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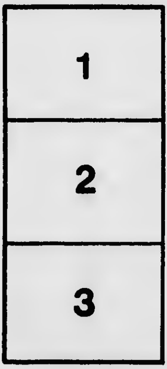

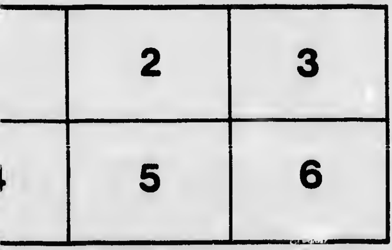

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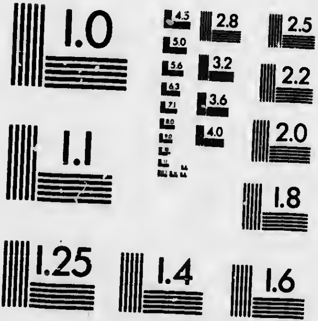

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Hamilton Water Works.

SPECIFICATIONS & ESTIMATES

OF THE

THREE SUCCESSFUL COMPETITORS

FOR PREMIUMS

OFFERED BY THE CITY COUNCIL,

FOR THE BEST MODE OF

SUPPLYING THE CITY WITH WATER;

TOGETHER WITH THE

REPORT THEREUPON OF T. C. KEEFER, ESQUIRE,

PUBLISHED, BY ORDER OF THE CITY COUNCIL, FOR THE INFORMATION OF THE INHABITANTS.

HAMILTON:

PRINTED AT THE SPECTATOR OFFICE, COURT HOUSE SQUARE.

1855.

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PLAN No. 1.

To Robert McElroy, Esq., *Chairman of the Committee on Fire and Water, of the Council of the City of Hamilton, C. W.*

Sir,—The City Council have proposed for " Plans, Specifications, and Estimates for supplying 40,000 inhabitants with water from Burlington Bay."

I respectfully submit herewith Papers and Plans, embracing the arrangement for this purpose, which under the circumstances, I am inclined to propose for the supply mentioned.

These papers consist of remarks on the system of Supply Proposed, Descriptive Specifications, and Estimates of Cost, and are accompanied by a General Plan, showing location of Reservoirs, Engine House, Force Tube, and Distributing Mains and Pipes, Plan of Engine House, Pumping Engine, Distributing Reservoir, and Pumping Reservoir Culvert.

The terms of the proposal of the City Council limit the investigations on the source of supply to the use of the water of Burlington Bay, and its elevation by means of forcing machinery. It is to be presumed that a supply through gravitation from inland sources, is, either from want of sufficient elevation, inadequacy of amount, objectionable qualties, or expensive access, placed by nature out of the question. Our attention is therefore to be limited to the waters of Ontario and the intervention of the Steam Engine.

The fact that the source of supply is thus imperatively fixed, is by no means, in my opinion, to be regretted. The economy of gravitation supplies is a principle not fully established by practice. There are numerous instances on this Continent as well as the other, going to shew conclusively, that the adoption of this principle has involved large preliminary outlays, the interest of which is largely in excess of the annual cost of a supply by pumping, and the arrangements of the works themselves, much more inconvenient, with an inferior quality of water.

In all large bodies of water there is a constant tendency to self-purification. The principle of subsidence operates on the mechanical impurities, and in connection with the chemical influences of the atmosphere, with which it is constantly brought in contact, the water of large rivers and lakes is, in many cases, much perferable to that of springs or brooks, for the manifold uses of a city.

In the case of Burlington Bay, chemical analysis shows its favorable comparison with the water in the inland vicinity, and that used in various cities, as appears in the following table of analyses:

Burlington Bay	8.44	grs. solid contents per gallon.
Grand River	12.66	" "
Lancaster Creek	13.78	" "
Hess' Spring	22.50	" "
Edinburgh	12.88	" "
New River Co., London	19.50	" "
Seine, Paris	12.00	" "
Artesian Well, Grenille	9.86	" "
Croton River	10.93	" "
Schuylkill River	5.50	" "
Hudson River	6.32	" "
Mohawk River	7.88	" "
Genesee River	11.21	" "
Lake Ontario, Rochester	10.00	" "

If the location of your city had been made with a view to its supply by steam power, few places on the Lake shore could have been found more favorably situated.

Burlington Bay is formed by a large indenture in the Lake shore, its commodious harbor being nearly enclosed by two narrow projecting tongues of land, approaching each other from the opposite banks.

The City of Hamilton is located on the primary terrace above this Bay, at an elevation of from 50 to 90 feet above its level. Behind the city a second terrace rises abruptly to an elevation of nearly 400 feet, where it meets the level of the inland country. The extension of the city southerly, is limited by this abrupt elevation. On the westerly side it is also limited by the Dundas Marsh, which is separated from the Bay for some distance by the bold and picturesque promontory known as Burlington Heights. These Heights are directly above the shore of the Bay, and command the entire populated district of the City, with the exception of a few villas built on the slope of the southern terrace.

The proposal of the City Council leaves the ratio of daily supply to each inhabitant undetermined, and the experience of large cities is so varied as to make this ratio somewhat a matter of doubt.

Much depends on the popular impression as to the character and cost of the supply, and the precuation taken to prevent waste. In life on shipboard, for instance, from one and a half to five gallons per day, suffices for all cooking and drinking purposes.

The average daily consumption in London, was in the year 1849, less than 30 gallons for each inhabitant, and as a general rule, this is a large ratio for European Cities. In the United States, however, the ratio is much greater, reaching, in the case of the City of New York last year, nearly 90 gallons. This enormous consumption may be accounted for by the popular opinion, that as the supply comes by gravitation, and costs a large sum, it has or ought to have no limit, and very few precautions are taken to prevent waste. The same experience is common to the City of Boston, also a gravitation supply, although the ratio is less, while in Philadelphia, where the water is pumped, the ratio is invariably much less.

The following comparative statement of the daily consumption of the last named cities, will more fully illustrate this point—

	Date	Philadelphia.		Boston.
For the year	1850	31.0	Wine gallons	41.7
	1851	37.1	"	47.5
	1852	37.3	"	51.2
	1853	40.7	"	55.1
July & August	1850	39.0	"	59.0
"	1851	47.1	"	49.7
"	1852	42.9	"	63.4
"	1853	50.3	"	55.7
"	1854	51.8	"	80.0
May	1854		"	71.0

The average daily consumption was therefore during four years, 36.52 wine gallons in Philadelphia, and 49.62 gallons in Boston.

As the average consumption during the warm months is much greater, I have deemed it best to adopt for the scale of the works and machinery, a ratio of 50 gallons (Imperial) per day, or a daily supply of 2,000,000 gallons for your city; the present population of which is, I believe, about half the number for which provision is desired to be made. On this point the plan of pumping has this consideration, that whatever your city uses under this quantity is a saving in the annual cost of working the Engine, and a virtual increase in the capacity of the Reservoir.

Another important point is not determined by the proposal of the Council, and that is, the sum at which it is desirable to limit the expense.

Not feeling at liberty to communicate with your Council on this subject, I have prepared the plans on such a scale of expenditure, as I presumed would meet its wishes. I have however to say, that these plans may be somewhat increased or diminished in cost as may be desired, without affecting their general features. While there are some portions in which I could not advise a change, there are others readily altered. I have aimed at durabilty and strength rather than ornament. A combination of substantial construction with a proper regard to appearances is what I suppose you would prefer.

REMARKS ON THE SYSTEM OF SUPPLY PROPOSED.

The system of supply proposed is comprised in the following description of the Location of Engine House, Character of Machinery, Location of Distributing Reservoir, and Distribution:

LOCATION OF ENGINE HOUSE.

In locating the Engine House a site must be found where the water may be taken at a proper depth; where it is not exposed to the present or future sewerage of the City, or the wash of the marshes on the east or west—where the supply may not be affected by the ice in winter and spring, or disturbed by the storms which sweep over the Lake, agitating and roiling the water of the Bay, and where a direct and short communication may be had with the Distributing Reservoir.

From a point where the curve of the Great Western Railroad leaves the deep cut in the side bank of Burlington Heights, to the commencement of the tangent in front of the Passenger Depot, the Road is constructed in embankment, leaving between its bank and the original shore of the Bay, a space varying from 100 to 250 feet in width, now filled with water, which has access to the Bay by a culvert through the Railroad bank.

Experience has shown that much expense and many serious difficulties are involved in the plan adopted in other places for Lake supplies, of building out a pier into deep water for the protection of a suction main to the Pumping Engine.

I propose therefore to avoid this difficulty, and secure at the same time the benefit of location above mentioned, by taking advantage of the Reservoir now partially formed between the Railroad bank and the original shore, locating the Engine House at the westerly end of a Pumping Reservoir thus formed. This will be connected with the Bay by a substantial stone culvert to be constructed for the purpose with a wire screen, bulk head, and sluice gates for regulating the supply, or shutting it out entirely in case of stormy weather : the Reservoir being of sufficient capacity to supply the Engine for from 5 to 8 days, depending on the level of the Bay, when shut off.

This plan secures a constant supply to the Engine of pure and clean water, it avoids the difficulty and expense of laying a suction main out into the Bay, and the serious objection to laying the force tube under the Railroad track, where it may be affected by the jar of passing trains and the limited facility for examination and repairs. It also affords an opportunity for an ornamental arrangement of the Engine House, Grounds, and Reservoir, exposed to the daily observation of hundreds of passing travellers ; while the contiguity of the Rail Wharves as built and contemplated, provides a convenient point for the reception of coal and other materials for the Engine House, at a light expense for intermediate transportation.

The location of the Engine House thus contemplated is about 1450 feet west of the Machine Shop.

CHARACTER OF MACHINERY.

The character and dimensions of the Pumping Engine and appurtenances, have been adapted to the scale of supply mentioned in the introductory remarks.

The dimensions and duty have been calculated as follows :—

POPULATION 40,000.

Supply to each daily	50 gallons, Imperial.		
Quantity per day	2,000,000 gall.	320,924	cubit feet.
" minute	1,388,8 "	222,86	"
" second	23,14 "	3,71	"

222.86 cub. ft. by $62\frac{1}{2}$ lbs. by 155 ft. 2.158.956 ft. lbs.

Elevation of Reservoir surface	155 feet.
Length of Force Tube	1700 feet.
Diameter of "	16 inches.
Friction of "	8 per cent.
Stroke of Piston and Plunger	8 feet.
Number of effective strokes, per min	$7\frac{1}{2}$
Diameter of Cylinder	54 inches.
Diameter of Plunger	26 inches.
Vertical pressure of Force Tube, per sq. inch	70.45 lbs.
Plunger resistance. " "	76.08 lbs.
Friction of Engine, assumed	20 per cent.
Average Piston pressure	20.95 lbs.

DUTY.

Water raised	2.158.956 ft. lbs.
Friction of Engine	431.751
" of Force Tube	172.816
	2.763.523 ft. lbs.
Horse Power	87.12.

The several sizes of the general parts of the Engine are determined by the duty to be performed, and the best practice of our Engineers. The style of Engine admits of some dissension, although experience in my opinion, is very conclusive on this point.

The Engine of Thomas Savery, was invented in 1698 for pumping water and has done to the present time; steam pumping Engines have been in constant use, and have attained a maximum of effective duty beyond that of any other application of machinery.

The extensive and varied experience of a century and a half has shown practically and theoretically that the arrangement of a Pumping Engine should be of the simplest possible character, and that the form of Engine, which is single acting, working with a counterbalance, commonly known as the Cornish Engine, with a slow motion, a long stroke, and a high ratio of expansion, is the best adapted to this purpose. Various other forms of Engines have been tried without equally favorable results. In the department with which I am connected, we have the largest double-acting-beam Pumping Engine on the Continent, and I speak from personal observation when I say, that it is by no means as valuable for this peculiar purpose as the style of the Engine shown in the accompanying drawings—a style which has received the sanction of 150 years experience. In recently preparing the plans of the pumping machinery for a daily supply of 40,000,000 gallons, the form of Engine adopted is identical with that above mentioned, although I believe but one Engine of the kind is at present in use in the United States, and that has been but recently constructed.

The boilers, which are the grand source of the vitality and success of the Engine, I have endeavoured fully to provide for in the Specifications on this point. Two are proposed at present, and the Boiler Room is made large enough to admit others, if the increase of the city should require a duty of the Engine greater than two can supply.

LOCATION OF DISTRIBUTING RESERVOIR.

Burlington Heights furnish several points for the location of this Reservoir. The most favorable point, however, I believe to be at the south-east corner of York and Dundurn streets, on the broad plateau from which the ground breaks down abruptly towards the City. This is higher, better adapted to a system of distribution, easy of access from the Pumping Engine, the distance being but 1700 feet, and has the farther advantage that at any future time the Reservoir may be enlarged beyond the capacity deemed sufficient for a population of 40,000.

A Reservoir can be constructed at this point, with a capacity of about 24,000,000 gallons, sufficient for a supply of 12 days, at an elevation of 155 feet above the Lake, which is 72 feet above the intersection of James and Market streets, 27 feet above the intersection of Main and Hess streets, and 28 feet above that of James and Hannah streets, commanding every building and spire in the City, except the villas mentioned at the foot of the southerly terrace.

I believe that no other point equally favorable as to elevation, can be found in the vicinity of the Bay. At the intersection of the South City Concession with Queen street, the ground rises rapidly towards a gorge in the terrace behind it, on which a Reservoir might be constructed at a much greater elevation. The distance however from the Bay would be a serious objection to its use in connection with the Pumping Engine, and there are no advantages to be gained by an increase of elevation above that adopted on Burlington Heights.

A supply which finds its way freely to the tops of the highest houses within the denser district is abundantly high for all practical uses. The experience of Philadelphia, New York, Boston, London and other large cities, shows beyond argument, that no elevation of supply can supersede the necessity of a department for protection from fire, without a complicated, expensive, and inconvenient arrangment of hydrants; and that every foot of elevation beyond a certain medium, involves additional risk of accident to the distribution and service mains and pipes, calling for more expensive guards wherever used, without compensating benefit.

While this argument is forcible in the case of gravitation supply it receives additional weight from the consideration that in a supply by pumping, the duty of the engine, the consumption of coal, cost of repairs &c., are increased directly with an increase of lift, and seriously affect the constant annual cost. This annual expense is therefore an item to be maturley considered in arranging the general features of the work and in working the machinery when in use.

DISTRIBUTION.

The system of Distribution which I propose to use, commences at York street from a line of 16 inch main, passing down this street to Caroline street from the central entrance of the Distributing Reservoir. It is then subdivided into 12, 10, 8 and 6 inch pipes, arranged with a view to a free and rapid circulation of water.

The accompanying estimates are made in relation to two distribution districts; the first confined to the more densely peopled portion of the City, and the second extending over wider limits, arranged in reference to use in case of fires, for the Railroad Buildings, &c., and the Shipping. Hydrants are provided for and located in accordance with the approved practice in such cases, and the necessary stop cocks for the various sizes of pipes.

In these estimates I have limited the smallest size of pipe to 6 inches in diameter. Four inch pipe has commonly been used for similar lines, but I am satified that it is not to be recommended, being entirely too small for its requisite purposes under ordinary pressure. The experience of large cities is becoming conclusive on this point, and it is much better to take advantage of this experience than to pay in the same way, for the same lessons—the difference in cost not being sufficient to affect materially the general aggregate. An error in the system of distribution under a mistaken idea of economy, is much to be deprecated, and cannot well be corrected after the pipes are laid.

I have also to remark on this subject, that the estimates for the cost of Distribution are made, as in the usual way, for cast iron pipe. I am inclined however, seriouly to question the propriety of advising its adoption, having been satisfied for several years, from personal observation, and the accumulating testimony on this Continent and the Eastern, that its use is open to grave objections.

It is found, I believe universally, that cast iron water pipes develope in use, "a tendency to the absorption of the iron in certain parts, and the formation in its stead of a substance resembling plumbago; also, to the gradual developement of local accretions or tubercles, in the interior of the pipes, by which their capacity is diminished and the flow of water impeded."

This is the conclusion of the Water Board of the City of Boston, in a Report on their Distribution System then three years in use, in which they state that "all the larger pipes that have been opened have been partially or entirely corroded on their inner surface, some with detached tubercles varying from ½ to 2½ inches base, with a depth or thickness in the middle of from ¼ to ¾ of an inch." "In one case a four inch pipe was found covered to a thickness of about one inch."

"The 36 inch and 30 inch mains have become already, in consequence of the actual diminution of their area, and also of the additional friction which has been occasioned, scarcely superior in capacity to those of 34 and 28 inches, having a clean surface."

The same facts are noticed by the French Engineers, and extended experiments have been made to determine the cause of the difficulty and its remedy. A visit to the Croton Pipe Yard of New York, or any other city using cast iron pipe, furnishes abundant testimony of the same results.

The destruction of the iron, and consequent formation of tubercles, by which the pipe is reduced in strength and capacity, is produced by the contact of the water with its internal surface :—the remedy which suggests itself, is to form an internal coating to prevent the contact of the water and iron.

Experiment, analysis, and a continued practice of years, have shown that the best material for this coating is Hydraulic Cement. This is the conclusion of the Engineers of France and the United States. In the latter country a number of Cities and Towns have been furnished with water pipe, made of wrought iron plates, securely rivetted together; the pipe thus formed being by an ingenious arrangement lined with a coating of cement, and the outside covered with the same material to prevent external corrosion. Pipes made in this way are now extensively in use as force tubes and distribution mains of different diameters—in some cases under a pressure of 240 feet head.

These pipes combine several advantages. The thickness of the iron can be adapted to any required degree of strength; the several lengths are readily connected in a continuous line, by sleeve joints, and when so connected, form a smooth and regular water way; they can be tapped for service-branches at any point, under any head without shutting off the water, and with little trouble or expense; their firmness and durability, so for as the cement lining and coating can affect them, increase with age, and when properly dried before use, they transmit the water without contamination of any kind; they are in addition more easily transported and handled than cast iron pipes, and can be furnished at a price at least 20 per cent. less. Under these circumstances, and in view of the testimony above mentioned, I should feel under professional obligations to advise their adoption without regard to comparative cost, although the fact of their superior economy is worthy of consideration. The estimates are made in view of their adoption in case you desire it.

Another point in connection with the subject of Distribution must be brought to your notice, although not included in the estimates, as I am not aware of the method by which you propose to meet the principal and annual cost of this work. I refer to the practice, lately becoming general, of determining the amount of water used and to be paid for, by each consumer, by means of a meteor which registers the weekly or monthly quantity of supply to each. In Boston, New York, Philadelphia, and other cities, this method has been adopted to a larger or smaller extent, with beneficial results. It is a feature however, not directly involved in the present investigations, though worthy of mention and attention.

The following schedules embrace the Reduced and Extended systems of Distribution, in detail, as proposed and estimated, giving the lengths and diameters of the several sizes of pipes, and the streets through which they are laid:

SCHEDULE OF DISTRIBUTION.

REDUCED DISTRICT.

Name of Street.	Diameter of Pipe.			
	12"	10"	8"	6"
Cannon				
Vine			2.450	
Gore				1.350
Merrick				1.100
Rebecca				1.250
Market				1.400
King William				300
Napier				1,400
Market St. West				530
King Street West				1.600
" East			1.900	
Maiden Lane		1.400		
Tyburn				1.350
Hunter				1.100
Peel			430	900
Caroline			1.100	
Bowery and Bay			1.100	450
Bond				2.720
Park				1.800
Charles				900
McNab				1.200
James				2.720
Hughson		2.720		
John				2.620
Catherine				2.550
Mary				2.670
York, 3450 ' 16"	2.040			700
	2.040	4.120	4.430	34.510

SUMMARY.

6 inch Pipe, ...
8 " " ....34.510 feet.
10 " " .... 4.430 "
12 " " .... 4.120 "
16 " " .... 2.040 "
6 " Stopcocks........................ 3.450 "
8 " " 16
10 " " 8
12 " " 3
Hydrants 1
" 4" Connections 70
.... 1.050 feet.

SCHEDULE OF DISTRIBUTION.

EXTENDED DISTRICT.

Name of Street.	Diameter of Pipe. 12 "	10 "	8 "	6 "
Brock	....	....	....	1.830
Stuart	....	....	....	730
Murray	....	....	....	430
Stinson	....	....	....	1.120
Concession	....	....	....	430
Barlow	....	....	....	1,110
Colborne	....	....	....	440
Sheaffe	....	....	....	870
Lind	....	....	....	1,110
Mulberry	....	....	....	1.850
Cannon	....	....	2.450	580
Vine	....	....	....	1.350
Gore	....	....	....	1.100
Merrick	....	....	....	1.250
Napier	....	....	....	530
Rebecca	....	....	....	2.820
King William	....	....	....	1.400
East Market	....	....	....	1,420
Market	....	....	....	300
Market, West	....	....	....	1.600
King	....	2.880	1.900	1.450
Main, West	....	....	....	1.850
Main, East	....	....	....	2.820
Maiden Lane	....	....	....	1.350
Tyburn	....	....	....	2.820
Hunter	....	....	430	900
Peel	....	....	2.820	
Bold	....	....	....	430
Augusta	....	....	....	1.070
Catharina	....	....	....	1.070
Maria	....	....	....	750
Railway	....	....	....	1.700
Caroline	....	....	1.000	2.800
Bowery and Bay	....	....	....	8.520
Bond	....	....	....	1.800
Park	....	....	....	1.670
Charles	....	....	....	1.200
McNab	....	....	....	4.750
James	....	5.240	3.300	
Hughson	....	....	....	5.930
John	....	....	....	5.860
Catherine	....	....	....	5.700
Mary	....	....	....	700
Walnut	....	....	....	1.000
Cherry	....	....	....	670
Nelson	....	....	....	550
Cathcart	....	....	....	300
Spring	....	....	....	670
Wellington	....	....	950	800
York, 3450 16 "	2,040			
	2.040	8,070	12.850	74.250

SUMMARY.

6	inch Pipe,	74.250	feet.
8	" "	12.850	"
10	" "	8.070	"
12	" "	2.040	"
16	" "	3.450	"
6	" Stopcocks,	10	
8	" "	8	
10	" "	3	
12	" "	1	
Hydrants		146	
"	4 " Connections,	2.190	feet.

SPECIFICATIONS.

The Specifications descriptive of the manner of construction for the several structures are managed in the following order:

1. Grubbing and Clearing.
2. Excavation.
3. Embankment.
4. Puddling.
5. Mortar.
6. Masonry.
7. Pumping Reservoir Culvert.
8. Pumping Reservoir.
9. Engine House.
10. Engine, &c.
11. Distributing Reservoir.
12. Distribution.

As there are at present several methods in practice of contracting works of this kind, either by a specific sum for each material and quantity, or by letting an entire structure, or by making a contract for the entire work, I have not drawn up the form of contract, which can be readily made to suit the plan adopted.

The latter system of contracting is becoming general, and under careful plans and specifications, with proper superintendence, and responsible Contractors, I consider it the most advantageous. This point, however, must be left for your future determination.

GRUBBING AND CLEARING.

From the ground required to be occupied by the several structures of this work, including embankments and walls, all trees, saplings, bushes, roots, wood, and perishable materials shall be removed and burnt up or otherwise disposed of, as directed by the Chief Engineer, care being taken that no damage is incurred to the lands or property adjoining those taken for the work.

EXCAVATION.

All necessary excavation and removal of earth, sand, stones, and other materials, shall be made for the construction of the works, including all excavations under water, and for all temporary and permanent structures.

These excavations shall be made to the proper depth and form for all foundations, the earth being properly cut and rammed for the same. All necessary shoring and plank shall be provided and placed. The excavations shall progress with the several parts of the work as required, and be so made as to avoid all unnecessary damage to property along the line. The material excavated shall be used for embankment and backfilling as required, the surplus earth being deposited agreeably to the directions of the Chief Engineer. Under this head all pumping, bailing, and draining, to keep the work free from water, while the mechanical structures are building, shall be performed in the most efficacious manner.

Under this head will also be included all embankments and backfilling made within 500 feet of the excavations, from the material excavated.

EMBANKMENTS.

All the embankments required for the construction of the several parts of the work shall be made of proper and sound material, with such slopes and method of construction as directed by the Chief Engineer.

The foundation of the embankments shall be prepared as described in Specification Nos. 1 and 2. In forming the embankments care shall be taken to raise them by successive layers, sloping towards the centre of the bank, of the full width of bank proposed, with other precautions to prevent slips.

When puddling, masonry, &c., are connected with the embankments, care must be taken to adopt one part of the work to the other in order to ensure the perfection of the whole.

The material shall be taken from the nearest excavation suitable therefor, or from borrowing pits provided for the same, of convenient access. Previous to the completion of the work the embankments, where required, shall be properly turfed or sodded, to prevent washing by rain or otherwise.

Under this head will be included all necessary backfilling for the several portions of the work not included under "Excavations."

PUDDLING.

In all parts of the work where puddling is required, the material used for this purpose shall be of proper quality, and worked in thin layers, each of which must be thoroughly wet and tempered, and worked so as to incorporate each course with those adjacent.

Care shall be taken to carry up the work in connection, to prevent checks and ensure its tightness. The dimensions and position of the puddle-walls, material, &c., to be as directed by the Chief Engineer.

MORTAR.

All the mortar used on the several parts of the work, must be made of the best quality of ground hydraulic lime, which shall be subjected to proper tests of its freshness and strength. In wet work it shall be made of equal parts of cement and sand, and in other places of two parts sand to one of cement, the proportions being ascertained by careful measurement. Strict care must be taken to protect the cement from the weather previous to its use.

The sand shall be free from all impurities, coarse grained, and shall be properly screened before its use.

In mixing mortar the cement and sand of the required proportions shall be mixed dry, then wet to a proper consistency, and used while fresh. Where grout is required it must be mixed as above described, and kept in brisk motion until it is used.

No mortar shall be used during weather sufficiently cold to prevent it from properly setting.

MASONRY.

Concrete Masonry shall be made of mortar as above described, by adding thereto five parts of durable broken stone and gravel to each part of cement, and thoroughly mixing and incorporating the mass. The concrete stone or gravel shall not exceed $2\frac{1}{2}$ inches in diameter, and shall be cleaned before using. The material thus prepared shall be immediately laid in the place intended for it, care being taken to provide a bed well rammed. After laying it shall be rammed until the mortar flushes to the surface. When the bed of concrete exceeds 12 inches in depth, it must be formed of successive layers to the proper height, each not more than 12 inches deep.

Dry Rubble Masonry shall be made of sound, durable stone, quarried out in regular beds of a proper area, and not less than 6 inches thick. The broadest and best bed shall always be laid down, the bed and vertical joints being levelled and filled up by suitable spalls. The work to be well tied with headers in a substantial bond.

Rubble Masonry shall be laid with stone of the quality above described, in similar manner, in a full bed of mortar. The vertical joints shall be grouted or filled with mortar, chips and spalls being put in afterward. The stone shall be clean and always wet before laying.

Dressed Masonry shall be of the material above described, and laid in a full bed of mortar, with a joint not exceeding $\frac{3}{8}$ths. of an inch. The top and bottom beds and end joints to be squared for a depth not less than 12 inches.

The face of the stone shall be made with a tool draft around the arris. The headers in the bond shall be equal to one-fourth the face stone.

Cut Stone Masonry shall be of the best material, of uniform color, laid in regular courses, the top and bottom beds and end joints being squared not less than 15 inches, and the joints not exceeding $\frac{1}{4}$ of an inch. The large stones shall be properly limited and set by machinery, and the work carried up agreeably to the plans and directions for the same.

Brick Masonry: In this work the bricks used and not exposed to sight must be of sound, durable quality, regularly shaped and hard burned; those exposed to sight after the completion of the work must be of the best quality of face brick of regular form and color.

They must be well soaked before laying, and placed with a good bond in a full bed of mortar, with struck joints inside and out, the bed being grouted where required. In arches, the beds shall be laid on the radius line, with uniform joints and alternate header and stretcher courses, where the thickness of wall admits.

PUMPING RESERVOIR CULVERT.

At such point as may be designated, a Culvert shall be constructed through the Railroad embankment, to be provided with a copper screen and gate chamber, with a bulk head, two gates, screw shafts, band wheels, and other necessary appurtenances.

After the excavation through said embankment is made, (over which a firm double track bridge shall be built as directed, for temporary use,) coffer dams of sheet piling and embankment shall be constructed as herewith provided.

The foundations of the culvert shall be of concrete masonry, 12 inches deep, laid $14\frac{1}{6}$ feet below low water level, on which cross planking of sound oak, 4 inches thick, shall be laid in a double thickness, and covered with a bed of rubble masonry 18 inches deep. On said bed the bulk head on the north end of the culvert shall be built 15 feet high, connecting with the culvert walls and arch, which shall be $12\frac{1}{2}$ feet wide and $8\frac{1}{2}$ ft. high in the clear, the arch being 2 feet thick. On the south side, the culvert shall terminate in the Pumping Reservoir, with two splayed ring walls, as drawn, to protect the embankments.

The foundations at the ends and sides will be protected by four rows of sheet piling, 5 inches thick, connecting with the concrete masonry, and supported at the ends by guide piles and ribonds, as per plans.

All the work to be done according to the plans and directions of the Chief Engineer, and the foregoing Specifications; to be commenced within days of the date of contract, and completed within months.

PUMPING RESERVOIR.

The space between the Railroad embankment and the original shore of the Bay, from a point 600 ft. west of the Railroad Machine Shop, marked A on the General Plan, to a point 850 ft. further West, shall be excavated to a depth of twelve feet below low water line of the Bay, the sides being formed to a slope of one and a half to one.

Around the excavation thus made, embankments shall be formed from the material excavated, of the form and height designated by the Chief Engineer; the balance, if any, being deposited as directed.

The embankments on the South side will be so constructed as to prevent the flow of surface drainage into the Pumping Reservoir.

Under this head will be included the Coffer Dam, Embankment of the Pumpwell and Culvert, and the filling and forming of the Engine House grounds.

The work to be done under the direction and plans of the Chief Engineer. To be commenced days after the date of contract, and completed in months.

ENGINE HOUSE.

The Engine House with its appurtenances shall be built with a Pump Well, Engine Room and Boiler Room.

The excavation for the Pump Well shall be made to a point 15 feet below the low water level of the Bay, the foundations being 30 feet wide by 29 feet long, and constructed, if so directed, on round spruce piles of 12 inches diameter at the butt, driven 3 feet from centre to centre each way, and about 20 feet long, or long enough to be driven to a uniform guage of one inch at the last blow. When the piles have been driven and cut off at the proper level, oak cap timbers of 12 inches by 6 shall be treenailed on them with 2½ inch treenails, and the intermediate spaces filled in with Concrete, flush with the top of the cap timbers and 18 inches deep, worked in firmly around the heads of the piles. On said timbers oak plank 6 inches thick shall be treenailed with 2½ inch treenails, on which the masonry of the Pump Well shall be built.

Said masonry shall be rubble masonry, built with an inverted arch of 13 feet 8 inches diameter, and side piers to the levels of the Pump Well and Engine Room floors. That portion of the work on the East front of the Engine House, between the water line and water table, to be faced with dressed masonry.

To be provided with the openings, bulkheads, grooves, cheeks, &c., for the copper wire screen and influx gates, and covered with a white pine flooring, 3 inches thick, fitted above the Well, so as to prevent evaporation into the Engine Room, the East wall being perforated to favor this purpose. All the Pump Well work to be built in connection with the bearings and fixtures for the Engine and appurtenances; access to be had to the Engine Room by an oak stair-way 4½ feet wide.

The foundations of the walls of the Engine House to be built on piles driven as described for the Pump Well, in an alternate double row, 3 feet between centres across, and 5 feet lengthwise the wall, 4 being driven at each corner, if such piling is deemed necessary. To be capped with 6 by 12 inch oak plank, treenailed down and filled in with Concrete, 12 inches deep, firmly worked around the piles, the top of the Concrete being 5 feet below the water table base. On this foundation rubble masonry 3½ feet wide at base and 2 at top, shall be built to the water table level.

The dimensions of the Engine Room shall be 52 by 40 feet external, 30 feet high to the top of the brick wall; and those of the Boiler Room, 40 by 32 feet, 16 feet high to the top of brick wall.

The Engine and Boiler Room floors around the Engine and Boilers, shall be flagged with 4 inch dimension flagging, laid on rammed sand, except over the Pump Well, where it will be supported by cast iron beams.

The walls to be built of brick masonry 16 inches thick, with 4 arched doors 10 feet wide and 12 feet high in the clear, and 16 windows 8½ by 4 feet wide, and 9 windows 7 by 4 feet, fitted and furnished complete. The chimney to be of brick masonry on piled foundations, with a 16 inch wall to a point 32 feet above water table, the entire height being 53¼ feet above water table; the flue being 36 inches square, carried up vertically.

The cut stone work to consist of the water table, window sills and lintels, chimney water table, and cap, rustic blocks of the doors and corners, and the centre pier of the working beam of the Engine.

The roof to be composed of an iron truss, with wrought iron principals, tie-rods bolts, nuts, jack rafters, &c., and cast iron braces, according to plans for the same. The principals to be placed not more than 8 feet apart between centres, and the jack rafters not more than 10 inches apart. The whole to be covered with the best quality of blue Vermont Slate, not less than 10 by 16 inches, secured by lead nails to the rafters; to be provided with a cast iron Cornice-Moulding and Gutter, and six 4-inch tin leaders, fitted and erected complete, the leaders having cast iron spouts.

All the work on the Engine House and appurtenances, to be according to the plans and directions of the Chief Engineer and the foregoing specifications, and to be commenced within   days after date of contract, and completed within   months.

ENGINE AND MACHINERY.

One Condensing Pumping Engine shall be erected in the Engine Room of the Engine House, on the foundation to be prepared for it:—built with a cylinder of 8 feet stroke and 54 inches bore, and a plunger of 26 inches diameter.

The engine to be provided in every respect with the valve chest, condenser, air-pump, force-pump, parallel motions, bearings, stuffing boxes, glands, connecting rods, guides, bolts, nuts, oil cups, and all other necessary appurtenances, of proper size, material, and workmanship.

To have a double cast iron beam, connected with collar-bolts, 24 feet long between centres, and a counterbalance chest attached to the plunger, connecting rod or beam, adjustable to different loads of the engine.

To be connected with two boilers by a sufficient steam-pipe, the boilers being properly built of boiler plate iron not less than $\frac{3}{16}$ of an inch thick, properly riveted and caulked, with all the steam and water guages, man holes, hand holes, plates, grate bars, flues, bridges, stays, safety valves, steam drums, stop valves, and all other appurtenances necessary or ordered. To be of the "double return drop flue" variety, with sufficient fire surface and steam-generating power, to enable the engine to pump 2,000,000 gallons, daily, into the Distributing Reservoir, and to maintain nine effective strokes per minute, with an average cylinder pressure of 30lbs. per square inch, cutting off at ⅓ the stroke. To be properly fitted, and so connected that either may be fed, or supply the engine independently of the other, and to be provided with the firing tools, shovels, &c., necessary. To be provided with one "Northington" steam pump, of 6-inch bore and 2 feet stroke, so connected with the force tube as to be used as an auxiliary.

Detail plans for the several parts of the Engine, Boilers, and appurtenances, shall be furnished by the Contractor, subject to the inspection, alteration or rejection of the Chief Engineer.

The iron and composition work, surface work, and finished work in dimensions and arrangement, to be in all respects according to the approved plans and directions of the Chief Engineer, and made of the best quality of materials and workmanship. Each part and piece to be subject at all times to the inspection of the Chief Engineer, during its construction and after it is in place, and to be thoroughly tested as to its fitness for use, when complete and in its proper place.

Under this head, as an appurtenance, will be included a line of force tube from the Air Chamber to the Distributing Reservoir, with four check valves, and all the necessary joints, flanges, bolts, nuts, &c., laid complete, and subjected to proper tests of its tightness, durability and strength.

The above work to be commenced within days of the date of contract, and completed within months.

DISTRIBUTING RESERVOIR.

The Distributing Reservoir shall be constructed on the vacant ground bordered on the North by York, and on the West by Dundurn Streets, the structure being 550 feet front on York, and 400 feet front on Dundurn Street.

It shall be divided by a division wall into two apartments, connected with a connecting wear of rubble masonry, provided with a copper wire screen and three gates, arranged so as to draw in succession from the surface to the bottom, and provided with screw shafts, columns, hand wheels, and all other necessary appurtenances.

It shall also be provided with a waste wear and well, common to each apartment, a distributing chamber to each, fitted with a copper wire screen and three gates adapted to 2 by 3 feet openings, arranged so as to draw down in succession from the surface to the bottom, and an influx and drainage chamber to each; said chambers connecting with the distribution and drainage pipes and force tube.

The walls on the West, South, East, and a portion of the North side of the Reservoir, to consist of an embankment, formed from the material excavated, 28 feet high above the bottom level, 10 feet wide at top, faced with a line of dimension flagging, 4 feet wide by 4 inches thick. The inner slope of said embankment shall be lined with brick masonry 8 inches thick, built on a slope of one to one; the outer slope shall be one and a half to one, supported by a wall of rubble masonry, about 6 feet high above the ground level, surmounted with a coping of flag stone $2\frac{1}{2}$ feet wide by 6 inches thick. To have a central wall of puddling constructed in benches, being 10 feet wide at base, 4 feet at top, and 31 feet in height. The retaining wall to have a foundation of concrete, 5 feet wide, 12 inches deep, laid 5 feet below surface of ground, and to be three feet thick, with a batir of one in six.

From the corner of Dundurn aud York streets, to the Central Pipe Vault, a Vault will be constructed inside of said retaining wall, forming a Chamber 6 feet high and $7\frac{1}{2}$ feet wide, with an arched roof, through which the force tube and drainage pipe will connect with the Central Pipe Vault. The retaining wall and embankments will be built as above described, to the junction with the Centre Pilaster.

The division wall shall be built of rubble masonry, with a section 10 feet wide at base, resting on concrete masonry 12 feet wide and 12 inches deep, and 3 feet 4 inches at top, the sides being $2\frac{1}{2}$ feet thick, filled in with puddling. On said wall a flag coping 4 feet wide and 4 inches thick shall be laid.

On the York street front the Central Pilaster will be built of rubble masonry, faced partly with dressed masonry and partly with cut stone masonry, per plan. The side walls at the junction with the earth embankment will be carried up plumb on the sides, with a thickness of three feet, and a face batir of one in six, to the level of the top of embankment: the central portion will be of cut stone masonry, with a face and side batir of one in six, being 20 feet wide at the coping. To be surmounted with a coping and parapet of cut stone, connected on either side with an iron railing 3 feet high, around the coping of said walls, and to have an entrance ornamented with cut stone jambs and lintels. The whole to have a rubble masonry foundation on a concrete bed.

The inner wall of the pilaster to be of rubble masonry 3 feet thick, with the same face batir, and connected with the outer, by a stone arch of $3\frac{1}{4}$ feet radius, on which the concrete filling and the flagging of the upper floor will rest. Said inner wall to connect with and form part of the waste wear, drainage and influx, and distribution chambers, aforesaid, and to be built in all respects according to plans and directions. On the outer side of each distributing chamber, wing walls will be built to support the embankment slopes which terminate against them.

The water chambers of the reservoir to be 25 feet in depth when full, and so arranged that either may be used for either influx or efflux.

Under this head will be included the line of drainage pipe, 12 inches in diameter, laid parallel with the force tube to the Engine House, and north side of the Railroad embankment, which shall be laid agreeably to the Specifications for "Distribution" and connected with the force tube as may be directed.

This work to be made, in all respects, according to the plans and directions of the Chief Engineer, and the foregoing specifications. To be commenced within days of the date of Contract, and completed within months.

DISTRIBUTION.

Through such graded streets of the City of Hamilton, as may be designated, the distributing mains and pipes, stopcocks, hydrants, hydraunt connections and drains, shall be fully placed and connected as directed, in the most substantial and workmanlike manner.

The mains and pipes to be laid with thin upper surface not less than 4 feet below the street grade, the trenches being excavated to a sufficient width and depth for this purpose, and the backfilling carefully replaced and rammed, and the pavement (if any) relaid, after the pipes are laid and connected as aforesaid.

The several lengths of pipes (or the material from which they are made) to be thoroughly tested, to the satisfaction of the Engineer. The York street main to be connected with the Distributing Reservoir, and the several mains and pipes to be connected with each other agreeably to directions.

All the work to be done according to the plans and directions of the Chief Engineer. To be commenced within days of the date of Contract, and completed within months.

ESTIMATES.

The estimates for the work, and its several parts, are arranged in the following order:—

Pumping Reservoir Culvert.
Pumping Reservoir.
Engine House.
Engine and Machinery.
Distributing Reservoir.
Distribution, (Cast Iron Pipe.)
" (Indestructible do.)
" (C. Iron do.) Reduced District.
" Indes. do.) " "

SUMMARY.

For more convenience in calculation, the detail prices are given in Dollars and Cents., the aggregate being made in Currency. The prices of the several parts of the work, I have endeavoured to keep at a safe and remunerative rate, preferring to make them somewhat above what may be considered the present value. Whatever excess of this kind there may be, you can readily judge.

I find that the aggregates compare very favourably with similar supplies to other cities.

ESTIMATE FOR PUMPING RESERVOIR CULVERT

		$ c.		$ c.
Excavation, 1,000 c. yds.	at	0,20	......	200,00
Embankment, 3,000 c. yds.		0,15	......	450,00
Sheet Piling, (oak) 3,870 b. m.		25,00	......	96,75
Ribands, 336 b. m.		30,00	......	10,08
Piles, 20 feet long. 8 b. m.		7,00	......	56,00
Concrete, 56 c. yds.		6,00	......	336,00
Rubble Masonry, 230 c. yds.		6,00	......	1,380,00
COFFER DAM.				
Embankment, 900 c. yds.		0,15	......	135,00
Piles, (20)		7,00	......	140,00
Sheet Piling, 5 inch, 6,000 b. m.		25,00	......	150,00
Excavation, 600 c. yds.		0,30	......	180,00
Bailing, &c.			......	1,500,00
Screen, (copper wire)			......	350,00
Iron Gates, complete, (2)		200,00	......	400,00
Temporary Railroad Bridge			......	500,00
				$5,833,83

ESTIMATE FOR PUMPING RESERVOIR.

Excavation, (under water) 24,000 c. yds.	at	0,30	....	7,200,00
Embankment, 6,000 c. yds.		0,18	......	1,080,00
Land, (4½ acres)		2000,00	......	9,000,00
				$17,280,00

ESTIMATE FOR ENGINE HOUSE.

Spruce Piles, 20 ft. long, (236)	at	7,00	....	1,652,00
Capping, (oak,) 4,600 b. m.		25,00	....	115,00
Planking, " 4,700 "		25,00	....	117,50
Treenails, (236)		0,05	....	11,80
Concrete, 107 c. yds.		6,00	....	642,00
Foundation Stone, 967 sq. ft.		0,25	....	244,00
Rubble Masonry, 500 c. yds.		6,00	....	3,000,00
Flagging, 4. 2,400 sq. ft.		0,20	....	480,00
Cast Iron Beams, 10,000 lbs.		0,04	......	400,00
W. Pine Flooring, 1,500 b. m.		20,00	....	30,00
Brick Masonry, 375 c. yds.		12,00	......	4,500,00
Cut Stone Water Table, 290 ft.		1,50	......	435,00
" Window Sills, (25)		3,00	....	75,00
" " Lintels, (25)		4,00	....	100,00
" Rustic Blocks, (404)		1,50	....	606,00
" Chimney Cap, (1)			....	100,00
Iron and Slate Roofing, 37 squares		0,44	......	1,628,00
Window Frames, &c., complete, (16)		10,00	......	160,00
" " " (9)		8,00	......	72,00
Oak Doors, " (4)		20,00	....	80,00
" " " (2)		10,00	......	20,00
Copper Wire Screen			....	320,00
Iron Gates, complete, (2)			....	400,00
Bailing, &c., Pumpwell			....	5,000,00
				$20,563,30

ESTIMATE FOR ENGINE AND MACHINERY.

	$ c.		$ c.
One Cornish Pumping Engine, Cylinder, 8 ft. stroke, 54 inch. bore, plunger, 26 inches diameter, condensing, with one copper-lined Air Chamber, 8 feet diameter, 16 ft. high, and two Boilers, fitted and erected complete		....	40,000,00
Force Tube, 16 in. diametre, 1,700 feet	6,00	....	10,200,00
Check Valves, (4)	400,00	....	1,600,00
Land, and Right of Way		....	2,000,00
		....	$53,800,00

ESTIMATE FOR DISTRIBUTING RESERVOIR.

Excavation, 53,600 c. yds.	at 0,20	....	10,720,00
Puddling, 14,250 c. yds.	0,40	......	5,700,00
Concrete, 620 c. yds.	6,00	......	3,720,00
Rubble Masonry, 5,500 c. yds.	6,00	....	33,000,00
Brick " 1,400 c. yds.	12,00	....	16,800,00
Cut Stone " 40 c. yds.	15,00	....	600,00
" Coping, 106 ft	4,00	......	424,00
" Door Lintels	50,00	....	50,00
" " Jambs	80,00	....	80,00
Flagging, 8,620 s. ft.	0,20	....	1,724,00
" 4,600 s. ft.	0,30	....	1,380,00
Iron Railing, 85 ft.	5,00	....	425,00
" Stairways		......	1,000,00
Flooring, &c		......	500,00
Iron Gates, complete, (12)	200,00	....	2,400,00
Copper Wire Screens, (3)	350,00	....	1,050,00
Oak Door, (1)		....	30,00
Stopcocks, 24 in., (4)	350,00	....	1,400,00
" 12 in., (2)	80,00	......	160,00
Land, (6 acres)	2,000,00	....	12,000,00
Drainage Pipe, 12 in., (2,000 ft.)	3,50	....	7,000,00
			$100,163,000

ESTIMATE FOR DISTRIBUTION,—Cast Iron Pipe.

6 Inch Pipe,	(74,250 feet)	at 0,98	....	72,765,00
8 " "	(12,850 ")	1,60	....	20,560,00
10 " "	(8,070 ")	2,40	....	19,368,00
12 " "	(2,040 ")	3,00	....	6,120,00
16 " "	(3,450 ")	5,00	....	17,250,00
6 " Stop Cocks,	(10)	40,00	....	400,00
8 " "	(8)	50,00	....	400,00
10 " "	(3)	70,00	....	210,00
12 " "	(1)	80,00	....	80,00
Hydrants,	(146)	40,00	....	5,840,00
Connections, 4 in.,	(2,190 feet)	0,70	....	1,533,00
Proving Press, &c.			....	2,000,00
Labor, &c., Proving			....	3,000,00
Cartage, (2,150 tons)		1,00	....	2,150,00
Laying Pipe, (100,660 feet)		0,40	....	40,264,00
Pipe Yard, &c.			....	1,600,00
				$193,540,00

ESTIMATE FOR DISTRIBUTION.—(Indestructible Pipe.)

6 Inch Pipe,	(74,250 feet)	at $0,80	....	$59,400,00
8 " "	(12,850 ")	1,20	....	15,420,00
10 " "	(8,070 ")	1,50	....	12,105,00
12 " "	(2,040 ")	2,20	....	4,488,00
16 " "	(3,450 ")	3,80	....	13,110,00
6 " Stop Cocks,	(20)	40,00	....	800,00
8 " "	(8)	50,00	....	400,00
10 " "	(3)	70,00	....	210,00
12 " "	(1)	80,00	....	80,00
Hydrants,	(146)	40,00	...	5,840,00
Connections, 4 in.,	(2,190 feet)	0,55	....	1,204,50
Proving Press, &c.			...	2,000,00
Labor and Proving			....	3,000,00
Cartage, (2,150 tons)		1, 0	....	2,150,00
Laying Pipe, (100,660 feet)		0,40	....	40,264,00
Pipe Yard, &c.			....	1,600,00
				$162,071,50

ESTIMATE FOR DISTRIBUTION.—(Cast Iron Pipe.)

REDUCED DISTRICT.

6 Inch Pipe,	(34,510 feet)	at $0,98	....	$33,819,80
8 " "	(4,430 ")	1,60	....	7,078,00
10 " "	(4,120 ")	2,40	......	9,888,00
12 " "	(2,040 ")	3,00	....	6,120,00
16 " "	(3,450 ")	5,00	....	17,250,00
6 " Stop Cocks,	(6)	40,00	....	240,00
8 " "	(8)	50,00	....	400,00
10 " "	(3)	70,00	....	210,00
12 " "	(1)	80,00	....	80,00
Hydrants,	(70)	40,00	....	2,800,00
Connections,	(1,050 feet)	0,70	....	735,00
Proving Press, &c.			....	2,000,00
Labor and Proving			....	2,000,00
Cartage, (1,250 tons)		1, 0	....	1,250,00
Laying Pipe, (48,550 feet		0,40	....	19,420,00
Pipe Yard			....	1,600,00
				$104,890,80

ESTIMATE FOR DISTRIBUTION.—(Indestructible Pipe.)

REDUCED DISTRICT.

6 Inch Pipe,	(34,510 feet)	at $0,80	$27,608,00
8 " "	(4,430 ")	1,20	5,316,00
10 " "	(4,120 ")	1,50	6,180,00
12 " "	(2,040 ")	2,20	4,488,00
16 " "	(3,450 ")	3,80	13,110,00
6 " Stop Cocks,	(6)	40,00	240,00
8 " "	(8)	50,00	400,00
10 " "	(3)	70,00	210,00
12 " "	(1)	80,00	80,00
Hydrants,	(70)	40,00	2,800,00
Connections, 4 in..	(1,050 feet)	0,55	577,50
Proving Press			2,000,00
Labor and Proving			1,600,00
Cartage, (1,250 tons)		1, 0	1,250,00
Laying Pipe, (48,550 feet)		0,40	19,420,00
Pipe Yard,			1,600,00
			$86,879,50

SUMMARY OF ESTIMATES.

	£	s.	d.
Pumping Reservoir Culvert	1,470	19	3
Pumping Reservoir	4,320	0	0
Engine House	5,140	16	6
Engine, &c.	13,450	0	0
Distributing Reservoir	25,040	15	0
Distribution, (Cast Iron Pipe)	48,385	0	0
	£97,807	10	9
Less for Indestructible Pipes	7,867	2	6
	£89,940	8	3
Engineering and Contingencies, (10 p. c.)	8,994	0	11
	£98,934	9	1

WITH REDUCED DISTRIBUTION.

	£	s.	d.
Pumping Reservoir Culvert	1,470	19	3
Pumping Reservoir	4,320	0	0
Engine House	5,140	16	6
Engine, &c.	13,450	0	0
Distributing Reservoir	25,040	15	0
Distribution, (Cast Iron Pipe)	26,222	14	0
	£75,645	4	9
Less for Indestructible Pipe	4,502	16	6
	£71,142	8	3
Engineering and Contingencies, (10 p. c.)	7,114	4	11
	£78,256	13	2

CONCLUSION.

In the foregoing pages I have endeavoured to comprise as concisely as possible, the general and detail features of the Plan of Supply from Burlington Bay, which has suggested itself as the one best adapted to the necessities of your City.

By this Plan the water is taken from the Bay at a point where the water is 18 feet deep, and most free from the wash of marshes and other contaminations, and the effects of cold and stormy weather. It is received in a capacious natural reservoir, by the use of which, among other obvious advantages, the location of the Engine House is fixed inside the Railroad Track, and at the foot of a ravine which forms the best and shortest line to the Distributing Reservoir. This reservoir is established on the Heights, immediately above the Engine House, with which it connects by a force tube, 1,700 feet long, and at an elevation, above the Bay, of 155 feet, giving a head of 72 feet above the more densely settled portion of the City, and containing a supply of 24 million gallons. The Villas at the foot of the Upper Terrace, which are not fully commanded by this elevation, can be readily supplied by a small steam pump and well, when deemed advisable, the primary and annual expense of lifting the entire supply to a sufficient height not being justified by circumstances. The scale of the work is founded on a supply of 50 gallons each to 40,000 inhabitants; a quantity abundantly large for a period as yet belonging to the future.

The aggregate cost of the work, as will be observed, is materially affected by the system of distribution preferred. For the most extended system it amounts to £98,940; and, for the reduced system, to £78,256, including a contingent allowance of 10 per cent.

The cost of maintaining the annual supply will be for fuel, attendance, and repairs of machinery, and the general superintendence and extension of the distribution. The latter items will depend on the extent of supply determined upon, and the additions annually made. A portion are to be classed in the Construction Account, and are covered by the Estimates made. The principal item of annual cost is that of fuel, and, for the maximum supply contemplated, I should consider an estimate of $3\frac{1}{2}$ tons, daily consumption, very liberal. This is based on an assumed duty for the engine, of 500,000 ft. lbs., (or pounds raised one foot high per minute,) which is, in many cases, less than one-half the duty of the Cornish engines. The average annual duty of 36 pumping engines I find to be 638,300 ft. lbs.

The average cylinder pressure required is 20.95 lbs. per square inch. Assuming an expansion of $\frac{7}{10}$, this requires an initial pressure of 28 lbs. The quantity of steam used, per stroke, will be 39.75 cubic feet, which, multiplied by $7\frac{1}{4}$, gives 288.19 cubic feet per minute, to be supplied by the boilers. Assuming the boiler pressure at 30 lbs., it is necessary to evaporate 1 cubic foot of water to make 883 cubic feet of steam, or, to supply the cylinder the boilers must evaporate per minute $\frac{288.19}{883} = 326$ cubic feet of water, or, $326 \times 62\frac{1}{2} = 20.37$ lbs. water. These boilers properly fired, will evaporate not less than 8 lbs. of water with 1 lb. of coal; but assuming the low rate of 6 lbs. per 1 lb. of coal, we have $\frac{20.37}{6}$ 3,395 lbs. of coal per minute or $3,395 \times 1440 = 4888,8$ pounds per day, or 2.18 tons. The estimate of $3\frac{1}{2}$ tons per day, covers, therefore, an abundant allowance for hauling and cleaning fires, and other sources of waste.

The limited time given for the preparation of these plans, and the pressure of other duties, have prevented me from extending more fully the arguments on the peculiarity of each part.

From the manner in which they are to be received, the difficulty experienced in adapting them to your wishes must be apparent. I am of the opinion, however, that the important features will present themselves properly to your consideration, and receive the attention they are entitled to claim: beyond this I have nothing further to ask.

SAMUEL McELROY.

I consider this competitor should receive the *first* premium.

THOMAS C. KEEFER.

MONTREAL, Dec. 23. 1854.

PLAN No. 2.

HAMILTON, Nov. 10, 1854.

To the Fire and Water Committee of the City of Hamilton, C. W.:

GENTLEMEN,

The accompanying Designs, which we beg leave to submit for your approval, have been prepared pursuant to your published advertisement calling for Plans and Specifications of the best method for supplying the City of Hamilton with Water from Burlington Bay.

As you have already fixed upon the source from whence the water is to be taken, we have only to ascertain and describe the best method of rendering it amenable for all its necessary purposes.

From the *Western* extremity of Burlington Bay, as being the purest, and in other respects (as we shall presently show) the most eligible point, we propose to take our supply, and force it by means of a Cornish steam engine through a cast iron rising main of two feet bore, to a storage reservoir at a level of 137 feet above the Bay.

The Reservoir will be of sufficient capacity to contain a supply for 40,000 inhabitants, for 7 days, at the rate of 25 imperial gallons each per day, amounting in all to a cubical quantity of 1,120,000 cubic feet, or 7,000,000 imperial gallons available supply.

The water will be distributed through the City by a main service pipe through King Street; from whence, at the intersection of each street, will branch off the various required sub-mains, or subordinate feeders. Provision is made for a Fire supply, by establishing Hydrants at the angles of the principal streets. A glance at the plan of distribution on "Street No. 1," will exhibit our ideas in this respect more fully and clearly.

The water will be served under a head of not less than 65 feet at the intersection of King and James Streets, which is amply sufficient for all ordinary purposes, although it will not possess sufficient force for use in fires, without the aid of engines. Nevertheless, the pressure under which it will enter the fire engines will diminish the labour of working them *one-half*, as the additional force required to be given to it by them will only be the difference between the velocity of the required jet and that of the water when it enters the engines, added to the friction power of the machine.

The topographical features of the City preclude the possibility of using any higher level, unless the side of the Mountain is chosen for the site, (of the "*Storing Reservoir*,") which is in many respects highly objectionable, on the score of its greatly increased cost, in quadrupling the length of mains and increasing friction, and consequently the annual expenditure as well as the first outlay.

Indeed, it will be readily perceived, upon reflection, that were the increased head, necessary to the extinguishing of fires, obtained without any additional cost either primarily or annually, it would not by any means be wise to make use of it for the ordinary purposes of life, as the certain result would soon be the rupture of service pipes.

The system which we have adopted, viz: the "constant service," under a continual head pressure from the reservoir, scarcely needs, we think, any explanation or defence at the present day.

The evils of the old systems, in connecting the rising mains with the service pipes, without the intervention of the storage cistern, in practice, soon become but too apparent. Whilst the motive power is in action and but little water drawn from the pipes, the pressure is frequently increased to an enormous and destructive extent. Then, again, in cases of sudden emergency, such as a conflagration in the night, when the motive power is at rest, some hours may elapse before any supply can be available.

The comparative low cost of the "direct system" has, in many cases, led to its adoption, where the contingent expenses caused by its irregularities (not at first calculated upon) were soon found to increase it beyond that of more complete operations.

As to the idea of future extension, we have made ample provision for it in all departments of the works, without allowing it to cause any interruption or dismembering when it is called for. As the City gradually extends its borders, the mains can be continued so as to keep pace with it.

Should the increase southward to the rising ground at the base of the mountain call for a liberal supply in that direction, we propose to furnish it from a secondary reservoir in the neighborhood, at a sufficiently high elevation to insure a free flow—the reservoir being supplied by a secondary main, branching from the rising main where it enters the longer reservoir. With this system of a high and lower head the works will be as perfect as there is any possibility of their being made.

When the fire alarm is sounded, the higher head can be temporarily turned on, thereby giving all the effect of a constant supply from that point, without the cost of raising the whole of the water to that height continually.

This combination has been tried and approved of in practice; the tendency to rupture in the service pipes whilst this pressure is in action, can easily be avoided by partially closing the neighboring stop-cocks, so as to retard the velocity, thereby causing loss of head to any amount at will. As to the other portions of our arrangements for extension, the mains are laid at present with maximum diameters and minimum velocities, so that they will serve if need be for five times the proposed number of inhabitants. The motive power is also at present calculated for slow operation and short terms of daily working, so that by increasing only the consumption of fuel they will readily do duty to four times the amount.

Having thus glanced at the leading features of our design, we propose to go more fully into the consideration of each individual department, and shall therefore commence by choosing that portion of the Bay which will be our

POINT OF SUPPLY.

Although Burlington Bay at the present time presents many points from which a comparatively pure supply of water might be obtained, still, as we must have an eye to future fitness equally with the present, the choice of the proper locality is by no means so obvious as might appear at first sight. Navigated water, when it is not purified by a current, is unfit for the purpose, insomuch as it is the common cess pool for all the offal of the wharves and the vessels which pass through it. Steam navigation in particular, has a deleterious effect, through the stirring up of the sediment on the bottom, by the action of the paddle wheels.

It may justly be surmised that before many years have elapsed the whole of the water frontage of the City on Burlington Bay, from the Railway Company's grounds on the West, to the extreme limits of the City on the East, will be occupied with wharves and all their attendant shipping, so that the idea of obtaining a supply from any point within those limits cannot be sustained.

The water eastward of the city is too far distant, not only from the city, but likewise from any elevated ground suitable for a cistern, for the idea of obtaining a supply from that quarter to be entertained for a moment.

The Western extreme of the Bay, between the Company's grounds and the Desjardin Canal, possesses the necessary qualifications of purity of element, and convenience of position, beyond any other point, in reference to this subject.

The bottom of the bay at this point is a clear sandy gravel, and quite free from the aquatic vegetation which pollutes the greater portion of the rest.

This itself is one great feature in its favour, insomuch as vegetation not only pollutes the fluid itself, but by harboring reptile life in great abundance, defiles the water beyond the cleansing power of mechanical filtration.

As to escaping navigation and all its attendant filth, the chances are as ten to one in favor of this point. The high precipitous nature of the shores forbid the idea of wharf accommodation, whilst the narrow formation of the table land above gives security against future pollution by sewerage. Its situation is such that it can never be used as a channel for the passage of craft of any description whatever.

The current of water through Burlington Bay is from west to east, passing from the Dundas Creek through the Desjardin Canal, eastward, and finally entering Lake Ontario by the Burlington Canal.

This motion of the water secures for the position in question the first flow of the fresh water, and prevents as well the possibility of defilement, by the passage westward of the navigated water.

Its proximity to the city and elevated ground is the crowning reason for selecting it above any other. Whilst according to the present survey of streets, a rising main may be taken *direct* to the site of our Reservoir, thereby avoiding all unnecessary friction arising either from distance or curves.

Having thus selected the point of the source from which we take our supply, we shall pass on to the consideration of the next most important point, viz.:—

STORAGE RESERVOIR.

The leading point to be observed in the arrangement of this department, is the obtainance of sufficient head as near as possible to the points of supply and distribution.

The position upon which we have fixed as the site of the Reservoir, is a block of unimproved land on the crown of the ridge towards the western end of the city.

The block, as may be seen from the plate, is bounded on the north by Governor Street, west by Princess Street, south by Oxford Street, and east by Lock Street.

It is the highest ground North of the Mountain, being at present full 117 feet above the bay level, or 45 feet above the intersection of James and King Streets: the depth of our reservoir will add 20 feet more to this head, so that 65 feet of head pressure will be available at the last mentioned point. This we consider quite sufficient for all ordinary purposes, and is in fact fully equal to that of $\frac{3}{4}$ths of the works at present in operation throughout the United States.

The Reservoir is designed in two separate departments, which may be used in connection with each other, or independently, at will. They may also be erected at different periods, without any inconvenience.

The benefits arising from the double reservoir are various. In case of a large demand for fire tending to lower the head, by reducing the quantity of fluid, the draft on the store may be wholly confined to *one*, leaving the other full to maintain the usual supply pressure when the temporary run is over. In case of any derangement in either, or accidental stoppage in pipes, or valves, the other may be turned on whilst the repairs are being effected. As the present population of our City is altogether but 20,000, many years must elapse before the actual water takers will exceed that amount, so that for the present a seven days' supply can be stored in one department, thereby saving the erection of the other until the increase of the population rendered it absolutely necessary.

There is another point to which we would call attention, in connection with this department, one which in the general arrangement of such works, elsewhere, has been too often neglected—we allude to the covering of the reservoir.

Were there no other benefit to be derived from covering, further than protection from the smoke or dust of the City, the expense would thereby be overbalanced. But when we consider the effect of the summer sun in not only increasing the temperature, but (where there is so large a quantity with but little motion) in fostering the production of animalculæ — we consider a covering indispensable.

The heavy frosts of winter will likewise hasten, to a very great extent, the decay or disruption of the basin. These evils a covering will entirely prevent. The roof we propose to cover with galvanized corrugated iron, supported by a light combination of wood and iron framing. The sides to be formed of moveable louver boarding, so as to allow the admission or exclusion of the sun or wind, at will.

The sides of the containing basin are to be constructed of,—First next the water a coat of Hydraulic Cement laid to the thickness of one inch upon alternate coursing of 9-inch and 4½-inch hard brick coursing, bedded in a layer of concrete. Immediately behind the concrete is a layer of puddled clay, varying in thickness according to the depth at which it is placed. Behind the clay is an earthwork embankment, held in position by the stone-work retaining wall, which forms the outward boundary of the Basin. Our reason for substituting the stone wall for the usual earthwork, is the great loss of space which is occupied by the outward slope, forming an important consideration where the ground is held at a high value. Besides with the facilities which the City possesses, for obtaining stone, the cost per runing yard of each will be equal.

The light sandy nature of our soil is a serious objection to the earthwork system, as it would require much more than the usual slope of 1½ to 1, to be serviceable.

We object likewise to the usual position of the *puddling clay* which forms the centre of these mounds. As the object of puddling with clay is to make the retaining structure impermeable, we cannot perceive the utility of placing it some 20 or 30 feet from the fluid which it is destined to check, as the whole of the intermediate strata must necessarily be in a state of saturation highly destructive to it.

The arrangement which we have made in service pipes and mains, in connection with the reservoir, not only gives the use of both or either at will, but allows the water to be shut off from both, and carried, if required, to a cistern at a higher level, as before proposed, under the idea of future extension. An overflow pipe will prevent the water rising beyond the proper level in the cistern. A valve pit and tool house which we have designed in connection with the cistern, contains all the stop-cocks for regulating the supply to either, with the exception of those for regulating the intermediate pipes between the cisterns.

The dimensions of either cistern if reduced into a rectangle of the same dimensions will be 185 + 160 feet, having 20 feet of available depth, the actual depth being 21 feet 6 inches, to allow of sedementary deposit.

Then ft. $\overset{\text{long}}{185} + \overset{\text{wide.}}{160} + \overset{\text{deep.}}{20}$ = 592,000 cubic feet storage, and cubic feet. 592,000 + 6¼ imperial gallons in a cubic foot will be equal to 3,700,000 imperial gallons in each, or 7,400,000 gallons in both.

Then the demand for 40,000 inhabitants, at the rate of 25 imperial gallons per day to each, will be 40,000 + 25 = 1,000,000 gallons, which, multiplied by 7 days, for a week's supply, makes 7,000,000 gallons—the full amount required for use.

By a comparison, therefore, of the cistern capacity, 7,400,000 gallons, with the necessary demand, we have an overplus amounting to 400,000 gallons, or nearly one half day's water, in favour of the cistern or reservoir.

DISTRIBUTION.

The experience of other water works has shewn that nearly one third of the whole daily supply is drawn from the pipes between the hours of 8 and 12 in the forenoon, so that the capacity of our pipes must be such as not only to admit of this amount, but likewise any extraordinary demand, such as fires, &c.

As high velocity in the water passing through pipes, by causing friction, tends to diminish the head pressure, we must in consequence avoid it, as far as possible, by making them of larger diameters than the present demand would actually call for, so that when the daily supply to be delivered has increased to twice the quantity, the mains may serve, without reducing the head pressure to any sensible amount. This we consider much more economical and effective than making the main to supply the present demand, and afterwards adding another when needed.

The reason is that the same quantity when passing through a single pipe of large diameter, does not meet with anything like the same amount of friction as it does when passing through two smaller pipes which, collectively, have the same area as the larger one. The cost of small pipes is also proportionally more when the same amount is delivered. The following figures will exhibit the diameter and velocity of flow in distributing mains

$\left.\frac{\text{160,000 cubic feet per day,}}{\text{4 hours.}}\right\}$ = 40,000 per hour, at the rate of delivering the whole in 4 hours if needed.

Then $\left.\frac{\text{40.000 hourly supply.}}{\text{3.600 seconds in minute.}}\right\}$ = 11.6 cubic feet to be delivered per second; or nearly.

Then $\left.\frac{\text{11.6 per second.}}{\text{3.1416 area of 2 feet pipe.}}\right\}$ = 3.3 feet velocity through mains per second.

Even at this comparatively slow velocity there will be some reduction of the head pressure, as may be more clearly seen by the following Table, exhibiting the available heights at the intersections of the various streets with King Street:

TABLE
OF
Levels of King Street, at the intersections of cross Streets.
Calculated for a Velocity of 3.3 feet per second.

STREETS.	ACTUAL HEADS.	THEORETICAL HEADS.	DIAMETERS
	Feet.	Feet.	Feet.
King	30.63	29. 6	2. 0
Pearl	21.22	19.72	2. 0
Rae	20.22	17.80	2. 0
Queen	28.91	25.50	2. 0
Hess	41.36	37.40	2. 0
Caroline	51.73	47.00	2. 0
Bay	55.82	50.80	2. 0
Park	59.12	52.50	2. 0
McNabb	64.49	56.70	2. 0
James	65.29	55.50	2. 0
Hughson	85.29	54.50	2. 0
John	65.28	53.50	1.10
Catherine	67.80	54.80	1.10
Mary	69.92	55.90	1. 6
			1. 6

By referring to Plate No. 1, the arrangement of service main and pipes will be seen. The supply main is taken from the Reservoir, along Lock Street to King Street, and from thence down through the centre of the City.

Sub-mains are carried from it into the cross streets wherever deemed necessary, and angle joints and stop-cocks left for future use, opposite each street, where water is not needed at present. Hydrants for fire supply are placed at the angles of each block wherever the water service is taken.

We have not made any provision for any general system of measurement—of the quantities of water used by the takers, as the high price of meters is a serious objection. It has been found quite sufficient to collect a general water-rate, and allow an unlimited use of the fluid. Indeed among the poorer classes the use of the water is rather to be encouraged than restricted. In manufactories, however, or any large public establishments, where considerable quantities are taken, we would advise the use of a registering meter. We have not included one in our details because there are numerous patents for the purpose which can easily be had at any time

As the Water from Burlington Bay, at the point from which we propose to take it, is sufficiently pure for domestic use, we have deemed it unnecessary to incur the expense of filtering. But as for drinking purposes it may require to be somewhat purified; we exhibit in our details a drawing of a very simple and efficient filter for attachment to the service pipes from which filtered or common water may be obtained at will from separate cocks.

Open fountains, or "Jets d'Eau," should be placed in the King Street Gore, and Market Square; the head pressure at these points will be sufficient to raise the jet about 30 feet. We include them in our estimate of the cost.

Before closing our remarks on this department, we will reconsider the amount fixed upon as the daily supply for each person, in comparison with that of other cities, a list of which collected from various sources we subjoin:

CITIES.	DailySupply each person. *Imp. Gallons.*	CITIES.	DailySupply each person. *Imp. Gallons.*
New York	50	Detroit	22
Boston.............	66	London	28
Philadelphia	35	Albany	31
Nottingham	70	Paris	20
Plymouth.	10	Hamilton	25

The variable results exhibited by the foregoing Table, are consequent upon the peculiarities of each City, not only as to natural advantages, but likewise to their progress in manufactures. The necessity for an artificial supply is greatly augmented by a stiff clayey impermeable soil, which retains the rain upon the surface, whilst in the case of a light sandy or gravelly soil, such as that of Hamilton, the natural supply from wells is quite sufficient, unless it may be in the densely populated portions which surrounds the business streets.

In the City of Detroit, for instance, the soil is of such an impermeable character, that the water which finds its way into wells is altogether surface water, charged with all the impurities which it collects in its course. The consequence has been the establishment of water-works in that city where the population was but 1,500 persons.

Extensive manufactures and dense population for the area of ground, likewise demand a heavy proportional supply.

The amount upon which we have fixed for Hamilton is about the general average, according to most cities.

Its natural advantages, however, are so high that in comparison with most others, its artificial demands might be placed at a minimum rate.

THE MOTIVE POWER AND CONVEYANCE.

The superiority of the Cornish pumping Engine, for raising water, has been demonstrated by a long and careful series of experiments extending over many years of operation in the mines of Cornwall.

In some instances, by the burning of one pound of coals, it has raised 1,254,848 pounds of water to the height of one foot, a duty which has not as yet been performed by any other engine.

The particular description of engine which we propose to use is the Single Reverse-Action Condensing Engine, using the steam expansively, the duty of which may fairly be stated at an average of 1,000,000 pounds of water, raised one foot high, for each pound of coals.

This amount, which we consider a fair average, will form the basis of our calculations in estimating the running cost per day of elevating our water supply.

In order to guard against the risk of stoppages, through derangement in machinery, we propose to use two small engines instead of one large one. By making the engines raise the whole supply for 40,000 inhabitants in 8 hours of working time per day for 6 days in the week, we have ample room for extension, by increasing their time of working.

Therefore, as the weekly supply—1.120.000 cubic feet—is to be raised in 48 hours, we have $\frac{1.120.000}{48} = 23.333$ cubic feet raised per hour, or nearly 389 cubic feet per minute.

Then, to find the necessary horse power of each engine, working at the rate of 10 strokes per minute, we have $\frac{389}{2} = 195$ nearly, for each, per minute or $\frac{195}{10} = 19\frac{1}{2}$ or say 20 feet at each stroke or lift. Then, as the stroke of pump is $5\frac{1}{2}$ feet $- \frac{20}{5\frac{1}{2}} = 3.63$ feet cubic, the area of pump—which will therefore be 2 feet 2 inches diameter in bore.

Then, as the total rise to reservoir is = 137 feet, by adding $2\frac{1}{2}$ feet for friction in pipes at a velocity of 2 feet per second, we have 139.5 feet, the theoretical head which the water requires to be raised to.

Then, 139.5×2.06 the velocity per second, gives 279.0, the number of cubic feet per second, or 279×60 seconds per minute = 16740 cub. ft. per minute. Then 16740×3.1416, the area of a pipe of 2 feet diameter, gives 52731, the cubical contents of the whole column. Then, $52,731 \times 62.5$, the number of pounds in a cubic foot of water, gives 3295687.5, which divided by 33.000, the unit of horse power, gives 99.8, or nearly 100 horse power to elevate the whole supply. As the friction of machinery requires the addition of one-fifth, it will amount to 120 horses for the whole power, or two engines of 60 horse power each, to elevate 1.120.000 cubic feet of water to a height of 139 feet in 48 hours.

The cost of fuel for this labour will amount to Nine Pounds currency, at the rate of one pound currency per cord of wood—assuming one cord of wood to be an equivalent to 960 lbs of bituminous coal.

The yearly cost of fuel would therefore be Four Hundred and Sixty-eight pounds currency, or nearly three pence for each person.

As provision against fires we have stationed at the angles of each block, wherever our pipes extend, Hydrants of double capacity to the number of 82.

We also use Stop-cocks at the intersections of the sub-mains with the principal one, to the number of 85 in all, including those engaged about the Tank, in order to be able to cut off supplies at pleasure, from any district.

SPECIFICATION

Of Work to be done and Materials to be used in the Construction and Completion of the Water Works, for the City of Hamilton, according to the accompanying Plans.

RESERVOIR.

To be constructed of dimensions and form as shewn on Plate No. 3, and as more particularly detailed in section, on Plate No. 4.

The Stone retaining walls will be finished on the exterior in coursed rock work, having not less than 10-inch beds. The interior of the wall will be formed of random-coursed rubble work, having all the stones dressed to rectangular forms with their beds laid level. The Cornice or String Course, along the top, will be formed of two thicknesses of Bush - hammered and tooled free stone, in lengths of not less than 4 feet, and of the respective widths of 2 feet and 3 feet for the under and upper courses. The wall will be built of mortar composed of one part of the best fresh well burnt lime to two parts of clean sharp sand, thoroughly incorporated together. Mortar to be well flushed up into the centre of the wall, so as to be quite solid. The exterior will be finished off with a neat $\frac{3}{4}$-inch tape joint, upon the rock work ; the upper two courses will be set in putty.

The earth work will be excavated or embanked in the various portions, as may be required to form the tank according to the drawings.

The embankments are to be well rammed down in 6-inch layers as they are formed. All new formed earth work, wherever it is placed in the works, must be thoroughly rammed. All superfluous earth must be removed from the site entirely, and distributed as may be directed by the City Authorities.

The puddled clay will be covered over the whole interior of Reservoir of the thickness and form denoted by section on Plate No. 4.

The puddling to be thoroughly worked with plenty of water in not more than six inch layers at a time.

The concrete will be composed of one part of the best well burnt fresh lime, mixed with six parts of screened gravel, thoroughly incorporated. The mixture must be first made without water, the lime being finely ground for the purpose. When wetted it must be briskly brought up, and deposited in its position while quite hot.

The brickwork will be built in alternating layers, as per section, solidly bedded in the concrete, having the joints made with Hydraulic cement.

The whole of the interior of reservoirs will be covered with an inch coating of Hydraulic cement, laid on in two coats of half inch thickness each.

The roof will be constructed as per plan, covered with corrugated galvanized sheet iron, fastened by galvanized nails to light heading pieces supported by rafters and framing, as delineated on plate No. 3.

The framing will be constructed as per plan, in the most workmanlike manner, with iron ties, bolts and nuts, where shown or required.

The sides will be formed as per plan, with moveable louvre boarding filling the intervals between the supports. The louvre boards will be connected together by tie or regulating rods.

The whole of the wood work, both inside and out, is to be finished with three coats of the best white lead and linseed oil, with approved toning colours.

ENGINE HOUSE AND WHARF.

The piling for Wharf and engine foundations is to be driven to a solid bearing, caused by the percussive power of a driver of 1800 lbs. weight falling from a height of 20 feet. The piles to be of hardwood of the necessary lengths, and not more than 14 inches or less than 10 inches diameter. The piling under walls of building will be driven in four rows, at 2 inch intervals.

The foundations for machinery and smoke chimney to be piled close under the whole area.

The foundations will be laid on two stratas of 3-in. pine planking, crossed and spiked to the level sawed heads of piles.

The Wharf will be covered with one layer of 4-in. pine planking, pinned down, close joints, to horizonial bearers framed upon the piles. The outer edges of wharf will be finished by 6 × 8 oak guard pieces. The sides will be planked to a depth of 6 in. below the water line with 3 × 6 in. battens well spiked to piles.

Provide and fix 8 heavy mooring posts 15 in. diameter and 4 feet high above wharf—of length sufficient to drive 6 feet into bottom, and at wharf level thoroughly joined by framing to the other timbers.

The conveying canal or tube from the pump well in engine house to the point of supply, will be constructed 4 feet in diameter, of circular stave work bound by iron hooping at every 2 feet run; the staves will be 12 feet in length, 2 in. thick, and not more than 6 in.

wide. A second bottom of horizontal planking, 4 feet in width, will be attached by braces and hoop iron bonds. The whole will be sunk and retained in its proper position by a ballasting of stones laid upon the false bottom.

The Building will be erected, as per plan and section, of brick-work with stone dressings; the timber used is to be clear, dry and sound, wrought according to the varying forms and details, in the most workmanlike manner. The whole of the wood work, inside and out, is to be painted in three coats of oil colours. The sashes are to be glazed with the best German sheet glass. Provide and fix all necessary iron work required in the construction of the building.

TABLE

Showing the position and diameters of Pipes as laid through the Streets.

STREETS WHERE LAID.	SPACES OF LAYING.			DIAMETERS. ft.	in.
Lock	Engine House	to	Reservoir......	2	0
"	Reservoir	"	King Street....	2	0
King	Lock Street	"	McNab Street ...	2	0
"	McNab Street	"	James Street ...	1	10
"	James Street	"	Hughson Street.	1	8
"	Hughson Street	"	John Street	1	6
"	John Street	"	Catherine Street.	1	4
"	Catherine Street	"	Mary Street....	1	2
Bay..........	King Street	"	Cannon Street..	0	6
McNab	Hunter Street	"	Cannon Street..	0	8
Park	Maiden Lane	"	Cannon Street...	0	6
James	King Street	"	Gore Street	1	0
"	Gore Street	"	Lind Street	0	10
"	King Street	"	Tyburn Street..	1	0
"	Tyburn Street	"	Augusta Street .	0	8
Hughson......	Main Street	"	Lind Street	0	8
John	King Street	"	Lind Street	0	10
"	King Street	"	Catherine Street.	0	8
Catherine	Tyburn Street	"	Henry Street...	0	8
Mary	King Street	"	Rebecca Street..	0	6

The piping to be laid through the various streets as delineated upon the Service Plan on Plate 1, and according to the diameters of bore as mentioned in the foregoing table. The pipes to be laid of the depths and ranges as shown in the profile sections of the streets, upon Plate 2, but nowhere approaching nearer the surface than five feet from the tops of the pipe. The filling in to be well rammed, as solid as before, and the street repaired and left in as good condition as it was found at first.

The piping joints to be formed as exhibited in details on Plate 6. The jointing will be first caulked with oakum, and then the outer portion run in with melted lead to the depth of 2½ inches, afterwards well caulked.

The pipes to be subjected to a pressure of 250 lbs. to a square inch, previous to laying, and no article whatever is to be admitted into this department of the works, which has not stood this test.

The open ends of the present terminations to service pipes are to be closed by a temporary cast iron cap, rendered water-tight and secured to pipe by wrought iron portable screw clamps. Stopcocks of the proper diameters for the pipes are to be placed at the junction of each of the subordinate feeders with the main in King Street, and likewise where denoted in connection with the reservoir, another not shewn in the designs must be placd at the bottom of rising main, in the engine house. The stopcock spindles are to be brought up through a faucet into a stone cap sunk below the level of the street. The opening in stone cap to be closed with a heavy cast iron cover.

Hydrants of the form and dimensions, as exhibited in the details on Plate 6, are to be placed to the number of 82, at the angles of the different streets, as marked on City Service Plan.

COST.

The works as we have designed them in the plates and specifications are of so heavy and permanent a character, that they would involve a much greater outlay than would be needed were the present or even future demands, for 10 years hence, to be taken into consideration alone. Our 2 feet mains are quite sufficient for the supply of a City of 200,000 inhabitants, and it is with a view of their being able to serve that demand, when the City requires it, that we have designed them so large. It is a common complaint with other cities, where such works have been for some time established, that the mains are insufficient to supply the increased demand, owing to their having been laid on too economic principles at the first.

The cost of constructing the whole of the works, according to the designs, will amount to the sum of 63,628 pounds currency, as exhibited in detail, in estimate on next page.

No. 1.—ESTIMATED COST OF THE WORKS,

AS PROVIDED FOR IN THE REPORT AND SPECIFICATIONS.

	£	S.	D.
Steam engines and pumping apparatus complete	6000	0	0
Engine House and Wharf, &c.	3000	0	0
Reservoir	16742	0	0
Distributing and Supply Mains	33781	0	0
Hydrants	820	0	0
Stopcocks	255	0	0
	60598	0	0
Engineering	3030	0	0
Total Cost	£63,628	0	0

No. 2.—ESTIMATE OF COST, IF EXECUTED ON A MORE REDUCED SCALE.

	£	S.	D.
Steam Engine and Pumps	4500	0	0
House and Wharf	2500	0	0
Reservoirs and Site	7300	0	0
Mains, Piping, &c.	16472	0	0
Hydrants	600	0	0
Stop-cocks	150	0	0
	31522	0	0
Engineering	1580	0	0
Total Cost	£33,102	0	0

Then to ascertain the yearly cost, we have

	£	S.	D.
6 per cent. Interest on Capital	3,817	13	7
Fuel	468	0	0
Wear of Engines, Tallow, Oil, &c	300	0	0
Salaries of employees	500	0	0
Yearly Cost	£5,085	13	7

Or about 3 pence currency for the elevation and distribution of 1111 gallons.

The estimate, No. 2, is provided in order to shew the decrease in cost by using mains of one-half the diameter which would be sufficient to supply the City for 20 years to come.

This estimate only takes into consideration the erection of one half the reservoir, without any covering. One of the Cornish Engines is also omitted, the other being sufficient to do the work, and a duplicate power for emergencies being provided, in the form of a High Pressure Engine, of 25 horse power.

As it does not remain with us to decide upon which scheme may be adopted, we have only to remark, in conclusion, although the balance at present is greatly in favor of the construction of works to meet the present or only immediate future demand, still, in the long run, we consider the first estimate for the more extensive works considerably the cheapest. When such projects as these are entered into by Cities so promising as Hamilton, the calculations should not be limited to the necessities of one generation, but be formed upon a wide and liberal basis, embracing the probabilities of the future as well as the necessities of the present.

We have the honor to remain,

Your most obedient servants,

"DETUR DIGNISSIMO."

JOHN RYALL.
THOMAS SMITH.
DAVID MURRAY.

I consider these competitors should receive the *second* premium.

Montreal, 23rd Dec., 1854. THOMAS C. KEEFER.

PLAN No. 3.

The Chairman of Fire and Water Committee, City Hall, Hamilton.

"NON QUO, SED QUOMODO."

REPORT AND SPECIFICATION OF PLANS

Herewith submitted, for the Supply of the City of Hamilton with Water from Burlington Bay.

The general arrangement of Main, and Sub-main, and Service-pipes, is indicated by blue lines on the accompanying enlarged Map of part of the City of Hamilton. The position of the Distributing Reservoir, Engine House, Stand-pipe, &c., is also shown thereon; and the height of the water in the Reservoir above the several streets, at their intersections, is given in red figures.

SITUATION OF RESERVOIR.

The situation chosen for the Reservoir is on the high ground to the south of the property of Sir Allan McNab; it occupies the entire Block bounded by Florence, Governor, Lock, and Princess Streets, and is slightly undulating (but in the main nearly level), affording an excellent base for the embankments, and is therefore preferable to a site, the natural surface and underlying stratification of which deviates in any great degree from an horizontal direction.

CONSTRUCTION, ETC.

The Reservoir is divided into two compartments by a central embankment, provision being made (as hereafter described) for the thorough cleansing of either compartment without emptying the other, or interfering in any degree with the continuous supply of water. The Embankments are proposed to be formed of clay of a retentive quality, an abundance of which can be readily procured in the neighborhood. The outer slope is at the rate of one and a half to one, and the inner at the rate of two to one; the bottom and inner slope to be lined with hard-burnt clinker Bricks, laid on edge, and grouted with hydraulic mortar, and resting upon a bed of concrete one foot thick, the embankment and bottom having been first puddled with blue clay; injury to the embankment from the percolation of water through its substance will thus be effectually prevented.

SIZE OF RESERVOIR, ETC.

The size of each compartment will be, at the water line, 170 feet long, and 150 feet wide: the depth of water will be 21 feet: the height of the water above the average level of the Bay will be 144 feet. The capacity of each compartment will be 2,022,433 gallons: the entire quantity of water in both compartments will be 4,044,866 Imperial gallons, or 4,850,338 American gallons, affording a supply for more than four days to 40,000 inhabitants, estimating the quantity to be supplied to each at 30 Imperial gallons per day, or 36 standard American gallons.

SUPPLY PIPE, &c.

Each compartment is provided with a separate influent or Supply Pipe from the Engine, entering the Reservoir at the point indicated on the Drawings. This pipe terminates in a chamber of masonry, arranged in such a way that the current of water therefrom is directed upwards, and is effectually hindered from wasting away or otherwise injuring the bottom of the Reservoir, as is frequently the case when the Reservoir being empty the water is let on from the Engine, and when no provision of this kind is made for diverting the force of the current from the bottom; it has also the effect of preventing the current from disturbing any sediment which may happen to be at the bottom of the Reservoir, and which would otherwise become mixed with the entire quantity of water therein.

VALVES, &c.

This Pipe is provided with a hinged Valve, so that when the water is shut off, or the Engine ceases to work, the water cannot flow back to the Stand-Pipe; and thus repairs can be effected upon the Valves and Stand-Pipe without any risk of flooding. Each branch of the Supply-Pipe is provided with a Slide Valve (shewn on sheet, No. 12,) by which, connection with the Engine can be stopped when necessary. These Valves, as well as those of the Cleansing-Pipes, are enclosed in a Valve House, for greater convenience in reaching them for repairs, or other necessary objects. The apparatus for raising or lowering the Slide Valves is placed in the Ground Floor of this Building (the whole of this apparatus is shewn in sheet No. 11,) so as to be easily within reach of the attendant.

CLEANSING PIPES, &c.

The Cleansing Pipes, one from each compartment, also pass through the lower story of this Building, and are provided with valves, similar to those already described. These Pipes communicate with a Well lined with masonry, and sunk below the bottom of the Reservoir, which inclines in every direction towards this well. The Cleansing Pipes pass from this point through the Valve House to a receiving well, placed outside the building. When it is required to draw off the water entirely from the bottom of one of the compartments, for the purpose of cleansing or repairing them, the Valve being opened, the last of all the contents is received in the wells above mentioned, and is drawn away through the Cleansing Pipe into the receiving well, and passes thence into the Main Sewer. A Man-Hole is constructed in the crown of the arch over this well for the purpose of giving admission thereto and for removing any silt or mud which may be deposited therein.

DELIVERY FROM RESERVOIR, &c.

The Delivery from the Reservoir is arranged in such a manner that the water may be drawn either from one compartment alone or from both at once, each division having its own separate outlet. The orifice of each effluent pipe is enlarged to receive a perforated screen of sufficient size to permit the quantity of water necessary for filling the pipe to pass into the Main, the screen preventing any grosser matters which may be in the Reservoir from passing into the delivery pipes. The effluent pipes pass through a Valve House similar to that already described, and are united in one principal Main of 18 inches diameter, at a little distance. The arrangement of these, as well as the influent and cleansing pipes is shown in the plan and details of the Reservoir, Sheet No. 10.

CONNECTION PIPE BETWEEN COMPARTMENTS, &c.

In order to keep the surfaces of both the divisions at a level, a connecting pipe is placed in the central embankment: this pipe is bedded in concrete; and midway a Slide Valve is inserted for opening or shutting the pipe. A circular well or Man-hole is constructed at this point to give access to the valve: a moveable oak frame, supported on stone corbels, projecting from the face of the wall, serves to steady the valve spindle, and to give standing room to the attendant when closing the valve. This framing, as well as the timber covering on the top, can be removed whenever it may be necessary to repair the valve.

WASTE PIPES, &c.

When the water has reached its proper height in the Reservoir, (which is 1 foot 6 inches below the top of the embankment,) and still continues to flow from the Engine, the surplus water rising in the waste pipes to the bend therein, falls over it into the water-bag in the waste-weir well below, and is thence carried off into the main sewer. At this point the embankment is raised between two retaining walls of masonry to the height of 4 feet over the pipes, so as to protect them effectually from the frost, and the mouth of these waste pipes is sunk to a depth of 8 feet below the water line for the same purpose.

SURFACE DRAINAGE.

A raised terrace, 10 feet wide, is formed round the base of the outer embankment to protect it at the foot; and on the outer margin of this is constructed an open paved drain, which will receive the superficial drainage of the embankment, and convey it to the sewer through the necessary gratings and gully drains constructed at each angle.

MODE OF DISTRIBUTION, &c.

The mode of distributing the water through the city is shewn in the accompanying enlarged map. The principal Main leaves the Reservoir on the South side, and passes along Railway Street to its intersection with King Street; thence along the latter to Queen Street; thence, keeping on the high ground in the neighborhood, on Hunter, Bond, and Anderson Streets, to the termination of the latter Street on the East side of the City. From this Main, Sub-mains proceed down McNab, James, Mary, and Wellington Streets to the North shore of the Lake. At the intersection of the several Streets crossed by these Sub-mains, service pipes are attached by curves of 15 feet radius; those service pipes proceed, as shewn on the Map, towards the East, in which direction the greater part of the ground on which Hamilton is built, inclines. After passing the several intervening blocks, these pipes are again joined to the main, east of that from which they started; and in every case they reach the former at a level very considerably below that of the point whence they first proceeded. The whole of the water is thus made to flow downwards, instead of being forced upwards in the pipes by the pressure of the head. By this arrangement all return currents are avoided, and any sediment there may be remains in a great measure undisturbed. For example, the water leaving the James Street Main, by the Service Pipe at the corner of King Street, reaches the Mary Street Main on the corner of Henry Street, at a level of 36 feet 6 inches below its level in King Street. And again, the junction of the Service Pipe out of the Main on Bay Street, at the corner of Cannon and Bay Streets, with the Main on

James Street, is 21 feet below the point at which it leaves the Bay Street Main. The great advantage accruing from this mode of distribution is that it precludes the necessity of having what are technically termed Dead-Ends, (that is where the ends of the Service Pipes terminate abruptly, without being joined to any other pipe,) which not only occasion a heavy and jarring pressure, but are invariably found to be the receptacles of excessive and very prejudicial deposit, which it is often both troublesome and expensive to remove. Instead of the great number of these Dead-Ends which the adoption of any other mode of Distribution would occasion, there will not be in the whole City any but those at the extreme ends of the Main Pipes; or, in other words, not more than four or five in all. The system, it is true, is to some extent a novel one, but is in every respect the most suitable and efficient for a City situated as Hamilton is. The circulation of the water is uninterrupted, and its descent continuous from the Reservoir to the furthest point to which it is conducted.

CUTTING OFF CONNECTION OF SERVICE PIPES, &c.

The manner of cutting off the connection of the Service Pipes with the Mains has also been carefully considered, and is exhibited in Sheet No. 13. It is effected in this way: At the junction of each Service with the Main, a Hydrant or Fire Plug is placed on the nearest side of the Street; a Sluice Cock is also inserted in the Service at the same place; at the union of the pipe with the lower Main another Stop-cock is inserted, and on the upper side of this is also an emptying cock bolted to a sleeper cast upon the Service Pipe. When it is desired to isolate any length of the pipe, the upper sluice is closed and the Hydrant opened; the water is thus cut off from the Main; the lower cock is next closed, so that none can enter from the lower Main, and the emptying cock being opened, the water contained in the Service is discharged into the receptacle below, and is thence carried into the Sewer by the small connecting Culvert. As the water leaves the Service Pipe, air is admitted, so that the water flows freely off, and the pipe can then be taken up or repaired as may be necessary. These Sluice Cocks are enclosed in arched wells of masonry, having Man-holes in the crown of the arch, so as to be readily accessible when required.

CLEANSING MAINS, &c.

The mode of cleansing the Mains from any accumulation in the bottom of such undulations as may necessarily occur in consequence of the unevenness of the ground, is shown in Sheet No. 13. A cleansing pipe of not less than 6 inches diameter is attached to the Main by a sleeve; this cleansing pipe passes through a man-hole or well, in which is placed a sluice cock, by opening which a quantity of water is rapidly drawn from the Main, carrying with it the silt or mud laying in the pipe, which falls into the water bag in the receiving well and passes thence into the Sewer.

HYDRANTS, &c.

The form of Hydrant or Fire Plug, as shown in Sheet No. 15, possesses many advantages which cannot be claimed for any other with which I am acquainted. In the Drawing referred to is exhibited a vertical section of the Hydrant complete—the cast iron shell is shown bolted to a branch elbow-pipe; this shell has an internal projecting rim or flange near the top, which is bored to receive the hollow brass plug through which the water finds its way into the hose from the Main. A double-threaded screw, one inch pitch, is cut on a projecting spindle, cast in a piece with the lower end of the plug; and this screw works through a brass cross piece checked into the bottom of the outer shell to act as a nut for the vertical movement of the plug in opening and closing the Hydrant. The water from the main always keeps the space between the exterior of the plug and the interior of the shell full as far up as the bored internal flange of the latter; and when the plug is screwed downwards to its lowest position, as in the Drawing, it escapes into the interior of the plug by the line of slots, and thence up the barrel to the Hose. The stuffing box of the plug being intended to stand excessive pressure, possesses several peculiarities. The gland is cast finished, of composition metal, in which tin forms the chief ingredient; the cupped portion at the bottom of its ring, which fits the plug, slightly overlaps a Gutta Percha Ring with a bottom flange; and in the groove formed by this flange and the bottom edge of the gland, a narrow packing ring of Hemp is placed as stuffing, the adjustment being effected by screwing down the three bolts of the gland in the usual manner. The interior of the top of the plug is grooved on each side for the reception of two feathers on the coupling for attaching the Hose; and the upper screw on this coupling is left-handed, so that when the Hose is attached the plug of the Hydrant may be turned to depress it in obtaining a supply of water, without endangering a twisting of the Hose. This Hydrant presents very superior facilities for repair, for it is only necessary to unscrew the four bolts which attach the shell to the Main, when the whole may be lifted out and taken to the workshop, another being put down in its place—the whole operation occupying only a few minutes, and leaving the street undisturbed. The working surfaces are well adapted for durability, and any slight wear cannot affect the tightness of the parts; and the internal pressure in the Mains tends only to close the plug by its action on the screw. Provision is also made for avoiding the effects of frost, as no water remains inside the tubular plug when closed, and as the orifices are passed a short distance above the packing ring, the water in the tube always flows out. The opening screw is of considerable pitch, one turn being sufficient to elevate or depress the plug an inch, and the gradual action of the screw prevents the occurrence of any sudden shock from the rush of water. No stand pipe is required, the communication with the Hose being entirely effected by a short brass tube screwed at each end. For opening and closing, nothing more is required than one of the small lever keys used by the Fire Brigade, so that no delay can occur from want of proper keys. In point of economy, too, this Hydrant possesses advantages over most others, as where they have been used in England they have been supplied at about £1 Sterling each.

PIPES.—SIZE, STRENGTH, &c.

As respects the diameter, thickness, and junctions of the Pipes intended to be used, it may be proper in this place to state, that the sizes of the several Main, Sub-Main, and Service Pipes, are marked in figures on the enlarged Map already referred to; and that the thickness of metal of these pipes will be, for

Service Pipes	of	2, 3 and 4	inches	$\frac{3}{8}$ In.
Sub-Main	"	6, 7 and 8	"	$\frac{1}{2}$ "
Mains	"	10 and 12	"	$\frac{5}{8}$ "
Do.	"	15	"	$\frac{3}{4}$ "

MODE OF JOINTING PIPES, &c.

With regard to the description of joint, it will be seen by reference to sheet No. , that the pipes are shewn with Socket Joints, packed with hemp and leaded, a groove being left in the socket for the lead to run into and thus ensure a perfectly water-tight joint. This method of jointing water-supply pipes has been much practiced, and is no doubt effective when properly done; but it has the disadvantages of greater cost, more trouble in laying, and extreme difficulty of removal should there ever be occasion, as compared with the less expensive, easier laid, and more readily removed and replaced Flange Joint Pipes, packed with Indian Rubber or Gutta Percha packings, and bolted together, as shewn in Sheet No. , and which, therefore, on the score of economy, and greater facility for laying and removal, I propose to adopt in the present works.

STAND PIPE, TOWER, &c.

As in works of this kind it is very desirable to relieve the Engine as soon as possible of the water delivered from the pumps, which is usually effected by the erection of a Stand Pipe, as near to the Engine as may be, and reaching to a height a little over that of the water in the Reservoir, advantage has been taken for this purpose of the high ground immediately adjoining the site of the Engine House, on which it is proposed to erect a Stand Pipe and enclosing Tower, as shewn by drawings on Sheet No. 8. The ground at this point is 83 feet 6 inches above the level of the water in the Bay, the Stand Pipe is 65 feet 6 inches high from the ground level; its total height therefore, about the clacks of the pumps, will be 149 feet, or 5 feet higher than the surface of the water in the Reservoir. At the bottom of the Stand Pipe, leading from the Engine, is fixed a Butterfly or Flap Valve, (also shown in the same Drawing,) the action of which will be to admit the water delivered by every stroke of the pumps to flow up the Stand Pipe, and, at the completion of the stroke, the Valve closes and prevents its return to the Engine—thus immediately relieving the pump valves from the pressure of the water.

A HIGHER SITE FOR THE RESERVOIR, &c.

It may be right here to mention, that although the Reservoir is shown in what to my judgment is, for all present and prospective purposes, the situation best calculated to ensure the completeness and general usefulness of the works, yet that there is another site for the Reservoir (indicated in lines on the enlarged Map), which, if it were deemed preferable to adopt, would secure an additional distributing elevation of 48 feet over the present site. And this change can be made without affecting in any degree the plan and arrangements laid down, further than that the Engines and pumping apparatus would be placed at the foot of Hess or Queen Street; the power of the Engines would have to be proportionately increased; and the leading Main be carried down James Street, and thence as already shown. This Reservoir would be sunk 10 feet below the ground level, and the embankments formed of the soil removed from the excavation. The arrangement of influent and effluent pipes would be similar to that already described, with the exception only of the effluent pipes, which would be made to pass through the same Valve House as the other pipes; and this Valve House would be situated on the North side of the Reservoir.

ENGINES, &c.

The Engines herein set forth are two double-acting condensing Engines, having a Beam supported on two longitudinal Girders and Columns for each. They are worked upon the High pressure expansion principle—that is to say, admitting the steam at a pressure of about 30 lbs. per square inch on the piston, and cutting off the same at an early period of the stroke; thus working at a high degree of expansion, and consequently greatly diminishing the weight and magnitude of the working parts of the Engine; in addition to these advantages, the one and all-important advantage is the saving of wood or coal, which is only to be effected by Engines on this principle. I do not say principle in form, but principle in theoretical construction, based upon practice and observation. The Engine is upon the rotative system, which perhaps to some may appear not so well adapted as the single-acting or Cornish Engine. The Cornish Engine is a very effective one, as it performs its work at a single stroke of the steam cylinder and pump plunger, but it must be remembered that the speed of the Engine is very slow, and one stroke of the piston is used for lifting the plunger, and for this purpose only the steam is employed—hence the ponderous weight and size of the different parts. And of course this Engine is very much more expensive than the Rotative expansive double-acting Engine. By reference to the Drawings (Sheets Nos. 1, 2, 3, 4 & 5) and annexed Specification, it will be seen that this Engine will work a double-acting Pump so constructed as to perform work at every stroke of the Engine, although the pump attached to each Engine has but one working barrel. The velocity of the piston in the steam cylinder will be 15 single strokes, or 30 double strokes, per minute, giving the pump a velocity of 90 feet per minute, which is but a very ordinary speed, and thoroughly effective. The Engine, with such a pump and speed, will at no period have to contend with sudden resistances, the work and speed of the machinery being perfectly uniform in consequence of the action of the pump. On reference to Drawing No. 3, it will be seen that while the pump piston is delivering the water on one side of the same and through the valve marked "*delivery valve*," the water is flowing through the valve marked "*suction valve*" into the space left *in vacuo* by the ascending and descending strokes of the piston—this is performed at every stroke of the same, so that when the stroke is complete and the return stroke is made, the piston meets with the same amount of resistance that it had in delivering the water on the other side—hence the uniformity of the work to be performed. Each Engine is equal to 35 horse power, and sufficient to accomplish the required amount of work.

PUMPS.

The Pump consists of a Cylinder truly bored and fitted with valves as shewn in the drawing. This pump will throw 60 gallons at one revolution of the Engine, or 1,296,000 gallons per day, which is more than is needed, but taking into consideration the waste, the quantity required for manufacturing purposes and fires, it is, I think, only a fair allowance. The total cost of the Engines, Pumps, and Boilers, I estimate at £6,000. The Specification of the Machinery, describing the different parts, is annexed to this Report.

PIPE INTO THE BAY, &c.

The mode in which it is proposed to conduct the water from the Bay to the Suction Well of the Engines, is as follows: a well will be sunk in the position shewn on the enlarged Map, of suitable dimensions, and bricked up in the manner described in the Specification, into which the water will be conducted by a Cast Iron inlet pipe, carried out into the Bay to a distance of 200 yards. This pipe will pass under the Great Western Railway, through the sluice already formed there at the foot of St. Mary's Lane. The pipe to be laid in a channel excavated in the bed of the Bay, surrounded and protected from the water, during the process of laying, by Coffer Dams of narrow width, and in such lengths as shall be found the most convenient to manage; the water being pumped out by a small portable Engine. The pipe will be protected by a covering of shingle and large stones, deposited over it after being laid in its place. The extreme end of the pipe to be terminated by a Perforated Cast Iron Screen. The water passing through this pipe will fall into the well just described, and will from thence be conveyed by a brick-built Culvert, into the Suction Well within the Engine House.

In submitting to the consideration of the Council, this plan for supplying the City of Hamilton with water, from the source specified in the advertisement, I would beg permission to direct attention to the essential requisites for completeness and efficiency which it has been my object to secure. In the first place, looking at the probable rate of increase in the population, my estimate for the supply has been based on double the present number of Inhabitants; and in order that the supply may be ample for public as well as private purposes, the allowance per head has been taken at the maximum. In the second place, to secure as nearly as may be an uninterrupted supply, and to provide as far as practicable against those accidents and contingencies which are inseparable from the system of pumping from the lowest level, I have not only deemed it necessary to put down two Steam Engines and two sets of pumps, but also to have each Engine of sufficient power to perform the needful work alone—working the Engines alternately and regularly, and so having one Engine and a set of pumps always in perfect order, and in reserve for any emergency that may arise. In the third place, I have so laid out all the Distributing Pipes as to secure as complete and continuous *circulation* of the water as possible, knowing that without this provision the quality of the water is often much deteriorated at the lower points, and that both in England and America, many otherwise well-designed works of Water-Supply have been marred in effectiveness by the omission of this preventative. In the fourth place, I have anxiously endeavoured to make full provision for cleansing and repairs, for a abundant supply of fire-plugs easily reached and readily managed, for flushing sewers, street watering, and for all other public purposes. And lastly, I have had such a careful regard to the outlay as is consistent with that durability and completeness which, in all Public Works, and more especially in works of this description and importance, it is the truest economy to make the first consideration.

SPECIFICATION

Of Work to be done and Materials furnished in erecting Reservoirs, Engines, Pumps, and other Apparatus for supplying the City of Hamilton with Water from Burlington Bay, in accordance with the Plans herewith submitted, and bearing the Motto "NON QUO, SED QUO MODO."

The Area of the Reservoir is to be brought to a uniform and fair level, the earth taken from the heights thereon to be used in filling up the depressions of the surface, to be wnll rammed and consolidated in layers of not more than 18 inches thick before the retaining embankments are begun. The Embankments to be formed agreeably to the Plan and Section herewith exhibited; the outer slope to be formed to an inclination of one and a half to one; the inner slope to two to one; the Embankments to be 22 feet 6 inches high from the level of the brick bottom of the Reservoir; the outer Embankments to be 10 feet wide on the top; the central one 6 feet wide, to be formed to the entire width in layers of not more than 18 inches thick, of clay or loam of a retentive quality, well worked and beaten together and thoroughly consolidated before the next layer be commenced; the side slopes to be neatly dressed off to the inclination mentioned above, but not till the whole embankment has been completed. Before the Embankments are commenced, the trenches for pipes, foundations for delivery and cleansing wells, and for Valve Houses, to be dug out to the depths and dimensions shown in the Drawings. A wall of puddley clay, 3 feet thick, to be formed in the centre of each Embankment, descending 4 feet below the bottom of Reservoir and carried up to within one foot of the top of the embankments, to be formed of a clay loam mixed with a suitable proportion of fine gravel, the whole well incorporated together and laid on in courses 12 inches thick, well wetted and cut through vertically with spades every ¾ of an inch till the whole is rendered compact and water-tight. When one course is set another should be immediately commenced, and during any interruptions of the work the last course to be covered with earth or wet straw to prevent cracking. The bottom of each Reservoir to be formed with a slight inclination towards the cleansing wells shown in the plan, and a shallow open paved Brick Drain laid as shown; the inner slope and bottom to be coated with concrete, formed in the manner hereinafter described, and to be paved with hard burnt clinker bricks laid on edge, and grouted between the joints with liquid mortar, composed of Hydraulic Lime and clean sharp sand in proper proportions.

The Cleansing and Receiving Wells, the Pipes, Foundations of Valve Houses, and all other portions of the work in which Concrete is exhibited in the Plans and Sections, to be laid and surrounded with Concrete made in the following manner:—The Concrete to be composed of unscreened ballast or gravel, (to be first approved of by the Engineer,) six parts, and of fresh well-burned stone lime, one part; the lime to be beaten or ground to powder on the premises whilst unslacked, the gravel and lime to be then thoroughly mixed in the proportions mentioned above, and in small quantities at a time, the lime at mixing being slacked with as little water as possible, and the concreted mass immediately after mixing to be thrown or dropped from a staging (constructed by the contractor) so as to fall into the trench provided for its reception from a height of at least 12 feet; the layer of concrete to be of such thickness as the Engineer shall direct, and extending the whole width of the trench, and to be well rammed before any masonry is laid upon it. The Receiving, Delivery and Cleansing Well, Valve House and Stand-Pipe Tower, and all other masonry connected with the Reservoir, will be built of the dimensions and forms as shewn in the respective Drawings of the same. And all the exposed portions of such work to be built of regular coarse masonry, the beds and joints to be dressed perfectly true, both vertically and horizontally, and closely set; the stones, in all cases to be laid on their natural beds with alternate headers and stretchers, the beds to be not less than 12 inches wide, and the courses not less than 12 inches high—the headers to be at the very least 1 foot 8 inches long. Those portions of the work shown as rock-faced masonry, including the pilasters, window jambs, arches, and quoins of Valve House, to be of the best free-stone, with a tooled draft of 1¼ inch wide to all joints and projecting arris. The whole of the rest of the mason work connected with the Reservoir, and also the Receiving and Cleansing Wells and Sluice Cock Wells, to be finished in a neat and regular course, hammer-dressed to a fair surface, and the joints to be close and true both vertically and horizontally. All this work to be backed with the best rubble masonry, of large flat stones laid on their natural beds, and the whole properly laid and bedded in mortar, compounded of one-third well burnt stone lime, and two-thirds of clean sharp sand, well beaten and carefully amalgamated. The parapet, cornice, mouldings, plinth, window and door sills of Valve House to be of free stone walling, tooled on the exposed surfaces—the beds and joints as before described—the door sills to be 12 × 8, and the window sills 12 × 6.

The masonry of the Engine House and Stand-pipe Tower to be executed in the manner herein above described, and in strict accordance with the drawings of the same; such portions as are not shown in rock masonry are to be executed in tooled ashlar masonry. The main shaft of Stand-pipe Tower, the flues, circular shaft of Engine Chimney, and all other work shown in brick, to be built of the best hard-burnt stock bricks—as also the brick casing round the Boilers, Ash-pit, &c.

A Well to be sunk in the position shown in the enlarged Map, for receiving the water from the Pipe into the Bay, will be built of hard bricks laid in Hydraulic Cement on a Cast Iron Curb, with a cutting edge downwards, the soil to be taken out from the interior, and as the Curb sinks the brick sides to be carried up in proportion—the brick to be moulded so as to radiate from the centre of the curve, and to be laid in heading courses two bricks (18 inches) thick. The Well to be sunk to the depth of 25 feet below the ground level: proper openings to be left in the side nearest the Bay, for the insertion of the cast iron Inlet Pipe. The back of the Well to be properly puddled. An arched Brick Culvert to be carried from the Well to the Suction Well of the Engine House.

ENGINES, PUMPS, &c.

The Engines and Pumps to be constructed in strict accordance with the several Drawings thereof annexed, and as hereinafter more particularly specified, viz: *The Cylinder* of each Engine to be 22 inches diameter, having a stroke of 5 feet; to be of fine hard cast iron and accurately bored and fitted in all respects; the cylinder cover and valve spindle-gland to be bushed with fine hard gun metal, and also the bottoms of the stuffing boxes. *The Piston* to be fitted accurately with two brass rings, which are to be acted upon by hemp in the inside of the same by means of a plate and screws. *The Piston Rod* to be of the best faggotted Wrought Iron and properly fitted into the cross-head, and secured by a colter. *The Beam* to be made as per detail Drawings, having the main and smaller gudgeons truly turned and fitted. *The Air Pump* to be of fine hard cast iron, and truly bored and fitted with a piston of the same description as the piston in the Steam Cylinder, and the bushes and glands to be of the same description as those in the Steam Cylinder. *The Air Pump Rod* to be accurately fitted into the gland of the Air Pump lever and attached to the back links of the motion. *The Condenser* to be cylindrical, and of the dimensions and form shown in the drawings, the joints to be all accurately faced and properly furnished with bolts and nuts. *The Injection Cock* to be made of brass, and fastened to the Condenser by means of a flange bolted to the side of the same, and to be provided with a spindle and handle for regulating the supply of Injection Water. *Hot Water Pump* to be of brass, and of the form and dimensions shown in the Drawings, fitted with strong conical valves and all the necessary pipes for suction and delivery: the ram to be of iron, truly bored, and having a rod jointed to the same and attached to the working beam. *The Cold Water Pump* to be made of the finest cast iron, as hard as that of the Cylinder, and fitted with a plunger truly turned, and connected to a rod, and to be worked by the working beam, at the distance shewn in the Drawings. *The Crank* to be of tough cast iron, the eye to be truly bored and fitted into the crank shaft and secured to the same by two strong keys, and not to be shrunk on to the shaft; the crank pin to be truly turned to the dimensions shown on the Drawing, and to be well fitted into the crank, and fastened by means of a colter through the crank and pin. *The Crank Shaft* to be of cast iron, truly turned as per Drawing, having its journals in the position and of the dimensions shown in the Drawing—to be accurately observed. *The Connecting Rod* to be of cast iron, and of the form shown in the Drawings; the small ends to be fitted with continuous straps, with the necessary brasses, pins and colters, all properly fitted; the large or crank end to be solid, having a pin slotted out and brasses truly bored and fitted into the same, and to be acted upon by the colter. *The Fly Wheel* to be 20 feet in diameter, having a section of its ring not less than 28 inches, and not to have less than six arms; to be cast in three pieces and secured at the nave by two wrought iron rings shrunk on to the same; the ring to be fastened by wrought iron straps shrunk on to pieces formed on the same for this purpose, and bolts to pass through the whole, thus securing the ring on both sides—a Drawing hereafter to be furnished. *The Eccentric Pully* to be of cast iron, and having the throw accurately secured according to the Drawing—to be properly bored out and keyed on to the shaft. *The Eccentric Strap* to be of brass, very hard with babbit metal, and fastened together with two nuts and bolts, and of the form shown in the Drawing, with the Eccentric Rod attached. *The Weigh Shaft* to be wrought iron, truly set out and finished, having the starting line and balance-weight of the dimensions shown on the Drawing. *The Slide Valve* to be a long D Valve, leaving the amount of lap shown on the Drawing—to be truly fitted and scraped to a proper surface, and to be cast of fine cast iron, not too hard, to be worked by two good side rods with solid ends fitted with brasses and colters, and attached to a cross head of wrought iron, and the same to be fitted to the valve spindle, which is to have nuts on either side of the same for the purpose of adjusting the travel of the Valve. *The Columns* for supporting the girders to be of the dimensions and form shown in the Drawings, and to be firmly fastened to the transverse plate built into the formation of the Engine Room. *The Girders* to be of the section shown, and fastened to the columns by four bolts; the longitudinal girders to have cheeks and chipping pieces cast on them, so as to be able to get up a true bed for the Plummer Blocks for carrying the main beam gudgeons. *The Plummer Blocks* to be of the form and dimensions shown—to be very accurately fitted in every respect, and the brasses to be of good tough gun-metal lined with babbit metal, and fitted with suitable lubricators. *The Parallel Motions*—the main links to be of the form and dimensions shown, fitted with hard gun-metal brasses, accurately bored, with distance pieces, gibs and colters complete; the back links to be open-ended, having hard gun-metal brasses with distance pieces and keys well fitted; the parallel bars to be round, larger in the centre than at the ends, and of the dimension shown in the Drawings—they are not to have straps, but to be fitted with brasses and keys, with cups for lubricating the working parts: the Radius Rods to be of the same form, very accurately centred. *A Blow-through Valve* to be provided and put in a convenient part for the Engineman to use with the levers of the starting geer. *The Large Pump* to have a Cylinder 17 inches in diameter and a stroke of three feet, with an air vessel to each, a drawing of which will be furnished hereafter: the Cylinder to be of good hard cast iron, very accurately bored and fitted, with a piston of the same description as that described for the Cylinder of the Engine; the Cylinder to be $1\frac{3}{4}$ inches thick, to be fitted with Valve Boxes and Valves; the Valves to be of leather, with a thickness of vulcanized India Rubber at the back of the Ram, the two being drawn together by bolts passing through two iron plates; the Valves to work upon metallic hinges, and this description of Valve to be employed in all parts of this pump, a detail Drawing of which will hereafter be furnished: the Valves must have checks fastened on the inside of the Valve Boxes, and so placed that the Valve shall not open too far; all the joints to be very truly faced, and the Valve Doors to be planed on the joint surface and well bolted to the Valve Box; the Piston Rod to be $3\frac{1}{8}$ inches thick, of the very best faggoted wrought iron. *The Pump Cover* to be well fitted to the pump flange, and thoroughly bolted down; it must have brass bushes and glands. A set of open Valves are also to be provided; all the other parts of the same to be as per Drawing, well bedded down to the bed plate which is to carry both this and the Cold Water Pump. The Piston to be worked by a rod attached to a parallel motion before described, and worked by the large beam. *The Boilers* are to be tubular, and four in number, having an internal Fire Box of the form shown in the Drawings, the thickness of which is $\frac{1}{2}$ inch; the outer shell of the Boiler is to be $\frac{3}{8}$ thick and well rivetted together by $\frac{3}{4}$ rivets $1\frac{1}{2}$ pitch; the tube plate near the Fire Box to be $1\frac{1}{4}$ inch thick, the one at the Smoke Box to be 1 inch, the front plate $\frac{3}{4}$ thick—the Smoke Box to be of $\frac{1}{4}$ Sheet Iron, of the dimensions and form shown, and fitted with a door inside—the *Tubes* to be not less than 56 in number, of

3 inches external diameter and 6 feet 6 inches long—they are to be of the best patent lap-welded iron tubing, proved to a pressure of 150 lbs. by Steam, or 200 lbs. by Hydraulic pressure, and fastened into the Fire Box tube plate by steel ferrules, and into the Smoke Box end by iron ferrules, which are to be truly turned, slightly tapered, and the holes in the tube plates to be bored to the same. *The Stays* on the top of the Fire Box are to be arranged as shown and ½ inch thick; each Boiler to be provided with 2 mud plugs and one 2-inch blow-off cock, and a spare set of fire bars—also, on one side a set of brass gauge cocks, and on the other with a glass water guage. *Safety Valves.*—On the Steam dome there must be two Safety Valves, and a regulator for stopping the communication between any of the Boilers, detail Drawings of which will hereafter be given; one of the Safety Valves is to be provided with a weight, and the other with a Spring Balance; and in addition to this each Boiler is to have a float apparatus for testing the height of the water in the Boilers, in the event of the other means failing by damage or other defects. *The Steam Pipes* are to be ½ inch thick, provided with expansion joints and well clothed, so as to be protected from the effect of cold, which would very much diminish the effect of the steam in its passage to the Boiler; all the flanges are to be provided with 1-inch nuts and bolts; the pipes to be 6 inches diameter inside. The Engines, Pumps and Boilers described in this Specification, to be thoroughly completed in a perfectly workmanlike manner in every respect, all the usual parts to be bright; and all Patterns and Castings to be submitted for inspection by the Engineer appointed for that purpose by the City Council. And it is further to be understood, that all details not herein mentioned, but shown upon the Drawings or otherwise intended to be specified and actually necessary to be made, are to be undertaken, with any slight alterations that may hereafter be decided upon for the best by the party or parties contracting or otherwise undertaking the said works—the same to be completed and set at work at the expense of the said Contractors on the place appointed for the erection of the said Engines, Pumps and Boilers.

AN ESTIMATE

Of the Cost of the Works herein reported upon, and to be executed in accordance with the Drawings and Plans herewith submitted, and bearing the motto, "Non quo, sed quomodo."

	£	s.	d.
Reservoir, Land and Appendages	2,500	0	0
Two 35 Horse-Power Engines, with Boilers, Pumps, &c.	6,000	0	0
Main Pipes, and Laying	25,000	0	0
Sub-main and Service Pipes	30,000	0	0
Engine House, Tower, Wells, &c.	2,500	0	0
	£66,000	0	0

This Estimate is for the supply of the whole area of the City, and the entire works as delineated on the Plans, but as the greater portion of the above amount would be expended in laying the pipes through districts, where, from the sparseness of the population, a supply of water will not be presently needed, the amount is of course very much above that required for the immediate necessities of the City. By confining the supply to the more central portion of the City, this amount may be very greatly diminished. My Estimate for the Mains, Sub-mains, and Service Pipes to supply the area bounded on the south by Hannah Street, on the north by Stuart Street, the west by McNab Street, and the east by Wellington Street, including the Reservoir, Engines, Stand Pipe, Hydrants at the intersection of every street, and all the necessary appendages, is £26,400 0 9

It is also right to state that although the use of the Stand Pipe is expedient and desirable, yet it is not absolutely necessary, the cost therefore (£950) may be deducted from this amount, thus making the sum £25,450 0 0

November 10, 1854. WILLIAM HODGINS.

I consider this competitor should receive the *third* premium.

Montreal, 23rd Dec., 1854. THOS. C. KEEFER.

REPORT OF T. C. KEEFER, ESQ.,

MONTREAL, *January 6th*, 1855.

ROBERT MCELROY, ESQ., *Chairman Fire and Water Committee, Corporation of Hamilton:*

SIR,—

I have the honor to report that in obedience to the Resolution of the City Council, transmitted to me in your letter of 15th November, I have carefully examined the Water Supply Plans, Specifications, and Estimates, of the six competitors for the prizes offered by the City of Hamilton on the 18th of September last.

Plans numbered 2, 4 and 7, fix the site of the Engines and Pumps near the Engine House of the Great Western Railway, and the Reservoirs upon the elevated plateau of ground lying between Lock and Dundurn Streets; of the remaining three, two place the Engines near Land's and Falkner's Wharves, and the third near the Great Western Railway Wharf, at the foot of Queen Street; and all plant their Distributing Reservoirs upon the Mountain Terrace.

It appears from the Plans, that with the exception of some Streets upon the terrace underneath "the Mountain," the City of Hamilton is built upon ground elevated less than one hundred feet above the level of Lake Ontario; and the first point to determine is—what height is the least which should be selected for the Reservoirs which regulate and control the supply? It is clear that if a point be assumed which shall command *every* building within the City limits, such an elevation may be much more than is needed for the adequate supply of the greater part of the City, and thus a greater expenditure be called for—in Engine power and maintenance—than would otherwise be needed.

RESERVOIRS.

Another consideration of much importance, and one which greatly influences the altitude, is the practicabilityof obtaining the greatest capacity of Reservoirs at the least expense in construction, and at the shortest possible distance from the pumps. The efficiency of any system of water supply, whether by gravitation or otherwise, depends upon having large Storing Reservoirs as near the centre of the distribution as practicable. In all cases the Reservoirs should be as large as can be afforded, both to ensure a supply sufficient to carry the City through any extensive conflagration, and maintain the head for ordinary consumption after such unusual demand has ceased, as well as to give some opportunity for purification of the water by subsidence. Such Reservoirs cannot be afforded, in the majority of cases, unless the ground on which they are placed is tolerably level and easy of excavation. Sidelong and rocky ground greatly increase the cost, and therefore rapidly diminish the capacity of Reservoirs, where, as is generally the case, a specific sum only can be afforded for this object.

It does not appear from the information afforded, that an economical site for capacious Reservoirs, is attainable at an elevation which will command the highest villas—even if it were advisable to pump the whole supply for the City to such a point—either to supply those villas or increase the pressure on the City proper. It would appear that if such an elevation is selected, Reservoirs of very limited capacity must be adopted.

The next considerations in importance are the proximity of the Reservoirs to the Pumps, and *their position*, as respects the latter and the City.

If the Reservoirs are placed *beyond* the City, the water must be pumped *through* the latter, and brought back by a separate descending pipe—or, the supply must be taken off the "rising main." In the first case you are put to the greatest expense for your large pipes, and increased power for forcing the greatest distance (irrespective of the height to which the water is elevated); or if, to avoid this, the supply be taken off the rising main, the flow in the latter is irregular, from the variable draught in the distributing pipes; the impulsive action of the pumps is brought to bear directly upon the house services—the fittings, and all the joints of the distributing pipes presenting the most unfavorable conditions for the regular working of the Engine, while no opportunity is given the water for subsidence in the Reservoirs.

If on the other hand the Reservoirs can be placed *between* the City and the Engine, so that the whole supply can be first pumped into the Reservoirs, and thence be drawn off for consumption, the system partakes of all the regularity of a gravitation one, as far as the distribution is concerned; the Engines work under a regular pressure, (the Reservoir serving the office of a Stand Pipe,) while, if the Reservoirs are ample, an opportunity is afforded for an improvement in the character of the water by subsidence.

The distances from the proposed Sites of the Engines, in plans 3 and 6, to elevated Reservoirs under the Mountain, are, as measured on the plans, about 12,800 feet and 8,500 feet, respectively, and back to the corner of King and James Streets, 4,300 feet, and 8,500 feet; while those between the Engines and Reservoirs placed on the Heights, near Dundurn, in plans 2, 4, and 7, are 1,700 feet 2,300 feet and 3,000 feet, respectively; and, through these Reservoirs, to the corner of King and James Street, 5,700 feet, 5,300 feet, and 4,800 feet,—making the total distance which the water must flow (on the assumption that the supply is not taken off the rising main) 17,000 feet in the former case—as compared with about 7,500 in the latter. This mode of comparison is taken because it places the Mountain Reservoirs on a par, as to efficiency, with those at Dundurn. The difference of say 8,000 feet of length, to a common central point on the distribution, in the ascending and descending mains, by the two routes, is equivalent to a saving in main pipe of about £15,000 in favor of the shorter one, with an assumed Main of 24 inches in both cases, and giving same altitudes for the two Reservoirs. The difference of about 10,000 feet between Plans 2 and 3, in the distance between Engine and Reservoirs, in favor of the Dundurn Site, not only reduces the power required for the same altitude and the same sized rising main, but, as the latter always carries more or less air with it from the pumps, and the flow in it is not so regular as in descending mains, it should always be larger than the descending one—the resistance from friction being diminished by an increase of diameter. The pumping main is exposed to the greatest pressure and severest strains, is more apt to leak than other pipes, and therefore the shorter it is the less the risk and cost of maintenance, and the larger it can be afforded. Thus, a short and direct route to the Reservoirs secures a more efficient pumping main, while a favorable site for these Reservoirs guarantees a larger capacity in them.

Every change of direction in a pumping main calls for increase of diameter or increased Engine power; therefore, if the main is short, increased diameter affords a cheap mode of overcoming the disadvantages of unavoidable curvature.

HIGH SERVICE.

With respect to the increased cost of pumping to the higher Reservoirs, this can only fairly be compared with the lower system, by taking into consideration the difference of the delivery in the two cases. The higher system calls for greater Engine power and greater annual consumption of coal and stores—increased length, cost, risk, and expense of maintenance of the rising main, and perhaps a somewhat increased thickness in it through the lower districts—but it would supply every house, and command the closely built streets with a pressure which would be very valuable for fire extinction. Where the supply is by gravitation, I consider a pressure of 150 to 200 feet on the distributing pipes the most desirable; and this may be increased, where necessary, to 250 or 300 feet without objection, if thereby suitable ground for Reservoirs is obtained, or otherwise inaccessible elevations are commanded. Ordinary pipes, under 18 inches diameter, will bear this pressure, and any increase in the thickness of the larger ones will be compensated for by a reduced size, allowable in consequence of the increased discharge given by the greater head. Where the supply is pumped by water power, the annual charge is so light that it is advisable (where the ground permits) to plant the Reservoirs so as to secure a fire pressure; but where steam is employed, the cost increases with every foot of elevation, and it would be manifestly injudicious to lift the whole supply beyond a point which would meet the general requirements of the population, unless there were other circumstances which warranted the increased high service. Thus, if a considerable portion of the population could not be supplied unless the higher service were adopted,—since these could not be left out, it would be advisable—if sufficiently elevated ground presented itself near the pumps—to raise the whole supply to the higher level, and thereby avoid two systems of distribution, with reservoirs of unequal altitude; because, the additional advantage of a fire pressure on the principal part of the town would be secured, and some compensation for the increased cost would be gained in a diminished size of sub-mains and service-pipes.

At Hamilton, the distance of any Reservoirs which would command *every* house from the water to be pumped—the unfavourable character of the ground for economical Storage Reservoirs of sufficient capacity, as well as the increased cost of construction and greater annual expense of maintenance—leave no room for doubt, upon my mind, that the lower plateau near Dundurn is the proper site for your Distributing Reservoirs; and that those portions of the City not commanded by this site should be supplied by a separate Reservoir and separate distribution.

I have understood that there is a Spring which has sufficient elevation, and discharge enough for a limited number of consumers, and which has already been proposed as one of the sources of a gravitation supply. If the capacity of this Spring should, as I am led to believe, be sufficient to supply all future residents above the influence of the Dundurn Reservoirs, and if the cost does not prove objectionable, this source of supply would be preferable to pumping; because these higher tenements would also have a full pressure, supplying the upper as well as lower rooms, and still higher building sites could be occupied without the great drawback of a want of water; whereas, if now supplied from the Engine, the lowest admissible site for the upper Reservoir would naturally be selected, for economical considerations, and the extension of the supply to higher points be thus arrested.

By a small Reservoir for the upper "gravitation" district, a fire pressure of the desired extent could be thrown, at will, upon the lower distribution, and thus greater advantages be secured than if the higher districts were supplied by pumping. The practicability of supplying the upper district by gravitation, and the cost, as compared with steam pumping, can only be determined by a survey.

PUMPING INTO THE DISTRIBUTION.

I have taken no account in these observations, of the plan proposed by competitor No. 5, of planting four tanks, holding one to three hundred thousand gallons each, or an aggregate of 800,000 gallons, on different elevations, as a reserve supply—and of pumping directly into the distributing pipes—but as the principle of depending upon the engine-power to maintain the supply and requisite pressure, is in operation in some pumping works, and is sometimes recommended for its primary economy, it deserves some notice. Moreover, as a comparison of the whole distance travelled by the water from the Engine, *viâ* the Reservoirs, to the intersection of King and James Streets, has been made between the Dundurn and "Mountain" sites, on the assumption (in the case of the latter) that the rising main is not tapped, the propriety of such a comparison should be vindicated, and the objections to tapping the pumping main on its way to the reservoirs, where it can be avoided, stated. It is found that by far the greater portion of the consumption is embraced between 9 A.M. and 1 P.M., or four hours of the day; and unless the power of the Engine and size of the pumping main are such as to deliver this supply as fast as it is consumed, there must be deficiency of water, and a great irregularity in the working, where stand pipes or small tanks are used instead of a Summit Reservoir of sufficient surface to prevent a sudden loss of head during the hours of greatest consumption. Again, where the Engine works directly into the distribution, and where a Summit Reservoir *beyond* the distribution is substituted for a Stand Pipe at the Engine, the impulsive action of the pumps strains every joint and pipe whenever the draught suddenly ceases or a valve is closed, producing a shock at the "dead ends," and tending to burst the pipes. Also, when a distributing pipe near the Engine bursts, the sudden relief of pressure causes an immediate acceleration of speed in the Engine, until it is brought up as suddenly by the action of the Reservoirs; all of which, particularly with the Cornish Engine, increase the risk of a break down. Lastly, the check given to the flow by counter currents and regurgitation of water, very much impairs the efficiency of the pumping main wherever it connects with the distribution before reaching the Reservoirs.

There can be no doubt that for the "constant" supply system, pumping into the distribution is decidedly objectionable. Under the "intermittent" system (by which a certain quantity of water is supplied to each tenant on stated days), which is not in use in America, the draught is tolerably uniform and the difficulty therefore less; and in proposing for America what has been extensively practised on the other side of the Atlantic, this distinction—and also the immense difference in the consumption per head in the two cases—is often overlooked.

By adopting Reservoirs at Dundurn, in preference to the Mountain site, you have the least cost for engines and pumping main, because the same expenditure in reservoirs will provide a capacity which will enable you to work a comparatively small power, steadily, throughout a longer period of the day, instead of a larger and more expensive Engine working irregularly to keep pace with the extreme draught, and provide for the rapid exhaustion of the smaller "mountain" Reservoirs, in case of fire.

CONSUMPTION OF WATER.

Another point which leads to a good deal of discrepancy in the different schemes, is the quantity of water necessary for daily consumption; for on this depends the amount of Engine power to be provided, and, to a certain extent, the cost of Reservoirs and pipes.

The usual estimates, based upon the transatlantic experience of private companies selling water upon the "intermittent system," have seldom exceeded thirty gallons per head of the population; but the experience of the "constant" supply in America shows, that during the hot months of Summer, when the greatest benefits of an abundance of water are experienced, the consumption has doubled, and in some instances trebled this estimate. Undoubtedly there has been reckless waste where the daily consumption has reached 90 gallons per head of the population; but there is abundant experience that where water is supplied under constant pressure, and at the public expense, a more liberal provision than 30 gallons, for the intense heat of our Summers, will be demanded.

The advertisement stated the population to be provided for, but not the average daily consumption. This being left to the competitors, becomes an element of consideration in appraising the several schemes, and we find their provision on this head varying from 15 to 50 gallons. Of course, it will take more Engine power and coal to raise 2,000,000 gallons daily (the required supply for 40,000 inhabitants at 50 gallons), than to raise half that quantity in the same time; while the Reservoirs, to contain the same number of days' supply, must be double the capacity in the one case over that in the other. The larger supply will also call for larger main pipes, or otherwise involve a greater loss of head.

I have thrown the details of the different plans and estimates into tabular form, and annexed them to this report; by this means the different views of the competitors will be readily perceived.

ENGINE POWER.

The question of the amount and character of the Engine power is most important in its bearings, on the efficiency and cost of the works, and requires some explanation.

The points to be determined, after the site of Engine and Reservoir are fixed are, the number of gallons to be raised daily, the number of hours within which this quantity is to be raised, and the capacity of the Reservoirs. If the Engine works uninterruptedly throughout the 24 hours, less power will of course be required to raise the same quantity to the same height, than if this effect is to be produced in 12 or 14 hours; but in the former case larger Reservoirs ought to be provided for the following reasons:—If the consumption be assumed at one or two gallons per head per hour (24 or 48 gallons per diem) it is found in practice that this draught is not uniform, but that three times as great a quantity per hour is drawn between 9 a.m., and 1 p.m., as for the remaining hours of the day; so that, if there were no Reservoirs, the Engine power, in order to meet the requirements of the distribution, should be *treble* what would be necessary if the *average* hourly consumption were pumped into Reservoirs large enough to meet, without too great a loss of head, the extraordinary demand during the four morning hours.

It would not be desirable to run the Engine constantly, even if no stoppages were to be provided for, because night-work is attended with greater risk and cost, as it involves the expense of a double staff of employees; it will be prudent, therefore, to provide Engine power sufficient to raise the supply in 12 or 14 hours, daily work, and have Reservoirs of sufficient capacity to maintain the head during the night, and upon Sundays. Such a provision of power could be worked 18 or 20 hours or more, daily, during the hot weather, whenever the consumption called for this extra supply.

With reference to reserve power or duplicate Engines, much would depend on the position and capacity of the Reservoirs, and the mode of pumping. The most economical mode would be one large Engine instead of two smaller ones, giving the same power; and where the risk is diminished by pumping, in day time, through a short main not connected with the distribution, and when the Reservoirs are sufficiently large to give a week or ten days' supply, there is scarcely a chance of repairs requiring a stoppage longer than the Reservoirs could sustain. The Engine House should, however, be constructed for a pair of Engines; and, as one would be sufficient for the commencement, if the amount to be saved proves an object, a cheap non-condensing Engine, sufficient for the lowest rate of consumption, could be provided as a reserve; to be sold when the second Engine is erected.

In short, with regard to the whole question of pumping power now required, capacity of Reservoirs, and extent of distribution, it is one of finance, and is to be determined by the amount of money which the City is now prepared to expend in these works. There being no limitation to the proposed expenditure, in the advertisement, the competitors differ as much as to the policy which the City should follow in the premises, as in the daily number of gallons required; and I may, therefore, be expected to propose a course. In doing so, however, every Engineer must consult the resources as well as the requirements of the City.

It is easy to fix a minimum limit, as the very nature of water works forbids cheap or temporary contrivances. Whatever is done must be well done; but it is also manifest that a maximum limit is not so easily determined. The larger the Reservoirs and pipes—the more complete and numerous the fittings, the more efficient will be the supply; and a large amount of money *may* be expended, and well expended, on really useful works; but perhaps the first question is—how much is it necessary now to expend in order to make an efficient commencement, and provide for future extension without prejudice to existing works?

While it is prudent to assume that a daily consumption of at least 50 gallons per head will be reached, and that in a very short time the population will reach 40,000, yet as this population will not probably exist until some time after the works are in operation, and as the consumption proposed will not be reached until a still later period—that is, until the distribution pipes are extended into every inhabited street—it is not necessary to make the preliminary outlay on the basis proposed in the advertisement. The cost of pipage, particularly, which will form so large a proportion of the whole required outlay, is an element of great elasticity, and the amount now required will probably be dictated to the Engineer by the decision of the Council as to the streets first to be supplied; its annual extension thereafter can be effected without financial inconvenience.

Whether one or two Engines are employed, it would not be desirable to economise much in the power provided, as the additional cost of horse power is comparatively small, and confined to the first outlay. The same staff will work the large Engine as the smaller one, and the consumption of fuel will be proportional to the work done; if there is therefore an excess of power at the commencement, the Engine will work shorter hours, while the advantage of surplus power enables it to over-run the ordinary consumption in all cases of emergency.

In the construction of the Reservoirs, also, little economy should be attempted. The value of duplicate reservoirs will be immediately appreciated; and by adopting the full size, they will be constructed cheaper in the first instance, in proportion to their capacity. But in the large item of pipage an important reduction, in the necessary provision for 40,000 inhabitants, may very properly be made.

Without detailed surveys at the points where the supply is drawn, and where the Engines and Reservoirs are planted, it would be imprudent to venture on specific estimates; but, from the information afforded, I am of opinion that the necessary expenditure to provide a first class supply, to meet the full requirements of the City, on the completion of the works, need not exceed One Hundred Thousand Pounds. I do not think a less sum should be provided, or that the City would consider that sum too much for a thorough supply.

The future extension of pipage for a supply of 40,000 would require about £25,000 more to be expended over a series of years. As a general rule, the cost of the distributing pipes, &c. may be taken at 25s. per head of the population for the time being; but there will always be a portion of the population scattered through suburbs too distant from the mains to warrant an immediate extension of the pipes to their quarters, which will be supplied from wells. The first provision will of course be in the more closely built streets.

With regard to the supply of the Mountain terrace, and those portions of the City above the influence of the Dundurn Reservoirs, it is first to be ascertained whether this supply will be afforded most advantageously, upon the whole, by gravitation or by pumping. There will be no difficulty about it by the latter mode, and at a moderate cost, by means of a branch (from the pumping main where it enters the Dundurn Reservoirs) leading to a small reservoir under the Mountain. The cost of these cannot be estimated until the number to be provided for on the upper distribution is known, the site for the Reservoir selected, and the size and length of the branch pumping main thereby determined, and the amount of pipage required in the distribution ascertained. As sufficient engine power will be provided for supplying the lower Reservoirs in about 12 hours daily working, an extra hour or two could be devoted daily to replenish the small upper Reservoir.

COVERED RESERVOIRS.

In one of the plans covered reservoirs are proposed, and considered "indispensable." Galvanised iron is the material recommended on account of its economy—but it is found that the evaporation of the water causes the speedy decay of this material, and that brick or slate is the only suitable covering. Even slate does not effectually exclude the light, without which result vegetation is not prevented; on this account brick is preferred.

Each Reservoir ought not to be less than one acre in surface, and the cost of covering two would be about £10,000, a sum which I consider makes covering out of the question, even if there were any necessity for it in this country. It has been found advisable, in England, for small and generally shallow reservoirs, surrounded with chimneys, on account of the precipitation of soot, which, becoming dissolved, imparts a bitter taste to the water; and in those reservoirs where, from deficient construction in the first place, vegetation flourished. The principle cannot be applied to large reservoirs without a sacrifice which renders it, commercially speaking, impracticable; and it would be objectionable always, on account of the natural tendency it would have to diminish the area of all reservoirs. After a sufficient depth is provided to prevent vegetation, and heating by the summer sun, surface area is more important than depth, and the efficiency of reservoirs is in direct proportion to the number of acres which they cover—the object being to make the heaviest draught upon them with the least loss of head.

Where Reservoirs are 20 feet deep, and properly constructed, no vegetation will take place. In our climate during one-third of the year, nature will provide an efficient covering; and with respect to any regulation of the temperature, either in winter or summer, the water will not often remain long enough in them to undergo any appreciable change of temperature from that of the Bay from which they are receiving daily supplies. Lastly, with reference to the collection of soot, dirt, &c., the consumption of coal is not so general or extensive as in England; but if it were, the situation of the Dundurn reservoir is most favorable. Occupying a narrow neck, forming a ridge greatly elevated above the surrounding district, and comprising ground more likely to be devoted to villa residences than manufactories or business—this site is but slightly exposed to any important collection of impurities in the surrounding atmosphere, while from its elevated and summit position, the wind sweeping over it will create a wholesome agitation of the surface, which will, in my judgment, make open reservoirs in such a position superior to covered ones. This advantage, as well as those of proximity to the pumps and economy in construction, would not be possessed by reservoirs under the mountain, where the latter would form a back ground, and aid in precipitating the dust and soot rising from the city below.

For all impurities which float on the surface of the Reservoirs an overflow will be provided.

FILTRATION.

Similar objections may be urged to the system of filtration—which is considered necessary by one of the competitors—viz: the great cost and little necessity for it.

The lowest cost of filtration in England has been 1-8 of a penny per thousand gallons—and it has cost as high as 5-8 of a penny: allowing for the difference of labor we cannot safely take less than one half-penny per 1,000 gallons, or 83s. 4d. sterling per diem, as the probable cost of filtering 50 gallons for a population of 40,000. This operation would entail a cost of about £1800 per annum, exclusive of the cost of filter beds, estimated at £17,000 for a daily consumption of 30 gallons—and increasing with the growth and consumption of the city. This cost of filter beds would be better applied to the construction of a subsiding Reservoir at the pumps [into which the water would only be admitted when in good condition] and the annual cost of filtering be thus avoided. Filtration, to be perfect, should take place immediately before entering the distributing pipes—and should anything more than is proposed above be hereafter desirable, a straining process, by means of vertical beds of gravel, can be applied at the outlets of the distributing reservoirs—which process is five times as expeditious as filtering. When we consider that Lake Ontario and Burlington Bay are, when undisturbed, reservoirs more pure, on account of their great volume, than any artificial ones can be maintained—and that their impurities are temporary and disappear with a calm, it is manifest that no provision for filtration need enter the plan of supply for Hamilton.

CORNISH ENGINE.

In nearly all of the plans the description of pumping engine recommended is that known as the single acting, or Cornish, which is the Engine that has been adopted in recent pumping works in the United States.

The fact that in the new works of the Lambeth Co. at Thames Ditton, for the supply of the city of London (where 600 horse power is employed in forcing a supply of 10,000,000 gallons daily, through a main ten miles in length, and to a height of nearly one hundred feet) the Cornish Engine has not been selected, proves that in London, where the question has been fully discussed, the superiority of the Cornish Engine is by no means admitted. These works were only completed in 1852 by Mr. Simpson, one of the most experienced Water Works Engineers living. Since then, the new crystal palace at Sydenham (the production of which may be said to have exhausted the talent of England) has been supplied with a large power for raising water to a height of two hundred feet, upon the same plan; and during the present year, the New River Company, the largest in London, has ordered four Engines from the same patterns as those at Ditton. The certified performance of these engines "is equal to 97,164,894 lbs., raised one foot for every 12 lbs. of coal consumed, and this includes the friction of the Engines and pumps, and the power required for working the air pumps, feed and charging pumps, and raising the water for condensation."

The Ditton Engines consumed 23,400 lbs. coal in 24 hours, or 975 lbs. in one hour; which, for 600 horse power, gives a consumption under 1 2-3 lbs of coal per horse power per hour. This was on a trial made in January 1853; when I visited the works, in July 1853, the Manager assured me that the regular consumption of coal did not exceed 2 lbs. per horse power per hour.

I find from "Brown's Cornish Engine Reporter" that between 21st October and 20th November 1854 the average duty of sixteen Cornish pumping Engines was 68,400,000 lbs. raised one foot by the consumption of 112 lbs. coal—and that the average consumption of coal was 3 1-2 lbs. per horse power per hour.

The performance of the Ditton Engines quoted above (viz., 97,064,894 lbs. with a consumption of less than 1 $\frac{2}{3}$ lbs. of coal per horse power per hour), was ascertained and is certified by Mr. Joshua Field (of Malnslay, Field & Son), who tested them on behalf of the Lambeth Co., for the purpose of reporting whether their performance was according to the contract made by the Co. with the builders of the Engines.

The following—also from Brown's Reporter of the above late date—is the performance of Cornish Pumping Engines doing highest duty:—

Towey Consols, 80 in. Single	Millions	102.7
Par Consols, 80 in. "	"	100.8
Great Polgooth, 80 in. "	"	87.2
Pembroke and East Crinnis, 80 in. Single	"	77 0
West Towey Consols, 60 in. "	"	76.0
Par Consol, 72 & 36 in., Sims' combined	"	75.2
Trelawney, 50 in. Single	"	74.9
Pembroke and East Crinnis, 70 in. Single	"	73.5

It will be seen that only two out of the eight give a higher reported duty than the Ditton Engines, and this duty only 3 to 5 millions more, while the other six give from ten to twenty-three millions less.

In point of economy of fuel, for the same duties performed, the Ditton Engines compare favorably with the Wicksteed and other Water Works Engines on the Cornish single-acting principle; but there are other considerations of no less importance which, in my judgment, make them preferable, for Water Works purposes, to the Cornish Engine.

The Cornish Engine is subject to dangerous accidents whenever a pipe bursts, or a pump valve is held up by any foreign substance getting into it—in which case the plunger may descend with its whole weight on the Spring beams. This Engine, therefore, requires much closer attention than double-acting ones. Again, the intermittent stream of water delivered by the Cornish Engines, causes much more strain on the machinery and pipes than the continuous stream from a double-acting Engine.

The gradual stopping and reversing of the motion in Crank Engines, is highly favorable to noiseless action, and greatly increases the durability of the pump valves; none of the pump valves at Ditton have yet been taken out for repair, although the first pair of Engines was started four years since.

The Ditton Engines, like the Cornish, are expansive ones—and they possess in this respect all the merit of the latter, with none of its defects.

The greatest economy of fuel is obtained when the highest steam is employed and expanded to the utmost limit. In the Cornish Engine this is done in a single large cylinder, which, with every other part of the Engine, must be made strong in proportion to the pressure of the steam employed, and therefore to the amount of economy in fuel aimed at. The economy of high pressure steam results from the greater extent to which the expansion can be carried, and to the fact that the pressure of steam increases in a greater ratio than its density; therefore, the higher the pressure the less proportionate quantity of water to be evaporated, and the less fuel is consumed—because a given quantity of fuel will evaporate the same weight of water at all temperatures.

This high pressure steam cannot be used without the intervention of a mass of matter to be first set in motion in order to check the speed caused by the initial excess of steam pressure wherever any great degree of expansion is aimed at. In Cornwall this mass of matter is furnished by the pump rods, descending 500 to 1,000 feet into the mines, and this necessary weight gave rise to the extension of the expansive principle and the economy resulting therefrom.

For Water Works pumping the Cornish Engine is necessarily loaded with many tons of metal which is lifted by the steam, and in descending, forces by its weight the water to be pumped. Thus it will be seen that at every stroke, extreme strains, on the first admission of steam to a single large cylinder, with their wear and tear, friction, &c., are unavoidable.

In the Ditton Engines the expansion is effected in two cylinders, whereby the action of the steam is rendered more uniform, and as the extreme strains are avoided, the weight of the parts may be made proportionally less, thus diminishing friction, wear and tear, &c. If any accident happens to the pipes or valves, the speed of the Engine, which may be increased thereby for a stroke or two, is speedily checked by the governor; whereas, under similar circumstances, with the Cornish Engine, unless the attendant is at hand, a break-down is risked.

The Ditton Engines being double-acting, and sending a continuous stream of water into the mains, do not require a stand pipe; whereas the Cornish Engine, raising water by the weight of a loaded plunger, can only work economically under one particular lift, to which this weight must be adjusted; and wherever water is pumped through a long line of main, the lift is variable in consequence of the friction increasing or diminishing in proportion to the square of the speed. So where water is pumped directly into the service mains, with the Cornish Engine, a stand pipe rising above the highest point to be supplied, is necessary to regulate the action of the Engines.

The theoretical advantage of any given degree of expansion, is the same whether effected by the Cornish single, or the double Cylinder Engine. The extent to which it may be carried will depend on the pressure of steam which it may be advisable in each case to employ; but it is known that Wolf in his double Cylinder Engine, carried the principle of expansion nearly twice as far as it has been carried in any single Cornish Engine.

With Reservoirs at Dundurn, the Cornish Engine would be placed in the most favourable conditions for its efficient working; the proximity of the Reservoir doing away with the necessity for a stand pipe; but if the Second Reservoir for a higher service is to be supplied by pumping, I consider a stand pipe will be required with a Cornish Engine. One competitor assumes 1,000,000 lbs. as the fair average of the duty to be expected from the Cornish Engine, and another estimates it as just one half, or 500,000 lbs. The performance of select engines at certain mines in Cornwall, cannot be taken as a criterion of the average working of the Cornish Engine, in supplying a town, because the circumstances under which the two work, are different. From the best information I can obtain, the performance of the Wicksteed Cornish Engine, at the East London Water Works, does not appear to have equalled that of the Ditton Engines, either in work done or fuel saved, and the annual cost of repairs must be greatly in favor of the latter.

All those improvements in boilers, valves, management, and economy of heat, which have done so much to give the Cornish Engine its deservedly high character, are applicable to double acting Engines; and as far as the expansion is concerned, it can be carried much farther in the double cylinder Engine than in the Cornish, and much beyond what in practice it would be desirable to do.

Taking into consideration the fact that the same sized double cylinder Engine does double the work of the Cornish. I consider them, as to bulk and first cost, safety of working, ease of action on pipes and valves, durability and economy, as the best kind of pumping Engine for the supply of your City.

CEMENT, OR "INDESTRUCTIBLE" PIPES.

One of the competitors considers the use of cast iron pipes "open to grave objections," and recommends that sheet iron and cement pipes, called "indestructible," which are stated to be now extensively in use. Where, to what extent, and how long these patent pipes have been employed, is not stated. The principal objection to cast iron is based upon the experience of Boston—a peculiar case, arising out of the quality of the water with which that City is supplied; but I am not aware that any such alarming developments have been made in the numerous cities and towns where cast iron has been used for so many years. Nor does it appear, from the experience of other towns, that the water of the St. Lawrence, and the Lakes, produces such deleterious effects in the interior of the pipes as that arising, perhaps, from the excessive purity of the Cochituate water. The proposal to expend over £40,000 on a patent article, of at least doubtful efficiency, cannot be viewed otherwise than as a great experiment. Taking the whole distribution, with the curved and branch pipes, valves, fittings, &c., I question very much whether there will be any advantage on the score of economy, unless the price of iron should be excessively high. I was called upon by an agent for this patent pipe, before purchasing for the Montreal Water Works, and found that the price for 24-inch cement pipe was higher than for the same size in iron. I can conceive of no material which, on the whole, possesses so many advantages as cast iron for the distribution of a water supply. The facility and economy with which any required curve or branch can be formed, of equal strength, durability and tightness, in cast iron—and the value of the old material when broken or superseded, are advantages which I cannot see could be equally obtained with the cement pipe.

It is stated in favor of the "indestructible pipe," that "their firmness and durability increase with age, and when properly dried before use, they transmit the water without contamination," &c. Pipes of pure cement or concrete, very thick and short, and of very small diameters, were used by the Romans—and there is no doubt of their durability; and with respect to the effect or rather absence of effect on the water, good cement or concrete is preferable to metals, but the strains to which pipes are subjected from the subsidence of ground, the action of frost, and of heavy traffic in the streets, demand a greater strength than is needed to resist the equable pressure of any required head of water. Therefore, in the patent pipes this additional strength is obtained by a combination of sheet iron, protected from oxydation by internal and external coatings of concrete; and it is with respect to the *durability of this combination* that experience is wanted. I do not think this question can be considered as settled by the experience already had with this composite pipe. Whether the sheet-iron is completely isolated and excluded, *particularly at the joints*, from any possible contact of air or water, in which case from it thinness, its destruction must be rapid, is a question of the first importance. It is well known that sheet, and all wrought iron, oxydizes much more rapidly than cast iron, when exposed to the action of water.

Lastly, the efficiency of such composite pipes must depend wholly on the excellence of the materials employed and the faithfulness of the workmanship, neither of which can be judged of beforehand with the same certainty as in the case of iron; and whether the cement itself proves of good quality or will adhere without fail to the iron, are points which can only be determined when it is too late to repair the error made.

I have the honor to be, Sir,

Your Obedient Servant,

THOS. C. KEEFER.

A.

HAMILTON WATER WORKS COMPETITION.—ABSTRACT OF COMPETITORS' PLANS.

Numbers of Plan.	Length of Pumping Main.	Diameter of Rising Main.	Number of Reservoirs.	Height of surface of Water in Reservoirs above the Bay.	Depth of Water in Reservoir.	No. of galls. per head estimated for daily consumption.	Contents of the Reservoirs in Imperial Gallons.	No. of Days' Supply provided in the Reservoirs for 40,000 persons.	Number of Engines.	Description and Power of Engines.	No. of feet of Pipes for full Distribution.	No. of feet of Pipes for reduced Distribution.	SIZE OF PIPES PROPOSED.					
													Under 6 inches.	6 inch.	8	10	12	16 & over.
2	FEET. 1700	16	2	155	25	50	24,000,000	12	1	Cornish, 87 h. p.....	100660	48550	....	74250	12850	807[illegible]	2040	3450
3	12000	24	1	250	22	30	3,000,000	2¼	3	1 of 80 in. } Cylin- 2 of 56 in. } ders. Cornish.	179520			34500	44500	4120	2040	3450
4	2300	16	2	{ 144 192 }	21	30	4,044,866	3⅓	2	{ " each 35 h. p. double acting. }	139300	......	2, 3 & 4					
5	....	12	4 T'ks.	{ 230 130 112 80 }	{ 30 20 20 15 }	20	800,000	1	2	{ Cornish, each 40 h. p. }								
6	8600	14	2	280	....	15	2,751,375	4½	2	do. one 70 & 50 h. p.								
7	3000	24	2	137	21	25	7,400,000	7½	2	do. each 60 h. p.....	......	27200						

HAMILTON WATER WORKS COMPETITION.—ABSTRACT OF COMPETITORS' ESTIMATES.

5	....	12	4 T'ks.	230 130 112 80	30 20 20 15	20	800,000	1	2	Cornish, each 40 h. p.		
6	8600	14	2	280	....	15	2,751,375	4½	2	do. one 70 & 50 h. p.		
7	3000	24	2	137	21	25	7,400,000	7½	2	do. each 60 h. p.....	......	27200

HAMILTON WATER WORKS COMPETITION.—ABSTRACT OF COMPETITORS' ESTIMATES.

Numbers of Plan.	Cost of Engine House. £ s. D.	Cost of Engines. £ s. D.	Cost [illegible]mping Main. £ s. D.	Cost of Reservoir. £ s. D.	Cost of Pipes. £ s. D.	Engineering and Contingencies. £ s. D.	Lot of Land and Right of Way. £ s. D.	Total Estimate. £ s. D.	Annual Cost of Working, Interest, &c. £ s. D.
2	5,140 16 6	10,000 0 0	2,950 0 0	25,040 15 0	48,385 0 0	8,994 0 0	(a) 6,000 0 0	98,934 9 1	(b)
Reduced					(Reduced Dist.) 26,222 0 0	7,114 4 11	....	(for red. pipage) 78,256 13 2	
3	(c) 16,600 0 0	24,967 0 0	19,431 0 0	8,020 0 0	67,852 0 0	15,252 0 0	....	(c) 169170 0 0	(d) 15,361 0 0
4	2,500 0 0	6,000 0 0	....	2,500 0 0	55,000 0 0	... .	Included in cost of Reservoir.	66,000 0 0	
5	8,184 0 0	2,000 0 0	8,353 0 0	11,537 0 0	38,000 0 0			63,774 0 0	
6	6,340 0 0	3,500 0 0	16,845 0 0	3,496 0 0	49,404 0 0	....	....	79,585 0 0	
7	3,000 0 0	6,000 0 0	... .	16,742 0 0	34,856 0 0	3,030 0 0	....	63,628 0 0	(f) 5,085 13 7
Reduced	2,500 0 0	4,500 0 0	....	7,300 0 0	17,222 0 0	1,580 0 0		33,102 0 0	

(a) $23,000 for Land, and $1,600 for Pipe Yard.
(b) Duty of Engine estimate at 500,000 lbs., daily consumption of coal, 3½ tons, working 24 hours.
(c) Including Pier, Wharf, &c. (d) Interest, £10,146. Depreciation, £1,390. Working Expenses, £3,825.
(e) £17,047 for [illegible]ter-beds. (f) 3817 13s. 7d. for Interest, £1,268 for Working Expenses. Duty of Cornish Engine estimated at 1,[illegible]0,000, as "fair average." Cost of Fuel estimated at £468 per annum, consumption taken at 9 cords of wood, or lbs. coal in 48 hours, (or 1½ lbs. coal, per horse power per hour.)

PROFESSOR CROFT'S ANALYSIS.

SIR: TORONTO, *July* 19, 1854.

In my first Report I described the relative qualities of the waters submitted for examination, and mentioned that the water marked (D) was decidedly the purest of the four, the quantities of solid matter left on evaporation being as follows:—

D	8.440	grains in Imperial gallon.
A	12.660	" "
C	13.784	" "
B	22.507	" "

I have since made some experiments to determine the quantity of sediment formed on boiling, as this is of considerable importance as respects the use of the water in Steam Boilers, and for other purposes. The quantities of sediment on boiling down to about one-half, are as follows:—

D	8.35	grains in Imperial gallon.
C	11.52	" "
A	12.23	" "
B	13.64	" "

Here you will perceive that D still maintains its superiority, although nearly the whole of the solid contents are precipitated by boiling. I am inclined to believe that my experiment gave the quantity of sediment for D a little too high.

C and A are about equal, while B gives decidedly more and leaves 8.867 grains of soluble matter, consisting chiefly of sulphate of lime, chloride of calcium, chloride of sodium, and organic matter.

The others, A, C and D contain scarcely perceptible traces of those substances.

In choosing water for the supply of a town, various circumstances have to be taken into consideration. 1st. The purity at the present time. 2nd. The certainty of its retaining that degree of purity. 3rd. The quantity available. 4th. The mechanical means for effecting the supply.

With regard to the first point,—if the water be derived from a river, the water would be rendered impure by any factories established along its course; if from the bay, then the supply pipes should be carried out so far from the City as to extend beyond the influence of the drains as far as possible. The second question here comes into consideration, as to how far the drainage of a rapidly increasing town will render the water unfit for use. I am inclined to believe that with proper precautions, as above-mentioned, this objection would not hold good.

Thirdly,—Can the water be supplied in sufficient quantity? It has been calculated that at least 20 or 25 gallons per diem for every inhabitant, is not too much, and as the calculation should not be made with reference to the present population, owing to its rapid increase, but for 3 or 4 times its amount, it can readily be ascertained whether the rivers and springs could possibly supply sufficient.

I need not allude to the mechanical means of supply, as you must be so much better acquainted with the details and with the probable expense.

From whatever source the water be obtained it should be allowed to stand in a large reservoir, to deposit any mechanically suspended matter, it should then be *filtered*, and this I would particularly impress on your attention, as here, in Toronto, we are suffering so lamentably from a want of this process.

Further purification of the water previous to filtering will, I think, be unnecessary with either specimen, especially with D. If thought requisite, it could be effected as in several of the London Water Works, by means of lime, the quantity required being easily calculated—thus, D would require about 4½ grains to the imperial gallon. I consider, however, that the water is quite sufficiently pure without its undergoing the lime process; in fact, I doubt whether it would be desirable to purify it still further on account of the possibility of its then acting on the lead pipes—very pure water in lead pipes becomes poisonous, which water with 8.10 grains of salts in the gallon does not act on them.

These are the principal points to which I would direct your attention; several other facts connected with the composition of the water, as shown in my analysis, are not of any practical importauce, and I have not therefore alluded to them.

I have the honor to be, Sir,

Your very obedient Servant,

ROBT. MCELROY, ESQ.

HENRY CROFT.