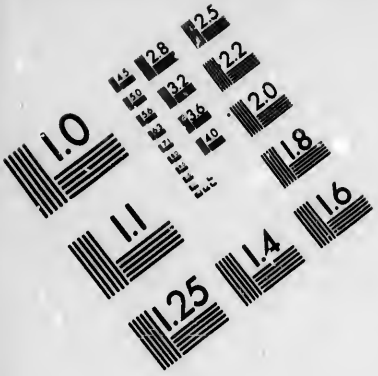

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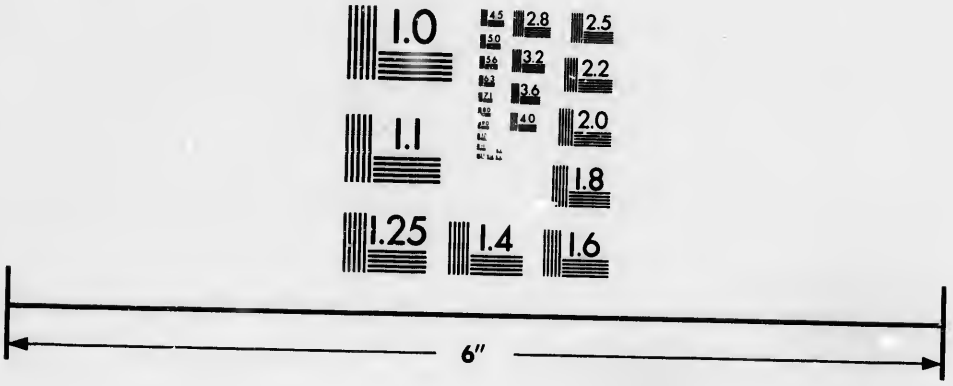

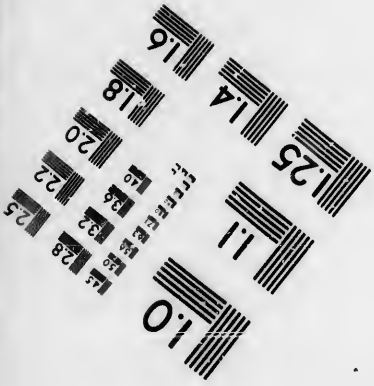

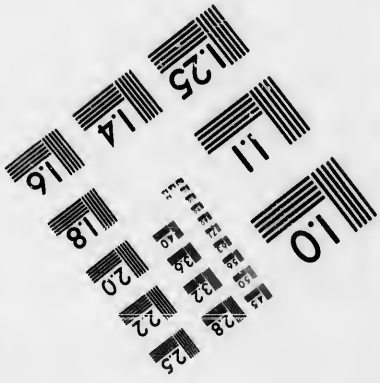

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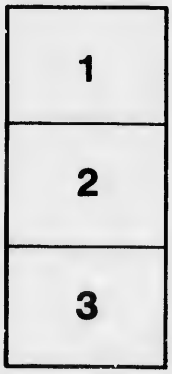

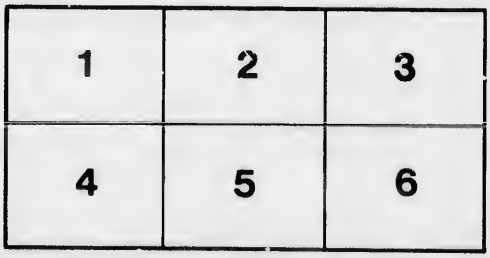

REPORT

ON THE

NECESSITY OF NEW WORKS

FOR

Increasing the Supply of Water

TO THE CITY OF QUEBEC,

NOW INSUFFICIENT FROM EXCESSIVE WASTE AT THE SERVICE PIPES AND ELSEWHERE WITHIN THE CITY.

To His Worship the Mayor, D. McGie, and J. B. Pruneau, Esquires, of the Joint Committee of the Fire Insurance Companies and City Council of Quebec:—

GENTLEMEN—Having been requested by you "to report on the present state of the Water Works of Quebec, with recommendations how any defects can be remedied;" and to report my "views as to the mode of preventing waste," and whether "the present supply of water, if properly regulated, is sufficient for the city, and, if not, what I would suggest to be necessary, with the probable cost thereof; whether a "reservoir or a double set of pipes," the report to be based on a population of 100,000 inhabitants; I beg leave to offer the following statements as the results of my investigations:—

Concerning the present state of the Water Works, so far as I could examine them, I found nothing that indicated unsoundness, insecurity or imperfectness beyond what ought to be expected in a work of the kind, constructed, as it was, some ten years ago. The 18-inch feeding-main from Lorette to Mount Pleasant was tested and found exceedingly tight, as will be shown hereafter. The greatest change that has taken place is the reduction of the bore of the pipe by oxidation; this was to be expected as at the time the pipe was laid down there was no known remedy against such a result; and even at the present day the most perfect protection that has been applied can only be considered as a palliative, that of dipping the pipes as soon as cast, before oxidation takes place, in a hot bath of Dr. Smith's Patent Coal Tar Varnish. This coating is considered the best, and has been generally used, so far as I am informed, throughout the Northern States within the last six years. It was applied to the Brooklyn pipes where cast-iron was generally used, and at Charlestown where the 30-inch force-main and the 24-inch feeding-main are of iron. There is some uncertainty as to the duration of this varnish—it will probably protect the pipes for some seven or eight years, but not much longer.

The effect of the incrustation on the 18-inch feed-main, as laid down from the Chateau d'Eau at Lorette to Mount Pleasant, appears by our experiments to have been, to virtually reduce the calibre of the main from 1.50 ft., its original size, to

1.28 ft—that is, comparing the discharge computed on a straight and smooth pipe of uniform section throughout its length, free from all obstructions except friction of the water against its interior surface, with the discharge, as ascertained by gauging the water, at the Chateau d'Eau, that actually flowed through the existing pipe under a known head and fall, using the same formula and head and fall in making the comparison. This comparison shows the pipe now in use to be of no more value, as stated above, than one of $1\frac{28}{100}$ foot diameter, clean, straight and smooth, showing a loss or difference of diameter of a $\frac{22}{100}$ foot, or $2\frac{5}{8}$ inches.

If there were no other way to account for this reduction of the discharge than the incrustation, the experiments would show that the pipe had actually an incrustation of 0.11 ft., or $1\frac{5}{16}$ inch thick; but, without doubt, several other causes do exist, such as eccentric joinings, irregularities in the alignment and curvitures, enlargements of bore at stopcocks and air-cocks, and possibly heavy substances like stones which were accidentally left in the pipe at the time it was laid down, and could not be scoured out afterwards; if anywhere, these would probably be found at the foot of Savageau Hill, or between the hill and the River St. Charles, which portion of the line, although an attempt was made, could not be thoroughly scoured for want of a sufficient supply of water at Mount Pleasant.

In all the computations we may have occasion to make on the subject of supply, a similar reduction of the diameter of the pipes will be made before computing the discharges, not regarding the possibility of keeping the pipes clear of incrustation many years by the modern practice of varnishing with prepared coal tar.

This filling up of the pipes by oxidation in the form of tubercles, more or less hollow, extends throughout the whole system of the distributing pipes within the city; and is, without question, one of the principal causes, why, in case of fires occurring in districts supplied by the smaller pipes, there is sometimes found an insufficiency of water and pressure at the hydrants, greatly increased of course by the present practice of the tenants leaving the water running from their services. Were this waste of water controlled by some stringent law or otherwise, I am of opinion its effect would be apparent.

At the time the Water Works were commenced, 4-inch service mains were generally used for the smaller mains both in Great Britain and the United States. Experience in England and Scotland at that time, had shown that the 3-inch pipes, often used then to save cost, were too small because of the filling up by oxidation, as at Aberdeen, where I found a 3-inch service main for a considerable extent was being taken up, and a 4-inch substituted; the former failing to perform its office by the accumulation of rust.

Both at New York and Boston, then introducing water, 4-inch pipes were laid down extensively for the outer or extreme branches of the distribution; but in the more recent distribution of water at Brooklyn, N. Y., no service mains less than 6 inches have been laid of cast iron, and these have, it appears, been coated with the coal tar varnish.

As varnish may decay or wear off, and not eventually prevent the usual oxidation, another kind of pipe has been introduced in several cities in the United States, where the pressure is not so excessive as at Quebec, which, if found to be as imperishable as cast iron, will be a valuable substitute for the latter in the distribution of water in cities generally; especially for all the smaller pipes of a system; but for the larger mains of 16 inches and upwards, it may not be found so well adapted. I allude to the "*Hydraulic Cement Pipe*" as laid down by the "*Jersey City Water and Gas Pipe Company.*" This pipe is formed by lining with Hydraulic Cement (such as may be made at Quebec), a sheet-iron pipe strongly rivetted along its joint, and when dry laid down in the trench on a bed of the same kind of cement, connecting the pipes together with a wrought iron thimble after the manner the drain pipes at Quebec were laid, covering the whole body of the pipe including the thimbles at the joints with the cement,

thus completely enveloping and isolating the sheet-iron tube both from air and water; in this state, it is found by examination, that after being exposed in the work 13 years, the pipes are perfectly free from oxidation. About 300 miles of this pipe have been laid in the United States during the last 18 years. Its cost in the States is about $\frac{2}{3}$ or $\frac{3}{4}$ that of cast-iron. There can be scarcely a material better calculated for preserving the purity of water than the cement of which this pipe is made.

Can the Hydrants at Quebec be improved?—This is an important question. In their present form, little it is believed can be done to improve their efficieney, except to remove any accretions that exist on their interior surfaces and in the lateral or branch pipes that connect them with the street mains; any important change would be attended with considerable expense. Should, however, it be deemed necessary to make such a change it would be well to try a recent and very ingenious invention introduced by the patentee, Mr. Loury, of Pittsburg, Penn. His Hydrant is attached directly to the street main, generally on the top of the three or four-way branches at the junction or interseetion of two streets, rising vertically in a well surrounding it, to near the surface of the pavement, the well being covered by a cast iron frame and movable circular cover about 12 inches diameter; the vertical pipe having a diameter of some 10 or 12 inches, forming one casting with the branch itself, and of course admits the water freely from all three or all four mains, as the branch may be one of three or four ways, when used in case of fires. A large stop valve closes the top of the vertical pipe, capable of being forced down against the pressure of the water by a screw, after the copper *hose-branch*, which the firemen bring with their engine, has been screwed to the top of the vertical pipe. The *hose-branch* carries at its upper end, four to eight separate nozzles to each of which a hose may be screwed. This Hydrant is very powerful and well calculated for supplying several engines at a time whether hand or steam as the hydrant cannot easily be exhausted.*

The principal objection to the general introduction of these hydrants into Quebec, arises from the difficulty there would be of keeping the snow and ice clear from the surface of the streets for a limited space around them; and perhaps from

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* The following is a description of a trial of one of these hydrants in Boston, which I witnessed, and is copied from C. L. Stevenson's Report on supplying the City of Lynn with water, dated September 1, 1864:—"The advantages arising from such an excess of supply from the mains to the hydrant were so well shown in a trial made in Boston in 1863, that a brief account thereof is pertinent. After an exhibition of the powers of this hydrant at Brooklyn, I requested Mr. Loury to send one to us as a sample, and if possible, for trial. By the courtesy of the Boston Water Board, and the Superintendent of the eastern division of the Water Works, every facility was afforded for a fair trial of its merits. The hydrant, a 4-way 6-inch was located in Winthrop Place, near Franklin street, at the intersection of two 6-inch, pipes; a 3-way 6-inch branch being taken out to admit of its introduction. The spare end of the hydrant was closed by shutting the gate therein. The delivery was therefore such as could be obtained from eighty-five square inches of pipe area, lessened by such accretion as has taken place in the iron; so that the actual effective area would probably not exceed 75 square inches.

"To this hydrant four of the most powerful of the steam fire-engines in the city were attached by 4-inch couplings. The indicated pressure on the water-gauge, before starting the engines, was 35 pounds. The engines were fired simultaneously, and, at the end of twelve minutes, were throwing nine powerful streams of water, subsequently increased to thirteen. With the nine streams the pressure on the water-gauge was thirty-two pounds, and with the thirteen streams was reduced to thirty pounds; thus, of course, showing an excess of pressure from the main of that amount. This result, so contrary to general expectation, was most satisfactory, in showing the advantage of tapping the mains at their junctions.

"Upon this same line of 6-inch pipe were located several hydrants of the usual style. To one of these, one steam fire-engine was attached. When throwing two streams the effect of exhaustion of the hydrant was noticeable; and the interruption to the stream, as shown by the air-spaces, denoted that the engine was drafting from the main."

the great pressure on the stop-valves in the lower parts of the city, when there should be an abundant supply of water and concentration, upon the district in which a fire happened. Probably, however, by some mechanical arrangement, this could be obviated.

I would recommend a trial of a few of these hydrants located where they could be most easily kept accessible in the the winter season. It is contended by the patentee that such hydrants may be placed at double the distance apart advisable for the hydrant in common use; nevertheless, it should not be forgotten that the nearer the hydrants are placed to each other, the less friction there will be to the flow of water through the hose and less time consumed in getting the water to a fire,—two important considerations which favor a multiplicity of hydrants, besides favoring the use of short lengths of hose to be kept in private buildings in all parts of the city, ready to be used immediately after the first alarm that a fire has commenced, either by a policeman or individual who may own the hose or have it under his charge, as has been recommended by Mr. McElroy, in an article recently published in the *Journal of the Franklin Institute*. Where, alluding to the Brooklyn Fire Service, he observes:

"From these notes it appears that the average use of hydrants is about four per fire, and the average length of hose per hydrant somewhat less than 450 feet, the average length of time for fires being $2\frac{71}{100}$ hours, though the variations in such duration are considerable, as are also the respective amounts of damage.

"The use, as here shown of about 1700 feet of hose per fire presents in resultant excessive friction, a strong argument in favor of shorter intervals between hydrants, while it forcibly illustrates the superior effects of prompt service from improved hydrants and short lengths of hose; and herein is contained the system of improvement which a better fire service evidently demands.

"This improvement in our opinion, should consist in the subdivision of the present fire districts of any large city, into small sections, through which the average running time, from hose station to extreme limit should not exceed three minutes, for a small, compact hose-reel and hand cart, which two men could easily manage; in addition, wherever it could conveniently be done, by arrangement with public spirited house occupants, or insurance stockholders, opposite hydrants, a couple of lengths of hose might be deposited in houses well known to the police and otherwise specially designated as such storehouses; this need not be done on every block, but at intervals of several blocks, so as to control spaces not exceeding 1500 feet in length, and in some localities the inter-spaces might be greater."

I make a further quotation from the same article thinking it not irrelevant to the general objects of this report:

"The value of water supply, for fire service, is one of the strongest arguments usually presented for its introduction; an argument which gains force by careful attention to the disproportion between annual fire loss and cost of water administration. It is not uncommon in city experience, that a single conflagration should much exceed in pecuniary loss, the entire cost of an ample supply, or should be so much aggravated through defective supply, as to exceed largely the cost of proper improvements; and while annual fire statistics are counted by millions, expenditures for the preventive are counted by thousands and hundreds of thousands. The loss by fire in Philadelphia, in 1862, was $450,176; the loss reported in New York, for the six months ending May 31st, 1864, was $2,512,696, or about one-ninth the entire cost of the original works, while the cost of annual administration, exclusive of extension, was $108,760; the loss at Cleveland in 1861-2 was $227,000; the original cost of water supply being $550,000 and the annual administration, without extensions, $9,117; and cases of special conflagrations might be cited, which, as at Troy or Albany, sweep a large part of a whole city out of existence, and are registered in the columns of millions. While a part of this article was being written, the telegraph flashed an account across the wires of $750,000 loss, in one night, on the American Hotel block at Buffalo, exceeding by $200,000 the cost of her Water Works, on which property the annual city tax alone, far exceed the whole annual expense of water administration."

Except the acknowledged excessive use of the water, by the water-takers generally, I discovered little that required changing or more care in the management or manœuvring of the stop-gates for distributing to each district its

proportionate quantity of the water the present feeding-main is capable of bringing to the city from the fountain head at Lorette. The officers of the Water Department appear well to understand their duties, and I am impressed with the conviction of their desire to serve the city faithfully. I would suggest in this connection a little more care at the water depôts in shutting off the water after a barrel has been filled. On one occasion, while observing the pressure near one of these depôts, the effect of the sudden turning off the water, was made apparent by the sudden elevation of the water-gauge attached to one of the hydrants connected to the street-main feeding the depôt, from 40 to 80 lbs. per square inch; such shocks do no good, and may, in the course of time, cause leaks and possibly failures in some of the neighboring pipes.

Can the waste of water from the service pipes be prevented?—Waste may take place from imperfect or worn taps, or from negligence, by leaving the taps open, thus allowing the water to run continually to waste; perhaps from design as a preventive against frost or for washing out the soil-pans and house drains.

It would be well if there could be sufficient water introduced into the city to allow of the continuance of this waste, as the climate is a maximum cold one, making it difficult, at least expensive, to guard the service pipes distributed through a house from frost; the effect of waste-water in washing out the drains is beneficial as a sanitary measure.

That a great waste does exist from the services is shown by the experiments which were carried out last autumn, the results of which will be herein exhibited. There should be power in the City Government to control this waste, or to charge a proportionate price for what is used over and above what was originally estimated to be sufficient for an individual, viz., 30 imp. galls. There are no mechanical means by which the supply can be cheaply gauged to the citizens; the meter is the best method we know of, and that would be costly, require frequent repairs, and be especially liable to become deranged by the action of frost. There is another invention called J. W. Bishop's improved patent water pressure regulator, by which the pressure on the services could be equalized throughout the city, provided the head of water could be kept constant or at the same general level; but the inventor is not certain that he could apply it to a varying head; but this, like the meter, would also be liable to become affected by frost, and likewise expensive. That there is no cheap means of controlling the waste of water we have conclusive evidence, from the practice both in Boston and New York, where mechanical means are only used in gauging the supply to large consumers.

It appears by a report of the Boston Water Board for the year 1864, that the deficiency became so alarming that the citizens were called upon by a circular to discontinue the use of hand-hose, and curtail as far as possible the waste of the Cochituate water, and at the same time they decided to employ a suitable number of persons to examine all the water fixtures throughout the city, and to report each day at the office any waste that might be discovered, and also all leaks. For the first ten days, which included about one-third of the city, there were reported 531 cases where water was running to waste, and 1353 cases where the fixtures were out of order and water was leaking on that account. The total number of water takers entered for 1865 was 27,046.

It appears also in the report that the average daily supply for the year 1864 was 16,681,000 gallons (wine) per day; the City Engineer reports that the average consumption for November and December of the year 1864 was 2,000,000 gallons less for the corresponding month of the previous year, a saving undoubtedly attributable as he states to the care of the citizens and extra exertions of the Water Board and its officers in tracing out the sources of waste. In conclusion, I can only recommend, in the case of Quebec, similar measures as likely to

ameliorate the deficiency, in case the introduction of an extra supply, by laying down another feeder, should not meet the approbation of the citizens.

Measurement of the quantity of water discharged into the city, when being supplied in the usual manner. Also, the quantities required to supply the different divisions of the city, the water being turned consecutively upon each division isolated as far as practicable from other contiguous divisions :—

Having prepared an apparatus in the Château d'Eau, by which the quantity of water discharged into the feeding main could be readily and accurately measured, simultaneous observations were made at Lorette and in the city, with the assistance of Mr. O'Donnell, Chief Engineer and Manager of the Works; Mr. Corrigan and other employés of the Water Department.

As circumstances made it convenient these measurements were continued from time to time, for ascertaining the quantity of water consumed in 24 hours by the city as a whole, and what it would consume on the supposition of its being divided into several divisions or districts, each having a feed main of the dimensions and capacity of that supplying the whole city, the head and fall, or in other words, the dynamic pressure varying according to the quantity of water each district consumed, and the varying dimensions of the street mains, through which the supply had to flow. These divisions were larger or smaller according to the practicability of isolating them from the remainder of the city by means of stop-gates; the object being to ascertain how far the waste of water was general or local, and if not general, in what part of the city we should look for any leak or extraordinary, heretofore unknown, use or waste from services or otherwise. And, at the same time, knowing the number and character of the services, to obtain an approximate estimate of the rate of consumption per inhabitant in each district or division so subjected to experiment.

These measurements were necessarily of short duration, and purposely made without warning to the people, as such a course would probably have affected the result. At the best, the gaugings of the water consumed and wasted can only indicate the amount approximately. Had they been repeated several times or prolonged, the results of course would have been more satisfactory. It is considered, however, that what was done was sufficient for immediate purposes.

It is proposed, in stating the results of the gaugings, to follow the order of the dates.

Oct. 21*st*, 1864.—Gauged the water discharged into the feed-main from the Chatean d'Eau chamber, at Lorette, while supplying the upper part of the city, viz , *St. Lewis and Montcalm wards*, as customary during a portion of the afternoon and evening, by shutting off the water from the lower levels of the city, along the lower side of St. John, Fabrique, and Buade streets; the gangings being commenced at 4h. 15m. p.m., and closed at 4h. 50m. p. m.

The rate of discharge, for 24 hours, at 4h. 15m. was.....			381,865	cubic feet
do	do	do 4h. 45m. do	379,385	" "
Average	do	do	380,625	" "

Equal to 2,372,090 Imperial or 2,847,270 wine gallons—a supply sufficient, at 60 Imperial gallons, for 39,532 inhabitants.

During this experiment, as indicated by the piezometer, or water guage, the pressure at Mount Pleasant was approximately	75.48 feet
Therefore, loss of head between Chateau d'Eau and Mount Pleasant.....	165.52 "
Total fall from Chateau d'Eau to the dial-face of the piezometer, deduced from the authentic levellings in the office of the Water Department....	241.00 "

The number of services within the range of this experiment cannot be very definitely stated, as an unknown portion of the supply is supposed to have passed the stop-gates into the lower parts of the city, supplying services there under a low pressure.

For comparison with the above experiment, the following result, by another measurement, made of the water feeding the same district, at the same hour of the day (on 25th Oct.), and under the same or similar arrangements of stop-gates, &c.:

	H. M.		
Rate of discharge per 24 hours.....	4 15	P. M.,	was 408,264 cubic feet.
	4 30	"	
	4 45	"	

Equal to 2,544,340 Imperial or 3,054,030 wine gallons—sufficient, at 60 Imperial gallons, *per capita*, for 42,406 inhabitants—the original estimate for Quebec, or, at 30 Imperial gallons *per capita*, sufficient for 101,800 inhabitants.

Oct. 22nd (Saturday).—Gauged the water flowing into feed-main from Chateau d'Eau, between the hours of 2h. 0m. and 3h. 10m. p.m., while supplying the city in the ordinary manner, just before diverting the water for supplying the higher portions of the city.

	H. M. CUB. FT.	
Rates of discharge for 24 hours.....	At 2 00...419,836	Average 427,872 cub. ft
	" 2 10...426,207	
	" 2 15...426,207	
	" 2 30...432,754	
	" 2 45...432,754	
	" 3 00..424,590	
	" 3 10...432,754	

Equal to 2,666,540 Imperial or 3,200,705 wine gallons.
The original estimate was, for 100,000 inhabitants, 480,000 cubic feet, or 3,000,000 Imperial or 3,590,650 wine gallons.

The gauged quantity would supply, at	60	Imp. Galls., *per cap.*,	44,442	Inhabitants.
" " "	30	" "	88,884	"
" " "	60	Wine Galls., "	53,345	"
" " "	30	" "	106,690	"

It is estimated that this average supply of 2,666,540 gallons per day was consumed and wasted by a population of 15,945 who inhabited the lower portions of the city into which the water flowed during the 70 minutes occupied by this experiment; a portion of the water going to supply manufactories, steam engines and animals.

Dividing the supply by the population, we get $167\frac{233}{}$ imperial gallons as the rate per head per day—nearly three times more than it should be.

The *maximum discharge* from the Chateau d'Eau, observed during the entire series of experiments embraced in this report, occurred while supplying the city over Mount Pleasant at 12h. 10m. p.m., Oct. 31, at which time 441,956 cubic feet per 24 hours were flowing into the city; this extraordinary discharge was, no doubt, caused by the mains in St. John street and lower parts of the city having become exhausted during the experiment just ended, by which the supply to these mains had been interrupted. At another time, Nov. 11th, at 9h. 30m., there being a freshet in the River St. Charles, the *maximum* for that day was found to be 432,806 cubic feet, or 2,697,291 imperial gallons, while supplying the lower portions of the city as usual, enough to supply the above estimated population of 15,945, who were receiving the water at the time, with 169.16 imperial gallons per day. No greater quantity of water can be thrown into the city than these maximums show, as the system of pipes are now arranged, supplied, as they are, over Mount Pleasant.

The leakage of the feeding-main measured.—Before testing the tightness of this pipe, the services leading to Mr. McCallum's brewery, at Savageau Hill, were closed, and there remained only two services where water could escape between the Chateau d'Eau and the stop-gate well at Mount Pleasant, except from leaks. One supplied a ball-cock cistern at Mount Pleasant; the other was a perpetual service to Mr. Picard's stable at Lorette; the waste from the latter was measured and found to be $495\frac{00}{}$ cubic feet per day; the waste from the other service was not ascertained. But, as the experiment was made between 3h. 22m. and 3h. 47m. p.m. (Oct. 22nd), before the water was turned up to supply the high service, the cistern fed by the service in question

may have been empty, and, on shutting the 18-inch stop-gate at Mount Pleasant, may have been filled more or less with water during the trial, an amount about that wasted at Mr. Picard's stable, say 400$\frac{24}{100}$ cubic feet a day. The leakage, then will be shewn by the following statement:

	Cub. ft.
The subsidence in chamber or well of the Chateau d'Eau during the 25 minutes, the feed-main was under trial was 0.22 feet; this multiplied by the horizontal area of the well, viz., 100$\frac{24}{100}$ square feet, gives 22$\frac{0528}{1000}$ cubic feet for the waste during the 25 minutes, and the rate per 24 hours equal to	1,270$\frac{24}{100}$
Deduct wasted at Mr. Picard's service	495$\frac{00}{100}$
Remaining for amount of leakage	775$\frac{24}{100}$
Equal to 4,831$\frac{37}{100}$ imperial or 5,799$\frac{20}{100}$ wine gallons a day.	
If the service at Mount Pleasant also discharged water during the trial, we are to make a further deduction, say	400$\frac{24}{100}$
Leaving for the net leakage per day	375
Equal to 2,343$\frac{75}{100}$ imperial or 2,805$\frac{29}{100}$ wine gallons per 24 hours.	

This result, considering the great pressure under which one-half of the 7$\frac{3}{4}$ miles of feed-main is subjected, may be considered entirely satisfactory. In all our calculation here no allowance has been made for waste arising from any cause on this pipe between the Chateau d'Eau and the well at Mount Pleasant.

Experiment when supplying the whole city over Grand Allée chemin summit.—Oct. 22nd.—Under this date, and immediately after testing the tightness of the feed-main, when most of the street mains were empty, or nearly so, the supply to the entire city was turned up De Salaberry street and over Grand Allée summit, where the grade of the 18-inch pipe, as it is laid, is about 165$\frac{00}{100}$ feet below the fountain head at Lorette.

For 43 minutes during the continuance of the experiment the discharge from the Chateau d'Eau well was found to be a constant quantity, and the rate per 24 hours 365,158 cubic feet—equal to 2,275,700 imperial or 2,734,570 wine gallons.

Sufficient at 60 imperial or 74$\frac{134}{100}$ wine galls., *per capita*, for					37,928 inhabitants.
"	"	60	"	"	45,573 "

For the purposes of the succeeding experiments the following approximate Table of Statistics has been formed from the best information at hand; much of it is assumed and must be consulted with considerable allowance for error. But as it has been used in our computations, it is considered proper to introduce it here:—

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APPROXIMATE TABLE OF STATISTICS OF THE QUEBEC

No. of Division.	Description of Division.		Number of Horses.	Number of Services. — Corrigan's count.	Families supp. exclusive of sundry. — Institutions.	Estim perso ba Corrig
1	West of Crown street	Services		122	139	
		Horses	70			
		23 Tanneries				
		2 Water depôts				
2	East of Crown street	Services		773	865	
		Marine Hospital				
		Horses	440			
		3 Ship yards				
		8 Tanneries				
		Steam engines				
		2 Broweries				
3	St. Paul & St. Peter sts., or Peter's ward	Services		285	313	
		Horses	160			
		Steam engines				
		Cabinet manufactories				
		Brewery				
		Flour Mill				
		Sugar refinery				
4	Champlain street	Services		228	241	
		Horses	150			
5	Mountain Hill	Services		51	54	
		Horses	20			
		Bishop's palace				
		Parliament House				
6	Palace ward, East part	Services		185	189	
		Horses	100			
		Laval Institution				
		Seminary				
7	Palace ward, West point	Services		62	67	
		Horses	40			
		Government Barracks				
		Hotel-Dieu				
8	St. John's ward, East of St. Augustin st.	Services		62	71	
		Horses	40			
		Water depôt				
		Normal School				
9	St. John's ward, between St. Augustin & St. Clairo streets	Services		210	226	
		Horses	120			
10	St. John's ward, West of St. Clairo street	Services		109	121	
		Horses	60			
11	St. John street, East of St. Augustin, including Fabrique & Buade streets	Services		157	163	
		Horses	90			
		Jesuit Barracks				
12	St. John street, West of St. Augustin street	Services		120	131	
		Horses	60			
	Totals for Lower portions of City		1,350	2,364	2,580	
13	DeSalaberry and the Protestant Home	Services		6	7	
		Horses	10			
		Distillery, Savageau hill				
		Home Institute				
14	Montcalm ward	Services		330	352	
		Horses	180			
		Convent Good Sheppard				
15	St. Lewis ward	Services		313	317	
		Horses	100			
		Garrison Hospital				
		Court House				
		Ursuline Convent				
		Jail				
16	Grand Allée chemin	Services		22	22	
	Totals for the whole City		1,700	3,035	3,278	
	By the Mayor's printed report for the year 1863, the number of services is stated at	3,266				
	Add services laid down in 1864	46				
		3,312		277	277	
	Deduct Mr. Corrigan's count as given at foot of above table	3,035				
			1,700	3,312	3,555	

TICS OF THE QUEBEC WATER WORKS.

Number of Services. — Corrigan's count.	Families supp. exclusive of sundry. — Institutions.	Estimated No. of persons supplied based on Corrigan's count.	Estimated No. of persons supplied with water in the City.	Quantity of water required for different purposes in Imp. galls. per 24 hours.	Quantity of water required for each Division in Imp. galls. per 24 hours.
122	139	695	695	41,700	
				700	
				31,500	133,900
			1,000	60,000	
773	865	4,325	4,325	259,500	
			230	13,800	
				4,400	
				18,000	332,300
				12,000	
				12,600	
				12,000	
285	313	1,565	1,565	93,900	
				1,600	
				13,400	
				1,500	119,400
				6,000	
				1,500	
				1,500	
228	241	1,205	1,205	72,300	
				1,500	73,800
51	54	270	270	16,200	
				200	
			25	1,500	20,900
			50	3,000	
185	189	945	945	56,700	
				1,000	
			100	6,000	69,700
			100	6,000	
62	67	335	335	20,100	
				400	
			200	12,000	62,500
			500	30,000	
62	71	355	355	21,300	
				400	
			500	30,000	53,200
			25	1,500	
210	226	1,130	1,130	67,800	
				1,200	69,000
109	121	605	605	36,300	
				600	36,900
157	163	815	815	48,900	
				900	68,700
			315	18,900	
120	131	655	655	39,300	
				600	39,900
2,364	2,580	12,900	15,945	1,080,200	1,080,200
6	7	35	35	2,100	
				100	
				6,000	12,700
			75	4,500	
330	352	1,760	1,760	105,600	
				1,800	113,400
			100	6,000	
313	317	1,585	1,585	95,100	
				1,600	
			300	18,000	
		2,685	100	6,000	162,700
			600	36,000	
			100	6,000	
22	22	110	110	6,600	6,600
3,035	3,278	16,390	20,710	1,375,600	1,375,600
277	277		1,385	83,100	83,100
3,312	3,555	16,390	22,095	1,458,700	1,458,700

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	Imp. galls.
If the above table was correct as to the number of individuals who take the water; and we assume 60 imperial or 75 wine gallons as a proper allowance per *capita*, the 20,710 persons, stated in the table, would require per day	1,242,600
And the various manufactories, steam engines, horses and cows, would require a further allowance of	133,000
Total supply being a daily rate *per capita* of 66-42 imp. galls...	1,375,600

Quantity of water used by the whole city during 24 consecutive hours.— October 24th & 25th.—This experiment was designed for ascertaining the total quantity of water consumed in the city during 24 hours, the lower and upper divisions receiving their supply as usual on other days. The gauge at the Chateau d'Eau, in this case, was tended by two of the employés of the Water Department, who noted down the reading of the gauge at intervals of fifteen minutes, commencing at six o'clock, P. M., on the 24th, and ending at six o'clock, P. M., October 25th.

The result of these gaugings shew:—

		Mr. Keefer made:—
First—The average rate per 24 hours discharge from Chateau d'Eau	408,391 $\frac{448}{}$	414,456 c.ft.
Second—The maximum rate per 24 hours discharge from Chateau d'Eau	432,760	
Third—The minimum rate per 24 hours discharge from Chateau d'Eau	308,263	
Fourth—The average do while supplying Upper Town..	368,137 $\frac{166}{}$	
Fifth—The average do do Lower Town..	417,680 $\frac{897}{}$	

These quantities, converted into imperial gallons, are shown below, with the number of persons the water would supply, giving to each 60 imperial gallons:—

	Imp. galls.			
First—The average rate per 24 hours.....	2,545,136	would supply	42,419	inhabitants.
Second—The maximum do do	2,697,040	do	44,950	do
Third—The minimum do do	1,921,260	do	32,021	do
Fourth—The average do do for Upper Town	2,294,267	do	38,238	do
Fifth—The average do do for Lower Town..	2,603,030	do	43,384	do

The table below exhibits the same quantities of water divided by the estimated number of consumers, given in the table of statistics, who took the water on the day the gaugings were made:—

First.—The average rate per 24 hours 2,545,136 imperial gallons, divided by 20,710 inhabitants, gives to each person 122$\frac{90}{}$ imperial gallons.

Second.—The maximum rate per 24 hours 2,697,040 imperial gallons, divided by 20,710 inhabitants, gives to each person 130$\frac{23}{}$ imperial gallons.

Third.—The minimum rate per 24 hours 1,921,260 imperial gallons, divided by 20,710 inhabitants, gives to each person 92$\frac{77}{}$ imperial gallons.

Fourth.—The average rate per 24 hours, for Upper Town, 2,294,267 imperial gallons, divided by 20,710 inhabitants, gives to each person 110$\frac{78}{}$ imperial gallons.

Fifth.—The average rate per 24 hours, for Lower Town, 2,603,030 imperial gallons, divided by 20,710 inhabitants, gives to each person 125$\frac{68}{}$ imperial gallons.

By referring back to the table of statistics we see that the quantity of water required by the present consumers, allowing sixty imperial gallons per twenty-four hours to each inhabitant who now is supposed to take the water, including its use for all purposes, based on the count of services in 1864, by Mr. Corrigan, amounts to 1,375,600 gallons, while the gaugings just given above show the consumption to be 2,545,136 gallons, a surplus or waste of 1,169,534 gallons or 85 per cent. more than what must be considered a liberal allowance to the consumers. But allowing that Mr. Corrigan's count which was made by perambulating the streets and marking down all the services as he passed them, being confident in his own mind of not missing any, was not correct, we will add the discrepancy between his estimate and that derived from the office of the Water Department, viz., 277 services equivalent to 1388 persons or an additional consumption of 83,100 gallons; making the whole quantity required by the consumers, 1,458,700 galls., as shown by the foot of the statistical table, this reduces the waste from 85 to 79 per cent.

Having no means at hand for deciding which is the correct count, and as we cannot correctly distribute the discrepancy among the several divisions into which the city has been divided for making the experiments which follow, it is proposed to adhere to Mr. Corrigan's count.

By taking the number of gallons given in the first twelve divisions of the table of statistics, which embrace all the lower parts of the city as ordinarily supplied during 19½ hours out of the 24, we find that 1,080,200 imperial gallons are required per 24 hours for the 15,945 persons now estimated to be supplied in that section of the city, being at the rate of $67\frac{74}{}$ gallons per head; while the gauging show the rate per 24 hours, was 2,603,020 gallons, and for the 19½ hours, supposing this section did not receive any water during the remaining 4½ hours of the day while supplying the Upper Town, viz., from 3.30 to 8, P.M., the whole quantity used was 2,114,961 or $132\frac{64}{}$ gallons per head, 6,490 gallons more than required.

By adding together the four other divisions of the table, viz., Nos. 13 to 16 inclusive, we obtain the quantity of water required for the supply of the Upper Town, amounting to 295,400 imperial gallons per 24 hours, or 62 gallons per head of the population of this section of the city, while the gaugings for the four and a half hours, show the rate per 24 hours was 2,294,267 gallons, or $481\frac{48}{}$ gallons per head for the estimated population of 4,765; giving for the four and a half hours a supply of 430,175 gallons, or $90\frac{28}{}$ gallons per head.

RECAPITULATING

We have for the consumption in the lower portions of the city during nineteen and a half hours 2,114,961 imperial gallons. Rate per head $132\frac{64}{}$ imperial gallons.

We have for consumption for upper portions of the city during four an a half hours 430,175 imperial gallons. Rate per head $90\frac{28}{}$ imperial gallons.

Total quantity of water ordinarily used in the whole city during twenty-four hours, supplying a population of 20,710 at the rate of $122\frac{89}{94}$ gallons a day, 2,545,156 imperial gallons. Rate per head $122\frac{89}{94}$ imperial gallons.

Series of experiments for showing the daily rate of consumption in Divisions described in the foregoing Table of Statistics—Oct. 27, Division No. 1, West of Crown Street.—The supply to this small district, in Jacques Cartier Ward, was unavoidably like many others connected with another portion of the city; in this case, with the west part of St. John's Ward, and St. John's street, west of St. Augustin street, including a few services in DeSalaberry street; the supply to these parts, as a whole, being first measured, Division No. 1 was cut off, when, by a second measurement, data was obtained for estimating the quantity of water used in Division No. 1, thus :—

	Cubic feet per 24 hours.
Supply to Division No. 1, in connection with west part of St. John's Ward, &c.	220,215
Supply omitting Division No. 1	166,929
Difference	53,286
The above difference is to be increased by the estimated volume of water that leaked back from John's Ward into Division No. 1, after it had been cut off	5,760
	59,046

Equal to 367,981 imp. or 441,695 wine gallons—sufficient for 6,133 inhabitants, at 60 imp. or $75\frac{4}{10}$ wine galls. per head. It did supply 1,695 inhabitants with 217 $\frac{10}{}$ imp. gallons per head.

By referring to the statistics we find the required supply per 24 hours, for this Division, to be 133,900 imp. galls., which, divided by its population, 1,695, gives 79 galls. a head per day, showing that this Division wasted or used more than necessary, 138 galls. per head, or that we had not allowed a sufficient number of inhabitants who were supplied from the water depôts.

Oct. 27th—Division No. 2, east of Crown street, including part of St. Rochs, Jacques Cartier, and St. Peter's ward. The supply to this division was passed from St. John street through the central part of St. John's ward.

	c. ft.	Per 24 hrs. cub. ft.
The whole supply to these portions of the city was..		301,251
Deduct measurement after cutting off Division No. 2	236,908	
This last quantity lessoned by what was estimated to leak through the stop-gate at foot of St. Augustin street into Division No. 2 after it was cast off	10,000	
		226,908
Total		74,343

Equal to 463,313 imperial or 556,124 wine gallons per day—sufficient for 7.555 persons at 60 imperial gallons per head. It did supply 4,555 persons with 101$\frac{71}{100}$ imperial gallons per head.

By the table of statistics the required supply is shown to be 332,300 imperial gallons, which, divided by 4,555 persons supplied, gives 72$\frac{95}{100}$ imperial gallons per head, showing the water takers in this division each received an excess of 28$\frac{76}{100}$ gallons.

Oct. 31st—Divisions No. 4 and 5, Champlain ward, and including all of Mountain Hill street, and part of Notre Dame street, but exclusive of Sous-le-Fort street.—The supply to this division was passed over Grande Allée street summit, feeding only a few services in that street, and through St. Lewis ward, which was supplied, except the services along St. John, Fabrique and Buade streets.

	Cub. ft. per 24 hrs.
Supply to Champlain, St. Lewis and Grande Allée divisions	276,623
Deduct water consumed in St. Lewis and Grande Allée divisions	233,607
Net supply to Champlain division	43,016

Equal to 268,080 imperial or 321,782 wine gallons—sufficient for 4,468 inhabitants at 60 imperial gallons per head. There were supplied 1,540 persons, each receiving 174$\frac{08}{100}$ imperial gallons.

Oct. 31st.—Divisions No. 15 and 16, St. Lewis ward, exclusive of services fed by the main in St. John, Fabrique and Buade streets.—The supply in this experiment, like the last, passed over Grande Allée summit and fed a few services there. The whole supply was, including Grande Allée, 233,607 cubic feet per 24 hours—equal to 1,455,620 imperial gallons or 1,747,502 wine gallons—sufficient for 24,260 inhabitants. It did supply 2,795 persons, each receiving 520$\frac{794}{1000}$ imperial gallons.

Oct. 31st—Divisions No. 14 and 16, Montcalm ward, and Grande Allée street.—After measuring conjointly the water used in Divisions No. 14, 15 and 16, St. Lewis ward was cut off, when the water consumed was found to be at the rate of 122,360 cubic feet—equal to 762,560 imperial or 915,316 wine gallons—a supply sufficient for 12$\frac{709}{1000}$ inhabitants at 60 imperial gallons per head. The estimated population, 1,970 gives to each person 387$\frac{030}{1000}$ gallons per day.

From the results of the three last measurements given above we obtain the quantity of water each of the divisions, separated from the others, consumed, viz. :—

Division No. 15.—St. Lewis ward consumed 54,896 cubic feet per 24 hours, equal to 342,117 imperial or 410,651 wine gallons.

Division No. 14.—Montcalm ward consumed 166,143 cubic feet per 24 hours, equal to 1,035,420 imperial or 1,242,836 wine gallons.

Division No. 16.—Grande Allée, including waste from the feed-main in the country, consumed 67,464 cubic feet per 24 hours, equal to 420,442 imperial or 504,666 wine gallons.

Making a total equal to the consumption, when all three divisions were supplied, as a whole, 288,503 cubic feet per 24 hours.

The rates *per capita* would be—St. Lewis ward, with a population of 2,685, consumed 12$\frac{742}{1000}$ imperial gallons per day; Montcalm ward, with a population of 1,860, consumed 566$\frac{68}{100}$ imperial gallons per day; Grande Allée street, with a population of 110, consumed 3,822$\frac{20}{100}$ imperial gallons per day.

The last statement shows a consumption inversely proportional to the number of consumers. One reason for the comparatively small quantity of water used and wasted in St. Lewis ward is undoubtedly that the houses in that ward, for the most part, are provided with ballcock cisterns, which, being soon filled, checked the consumption; the fact being indicated by the extra pressure on the piezometer that was applied to the hydrant at the corner of St. Denis and Laporte streets, and where the pressure showed a head of water of over a 100 feet.

The excessive consumption in Montcalm ward arose also, I apprehend, from the great head of water that was on the open services, whether connected with cisterns or not, during the trial, as indicated by the piezometer attached to the hydrant at head of Lachevrotière street, viz., 140 feet. This high pressure arose from the freedom the water reached this division through the 18-inch main direct from the Chateau d'Eau.

On shutting off Montcalm ward we find the consumption per head of the estimated population on the Grande Allée chemin to be enormously increased. In this case I am apprehensive that some of the stop-gates had been but partially closed or had not been shut soon enough to secure a correct measurement of the water usually consumed or wasted in this division (No. 16). But for our purpose of obtaining what the whole city, under the existing condition of the Water Works, would consume, if an unlimited or an abundant supply were at command, it may be as well to admit the result of the Grande Allée experiment to stand as given above.

Nov. 3—*Division No.* 3, *St. Peter's ward.*—The extent of this division, from Sous-le-Fort street, to St. Nicholas st., including both streets, was supplied from St. John street within, by the service main leading down Palace street, and by the four inch main down Dog Hill—the water expanding through the whole of Palace ward excepting the Bishop's Palace and services on St. John, Fabrique and Buade streets

	Cub. ft. per day.
The supply to this division, including Palace ward and St. John street, amounted to	332,773
Deduct water consumed by Palace ward	292,407
Net supply to St. Peter's Ward	40,366

Equal to 251,565 imp. or 301,959 wine gallons—sufficient for 4,193 inhabitants at 60 imp. galls. per head. The population being 1,565 persons, each received $160\frac{744}{1000}$ imp. galls.

Nov. 3*rd*—*Divisions Nos.* 6 *&* 7, *Palace Ward.*—The supply to this Division embraced the whole of Palace ward excepting the Bishop's Palace and the services on the lower sides of Buade, Fabrique and St. John streets, and was passed through St. John street from Mount Pleasant.

	Cub ft. per 24 hrs.
The total quantity of Water consumed in Palace ward and in St. John, Fabrique and Buade streets..	292,407
Deduct consumed in Divisions No. 11 and 12, or said streets	194,047
Leave for the net supply to Palace Ward Division	98,360

Equal to 612,989 imp. galls. or 735,784 wine gallons—sufficient for a population of 10,216 at 60 imp. galls. per head. The estimated population being 2,180, each person received $281\frac{197}{1000}$ gallons per head per day.

Nov. 3*rd*—*Divisions Nos.* 11 *and* 12, *St. John street entire with Fabrique and Buade streets.*—This division comprehends all the services on either side of streets named from Mount Pleasant stop-gate well to the stop-gate at the top of Mountain Hill street, all the stop-gates on both sides these streets being closed. It also includes DeSalaberry street and the Home Institution.

The water consumed in this division was 194,047 cubic feet per 24 hours—equal to 1,209,197 imperial or 1,451,423 wine gallons—sufficient for a population of 20,153 at 60 imperial gallons per day each. The estimated population being 1,895, each received $638\frac{100}{1000}$ imperial gallons per day.

The high rate of consumption this experiment shows agrees with what has been found to follow the contraction of the area supplied, as was the case when supplying

St. Lewis, Montcalm and Grande Allée Divisions. In this case the piezometer applied to the hydrant at the Upper Town market place, indicated a pressure of about 295 feet head of water.

Nov. 3rd—Divisions Nos. 8, 9, *and* 10 *St. John's ward, exclusive of the service in St. John street.*—The first measurement of the water supplied to this district or ward shew a net consumption of 175,571 cubic feet per day; but not being entirely satisfactory a second measurement was made as follows :—

		Cub. ft. per day.
Supply to St. John's ward, St. John street, &c....		221,934
Deduct estimated supply to St. John street west of St. Augustin street	54,724	
Add estimated waste at water depôt in Glacis street	1,450	
		56,174
Net consumption of water in St. John's ward		165,760

Equal to 1,033,033 imperial or 1,239,970 wine gallons—sufficient for 17,217 inhabitants at 60 imperial gallons per head. It did supply 2,615 persons with $39\frac{504}{1000}$ imperial gallons per day each.

By table of statistics the required daily supply is 159,100 imperial gallons, which divided by 2,615 persons supplied gives $60\frac{84}{100}$ imperial gallons per day, showing an excess each person received of $33\frac{420}{1000}$ gallons.

Note.—The discharges from the Chateau d'Eau on this occasion were :—

	Cub. ft. per day.
Nov. 3, at 0.15 P.M.	236,974
do 0.30 do	236,974
do 0.45 do	230,192
do 1.00 do	230,192
do 1.15 do	230,192
do 1.30 do	226,664
do 1.45 do	220,796
do 2.00 do	223,072

Average 221,934 cubic feet—the adopted discharge in this experiment showing that the exorbitant consumption in this ward did not arise from filling empty pipes.

The results of the above experiments are recapitulated in the following table, avoiding a duplication of any of them, for the purpose of showing approximately how much water would be consumed by the entire city on the supposition that everything connected with the supply at the time of the experiments should remain the same in the future.

SUMMARY OF THE ABOVE EXPERIMENTS.

Divisions.	Number of persons supplied.	Quantity of water supplied to each Division in a day of 24 hours.			Supply to each person per day.		
		Cub. feet.	Imp. galls.	Wine galls.	Cub feet.	Imp. galls.	Wine gll.
Division No. 1..... W. of Crown street...	1,695	59,046	367,981	441,695	....	217,10	
Division No. 2..... E. of Crown street...	4,555	74,343	463,313	556,124	.....	101,71	
Div. Nos. 8, 9, & 10.. St. John's ward.....	2,615	165,760	1,033,033	1,239,970	.....	395,04	
Divisions Nos. 4 & 5 Champlain ward.....	1,540	43,016	268,080	321,782	.....	174,08	
Divisions Nos. 6 & 7 Palace ward.....	2,180	98,360	612,989	735,784	.....	281,19	
Division No. 3..... St. Peter's ward.....	1,565	40,366	251,565	301,959	.....	160,74	
Div. Nos. 11, 12 & 13 St. John street, &c...	4,895	194,047	1,209,197	1,451,423	.....	638,10	
Division No. 15..... St. Lewis ward	2,685	54,896	342,117	410,651	....	127,42	
Division No. 14..... Montcalm ward.....	1,860	166,143	1,035,420	1,242,836	....	556,68	
Division No. 16..... Grande Allée street..	110	67,464	420,442	504,666	.....	3,822,20	
	20,710	963,441	6,004,137	7,206,899	.....	289,91	average.

Having by the foregoing experiments ascertained that the estimated 20,710 inhabitants would consume 6,000,000 gallons per day if not controlled by some stringent law or otherwise, we proceed to show by what arrangement of feed-mains a further supply than now enjoyed may be introduced into the city from the fountain head at Lorette. It has already been mentioned that virtually the present feed-main, originally $15\frac{0}{0}$ feet diameter, had been so affected by incrustation that its discharging power now was only equivalent to one of $12\frac{8}{0}$ feet diameter; and as no mechanical application to the interior of a cast-iron pipe can be used without producing a similar reduction of its "calibre," and as we know of no chemical efficient remedy against oxidation, I have in all my computations of discharges through such pipes made allowance for incrustation.

By the instructions of the committee, I am directed to base this report on the supposition that 100,000 inhabitants are to be supplied, but no limit was stated as to the quantity of water they would require, and I am left to recommend what that supply should be.

Arrangement No. 1.—Owing to the great head of water to which the feed-main would be subjected in its passage across the valley of the St. Charles, and the consequent rapidly-increasing cost, as its diameter should be increased, and the great damage a large pipe might cause in the valley in case of fracture, I have assumed for my present purpose a pipe of $2\frac{33}{0}$ feet or 28 inches calibre, supposed to be reduced by incrustation to one of $2\frac{12}{0}$ feet. Such a pipe would deliver at Grande Allée summit, opposite the Riding school, 5,139,920 imperial gallons or 6,169,550 wine gallons, with a pressure at the summit of $99\frac{56}{0}$ feet, supposing it laid at the same level or grade the present 18-inch pipe has at that point. By reducing the pressure to 16 feet above grade at the summit, which is the same thing as calling the *head and fall* there $149\frac{72}{0}$ feet below the dam at Lorette, the discharge through the same pipe over the summit or into a reservoir, if one should be constructed there, would be increased to 7,745,691 imperial or 9,296,572 wine gallons, a supply at 60 imperial gallons per head per day for a population of 129,085, and adding to this what the existing 18-inch feed-main would convey to the same point under the same head and fall, viz., 2,180,992 imperial gallons, I obtain a total of 9,926,083 imperial gallons, a supply, at 60 imperial gallons per head per day for 165,435 inhabitants, or $65\frac{32}{0}$ per cent. more than the above summary of experiments show was consumed and wasted in the whole city at the time of our investigation.

Arrangement No. 2.—To save immediate cost, we will suppose the 28-inch feed-main laid only to the westerly end of Arago street at the foot of Savageau Hill and there united to the present 18-inch feed-main. By such a change the above-mentioned 5,139,920 imperial gallons of water would then flow over Grande Allée summit with 16 feet pressure; the total distance from Chateau d'Eau being 43,845 feet, of which 39,047 feet would be a new pipe of 28 inches, and 4,798 feet of the old 18-inch pipe now in use. In case the 28-inch main was laid down only to Arago street and there connected with the 18-inch now in use up Savageau Hill and through De Salaberry street, the other part of the 18-inch main from Lorette being thus detached should be continued by new pipe along Arago street to the head of Crown street, where, under a head and fall below the dam at Lorette of $149\frac{72}{0}$ feet, or at a height above the latter street of 277 feet, the distance from the Chateau d'Eau being assumed at 42,450 feet, it would discharge 2,216,540 imperial gallons. Adding this to what the compound feed-main would convey to Grande Allée summit under the $149\frac{72}{0}$ head and fall, viz., 5,139,920 imperial gallons, makes the total supply by this arrangement 7,356,460 imperial gallons, sufficient for a population of 122,607 at 60 gallons a head per day, being $22\frac{52}{0}$ per cent. more than the summary table shows the city to have used during our experiments.

Arrangement No. 3.—The third arrangement of feed-mains consists in laying down a 28-inch main from the Chateau d'Eau to St. John street at foot of De Salaberry street, which would discharge there, under a head and fall of 77 feet, distant from the Chateau d'Eau 40,799 feet, 5,759,237 imperial gallons; the present 18-inch main to remain as it is, except connecting it with the 28-inch pipe at Mount Pleasant, where the 18-inch would discharge a further amount of water under the same head (77 feet) and distance (40,799 feet), viz., 1,621,783 imperial gallons; total supply delivered at the junction of St. John and De Salaberry streets, where the pressure on the pipes would be about 169 feet, 7,381,020 imperial gallons. This supply would give 123,017 inhabitants 60 imperial gallons each. The above 5,759,237 imperial gallons conveyed by the 28-inch main to Mount Pleasant, would pass on through the 18-inch main to the summit of Grande Allée, where it would flow over the summit with a pressure of 16 feet above grade of 18-inch pipe towards St. Lewis ward, or into any reservoir provided to receive the water on either side of the summit; the loss of head there being 150 feet or thereabouts. The other portion of the supply, viz., 1,621,783, would enter the 14-inch main now in use, leading down St. John street into the heart of the city.

Arrangement No. 4.—As considerable increase in the supply to the city would arise by increasing the capacity of the feeding-main at Lorette, as far down the line as the head of the Misère road, where the pressure would not require a pipe of extra thickness, I will propose in this arrangment a 34-inch-main to be laid down from the Chateau d'Eau, alongside the existing 18 inch main, for a distance of 4,550 feet, where it would be reduced and joined to a 28-inch main, that should be laid down thence to Mount Pleasant, at junction of DeSalaberry with St. John street; at the latter point it would connect with the 18 and 14-inch main now used for supplying the city by way of DeSalaberry and Grande Allée streets, and down St. John street. This new line of main, completed as above specified, the existing 18-inch main now in use, between Arago street and Mount Pleasant, would be taken up and relaid along Arago street, towards the head of Crown street, to the extent the pipes would lay, more new pipes to be procured for its extension to the head of Crown street, where it would feed the several large service mains that radiate from that point. This arrangement of an independent 18-inch feed-main entering Jacques Cartier ward, would make it quite practicable to furnish an independent supply to a large district, consisting of the lower portions of the city, say all below the bluff, excepting perhaps Champlain ward. The higher wards to be permanently cut off from this supply, excepting on the occurrence of fires. Champlain ward could probably be better supplied through the Upper Town, and by a new pipe that should be laid down from Grande Allée, in the direction of the Cove, above the Mariners' Church. By this plan it would be practicable to throw into the city 8,000,000 imperial gallons, and the whole of the water delivered (if not drawn to waste) at levels ranging between 113 and 122 feet below the surface of the water in the Chateau d'Eau. This quantity of water would be distributed as follows:—

	Imp. galls. per 24 hrs.
The 18-inch independent feed-main, from the Chateau d'Eau to the head of Crown street, with a length of about 42,450 feet, and under ahead and fall of 122 feet, would discharge.....	2,000,000
The compound feed-main, consisting of 4,550 feet of 34-inch pipe, and 36,229 feet of 28-inch, extending from the Chateau d'Eau to St. John street, at Mount Pleasant, would convey to the latter point 6,000,000 imp. galls., of which quantity the 18-inch feed-main would convey up DeSalaberry street and along Grande Allée to its summit, a distance of 3,066 feet, where, under a head and fall of about 113 feet, it would discharge	4,000,000
Carried over.....	6,000,000

	Imp. galls. per 24 hrs.
Brought forward	6,000,000
And the 14-inch feed-main, as now laid down in St. John street, say 3,100 feet to its intersection with St. Augustin street, would discharge there under a head and fall of 122 feet below water in the Chateau d'Eau....	2,000,000
Total supply to city, per 24 hours, by this arrangement	8,000,000

I will here state cursorily, that, could the consumption be so nicely regulated to the three different unconnected districts, into which the three branch feed-mains would enter, each fed by its appropriate pipe, and just consuming its quota of water and no more, as specified in the table above, the pressures on the several pipes at the points named below would be approximately as follows :—

	Feet pressure.
At head of Crown street, equal to a head of water exceeding	200
At intersection of St. Augustin street with St. John street, do do	200
At summit of Grand Allée chemin, about do do	38
At Mount Pleasant at foot of DeSalaberry street, do do	168

Should more water be drawn than here supposed, these pressures of course would be reduced, and *vice-versa*.

The following are estimates of the cost of laying down the feed-mains, according to the four plans as described above :—

Head Fall 149 12 *Estimate No.* 1. *Supply* 9,926,083 *Imp. galls.*

Cost of laying down a single line of 28-inch pipe from Chateau d'Eau at Lorette to Grande Allée Summit, according to arrangement No. 1.

Items.	Quantities.	Price in cts.	$ cts.	Total amount. $ cts.
Changes required at Chateau d'Eau for admitting new pipe to well				300 00
Laying down thin 28-inch pipe from Chat. d'Eau to near head of Misère Road.	4,550 ft.	7 50		34,125 00
Laying down 28-inch pipe of medium thickness in extension of the thin pipe to near Bedard's	12,000 "	8 15		97,800 00
Erecting a stone bridge at River Desmères.			5,000 00	
Stop-gate and well (28-inch pipe at do			550 00	
Stop-gate for scouring pipe do do			100 00	5,650 00
Laying down 28-inch thick pipe in field near and below Bedard's barn to Mount Pleasant in city..	24,200 "	10 40		251,981 60
Stop-gate 28-inch at Riv. St. Charles & well			550 00	
8 " scouring gate do do			100 00	
Stone bridge across Riv. St. Charles, say..			55,000 00	55,650 00
Laying 28 inch pipe of medium thickness in DeSalaberry street and Grande Allée to summit	3,066 "	8 15		24,987 90
28-inch stop-gate at Grand Allée summit...				550 00
Special castings for the entire length of pipe				120 00
Air valves along the line of pipe				72 00
Land damages if line is changed at River St. Charles				2,000 00
				$473,236 50
Contingencies..				30,263 50
Total cost of a single line of 28-inch feed-main				$503,500 00

Head and Fall 149 $\frac{72}{}$. *Estimate No.* 2. *Supply* 7,356,460 *Imp. galls*

Cost of laying down a 28-inch pipe from the Chateau d'Eau to Arago st., and an 18-inch pipe through Arago street to Crown street.

Items.	Quantities.	Price in cts.		Total amount.
			$ cts.	$ cts.
Changes required at Chateau d'Eau				300 00
Laying down a 28-inch pipe from Chateau d'Eau to commencement of curve at Arago st., viz.:				
Thin 28-inch pipe	4,550 ft.	7 50	34,125 00	
Medium 28 " "	12,000 "	8 15	97,800 00	
Thick 28 " "	22,400 "	10 40	232,960 00	
Laying an 18-inch new pipe from commencement of curve on main line through Arago st. to head of Crown st.	3,500 ft.	5 95	20,825 00	385,710 00
Specified works at River Desmères as stated in Estimate No. 1			5,650 00	
Specified works at River St. Charles as stated in Estimate No. 1			55,650 00	61,300 00
Special castings, air valves and cocks	5v's.	32 00	160 00	
Branches on main line	12 ps.	8 25	100 00	
do do Arago street	15 "	6 00	90 00	
18-inch stop-gate at West end Arago st.			335 00	685 00
Extra work making connection at Arago street, &c., &c.				105 00
Land damages if line of pipe is changed at River St. Charles				2,000 00
				$450,100 00
Contingencies				27,900 00
Total cost of the works proposed by second arrangement				$478,000 00

Head and Fall 150 *ft. Estimate No.* 3. *Supply* 7,381,020.

Cost of laying down a 28-inch pipe from the Chateau d'Eau to St. John street, Mount Pleasant, at foot of DeSalaberry street.

Items.	Quantities.	Price in cts.		Total amount.
			$ cts.	$ cts.
Changes required at Chat. d'Eau as before				300 00
Laying down 28 inch thin pipe	4,550 ft.	7 50	34,125 00	
do 28 " pipe med. thickness	12,000 "	8 15	97,800 00	
do 28 " thick pipe to Mount Pleasant	24,229 "	10 40	251,981 60	383,906 60
Specified works at Riv. Desmères as before			5,650 00	61,300 00
do do St. Charles do			55,650 00	
Special castings, air valves and air cocks			160 00	
Branch pipes			100 00	260 00
Land damages if change of line is made at River St. Charles				2,000 00
Extra work making connections at Mount Pleasant, &c.				123 40
				$447,890 00
Contingencies				28,110 00
Total cost of the works proposed by the third arrangement				$476,000 00

Head and fall 113 *to* 122 *feet. Estimate No.* 4. *Supply* 8,000,000 *imp. galls.*

Cost of laying down a compound pipe of 34 and 28-inch from the Chateau d'Eau to Mount Pleasant, removing the existing pipe between Arago street and Mount Pleasant and relaying it along Arago street to the head of Crown street.

ITEMS.	Quantities.	Price in cents.		Total amount.
			$ cts.	$ cts.
Changes required at Chateau d'Eau				300 00
Laying down 34-inch pipe from Chateau d'Eau to near the head of Misère road	4,550 ft.	9 70	44,135 00	
Laying down thin 28-inch pipe from head of Misère road to the fields below Bedard's barn	12,000 ft.	8 15	97,800 00	
				141,935 00
Specified works a River des Mères			5,650 00	
do do do St. Charles			55,650 00	
				61,300 00
Laying down thick 28-inch pipe from field below Bedard's barn to Mount Pleasant	24,229 ft.	10 40		251,981 60
Air-valves and air-cocks along line			160 00	
Special castings			100 00	
				260 0
Land damage, if line is changed at River St. Charles				2,000 00
Extra work making connections, &c., &c				123 40
				$457,900 00
Removing 1,829 feet of 18-inch pipe from Savageau's Hill and Mount Pleasant to Arago street	1,820 ft.	1 00		1,829 00
Extending 18-inch pipe in Arago street to the head of Crown street	1,671 ft.	5 95		9,042 45
				$469,671 45
Contingencies				30,328 55
Total cost of works required by fourth arrangement				500,000 00

From the above four *Exhibits*, which give the estimated cost, the *Quantity of Water* and the *head* under which the water would be received into the city, according to the several *Arrangements* previously described, I presume there would be no difficulty in determining which if any should be adopted.

The following is an approximate estimate I have made of a reservior supposed to be located between the Martello Tower No. 1 and the Grande Allée chemin, on the ground that was purchased by the City of Quebec and known as the Pelletier lot. The estimate is based on one that was made for the Water Department several years ago, but made for one of more capacity to be covered in by brick arches and earth work, a plan which I unhesitatingly recommend if ever one should be required. Its capacity is for 12,000,000 imperial gallons, or what may be considered sufficient for supplying the city two days.

ESTIMATE of cost of erecting a covered distributing Reservoir 460 feet long by 260 feet wide at top water—depth of water 20 feet.

ITEMS.	Quantities.	Price in cents.	Total amount.
			$ cts.
Concrete floor and stone foundations for piers	162,324 c. ft.	18	29,218 32
Side walls in stone	43,677 c. ft.	25	10,919 25
Brick work, including pier walls, arches, &c	198,738 c. ft.	40	79,495 20
Drain pipes of burnt clay, 12-inch pipe	5,460 ft.	50	2,730 00
do do 4 do	500 ft.	15	75 00
Rough or cheap concrete on arches	68,640 c. ft.	15	10,296 00
Earth work to cover over brick work	477,312 c. ft.	1½	7,159 68
Excavation, removing sods	151,500 c. ft.	½	505 00
do puddle ditch	76,912 c. ft.	½	256 37
do bottom of reservoir, part rock	143,896 c. ft.	2	2,377 92
Embankment, exclusive of puddle wall, &c	952,334 c. ft.	1	9,523 34
Puddle wall in embankment	414,657 c. ft.	1½	6,219 85
Hydraulic stone masonry for receiving culvert			1,225 31
do do distributing do			3,719 96
Excavation and laying 28-inch pipe from reservoir to Grande Allée	612 ft.	750	4,590 00
Stop-gate for 28-inch pipe and well			550 00
Contingencies			10,638 80
Total cost of reservoir			$180,000 00

In regard to the necessity of a reservoir as a substitute for a *double set of pipes*, I do not see that one would assist in the least unless by shutting off the city during a certain portion of the night to be opened in the day time to aid the general supply, to turn the present feeding main into one would not fill it; the water would run out as fast as it entered with a considerable loss of head into the bargain. In the night, in case of fire, the street mains would be all empty, and a long time would elapse before water could be had where wanted most.

It is important that all the street mains should be under pressure at all times, that no delay may occur on the outbreak of a fire.

I do not see therefore that a reservoir would be of much, if any, use under the present circumstances. Another pipe is the only sure remedy, and I therefore recommend one to be laid down that should have a *calibre* of at least twenty-eight inches as given in the estimates. Such a pipe laid, I have no doubt but all would be satisfied with the result; provided, in addition, that the city authorities should call to their aid some of the most influential of the citizens who should form themselves into societies who would seek out and try to influence those who allow the water to be wasted, and if any law could be brought to bear upon those offending, to report the offenders to the Water Department. This course was taken by the Boston Water Department last year, and the result was most encouraging. It should be mentioned, however, that the laws here can be applied with effect upon the water tenants who are wilful or negligent in the use of the water.

I have the honor to be, Gentlemen,
Your very obedient servant,

(Signed,) GEO. R. BALDWIN.

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