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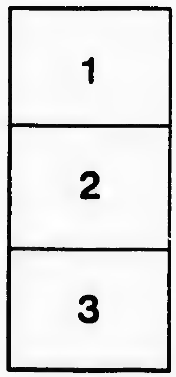

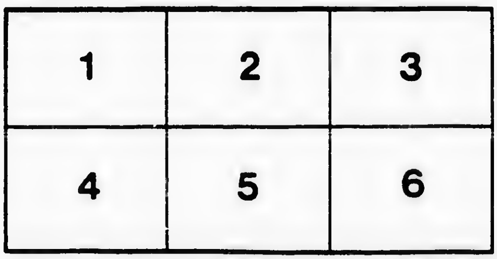

THE WATER WORKS OF MONTREAL

OBSERVATIONS UPON THE REPORT OF

MR. McALPINE, C. E.

AND

THE FUTURE SUPPLY OF THE CITY,

Addressed to J. W. McGauvran, Esquire,
Chairman Water Committee.

BY

R. P. COOKE, C. E.,

AND

E. W. PLUNKETT, C. E.

MONTREAL:
EUSÈBE SENÉCAL, PRINTER AND PUBLISHER
Nos. 6, 8 and 10, St. Vincent Street.

MONTREAL, 30TH DECEMBER 1869.

J. W. McGAUVRAN ESQ.

Chairman Water Committee

Corporation of Montreal.

Sir,

Want of time has prevented us from sooner submitting to your Committee some remarks on Mr. McAlpine's late report respecting the Water Works. We now beg to direct your attention to certain portions of that document which demand correction and comment at our hands.

As age and experience usually impart much weight to the views of professional men, we, no doubt, stand at a disadvantage in differing from Mr. McAlpine in matters purely of opinion; but in the present case, the questions to which we desire to call the attention of your Committee, and the Council, are not merely matters of opinion, but of facts and figures, whose inexorable logic no length of experience can resist.

McAlpine's Report consists principally of General Statements.

The chief feature of Mr. McAlpine's Report, and that which will strike any one as most remarkable in an engineering document, is the masterly way he confines his observations, with a few exceptions, to general statements, and avoids committing himself to particulars—and above all to,—figures. To such an extent does he carry his caution in this respect, that although he strongly advocates an open canal somewhat like that proposed by Mr. Lesage, yet he completely abstains from giving any opinion respecting two of its most important features, as will be seen from the concluding portion of his report, as follows.

> "Before new works are commenced it may be advisable
> "to have this question of the *form of the prism* again care-
> "fully examined.

"Before I could advise, in regard to the *details of the* "*protections and form of the entrance* to the new canal, it "would be necessary to obtain more information than I now "have of the action of the ice and frasil which passes down "the river at that place.'

No estimate of cost given.

Even on the very important question of cost, Mr. McAlpine gives no estimate whatever.

It thus appears, that the *gist* of the report merely consists of a general recommendation to build an open canal, of which "the form of prism," "details of the protections and form of the entrance," and cost of construction, are still undetermined and unknown.

A former estimate of Mr. McAlpine's.

Mr. McAlpine's reserve on the question of cost will be appreciated, when the following facts respecting a former estimate of his, are called to mind :

In 1853 Mr. McAlpine stated in his report on Montreal Water Works that they conld be constructed for....	$600,000
In 1857 Mr. Keefer the Engineer, reported to Council, that the Works actually cost. (£286,236).........	$1,144,945

Inapplicable Formula.

At page 11, Mr. McAlpine says :

"In the annexed table I have used Eytelwein's Formula "$V=\sqrt{h \times 2f.}$, which is not strictly correct, but, sufficiently so, for the purpose of making the general compa- "risons.

Now with regard to the formula, we beg to say, it is not applicable to our covered conduit, and even for open channels it is merely intended to give the *approximate superficial* velocity, not the *mean velocity* from which the discharge should be calculated. What induced Mr. McAlpine to parade it in his report, instead of using some one of the many simple practical tables, such as Nevilles, Beardmores, &c., we cannot imagine; unless indeed, it is intended for mere ornamental effect similar to that aimed at in page 4, where, *as a reason* why "you should avail yourselves of this (water) power to the fullest extent," he says :

"A stranger readily perceives the strong feeling of favor which your Citizens and Engineers entertain, for the utilization of the immense water-power which surrounds your City. It is one of the most distinguishing characteristics of its location. With oceans vessels coming into your port, with shorter voyages from the great European markets ; standing, as you do, an hundred miles nearer the chain of great Lakes, which penetrate the most fertile grain producing region of the world, from which inland vessels of large burthen can float and transfer their cargoes of the cereals directly to ocean-bound ships, or to mills, where such grains may be condensed in bulk and weight by cheap water-power. Such advantages of water-power ought not to be ignored by your municipality in its own works.

Nowhere else, on the American continent, do these advantages of transport and water-power unite as they do at Montreal; *and hence it furnishes an additional reason* why you should avail yourselves of this power to its utmost extent in your municipal works, and thus encourage its development for those other important purposes."

Inaccurate calculations.

We will now proceed to shew, that the "Table" is entirely unreliable and erroneous: as it will be often referred to hereafter, we copy it in full below.

	COVERED CONDUIT.	ENLARGED AQUEDUCT.	RATIO.
Areas. At Winter low water 36 x Sq. ft	281	1,023	1 to 3.64
At Summer low water 38 x " "	281	1,287	" 4.58
At 36 x with Ice 3 feet thick " "	281	672	" 2.30
At 38 x " " " " "	281	900	" 3.29
Discharges per minute At 36 x Cu. ft.	51,620	111.375	" 2.16
At 38 x " "	56,565	150,772	" 2.67
At 36 x with 3 feet of Ice " "	51,620	84,672	" 1.64
At 38 x " " " " "	56,565	122,760	" 2.17
Theoretic Horse Power At 36 x H.P.	782	2,950	" 3.77
At 38 x "	977	4,569	" 4.66
At 86 x Ice 3 feet "	782	1,764	" 2.25
At 38 x " " "	977	3,021	" 3.10

A full and complete analysis of the above "Table" would perhaps involve too many technicalities for general purposes. We propose therefore to confine ourselves to a few simple illustrations of its inaccurracies.

Analysis of Table shews inaccuracy.

First, taking the Table itself and using only the data found there, we abstract the following particulars of enlarged Aqueduct and compare them as follows.

At Level 36 the discharge is given as 111375
cu. ft. per min; this is stated to be equal to
2950 H. P.; that is each H. P. equals about..38 C. ft. water per min.

At 36 with ice the discharge is given as 84672
cu. ft. per min. and this is stated to be equal to
1764 H. P.; that is each H. P, equals about..48 C. ft. water per min.

At level 38 the discharge is given as 150,772 cu. ft. per min; this is said to equal 4569 H. P.; that is each H. P. equals about......33 C. ft. water per min.

At level 38 with ice the discharge is given as 122,760 cu. ft. per min. and this is said to equal 3021 H. P.; that is each H. P. equals about..40 C. ft. water per min.

It will thus be seen that Mr. McAlpine makes a Horse Power equal to;

In	1st case	38	cu.	ft.	water	per	minute.
"	2nd "	48	"	"	"	"	"
"	3rd "	33	"	"	"	"	"
"	4th "	40	"	"	"	"	"

As the fall of the water, as applied to the Breast Wheels proposed to be used by Mr. McAlpine, will be the same in all cases, it is, of course, an utter absurdity to say, that a Horse Power requires 20 to 25 per cent more water in one case, than it does in another; yet that is practically what Mr. McAlpine's calculations tell us.

The above simple manner of examination may be extended further; thus the open canal it is said,

At 38 (Summer) will discharge	150,772 cu. ft.	and give	4569 H. P.
" 36 x ice " "	84,672 " "	" "	1764 H. P.
Difference..........	66,100 cu. ft.		2805 H. P.

Here, we have a difference of something less than 44 per ct. in the discharge, while the difference in the H. P. is calculated as 61 per ct.! Or, taking it in any another way, the "Table" shews that at level 38 without ice, the open canal will discharge 66100 cu. ft. per min. more water, than at level 36 with ice, and that this 66100 cu. ft. per min. of water will give 2805 more H. P.; that is, every 23 cu. ft. of water equals a H. P.

It has been already shewn from the other calculations that at level of 38 a H P. equals..........33 cu. ft. per min.

The second calculation above, makes a H. P. at same level equal to...........................23 cu. ft. per min.

Difference about 30 per cent 10 cu. ft. per min.

The foregoing examples shew the inconsistency and consequent worthlessness of the " Table ", *as judged by itself.*

Practical Comparison of enlarged aqueduct with Lachine Canal. Also proves inaccuracy of the " Table."

We will now compare the calculations given in " Table", with those found in another portion of the report; at page 14 he says

> " Mr. Sippel informed me, that, in the worst times the Lachine " Canal had an area of five hundred square feet under the " ice, with a velocity of fifty feet per minute, which indi- " cates a fall of but two inches per mile, and a theoretic " horse power, under fourteen feet head, of six hundred and " sixty-three, "

It is stated above that the winter power of Lachine Canal under a fall of 14 ft. is....................................	663 H. P.
The " Table " gives the winter power of proposed Enlarged Aqueduct as..	1764 H. P.

That is, the proposed enlarged aqueduct will have $2\frac{1}{4}$ times as much power as the Lachine Canal, under the same fall.

As the enlarged Aqueduct will be, at most, only from 10 to 20 per cent more capacious than the Lachine Canal, it is evidently absurd, to calculate upon getting 225 per cent more power from it under the same fall, as stated in " Table."

Comparison with Mr. Shanly's calculations proves inaccuracy of the " Table."

We will now test Mr. McAlpines calculations with some of those made by others;

Mr. Shanly in his supplementary Report p. 3 says the discharge from a Canal almost identical in size &c. with the one recommended by Mr. McAlpine, would be in winter, in gallons per 24 hours about............	450 millions
Mr. McAlpine calculates his Canal in winter will give 84672 c. f. per min.; this in gallons per 24 hours is........	760 millions
Difference between Mr. McAlpine and Mr. Shanly 70 per cent	310 millions

Comparison with Mr. Lesage's calculation proves inaccuracy of " Table."

Mr. Lesage in his printed Estimate of cost of open Canal, calculated its discharge in summer; this he makes at a level of $37\frac{1}{2}$ equal to 895 millions of gallons per 24 hours; at a level of 38 it would be in gallons per 24 hours about..........................	981 millions
Mr. McAlpine gives discharge of open canal in his Table (at level 38) as 150 772 cu; ft; per min; which equals in gallons per 24 hours..........................	1357 millions
Difference between Mr. McAlpine and Mr. Lesage 38 per cent	376 millions

(While on this subject, we would call the attention of your committee to the fact, that the calculations of efficiency given by us respecting the conduit, have been endorsed by Mr. Shanly as virtually correct; and further that neither Mr. McAlpine nor Mr. Lesage have ventured to question them in any particular).

The foregoing comparisons summed up are as follows:

1.—The Table analysed, or, as it were, compared with itself gives results varying from each other from	10 to 30 per cent.
2.—The calculation in "Table" of winter Power of enlarged Canal, exceeds the winter power of Lachine Canal.....	225 per cent.
3.—Mr. McAlpine's calculation in Table differs from Mr. Shanly's	70 per cent.
4.—Mr. McAlpine's calculation in Table differs from Mr. Lesage's.....	38 per cent.

The above considerations we think, fully warrants us in saying, that the so called "Table" is altogether unreliable and erroneous, and consequently, that the deductions and conclusions based on it are worthless and undeserving of attention.

Frazil.

The next point in the report to which we desire to call your attention, has reference to Frazil; at page 12 it is stated.

"The current in the enlarged Canal will be so much less "than in the covered conduit, that, the quantity of the frasil "drawn into the former will be much less, and in this con- "nexion it may be suggested that, the frasil, when disengaged "from the bottom of the River, at first floats below the sur- "face, and is more liable to be drawn into the Syphon "formed conduit, than it would be in a wide Canal of less "depth.

It is stated above, that as the current will be so much less in enlarged Canal, less frazil will enter &c.: Mr. McAlpine does not, and can not know, whether the current would be "less" or not. In plans of conduit furnished Mr. McAlpine by us, the form and size of entrance were purposely omitted, as we intended leaving those "open questions," until sufficient data respecting frazil, had been obtained during the next few winters, to enable us to design an entrance that would effectually exclude it—should it be found in Frazers Bay. If observation proved a slow current to be the most favorable, we proposed to regulate the *size* of our conduit entrance so that the water could be introduced *at any desired velocity.*

It is thus evident that Mr. McAlpine's argument respecting quick and slow currents at entrance, practically, amounts to nothing.

But we go further and say, that in our opinion he is altogether wrong in stating, that a quick current will bring more Frazil than a slow one.

If the frazil is *uniformly* distributed in the water, each gallon entering an opening, will bring in its proportion of frazil, be the current quick or slow. For this reason, if the open Canal will pass 60 percent more water, as Mr. McAlpine says it will, 60 per cent more frazil will enter with it.

If the frazil is *not uniformly* distributed in the water, it must be at the bottom, top, or some intermediate position. We maintain that once freed from the bottom, the great bulk of the frazil will be found *at, or close to the surface, and consequently that it will not enter a submerged Entrance.*

In support of this view we refer to the following opinion of Mr. Keefer quoted by Mr. McAlpine.

> At about 40° the anchor ice (Frazil) leaves the bottom and "bursts to the surface," and as it is " nearly of the same " specific gravity as water, floats *chiefly* below the surface " and is easily drawn by any current *under* the fixed sur- " face ice"

Mr. Keefer in his report to Council 10 June 1868 also says.

> " With the contraction of the water way the strength of the " incoming current to supply the wheels is increased, and " then the frasil, which is stealing along shore, *rising from* " *the bottom or blown by the wind into the open unpro-* " *tected mouth of the aqueduct*, is sucked under the aque- " duct, ice and pressed up by its *buoyancy* to the underside " of the latter where it attaches itself, thickening the sheet " from below, or packing in upon the slopes."

Mr. Shanly in his letter 25 Oct. 69 also confirms our position as follows.

> "I have no hesitation in saying that your plan of a covered " conduit all below low water level, and with the entrance " fully 10 *feet below the surface*, would effectually obviate " all the difficulties that now interfere with the winter " efficacy of the Water Works."

Lastly, Mr. McAlpine himself furnishes the strongest evidence that Frazil will not enter conduit, in as much as he says there will be none at the place we proposed locating Entrance: in the following extract from his report p. 15 referring to Frazers Bay he states.

> " It is generally believed that the frasil does not form under " ice or any other covering over the water and hence, that

"as this bay will freeze over early in the winter, no frasil
"will form at that place, and the course of the current in
"the river will carry that which is detached from the
"bottom above this entrance, mostly outside of this bay."

Before concluding on this question of Frazil, we desire to call attention to the fact that no mention whatever is made in the report about frazil forming in the enlarged Aqueduct.

Mr. McAlpine quotes Mr. Sippell respecting the discharge of the Lachine Canal, but it is noticeable he has omitted altogether an important fact respecting frazil also communicated to him by that gentleman, in Mr. Cooke's presence: namely, that it formed plentifully in the Lachine Canal, before the ice took that the chief difficulties on account of frazil, *were caused by such as formed in the Canal itself, which at times reduced the power practically to nothing.* With such results in this case, there can be no doubt similar difficulties would occur in enlarged Aqueduct.

Cost.

With regard to the cost of covered Conduit and enlarged Canal, as before remarked, Mr. McAlpine does not venture on any figures whatever; he simply disposes of the subject in the following off-hand manner.

"I am decidedly of the opinion, that the cost of this covered
"conduit, will be fully equal to that of the proposed enlarged
"Canal.

We placed Mr. McAlpine in possession of Plans, Sections. Bill of quantities and prices, also statements of cost of Conduit. He now presumes to speak of our not having fully "digested" (p.11) our project, yet out of the seven Plans he undertook to report upon, we believe there was only one other besides our own accompanied with the particulars we have mentioned. As Mr. McAlpine was furnished with the fullest particulars of covered Conduit, it was a simple matter for him to point out any inaccuracies in our statements had they existed.

We now beg your committee to notice that he has failed to do so.

Practical difficulties & objections.

Mr. McAlpine's *allusion* to "practical difficulties and objections" likely to be encountered in the construction of covered Conduit, partakes of the indefinite character of some of his remarks on other subjects equally important. A vague hint dexterously used may sometimes influence opinion; and generalities save troublesome explanations.

No large undertaking, however simple, can be carried out without meeting a certain amount of practical difficulty; even the most insignifiant works are not free from obstacles. To use a homely illustration, a fence post cannot be sunk in the ground without risk of meeting a stone. Now according to Mr. McAlpine's reasoning, the sinking of fence posts should not be attempted on account of anticipated practical difficulty.

Had Mr. McAlpine shewn, that the difficulties to be encountered in proposed Conduit, could not be met at the estimated cost his statement would merit attention.

In the report, much importance is attached to the evidence of Mr. McDonald, the contractor for the present Aqueduct, respecting the nature of the excavation, difficulty of working &c. This evidence goes to show, first,—that much trouble may be expected in excavating below the level of the bottom of the present Aqueduct: and second,—that no price likely to be offered, would induce Mr. McDonald to undertake such work.

With regard to the first, we beg to say that we fully appreciate all the "practical difficulties" to be anticipated in the construction of the work proposed by us, and have amply allowed for them, in our Estimate; and as to the second, we would respectfully remind your committee of a fact that seems to have escaped Mr. McAlpine's notice altogether, viz, that Mr. McDonald is not the only responsible contractor on the Continent; and further, that this question of cost can be easily settled by advertising the work for contract, when, we venture to say, the Council will have no difficulty in getting responsible parties to undertake and complete the work, even below our Estimate.

At page 10 in report the following occurs:

Mr. McAlpine's error as to route.

> "The route proposed for this Conduit, and the place of its "entrance into the River, are the same as proposed by Mr. "Lesage for enlarged Canal."

This statement is erroneous. We proposed to locate the covered Conduit, for over four miles of its length, on the *land at present owned by the Corporation* on the *North side* of present Aqueduct.

The open Canal as proposed by Mr. Lesage, according to the plans of it in City Hall, intersects the present Aqueduct and lies on the *South side* of it, on *land to be bought for* the purpose.

The land for enlarged Canal will cost at least $100.000.

The land for covered Conduit can all be bought for about $10.000.

" Syphon principle" ***not*** **used.**

At same page another singular error occurs.

> " The Syphon principle at the entrance of the Aqueduct,
> " which, it is claimed, will secure greater purity of water,
> " escape from the frasil, and a certain supply of water at all
> " times, can, if desired, be applied in precisely the same
> " manner as proposed by Messrs. Cooke and Plunkett, on
> " all of the open Canal plans."

It is stated above, we made certain claims on acconnt of the " Syphon principle." That " principle" involves the use of combined air and hydrostatic pressure. We did not propose or intend to adapt it to any part of the condnit or entrance. Mr. McAlpine therefore misunderstands, either the nature of our Plan, or that of the " principle" he refers to.

Wheels.

At p. 18, Mr. McAlpine recommends " Breast " Wheels.

> " For your works, and especially after they have been
> " enlarged as proposed, I am of the opinion that Breast
> " Wheels will be the most suitable."

In report 20 May 1853, he recommended " Turbines " in the following language.

> " Should you apprehend considerable difficulties in the use
> " of the Wheels proposed (i.e. Breast Wheels) I would recom-
> " mend the adoption of the Turbine, as the danger of its being
> " stopped by ice or back water is trifling, if it be properly
> " arranged and guarded "
>
> The operation of this wheel at Fairmount works (Philadelphia) has given entire satisfaction. The Superintendent

> in his last report alluding to it, says : " The perfect success
> " of this wheel affords the means of increasing the power of
> " the works, (by substituting Turbines for the Breast wheels
> " now in use) to the extent of from four and one half to six
> " millions of gallons per day."

Mr. McAlpine thus showed in 1853, that " Turbines" actually performed thirty per cent more work than "Breast" Wheels under the same circumstances. Since then more improvement has taken place in the Turbine than in the Breast Wheel. The substitution of the one kind for the other, as described in the above extract, still goes on at Philadelphia.

It is well known, that besides giving a larger percentage of power than the Breast Wheel, the Turbine works well under a variable head and in back water: the Breast wheel does not. At certain seasons both the latter conditions prevail at the Wheel House.

A practical test of the relative merits of the Breast Whee and those of the Turbine class, is, that no Miller or Machinist in the country ever uses the former in preference to the latter: Moreover the experience of your own works shews the superiority of the Turbine.

We think the above facts prove, that in recommending Breast Wheels, Mr. McAlpine has given an unsound opinion.

Purity of water.

The question of the purity of the water to be supplied has not received from Mr. McAlpine, the particular attention, such an important matter ought to command. On this point he merely says at p. 10.

> " The advantage of a covered conduit, so far as it maintains
> " the purity of the water, will be obtained in the open
> " Canals during the winter, and at other seasons defilement
> " may be prevented by outside drains and strict supervision."

In this climate, the seasons during which defilement takes place, are, Spring, Summer, and Autumn, and these are precisely the periods when the " advantage of a covered conduit," *is not* obtained by " open Canals."

We consider the statement that defilement may be prevented by " strict supervision", unworthy the reputation of a *practical* engineer.

If " outside drains and strict supervision" are sufficient, why has not the water supplied heretofore been free from impurities and defilement ?

Owing to its situation and construction, the present Aqueduct has been subjected to much contamination, especially in the vicinity of its junction with the river. This fact was abundantly proved to His Worship the Mayor, many of the water committee, and also Mr. McAlpine himself, on the occasion of the latters visit to this city, when the most disgusting causes of defilement were to be seen on all sides of the entrance bridge.

Appliances for securing purity of water are considered of paramount importance in every large city and town guided by an enlightened and prudent policy. New-York, Boston, Brooklyn and many other large centres of population on this continent, as well in Europe, have their covered Aqueducts.

If such works have been found necessary in those places, how much more are they needed here, with the addition of great climatic difficulties. Yet Mr. McAlpine's arguments against the covered conduit for Montreal apply equally to similar work elsewhere.

We beg to quote the following important evidence—as specially bearing upon the question of purity of water and also covered versus open Aqueducts,—given before a Parliamentary Committee in England in 1853 by scientific men. The subject under discussion was the New River cut—an open Canal which at that time supplied a large portion of London with water.

CAPT. VEITH, R. E., EXAMINED.

Quest. 2896.—Is it an open Canal all the distance ?
Ans.—Nearly all the distance.
Q. 2897.—What is the rate of flow of the water ?
A.—I understand the fall is graduated at the rate of 3 inches per mile—as they find that a greater inclination than that would render it turbid by the friction against the bottom and sides.
Q. 2898.—Is that an Aqueduct which is not lined but merely cut into the earth ?
A.—Wherever I have observed it, it is simply cut in the earth.
Q. 2899.—If the current were quicker it would render the Water turbid ?
A.—It would do so and be apt to destroy the banks,

Q.—Is the fact that it is an open Aqueduct injurious to the quality of the water when brought to the New River Head ?

A.—No doubt it must deteriorate to a considerable extent because having such a wide surface and such slow motion in summer weather it is obvious that the heat must be considerable and vegetable and animal life must be encouraged in some degree.

Q. 2901.—In bringing water from a distance to London would it be proper that the Aqueduct should be a covered one.

A.—I conceive that bringing it in the shortest distance you can bring it from the springs is important and also that the Aqueduct, should be covered and not only covered but as far under ground as the engineering circumstances would permit, that is in a tunnel form, if the country will permit.

EDWARD CRESY, C. E., EXAMINED.

Q. 3423.—Do you consider with Capt. Veitch that it would be desirable that the cut should be arched.

A.—I do so.

DR. HASSALL, CHEMIST, EXAMINED.

Q. 3907.—Is it desirable to deliver it (the water) by any means in London in nearly the same condition it is at the Well Head.

A.—I think it is.

Q. 3908.—By what means?

A.—Either through a large pipe or a covered Aqueduct.

Q. 3909.—You could deliver it in London in nearly the same state as when taken at the well ?

A.—Certainly.

Q. 3910.—Do you object to bringing water in an open channel ?

A.—Very much indeed.

Q. 3911.—Do you consider the system on which the water of the New River Co., is brought is objectionable ?

A.—Very objectionable, I believe the best water it would be possible to obtain would be completely spoiled by such a mode of conveyance, if conveyed in an open channel.

The above extracts express the opinions of engineers and chemists in England, on the subject of open channels for conveying water. Much more, did space permit, might be quoted to the same effect, viz that *pure, cool,* water cannot be obtained at all seasons in open aqueducts.

In this connection we would also refer to a portion of the report of Mr. Jervis in 1855, on your present works. Speaking of Mr. Keefer's plan for an open aqueduct he says :

"The plan contemplates the best for an open channel.
"*It could not be improved except by a covered aqueduct.*"

We consider the question of purity of water of first importance, and had we not felt the necessity for improvement in that respect, we would never have proposed a new Aqueduct of any kind.

If the *quality* of the water at present furnished is satisfactory to the Council and citizens, then we say, that the required *quantity* can be supplied for the next twenty years, by steam power, for less than one third the cost of any system of water power whatever; more especially Mr. McAlpine's open canal.

Steam Power.

In Mr. McAlpine's report the whole question of steam power is treated of, and summarily dismissed, in the following short paragraph.

> " That the use of steam power except as an adjunct and
> " for temporary purposes would be as costly as water power
> " and inexpedient."

That the above conclusion is as erroneous as many others to which we before referred, will be evident from a careful examination of the accompanying Table, which we have prepared with a view of shewing in detail, year by year, the relative cost of the two systems.

The data used in the construction of the Table is derived from *actual experience* of your present works: there is no doubt, therefore, of its practical accuracy. A full explanation of this data is given in note A.

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Per Month
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,989 00
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3,718 00

MONTREAL WATER WORKS.

TABLE SHEWING RELATIVE COST OF SUPPL

FUTURE DEMAND.

QUANTITY REQUIRED PER DAY IN EAC

MILLIONS OF GALLONS.

PRESENT AND FUTURE SUPPLY.

QUANTITY AVAILABLE FROM PRESENT WORKS. MILLIONS OF GALLONS.

QUANTITY TO BE SUPPLIED (in addition to present w

MILLIONS OF GAL

	QUANTITY	7		7½		8		8½		9		9½		10		10½		11		
	YEAR	1870		1871		1872		1873		1874		1875		1876		1877		1878		1
Per Day.	During the Month of.	Per Day	Per Month	Per Day	Per Month	Per Day	Per Month	Per Day	Per Month	Per Day	Per Month	Per Day	Per Month	Per Day	Per Month	Per Day	Per Month	Per Day	Per Month	Per Day
5	JANUARY	2	62	2½	77	3	93	3½	108	4	124	4½	140	5	155	5½	170	6	186	6½
2	FEBRUARY	5	140	5½	154	6	174	6½	182	7	196	7½	210	8	232	8½	238	9	252	9½
2	MARCH	5	155	5½	170	6	186	6½	201	7	217	7½	233	8	248	8½	264	9	279	9½
5	APRIL	2	60	2½	75	3	90	3½	105	4	120	4½	135	5	150	5½	165	6	180	6½
10	MAY	....	....	....	....	....	....	....	....	....	....	....	....	....	....	½	16	1	31	1½
10	JUNE	....	....	....	....	....	....	....	....	....	....	....	....	....	....	½	15	1	30	1½
10	JULY	....	....	....	....	....	....	....	....	....	....	....	....	....	....	½	16	1	31	1½
10	AUGUST	....	....	....	....	....	....	....	....	....	....	....	....	....	....	½	16	1	31	1½
8	SEPTEMBER	....	....	....	....	....	....	½	15	1	30	1½	45	2	60	2½	75	3	90	3½
8	OCTOBER	....	....	....	....	....	....	½	16	1	31	1½	47	2	62	2½	78	3	63	3½
8	NOVEMBER	....	....	....	....	....	....	½	15	1	30	1½	45	2	60	2½	75	3	90	3½
5	DECEMBER	2	62	2½	77	3	93	3½	108	4	124	4½	140	5	155	5½	170	6	186	6½
	TOTAL YEARLY QUANTITY required to meet above demand.	479		553		636		750		872		995		1,122		1,298		1,479		1

COST.

YEARLY COST of supplying above quantity by **WATER POWER** (*i.e.* New Canal):										
Steam during Construction	$ 8,143 00	9,401 00	10,812 00							
Interest do. do. (on $300.000 per Ann.)	10,500 00	31,500 00	52,500 00							
Do. on Cost of Work ($1.000.000)	....	....	....	$70,000 00	70,000 00	70,000 00	70,000 00	70,000 00	70,000 00	70
Working Expenses, $3 per million Gallons.	....	....	....	2,250 00	2,616 00	2,985 00	3 366 00	3,894 00	4,437 00	4
TOTAL	$18,643 00	40,901 00	63,312 00	72,250 00	72,616 00	72,985 00	73,366 00	73,894 00	74,437 00	74,
YEARLY COST of supplying above quantity by **STEAM POWER** at $17 per Mill. Galls.	$ 8,143 00	9,401 00	10.812 00	12,750 00	14,824 00	16.915 00	19,075 00	22,066 00	25,143 00	28
YEARLY SAVING by STEAM POWER	$10,500 00	31,500 00	52,500 00	59,500 00	57,792 00	56,070 00	54,292 00	51,828 00	49,294 00	4

We believe the amount saved, as above, by Steam Power, is *less* than it would prove to be in practice, for these reasons:

1st. The quantity of water from present works is underestimated.
2nd. The future demand is overestimated.
3rd. The cost of New Canal will exceed the amount calculated upon, viz., $1,000,000.
4th. The cost of Pumping by Steam is overestimated, being based on "Duty" of Montreal Engine.
5th. The interest on amount saved every year by the use of Steam is not taken into account.

...G RELATIVE COST OF SUPPLYING THE CITY BY **WATER POWER** AND BY **STEAM POWER** TO YEAR 1887.

...D PER DAY IN EACH YEAR.

...S OF GALLONS.

10	10½	11	11½	12	12½	13	13½	14	14½	15	TOTALS.	REMARKS.
1876	1877	1878	1879	1880	1881	1882	1883	1884	1885	1886		

(in addition to present works) **TO MEET THE ABOVE DEMAND.**

MILLIONS OF GALLONS.

1876 Per Month	1877 Per Day	1877 Per Month	1878 Per Day	1878 Per Month	1879 Per Day	1879 Per Month	1880 Per Day	1880 Per Month	1881 Per Day	1881 Per Month	1882 Per Day	1882 Per Month	1883 Per Day	1883 Per Month	1884 Per Day	1884 Per Month	1885 Per Day	1885 Per Month	1886 Per Day	1886 Per Month
155	5½	170	6	186	6½	201	7	217	7½	233	8	248	8½	264	9	279	9½	295	10	310
232	8½	238	9	252	9½	266	10	290	10½	294	11	308	11½	322	12	348	12½	350	13	364
248	8½	264	9	279	9½	295	10	310	10½	326	11	341	11½	357	12	372	12½	388	13	403
150	5½	165	6	180	6½	195	7	210	7½	225	8	240	8½	255	9	270	9½	285	10	300
....	½	16	1	31	1½	47	2	62	2½	78	3	93	3½	109	4	124	4½	140	5	155
....	½	15	1	30	1½	45	2	60	2½	75	3	90	3½	105	4	120	4½	135	5	150
....	½	16	1	31	1½	47	2	62	2½	78	3	93	3½	109	4	124	4½	140	5	155
....	½	16	1	31	1½	47	2	62	2½	78	3	93	3½	109	4	124	4½	140	5	155
60	2½	75	3	90	3½	105	4	120	4½	135	5	150	5½	165	6	180	6½	195	7	210
62	2½	78	3	63	3½	109	4	124	4½	140	5	155	5½	171	6	186	6½	202	7	217
60	2½	75	3	90	3½	105	4	120	4½	135	5	150	5½	165	6	180	6½	195	7	210
155	5½	170	6	186	6½	201	7	217	7½	233	8	248	8½	264	9	279	9½	295	10	510
1,122		1,298		1,479		1,663		1,854		2,030		2,209		2,395		2,586		2,760		2,939

1876	1877	1878	1879	1880	1881	1882	1883	1884	1885	1886	TOTALS.	REMARKS.
,000 00 3 366 00	70,000 00 3,894 00	70,000 00 4,437 00	70,000 00 4,989 00	70,000 00 5,562 00	70,000 00 6,090 00	70,000 00 6,627 00	70,000 00 7,185 00	70,000 00 7,758 00	70,000 00 8,280 00	70,000 00 8,817 00		
,366 00	73,894 00	74,437 00	74,989 00	75,562 00	76,090 00	76,627 00	77,185 00	77,758 00	78,280 00	78,817 00	$1,177,712 00	Total Cost of Water Power to 1887.
,075 00	22,066 00	25,143 00	28,271 00	31,518 00	34,510 00	37,553 00	40,715 00	43,982 00	46,920 00	49,963 00	$ 452,540 00	Do. Steam Power do. do.
,292 00	51,828 00	49,294 00	46,718 00	44,044 00	41,580 00	39,074 00	36,470 00	33,796 00	31,360 00	28,854 00	$ 725,172 00	Total Saving (exclusive of Interest) by means of Steam Power to 1887.

R. P. COOKE,
E. W. PLUNKETT,
Civil Engineers

Steam Powe

In conclusion we would repeat what we said before, and what we think must be evident to any *unbiassed person* who will devote sufficient time to the matter, viz: that if the citizens of Montreal desire, and are willing to pay for an *ample supply of good, pure water*, the cheapest and only way of obtaining it is by means of a covered conduit; but on the other hand, if they are satisfied with the quality of the water heretofore supplied, *by far the cheapest* way of obtaining the necessary amount, is by means of auxilliary steam power in connection with the present works.

We have the honor to be

Sir,

Your obedient Servants.

R. P. Cooke,

E. W. Plunkett,

Civil Engineers.

Note A.—The following gives the data used in construction of Table prepared by us, and also the authority from which it is derived.

1st. The quantity of water available from present works is taken from the Superintendents Reports for the last ten years; it is the minimum supply and may be safely counted upon during the period named in *Table* according to past experience.

2nd The daily consumption is assumed to increase at the rate of half a million of gallons per annum: this rate is taken on the authority of Mr. Shanly (report p 9) and Mr. Lesage's Reports.

Comparing the maximum daily consumption in 1859 and the same in 1868 as given in your Superintendents Reports, we find the actual increase has been only a quarter of a million of gallons from the former year to the latter; but half a million of gallons having been named by Mr. Shanly and Mr. Lesage as above, we have preferred to adhere to that assumed increase.

3rd. The cost of pumping by Steam power is taken at $17 per millions of gallons raised, and is arrived at as follows.

We find from Mr. Risley's report on Montreal Engine that its actual performance was 4½ millions pumped with 12 tons (2240) coal. This would be for 5 millions pumped 13.33 tons (2240) say 14 tons.

The cost per ton of this coal is taken at $5. the price named by Mr. Shanly. Steam coal can be bought on the wharves for $4.25 in large quantities including wharfage. There seems to be no reasonable doubt therefore that $5 per ton is ample.

The items are :

14 tons of coal at $5	$70.00
Engineman per day,	2.50
2 Firemen "	2.50
Oil, Tallow, Waste &c,	5.00
Engine repairs, $1500 per annum.,	5.00
Daily total for 5 million gallons	$85.00
or for 1 " "	$17.00

In the above no account is taken of interest, on cost of machinery, or renewals as these items are also neglected in cost of pumping by water. There will not be much difference in the value of machinery for both systems, so that leaving it out in each estimate will equalize the results.

4th. The cost of enlarged canal is taken at $1,000,000. Mr. Shanly in his report states it " will exceed rather than fall short" of that amount. Mr. Lesage's estimate is in excess of it, and we believe it is more likely to exceed $1,500,000.

5th. Interest on expenditures is taken at 7 per cent.

6th. The pumping expenses connected with water power, apart from renewals and repairs, are taken on the authority of Mr. Shanly (report p. 19) at $3. per million gallons raised. Repairs to water power pumping machinery are neglected as they will be small. In steam power, it will be observed, a liberal allowance is made for them. Renewals are alike neglected, as before stated, in both calculations.

7th. The cost of repairs to enlarged acqueduct is also omitted from statement of yearly expense connected with that work, although it is evident, a considerable outlay will be necessary to maintain and repair Slopes, Bridges, Culverts, Fencing and other works. This item if included, would of course make the comparison even more favorable to steam.

FIRST PROPOSITION

ABOUT PROPOSED

COVERED CONDUIT.

The following is the text of the communication made by Mr. Cooke and Mr. Plunkett, civil engineers, to the Council, respecting the Water Works:

To the Mayor, Aldermen, &c.:

Gentlemen.—We beg to inform you that we have devised a plan for increasing and improving the water supply of this city; and we are prepared to shew that said plan possesses the following advantages:—

1st. Perfect certainty of supply, irrespective of winter difficulties.

2nd. Purity of water.

3rd. Non-interference with present works, or supply.

4th. Facility of future enlargement, at moderate expense, without interfering with the works or supply then existing.

5th. Economy, both in construction and maintenance; the original cost being fully 25 per cent. less than that of any other plan for supplying on equal quantity of water, and the expense of maintenance being a minimum.

Our plan, as it now stands, is calculated to supply the city with 10½ millions of Imperial gallons per day, *under the most unfavorable circumstance of low water, frost, and ice obstructions*, and *quite irrespective of the present aqueduct.* The estimate of cost of this plan is $700,000. (seven hundred thousand dollars).

Should the Council, however, decide that a larger quantity than the above would be required to begin with, our plan can be modified accordingly, as follows:

12½ millions of gallons per day will cost $780,000.

15 millions of gallons per day will cost $900,000.

These quantities are also calculated to be supplied under the most unfavorable circumstances.

With regard to the feasibility of the sheme, and the first four advantages claimed for it, we are willing to submit *these points* to the decision of any competent engineer, say Mr. W. Shanly, Mr. T. C. Keefer, or Mr. J. B. Francis, and in order to satisfy the Council respecting the fifth advantage claimed, *i. e.* economy, we beg to say, we are ourselves willing to undertake the work for the sum mentioned, and give unobjectionable security for the proper fulfillment of the same.

If, however, the Council is willing to adopt our plan, but prefers any other mode of carrying on the work, we are willing to act as Engineers in designing, laying out, superintending, and measuring the work, for a reasonable commission on the outlay.

We have the honour to be, Gentlemen,

Your Obedient Servants,

R. P. COOKE,

E. W. PLUNKETT,

Civil Engineers.

DESCRIPTION OF PROPOSED COVERED CONDUIT.

MONTREAL, August 12, 1869.

JOHN W. MCGAUVRAN, ESQ. Chairman Water Committee, City Council, Montreal.

SIR,—In our communication to the City Council, dated 15th June last, we claimed certain advantages for a plan we proposed by us for "increasing and improving the water supply of this city," and we now beg to offer for the consideration of the Water Committee the following short description of the proposed works, and our reasons for believing that, if properly carried out, they will possess the advantages we claim for them.

The chief features of our sheme, and those wherein it differs most essentially from the present system and all others heretofore proposed, are as follows:—In the first place, instead of drawing our supply from the surface water, in a comparatively shallow part of the St. Lawrence, we propose having our entrance in deep water, and fully *ten* (10) *feet below the surface;* and secondly, instead of an open canal with a very small fall from the entrance to the Wheel-house, we propose a substantial tunnel or conduit with a *good fall*, say fully six times that of the present aqueduct. There are, of course, many minor items of detail on which the efficiency of the works will, to a great extent, depend, but which it is not necessary to enter into here; our present object being to explain the general principles of our scheme and the results to be anticipated therefrom, if properly carried out, rather than the particular style of works we would recommend for that purpose.

The advantages we claim are as follows:—"Perfect certainty of supply, irrespective of winter difficulties." Second. "Purity of water supplied." Third. "Non-interference with present works or supply." Fourth. "Facility of future enlargement without interfering with works or supply then existing." Fifth. "Economy." We will now endeavour to show how these advantages are attained.

1st. Certainty of Supply.—In the Superintendent's report (1866,) after giving an account of "the difficulties attending the working of the wheels since the beginning," and explaining how, by deepening the mouth of the aqueduct, he got rid of the trouble heretofore caused by "frasil" or "anchor" ice, he goes on to state that "the causes of the present embarrassment in the aqueduct are: 1st. "Low state of water in the St. Lawrence;" 2nd. "Formation of ice over the aqueduct;" and 3rd. "The sinking of this volume of ice, caused by the rise and fall of water in the St. Lawrence and by the working of the wheels." Now, as the soffit of the proposed conduit will be lower than the lowest known water leved in the St. Lawrence at the "entrance," and as the efficiency claimed (fifteen million gallons per day) is only *its minimum capacity* calculated for such lowest water level—a level at which the present works are nearly, if not entirely, useless—it follows then that we need fear no trouble from "low water;" and as all frasil and floating ice will be excluded by the position of the entrance, and the formation of ice and accumulation of snow in the aqueduct itself be effectually prevented by the supeincumbent covering of earth, &c., we think we may safely count on freedom from the other two "causes of embarrassment," and confidently predict that "the supply will be certain and irrespective of winter difficulties."

2nd. Purity of Water.—On this head we think it unnecessary to enter into any elaborate argument to prove the advantages of the plan we propose over the present arrangement. The water obtained from the river, in the first place, being drawn from at least a depth of ten feet below the surface, will be free from the dirt and impurities of all kinds which usually accumulate on the surface, more particularly near shore; and being protected in its course from thence to the pumps from the many sources of impurity and defilement to which water in an open sluggish canal, five miles long, must necessarily be exposed, it will be delivered in an equally pure condition into the reservoir.

3rd. Non-interference with the present Works or Supply.— Here it is only necessary to remark that, as we intend locating the proposed tunnel from "Frasers," to the "Rock Cut," and thence along the north side of the present aqueduct to the wheel house, as shown on the accompanying plan, there need be no interference whatever with the present works, which unquestionably would not be the case if any of the other plans for enlargement by means of cribwork, dredging, or excavacation of slopes, were carried out.

4th. Facility of enlargement.—The proposed aqueduct will have a capacity equal to about 15,000,000 gallons per day, to the level of the McTavish street or, if deemed preferable, say 10,000,000 to that elevation, and 3,000,000 more to a level 100 feet higher. But, as a matter of course, to obtain this result new pumping machinery properly set, will be required so as to obtain the full value for the power expended. This machinery, however, need only be purchased as required, or, if the Committee see fit, they may, for a time at least, use the discharge from the new tunnel to work the old wheels and pumps. This, however, we only recommend as a temporary expedient in order to avoid the expense of new machinery as long as possible, our objection being the level at which the wheels are set. That there has been a mistake made in setting the wheels so high, is, we believe, generally admitted *now*, as, had the aqueduct even ten times its present capacity, and were there no such things as ice obstructions at all, still would there be "causes for embarrassment," as often as the water in the St. Lawrence falls (as it does) below the level at which the wheels were calculated to work. Partly with a view of avoiding any such trouble in future, and partly for the sake of the immense increase to the efficiency of the aqueduct which will be thereby effected, we intend, not only to keep the soffit of our tunnel well below the lowest known water level at the entrance, but to give it a good fall from thence to the wheels. By this means we insure, in the first place, that the conduit runs all the time full, and in the second we greatly increase its pumping power or capacity. That this will be the case can easily be shown as follows :—If the water level at the entrance be, say 37 feet, and that in the tail race 22 feet above "datum," we will have a total fall of 15 feet, to be used partly as a fall in *giving motion to the water in the aqueduct* and partly as a head in driving the wheels. Now, by the present arrangement, this total fall is appropriated somewhat thus:—Fall in aqueduct 1 feet (or about 2½ inches per mile) and head on wheels 14 feet; total, 15 feet. With such a fall we would make quite a different and, as we believe, more judicious apportionment, thus:—Fall in aqueduct 6.3 (1.3 per mile) and "head" on wheels 8·9. Total, fifteen feet. Let us now compare the working of these two arrangements. According to the best authorities the discharge from any channel having a fall of 1.3 per mile will be nearly three times that from a similar one with a fall of 2½ in per mile, or more exactly 280 gallons (weighing 2,800 lbs.) will be discharged from the one, while 100 gallons (weighing 1,000 lbs.) flows from the other. In the one case we have 2,800 lbs. x 8·9 (the "head") = 24,500 foot pounds, as against 1,000 lbs. x 14.0 (the "head")=14,000 foot pounds. A gain of fully 70 per cent. Feeling therefore that we are right on this point, we have considered it better in designing the new works to follow what we believe to be correct engineering principles, and true economy in the long run, than sacrifice ulterior advantages of such vast importance, in order to adjust the works better to what we believe is a mistake, viz., the level of the present pumping machinery. Hence it is, that although the discharge from the proposed conduit can be used (in connection with that afforded by the old aqueduct) to operate the existing machinery, still its full capabilities will not be thereby developed, as would be the case with new machinery, set at a lower level. This new machinery, however, need not be put up till the consumption of water approaches the full capacity of the present wheels and pumps, and then, as before remarked, it can be added to from time to time as required, till finally, we obtain the full benefit to be derived from the new conduit, viz., fifteen million gallons per day to the McTavish reservoir, or its equivalent, to a higher level. As a further means of enlargement, we would propose to build a similar tunnel of equal dimensions, parallel to the one now under discussion, making use of the present aqueduct channel as far as practicable for that purpose. The cost of this would, of course, be far less than that of the one now proposed, and would, when completed, furnish, in conjunction with the other, fully

20,000,000 gallons per day to the McTavish reservoir and about 6,000,000 *more* to a further elevation of 100 feet.

5th. Economy.—In making out our estimate for this work we have, of course, carefully noted the difficulties met with in excavating the present aqueduct, and have accordingly, been liberal in both our quantities and prices. So liberal that we are perfectly satisfied our estimate of cost is fully ample, and are quite prepared to undertake the work ourselves and give unobjectionable security that we will complete it properly for the sum mentioned, viz: $900,000. We are not disposed to criticise the various other plans proposed, or the estimates given for them, but still we cannot avoid asking the committee to bear with us while we run through the following simple rule of proportion, whereby we believe we may arrive at a pretty correct idea of the cost of one of the proposed plans, and that far and away the most practicable and reliable in its effects, as well as the only one for which we have any reliable *data* as to cost. We allude to the large open channel, as proposed by Messrs. Shanly and Francis. The total quantity of excavation in this work would be (according to Mr. Lesage's measurement) about 1,900,000 cubic yards, while the total quantity in the present aqueduct was about 684,000 cubic yards. Now, with the exception of fencing, puddling banks, and stone lining of slopes, which would be about equal in either case, we may safely say that all the other works would be in about the same proportion as the excavation. Then, when we remember the increase in the value of land since the present aqueduct was built, and the greater depth to which it is proposed to sink Messrs. Shanly and Francis' channel, and consequently the chance, nay certainty of meeting a larger per centage of rock and "hard pan," we think we are not far out in stating that the cost of the new channel would bear about the same proportion to the cost of the present aqueduct, that the total amount of excavation in the one bears to that in the other. That is, as 684,000 is to 1,930,000, so will $600,000 (the first cost of present aqueduct) be to $1,693,000, the probable cost of the new one. This is, of course, a very rough mode of calculation, but still, we believe it is sufficiently correct and practicable to give all we require, viz, a general idea what the probable cost would be. Let us now enquire whence comes this great difference of at least $700,000 in the cost of the two schemes, one being a large open canal, the other a subterranean aqueduct of at least equal capacity. It is chiefly owing to the two following reasons: First, the subterranean aqueduct need not, as in the case of the open canal, be made fully double *the size actually necessary for the passage of the water* in order to provide room enough for accumulations of ice and snow in winter; and secondly, by giving it a good fall as previously explained, we are enable still further to reduce the dimensions without in the least curtailing its efficiency.

Subjoined will be found—1st. A plan showing the proposed location of conduit. 2. Cross sections of same, showing dimensions and mode of construction; first (at about station 10) in a deep cutting where no solid rock is found, and secondly (about station 100) where such rock may be found sufficiently solid and durable, to be made use of, in its natural formation as bottom and side walls of conduit. 3rd. A general specification describing the style of work we propose. 4th; A calculation of efficiency showing the data we base our figures on, and the process by which we arrived at the conclusion that the works we proposed if honestly carried out, have a capacity or power (at the lowest known water level in the St. Lawrence) sufficient to furnish and pump fully 15,000,000 gallons of water per day to the McTavish Street Reservoir.

In proposing this plan for the improvement of the Water Works of this city, we are desirous of submitting it to the fullest enquiry and scrutiny, and the higher the professional standing of the engineers to whom the Water Committee we may refer the matter, the better we will be pleased, as we are convinced that, however we may differ as to the details, there will be only one opinion on the chief point, viz., that a subterranean aqueduct is in every way far preferable to an open channel for the conveyance of water for domestic and city purposes, more especially in a severe climate. We may add our own firm convictions that, sooner or latter, it *will* be adopted as the cheapest and most reliable way of supplying water to the city of Montreal.

We remain, gentlemen, your obedient servants,

(Signed,) R. P. Cooke,
E. W. Plunkett,
Civil Engineers.

CALCULATION OF EFFICIENCY OF PROPOSED COVERED CONDUIT.

DATA.

Water at entrance, lowest level..............	35.70 above datum
" Wheel House	29 20 " "
" in Tail Race (this level is quite practicable. see similar statements by other Engineers...............................,	19.00 " "
Fall in Aqueduct (15 in. per mile)............	6 50 ft.
' Head " on Wheels.......................	10 20 "
Sectional area of Aqueduct..................	280 sq. feet
Perimeter.....	61.5 feet
Hydraulic mean depth......	54 inches
Length of aqueduct.......................	5.20 miles
The velocity of water in a channel with the above fall and hydraulic mean depth is, according te the best authorities.....	172,05 feet per minute.
Discharge per minute.....	48,170 cubic feet per m.
Deduct for pumps, say.....	2,000 " " "
Available for wheels.......................	46,170 = 2,838,000 lbs.
Fall on wheels..........................	10 20 feet.
" Foot pounds ".....................	29.356,000
Horse power (nominal)...........	890

DEDUCTIONS.

1st. By Theory.—The power (nominal) as shewn above is 29,356,000 " Foot Pounds," while the work to be done is (10,-416 gallons to be lifted 175 feet every minute) only 18,228,000 " Foot pounds," not 63 per cent of the power expended.

2nd. By Analogy.—Mr. Lesage actually pumped at the rate of 5,431,603 gallons per day with 317 horse power (nominal). Therefore as 317 is to 5,431,608 so is 890 horse power to about 15¼ millions of gallons capacity at " the very lowest " known stage of water.

(Following this is a General Specification of the proposed work which we need not repeat here, as it is too much of a technical document to interest the general public. We may state, however that the structure referred to in it, and shewn in the drawings, accompanying Report, is a large Conduit or Pipe of substantial masonry, buried in the ground from 8 to 12 feet under the surface. It is proposed to run the river or entrance end of this conduit into 40 feet of water in the St. Lawrence, at about Frazer's Bay. The water will enter the conduit from the river at a mean depth of 18 feet below the lowest known level of the latter. The advantages of such an arrangement are obvious. The size of the conduit to supply water to pump over

15 millions of gallons per day into the McTavish Street Reservoir, under the most unfavorable winter conditions is 20 feet wide by 17 feet high inside. The proposed open canal to do the same work is about 125 feet wide at water surface.

MR SHANLY'S OPINION OF PROPOSED COVERED CONDUIT.

HOOSAC TUNNEL,
Contractors Office,
North Adams, Mass., U.-S.,
25th Oct., 1869.

GENTLEMEN.—Much press of business in connection with my work here, has prevented my taking up sooner, the papers you sent me some time ago, in reference to your project for improving the water supply of Montreal; and even now, I have not been able to give them more than a general and cursory examination, from which I come to the following conclusions:

1. A comparaison between an open canal and a covered conduit, speaking of the particular case under discussion (and aside from the question of cost), is largely in favor of the latter.

2. The capacity for discharge of such a conduit as you propose to construct, is not, I think, overstated in your report.

3. Of the correctness of your estimate of quantities and their, classification I have no means of judging.

4. In respect of cost, your prices appear to me to be all somewhat slender, and in the items of Culverts, Entrance, and Lands are, in my judgment quite too low. You have, I observe, added 12½ per cent. to your summary to provide for contingencies. I thing 25 per cent. would have been none too much, considering the great depth to which you propose to excavate the aqueduct and the consequent certainty of being much troubled with water.

I have no hesitation in saying that your plan of a covered conduit all below low water level, and with the entrance fully 10 feet below the surface, would effectually obviate all the difficulties that now interfere with the winter efficiency of the Water Works.

Yours very truly,

(Signed), W. SHANLY.

Messrs. Cooke & Plunkett,
Civil Engineers, Montreal.