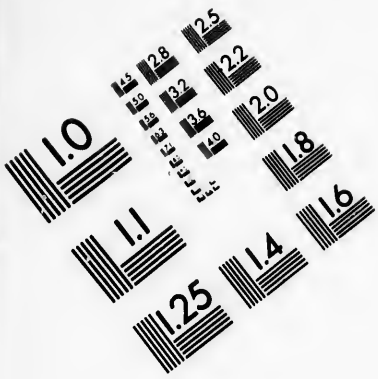

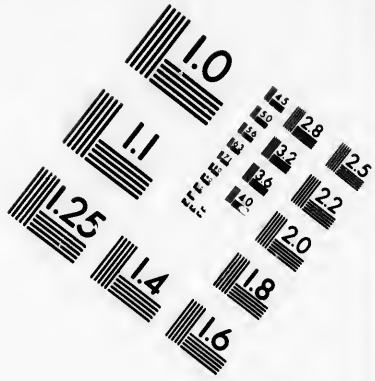

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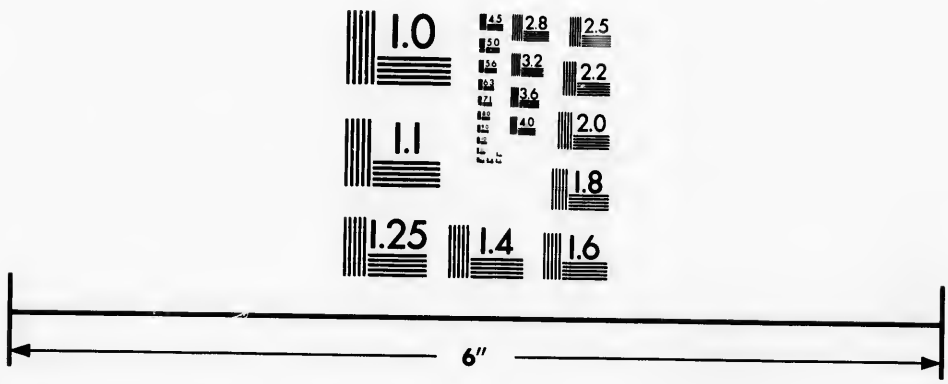

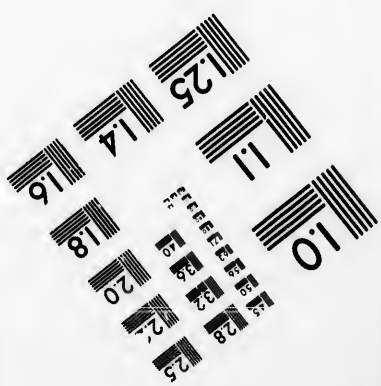

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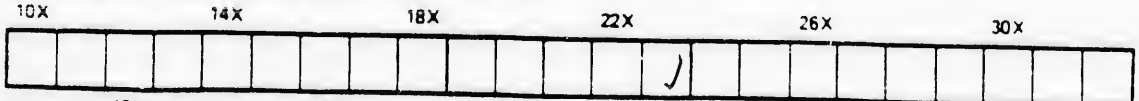

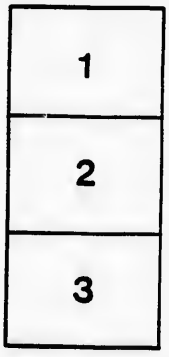

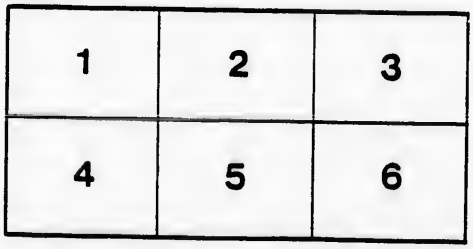

REPORT

OF

WALTER SHANLY, Esq, C. E.

ON THE

WATER WORKS

OF

THE CITY OF MONTREAL

ACCOMPANIED BY A

REPORT

OF

JAMES B. FRANCIS

HYDRAULIC ENGINEER OF LOWELL

ON THE SAME SUBJECT.

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REPORT.

JOHN MCGAUVRAN, Esq.,
Chairman Water Committee,
City Council, Montreal.

SIR:

On 15th March I received from the City Clerk copy of a Resolution of the Water Committee of the City Council, empowering yourself and Councillor Lyman to treat with me "with the view to have such an examination and report upon the Water Works, present and prospective, as the case may seem to require." The same Resolution authorises me to "obtain the advice of other professional gentlemen" should I "deem it necessary to do so."

On 18th March, I received official intimation that Mr. J. B. Francis, Engineer of the Lowell Manufacturing Companies, had also been called in for consultation on the water question, and I was requested to meet and confer with him—which I, accordingly, did; having previously, at an interview with yourself and Mr. Lyman, undertaken to examine into and report on the matters referred.

On 21st March, Mr. Francis and myself, accompanied by the Mayor, yourself, as Chairman of the Water Committee, and other members of the Corporation, inspected the Aqueduct and Pumping Machinery, and made a cursory examination of the river-margin from the entrance of the Aqueduct up to the old Church of Lachine.

Mr. Francis' Report, already in the hands of the Committee,

I will have occasion to refer to further on, and will now proceed, as required by the reference, to speak of the condition and capacity of the works as they exist.

The present Water Works were designed some sixteen years ago—at a time when the population of the city was assumed to be about 60,000,—and were planned with a view to providing for double that number of inhabitants a daily supply equal to about 40 gallons per head. In other words, to furnish, in addition to five million gallons, estimated as likely to be required for the future of city use, in each day of 24 hours, the power for pumping that supply into a Reservoir situated on the side of the mountain, some 200 feet above the level of the river.

The water, alike for supply and for power, is conducted in a canal or aqueduct, some five miles in length, from a point on the St. Lawrence, a short way above the Lachine Rapids, to where are placed the pumping machinery and pumps. The former, as originally designed and executed, consisted of two breast-wheels 22 feet diameter each. A turbine wheel, 8 feet diameter, has recently been added.

The bottom of the Aqueduct, to which is given a longitudinal slope of 5 inches in the mile, has a general width of 20 feet; the surface width being 40 when the water stands at its least (assumed) depth of 8 feet. These dimensions give a sectional area of 240 feet of water, and a volume or discharge—with 14 feet fall on the wheels—equal to nearly 300 horse-power—ample for effecting what in 1852 was considered to be the outside limit to which this generation was called upon to go in providing a water supply for the future of the city, and which, as already observed, was based on an estimate of 40 gallons per head, one day with another the year round, for a population of 120,000.

The surface of the river, where tapped by the Water Works Canal, was taken to be, at its lowest stage, 36 feet above *datum* level of Montreal Harbour; but in point of fact, the river has never yet, save in the depth of winter—and that in exceptional winters only,—fallen to the (assumed) *minimum* level of 36. It reached its lowest (recorded) summer point in September of last year, when, on the 20th of the month, it stood at 36½.

On that day all three wheels—the two breast-wheels and the turbine—were in motion, and the duty performed was as follows:

The Breast-wheels - - -	4,652,824 gallons
The Turbine - - -	4,001,838 "
Total pumped in 24 hours	8,654,662 "

This pumping was done under high pressure—80 lbs. on the square inch—and Mr. LeSage informs me that, had the breast-wheels alone been worked on the day in question, they could have sent up six million gallons to the Mountain Reservoir. Their estimated capacity, it will be borne in mind, was five million gallons per day, with the river at its (assumed) *minimum* level of 36, and the Aqueduct with its (assumed) least depth of 8 feet.

The gauging of the water at the entrance of the Aqueduct shows the general (summer) level of the St. Lawrence, at that point, to be above, rather than below, 38; or one foot and four-tenths higher than the lowest observed (summer) water referred to as having occurred on 20th September, 1867. At that level, 38 feet above Montreal Harbour, the river may be said to be in its normal summer condition; and the Water Works, with the existing arrangement of banks, sluices, and wears, at their *maximum* of utility, signifying the ability to supply not far short of ten million Imperial gallons in a day of twenty-four hours; while their *minimum* (summer) capacity is limited within eight millions.

The above figures have reference to that portion of the year, say from middle of April to middle of December, when the flow of water is unimpeded by frost. The turbine wheel and a second Rising-main have recently been superadded to the original plan of the works. The Aqueduct remains as at first constructed, and by its capacity has to be measured that of the whole scheme. It would seem, then, that for eight months out of the twelve, at all events, the Water Works in their existing condition are fully "up to their engagements"—capable of performing all that was promised for, and more than was deemed likely to be required of

them, by the generation under whose auspices they were planned and carried out.

But winter, which works such a mighty transformation in our river, effects a marked change in the size, so to speak, of the Aqueduct, a change all the more difficult to deal with because of the frequent fluctuations in the level of the St. Lawrence at the entrance.

Looking back over the records of the last seven winters, it is seen that the water at the head gates has seldom fallen below 36½, but even could it be maintained at the uniform gauge of 38, the capacity of the canal, then having a least depth of 10 feet, would still be greatly diminished through the solidifying into ice of the first three feet, or thereabouts, from the surface; thus at once contracting the water-way from 325, its sectional area with the top-surface unfrozen at 38, to 210 square feet, which it measures with the liquid surface at 35. And it is not alone in the reduced area of the volume of water passing through it that the reduced capacity of the canal is to be looked for—a further practical diminution of discharge being brought about by the conversion, through means of its solid covering of ice, of what, in the unfrozen period of the year, is an open and free-flowing canal, into a close pipe or tunnel during the winter months.

Still, notwithstanding the contraction of its water-way, the Aqueduct has, once at all events since the winter exigencies of the service began to approach five million gallons per day, proved its ability to respond to the demands made upon it. In the four winter months of 1866-7, for instance, the Reservoir was maintained at its full level almost throughout, and the average daily duty of the pumps was as follows:—

December, 1866 - - -	5,721,491 gallons.
January, 1867 - - -	4,809,262 "
February, " - - -	5,230,228 "
March, " - - -	4,827,070 "

These averages are of days of 24 hours. Were they struck upon the actual number of hours (there were days when full time was not worked) in which the wheels were in motion, the

duty performed would show considerably higher. Two wheels—sometimes both breast-wheels; sometimes one breast-wheel and the turbine—were generally in action at the same time, the two former frequently pumping upwards of five million gallons in the 24 hours, and, notedly, on 18th February, almost always the month most trying upon the works, they lifted 5,702,736 gallons under Reservoir pressure. On 26th December (1866), when the coating of ice must have nearly reached its *natural* thickness, one breast-wheel and the turbine, working in unison, sent up nearly nine million gallons for their day's work. The January (1867) performance of two wheels frequently exceeded six million gallons per day, and the March work, nearly altogether due to the breast-wheels, was as often in advance of five million gallons for the twenty-four hours.

With the foregoing facts in view, it may seem unnecessary to state that in that winter (1866-7) the river did not fall to an unusually low stage; in fact, it maintained what I have termed its normal, summer, level of 38 almost all winter, the gauging showing it to have been more frequently above than below that line. Witness the following averages:—

In December, 1866 - - - -	38.22
" January, 1867 - - - -	38.31
" February, " - - - -	38.38
" March, " - - - -	37.87

figures which, taken in conjunction with the duty performed by the pumps, lead to the conclusion, that did the river, where drawn upon by the Aqueduct, never fall below 38, or could the level of the latter be, by artificial means, maintained at that *datum*, water troubles, such as those which so vexed the city in the winter of 1865-6, and again in that from which we have just now emerged, would not have to be feared—not, that is to say, while the supply required is limited within from five to six million gallons per day.

But recent experience teaches that the river at the point of supply is occasionally subject to much wider fluctuations than

were calculated on when the Water Works were planned—for instance:—

In February, 1866, it fell to - - - - - - 35.45/100.
And in February, 1868, it stood for days together at - 35.

At these levels the breast-wheels will not work at all, while the turbine can scarce perform half-duty—observations that would apply even were ice obstructions not superadded to extreme lowness of water. The evils arising from the two in conjunction were first most seriously felt, to the extent indeed of almost cutting off the supply from the city, in February, 1866, and were brought about in this way:—

The draft on the Aqueduct, to keep even the turbine, alone, in motion, lowered the water so rapidly that it was found necessary every now and again to shut it off altogether from the wheel. It would then begin to rise, and, backing up, would overflow the ice, which had lowered as it lowered, but, fast bound between the banks of the narrow channel, refused to rise again as the water rose. This surface-water quickly froze on top of the original ice, and the same operation repeated at intervals, and aided by the influx of water at the entrance, which, as the river occasionally rose, also overflowed the sunken ice, still further crushed down at points by the weight of heavy snow-drifts, a solid mass, built up, as it were, in courses, speedily formed in the channel, leaving but scant space for the flow of water underneath.

In the winter that has just passed away, the condition of the Aqueduct, from an exaggerated combination of untoward causes similar to the above, was even worse than in 1866, the breast-wheels resting motionless and powerless for days, if not weeks, together, and the turbine, working at half-stroke, barely able to send an insufficient supply of water to the height of the St. Catherine Street, or, at most, the Sherbrooke Street main. Soundings made on 9th March found the water-way, generally, throughout the Aqueduct contracted to less than half the dimensions sufficient for the passage of the least, summer, volume of water; while for some way below the entrance, but 54 square feet were

available for the water-flow—the least summer volume alluded to being represented by 264 square feet of area. The thickness of the ice over this portion of the canal measured *within two inches of six feet.*

Sufficient has now been noted of the plan and capacity of the Aqueduct to show that, under the most favoring conditions of river and season, ten millions Imperial gallons per day is about the limit of its ability to supply water to the city; while there will be times, even in summer, when not eight million gallons can be depended on. For winter prospects, the best that can be hoped for is an occasional re-enacting of the conditions that obtained in 1866-7, when the river maintained a higher level than it usually does in the cold season, and the works were able to respond to the calls made upon them to the extent of five million gallons, daily average, and might possibly have been pressed up to six millions. That is the *best* that can be looked for, however comparatively favorable the season, in the existing condition of the works. What the *worst* is, we have learned from last winter's experience, which saw the Reservoir all but dry, and the city almost literally without water, during the greater part of February and March.

It is with a view to obviating these worst-winter troubles that this water question must now be considered, and whatever the measure of supply, to whatever proportions it is assumed that the population of the city may possibly expand, and how much soever per head of population may be allowed for the daily average of consumption, estimates and calculations should be predicated on providing that the *maximum* of allowance for the hottest days of summer should be alike available in the coldest spells of winter.

The draught upon the Water Works is annually increasing at the rate of half-a-million gallons per day: that is to say—it is ascertained at the close of each year that the quantity of water pumped throughout the year has averaged 500,000 gallons more each day than it had done in the previous twelve months. The daily demand is now approaching seven million gallons: the requirements of the winter months appearing from the records

of the Water Department to be not very far behind those of the summer.

With such rapid *ratio* of increase, more likely to be accelerated than checked in the near future, it is plain that the present works, even when not shorn of a portion of their intended usefulness by an untoward winter condition of the river, are fast becoming unequal to the growing needs of the city, and that the time is at hand when measures will have to be adopted for providing a much larger supply of water than they, at their best, are able or were designed to furnish. The growth of Montreal has far outstripped the most sanguine anticipations of sixteen years since; and it is not alone that the population has increased so much more rapidly than was looked for, but the quantity of water used per head of population is also far in excess of what was at first considered a liberal provision. Mr. Keefer's calculation, in 1852, was for 40 gallons—the actual demand has reached almost, if not fully, to 60 gallons per head per day; the causes for such excessive demand being to be found in the great increase of manufacturing establishments, using steam machinery, throughout the city, and in the generally lavish and perhaps wasteful use of water for all domestic purposes, sure to follow where the supply, as has usually been the case in Montreal since the final completion of the present works, is copious and unstinted.

In seeking a remedy, therefore, for the inconveniences and risks that the citizens have suffered and incurred in the two winters instanced above, and that they are liable to suffer and incur every winter while the Water Works remain as they are, it is not alone to be considered what may possibly be done to raise the present Works to their originally intended standard of usefulness, but, further, to devise some plan having for its end to ensure an ample and unfailing supply of water for the future that may now, with some degree of certainty, be predicted as waiting, and in no far off years, on the city of Montreal.

In devising such plan some given point must be had as a basis of calculation, and if the Water Committee of the Council deem that fifteen million gallons per day (75 gallons per head for a population of 200,000) be more or less than they are called

upon to assume as likely to be needed, the projects submitted for their consideration can be modified in point of dimensions and capacity, and, consequently, as to cost, to meet the views that may be finally adopted for their course of action in this important question of water supply. Upon the above hypothesis, in the meantime, I will proceed to speak of the several plans proposed for the

ENLARGEMENT OF THE WATER WORKS,

And first, with respect to what I shall call

PLAN NO. 1,

which is that recommended by Mr. Thomas C. Keefer, whose opinion, not alone from his high standing as an engineer, but also from his intimate knowledge of the existing works, and his thorough acquaintance with the subject of water supply for cities generally, is entitled to the highest consideration.

Mr. Keefer proposes to extend the present Aqueduct some two miles upwards from the entrance, by embanking out from the river a broad and deep canal, after the manner in which many portions of our St. Lawrence canals have been constructed. It would, as observed, be practically an extension of the Aqueduct as now existing, only very much wider—he proposes, I think, 60 feet width of bottom. The embankment shutting out the river would be water-tight, so that the water in the canal would carry its level from the point to which it is proposed to extend down to the present head-gates, through which the inner existing canal would then be fed from the outer one, instead of, as now, directly from the river. The water within could then be so regulated as entirely to prevent the fluctuations that now, in winter especially, so impair the usefulness and efficiency of the Aqueduct.

It is proposed to carry up this outer canal or "Feeder" to a point nearly opposite the old Church of Lachine—a distance of about two miles. The increased head of water gained would be a trifle over 3 feet. That is to say: when the river stands at 38 at the entrance, its level at the old Church has been found to be $41\frac{30}{100}$. Careful observations made during the past winter have also established the fact that the fluctuations at the latter point

are less marked than they are below. For instance: when the water at the entrance had reached its lowest stage of 35 (in February), it gauged $38\frac{85}{100}$ at the Church. That level may safely be depended on in the most unfavourable winters, and would allow of the Aqueduct, supposing the "Feeder" completed, being kept up steadily at 38, however low the river outside, opposite the present entrance, might happen to fall, it being wholly improbable that a lower stage of the water than prevailed last February will ever be experienced, unless we are to believe that the St. Lawrence is gradually undergoing some permanent lowering of level.

Assuming the extension made, and the present Aqueduct left as it is, save as to the necessary raising of the banks to accommodate the raised level of the water, the results would be as follow:—

At the medium summer level of - - -	38
The area of water-section of Aqueduct is -	325
And the CAPACITY—	
Measured by horse-power - - -	420
" by No. of gallons furnished to city per day - -	10,000,000
At the raised level of - - - - -	41
Area of water-section - - - - -	420
CAPACITY—	
By horse-power - - - - -	650
By gallons pumped per day - -	15,000,000

as large a supply, in my judgment, as the present generation should be taxed to provide.

But it is only while not frozen that the Aqueduct, with its additional head of water, could be counted on to furnish to the city fifteen million gallons a day: *frozen* at that level (41)—and undeniably there would be winters when it could be maintained somewhere near that line throughout—its apparent capacity would be represented by the figures first above given, three feet being taken off the liquid surface for the thickness of ice. The

actual capacity, however, would be less than with the summer level at 38, because of the diminution of discharge due to the covered character of the channel. Under the most favouring conditions, therefore, the winter capacity of the Aqueduct, with its raised surface, would barely be equal to the raising of ten million gallons per day. In short, as Mr. Francis in his report observes, the effect of the extension would be to confer on the present works a winter capacity about equal to what they now possess in summer.

But it is against the difficulties of the *least* favorable winters that we have to take measures, and we know that what occurred this year may occur again—to-wit, a lowering of the river at the church to 38·85, which would allow, were the extension scheme completed, of the Aqueduct being kept up to about 38½, putting matters just about where they were in the winter of 1866-7, when the average height of water at the entrance was over 38, and the average duty of the pumps, daily, for the four winter months, a little over 5,000,000 gallons; and six millions the very outside that might possibly have been forced, one day with another.

The construction of the Feeder, then, would not in itself effect all that is needed. In order to guarantee fifteen million gallons a day, the year round, either the existing Aqueduct would have to be enlarged to dimensions commensurate with those of the extended canal outside, or else a new one made.

To effect the enlargement of the present work, the water would have to be drawn off and a supply for city uses sought at some other point in the meantime, involving the use of steam power on an extended and expensive scale. The enlargement project will, therefore, I fear, have to be dismissed, and the making of a new and distinct Aqueduct, alongside the existing one, considered:—This embraces

PLAN NO. 2,

and speaking of it, Mr. Francis says, assuming the up-river extension to have been carried out, that, even then,

"The time must soon come when the supply in the winter "would be insufficient and the troubles of past winters be "repeated. When that time arrives, additional provision must,

" of course, be made. To enable the works to furnish the
" required additional supply, either the present canal must be
" enlarged, or an additional canal be constructed, in order to
" furnish a sufficient supply of water at the wheel-house to drive
" the required number of additional pumps in winter."

" If the enlargement of the present canal is anticipated at an
" early day, the question arises whether it had better not be
" undertaken at once and dispense entirely with the proposed
" extension. A greater enlargement would undoubtedly be
" required, if the proposed extension is not carried out, but I
" cannot help thinking that the cost of the extension, together
" with the corresponding enlargement, would considerably exceed
" the cost of the enlargement that would be required without the
" extension."

In conversation with Mr. Francis, I found him very decidedly inclined to the construction of a new canal, pure and simple, with the lowest known stage of the river for the standard head of water. That he looks upon as the most certain remedy for the difficulties experienced in the past, and as the plan best adapted, by giving it ample proportions, to ensure an unfailing supply of water at all times and seasons in the future. " The pumps," he says, " can be as well operated by twelve feet head as by fifteen
" feet head, if the supply of water is sufficient, and the wheels
" arranged to suit the head."

There can be no doubt as to the correctness of Mr. Francis' views. In a climate such as ours, *size* is the surest mode of obviating winter obstructions in hydraulic works, and it is very certain that a wide canal with the lesser head will prove a more effective and reliable power than a narrow one with the greater.

A canal to fully meet the exigencies of the case will be a work of no little difficulty and of large cost. It will require to be sunk to a depth equal to three feet below the bottom line of the existing one, and its general proportions must be on a scale to ensure the passage of at least 600,000,000 Imperial gallons, in each 24 hours, under the most obstructive conditions of frost and ice. I would have the entrance at, or opposite, " Fraser's Hill," some 3,000 feet above the present inlet,—and would construct it, not by at

once cutting into the land at that point, but by means of an embankment in the river, after the manner of the proposed extension (Plan 1), commencing the land-cut a little above or below the present entrance.

By taking the water from Fraser's, we would gain, at the worst times, when every inch is of value, eight inches over the lowest level (35) to which the river has been known to fall at the lower point, and it (Fraser's Hill) can be reached at less outlay by means of a river embankment than a land-cutting, there commencing, would cost.

The new Aqueduct plan, as here suggested, would also ensure a purer supply of water than the extension scheme would bring you. Without paying the owners of the river-front large sums in compensation therefor, you could not cut them off from access to the water—that is to say, from your canal,—and in a variety of ways the throwing of it open to them might render the water liable to suffer disturbance and contract impurities. As an extension of the first proposed extension, Mr. Keefer has suggested carrying it up, at some future time, still two miles further, to gain the level of Lake St. Louis; thereby adding about three feet to the three feet additional head gained at the old church. This would make the outer canal, or "Feeder," some four miles long; its entrance being in the Lake alongside where that of the Lachine Canal is. Much deep water would probably be encountered on those upper two miles, tending greatly to swell the cost of construction,—while the result, in part, would be to leave you with four additional miles of canal upon your hands, none of it exclusively under your own control, unless you were to undertake to buy the littoral rights of all the long-shore proprietors, and all of it subjected at a multiplicity of points to the chances of defilement.

Nor would the hydraulic results be wholly satisfactory, not at all events without also giving increased capacity to the existing works, bringing us back to the original proposition that an enlarged or new Aqueduct is an inevitable element of any plan that will have for its end to secure, within your own ownership and control, an unfailing supply of water to the city.

As between the Plans 1 and 2, therefore, I have no hesitation in recommending the latter;—that is to say, a new and large Aqueduct alongside of, but distinct from, the existing one, and having its entrance, as above described, at "Fraser's Hill."

ESTIMATE OF COST.

During the past winter, Mr. LeSage had surveys made and soundings and cross-sections taken in connection with the extension plan, but to arrive at a correct estimate of the cost of the work it would further be necessary to have borings made at each point of cross section, in order to arrive at a knowledge of what the material within the section of the proposed Canal consists.

Approximately, however, the cost of carrying up the extension as far as the old church—or, strictly speaking, to a point 500 feet above it—and including the raising of the banks of the Aqueduct, but not including any damages or compensation that may have to be paid for lands or rights, will involve an outlay of about $225,000, no allowance being made, either, for any rock that may possibly be found to exist within the section of excavation.

Mr. LeSage has also had a centre-line run for a new Aqueduct on the lower, or easterly, side of the present one, and from it an approximate estimate of the cost of that work, also, may be arrived at.

Including the river embankment, or mole, from the head gates at the entrance of the land-cut to Fraser's, the cost of the new Aqueduct will exceed rather than fall short of one million of dollars ($1,000,000), and for a less amount no complete remodelling of the water power of the Water Works, on any plan that will stand the test of time, can, in my judgment, be had.

One or both of the surveys, including borings and test-pits, above referred to, ought to be put in hands for completion forthwith; both of them, should the Water Committee have doubts as to which of the plans to adopt; one of them, only, should they at once make a final selection between the two; but, of course, neither need be pursued further should both plans be alike rejected.

In view of the possible demand for increase of power in the more distant future, I would just observe that the three feet additional head obtainable at the church may, whenever the exigency arises, be made available on the large Aqueduct, the construction of which is now recommended, by carrying out Mr. Keefer's plan of extension; and to ensure *for ever*—in anticipation of such exigency—a supply of pure water for the city it may be advisable, provided the ground is as favorable, or nearly as favorable, to construct the new Aqueduct on the upper, or western, rather than on the lower side of the old one—leaving the latter in free and direct communication with the swift water of the unpolluted river.

But other schemes, also, for solving the water question have been mooted; and, notably, a proposal made by the "St. Louis Hydraulic Company," referred to me by a Resolution of the Water Committee, under date of 26th March last.

This Company contemplate throwing a dam across the arm of the river passing between the north shore and Isle-aux-Herons—about two miles below the entrance of the Aqueduct—with a view to creating an immense hydraulic power.

They offer to lease to the City Corporation water to the extent of one thousand horse-power, charging therefor at the rate of fifty dollars per horse-power *per annum;* making a yearly rent, that the City would have to pay to the Company, of $50,000.

The Corporation to be at the expense of erecting their wheels and pumps on the margin of the river, where the power would be supplied them, and of the connecting mains thence to where the present ones pass underneath the Lachine Canal—distant about 3¼ miles. The water for supply, as distinguished from

power, also to be brought at the expense of the City from the present Aqueduct to the new (proposed) site of the pumps.

This offer or proposal may be converted into money form about as follows:—

Annual rent ($50,000) represents, at 7 per cent. per annum, a capital of - - -	$714,330 00
Double rising main from pumps to canal culvert=6½ miles single main, say -	200,000 00
Connection for supply with present Aqueduct, say - - - - -	25,000 00
	$939,330 00

For this the City are to get a water power rated at 1000 horses, but which, to the City, would not be the equivalent of an equal power applied to the pumps at the present wheel-house, seeing that the supply would have to be forced through a so much greater length of main; the whole distance, following the line of pipe, from the proposed site of the St. Louis Hydraulic Company's dam to the reservoir, being 5½ miles, as against 2⅓ miles between the latter point and the place where the pumping is now done. They (the City) would, moreover, not be owners in fee of the water-power, but tenants, and as such would have to accept all the chances of accident to the dam and works, from ice or other causes, with the not improbable risk, too, of having their wheels embarrassed by back water in occasional winters. In a short time, also, should the Hydraulic Company prove a success, as it is to be hoped it may, the Corporation would find their pumping works surrounded by factories, and in the midst of a thronged population, instead of, as now, isolated and wholly under their own control. In fact, nothing could be better for economical management and *discipline* than the situation of the present wheel-house.

This proposal of the "St. Louis Hydraulic Company" is not, in my opinion, one that the Corporation ought, in its present shape at all events, to entertain; especially as it comes before

them divested of any guarantee whatsoever as to when the water-power would be made available.

With respect, generally, to this question of water-power, I would strongly recommend the Water Committee, whatever plan they may finally adopt, to make the keeping of the works, in all their parts, entirely under City control part and parcel of their plan. The apportionment of water-power between many lessees or proprietors is a fruitful source of contention and litigation, and the Corporation of Montreal, looking well ahead, should lease neither to nor from any individual or Company any portion whatsoever of theirs.

Steam Power

also has its advocates, in total substitution of water-power, among the many who have given their views on the water question to the public.

From the annual Reports of your Superintendent, I learn that the actual pumping expenses—that is to say, the simple working of the pumps, apart from renewals and repairs—scarcely reaches, one year with another, $3 for each million gallons of water raised to the reservoir.

Effected by steam agency, the same work would probably cos, $20; supposing your engines to be of the most improved construction and coal always to be had for $5 per ton.

The cost of repairs and renewals of machinery, too, would be in favor of water-wheels, as compared with steam engines.

Assuming the average daily consumption of water to have reached fifteen million gallons, a comparison of actual pumping expenses, according to the above figures, and including superintendence, labor, lubrication, &c., on the one side, and the same items with fuel superadded on the other, results as follows:—

Water-power expenses, per day - -	$45 00	
Do. do. do. for the year,	$16,425 00	
Steam expenses, per day - -	$300 00	
Do. do. for the year - -	$109,500 00	
Difference in favor of Water - -	$93,075 00	
A sum which represents, at seven per cent., a capital of over - -	$1,300,000 00	

In the face of these figures, and of the fact that no city in the world is more munificently endowed with the means of water-power than Montreal, I could not advise the use of the steam engine save as a temporary expedient pending improvements in your hydraulic system.

Wheels and Pumps.

Nothing can be better than the plan, construction, and arrangement of the wheels and pumping machinery generally. The turbine has proved a most efficient auxilliary at all seasons, since it was brought into use, especially so in periods of low water and extreme cold; but for steady, regular action, for simplicity of construction, and for perfect adaptation to the winter conditions of our climate, the breast-wheel is the best motor for your pumps. Compared to it the turbine is a complex and delicate piece of mechanism, liable to cause trouble and detention at any moment, if deranged by the accidental admission of some stray piece of float-wood or other obstructive substance. Give the breast-wheel plenty of water, and it will *always* do its work well.

Reservoir.

I have not yet had an opportunity of considering the question of increased storage, the whole of the very limited time at my disposal since the reference was made to me having been given to the primary and all important question of how best *to get the water*. In comparison with the latter, the former proposition is a very simple one, to which, if it be so desired, I can devote some attention by and by.

And now in respect of the

Time

required for a remodelling of the Supply-Canal on a scale that will place the Water Works in a condition of permanent efficiency. I would say, briefly but emphatically, that no amount of energy or means that may be brought to bear, whatever the plan of improvement adopted, will serve to effect an immediate remedy for the ills, consequent on the cutting off of the water supply, from which the citizens suffered so severely last winter, and to a

recurrence of which in winters to come they may well look forward with dread.

Should the construction of a new Aqueduct on the plan I recommend be determined on, and proceeded with, with all possible vigor, still two winters, at all events—very likely three, would intervene before the enlarged water-power could be brought into use; and if the extension plan (Mr. Keefer's) be selected—even then the possible casualties of two winters certainly would have to be provided against, ere the completion of that work would bring the relief that will not bear waiting for. It is against such winters as last that measures must be taken, counting for nothing the chances of a more favourable condition of the river, and to do that effectually but one way is open to you——STEAM.

Two powerful engines will be required, capable together of throwing 5,000,000 gallons daily into the Reservoir, which, with the assistance you can always count on, in the very worst times, from the turbine, pumping directly on the city, would serve to keep you out of trouble until the lasting remedy in the form of increased and ample water-power has been attained.

I repeat that you have no choice in this matter. I have carefully considered the question of an auxilliary supply of water, pending the completion of your own Works, from the Lachine Canal, tapping it above Cote St. Paul Lock; but knowing the pressing necessities of the mill-owners for every drop of water that can be spared them, it would be in vain for the City Council to apply to the Government for help from that quarter. That alternative, therefore, however practical, and it is easily so in an engineering sense, must be considered as "ruled out." Steam you must have, and I would advise you at once commissioning Mr. LeSage to visit some of those cities in the United States where the water supply is obtained solely through that agency, with a view to obtaining every information as to the most recent improvements, which are marked and manifold, in pumping engines. I would especially direct attention to those in use at the Brooklyn (N. Y.) Water Works.

To provide for the pumping by steam of five million gallons

per day, you will have to incur an outlay of about ($70,000), seventy thousand dollars.

I have the honor to be,
Sir,
Your obedient servant,

W. SHANLY.

OTTAWA, 12th May, 1868.

To the Water Committee
Of the Council of the City of Montreal.

Gentlemen:

I have been requested by you to give you my views as to the proper course to be adopted to afford an adequate supply of water to the city at all seasons of the year.

The prominent difficulty now existing is the insufficiency of the supply of water at the Wheel-house to furnish power to drive the pumps; this is evidently caused by ice in the canal, which occupies so large a proportion of the section as to greatly obstruct the flow of the water. Various remedies have been proposed, that suggested by Mr. Thomas C. Keefer of extending the canal about two miles further up the St. Lawrence River has been particularly brought to my notice. By this plan it is expected that the surface of the water at the head of the present canal would be raised about three feet. This would be a very great improvement, and I think would remedy to a great extent, if not entirely, the present difficulty from the ice. It could not be expected, however, to render the works any more efficient in the winter than they now are in the summer. If this is deemed sufficient, then, assuming that it is practicable to construct a permanent work at this point, within a permissable cost, and that the ice would not gather in it to an injurious extent, on neither of which points have I the means of forming an opinion, I see no reason why the extension proposed by Mr. Keefer would not afford adequate relief and be proper to adopt.

I am informed, however, that the daily consumption of water is annually increasing at the rate of half a million of gallons, and that the existing works are not capable of supplying even in summer much beyond the present consumption.

If I am correct in this information, it appears to me that even if the proposed extension accomplishes all that is claimed for it, although it would enable a much larger supply to be furnished in the summer than at present, the time must soon come when the supply in the winter would be insufficient, and the troubles of the past winter be repeated. When that time arrives, additional

provision must of course be made. To enable the works to furnish the required additional supply, either the present canal must be enlarged, or an additional canal be constructed, in order to furnish a sufficient supply of water at the Wheel-house to drive the required number of additional pumps in the winter.

If the enlargement of the present canal is anticipated at an early day, the question arises whether it had better not be undertaken at once, and dispense entirely with the proposed extension. A greater enlargement would undoubtedly be required if the proposed extension is not carried out; but I cannot help thinking that the cost of the extension, together with the corresponding enlargement, would considerably exceed the cost of the enlargement that would be required without the extension.

A greater head of water at the Wheel-house would undoubtedly be obtained by the combined extension and enlargement than by the enlargement alone, but this can be fully compensated for by making a greater enlargement in the latter case. The pumps can be as well operated by twelve feet head as by fifteen feet head, if the supply of water is sufficient, and the wheels arranged to suit the head.

Which of these plans it would be most advisable to adopt, and whether to enlarge the present canal or construct a new one, must depend very much on the cost of the works, and I would suggest that estimates be made of their cost, together with the cost of temporarily supplying the deficiencies of water to the city while the new works are in progress. With this information I think there would be no great difficulty in arriving at a definite opinion.

As you are aware, the time I have been able to devote to the investigation of this important matter has been very limited, too much so to enable me to offer a decided opinion, and I must therefore beg you to consider what I have said rather in the light of suggestion than of opinion.

Respectfully submitted,

(Signed) JAMES B. FRANCIS.

MONTREAL, March 23, 1868.