumps.—It is proposed to erect two breast wheels, constructed wholly of iron, with ventilated buckets, having a diameter of about 20 feet and not less than 22 feet length of bucket. The power is to be taken off the *inside* of the periphery of the wheel upon the loaded side only. The power of each of these wheels to be about one hundred horses. The breast wheel, for falls under 20 feet, possesses several advantages, particularly for the slow and regular motion required for driving the pumps. By admitting of a diameter greater than the fall, it receives and discharges the water to better advantage,—works longer in and is less retarded by back water than the overshot wheel.

The wheels and "plunger" pumps will be placed within a substantial building, fire and frost proof: the bulk heads, foundations, tail races, &c., to be constructed upon the most substantial and improved plans.

THE RISING MAIN.—This should have as large a diameter as can be afforded, in order to diminish the friction and strain on the pumps and pipe itself, and lessen the power required. From the unavoidable distance of the pumps from the reservoir and centre of the city, it is desirable that the main supply pipe should have the largest capacity possible, and thus plant a good body of water as near the centre of distribution as practicable. This is assuming as probable—that as the "rising main" traverses the city on its way to the reservoir, the supply will be taken from it at intermediate points.

The track of the "rising main" may enter St. Catherine Street either by Mountain Street, or ascend the Cote beyond the Baptist College, and come down St. Catherine Street to the Protestant Orphan Asylum,—where a branch would turn up to the Reservoir, and the main may continue on through this street to the north-eastern quarter of the City. Taken in respect both to elevation and position, the line of St. Catherine Street traverses the City in a central position—planting a large body of water everywhere within reach of the smaller pipes already laid.

QUANTITY OF WATER.

The scale of works contemplated by this survey,—as assented to at the commencement,—was for a daily supply of 5,000,000 imperial gallons, and for a reservoir at an elevation of two hundred feet above Montreal harbour—being about 140 feet above the higher points of Notre Dame Street. Thirty gallons per head, is the usual provision, with proper allowances for the increase of population—but recent experience has shewn the average consumption in New York and Boston to have risen as high as fifty to sixty gallons per head. The above amount provides about 40 gallons per head for a population double that of the City at present, and considering the facilities for extending it under the proposed plan, is, I consider an ample provision. The dimensions of the Aqueduct are sufficient to conduct water enough for an effective power, on breast wheels, of three hundred horses—in summer when the flow is unimpeded by ice; and as this is the season when the greatest supply is required, the erection of an additional wheel and an increase in the speed of the pumps will enable you to extend the supply as required. With you, therefore, it may prove the wiser policy to provide for that *waste* of water so much complained of in New York and Boston—rather than to rely upon your future ability to check or prevent it.

The Estimate.

Since the great fire a natural anxiety has been manifested to obtain the results of this examination at the earliest possible period. The limited nature of the appropriation did not admit of the preparation of detailed plans and estimates of the different structures required. It was therefore understood that the object of the present survey was principally to ascertain the practicability of the proposed plan, and the approximate cost of the same, in order that it might be submitted—when if the scheme were rejected, no more time or money would be wasted upon an unsuitable project. The importance, however, of the subject, and the strong probability that the present plan would be recognized as the only efficient mode of supply—rendered it desirable that the whole available ground should be examined, and all the main features of the project weighed before an estimate, which is to be the basis of future operations, could with safety be offered. The intermediate country has been topographically surveyed—two lines have been located, and the nature of the excavation ascertained by test-pits and borings. The survey, therefore, is only wanting in the detailed plans and estimates of the different mechanical structures required :—but ample provision has been made for these under any variations of the plan which experience in the development of the works may suggest.

One important item in the estimate is the rising main —which is *single* and 30" diameter. As a precautionary measure, two pipes of smaller size are often substituted for the larger one—in case of accident or repairs to one. One large pipe is however cheaper and better than two smaller ones of equal area ; and, from the great length of this pipe I do not consider the remote risk would justify the expense of a double one. Properly constructed, there should be no more necessity for the duplicate system in this pipe than in other parts of the work. The 30 inch pipe, however, is provided to afford the full supply of 5,000,000 gallons daily. As this quantity may not be required for some time,—a smaller pipe may now be laid, and an additional one at a future date :—the only point where a double pipe may be desirable, would be in the passage *under the canal*, where the pipe would be inaccessible during the season of navigation.

I estimate the cost of the aqueduct, wheels and pumps, rising main, reservoirs, with the land purchase, masonry, bridges, enclosures, &c.,—all the work to be done in the most substantial and permanent manner,—at the sum of *one hundred and fifty thousand pounds.*

Estimate of Revenue.

The population of Montreal being taken at 60,000—the number of "water tenants," according to the experience of other cities, should be about 8000. The average charge per tenant in New York and Boston is about $10 per annum, and in the city of Philadelphia about $5. At the Philadelphia rate, the present population of Montreal should give a gross income for water rates of £10,000 per annum.

The actual income from the present water works of this city is as follows:—

1064 annual tenants,...............	£5345	3	10	
Sale at water taps (2d. per puncheon),	1090	14	3	
Special tenants, ...	47	10	0	
				£6483 8 1

The foregoing is the *revenue* only. The amount *paid* for water by the city is much larger. In addition to the £1090—paid the city for some 130,000 puncheons at the water taps—the consumers pay for cartage of the same (at 7d. per puncheon) the sum of £3790. What amount of water is carted from the river is not known—but here we have £10270 paid for water supplied by the present water works. It is probable that the amount paid for cartage of water from the river during the winter, would increase the gross annual payment for water by the city, exclusive of wells, &c., to some £11000 or £12000.

The inefficiency of the present supply needs no demonstration. The capacity of both engines, working constantly, is reported at 1,000,000 gallons in 24 hours or about 16 gallons per head of the population; what quantity is furnished, on the average throughout the year, cannot be ascertained,—probably not ten gallons a head per diem. This inferior supply costs the water works department about £2500 per annum. Assuming that one millions of gallons were raised daily, this would be the extravagant price of £7 per million gallons—and it most probably is £10 per million gallons. The cost of raising one million gallons, at the Fairmount works, Philadelphia, in 1850, was 8s. 0½d., only!

If the new works were constructed, five times the quantity of water at present supplied would be furnished to eight times as many tenants, at a cost to each of about one-third the present charge. The *present* population of the city, at the Philadelphia water rates, (the lowest in America,) should pay an annual revenue of £10,000—a sum nearly sufficient to cover the interest of the new outlay and the annual charges of management, &c., giving the City water for fires, street watering, and fountains, free,—and as the population increases, the rates may be reduced, or a sinking fund be formed of the surplus, for extension of the works or extinction of the debt.

These favorable prospects are due to the cheapness at which an abundant supply can be obtained at Montreal, as compared with some other cities. The Croton works cost the citizens of New York about £10 per head—the Boston works cost that city about £8 per head. Equally efficient works here can be had for £2 10s. per head, exclusive of the cost of distribution.

Nor should the other advantages of a full supply and of the new plan be overlooked.

The extension of manufactories—particularly those requiring a supply of pure water—would not only enrich the city, but enlarge the water rates. The Fairmount works number in their water tenants no less than 138 steam engines, and several hundred manufactories of every description: some of these engines pay £50 per annum for water, and one sugar refiner pays $750 annual water rate.

The diminution of the annual cost of supply on the new plan, is forcibly shown by the following comparative statement of the cost of water power, and of steam power —in the City of Philadelphia.

The total expense of running the eight wheels and pumps at Fairmount in 1850 was as follows:—

"For wages of workmen, tallow, oil, packing yarn, and fuel for heating "the mill house, \$2594,91 per annum, or \$7,10$\frac{3}{10}$ per diem.

" For repairs to wheels " and pumps, during " the year,	216,27	59$\frac{3}{10}$
	\$2811,18 per annum,	\$7,70 per diem,
	£ 702 15 11 do	£1 18 6 do

" For which sum an average of 4,785,338 ale gallons per day were " pumped by the eight wheels and pumps, equal to a cost of about \$1,61 " per million gallons raised per day.

" The cost of pumping by steam power at the Spring Garden and Northern " Liberties works in 1850, was as follows:—

" For coal, wages of workmen, " tallow, oil, yarn, &c.,	\$16,644 per annum=	\$45,60 per diem.
" Repairs to engine and pumps, " during the year,	5,127,46 do	15,06 do
	\$21,771,46	\$60,66
	£ 5442 17 3½ do	£15 3 3½ per diem.

" For this sum an average of 3,231,254 gallons per day, were pumped by " three engines and pumps,—about \$18,77 per million gallons per day."

Thus the cost per million gallons by steam was \$18,77.
Do. do do do water, do 1,61.
or, in other words, 4¾ millions of gallons were supplied at a daily cost of 38s. by water power, while 3¼ millions pumped by steam cost 303s. daily: and the Fairmount works, at a cost of £702 per annum, furnished one-third more water than the steam works, at a cost of £5442 per annum.

I am informed by the manager of one of the principal insurance offices in this City, that, previous to the great fire, the average amount of premiums paid at all the offices on property insured within the City might be estimated at about £25,000: and that since the fire the rates have been increased upwards of fifty per cent;—so that the premiums *on the same amount of risks* would now amount to about £40,000 per annum. The same gentleman is of opinion that an efficient supply of water would have reduced the old rates twenty per cent, or that—instead of £25,000 the amount of the premiums before the fire would have been reduced to £20,000. From this it may be inferred that the City is now paying a penalty of £20,000 per annum in extra insurance from the want of proper means for extinguishing fires. No doubt part of the present increased rates of insurance are levied to make up losses—and some part of it may have reference to the fire department, but it does not appear unreasonable to assume that at least £10,000 per annum would be saved in this single item of insurance, if the city were in possession of an ample supply of water. This sum would pay the interest on the cost of the works, and is therefore all that need be claimed under this head: but, the actual money value of the additional security obtained through an abundant supply of water would be far higher, because it will embrace the reduced risk upon *all* the property in the city, whether insured by the Companies or by the owners.

But arguments are unnecessary to prove the great economy of a water supply on an efficient scale. With the experience of the past year no rates would appear safe for insurance companies—and with the recurrence of such calamities insurance must become impracticable or *unnecessary*. It is argument enough for the expenditure of £150,000 for preservation from fire alone (setting aside the other advantages of abundance of water) that we have seen property to five times that amount utterly annihilated in a few hours, and that a repetition of such a catastrophe is by no means impossible.

I have the honor to be,

Sir,

Your obedient Servant,

THOS. C. KEEFER.