REPORT

ON THE

WATER SUPPLY

FOR THE

CITY OF CHARLOTTETOWN,

BY

GILBERT MURDOCH, ESQ.,

CHIEF ENGINEER WATER WORKS,

ST. JOHN, NEW BRUNSWICK.

CHARLOTTETOWN, P. E. I.

COOMBS & WORTH, STEAM PRINTERS, 18 QUEEN ST.

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REPORT.

To His Worship the Mayor, and the City Council of Charlottetown, P. E. Island.

GENTLEMEN;

In September, 1875, I received instructions from your honorable Board "to make a survey, and report in writing "the best and most economical system, and probable cost of "furnishing Charlottetown with a copious supply of water, "sufficient to meet the demand for domestic purposes and "for extinguishing fires."

Various circumstances have conspired to delay this work and keep me from making a final Report; chief amongst which was the boring undertaken at Mount Edward, to test the practicability of obtaining a supply from wells and the subsequent action of your honorable predecessors in reference to this and the subject generally,—actuated I have no doubt by an honest desire to promote the best interests of the City and the City's tax payers.

It gives me pleasure to be able even now to Report and lay before your honorable Board, in obedience to your late request, the information collected in relation to this important subject, together with my opinions and estimates of "probable cost &c."

With a view to obtain the necessary data, for the proper performance of the duties entrusted to me, I had careful surveys and gauging made of Winter River, and of the Gates and Curtis brooks during the fall of 1875, and the spring and summer of 1876, but it may be well before proceeding to discuss their several merits, and estimate the probable cost of each, to devote a few pages to some

GENERAL CONSIDERATIONS

which are more or less common to all systems of water supply, and to a proper conception of which at the outset, much of the success of undertaking of this sort depends.

The ground which must be gone over in this connection will not be new to such of your citizens as have given attention to the subject, but to those who have not had an opportunity to study the several questions involved in a good water supply, a few preliminary remarks may not be uninteresting and may help them to form correct views as to the principles and practice which should prevail in all public systems of water supply.

A primary and highly important consideration in connection with this is the

SOURCE OF SUPPLY.

This is a question of vital interest, and should be carefully considered before coming to a decision; as an error in this respect may lead to a vast amount of mischief, besides a needless waste of money.

A good source of supply should be able to furnish :—

(1) An abundance of water for every purpose at all seasons of the year, and

(2) The quality should be such as to fit it for manufacturing and family use, as well as for ordinary municipal purposes.

In relation to the quantity which a stream or other source of supply may be capable of furnishing to meet the daily wants of a City, two questions arise, viz:—what shall be the unit of supply? and what provisions shall be made for the future? Both questions are of great practical importance.

UNIT OF SUPPLY

is a technical term which means the average number of gallons which should be provided daily for each member of a community—young and old. On this point there has been and still is a great difference of opinion among Engineers, as well as municipal authorities.

One class says limit the supply to a reasonable amount, and by well devised and strictly enforced regulations keep it from getting beyond this; while another says, why limit that which is so essential to life and health and comfort? Furnish water to all without stint or limit; give it freely, cheaply, copiously, that all may learn to wash and be clean. And there is no doubt the drift of public opinion is towards the latter view; and that too in a marked and unmistakable manner, as will appear from a few well authenticated facts connected with this branch of the enquiry.

As the circumstances and social habits of Cities are never exactly alike, no definite rule can be given for finding a "unit of supply." Each case must be judged independently, and the conclusions at best are only approximate; but in this as in everything else that effects our future well-being, it is wise to err on the side of safety, and make an ample allowance at the beginning,—even at a considerable increase in first cost.

In old times when the sanitary value of water was less known and appreciated than it now is, from five (5) to ten (10) gallons a day were considered a liberal unit of supply, and fifteen (15) gallons were spoken of as extravagant waste. Then however City supplies were mostly intermittent and much of the water used was drawn from "stand pipes" exposed in courts or other open places for common use. Baths and water closets were generally speaking unknown, and few had learned the value of water as a labour saving as well as health preserving agency.

The gradual introduction of the *constant supply* system—enlightened views in relation to the laws of health—to better modes of drainage—to the domestic value of bathes and water closets—to the saving of labour effected, when water, (hot and cold,) could be drawn in the stable, the scullery and the kitchen, as well as in bath rooms, dining rooms and bed rooms every hour of the twenty-four, (24) combined with a growing demand for manufacturing and municipal purposes,—has led to a unit of supply not dreamed of forty (40) years ago.

At the period named the unit had risen to thirty (30) gallons, and this was really in excess of what experience then showed to be the actual consumption. This was the unit adopted by the able and experienced engineers who planned the Croton works for the supply of New York; and was believed to be not only ample but sumptuous and sufficient for every possible use to which the water could be applied.

Under this impression the works were designed and executed, with a supposed capacity to meet the wants of the City for twenty-five (25) or thirty (30) years, but they had not been in operation ten (10) years, when it was discovered that it would be not only impossible for them to do this, but to maintain the supply to a population less than one-half of that originally contemplated, further expenditures of millions of dollars would have to be made.

The experience of New York in this respect has been the experience, to a greater or less extent, of Boston, of Brooklyn, of Philadelphia, of Chicago, of Detroit, of Hamilton, of Toronto, of Montreal, of Halifax, and of Saint John: and in short of every place of note having a public water supply. The history of one is the history of all. Under the constant supply system, (which is the only one ever thought of now) the daily per capita consumption has advanced steadily, till sixty (60) gallons is now accepted as a moderate average; and the indications are that it will yet rise above this, as will appear from the following recent rates of consumption, taken from reliable sources:

	GALLONS.		GALLONS.
Albany, N. Y.,	50	Hamilton,	60
Brooklyn,	60	Montreal,	70
Buffalo,	80	Manchester, Eng.,	60
Boston,	98	New York,	90
Chicago,	123	Philadelphia,	67
Cincinatti,	55	Reading, Pa.,	75
Detroit,	107	Springfield, Mass.,	66
Glasgow, Scotland,	60	St. John, N. B.,	70
Hartford,	80	Toledo,	45
Newark,	61	Wilmington,	80
Toronto,	60	Erie,	107
Cleveland,	60	Ottawa,	65

These "units" or quantities are averages of daily consumption, *per capita* of the cities named, for the whole year; and do not show the maximum at any particular time.

At some seasons of the year, when the weather is very hot or very cold, these averages will rise considerably above the figures given. During the midsummer months, for instance, water is often allowed to run freely to keep it cool,—for cleansing sewers,—creating currents of air to remove bad odors,—sprinkling streets,—for washing sidewalks, windows and carriages; while in winter it is used copiously to keep imperfectly protected fittings from freezing: a constant run of water being an easy and effectual remedy, when drains exist to carry what is thus wasted quietly and quickly away.

The cold weather waste has hitherto defied the most stringent laws and active measures for its suppression. As a rule it is beyond the reach of Inspectors, and is heaviest at times and seasons when detection is all but impossible, in our climate. The greatest waste is generally in connection with kitchens and water closets during the still hours of night, when doors are locked and secured against intrusion. It is therefore beyond control and should be provided for at the outset, if efficiency is to be maintained and unpleasant embarassments avoided. And in doing this the wants of the *future* as well as the present should be considered carefully.

In view therefore of the experience of the past, and of the habits of our own times in regard to the use and waste of water, I could not recommend a smaller "unit" for Charlottetown than sixty (60) gallons per day for each individual within the City's bounds; and in doing so I feel assured that large as this may appear, it will not be found extravagant, when your city is sewered, your houses fitted up with baths and water closets, and your people have learned the use and value of water as a labor saving and health giving agent.

Having fixed on a unit of supply the next consideration is the

POPULATION TO BE PROVIDED FOR,

present and prospective. For this there is no definite rule, nor can there be, as the circumstances of no two places are precisely alike. Each must be judged by itself, due regard being given to probable future growth.

From the geographical position of some cities their growth will be more rapid than others not so favorably circumstanced. It is prudent therefore to consider this, and when there is reason to believe that such will be the case, make ample provision for it at the outset, especially in such parts of the work as cannot be easily and readily enlarged afterward.

In some cases when the towns to be supplied are small and almost stationary, scarcely any provision is needed for future enlargement, while in others by being seats of manufacturing industries,—ports of shipment, or centres of trade and travel, prudent forethought requires that immediate provision be made for future expansion.

There is reason to believe that Charlottetown from its insular position, and the beauty and fertility of the Island of which it is the commercial as well as political Capital, increased facilities for travelling, etc., will grow more rapidly in the future than in the past. And though its onward progress may not equal some of the great cities of the west, yet it would not be safe in designing works for its future water supply to provide for less than double its present population, or rather double what it may be when the works now contemplated are completed and ready for use.

In order to ascertain what this may be, it is necessary to take a look at the past and on the data thus obtained base estimates of the future, which will be at least approximately correct.

By the census returns of 1871, the progressive growth of your City seems to have been as follows, viz :—

Population in	1841	3896				
do	" 1848	4717	increased in	7	years,	821
do	" 1855	6513	"	7	"	1796
do	" 1861	6706	"	6	"	193
do	" 1871	8807	"	10	"	2101

By these returns, it appears that the increase for the *seven* (7) years ending in 1848, was fully 21 per cent; for the next *seven* (7) years about thirty eight per cent; while for the following *six* (6) it was but 2·96 per cent; and for the succeeding *ten* (10) years it was 31·3 per cent.

As there is no reason given in the census returns for the apparently small increase between 1855 and 1861, it would be reasonable to consider the figures 6513 a misprint, and that the corrected number should have been 5613. This alteration would make the increase for the *seven* (7) years ending in 1855 about 19 per cent, and for the *six* (6) years ending with 1861 nearly 19·3 per cent.

Corrected in this way the increase between 1841 and 1848 was equal to a decennial increase of 30 per cent; between 1848 and 1855 of 27 per cent, and from 1855 to 1861 about 32½ per cent. It may be a mistake to surmise that 6513 is a misprint, but whether it is so or not, the result will be much the same, if the periods are combined and the whole 13 years taken as one.

As it is probable—with a copious supply of water suitable for domestic and manufacturing purposes—that Charlottetown will continue to grow, with a somewhat greater rapidity in the future than in the past, I propose to base my prospective estimates on a steady decennial increase of 32 per cent from 1881 when the population of Charlottetown and Royalty should be 11,566, if the rate of increase has been the same between 1871 and 1881 as for the preceding *ten* (10) years. On this basis the population at the end of each succeeding decade would be about as follows, viz:—

Population	1881	about	11,625,
"	1891	"	15,345,
"	1901	"	20,255,
"	1911	"	26,736,

As these estimates include what is called the *Royalty* as well as the City proper, the inhabitants of which are not likely at any time to be consumers to any great extent, and as a number of years must elapse before the people are led from their wells to the use of pipe water, it would not be proper to consider all as water takers. At best—even in the City proper—a considerable time must elapse before the new supply becomes general for house purposes; and in view of this it will not be improper, in trying to approximate the daily consumption to estimate for a certain per centage of the population. This, without doubt, will be a constantly increasing number; the ratio of increase depending, to some extent on the relative qualities and economies of the new and old supplies, and the rate at which the distributing pipes are laid through the streets of the City.

For the reasons stated it may be assumed that in 1882, should the works be then in operation, that about one fourth the population would draw a supply from the City Mains, directly or indirectly—in 1891 two thirds, and 1901 and following years the entire population.

On this basis and a per capita of 60 gallons, the population to be provided for and the gallons required daily would be as follows at the dates named,

YEAR.	No. of water users at the end of each period.	Daily consumption at sixty gallons unit.
1882	2,999	179,940 gallons.
1891	10,230	613,800 "
1901	20,255	1,215,300 "
1911	26,736	1,604,160 "

The approximate accuracy of these figures will depend materially on the management of the works, and the demand that may be made on them for manufacturing purposes. If in the former there should be laxity and carelessness—as too often happens when works of this kind are controlled directly by City councils; or should there be an unexpected increase in the latter, induced by the improved facilities for industrial investments, which come of a copious supply of water suitable for steam purposes, larger volumes may be required at the dates given: but with proper attention to inside fittings, strict surveillance and a steady determination to prevent and suppress waste, the quantity named would be abundantly ample for all legitimate uses, public and private.

Any source therefore which may be selected should be able to furnish not less, ultimately, than from *one and a half* to *two millions of gallons daily;* and its water should be suitable for manufacturing and household use as well as for municipal purposes. Water for

MANUFACTURING PURPOSES

should be clear and free if possible, from impurities of an earthly or calcareous character. The presence of the latter gives what is called *hardness* to water and makes it unsuitable for steam purposes, and such manufacturing operations as require for their proper prosecution *soft* water— such as tanning, bleaching, dyeing, wool washing, &c.

When hard water is used for steam purposes, lime as a carbonate or sulphate is deposited in the boilers, with greater or less rapidity, according to the character of the water used; the largest deposits being obtained from the hardest water.

Such deposits when allowed to accumulate become in time as hard as stone, and are always dangerous and detrimental to boilers. They prevent perfect contact between the boiler and the water and cause the plates of the former to burn out rapidly, making frequent repairs necessary, and to this and cognate causes explosions are often attributed.

Such incrustations are likewise bad conductors of heat, and to overcome the resistance thus offered and perform the same amount of work, extra fuel is required; which means extra cost, in addition to periodical losses of time and labor in stopping to "scale" or remove by hand the deposit thus formed.

Manufactures seldom thrive where a reasonably soft and pure water cannot be had. This is indispensable to their success. A cheap and copious supply of water, for steam purposes alone, has proved in other places a great incentive to local industries, attracting population and furnishing a ready means of profitable employment to the youth of both sexes. Such has been the case in St. John, and such without doubt will be the case in Charlottetown also, as soon as it is provided with water suitable for steam purposes. Water fit for

HOUSEHOLD USES

such as cooking, drinking and washing, should be comparatively free from organic impurities, pleasant to the eye as well as to the palate, and reasonably soft, clear and transparent. But these qualities are not always obtainable; nor would the absence of one nor all of them to a moderate extent necessarily imply an unwholesome water. Some waters are bright, sparkling and pleasant, and yet eminently dangerous, whilst others possessing neither of the qualities named, are safe and wholesome. Still it is desirable that water which is to be used in the household for dietary purposes should be free, if possible, of everything of an offensive character, even though it should be harmless in itself: and no source should be selected which cannot meet the conditions named, to a reasonable extent at least, as it is of the utmost importance that water which is to be used for culinary purposes should be

PURE AS WELL AS PLEASANT.

Purity, here is to be understood in a hygienic rather than a chemical sense; for no water is ever perfectly pure, no matter whence it comes—whether from the earth or the air. Being a powerful solvent it takes from everything it touches or with which it comes in contact. As dew and fog and rain it takes from the atmosphere organic dust and dirt; the products of combustion, of respiration, of decaying animal and vegetable matter, zymotic germs, &c. The impurities drawn in this way make rain water frequently unfit for cooking or drinking before it is filtered or clarified by subsidence and aeration. Such impurities are greatest in the neighborhood of cities, and least at a distance therefrom.

The impurities which water derives from the earth depend on the geological character of the soil over which it passes, or the strata through which it permeates in its progress downward. Should the soil contain animal excreta, or sewage matter, the impurities derived therefrom are always dangerous; and especially so when zymotic diseases prevail, as cholera or fever, in the district from which the water is drawn. Such impurities are frequently found in

SHALLOW WELLS,

—wells say of 20 to 50 feet deep—when placed near human habitations, and some by infiltration from neighboring cesspits and privies.

The more open and porous the rock or earth is into which such wells are sunk the greater is the danger of their waters becoming contaminated, and unfortunately the poison which enters in this way is seldom detectable by the senses. On the contrary, it often happens that water which is highly impregnated with night soil and barnyard soakage is bright and sparkling, and pleasant alike to sight and taste. No such water is fit, however, for human use. At least it is never a safe beverage, as it is constantly liable to pollution, and often *is* polluted and dangerous when least suspected. All such water should be avoided as much as possible.

In relation to this class of wells, the Rivers Pollution Commissioners in their *Sixth* and last report, say that "the sources of pollutions around them are so general, numerous and patent, as to leave but few of eighty-seven (87) samples examined of sufficient purity for safe domestic use; although most of them were pure and palatable." In a great majority of the samples examined, the total solid impurity was excessive, ranging as high as *two hundred and forty* (240) parts in 100,000, or one hundred and sixty-eight grains per imperial gallon. The organic matter in wells of this kind is, as a rule, derived from sewage, or refuse animal matter, and is, therefore, highly objectionable. Yet such is the general character of all city wells, and to this cause is often traceable the sudden outbursts of epidemics in particular places.

The Report to which I have just referred is not only the latest but is also the most complete and exhaustive that has yet been made on the potable waters of Great Britain, and it is worthy of remark that the judgment of the Commissioners corresponds with and confirms the opinions advanced by the medical professors of your city in reply to a series of pointed and pertinent questions submitted to them in 1876, by William Heard, Esq., a gentleman who appears to have given much attention to the question of water supply, and brought to the discussion of the same a rare amount of intelligence, zeal and good judgment.

For this and other information relating to the dangerous character of the shallow well water with which your city is supplied at present, see Appendix A. The impurities named above are seldom found in

DEEP WELLS,

wells, say, of *one hundred* (100) feet deep and upwards, when the rock through which the water percolates is free from fissures, and the surface water carefully excluded. When the water received into such wells is compelled to filter through the surrounding strata from the surface downward, the impurities it contains are rendered harmless, though it may have been loaded with polluting matter when it began to penetrate the earth.

This result depends of course on the strata being fairly compact and porous. When opposite conditions prevail, when the strata contain numerous cracks and chasms, through which the water may flow with little or no resistance, as is the case in your city and neighborhood, the impurities received on the surface will retain most or all of their dangerous qualities, no matter how deep the well may be.

Next to purity in water for household purposes is

SOFTNESS.

This quality in a water which is to be used daily in the ordinary operations of cooking and cleansing, is one of primary importance from an economical standpoint, irrespective of the pleasure which comes to the touch from the use of such water, and the sense of cleanness which remains when one's ablutions are ended.

In the *process of cooking* a soft water operates more readily on the soluble parts of such materials as are submitted to boiling, or to simmering at a high temperature; whilst in the preparation of bread, of tea and of coffee, in the making of soups and boiling of meats, better results are reached by a soft water than by a hard one, through its greater *extractive* power.

For this reason less time and material are required to produce an extract of a given strength and richer flavor; and as a saving in time means a saving in fuel as well as in material, both have an actual money value, though not always apparent to the operator.

Exact an' elaborate experiments in cooking with *hard* and with *soft* water have shown beyond doubt a saving of time, in many inst·nces of *twenty five* (25) per cent. in favor ot the soft water, while the color and strength and flavor of the meats, soups and vegetables were more fully and delicately brought out.

In the making of *tea* most housekeepers know that a soft water is superior to a hard one for extracting the full strength and flavor, but it may not be so generally known that a given measure and quality of tea which would yield when made with *hard* water three (3) cups, would furnish *five* (5) of equal strength and flavor when made with *soft* water.

This may not appear to be a matter of much importance, but yet I am satisfied that the introduction of a soft water into Charlottetown would result in a considerable annual saving in the item of tea alone. Dr. Philip Holland found in the course of his researches and observations that he could save *eight* (8) parts out of every *eighteen* (18) parts of tea, when made with water of a given softness, and that his weekly saving in this alone was equal to one half of his water rate. For fuller particulars on this point see Appendix B.

But the value of soft water in household economy does not end with the cuisine. It extends to other departments as well, and with still more striking results. It makes personal ablutions pleasant to the skin and encourages cleanliness—it facilitates all scouring and scrubbing operations—it is less destructive to cotton or linen fabrics, that require frequent washings—and permits large savings in fuel, soap and labour.

Hardness in water is caused by the presence of mineral substances, chiefly salts of lime, magnesia and iron; and is commonly measured by what is known as "Clark's scale,"—named after the gentleman who first suggested its application as a test or measure of the relative amount of hardening materials in different waters. It is a soap test; and the degree of hardness is determined by the amount of soap required to produce a lather of a given strength.

The soap solution is prepared by dissolving hard curd soap in proof spirits, in the proportion of one ounce (avoirdupois) of soap for each gallon of spirits, and then filtered into well stoppered "glass vials capable of containing 2000 grains of distilled water." The entire *modus operandi* is exceedingly simple and all but universally adopted as a comparative measure of degrees of hardness. Experience, however, is required to perform the operation successfully, even in the laboratory of the chemist.

By Dr. Clark's notation *one* degree of hardness represents as much of the hardening salts as would take up and precipitate as much soap as a grain of carbonate of lime would do in a gallon of water; and *each degree* of *hardness* in this scale means the use or waste of one hundred and ninety-two (192) ounces of hard soap in ten thousand (10,000) gallons of water, or 1.92 oz. per hundred gallons.

By the use of this scale the economical or commercial value of one water compared with another can be readily ascertained. For instance, if water of *one* degree of hardness require 1.92 oz. of soap, per hundred gallons, water of *ten* (10) degrees will require 19.2 oz.; of *twenty* (20) degrees 38.4 oz., and of *thirty* (30) degrees 57.6 oz. But the saving effected in this way may be put in another form.

Suppose a city of, say, 12,000 inhabitants or 2,000 families supplied with a wholesome river water of *five* [5] degrees of hardness, and another of the same size supplied with well water of *eighteen* (18) degrees of hardness, which is not uncommon in red sandstone districts, and is indeed below the average obtained by the elaborate experiments of the River Pollution Commissioners; and that the average daily consumption of water in which soap is used is *one* gallon only per person, or six [6] gallons per family for washing, scrubbing and personal ablutions.

The difference in hardness it will be observed is *thirteen* (13) degrees, and the daily consumption 12,000 gallons. Now as each degree of hardness requires 1.92 oz. of soap per hundred gallons, to reduce it to the assumed standard of *five* [5] degrees of hardness, the total extra consumption of soap will be $\frac{[1.92 \times 13 \times 120]}{16}$ equal to fully *one hundred and eighty-seven* (187) pounds per day, or sixty-eight thousand two hundred and fifty-five [68,255] pounds per annum; representing a money value at *eight* cents per pound of *five thousand four hundred and sixty* [5,460] dollars and *forty* [40] cents, or the interest at six per cent. on a outlay of $91,000.

This may appear a large result, but the evidence on which it rests is indubitable and worthy of implicit confidence. It is not drawn from guess work nor crude empiric rule, but from the experiments of the ablest scientists, and the observations of the most intelligent operatives of Great Britian and Ireland—such as dyers and bleachers—whose business requires quantities of soap.

So valuable is a soft water supply considered in the manufacturing centres of England and Scotland, that hundreds of thousands of pounds sterling are not infrequently spent to change a city's supply from hard to a relatively soft one; chiefly from economical considerations. "Hence it is" says *Balfour Brown* in his recent work on "*Water Supply*" "that Glasgow has sought and procured a water which is only 0.8 of a degree of hardness, Loch Katrine; that Manchester has procured the Longendale water for its present wants, which is 1°.5 of hardness, and Therlemere for its future requirements, which will afford even a softer water; that Liverpool is promoting a bill in the present session of Parliament (1880) to secure the water of the Vwyrng, which at Point Hagel is 1°.5 of hardness; and that Bradford, Halifax, Bolton, Dewsberry and Wakefield, have secured abundant soft water supplies."

It is also claimed by many physicians and sanitary chemists that soft water is more conducive to health than hard water, but though the balance of opinion and evidence seems to favor this view, yet it is still a disputed point—so long as the hardness does not rise above *fifteen* (15) degrees. When it goes beyond this, however, as it almost invariably does in the *shallow* wells of the new red sandstone, there is a great unanimity of opinion in opposition to its use for drinking or dietary purposes, even when free from suspicion in other respects.

A water, whose permanent hardness does not rise above *six* [6] degrees of Clark's scale, is taken conventionally as a soft water—from this to about 15° as moderately hard, and all above this is decidedly hard and objectionable.

The term *permanent* hardness has just been used, and it may be well before proceeding further to explain what this means that clear notions may be formed of its character and influence.

As remarked in a previous paragraph, hardness in water is caused chiefly by salts of lime, magnesia and iron, as carbonates or sulphates. And the resulting hardness is spoken of as *temporary*, *permanent* and total, the last named being the sum of the two first.

When the hardening elements exist in the form of *carbonates* they may be dissolved and the water softened to a certain extent by boiling—the carbonic acid escaping through the water, while the mineral or earthly elements are being deposited in the containing vessel. Similar results take place with the sulphates, but not to the same extent, Now what is known as *temporary* hardness is that which disappears during boiling, and *permanent* hardness is that which remains.

Water obtained from chalk formations make large deposits of their hardening substances when subjected to boiling, but the waters of the new red sandstone do not. The *permanent* hardness of the latter, therefore, is always much greater than that of the former; and as a consequence it is less desirable for manufacturing or household purposes, when softness is at all times an important consideration.

But besides this, water which has a high degree of permanent hardness may be fairly suspected, if not entirely condemned, as its hardening elements consist probably of sulphate of lime and chloride of calcium, and it may be magnesian salts. The latter are considered by many authorities as particularly objectionable and likely to produce diarrhea and goitre or glandular diseases.

Perhaps I have dwelt at greater length on this branch of my Report that to some may seem necessary, but not more I hope than its importance deserves; in view of the loose notions that prevail generally respecting water and the qualities it ought to possess to fit it for drinking and dietary purposes. It is one of great moment to individuals, as well as to communities, and the teachings of science and experience in relation thereto cannot be neglected nor ignored with impunity.

The only point now remaining to be considered briefly is the

MUNICIPAL REQUIREMENTS

of your city. These may be briefly summed up in street sprinkling, gutter washing, sewer flushing, street fountains and fire extinguishment. For such purposes the quality of the water used is of less importance than the force and volume with which it can be delivered. Any ordinary water will answer for ornamental fountains, the sprinkling of streets, the flushing of sewers, the washing of gutters and the suppression of fire; but for all these purposes, and the last named especially, a very considerable force or pressure is essential to effective work.

An ever ready and copious supply of water for the cleaning of sewers and gutters in hot summer weather is invaluable, from an economic as well as a sanitary standpoint, but the greatest material benefit which comes to a city through a *high pressure* water supply is the protection it gives against the ravages of fire. Like the savings effected in *tea* and *soap*, they may not be always visible, yet it is no less true and substantial. The saving which comes in this way arises from two sources, (1) reduced volume of insurance, and (2) reduced premiums of insurance, both of which are sure to follow an efficient water supply and a proper distribution of fire hydrants.

It may be difficult to estimate accurately what this would amount to annually, but with a knowledge of the approximate value of the real and personal property shown by the returns of your assessors or city valuators, and a knowledge of the results that have followed the introduction of high pressure water supplies in other places, the money value of this saving may be estimated with sufficient accuracy to command attention, and show that the savings thus effected annually would warrant a large outlay of capital on this ground alone, did no higher reason exist, and still leave a large margin of profit in favor of the rate payer. Let us try to ascertain approximately what this annual saving would represent financially on a reasonable basis of calculation.

I am not in a position to state exactly the gross value of the burnable property of your city, but it will be safe to assume it $5,000,000, which, there is reason to believe, is considerably below what it should be—and that two-fifths, or $2,000,000 worth is insured, and pays annually for its protection according to present ratio, that is from one-half of one per cent to four per cent. premium. An average saving in premium of *one quarter of one* per cent. would amount to $5000 per annum, and an average of *one* half of one per cent. to twice this amount, or $10,000. The smaller sum, it will be observed, is equal to the interest at six per cent. on a capital outlay of $83,000, and the larger to an outlay of $166,000.

The largest reduction is less I fully believe than the actual amount will prove to be, or the experience of Charlottetown will differ from that of every other City with which I am acquainted. In many places the reductions that have followed a bountiful supply of water have greatly exceeded the largest amount named, and it would be no cause for astonishment if such were the experience of your citizens. This remark is not to be understood as applying to every individual case, but to the average of reductions that would surely follow the introduction to your City of a high pressure water supply.

And in this estimate, it should be observed no notice has been taken of the other *three fifths* of the burnable property of your City, on which your citizens carry their own risks: and which when *measured* by the *insurance standard* of *safety* would represent an additional indirect annual saving of from $7,500.00 to $15,000.00. It is true that this amount of money is not actually paid out, but it is not the less the equivalent and money measure of the advantages which accrue to a City, from an insurance stand point of a protective water supply. But to secure the advantages named the supply must be effective and an

EFFECTIVE WATER SUPPLY

for fire purposes, is one that embraces *copiousness*, *proximity*, and *pressure* in times of danger. That is to say (1) the source of supply must be unfailing and competent to furnish in your case not less than *one thousand* gallons of water per minute, or sufficient to supply eight (8) powerful streams when needed.

(2). The leading and distributing mains must be sufficiently large to convey this quantity of water, not only to the city, but, when fire breaks out, to the place of danger.

(3) The fire hydrants should be large, well drained, properly protected, readily accessible and sufficiently near each other in the dense parts of the city to require not more than *two hundred* [200] feet of hose on ordinary occasions, and

(4) The pressure should be sufficient when a maximum supply is required to send *eight*, or more, inch streams to a height *fifty* to *sixty feet*, and still be able to strike the fire with effective force.

When such is the case each hydrant is equal to a steam fire engine, standing near the point of danger with steam up and ready for work on the shortest notice.

The height named represents a hydrant pressure (according to *Leshure* and *Ellis*) of about 38 to 46 lbs., and a nozzle *pressure* of 24 to 30 lbs. per square inch. The loss or difference between the hydrant or initial pressure, and that at the nozzle or point of discharge, is occasioned by hose frictions.

But there is another question in connection with this insurance business which should not be overlooked nor lost sight of at this time, viz: *will the present premium rates continue?* I have taken some pains to obtain information on this point, and I am satisfied that the present low rates cannot continue. A moderately severe fire is sure to double them, and this may happen without such a disaster. The strongest and the best companies feel that the present premium rates are absurdly low, and must either be raised or the city abandoned, and with a view to this some are even now, so I have been credibly informed, curtailing their business.

The question, therefore, of an improved water supply is one of pressing importance from a protective point of view alone, and cannot be delayed indefinitely without your city paying the penalty of procrastination in some form or other. Insurance companies may be generous for a season, but they cannot continue to ignore the law of average with impunity, and are too intelligent and keen sighted to do so beyond a limited time. A general increase, I have been assured on reliable authority, is sure to follow in a relatively short time if your city resolves to leave its water supply as it is.

In addition to the saving which would accrue in soap and in insurance, there would be a further saving in the running expenses of your

FIRE DEPARTMENT.

Under a high pressure water supply, steam and hand engines could be dispensed with, and the capital they now represent relieved and applied to other city purposes; and to dispense with these means a large reduction in the shape of salaries and maintenance. I do not know what the engines have cost, nor what their present value would be if placed for sale, but I think it would be a moderate calculation to put the annual saving from this branch of the public service at $1,500, and doubtless it would rise above this sum could all your engines be dispensed with at once. But I take the smaller amount, as I do not wish to force a result that will not bear subsequent investigation. Then again the annual maintenance of

PUBLIC AND PRIVATE WELLS

would be saved to your city and citizens were they furnished generally with wholesome pipe water—from either of the chief sources noticed at the beginning of this Report. It is impossible to say what these two items amount to annually. The first is known, but the last must be approximated, and in doing this it will be safe, I think, to assume that the annual cost of the private wells of your city is equal at least to that of the public ones; and if this is the case the annual maintenance of both classes cannot be less than $2000 per annum. An average of 1877, 1878 and 1879, would show a larger sum than this, viz: $2,284, but for the purpose in view to reach approximately the annual cost of your present bad and imperfect water supply, I prefer the lower figures.

But to the cost of maintenance should be added the sum paid annually for the cartage of water from Spring Park. In 1877, your then Mayor, the Hon. Senator Carvell, estimated the water furnished from this source at 72,000 gallons per week, and the cost at a penny per pail at $243.30 or $12,692.15 per annum. Assuming these figures to be correct, and they appear to rest on reliable data, the yearly cost of the wells, and well water supplied to your city, is not less than $14,692, or the interest (at 6 per cent.) on a capital outlay of nearly $245,000.

Having noticed with more or less fulness the leading features of a desirable water for a city like Charlottetown, in its sanitary, in its protective and in its economical aspects, a brief resume of general results, or conclusions deducible therefrom, may not be unappropriate before proceeding to consider the claims of the various sources of supply, and the probable cost of each. And from what has been said the following conclusions may be fairly drawn, viz:

(1). That the water supplied from the shallow wells of your city—surrounded as they are with cesspools and privies, and subject to pollution from surface soakage, is not only bad, but positively dangerous, and wholly unfit for human use; and by reason of its hardness, detrimental to the manufacturing interests of your city.

(2). That a new supply is indispensable, a pressing necessity, and should be obtained at almost any cost and with the least possible delay.

(3). That the source selected should be able to furnish a water that is fairly soft and sparkling, pleasant to sight and taste, free from organic impurities and capable of furnishing an immediate supply of about 750,000 gallons daily and a prospective one of fully twice this quantity.

(4). That the new supply should be a constant service one and delivered at high pressure, so that the water would rise freely to the upper stories of houses in the highest parts of the City, and have sufficient force and volume to be effective in the suppression of fire without the help of Engines.

(5). That the distributing mains should be sufficiently large to convey a a copious supply of water to all parts of the City for fire purposes, in times of greatest danger.

(6). That the fire hydrants should be sufficiently large and closely set in the principal parts of the City, that not more than 200 feet of hose would be required to reach an ordinary fire.

(7). That a supply of water like that now contemplated would conduce to the general health of the City, and prove a great protection against diphtheria, fevers, cholera and other virulent and fatal epidemics.

(8). It would allow the streets to be thoroughly sprinkled in dry windy weather, and the suppression of dust would add to the sweetness and purity of the atmosphere, to the comfort of citizens and to the protection of goods exposed for sale by shopkeepers and others.

(9). It would permit sewers and gutters to be freely flushed and flooded with water in hot summer weather; lessening thereby the cost of your scavenger work, and adding to the general health of the city by the swift removal of decaying animal and vegetable matter.

(10). It would give encouragement to the use of steam—lead to the establishment of manufactories—to a demand for labour and to an increase of population; help to make your city a favorite summer resort, add to the value of its property and to its general prosperity.

(11). It would give greater security to burnable property and reduce insurance rates; lessen the cost of your fire department, and relieve your citizens from the maintenance of public and private wells.

(12). It would facilitate the work of the household, increase its conveniences and diminish its labor—when water is to be had at pleasure without leaving the premises. *Reduce* the *present actual* cost of water—allow important savings to be made in soap and tea—give richer results in cooking and add in many ways to the comfort of home in health and sickness;—when baths and water closets are household appendages.

(13). That the estimated annual savings which would accrue to your citizens in dollars and cents, would not be less, directly and indirectly, than *twenty-six thousand six hundred* and *fifty-two* [26,652] *dollars*, as follows, viz:—

Saving in	Soap,	$5,460.00
do	Insurance,	5,000.00
do	Fire Department	1,500.00
do	Public Wells,	1,000.00
do	Private do	1,000.00
do	Sp. Park Water	12,692.00
Total annual saving,		$26,652.00

And in reference to these figures it may be remarked that the estimated saving in soap is but a fraction more than $2.73 for each of 2000 families, which should be about the present population of your city, if its progress since 1871 has equalled that of the preceding *ten* years. The amount placed for insurance is the least estimated saving, and does not include benefits of a substantial character accruing to burnable property that is *not* insured. The sum set down for the fire department is less than two-fifths of its average cost for the years 1877, 1878 and 1879, and the saving in public wells is $142 less than the average annual outlay for *three* years just named.

(14.) The above figures show an average annual outlay of fully $13.32 per family as the cost of their present imperfect water supply, or the interest at 6 per cent. on a capital outlay of upwards of $444,000, which is equal to a capital expenditure per family of $222, or a per capita outlay of $36 fully for each man, woman and child of your community.

These amounts may seem large to some, but I am satisfied they are really less than the actual results will show when your city has become sensible of its danger, shaken off its lethargy, abandoned its wells and obtained for itself a constant and copious supply of wholesome water from one or other of the following sources, viz :—

1st from "Artesian" or deep wells,
2nd from Winter River,
3rd from Gates' Brook, or
4th from Curtis' Brook.

Having pointed out the principal features of a good water supply and some of the benefits that come therefrom, it will be in order now, to consider briefly the special claims of the several sources named—the fitness of each to meet the present and future wants of your city—the class of works necessary for its utilization and the 'probable cost'; exclusive of distribution. The latter will be dealt with by itself, bye and bye; as its cost will be a constant, common alike to all the schemes.

"ARTESIAN" OR DEEP WELLS.

The artesian or deep well scheme was looked on with favor by a large number of your most intelligent citizens, in 1876, and was an unsettled question when the surveys were made.

The new red sand stone was known to be an excellent water bearing formation; and in England and other places, many towns and cities obtained abundant supplies of wholesome water from its subterranean reservoirs. It was natural therefore that some of your citizens should consider this source as probably available for your city, and were anxious that their theories should be tested, before a large outlay was made in bringing water from a distant source. The desire was a reasonable one. No one could speak with certainty of the result when submitted to trial. Some doubted; but all wished to see it fairly and finally settled one way or another.

With a view to this, borings were undertaken by my advice in 1877 by Mr. Foster Pickard, a practical borer of the firm of James Harris & Co., St. John, and continued with varying success until a depth of 498 feet was reached, when the work was suddenly suspended and finally abandoned by the contractors. This work, I deem it due to myself to say, was not under my supervision, nor was any report made to me during its progress.

In a report submitted to your city council in 1878, Mr. Pickard says he had found several "large veins of water, "but the open character of the rock prevented it from rising "to the surface. That from the same cause, even at a far "greater depth a flow of water in any quantity cannot be expected," &c. Nothing has been done I believe since this report was written, and if I am correctly informed the work was abandoned, in consequence of a drill having been lost irrecoverably in the hole at the depth above named, 498 feet.

To this depth, at least, it seems certain, there is no such volume of water to be had as would be necessary to supply your city, and a further fact is brought out, that has proved destructive to many similar efforts—namely: rents in the rock, by which the water appears to escape, and find outlets in other directions. This is no uncommon obstacle to success in the new redsandstone, and to this and kindred causes are chiefly due the many failures to find water, recorded of this formation.

I do not know that you mean to do more than has been done already for the settlement of this question; but I could not advise any further expenditure in this way, as I see no good ground for believing in future success. The stratification of the rock, as well as the numerous cracks and fissures with which it abounds and the great uncertainty of getting a *usable* water, even if found in abundance, lead me to think it would be injudicious to look to wells of this character for the future supply of your city. Many of the sand stones which surround and underlie your city are porous and some of them a good deal jointed. Under such conditions it is not unreasonable to believe they may be permeated by sea water.

WINTER RIVER.

By the surveys of 1876 this river was found to have an elevation, at what is known as the "Henderson" mill site of 107 feet above high water at Charlottetown, or 57 feet above the highest point of land in the city proper; and at a point on the "Cobb" or "Bryanton" farm (say one mile lower down) an elevation of 74 feet in round numbers, or 24 feet above the highest point in the city.

The area of the water-shed above the last named point is about 3,100 acres; one half of which discharges above the Henderson Mill site and one half below it. The Matthewson Mill dam is about one and three-eighths of a mile farther down the stream than Cobb's and is about 70 feet above city datum. The water-shed between Cobb's and Matthewson's has an area of about 2000 acres, or say 5000 acres in all.

By the erection of a dam at Cobb's of about 16 feet high and 264 feet long, the surface of the stream could be raised to 86 feet and a reservoir obtained with a surface area of about 19 acres and a storage capacity of about 3,600,000 cubic feet or 27,000,000 gallons.

The flow of water in this stream is pretty steady but like all other streams it is affected to a greater or less extent by the character of the season. With a view to approximate the flow, wiers were erected at Henderson's, Cobb's and Matthewson's for some weeks during the fall of 1875 and at the two places first named during the spring and summer of 1876.

The gaugings made during the Autumn months show a greater discharge than do those of the spring and summer, the rain fall having been heavier. The gaugings at Henderson's were continued during the months of June, July, August, and September, and the ones at Cobb's during the months of August and September, only, while the water was lowest.

The greatest daily discharge obtained from the Henderson wier was recorded for the 15th day of June and was equal to 735,000 gallons in 24 hours; and the least daily discharge to 35,200 gallons 19th day of August.

At the Cobb wier the daily discharge oscillated during August and September, when the streams were lowest, between 2,068,000 and 1,607,000 gallons per 24 hours.

No observations were made during 1876 at the Matthewson dam, as the volume of water flowing there—the product of the entire drainage area—is beyond doubt ample for all the legitimate wants of a population from *three* to *four* times greater than now resides in Charlottetown.

The water of this "river" is clear and soft and pleasant to the taste; and appears to possess all the essential elements of a water well fitted by nature for domestic and manufacturing purposes. From the character however of some portions of the collecting ground there is reason to believe that it may be subject at times, when heavy rains prevail, to more or less discoloration; but though this may render it for a time slightly unpleasant to the eye there is no reason for believing that it would otherwise impair its quality. This is a point on which there is great unanimity of opinion between the chemical and medical authorities of Europe and America.

Winter River lies in a northeasterly direction from the city and by the nearest available route is about five and a half ($5\frac{1}{2}$) miles distant from the Colonial Buildings. Its sources are on the northern slopes of the high land that stands between it and the city, and it follows a northeasterly course to the Gulf of St. Lawrence via Bedford Basin.

As the summit of the ridge just named is about 186 feet above high water or 100 feet higher than the suggested "Cobb" reservoir, to make its water available for city use *pumping* or *tunnelling* would have to be adopted.

By the former (pumping) the water would be delivered in the city with a high pressure force; that is to say from 100 to 136 feet (or more if desired) above your highest city level, and the whole of the impounded water would be available in dry seasons, should the natural flow happen to be less at any time than the city's daily consumption. By the latter or tunnelling the water would be delivered at from 30 to 36 feet above your highest city level and about 24,000,000 gallons of the stored water would be available in seasons of extra drought.

The "*lift*" or difference of level between the pumps and the summit of the hill would be about 100 to 120 feet; and the water could be sent direct to the city, by gravitation.

The length of the lifting or rising main between the pumps and the reservoir, would be about 7000 feet and the length of the leading main from thence to the city about 21,000 feet. Both should be made of good cast iron and neither should be less than 12 inches in diameter. Indeed it would be better if the rising main were larger than this.

A 12 inch pipe drawing its water from a reservoir at this height and discharging at a point 25 feet above your city datum, or midway between your highest and lowest levels, should deliver, if properly laid and graded about 2,000,000 gallons daily or 83,333 gallons per hour.

The pressure under which this discharge would take place would be well fitted for fire purposes, *without* the *aid* of engines; but much more than is necessary for ordinary daily use; a medium pressure being more easily managed and desirable for domestic purposes, and less wasteful of water and water fittings. This could be readily regulated however by self acting mechanical arrangements, through which an ordinary pressure could be had for ordinary occasions and a high pressure in fire times.

The summit reservoir should be built with a view to future extension and be able to store not less than two millions four hundred thousand (2,400,000) gallons of water to begin with. To do this it would require to have a solid capacity in round numbers of a rectangular body 160 feet long by 80 feet wide and 25 feet deep. Part of the work of construction would be in excavation and part in embankment.

The engines and pumps should be able to place in this reservoir about 50,000 gallons per hour or 600,000 gallons per day of 12 hours; and the engine house should be sufficiently roomy to accommodate a second engine should such be deemed requisite in years hence.

The length of *tunnel* required to bring the water of Winter River to the city would not be far short of 2½ miles and may possibly exceed this; and the length of iron main about 16,500 feet.

The dimension of the tunnel could scarcely be less than 4.5 × 6 feet. This area is not required for supply purposes but to give ordinary room for mining and removing of the debris.

Shafts will be required along the whole line of tunnel, one probably every 600 feet, for ventilation and the removal of excavated material, and it may be for pumping should water be met with. The average depths of these shafts will be about 50 to 60 feet and each one will require a set of hoisting machinery, worked by steam or horse power as may prove most economical.

As the new red sand stone in the neighborhood of your city is porous and jointed, it is not improbable that a part or the whole of the tunnel would have to be lined with brick, to fit it for the duty it would have to do; but this is a circumstance that can only be found out as the work progresses. The additional expense incurred in this way may be much or little and may reduce or add considerably to the estimated expenditure. Work of this sort is always surrounded with doubt and uncertainty as to final cost, and requires a larger margin than ordinary undertakings.

Gate chambers and gates will be required at each end, to regulate the flow;. and at the city end, at least, substantial strainers to intercept the fish and prevent them from entering the main pipe. These chambers need not be large but both should be in duplicate and the arrangement such that either could be shut off at pleasure and cleaned without disturbance to the ordinary daily supply of the city.

The supply of water derived from Winter River in this way would be an eminently *low* pressure one and useless in a great measure for fire purposes without the aid of engines. It would be a fair pressure however for ordinary purposes to the greater part of the city, but might not be uniformly satisfactory to dwellers on the summits.

A 12 inch main leading from the termination of the tunnel to the city and discharging at a point 25 feet above city datum should deliver when new and well laid about 1,590,000 gallons per day or 66,250 gallons per hour. This it will be observed is greatly less than the quantity obtained from a pipe of the same size discharging under the superior pressure of a summit reservoir. To get the same results in gallons of water brought to the city daily, a pipe of not less than 14 inches diameter would have to be laid between the city and the tunnel.

The course of tunnel and pipe are shown approximately by full red lines on the accompanying plan, subject of course to revision and change should location surveys ever be made, which is rather doubtful.

The following figures give the probable cost by tunneling and by pumping.

PROBABLE COST BY PUMPING.

Reservoir at Cobb's.		
6000 Cubic yards embank't @ 30 cents .	$1,800	
Gate House and Gates . . .	600	
Compensation culvert	300	
Waste way	750	
Land and water rights	3,000	6,450
Engine House and coal shed . . .	2,500	
Ground	500	
Quadruple Engine, pumps & boiler set	16,000	19,000
Iron pipe		
7,000 feet rising main		
21,500 summit reservoir to City		
28,500 feet, 1,110 tons @ $30.00 . .	33,300	
Stop cocks	430	
Special castings and air valves . .	250	
Lead 37,000 lbs. @ 5 cents . . .	1,850	
Spun yarn	140	35,970
Labour excavating and refilling say 29,000 feet @ 20 cents	5,800	5,800
Summit Reservoir		
6,100 cubic yards excavating and embanking	1,830	
Land	500	
Culvert and gate house	600	
Special castings	100	3,030
		$70,250
Unforeseen expenses & engineering $7\frac{1}{2}\%$.		5,269
		$75,519

PROBABLE COST BY TUNNELING.

Reservoir. Same as in pumping . .	$ 6,450
Tunneling and Shafts	
11,880 lineal feet at $12·00 . . .	142,560
Gate chamber, gates and strainers .	1,500
16,500 feet 12 inch iron pipe, 640 tons	
at $30.00	19,200
Stop cocks	260
Lead and spun yarn	1,120
Special castings	200
Cartage 700 tons at 75 cents . .	525
Labour. Digging, laying pipe and refilling	
16,500 feet at 20 cents . . .	3,300
Extra land and water rights, say . .	6,000
	181,115
Unforeseen expenses and engineering 10 per	
cent	18,111
	$ 199,226

Before proceeding to notice other sources of supply it may be noted, that if in the progress of time the wants of your city require more water than could be obtained from the Cobb reservoir, an additional supply could be had by placing a dam of about 20 feet high, at the Matthewson Mill site, or thereabouts. This would raise the level of the stream, from Matthewson's upwards to 86 feet, and give the whole drainage area (5000 acres) for a collecting ground. A reservoir formed by damming the river at Matthewson's would have a great surface area, but it would be deficient in the important feature of depth. A wide spread surface causes a greater loss by evaporation, and shallow water is unfavourable to coolness and purity.

No special notice is taken of the Henderson Mill site for reservoir purposes, as its water-shed *alone* is considered inadequate for the future wants of the city and for engineering reasons as well. The next source examined was the

GATES BROOK

which is about three (3) miles from the city in a northerly direction. The water of this brook like that of Winter River, is the product of springs and is not only soft and clear, but from the nature of its collecting ground it is not likely to be affected injuriously by heavy rains.

The bed of the stream at the base of the Gates Mill dam is about the the same as your city datum and at a point about three quarters of a mile above this, 30 feet above high water or *twenty* feet lower than the highest land in the city.

It was at this last named point the gauge was placed and by raising an enbankment here, of say 34 feet, a reservoir could be had capable of containing about 57,000,000 gallons of water but by gravitation works a part only of this reserve would be available for city use in seasons of drought, as will be noticed more fully hereafter when the different sources are being compared.

The water-shed which falls into this brook, above the gauge has an area of about 1,550 acres and between this and the Gates Mill dam 870 acres or 2,420 altogether.

The highest daily flow recorded was 1,830,900 in October and November 1875, and the smallest 416,000 gallons in August and September 1875.

The average daily discharge during October 1875, when the gaugings were made was 1,744,000 gallons per 24 hours; and in June, July and August 1876, the average was 796,000 gallons per 24 hours.

The October observations represent an average daily discharge of about 1,125 gallons per acre and the summer average of 1876 about 513 gallons per acre.

These results it will be observed are exclusive of the 870 acres of water-shed between the Gates mill dam and where the gauge was placed on the brook about ¾ of a mile above. Assuming a corresponding discharge from this area as from the one above it, the average daily discharge at the mill during October 1875 must have been about 2,723,500 gallons; and the summer flow of 1876 about 1,242,800 gallons.

These estimates must be understood as approximate only, as the time was insufficient for a more extensive and satisfactory series of observations on this and the other streams (and the cost more than the city was inclined to bear) but imperfect as they are they give better evidence than rainfall alone could give, of the relative merits of the several sources of supply.

There are two ways by which the water obtainable from this district could be made available for city use, (1st) by *gravitation*, (2nd) by *pumping*. For the first it would be necessary to build a dam 34 feet high at least to raise the surface level of water 12 feet above the highest city grade; and lay about 3½ miles of 12 inch cast iron pipe.

A pipe of this size would be able to discharge at the junction of Euston St. and Spring Park Road about 43,900 gallons per hour; and give to the city a good *low* pressure supply but would be ineffective for fire purposes, without the aid of engines.

Under the head named, 14 feet, the water would seldom rise above the basement of houses situated on the 50 feet grade above the city datum and as the distributory arrangements were extended and the consumption increased a time would soon come when the summits would be left for longer or shorter periods without water. Such at least is the experience of gravitation supplies in other cities having a relatively low head.

Besides this only a fractional part of the water held in the reservoir could be drawn for city use, and as the water fell, as it would do in dry seasons, when the daily draft exceeded the natural flow, the initial head would be still further reduced—the general supply diminished and that at the summits made more precarious and unsatisfactory.

The only way by which the best results could be obtained from this source is by pumping—either into a service reservoir situated on some conveniently high point near the city, or *directly* into the mains, without the intervention of reservoir or stand pipe—the working pressure being controlled by hydraulic regulators, as in the Holey and Waterous systems, and run *high* or *low* as required for fire or ordinary city purposes.

When a reservoir is used in connection with pumping, one engine and one set of pumps may suffice for the work, but when there is no reservoir the engines and pumps, as a matter of ordinary prudence, should be duplicated to prevent interruption in times of accident, and must be worked continuously day and night without ceasing, Sunday or Saturday.

In the event of this source having been chosen and pumping decided on, the engine might be stationed (1) near the Gates' Mill about G on plan, (2) at a point marked F on the plan, 4000 feet nearer to the city, or (3) near the western end of Brighton Road, marked D.

If the *first* named site were selected, the water might be forced through a rising main of suitable size to a reservoir on College hill, or in some other more desirable place, and from thence sent into the city to supply the ordinary daily wants of the people, at a moderate pressure; the arrangement in regard to valves, &c., being such as to permit an immediate increase of pressure in case of fire.

The arrangement of the second location would be much the same; with this advantage that if in the progress of time, more water was wanted by your city than could be got from the Gates' water-shed, an additional supply could be drawn at or about this point from the "Curtis" water-shed, as will be noticed more fully hereafter, and coal for fuel could be landed more conveniently here than higher up the river. In either case however the necessary rising main to lead from the pumps to the reservoir and thence to the city, would be costly.

By placing the pumping station somewhere near the western end of Brighton Road, the rising main would pass through Euston Street, and supply to right and left as it went on its way to the reservoir, could a site near the city be obtained for this purpose. The latter, however, is not an indispensable though a very desirable and valuable appendage to a city's water supply; but in its absence the engines and pumps as already noted, would require duplication.

To bring the water to the pumps, a light iron or heavy stone ware pipe might be used or a small brick aqueduct built. The length of this pipe or aqueduct would be about 19,900 feet and its general course as well as suggested lines for rising mains from point F as well as from Gates' mill are shewn approximately by full red lines on the map or plan accompanying this Report.

The estimated cost by each of the ways suggested is as follows, viz :—

ESTIMATED PROBABLE COST.

No. 3 Line, gravitation, storage reservoir about 4000 feet above Gates' mill dam.

Storage Reservoir.		
Dam 59,000 cubic yards embanking at 30 cents	$17,700	
Gate house and culvert . . .	1,950	
Gates and special castings . . .	250	
Waste way	1,500	
Land and water rights . . .	10,000	31,400
Leading Main 12 inches in diameter.		
18,500 feet, 720 tons at $30.00 . .	21,600	
Stop cocks, air valves & special castings	530	
	22,130	31,400

Brought forward,	22,130	31,400
Lead and spun yarn	1,280	23,410
Labour, Cartage 800 tons at 75 cents . .	600	
Digging, laying pipe and refilling, extra labour, deep cutting . . .	6,380	6,980
		$61,790
Unforeseen expenses and Engineering 7½ per cent		4,634
		$66,424

ESTIMATED PROBABLE COST.

No. 6 Line, pumping, storage reservoir about 4000 feet above the Gates' mill dam and pumping station near Gates' mill marked G on plan.

Storage Reservoir.		
Dam 22,000 cubic yards embanking at 30 cents	6,600	
Gate house and culvert . . .	1,740	
Gates and special castings, streams &c.	300	
Waste way.	1,500	
Land and water rights . . .	10,000	20.140
Engine house and coal shed . . .	2,200	
Engines pumps and boilers in . . .	16,000	18,200
18,900 feet 12 inch iron main, 728 tons at $30.00	21,840	
Lead and spun yarn	1,315	
Stop cocks, air valves & special castings	680	23,835
Labour, cartage	600	
Digging, laying pipe and refilling .	3.780	4,380
College Hill reservoir and gate chambers .		3,350
		$69,905
Unforeseen expenses and engineering 7 per cent		5,243
		$75,148

ESTIMATED PROBABLE COST.

No. 4 Line pumping, Storage reservoir about 4,000 feet above the Gates' dam. Pumping station at point marked F on plan. Distributing reservoir on College Hill.

Storage Reservoir.		
Dam, gate house and culvert &c., same as for No. 6		20,140
Engine house and coal shed . .	2,200	
Quadruple engine, boilers and pumps complete	16,000	
8,000 feet 14 inch cast iron pipe, 336 tons at $30.00	10,080	
Stop cocks & special castings, . .	180	
Labour digging laying & refilling 8000 ft. at 20 cts.	1,600	30,060
5000 ft. 12 inch rising main		
5600 ft. 12 inch delivering main		
10,600 ft. 12 inch pipe, say 400 tons at $30.00	12,000	
Stop cocks, air valves & special castings	630	
Lead and spun yarn . , . .	761	13,391
Labour digging, laying, refilling 11,000 ft. at 20 cts..	2,200	
Cartage, 600 tons at 60 cts. . .	360	2,560
College Hill reservoir, Gate, Chambers and connections		3,350
		$69,501
Unforeseen expenses & engineering 7½%		5,212
		$74,713

ESTIMATED PROBABLE COST.

No. 5 Line. Pumping on Holly system, without reservoir on College Hill. Duplicate pumps and engines. Pumping station near the western end of Brighton Road and storage reservoir as before, about 0$\frac{3}{4}$ of a mile above the Gates' dam.

Storage reservoir.		
Dam, Gate House and culvert, the same as No. 6, ...		20,140
19,800 ft. 14 inch iron pipe between reservoir and pumping station, 832 tons, at $30.00	24,960	
Stop cocks & special castings . .	350	
Wedges for jointing	175	25,495
Labour digging, laying and refilling 19,800 ft. at 20 cts.	3,960	
Cartage 840 tons, at 60 cts. . .	504	4,464
Engine House and land . . .	2,700	
2 Quadruple Engines, boilers & pumps complete in	28,500	31,200
3,300 ft. 12 inch rising main 128 tons, $30.00	3,840	
Stop cocks & special castings . . .	340	
Lead and spun yarn . . .	241	4,421
		$85,720
Unforeseen expenses & engineering 7½% .		6,433
		$92,153

CURTIS' BROOK.

Proceeding in a northwesterly direction about 3 miles from the Gates gauge, the Curtis brook and Mill dam are reached, and here there is a fine flow of excellent water, which appears to be well suited for city purposes, being soft and clear and pleasant to the taste.

The bed of the brook between the bridge and the mill dam is not much above city datum, but proceeding upwards for about 1¼ miles a point is reached which is 54 feet above high water, or 4 feet higher than the highest land in the city. It was at this point (marked on plan) the gauges were placed and observations made on the volume of water flowing daily in the brook.

The surface water-shed of this brook is about 2300 acres; 1400 of which are *below* the gauge and about 900 above it. It was apparently from the last named area the water was obtained which passed over the Curtis wier; but from the fact that with a greatly diminished drainage area the flow was greatly in excess of that obtained at the Gates gauge and relatively greater even than that obtained on Winter River, there is reason to believe that a portion at least of the water which comes to the surface in this valley comes from sources beyond the summit ridges, that outwardly define the water-shed; in other words the hydrographic basin is more extensive than is shown by the surface area.

The greatest daily flow observed was 1,712,800 gallons in June and July 1876 and the lowest 719,600 gallons in August of the same year.

The average daily discharge during the continuance of the observations in October 1875 was 1,369,900 gallons and for June, July and August 1876 about 1,235,000 gallons. The former represents an average daily discharge per acre of about 1520 gallons and the latter of about 1370 gallons. These estimates and observations, like the others, are only approximate, and so far as they go do not, I think, over state the case.

These figures show that the Curtis' brook has a much more steady and equable flow than Gates' brook or Winter river, and is less *directly* affected by the rain fall. This trait favours the theory that the water found here comes from deeper and more distant sources than that which appears in the "Gates Valley" and makes it more suitable for city purposes.

To utilize this water a storage reservoir would have to be created above where the gauge stood. This could be done by placing a dam across the valley, a short distance below where the measurements were taken. The banks on each side are favourable and would permit an embankment fully 35 feet in height, at its deepest part.

By a dam of this height the surface water of the reservoir would stand about 85 feet above high water, or 35 feet above your 50 feet summit; and its capacity would be about 170,000,000 gallons, about 147,600,000 gallons of which would be available in dry seasons and still leave a fair head pressure.

I would feel some uneasiness however in placing a reservoir of this capacity in this valley; not that the embankment, in itself could not be made secure but as to the effect this large body of water would have on the substrata—whether the overlying soil would be sufficiently compact to retain the water and keep it from wasting by percolation, as well as by evaporation. I do not know that there is any substantial ground for this fear, but still I name it as a point that should receive careful consideration before a work of this kind is undertaken. This remark applies to the Gates as well as to the Curtis reservoir.

The circumscribed collecting ground surrounding this reservoir is unfavourable to its selection had it no other source of supply beyond what appears on the surface. But as already shewn there is strong reason for believing that it has other and wider sources of supply; and outside of this a large part of the drainage area of Winter River (say 1800 acres) could be turned in this direction, were the water of this brook required to furnish a *direct* supply, or only a supplemental one to the city. A maximum cut of about 18 feet deep would be required for this purpose, and the new district or drainage territory is shown approximately by blue shaded lines on the general map or plan.

About 7 miles of cast iron pipe would be required to bring the water of this brook to Charlottetown and the size should not be less than 12 inches. If this source be selected I would prefer a larger main than this for a part of the way at least—a pipe say of about 16 inches in diameter for about half the distance.

Assuming the point of delivery in the city to be at the junction of Spring Park Road and Euston Street or 25 feet above high water, the difference in elevation between this point and the Curtis' reservoir would be 60 feet: or an average fall when the reservoir was full of 8.57 feet per mile, and of 6 feet when drawn down to its assumed mininum of 67 feet above city datum.

A 12 inch pipe would deliver when new and well laid about 40,000 gallons per hour under its maximum head and about 33,750 gallons under its mininum of 6 feet per mile. The former is equal to a daily supply of 960,000 gallons and the latter to about 810,000 gallons, each 24 hours.

A 16 inch pipe discharging under the first named head would deliver 83,700 gallons per hour and under the second or lower head 70,200 gallons—the former being equal to a daily discharge of 2,008,000 gallons and the latter to 1,684,000 gallons, per 24 hours.

By laying a larger sized pipe next the reservoir a higher duty would be obtained from the 12 inch pipe than is given above and in after years when the city's wants outgrow the capacity of a single main the supply could be increased by laying a second pipe from the city to the termination of the larger one, whenever this might be.

In the following estimates of "probable cost" I have assumed that one half of the whole pipe required for this scheme would be 16 inches in diameter, or pipe equivalent thereto.

The estimated cost of the works required to make this source available for City purposes, in the way suggested, is $109,529.00 as follows.

ESTIMATED PROBABLE COST.

No. 7 Line, gravitation, from the Curtis reservoir to the City, leading main 12 and 16 inches in diameter.

Storage reservoir.		
Dam 91,000 Cubic yards embanking at 30 cents	$27,300	
Gate house and culvert	1,905	
Special castings and gate strainers .	450	
Waste way.	1,500	
Land and water rights . . .	10,000	41,155
Leading Mains.		
18,500 feet 16 inch pipe, 935 tons at $30,00	28,050	
18,500 feet 12 inch pipe, 713 tons at $30.00	21,390	
Stop cocks and special castings . .	870	
Joining, pine wedges, lead and spun yarn	1,476	51,786
Labour, Cartage, 1660 tons at 75 cents .	1,245	
37,000 feet diging laying pipe & refilling at 20 cents	7,400	8,645
		$101,586
Unforeseen expenses and engineering 7½ per cent		7,643
		$109.229

The estimated cost for a main of 12 inches diameter for the whole distance from the city to the reservoir is $101,545. The difference therefore is less than $8,000, a mere bagatelle compared with the great advantage which would accrue from the larger main, if this source and system of supply should be selected for your city.

SPRING PARK.

Some attention was also given to Spring Park well, but no continuous observations were made here, as at the Gates' and Curtis' Brooks, as the traffic and cattle wandering about the well looking for water, made the maintenance of a gauge all but impossible, without fencing, which we had no right to do.

In reference to this well I would say however that it is not *per se* a desirable source of supply. Its situation is unfavourable on sanitary grounds—its water is inferior to that of Winter River and to both of the Brooks named above, and the quality obtainable is greatly less than what will be required to meet the growing wants of a City like Charlottetown, when its citizens begin to know the value of a constant water supply.

The quantity could be increased probably, by sinking a deep shaft or well and opening adits in different directions for the inflow of water, but even then, and supposing the quality to be maintained when drawn from below the tide level, which is very doubtful, and that by sinking an abundant supply could be had, still the constant risk of sewage contamination, to which the water would be exposed, from surrounding dwellings, barns and privies would make it an unsafe and undesirable source of supply for domestic purposes.

In October 1875 the flow here oscillated between 125,400 and 596,100 gallons per 24 hours, and in June 1876 between 254,000 and 346,200 gallons, but for reasons already stated, these observations were not so satisfactory as the others were outside of the city.

To make the water obtainable here available, a deep well would have to be sunk, and pumping of course resorted to ; but I have made no independent estimate of the cost, as I consider it inadequate in many ways for the wants of your City.

DISTRIBUTION.

The distributory arrangement of every public water supply is of great importance and deserves special attention. A well matured plan should be adopted at the outset, and each subsequent extension should be made in accordance therewith; subject of course to such changes as time and local circumstances may show to be necessary. One of the greatest evils that can befall a water supply is the adoption, through a craving for cheapness, of a careless system of hap-hazard extension, which looks at the present only and takes little or no heed to the future. Such a practice is sure to lead to trouble and to an unnecessary waste of money; and will be avoided, I hope, by your City.

Plan No. 2, which shows the distributory system suggested for your City, is not given as absolutely correct, but is designed to show approximately what this should be when your City is supplied by pipe water only. A closer study and better knowledge of your City's wants and habits are necessary before a final and intelligent decision can be come to on this point.

MAIN PIPES.

All your main pipes should be of cast iron and sufficiently strong to resist successfully the greatest strain that is ever likely to be placed on them. They should be made of the best quality of pipe metal, and protected as far as possible against internal accretion and external corrosion. They should be large and well laid, and arranged with a special view to fire protection. For this purpose they should be not only large for the work expected of them, but they should be so connected and interlaced, the one with the other, that each and all would assist in maintaining a copious and effective discharge, when extra demands were being made for fire purposes in any particular locality.

The mains for the supply of fire hydrants should not be less than 6 inches in diameter, and the pipes leading therefrom to the hydrants not less than 4 inches. Larger mains and supply pipes would be preferable, and for this reason I have estimated for a liberal percentage of 8 inch pipe, as will be seen by a reference to the plan. And it may be noticed that the 4 inch pipe shown thereon is used for connecting the larger mains and furnishing a house supply in short sections of streets where hydrants are not required.

Should it be thought that the larger pipe is beyond the present means of your city, it can be replaced with a smaller one—and the cost reduced thereby some thousands of dollars; but this would be a short-sighted policy, that necessity alone could justify. The same excavation, for example, is required for a *six* inch pipe as for an *eight* inch one, and the time required for laying and jointing will be about the same for both. A little more lead will be required for an eight inch pipe than for a six inch one, and the metal in the former will exceed the weight of the latter about *fifty* per cent. but as an offset to this the *eight* inch pipe will deliver upwards of *one hundred* per cent more water, in a given time, than a *six* inch one; under the same conditions as to pressure, etc. Past experience and present practice favor the adoption of relatively large mains when a first class water supply is desired for fire purposes, as the accruing advantages exceed greatly the additional outlay.

In laying the mains special care should be taken to avoid what is technically known as "dead end," and secure, if possible, a perfect and complete current in the pipes. This is necessary to preserve sweetness and purity. Water lodging at "dead ends" being stagnant, soon becomes foul and unfit for use; and when such are unavoidable, as sometimes happens, flushing cocks should be attached through which they may be scoured and cleaned as often as necessary. Arrangements should also be made for flushing the several mains at their points of greatest depression, as well as along the harbor line. These flushing cocks are useful also for emptying the mains when repairs or alterations have to be made.

STOP COCKS.

A judicious disposition of main stop cocks is also of great practical importance, so that when circumstances necessitate a shutting off for any purpose, it may be done with as little inconvenience as possible. With a view to this, stop cocks should be placed at all intersections and arranged in a way that one side or section only of a block will be deprived of water when alterations or repairs make shutting off an absolute necesity.

This involves a larger outlay at the first, but it is true economy in the long run, and is the only way by which the inconvenience can be diminished and the risk of shutting off reduced to a minimum. Only those who have had the experience and the responsibility of shutting off large and populous districts, at, it may be, very inopportune times and seasons can know and appreciate fully the importance which attaches to a proper disposition of stop cocks.

It not infrequently happens when a city is first entering on a public water supply, that from motives of economy in first cost, facilities of this sort are deliberately ignored and long stretches of pipe are left without appliances for shutting off. This practice however is highly reprehensible and causes a large after outlay for the insertion of stop cocks that could have been placed much more easily and at much less cost when the mains were being laid.

FIRE HYDRANTS.

The fire hydrants used should be of the most approved pattern, capable of furnishing a good force and volume of water when needed for the suppression of fire. They should be strong and of simple construction, capable of removement for repair without interfering with the general supply of the block or district to which they belong, and should be proof if possible against frost. The last feature is one of immense importance which should be secured at any cost almost. Good drainage is an essential element in fire hydrant protection and without this it is extremely difficult to keep hydrants in a usable state during the winter season.

It is not necessary at present however to do more than name the chief points of importance in this connection. There are so many claimants for public favour in this line of business that you should have no difficulty, when the time comes for selection, in obtaining at a moderate cost a hydrant of modern design which will meet your circumstances.

As already remarked those hydrants should be set closely together. The *average* distance should not be more than *four hundred* (400) feet. When this is the case there is a great saving in the wear of hose as well as in time necessary to reel it out and get water on to the fire. And besides this there is a great reduction of frictional resistance in short over long lines of hose, which gives a more active pressure at the nozzle and a more effective stream for the fire.

SERVICE PIPES.

Lead pipe should be used for house service. Many other materials have been tried. but none have been found equal to the lead in durability and readiness in laying and repairing, and none is more wholesome when used, as this will be, under a constant high pressure service.

The ordinary size for house supply should not exceed *four-eighths of an inch in diameter*, anything beyond this should be paid for by the taker, and each service should be controlled by a stop cock, driven into or placed near the main.

The exact position of each of these stop cocks, as well as the main pipe ones, should be accurately plotted to a large scale, and recorded besides in books prepared specially for this purpose. When this is not done, much confusion and waste of time and money are sure to follow. That a stop cock may be reached when wanted, without digging to the main, a box and cover are usually placed over it, and the cover as a rule is even with the surface of the street.

The main pipes should be protected from frost by a covering of about 5 feet of good earth, and service pipes should not have less than 6 feet. This grade should be continued to the inside of the building, where a stop cock and waste for winter use should be placed and secured against frost. The wall also through which the pipe is to pass should be carefully opened, and a block of wood, bored for the pipe, built into it. The last named device is simple and inexpensive, and does excellent service in resisting the approach of frost.

The estimated cost of the distributing service shown on the plan is $57,159, including mains, hydrants, stop cocks and service pipes, as follows, viz:

8 inch pipe.		
11,450 feet, 257 tons, at $30.00	$ 7,710	
Stop cocks, 25 at $30.00	750	
Special castings,	70	
Lead and spun yarn,	460	
Labour, cartage,	240	
Labour, digging, laying and refilling,	2,151	11,381
6 inch pipe.		
25,930 feet, 402 tons, at $30.00,	12,060	
Stop cocks, 58 at $20.00,	1,160	
Special castings,	250	
Lead and spun yarn,	850	
Labour, cartage,	200	
Labour, digging, laying and refilling,	4,682	19,202
4 inch pipe.		
25,970 feet, 247 tons, at $30.00,	7,410	
Stop cocks 196, at $15.00,	1,248	
Special castings,	24	
Lead and spun yarn,	650	
Labour, cartage,	100	
Labour, digging, laying and refilling,	5,194	14,626
		$45,209
79 Fire Hydrants, at $50.00,		3,950
1,000 Service pipes,		8,000
		$57,159

The above estimates, it may be remarked, embrace the *whole* city, but the expenditure will be a gradual one, regulated by the will as well as the necessities of the people, and may extend over a period of *ten* (10) years or more. But such a course would be injudicious. For the sake of revenue as well as health and protection against fire, the whole city should be supplied soon as after the works have gone into operation as possible.

With the cost of distribution added, the relative cost of the different schemes stand about as follows, viz:

TABLE No. 1.—Giving a comparative view of the total estimated cost of each of the several schemes proposed, with whole of distributing pipe laid.

	COST OF WORKS.		
	OUTSIDE OF THE CITY	INSIDE OF THE CITY.	TOTAL.
Winter River.			
No. 1 on plan, Tunnelling	$199,226	57,159	256,385
" 2 " Pumping,	75,519	57,159	132,678
Gates' Brook.			
No .3 on plan, Gravitation	66,424	57,159	123,583
" 4 " Pumping,	74,713	57,159	131,872
" 5 " "	92,113	57,159	149,272
" 6 " "	75,148	57,159	132,307
Curtis' Brook.			
No. 7 on plan Gravitation	109,229	57,159	166,388

The above table shows at a glance the financial aspect of each of the sources named, when every street in your city is supplied with pipe water; and includes *one thousand* house supply pipes, *seventy-nine* fire hydrants, and upwards of *sixteen* miles of main and service piping.

The extensive and universal distribution of the water must be, of course, a work of time, and may occupy, as already remarked, *ten* years or more. It would be safe, therefore, to estimate the immediate outlay for distribution at not more than 25 per cent. of the above and with this modification the probable cost of each of the several schemes would stand as follows, viz:

TABLE No. 2—Showing total estimated cost of each of the seven schemes proposed with 25 per cent of the distributing pipe laid.

Winter River	No. 1	Gravitation and Tunneling	$213,516.00
do do	" 2	Pumping into Reservoir .	89,808.00
Gates' Brook	" 3	Gravitation . . .	80,713.00
do do	" 4	Pumping into Reservoir .	89,002.00
do do	" 5	Pumping directly into mains duplicate Engines . .	106.402.00
do do	" 6	Pumping into Reservoir .	89,437.00
Curtis Brook	" 7	Gravitation . . .	123.518.00

Arranging the foregoing figures in the order of their magnitude, they would stand as follows, viz:

1. Winter River.—Gravitation and tunneling .	$213,516
2. Curtis' Brook.—Gravitation from Reservoir in valley above Curtis' Mills	123,518
3. Gates' Brook.—Pumping directly into the city main from Station D.	106,402
4. Winter River.—Pumping into summit reservoir from Station C	89,808
5. Gates' Brook.—Pumping into College Hill reservoir from Station G.	89,437
6. Gates' Brook.—Pumping into College Hill reservoir from Station F.	89,002
7. Curtis' Brook.—Gravitation from reservoir in valley above Gates' Mill	80,713

With a single set of machinery the cost by pumping from station D would be reduced to $94,000.00. But by doing this the risk would be greater than ordinary prudence could justify, as in the case of the engine being disabled from any cause the city would be left without water until the necessary repairs were made, and in the event of a fire breaking out at such a time the result might prove exceedingly disastrous. A strong point in favour of this as well as station F is the superior opportunities that both appear to present for the landing of coal close by the works and saving thereby extra handling and cartage. Could a proper site be obtained for a distributing reservoir near the city, a single quadruple engine could be used with comparative safety, but not otherwise.

That a fair comparison may be made however between the pumping and gravitation schemes noted above, the annual cost of each should be fairly considered and compared—that is to say the annual interest payable on the original outlay of capital and the running expenses connected with each.

I have endeavored to do this, and the different schemes tried in this way give the following results: based on an hourly supply of 50,000 gallons or 600,000 gallons per day of 12 hours lifted to a height of 60 to 100 feet, by steam power pumping and the hourly discharges obtainable from the sevreal gravitation schemes under their respective gradients.

TABLE No. 4.—Comparative view of estimated annual cost of the several schemes proposed.

Winter River No. 1, Gravitation.		
Interest on say $213,500 at 6 per cent	$12,810	
Management	1,800	14,610
Winter River No. 2, Pumping.		
Interest on say $89,800 at 6 per cent	$ 5,388	
Estimate cost pumping reservoir	2,800	
Management	1,500	9,688
Gates' Brook, No. 3, Gravitation.		
Interest on say $80,700 at 6 per cent	$ 4,842	
Management	1,800	6,642
Gates' Brook, No. 4, Pumping F.		
Interest on say $89,000 at 6 per cent	$ 5,340	
Estimate cost pumping into reservoir	2,000	
Management	1,500	8,840

Gates' Brook, No. 5, Pumping D.		
Interest on say $106,500 at 6 per cent .	$ 6,390	
Estimate cost pumping direct . .	2,500	
Management	1,500	10,390
Gates' Brook, No. 6, Pumping G.		
Interest on say $89,400 at 6 per cent .	$ 5,364	
Estimate cost pumping into reservoir .	2,000	
Management	1,500	8,864
Curtis' Brook, No. 7, Gravitation.		
Interest on say $123,500 at 6 per cent .	$ 7,410	
Management	1,800	9,210

Assuming as has been done in a former part of this Report that by the time the works now contemplated are in operation, your city will contain 2,000 families or a population in round numbers of 12,000, the capital and annual outlay per head and per family would be about as follows from either of the sources named.

Table No. 5.

Shewing the estimated supplying capacity of the several schemes proposed, together with the capital and annual cost of each per head, and per family, (with an assumed population of 2,000 families or 12,000 inhabitants) compared with estimated cost of present supply.

NAME OF SOURCE.	POWER PROPOSED.	Supply in Gallons per hour.	Greatest capacity in Gal. per 24 hours.	CAPITAL COST.		ANNUAL COST.	
				Per Family.	Per Head.	Per Family.	Per Head.
				\$ c.	\$ c.	\$ c.	\$ c.
Winter River, ...	Gravitation			106.76	17.79	7.30	1.22
do.	Pumping	50.000	1,200,000	44.90	7.48	4.84	0.81
Gates' Brook, ...	Gravitation			40.36	6.73	3.32	0.55
do.	Pumping station F	50.000	1,200,000	44.50	7.42	4.42	0.74
do.	do D	50.000	2,400,000	53.25	8.87	5.19	0.87
do.	do. G	50.000	1,200,000	44,72	7.45	4.43	0.74
Curtis' Brook, ...	Gravitation			61.76	10.29	4.60	0.77
Spring Park.	Water Cart					6.35	1.06
Estimated present annual cost in Insurance, in soap, in Fire Department and Public and Private wells.				222.00	37.00	13.36	2.22

The foregoing figures are sufficient in themselves to arrest attention, as they show clearly that a large sum of money could be spent in bringing to your city an abundant supply of soft and wholesome water and the average annual outlay paid therefor in the shape of interest and running expenses fall far below what is now paid directly and indirectly for a bad and imperfect one. And here I would again remark that in preparing the preceding tables much care has been taken to make them as accurate as possible, from the data at command. Nothing has been exaggerated nor understated intentionally. Nor is there any occasion whatever to attempt either in your case, as few places on either side of the Atlantic are more favourably circumstanced than Charlottetown for obtaining for itself a cheap and copious supply of water.

To some of your people the cost may seem great, but a careful study and analysis if they please of the several points and tables brought out in this Report, will show that it is not so in reality and that the per capita cost to few cities in England or America is as low as it would be in your case with any of the schemes proposed.

As a few hints on this point may be of service to your people I subjoin the following tables: showing the total and per capita cost &c. of water works in other cities, compiled from recent departmental Reports and parliamentary returns of a late date, viz. 1879, and as the works were undertaken in most cases from sanitary reasons alone, the prices paid by the cities named indicate the value set on a wholesome water supply when the laws of health and hygiene are rightly understood and practically appreciated.

TABLES

SHEWING COST, &C.

Of Water Works

IN OTHER CITIES.

TABLE

Shewing the Maximum capacity, the daily per capita
Also cost per Million Gallons, collected

Name of City. or Town.	Population Census 1871.	Power used.	Maximum capacity of works, 1878, Imperial Gallons	Maximum daily av'g. per head.
Margate	12.000	Steam	700,000	58
Hastings	26,300	Steam	600,000	20½
Chichester	8,730	Steam	360,000	32
Southampton	53,700	Steam	3,500.000	65
Reading	32,300	Steam	1,100,000	34
Uxbridge	7,500	Steam	250,000	33
Northampton	44,900	Gravitation	520.000	12
Cambridge	30,100	Steam	1,500.000	50
Weymouth	13,300	Gravitation	2,000,000	150
Exmouth	5,600	Steam	120,000	21
Penzance	10,500	Gravitation	300.000	28
Kiderminster	19,500	Gravitation	630.000	32
Rugby	7,800	Steam	177,000	21
Southport	21,200	Steam	1,000,000	47
Birkenhead	45,500	Steam	1,810,000	40
St. Helens	45,300	Steam	2,100.000	46
Stalybridge	21,100	Steam	500,000	24
Blackburn	93.300	Gravitation	2,000,000	21
Whitby	12,400	Steam	300,000	24
Ryde	11.200	Steam	600.000	54

Average cost per million Imperial Gallons daily $430,357.00
Average cost Wine or Standard Gallons, . 358,631.00
Average per capita cost, ... 14.11
Average Maximum supply per head of population
Imperial Gallons, ... 40.6 gallons
Average Maximum supply per head of population
Wine Gallons, ... 48.7 "

No. 6.

Supply and the per capita cost of twenty English Towns, from Parliamentary Blue Book, 1879.

Cost of works reduced to Canadian Currency.	Average per Capita Cost.	Rate of cost per Million Gallons.	Cost per million Wine Gallons.
$	$	$	$
140,000	11.67	200,000	166.667
536,300	18.30	893,900	744.917
72,500	8.30	201,400	175.334
586,900	19.00	159,114	132.595
412,500	12.77	375,000	312.500
125,000	16.60	500,000	416.666
294,500	6 55	566 300	471.917
300,000	9.96	200,000	166 666
188.000	14.13	99.000	82 500
100,000	17.85	833,300	694.416
87,000	8.28	290,000	241 666
112,200	5.73	178,100	148.417
120,000	15.38	678,000	565.000
750,000	35.37	750.000	625.000
652,000	14.32	360,280	300.234
496,500	10.96	236.400	197.000
510,000	24.17	1,020,000	850.000
931,500	9.98	465,750	388.125
90,000	7.25	300,000	250.000
175,000	15.70	291,600	243.000

TABLE

Showing the maximum capacity, the daily supply in
Also cost per million gallons.

Name of City	Estimated Population.	Power used.	Daily Supply. Maximum Capacity Gallons.	Average for year named. Gallons.	Max. avg. per head.
Salem	24,000	Steam	5.000.000	3,000,000	208
Ottawa	30,000	Water	9.000,000	2,250,000	300
Columbus	50,000	Steam	10.000,000	1.600,000	200
Detroit	120 000	Steam	15,000.000	14,000.000	125
Lawrence	38,200	Steam	5,000,000	1,456.000	131
Lowell	60.000	Steam	6.000.000	2,024.7C0	100
New Bedford	26,000	Steam	6,000,000	3,000.000	222
Cambridge	50.000	Steam	10.000,000	2,500,000	200
Waltham	11,500	Steam	1,500,000	350,000	139
Manchester	27,000	Steam	3,000,000	1,247.000	111
Toronto	75,000	Steam	12.000.000	4,440,000	160
St. John	40,000	Gravitation	10,000,000	4,000,000	250
Montreal	130,000	Water and Steam	28,000,000	9,000.000	215
Toledo	58,000	Steam	14.000,000	2,600,000	241
Cleveland	157,000	Steam	28.000,000	9,500,000	180
Erie	28,000	Steam	6,000.000	3.000.000	214
Buffalo	145,000	Steam	33,000,000	12,000,000	227
Rochester	82,000	Gravitation and Steam	16,000,000	3,250,000	
Dayton	37,500	Steam	4,000,000	1,000.000	
Lynn	35.000	Steam		1,266,000	

Average of cost per million, Wine or American standard gallon, maximum capacity . $167,026.00
Average do. to present population . . 559,625.00
Average of per capita cost 29.65
Mean of maximum capacity per head do. 185½ galls.

No. 7.

(W. S.) gallons and per capita of twenty American Cities. Collected from recent Reports.

COST OF WORKS.			
Total cost to present Population.	Per Capita Cost.	Per million gallons, Maximum capacity.	Per million gallons to present population.
$1,100.000	46.00	220.000	366,600
1.100,000	36.67	122.200	490,000
651,000	13.00	65,100	406,800
2,559,000	21.30	170,600	182,800
1,538,500	40.28	307,700	1,056,600
2,156,000	36.00	359,300	1,064,800
980,900	33 00	163,400	326,800
1,696 500	33.93	169,650	678,600
300,000	26 00	200.000	857,100
945,000	35.00	315,000	756,000
2,000,000	26.60	166,600	450,400
1,000,000	25.00	100 000	250.000
6,500,000	50.00	232,100	722,200
1,000,000	17.24	71,400	384,600
2,500,000	16.00	89.280	263.100
700.000	25 00	116,600	233,300
3,000,000	20.70	90,848	250,000
3,500,000	43.50	218,750	1,077 000
648,000	21.60	162,000	648,000
921.500	26.33		727.800

TABLE

Giving general view of the capacity and per capita cost of with water, compared with the averages obtained from

	Maximum capacity in standard gallons per day of 24 hours.	Maximum average per head of population.
Water works of 20 American Cities.		
Average cost by Table No 7 . .		185½
Water Works of 20 English Towns.		
Average cost by Table No. 6 . .		48¾
Charlottetown Water Works. estimated average cost with a population of 12,000.		
Winter River, Gravitation No. 1 . .	1,440,000	120
do do Pumping No. 2 . .	1,200,000	100
Gates' Brook, Gravitation No. 3 . .	1,000,000	83
do do Pumping No. 4 . .	1,200,000	100
do do Pumping No. 5 . .	2,400,000	200
do do Pumping No. 6 . .	1,200,000	100
Curtis' Brook, Gravitation No. 7 . .	1,600,000	133
Charlottetown Water Works with a population of 15,000.		
Winter River, Gravitation No. 1 . .	1,444,000	96
do do Pumping No. 2 . .	1,200,000	80
Gates' Brook, Gravitation No. 3 . .	1,000,000	66
do do Pumping No. 4 . .	1,200,000	80
do do Pumping No. 5 . .	2,400,000	160
do do Pumping No. 6 . .	1,200,000	80
Curtis' Brook, Gravitation No. 7 . .	1,600,000	107

No. 8.

the several schemes proposed for supplying Charlottetown the 20 English and 20 American named in Tables 5 and 6.

Total Estimated Cost.	Estimated per capita cost.	Estimated cost per million gallons, maximum capacity.	Max. Pressure above High water in feet.	Max. Pressure above Highest point in City, feet
	$29.65	$167,026		
	14.11	358,631		
270.534	22.54	187,875	80	30
146,777	12 23	122,331	186	136
137,682	11.47	137,682	62	12
145,918	12.16	121,600	100	50
163,347	13.61	68,011	100	50
146,406	12.20	122,005	100	50
180,487	15.04	112.805	86	36
270,534	18.04	187,875	80	30
146.777	9 78	122,331	186	136
137,682	9 11	137,682	62	12
145.918	9.72	121,600	100	50
163,347	10.89	68,011	100	50
146,406	9.76	122.005	100	50
180,487	12.03	112.805	86	36

The foregoing tables are not given as absolutely correct, but reasonable care has been taken to make them as nearly so as possible, and are sufficiently accurate to show approximately the relative cost of water supplies in other cities and the quantities usually provided for present and future use.

So far as the American cities are concerned the particulars of capacity, consumption and cost have been culled from official Reports of 1878 and 1879, and the populations have been checked as far as practicable by recent census returns. The maximum daily capacity, when steam or water power is used, is the combined capacity of the pumps, and in gravitation works the greatest capacity of the leading main or mains.

Had the enquiry been as to the relative cost of steam or water power and gravitation, the annual cost of pumping would have had to be capitalized to contrast fairly the merits of each as to economy &c.; but as the tables were constructed to show simply the outlays made by cities for suitable water supplies, the annual costs of pumping and maintenance have been eliminated.

The information on which table No. 6 is based was obtained from a parliamentary "Blue Book," published by order of the British House of Commons, in July 1879, and entitled "*Urban Water Supply.*" The particulars generally relate to the latter half of 1878, and embrace returns as to the supply of drinkable water, quantity, quality, cost &c. from 944 sanitary districts. The few places selected were taken at random and give I think a fair representation of the whole.

TABLE NO. 8 shows at a glance the leading features of the seven systems that have been proposed for giving your city a satisfactory water supply compared with the averages obtained as to cost &c. from tables 6 and 7. By a careful inspection of this table it will be seen that your city is not so unfavourably circumstanced in regard to water as some are disposed to believe; but has, on the contrary, the natural facilities of obtaining for itself a bountiful supply of excellent water, at a cost far below the average of what is paid for similar works in England and America, whether the price be measured by per capita cost, or capacity of daily supply.

Having discussed, however, to a greater extent than I at first contemplated, the several points involved in a consideration of the "best and most economical system of furnishing Charlottetown with a copious supply of water," as directed by your honorable Board, a brief resume of the salient features of each of the schemes may form a fitting and useful closing to this rather lengthy Report.

WINTER RIVER.

(No. 1) *Gravitation and Tunneling.* To make the water of this river available in this way a dam is required at *Cobb's* about 16 feet high and 264 feet long, to raise the water to 86 feet above the city datum. The area of the reservoir thus created would be 19 acres and the storage capacity about 2,700,000 gallons. Water of excellent quality, but subject at times to discoloration. Quantity of stored water usable in dry seasons about 2,400,000 gallons in addition to the natural flow from the collecting grounds above the dam.

Length of tunnel about 2¼ miles and of 12 inch iron pipe—from outlet end of tunnel to the city—about 16,500 feet. Estimated discharge from pipe, at a point 25 feet above high water, about 66,250 gallons per hour, or 1,590,000 gallons per day of 24 hours.

Extreme elevation of reservoir when full, above city datum about 86 feet, or 36 feet above the highest land in the city. Estimated probable cost with 25 per cent. of the distributing pipe laid $213,516.00 and with the whole of the last named pipe laid $256,385.00.

The great and uncertain cost of this work, combined with the fact that the supply obtained in this way would be at best a *low* pressure one, and as such deficient in protective power, do not commend this scheme to my judgment, nor could I advise its adoption unless as a last resort.

(No 2) Pumping by Steam power from Winter River, dam and reservoir the same as for No. 1 scheme. Capacity of engine and pumps 50,000 gallons per hour, 1,200,000 gallons per day of 24 hours. Whole of the impounded water available in dry seasons, when the natural flow was less than the city's daily consumption.

Water to be lifted 100 to 120 feet and placed in a summit reservoir for distribution. Contemplated present capacity of reservoir about 2,400,000 gallons and increased in time to 10,000,000 or more.

Elevation of reservoir above city datum 186 feet, or 136 feet abôve the highest point in the city, giving an effective *high* pressure supply for fire purposes without the aid of engines.

Estimated capacity of 12 inch main discharging at a point in the city 25 feet above high water, about 83,333 gallons per hour, or 2,000,000 gallons per day of 24 hours. The difference between this and the power of the pumps to be made up on extra occasions, as fire times, from the surplus stored in the reservoir.

Estimated "probable cost" with 25 per cent. of the distributing pipe laid $89,808.00 and with the whole of it laid $132,678.00.

This scheme appears to meet fully the requirements of your city in respect to quantity, quality and pressure for fire purposes, but the distance of the pumping station from the city (5½ miles) is a serious draw back to its adoption. It is recommended however to your favorable consideration.

GATES' BROOK.

(No. 3.) By *gravitation.* To make this source available by gravitation, a dam would have to be built at a point in the valley about $\frac{3}{4}$ of a mile above the Gates' Mill. Height of dam 34 feet and length 650 feet. The reservoir thus erected would flow about 21 acres of land, and contain when full about 57.600,000 gallons of water; but less than half of this would be available for city use in dry seasons, when the natural flow of the stream fell below the daily draft in the city. And there is a doubt about the prudence of trusting a reservoir of this depth and capacity in this valley.

The surface water of this reservoir when full would be about 62 feet above high water, or 12 feet only above the highest land in the city. This would be an eminently *low* service supply and would be of little value for fire purposes, without the aid of engines.

A 12 inch main laid from this reservoir to the city would discharge at the 25 feet point already named about 43,900 gallons per hour, or 1,050,000 gallons fully per day of 24 hours, when working under a full head, but this quantity would diminish as the water in the reservoir fell.

The estimated probable cost of this supply is $80,713.00 with 25 per cent. of the distributing pipe laid, and $123,583.00 with the whole of this pipe laid.

As the supply obtainable for this source by gravitation could not be otherwise than unsatisfactory, I cannot recommend it to your serious consideration.

(No. 4.) *Pumping by steam power from station* F. The leading features of this scheme are the erection of a dam of about 20 feet in height and 516 feet in length, on the site proposed for No. 3's dam, and the creation thereby of a storage reservoir capable of containing about 34,800.000 gallons of water. The water thus impounded to be led by an iron pipe or brick aqueduct, to the pumping station at F and forced from thence into a reservoir on College Hill or vicinity, and taken therefrom to the city by a 12 inch cast iron main for distribution.

The whole of the water impounded in the storage reservoir would be available for city use in dry seasons; and if in the progress of time the wants of the city exceeded the supplying capacity of the Gates' valley, the waters of the Curtis brook and about 1800 acres of the Winter River collecting grounds could be brought, by a moderate outlay of money, to the pumping station at F. It is not necessary to point out now how this could be done, as its realization is probably far in the future, but a reference to plan No. 1 will show its practicability, and this is a strong point in favor of the Gates brook and station F.

The proposed College Hill reservoir is to have a capacity of 2,400,000 gallons to begin with, and an elevation of about 100 feet above high water, or 50 feet above the city summits. The pressure obtainable from this reservoir would be an excellent one for daily use and a fair one for fire purposes, but greatly inferior to the pressure obtainable from the summit reservoir of Winter River.

The capacity of the engines and pumps would be the same as on Winter River, viz: 1,200,000 gallons per day of 24 hours, and the calculated discharge of the 12 inch main at the assumed level of 25 feet above high water about 116,666 gallons per hour, or 2,800,000 gallons per day of 24 hours.*

This station can be reached readily from the city and possesses superior advantages for the landing of coal or fuel direct from the river. The estimated probable cost with 25 per cent. of the distributing pipe laid is $89,002.00 and with the whole of the distributing pipe laid $131,872.00.

This scheme recommends itself strongly to my judgment as one that is worthy of a careful consideration before coming to a final decision.

*A 10 inch pipe under the same conditions would deliver about 1,700,000 gallons per day of 24 hours, and if substituted for the 12 inch one would reduce the cost about $1,400.00.

(No. 5.) Pumping by steam power from station D. (near the western end of Brighton road) directly into the distributing pipes as in the Holly system. By this arrangement no reservoir would be required, but the pumps would have to be run day and night without ceasing, and to guard against interruption to the usual daily supply by accident, the engine and pumps should be duplicated.

Under this system any desired pressure for ordinary or extraordinary occasions could be had, but the duplication of the pumping machinery and the constant working of the pumps would add considerably to the running expenses. If land of proper elevation for a reservoir can be obtained near the city, one of the engines could be dispensed with and the working time reduced as at station F. and Winter River.

This station would be still nearer to the city than that of No. 4, and would possess equal if not greater facilities for the water carriage of coal and other materials.

The water of the storage reservoir would be brought to it by an iron pipe or brick conduit, as may be considered best hereafter. The estimate is for the former, that the head or pressure from the reservoir may be utilized in pumping. And if on mature consideration this station and system of supply should be adopted, the Curtis' Brook and Winter River water could be made available here, as well as at Station F.

The dam and storage reservoir in the Gates' valley would be of the same size and capacity as described in No. 4, and the whole of the impounded water would be available in dry seasons.

The estimated "probable cost" of this system with 25 per cent. of the distributing pipe laid is $106,502.00 and with the whole of the latter laid $149,372.00.

This scheme and system are also worthy of additional consideration before coming to a final decision.

(No. 6.) Pumping by steam power from a station in the immediate vicinity of Gates' Mill. The same dam and reservoir would be required for this as for Nos. 4 and 5. and like the former the water would be forced into a reservoir placed on College Hill or some equally elevated and convenient spot, if such is obtainable.

This station is less desirable, however, than either of the others, as it is doubtful if the supplemental supply already alluded to as obtainable in the distant future, from the Curtis' Brook and Winter River, could be made so easily available, and the cost of fuel would be increased by extra cartage. It is also farther from the city and more exposed to damage by the bursting of the reservoir, should such an untoward accident ever take place.

The supply as well as the pressure obtainable in the city would be the same as in No. 4 scheme, and could be increased in a similar way.

Estimated "probable cost" of this line with 25 per cent. of the distributing pipe laid, $89,437.00 and with the whole of it laid $132,307.00.

CURTIS' BROOK.

(No. 7.) *Gravitation.* To make the water obtainable here available, a dam 35 feet high and 1070 feet long would have to be built, to raise the water 85 feet above city datum.

The reservoir thus created would flood about 55 acres of land and impound about 170 millions of gallons, 147 millions of which would be available for city use, in dry seasons, should the ground prove sufficiently retentive under this body of water.

When the reservoir was full, the daily discharge from the mains proposed to be laid would be about 960,000 gallons per day, or 40,000 gallons per hour, and when it had fallen six feet, about 810,000 gallons; diminishing steadily as the water in the reservoir fell.

As this, like the other gravitation schemes, would be a *low* pressure supply and less serviceable and satisfactory for fire purposes than either of the pumping plans suggested, I cannot recommend it for your adoption.

The estimated cost with 25 per cent. of the distributing pipe laid is $123,518.00 and with the whole of it laid, $166,388.00.

CONCLUSION.

In conclusion I beg to say that I am not prepared to recommend any of the gravitation schemes as suitable to your circumstances.

In my judgment the best and most economical system of water supply for your city, is to be obtained by pumping from Winter River or the Gates' Brook.

My present inclination is to the latter from station F. on line No. 4, but before coming to a final decision a careful revisory examination should be made, and exact information obtained as to suitable sites for reservoirs—cost of land and water rights—pressure considered necessary for the extinguishment of fires by your fire department and relative economy as to the conveyance of fuel and other material to the several pumping stations named.

Your city has a choice of sources and systems, and the selection should fall to that one which will give the best results in completeness and economy.

Respectfully submitted,

GILBERT MURDOCH,
Engineer.

Saint John N. B., March 2nd, 1881.

APPENDIX.

APPENDIX A.

QUESTIONS submitted to the medical profession of Charlottetown in relation to water supply and drainage, and replies received, in 1876. The questions, Mr. Heard said, had been submitted to every medical man in the city, and at the time he wrote, nine replies had been received, as follow:

QUESTION 1. Owing to the absence of a proper system of drainage, and the surface soil having hitherto received nearly the whole of the drainage of the city: Are our wells likely to be affected thereby? If so, to what extent are the public likely to suffer therefrom?

ANSWERS:—

1. Undoubtedly they must be affected, and the public are likely to suffer therefrom.

2. Yes, to such an extent as to render the water unwholesome in the highest degree. It cannot be otherwise in a town where there is no proper drainage; and where all matters which should be carried away are allowed to soak into the earth, and where the soil is as porous as that of Charlottetown there is little or no obstruction to its passage.

3. I must say the absence of a proper drainage system must be apparent to all. Most of the wells of the city, from their peculiar location, receive the surface drainage, and with it a large amount of decayed and decaying animal and vegetable matter, which is decidedly deleterious to the health of the community, and no doubt very much assists in the development of fever in its various types.

4. It is impossible to have health in a city without a thorough drainage, more particularly in a city where the soil is of a soft nature, which will absorb all the offal that is daily being thrown on its surface; and as the wells of the city must be affected by the very refuse excreted by human bodies and animals, this poisoned water must be injurious to the people.

5. As a general rule I do not think that the wells of this city have been or are likely to be affected by deposits upon the surface of the soil, as I think that nothing can percolate through its undisturbed and unbroken surface that can injuriously affect them. But that certain wells are, or may be, rendered exceedingly noxious by the pouring into them of surface drainage, or by leakage from around their built walls, I think is quite possible; and that such wells may have their water so poisoned as to become sources of most dangerous and widespread disease.

6. Owing to the exceeding porous quality of the soil, all sewerage and watery liquids spilt on the surface are liable to filter and penetrate to a depth varying from 20 to 30 feet. unless prevented by strata of the red sandstone rock. It is not generally known that the whole of the wells in Euston Street, from the Malpeque Road to the pond, have been rendered useless and dangerous by misdirecting that abominable and costly sewer from Great George Street. The water of one of these wells smells like rotten eggs—redolent of hydrogen gas—no animal will drink it.

7. The public suffers from bad water in the wells, as also from the vapors that arise from the accumulated filth.

8. Yes, the public health is likely to be seriously affected.

9. I believe the water of all, or nearly all, the wells of this city is injurious to health, and should not be used for drinking purposes.

QUESTION 2. In the event of any wells being appropriated to sinks and privies in this city: How far do you suppose other wells in the neighborhood would be contaminated thereby, and with what result?

ANSWERS :—

1. Any contamination from such sources would be injurious.

2. It is a well known fact that water obtained from wells situated near a graveyard, invariably contains animal matter, provided the soil be sufficiently porous.

3. I have noticed that the privies and wells of Charlottetown are very closely connected, so much so that the one must receive a benefit from the other, as there is not enough earthy matter between to act as a proper filter. This is a very important subject, and bears strongly on the health of the public.

4. The appropriation of wells as sinks and privies is very wrong, and should not be tolerated. I know of one such well in this city, which was the means of poisoning another well distant about 60 yards therefrom.

5. Should there be a more or less direct connection between the wells, through the crevices of the rock, or otherwise, there would unquestionably be very dangerous contamination from the polluted outflow of the supposed sink or privy; a fact, however, which I should think would at once make itself known in any particular instance in which it might so occur.

6. In the event of a well being appropriated to a privy, I consider that it is liable to filter through a circumference varying from 80 to 100 feet, unless stopped by strata of rocks; of this I have ample proof.

7. The well cannot help but be contaminated from the porous nature of the soil.

8. The soluble contents of such wells must contaminate the neighboring wells.

QUESTION 3. Is the health of this city likely to be affected in hot or damp weather by exhalations from the soil, or from the want of proper drainage?

ANSWERS:—

1. Decidedly yes.

2. It cannot but be that the health of the city will be affected in hot and damp weather by exhalations from the soil and from the want of proper sewerage. Even our surface drainage is useless, or nearly so, from the fact that so few of our streets have sufficient incline to allow sewage to run, and consequently what does not soak into the ground, stagnates and festers under the hot summer sun.

3. The decomposition of animal and vegetable matter is much more rapid in warm weather than in cold, and I believe a damp atmosphere is a powerful assistant.

4. Reducing the subject to a fine point, it is an utter impossibility to ward off these epidemic attacks of fevers without a thorough system of drainage and water; and it would be well for the public to attend to these matters at once; if they do, they will find the rate of mortality greatly lessened.

5. I think so, most decidedly.

6. For the last few years I have remarked that Ward 5 is liable to be attacked by an epidemic fever of the low typhoid type, with cases of dysentry; the usual results of tainted water, ending in many instances fatally.

7. Most certainly.

8. Yes.

QUESTION 4. Have you observed any injurious effects resulting from the use of our well water?

Answers :—

1. I cannot speak positively on this point.

2. I have no doubt that typhoid and other fevers, also dysentery and diarrhœa which visit us so regularly every year, are in a great measure due to its use, and perhaps also to over-crowded and ill-ventilated houses.

3. I hear many complaints from my patients and others regarding the bad water.

5. None whatever.

6. There is always a risk to health in living near a swampy or undrained locality; in short, what is universally acknowledged to be a focus, productive of typhus, dysentery and cholera. I have had cases of ague in hot weather, which appeared to proceed from the pond, when nearly drained.

7. I cannot say I have.

8. I have no doubt that the drinking of this water must be injurious to the public health.

9. Horses from the country will not drink the water of the city wells; this is owing to the vast amount of drainage, which finds its way into these wells.

Question 5. Do you think the prevailing diseases such as scarlet, typhoid or other fevers which visit us annually have any connection with the use of our well water, or with defective drainage.

Answers :—

1. I believe the latter cause, viz: defective drainage, to be the chief source of diseases mentioned.

2. There can, I think, be no doubt that as long as the people continue to use water from our public wells, just so long will they suffer to a great degree from various diseases which might be traced to its use.

5. I do not think that any of the epidemic diseases mentioned are traceable to the use of our well water, but more probably, in great part, to periodic atmospheric waves charged with miasma, also to direct importation of specific contagious disease by persons affected therewith, and in so far as they originate, de novo, to exhalation from surface and cesspool filth.

6. Our present epidemics, scarletina, measles, and whooping cough, depend on specific contagion, and not on malaria, and do not originate in unhealthy localities, as we find them prevalent over the whole Island.

7. I do not think the fevers occurring here are occasioned so much by the well water, as from the heaps of mud and filth collected in back yards, producing noxious vapours, which the sultry weather produce; as fevers occur and great mortality in cities which have good water and sewerage in abundance.

8. I believe that epidemics of these diseases become more virulent from these causes.

9. Typhoid fever, which prevails during the autumn and early part of winter, is caused in numberless instances from the surface drainage of the city, and the use of the water of the city wells.

QUESTION 6. Is there any public work which you can suggest as likely to promote the general health, or by which the rate of mortality can be lessened?

ANSWERS:—

1. Obviously a proper system of water supply and drainage combined.

2. There can be no doubt that a proper system of sewerage, combined with a plentiful supply of pure water, would go far toward lessening the amount of disease; and in cases where it did not prevent its occurrence, the mortality would be diminished very materially.

3. I have no hesitation in saying that the public health would be much improved, and the fevers which prevail here so largely every spring and fall vastly mitigated, by a proper drainage system, and a supply of good wholesome water.

4. In all well conducted cities there is a Board of Health, consisting of several medical men, presided over by one called the Health Officer. The duty of these men is to inspect the different wards of the city, and report to the Health Officer anything that would be dangerous to the health of the community.

I would suggest the enforcement, especially in the season of spring and autumn, of strict regulations, ensuring the cleanliness of out-premises. I would have a law to forbid the breaking of the soil surface for the purpose of sinks or privies, and would strongly urge the adoption of the dry closet system, on a plan which would utilize the ashes of the house for the purpose of deodorizing and drying the contents of the privy, and which would necessitate the regular and frequent emptying of it. The wells should be made secure from the possibility of leaking from without their built walls, and there should be a systematic and efficient cleansing of them, and the immediate filling up of any that may prove to be affected by any contaminations otherwise incurable.

7. The Board of Health, by enforcing cleanliness in houses, back yards and privies, airing cellars, fumigation, &c., seeing that the poor had wholesome food and clothing, &c.

8. With reference to the above system of public works by which wholesome water can be obtained, will conduce very much to the public health.

9. I think that a proper system of sewerage is required immediately to preserve the public health. In the latter part of the 7th century there were sewers at Merida in Spain according to the chronicle of King Roderigo, the last of

the Goths; "From each house there runs a sewer under the ground, and all these sewers run into one great one, which is in every street, in order to carry off the rain water." If such improvements existed among the Goths of the seventh century, it is surely time for the enlightened citizens of Charlottetown in the nineteenth, to make some effort toward the preservation of the public health. A proper system of sewerage must be adopted, or disease, pestilence and death will inevitably follow. A large supply of good water is essential for the public health.

No slaughter-house should be permitted to exist within the city. In the third year of Richard the 2nd a law was passed in London, by which no slaughter-house was allowed in that city, only at Knight's Bridge.

QUESTION 7. Should not the Government at once establish a general Registry of Births and Deaths in this Island.

ANSWERS :—

1. I long ago called the attention of the Government to the necessity of such an office.

2. It is a matter of astonishment that something of the kind has not been attempted long ago. I suppose there is hardly a Province or State in America, where such a Registry is not kept. In Nova Scotia, the system employed works admirably and there can be no reason why a similar one should not be put into successful operation here.

4. It would be well for the Government of this Island to establish a law compelling a Registry of Births, (whether alive, or, if still born, the cause of death) and Deaths. In case of death a certificate from a medical man stating the cause of death. No grave to be opened without such certificate.

5. I think it extremely desirable that there should be such a Registry as you mention under Government control. The Death Register would prove most helpful in suggesting and

promoting the most judicious sanitary schemes; as it would be likely to lead, with almost certainty, to the discovery of the true origin of our epidemic diseases.

6. A general Registry of Births and Deaths is a very desirable measure for ascertaining the rate of our onward progress, and comes next to a general census in public utility.

7. Most certainly, that would bring the mortality prominently before the country.

8. Yes.

9. The establishment of a Registry of Births and Deaths is doubtless necessary, and could not fail to be of essential service.

From the above testimony we may conclude that our present water supply is rotten to the core, and that if we wish to regain our lost reputation for health and salubrity, and escape the consequences resulting from the worst type of epidemics or pestilence, it is absolutely necessary to provide an abundance of good water and attend to the drainage without delay.

Yours respectfully,

(Signed) WILLIAM HEARD.

APPENDIX B.

PROPAGATION OF EPIDEMIC BY POTABLE WATER.

The River Pollution Commissioners in their highly instructive Report on the "Domestic Water Supply of Great Britain," say in the section devoted to the propagation of epidemics by potable way, that "numerous researches made both by physiologists and chemists have led investigators to the conclusion that several at least of those diseases which are propagated in the manner of epidemics, diffuse themselves by living germs or spores, which finding a suitable *nidas* in the bodies of animals, then multiply and produce this specific disturbance of the normal vital functions which characterizes a disease of the zymotic class. *** This view is as yet far from being established on a firm scientific basis, *** but be the theory true or false, it is a fact that cow pox, sheep pox, small pox, hydrophobia, glanders and syphillis can be with a very small percentage of failures propagated from individual to individual by means of an excessively small amount of organic matter. *** In like manner it is a fact that scarlatina, diphtheria, measles and typhus fever can be transmitted from diseased to healthy persons, not only without contact, but also without any apparent communication, the poisonous matters in these cases being presumably conveyed through the air from person to person.

Again, it is a fact that cholera and typhoid or enteric fever can be communicated from individual to individual; and the infectious matter of those diseases, which resides in the discharges from the stomach and bowels of the patient, is believed to be occasionally conveyed by air, but a great mass of experience renders its propagation through the medium of *drinking water* almost certain. *** We are of opinion that the cases in which exposure to infected water has been followed by attack are sufficiently numerous and decisive to warrant the conclusion that water polluted by the discharges from the stomach or bowels of cholera or typhoid patients can propagate these diseases. That such an unspeakably disgusting mode of infection is not only possible but imminent, is conclusively proved by the numerous analyses of drinking water recorded in the preceding part of this Report. So far from the horrible practice just indicated being exceptional, it is the rule. As the result of our inquiries into the polluted waters of this country, we are compelled to state that it is a widely spread custom, both in towns and villages, to drink either the water of rivers into which the excrements of man are discharged, or the water from *shallow wells* which are largely fed by soakage from middens, sewers or cesspools. Thus vast multitudes of the population are daily exposed to the risk of infection from typhoidal discharges and periodically to that from cholera dejections. That this risk is not inconsiderable, is abundantly proved by the following evidence, which we now adduce in confirmation of the statement that cholera and typhoid fever are propagated through the medium of water polluted by human excremental discharges.

The evidence cited is pointed and complete, and the conclusions to which it leads irresistible. But a few extracts only can be made.

PROPAGATION OF CHOLERA BY WATER.

"London," the Commissioners say, "has suffered on former occasions from epidemics of Asiatic cholera, which occurred in the years 1832, 1849, 1854 and 1866. The mortality of 1832 was undoubtedly great, but, at the same time, there was no official registration of the causes of death; the number of deaths reported to the Privy Council, however, was 5,275, and as the population of London then amounted to 1,681,641, the proportion of deaths to 10,000 of the population was 31.4. In 1849 cholera killed in the metropolis 14,137, or 61.8 out of 10,000; in 1854 the number of lives destroyed was 10,738, or 42.9 per 10,000; and in 1866 cholera slew 5,596 persons, or 18.4 per 10,000. During the period from 1832 to 1866 the water supply underwent important changes.**The results are thus tabulated:—

	Character of water supply as regards excremental pollution.	Total mortality from cholera.	Mortality per 10,000 of population.
Epidemic of 1832	Polluted	5,275	31.4
" 1849	Very much polluted	14,137	61.8
" 1854	Less polluted	10,738	42.9
" 1866	Much less polluted	5,596	18.4

These are the results arrived at by the most general investigation of the subject. They show that in every epidemic the mortality varied directly with the intensity of the excremental pollution *drunk by the people.*

Dr. W. Farr, F. R. S. in a letter to the Registrar-General on the cholera visitation of 1849, showed by statistical tables "that in Lambeth which was supplied partly by the Lambeth and partly by the Southwark company the deaths from cholera which were 1618 in 1849, fell to 904 in 1854. In 26,000 houses supplied by the Lambeth company the deaths were 294, whilst in 40,000 houses supplied by the Southwark company they were 2,248. In the houses supplied with comparatively pure water the deaths from cholera were 40 per 10,000 of the inmates, while in those supplied with foul water, the deaths were 130 to 10,000. These houses were in the same district, the pipes of the two companies interlacing; it is therefore to be presumed that both were equally exposed to any other deleterious influences which affected the health of the district at that time, the quality of the water supplied by the two companies constituting, so far as is known, the only difference in the conditions under which the population was placed. ***

Mr. John Simon, F. R. S. medical officer of the Privy Council testified to "dangerous qualities of water supply which chemists were wholly unable to measure. *** In the old epidemics when the south side of London suffered so dreadfully from cholera, the great cause of the immense mortality there was the badness of the water supply then distributed to those districts of London." Coming to another cholera epidemic Mr. Simon says it is now a matter of notoriety within the area of another water company in London, the population last year suffered very dreadfully from cholera, I refer to certain Eastern parts of London; cholera in high development was confined to those parts, and those parts of London were in the area of one water company. And what makes the case the more remarkable is, that *not the whole area of this water company suffered*, the company gave two waters and the high cholera mortality was apparently restricted to those parts of London which received one of these two supplies, so to speak to half the district of the East London water company. The source from which the company supplied this half of its district was a source peculiarly exposed to contamination from a foul part of the river *Lea*. The contamination was sewage. Speaking broadly for the whole metropolis the area of intense cholera in 1866 was almost exactly the area of this particular water supply, nearly if not absolutely filling it and scarcely if at all reaching beyond it.

The waters of the Southwark and Vauxhall company were submitted to microscopical and chemical examination by the "*committee* for *scientific enquiries*" and the foulness they say was almost incredible. It swarmed with infusorial life and contained unmistakable molecules of excrement. ***

The tenants of the *Lambeth* and the *Southwark* companies were not set in different parts of the south of London area each isolated from the others. On the contrary the two populations were so to speak mutually interfused. *** It likewise deserved notice that the materials for comparison were not on a small scale. It was not village against village. The investigated districts composed about a fifth of the entire population of London. They contained in 1849 about 466,000 persons and in 1854 about 511,000. In 1854 (after the termination of the cholera epidemic) the water supply was investigated, nearly 25,000 houses could be shown to derive their water supply from the Lambeth company and 40,000 from the Southwark company. In the houses supplied by the Lambeth company, there occurred 611 deaths being at the rate of 37 to every 10,000 living while in the houses supplied by the Southwark company there occurred 3476 deaths being at the rate of *one hundred* and *thirty* to every 10.000 living. The population *drinking dirty water therefore suffered* 3½ times as much *mortality* as the *population drinking* the other water.

BROAD STREET WELL.

After citing much evidence of a similar character, the Commissioners proceed to remark: "The results of these gigantic experiments on the effects of water contaminated with choleraic sewage upon the lives of most communities inhabiting large sections of the metropolis are as conclusive as can be expected of experiments of such a nature. *** There are, however, not wanting analogous experiments, which, being on a smaller scale, were perhaps more manageable, and consequently capable of closer investigation. One of those occurred in the year 1854, in a circumscribed district around Golden Square, St. James, Westminister. *** It included 31 streets, 12 courts and 1 square. All the houses were inspected and the inquiries were both careful and minute. The houses were let at high rents, and were not of a low class.

During the month of August cholera was prevalent in the locality, but only 26 cases were registered during the month. On the morning of the 1st of September, however, the disease broke out with fearful and fatal violence, and continued with little abatement until the morning of the 5th, when it began rapidly to decline.

The center of the pestilence was in two blocks of houses bounded on the north by Broad Street, on the south by Silver and Putney Streets, on the east by New Street and on the west by Marshall Street. ***

One of the most important features of this memorable attack was its suddenness, and the large number of individuals attacked simultaneously in different parts of the district. The epidemic attained its maximum intensity on the second, if not on the first day of the outbreak. It then remained nearly stationary, and on the 5th day declined by nearly 50 per cent.

The population of Broad Street was estimated at 860, of whom 90 died, besides 25 others who worked in Broad Street but died in other parts of London; of these latter two men and fourteen girls at a percussion cap manufactory, No. 38 Broad Street.

The total number of deaths on the 1st and 2nd September, including persons removed to the hospital and workhouses, was *two hundred and one;* from the 1st to the 13th, *five hundred and sixty-nine*(569) from that to the 20th *thirty-one;* and from this to the end of the month *ten;* making the total number of deaths from cholera in this limited district *six hundred and ten* (610). **** The western half of Broad Street which contained public pumps was the centre of the infected district and starting from thence a person walking at a moderate pace in any direction would have got beyond its limits in three minutes.****

A special examination of the cesspool and drains belonging to the house No. 40, Broad Street, immediately adjoining the pump just mentioned, proved conclusively that the contents of the former gains direct access into the well supply of the latter. About seventy-eight hours before the great outburst a child was fatally attacked in this house with diarrhœa, and its dejections were poured into the drain which ran within 2 feet 8 inches of the well. Yet the water of this well was in great repute for drinking purposes. Its use was very general, from choice on the part of some, from necessity on that of others.****

Dr. Snow, of the Cholera Inquiry Committee, thus summarizes the connection between the well and the sudden choleraic outbursts just noticed, as follows:

1st. That the outburst, properly so called, was principally confined to the area about the Broad Street pump.

2nd. That 61 out of 73 persons who died during the first two days had been accustomed to drink the pump water, either constantly or occasionally.

3rd. That the water was used many other ways, and might so have been taken in cases when its use in the ordinary way could not be distinctly traced.

4th. That in the workhouse, where the well water was not used, only *five* deaths occurred, whereas 50 would have been the ratio proportionate to that of the neighborhood around.

5th. That in a factory employing 200 people, where the water was drunk daily, 18 people died.

6th. That 70 men employed in the brewery in Broad Street never drank the water and escaped cholera.

7th. That in a number of individual instances, which were particularly investigated, the drinking of the water was followed by cholera; in one case a lady living quite away from the district who had the water sent out to her died after drinking it; her niece also died under the same circumstances.

8th. That at any point decidedly near to a pump, the mortality from cholera as a rule ceased.***

9th. That in a particular street containing 14 houses, the only *four* that escaped, without a doubt, were those in which the Broad Street water was never drunk.

10th. That the water was used for drinking purposes only, and was used cold. **** That it must have been not merely generally contaminated by *cesspool drainage*, but especially with the evacuation of a cholera patient.

After adding an overwhelming amount of evidence showing the malignant influence and constant danger attending the use of shallow well water during cholera epochs, the Report proceeds to show how

TYPHOID FEVER IS PROPAGATD BY WATER.

The poison of typhoid fever, like that of cholera, exists in the evacuations of persons suffering from the disease, and its conveyance from infected to healthy persons requires conditions analogous to those which propagate Asiatic cholera, viz., from the use of water polluted by sewage. Of the many cases cited by the Commissioners in proof of this from all parts of England, I will give a few only.

MILLBANK PRISON.

The number of convicts confined in this prison ranged from about 600 in the earlier years of occupation to upwards of 1,200. For many years the prison had a bad reputation for unhealthiness. Its inmates from the first suffered a very high rate of mortality. Of the four epidemics of cholera that visited England, the first three, viz., 1833, 1849 and 1853-4 were very fatal.

In 1854 a new supply of water was introduced from an artesian or deep well in Trafalgar Square, and in the fourth epidemic, that of 1866, the convicts entirely escaped. Typhoid fever has become extinct, and diarrhœa and dysentery have ceased for many years to appear as causes of death.

Surgeon Major A. C. C. De Renzy, in an article contributed to the *Lancet* in 1872, discussing this change and the causes that led to it, after noticing the drainage, the ventilation, the dietary, the clothing and the discipline, remarks as follows in regard to the water supply :—

"The Water supply was changed on the 10th of August, 1854. Up to that date the prison had been supplied with water pumped from the Thames as it flowed by the institution and *purified* by *filtration*. The new source of supply was the artesian well in Trafalgar Square. The change was carried into effect in the midst of the cholera epidemic which so severely visited London in that year, and the prison was suffering from cholera at the time. *Six days after the change the disease suddenly ceased*, and a marked improvement took place in the health of the prisoners. From the date of the introduction of the new water supply, up to April of the present year, (1872) a period of nearly *nineteen* years, there have been only *three* deaths from typhoid, and one from diarrhœa and dysentery." It is thus shown conclusively that the disappearance of typhoid coincides exactly with the disuse of the Thames water, and as this change occurred whilst in all other respects the sanitary condition of the prison remained unaltered, there can be no doubt the two events were not coincidences only. There must have been a casual relation between them.

TERLING ESSEY.

Here then was a severe outbreak of fever in 1867. Of 900 inhabitants fully 300 were attacked in less than *two* months. No class of persons was exempt—the rich, the well fed and clad were attacked in common with the poor and destitute. Dr. R. T. Thorne, who was appointed by the Privy Council to enquire into the surrounding circumstances, found, after a diligent investigation, that the cause of the outbreak was in the *shallow wells* of the village. They had been contaminated, poisoned by sewage and excremental matter.

CHICHESTER.

This city had for five years been severely visited by typhoid and low fevers when Dr. Edward C. Seaton was instructed to inquire into its sanitary condition. He found the city supplied by *shallow well* water constantly subject to pollution from surrounding cess-pits and privies, and clearly proved that it was from these the poison was unconsciously taken that proved so fatal in many cases. "The conditions under which the water became offensive were (1) where the wells were low, the solution of sewage being then most concentrated; and (2) when heavy rain by over flowing or soakage sent a lot of cesspool stuff direct into the wells."

SALISBURY.

During the period 1842-52 Salisbury was supplied with water from wells, 8 or 10 feet deep, in which the water stood 2 or 3 feet from the surface. These wells were generally situated close to cess-pits, the liquid contents of which soaked into the surrounding porous strata from which the wells were fed. The annual mortality from typhoid fever during a period of 9 years averaged 7½ per 10,000 inhabitants. In 1856 a new supply of water was obtained from a deep well sunk into the chalk and a constant supply furnished at the rate of 40 gallons per head per day: and during the 8 years ending with 1864 the average annual mortality from typhoid fever was only 1¾ per 10,000 inhabitants.

TOTTENHAM

Had two sources of supply, one the common shallow wells of the neighborhood and the other from the water works of the local Board of Health. It too had an outbreak of fever in 1864 and 1865, and an inquiry made by Dr. Seaton on behalf of the Medical Department of the Privy Council, elicited the fact that of 58 houses inspected the approximate number of cases in each was as follows: In 24 houses supplied from surface wells 80 cases. In 34 houses supplied from public water works 22 cases.

And a further investigation showed that in most of the last named class, in which the fever had broken out, the inmates had been in the habit of getting water for drinking purposes from neighboring wells. Unconsciously imbibing fever and diarrhœa.

SOUTHAMPTON.

In his evidence before the *Royal Commissioners* on water supply, (1869) Dr. E. A. Parkes, F. R. S. professor of Medical Hygiene in Army Medical School at Netley, says :

I have got a good deal of evidence together as to diseases which may be communicated by water. *** I have made a list of diseases all of which are occasionally communicated by water, not solely communicated by water. For example, typhoid fever of which I have collected about 23 instances of local outbreaks of severe typhoid fever, and some six or eight more the particulars of which I have not got, are known to me arising from water impregnated with typhoid sewage, or possibly with simple sewage. When I speak of typhoid sewage I mean sewage from persons suffering from typhoid fever.***

How did you ascertain that those outbreaks were due to water impregnated with typhoid sewage?

On account of the cases immediately following that impregnation with typhoid sewage. I do not wish to deny that simple sewage may produce the same disease; but that is a question still undecided.**

Have you obtained any confirmatory results from that observation?

There have been altogether a considerable number of cases now placed on record by different writers of such an effect following the passing of typhoid sewage, or possibly of simple, into drinking water. We had a case in the neighborhood of Southampton, only this last year, in a young ladies' school where a drain pipe passed within three feet of the well; at the point nearest the well the soft ground below the drain pipe had given way, and the pipe had sunk and the sewage passed into the water of the well. Immediately following that was an outbreak of typhoid fever, which affected something like 80 per cent. of the population, that is to say, 18 or 19 persons were affected out of a population of 24 or 26; there were many deaths, and many of them very severe cases. In that case it was impossible to prove whether or not it had been through typhoid sewage passing into the well; but the impregnation of the water with sewage was certain and coincident at that time; and that, coupled with several cases of the kind, seems to show that the outbreak of the fever was owing to the impregnation of the water with sewage.

Numerous other instances could be cited from this invaluable Report, showing the constant danger to which communities are subjected whose dietary water is drained from shallow wells sunk in a porous soil and surrounded with ash pits and privies; but time will not permit. I cannot close, however, without placing before you the following remarks of the Royal Commissioners in relation to the propagation of disease through sewage pollution, page 183.

" The records of the poisoning of communities and families by the discharges from the stomachs and bowels of cholera and typhoid patients are obviously less strictly conclusive than corresponding instances in which men have succumbed after swallowing arsenic or strychnine, because in the former case the specific poison has not been chemically or microscopically recognized, whilst in the latter the noxious agent can be traced throughout its entire course, and everywhere chemically identified. Nevertheless, after a careful consideration of all the facts accessible to us, we are of opinion that the existence of specific poisons, capable of producing cholera and typhoid fever is attested by evidence so abundant and strong as to be practicably irresistible. The poisons of each of these diseases is contained in the discharges from the intestinal canals, and in typhoid fever it appears to be present in a yellow matter, which is secreted from an ulcerous corruption in the bowels of the patient. Both this and the cholera poison may be disseminated, firstly by water, either as suspended matter in such an excessively fine state of division as to pass easily through ordinary sand or domestic filters; and secondly by air, either in the form of dust, or as the fine spray of liquid containing the poisonous matter. Through either of these two necessaries of life the zymotic germs of both diseases may thus be conveyed into the stomachs of large communities; but their effect will be determined, firstly by the power of the individual to resist the poison, and secondly by the degree of dilution of that poison. It is further exceedingly probable that a very attenuated poison will suffice to infest persons who are very susceptible of the disease, whilst on the other hand a very concentrated poison may fail to tell upon a person endowed with extraordinary powers of resistance; such a power, for instance, as is conferred in the case of typhoid fever by a previous attack of the disease. The history of a large number of outbreaks of both diseases shows that where the poison was concentrated the disease manifested itself suddenly, that is to say, with a short incubation, and in these cases a large per centage of individuals exposed to it were attacked. *** We have restricted the above remarks to two zymotic diseases, but evidence is not wanting to show that other scourges, such as dysentery and diarrhœa are probably propagated by water which has received the excrements of patients suffering from those diseases. *** The means for preventing much of this death and torture are now well known and capable of practical application. Their neglect really means the destruction of the people by parasitic organisms that we have the means but not the will to exterminate.

APPENDIX C.

SOFT WATER IN COOKING.

That the influence of hard and soft water in cooking may be shown more clearly, the following brief extracts from evidence given at sundry times since 1850—when the question of city water supply in relation to health &c., was first submitted to scientific and searching inquiry by the General Board of Health, London (England)—to the present time, may interest such of your citizens as have not had an opportunity of investigating this subject heretofore:

Among the witnesses called by the General Board of Health, was the then justly celebrated cook (since deceased) *Mons. Soyer.* This gentleman had published several works on cooking and had made many experiments with a view to test the qualities of different waters for cooking purposes and in giving the results of his experience testified:

That in boiling cabbage, greens, spinach and asparagus, hard water gave them a yellow tinge—especially in French beans. Hard water shrivels greens and peas, and will be more particularly noticed in French beans. The process in *boiling* is also *longer.* "The difference of time with dry vegetables was *one fourth* more," which means 25 per cent more fuel. He did not think it acted so much on potatoes, but still it had an influence on all sorts of vegetables; not so much on roots as on leaves generally.

On salt beef hard water does not open the pores so freely as soft water. On fresh meat it likewise had a prejudicial effect, but not equal to that on vegetables. It has the effect of making very white meat whiter than the soft water, upon all delicate things it has however a more marked effect—for example in making beef tea, chicken or beef broth, or upon lamb, and the more delicate a substance is the greater is the influence of a hard water upon it. A hard water as it were *compresses* the pores, whilst a soft water dilates them, and the succulent matter which they contain. It makes them more nutritious. The evil of hard water is more visible in small quantities, such as broth or beef tea.

BREAD.

He, Mr. Soyer, had not had practical experience in bread making, but there was not the least doubt that soft water was of the greatest importance as making the best bread. This is exemplified in Paris, where the water is hard and where that bread which is made in imitation of Gonness bread, though made with the same flour and by the same bakers, never equals that made at the place itself where the *water* is *soft*. *** At Glasgow the water is very soft and the scotch bakers from thence when they first come to London cannot understand why the bread does not rise so well as in Glasgow, even though they make use of the same yeast and flour; and (referring to London water) it is well known that the addition of a small quantity of bi-carbonate of magnesia in the water renders bread lighter and whiter.

TEA.

"Hard water is injurious in deteriorating the flavour of tea. It also requires more tea to give an equal strength. There can be no doubt that soft water is of very great importance, *** whilst with hard water *three* cups might be made with *soft*, *five* cups could be had from an equal quantity of tea of the same quality. The effect on Coffee is similar but not quite so powerful. (Report General Board of Health page 65-66.)

At the request of the Board before whom this testimony was given Mon. Soyer made a further series of experiments with a view to a closer comparison of the relative values of Thames water and the Artesian or deep well water of London for tea making, taking into account flavour as well as strength of extract. At the close of the experiments, he reported to the Board as follows:

In making the experiments as time is of importance for the effect, as well as economy, I thought proper to take an account of it.—For culinary purposes, I am confident that water which boils the quickest is the best; and I conceived that this might be ascertained in respect to tea. I took samples of common tea in use by the population, green tea and tea of a third class, and prepared them with equal quantities of water. I took as a standard of soft water, distilled water which I got from Apothecaries Hall. The whole results were more striking then I had at first anticipated. The softest or distilled water had an extraordinary power in obtaining a quick extract. The result shewed perhaps too high a power, for it drew out the woody flavour. Next to it was the Artesian well water, which is one third less hard than the Thames water. I should indeed prefer that water to any other tried in these experiments; although the distilled water draws out the aromatic property of the tea more than the Reform Club water, it does not, I think, produce so good an extract. Each water gave its own shade and had its own distinct extract.

Finding the results so extraordinary I solicited the assistance of two friends, the Messrs. Hooper, the most eminent tea tasters in London, the results were the same.

Mons. Soyer then gives in a tabulated form the time taken to boil the different waters experimented with (eight in all) and their rank in making tea. A pint of each was boiled in a saucepan, with a gas lamp, under precisely the same conditions, and while the softest reached the boiling point in 5½ minutes, the hardest required *ten* minutes, and their rank as tea makers, stood as *one* to *four*. Respecting the relative power of the hardest and softest water, Mons. Soyer gave it as his opinion, based on experience and observation, that while with hard water *three* (3) cups might be made from a given quantity of tea, with soft water *five* (5) could be obtained of *equal quality*, and that the extra expenditure caused to Londoners by the use of Thames (hard) water in making tea was nearly *one-third* greater than it would be with soft water.

Having been asked if he considered the action of water in tea a fair test and representation in general in all the delicate processes of cookery, he replied:

"Yes I do; and I have proved it in the following way: I have taken the solution of 16° and compared it with the water from the well of the Reform Club. *First*, with vegetables, that is carrots, turnips and onions, cut into small pieces of about one inch long and an eighth of an inch square, such as are used in Julienne soap, placed in two small pans with the same quantity of water and on the same gas stove. Those cooked in the Reform Club water were quickly done, and the flavor of the vegetables was in the water; whilst those cooked in the solution (of 16° of hardness) *never became tender nor did the flavor go into the water*. *Secondly*, with potatoes, I cut a peeled potato into two, and boiled them at the same time in the above waters. The difference was easily distinguishable. That which was boiled in the hard water being harder, but at the same time whiter. *Thirdly*; in extracting the juice or gravy from meat, the *soft* water does so quickly and well, but the hard water instead of *opening* the meat seems to draw it closer together and to *solidify* the gluten, and I believe the true flavor of the meat *cannot be extracted by hard water*. And at the same time the meat is not so tender as when boiled in soft water.*** I should in every way give the preference to *soft* water."

In support of the statements of Mons. Soyer, Mr. Phillip Holland related certain accurate experiments that he had made with a view to discover the relative tea making qualities of hard and soft water.

He had tea made with equal quantities of the leaf and equal quantities of boiling water, and found that the tea made with the softened water "was *stronger* and *better flavored*, and the infusion had to be diluted with *eighty per cent.* of *hot* water to bring it down to the strength of the hard water tea.

Professor Clark also testified to certain experiments he had made in tea making with waters of 4°, 8°, 12° and 16 degrees of hardness. Each experiment with half an ounce of tea and one pint of water placed in similar and separate teapots and the same conditions respecting time and heat.

The strength was easily distinguished by the colors. With water of 4 degrees of hardness the infusion was transparent with no sensible "muddiness; and at 16 degrees of hardness it was disgusting." Experiments were made likewise on *second* "drawings" of the same tea, and the water which was bad for a first infusion was still worse for a second; and the conclusion come to by Professor Clark was that the only way to make an infusion of tea with waters of 4°, 8°, 12° and 16 degrees of hardness equally strong was to increase materially in each case the quantity of tea. (Report G. B. H. page 69-70.)

The testimony of Mons. Soyer in relation to the marked superiority of soft over hard water in all culinary operations has been confirmed since by many other observers, and endorsed by the Royal Chemical Commission of 1851, the Royal Commissioners on Water Supply in 1869, and by the Rivers Pollution Commissioners in 1874.

SOAP.

Equally strong and convincing evidence is on record respecting the superior economy of *soft water* in the household, as well as in many manufacturing operations. A few extracts may be instructive on this point. Great attention was given to this subject in 1850 by the General Board of Health, (London, England,) and in their Report of that year are the following remarks—page 72.

"The expenditure by families of the middle class in washing amounts often to nearly one-twelfth or one-thirteenth of their income. We find that the expenditure of a number of middle class families for washing in the metropolis rarely falls short of one-third of the amount of their rent *** " the present expense and inconvenience of this important sanitary operation (washing) is the great obstruction to its due performance by the present distribution of water, and that expense is materially augmented, as will be seen by the *waste of soap occasioned by hard water*. This waste amounts to 25½ oz. of soap in the use of each 100 gallons of water of 16 degrees of hardness over and above that which would be required with a water of 4 degrees of hardness; or with the piece of soap at 5 pence the pound, causes an extra cost of 8 pence on each 100 gallons, or six shillings and eight pence on each 1000 gallons; being more than *twenty* times the *cost* of an *economic water supply*, as furnished in several towns, or as might be furnished to the metropolis, allowing 7½ per cent. on the capital required.

Mr. Donaldson, the agricultural surveyor, who has paid attention to this subject estimates the saving as follows:

From several analyses and calculations he says, as to the saving in soap by the use of soft water, and from inquiries I have made of numerous consumers of the quantity of soap used per individual, it appears that for every 100 gallons of water used in washing *two ounces of white curd soap is* *required for every* degree of *hardness*. Thus water of 5° of hardness takes 10 ounces of soap, and one of 15° of hardness takes 30 ounces of soap.

I find that 14 lbs. per individual per annum is about the average consumption of yellow soap for washing and domestic use, and the price is about 5 pence per pound. Therefore, 100 individuals using water at 15 degrees of hardness, take 1400 lbs of soap at 5 pence per pound, £29 3s. 4d. stg.; and with water at 5 degrees of hardness, 466 lbs. £9 14s. 3d. stg. Difference or saving, £19 9s. 1d. stg.

In round numbers the saving of soap by using water 5 degrees of hardness instead of 15 degrees of hardness "is £20 stg., (say $100) per 100 individuals, exclusive of the tear and wear of clothes from washing in hard water, which will fully equal the saving in soap."

In regard to the effect of hard water on the wear of linen, Professor Clark observed:

"With regard to the *softness* of water this quality is of importance, not merely for the saving of soap to household, for the agreeableness of washing at the toilet, for the agreeableness and utility of bathing, which I account a most important practice for promoting the health of the inhabitants of a town, but also in respect to the wear and tear of linen due to hard water. Such wear and tear comes to be a very large item of expense to the inhabitants of a town.

"The inhabitants of London are not aware, probably, so much as visitors from the country are, of the amount of destruction to clothes in consequence of the hardness of the water and the use of soda in order to get rid of the hardness. I remember an occasion which I may mention, where the amount of wear and tear was brought out in a very conspicuous manner. Two young men, brothers, in Glasgow, were put into counting houses, one in London, and the other in Glasgow. They had each a similar assortment of shirts given to them. Sometime after when the brother in London came back on a visit to Glasgow, the lady of the house pointed out, to the wonder of her female friends, the difference there was in the wear of the shirts of the two brothers, that had been given at the same time; those that had undergone the London washing were so much more worn than the others that had been washed in Glasgow *** The hardness of the Glasgow water was about 4^0 and that of London about 12 degrees."

At Bolton, when a change was made from water of about $5\frac{1}{2}$ degrees of hardness to water of about *two* degrees of hardness only, the reduction of the expense of soap and ashes for washing at the Bolton Union Workhouse was found to be on the average of 13 weeks from £2 10s. 1d. stg. before the change to £1 11s. 10d. stg. per week with the purer water. *** A lady who recently came to reside in London has found the difference in quantities of soap and soda required to wash the clothes of the same household as follows:

Cost in the country with rain water,	£0	5s.	$3\frac{3}{8}$	stg.
Cost in London, Chelsea water,	0	10	$10\frac{7}{8}$	

In addition to twice the time being required to perform the work, (page 78-79.)

And in reference to this same subject the *Chemical Commission of* 1851 say, "The softer the water the better it is adapted for washing with soap; the earthy salts present causing a definite and calculable loss of soap which may be taken as amounting with every gallon of water used in washing to 10 grains of soap for each degree of hardness in the water. Thus, with one gallon of Thames water at 14 degrees of hardness before boiling the loss of soap would be 140 grains, and at 5 degrees of hardness 50 grains; or with 100 gallons of water the loss in the first case would be 32 ounces and in the second $11\frac{1}{2}$ ounces of soap. But such data are not alone sufficient for calculating the saving of soap effected by the use of a soft water over a hard water; for soap is used in washing, not merely in quantity sufficient to soften the water, but in excess to act as a detergent. The problem is to determine how great the portion of soap lost in softening is, compared with the portion perceptibly used in washing in the softened water *** In the washing of the person the saving of soap by the use of soft water is most obvious. For baths soft water is most agreeable and beneficial. *** Its superior efficiency to hard water in washing floors and walls is calculated also to promote cleanliness in the dwellings of all classes *** while in the occasional domestic washing of linen the saving of soap makes a soft water highly desirable *** there is no doubt that a saving of about *one-third of the soap* would be made by washing linen in water entirely soft compared with London water, of which one-third had been previously softened by boiling. The saving in labor would be still more considerable."

And Mr. J. F. Bateman, the justly celebrated Engineer of the Loch Katrine Water Works of Glasgow, (Scotland) gave the following evidence to the Royal Commissioners of 1861, in reference to the saving effected in Glasgow by the introduction of the soft water of Loch Katrine.

"There is a great advantage and economy in using soft water, because it produces a lather with a less amount of soap; you use less tea for making tea, and you use less coffee for making coffee. *** I can give you the actual results in Glasgow from the introduction of the Loch Katrine water. *** The saving of soap was as follows: The manufacturers who used large quantities of soap and knew what their consumption was, found that they did the *same work better with three* (3) boxes, than they had done *previously with eight* (8) boxes of soap; so that they saved five-eights of the soap previously used. I personally inquired among some of the large printers and those who used water in Glasgow, and the saving varied from fully half to five-eights, but the most general computation was one-half. *** Then from calculations made by very careful housekeepers, they calculated that the *saving* by the use of Loch Katrine water, to say nothing of the wear and tear of clothes in washing, was quite equal to the rate which they paid for water, and on the north side of the river it was then £36,000 stg. a year; so that the saving to the city of Glasgow *** amounted to *two shillings per head per annum* *** I may mention (Mr. Bateman continues to say) that in my own house in the country I introduced about three years ago very soft water, equal to Loch Katrine water, in place of hard water, which I had before, and the *saving* amounts to about *four* to *five shillings* per head on the household soap used in my establishment for house purposes and washing. *** Those who know the delight of washing in Manchester or in Glasgow in their water as compared with the London water, will understand the difference. *** All you have to do with these waters is to touch the soap and you have soap enough to wash yourself perfectly. In many other ways, in the health of the people and in the tear and wear of clothes, they are saving. It is difficult to put the matter in figures, but if the saving in Glasgow is some *forty thousand pounds* (stg.) a year, upon a population of 400,000, they would save in a population of 3,000,000 (London) *three hundred thousand pounds* (stg.) a year, supposing the difference in the hardness to be the same. The change in Glasgow was from water of 9 degrees of hardness to 1½ degrees."

These extracts and opinions might be extended to a great length, but it is unnecessary. In the course of the inquiry, from the evidence in which I have just been quoting (Royal Commissioners on Water Supply, 1861,) the ablest engineers, physicians and chemists of Great Britain were examined, and all, without exception, gave a general support to the great economic value of soft water over hard for cooking and washing, though there was a considerable divergence of opinion concerning the actual per centage of saving in soap and other articles. And in summing up, the Commissioners say: "*There is no doubt that the evidence is conclusive and cogent as to the great advantage of soft water over hard for washing, and with some few important exceptions, for manufacturing purposes.*

And the Rivers Pollution Commissioners in their summary of conclusions as to the superiority of soft over hard water for washing, cooking, and manufacturing operations, say, (1) "The washing of linen can only be performed with soft water. If the available water be hard it must be artificially softened—an operation which on the domestic scale must be performed at a great expense by the aid *either* of fuel, soda or soap. In personal ablution, also, the use of soft water is much more pleasant and efficient. It is *also economical;* but by the general use of a very small quantity of water the waste of softening material is much less than in the laundry."

(2) "In cooking, the extraction of the soluble parts of such materials as are submitted to boiling or to digestion at high temperature, is more completely and economically effected by soft than by hard water.

(3) "In manufacturing operations involving the use of water, soft water is almost without exception preferable to hard. Dangerous incrustatinns in steam boilers are prevented by the use of soft water." Report, page 427.

APPENDIX D.

ANALYSES OF WATER, BY PROF. HAYES.

The water marked (A) was taken from the head of Winter River, six miles from Town: that marked (B) from Spring Park, and that marked (C) from a City Pump near the Post Office.

The communication accompanying the Report is as follows:—

MR. PETER MACGOWAN, CITY CLERK,—

DEAR SIR;

I have taken more time than usual to these analyses and have made them with great care, which will account for the seeming delay in sending you the results. I will add to the Report by answering any reasonable questions that may occur to your City Officials.

Now that the analyses are completed, will you be kind enough to tell me the sources of these different waters, that I may enter them in my records? And if this Report is printed, will you also send me two or three copies of it, at your convenience?

And oblige, yours very truly,

S. DANA HAYES, S. A.

REPORT.

STATE ASSAYER'S LABORATORY,

No. 4, State Street, Boston,

December 24th, 1872.

To the Honorable the Mayor and Common Council of Charlottetown, Prince Edward Island;

GENTLEMEN:—I have completed a very careful chemical analysis of three kinds of water received from your City Clerk, Mr. Peter MacGowan, by the hands of Messrs. Silas Pierce & Company, of Boston, and I now present, for your consideration, the following report of the results obtained.

These specimens of water came to my hands in good condition, having been packed in glass bottles, thoroughly sealed, and marked with the letters "A, B, and C," and the analyses were commenced immediately after their arrival here. The results of these analyses are stated below in two tables, for convenience in reading and comparing them. When examining these results, it should be borne in mind that the total weight of impurities contained in each water is to be considered as of first importance, and after that the most objectionable constituents are, first, the organic matter, and secondly the sulphate of lime, or gypsum.

Now, referring to the analyses, it will be seen that specimen A contains less impurity of any kind, than either of the others; while specimen C contains about nine times as much impurity as A. The water marked A is thus the purest and best of these specimens. It is a good wholesome water suitable for general service distribution in a city situated like your own, where it would be used for drinking, manufacturing and laundry purposes. It contains more lime, and is harder than the remarkably pure waters used in some other cities which are so fortunately situated as to have the sources of such supply within reach; but it is also much better than the waters supplied to many other large cities like London, in England, for instance.

Specimen B is in every respect inferior to A, although apparently belonging to the same general class of waters. It contains about twenty per cent. more organic matter, and considerably more sulphate of lime.

Specimen C represents a very bad water for domestic purposes, and it should not be used if either of the others can be obtained. It contains an uncommonly large proportion of *nitrates* or saltpetre, which indicates the presence of *decaying animal* matters such as are found in drains and cesspools, one of the most dangerous contaminations present in any water.

To briefly recapitulate: A is a good water of average quality, B is quite inferior to it, and C is very impure and unwholesome.

TABLE I.

Showing the gross weight of impurities, in grains, in one American gallon [231 cubic inches] of the waters received from Charlottetown, P. E. I.

	MARKS OF WATERS.	MINERAL MATTER.	ORGANIC MATTER.	TOTAL Impurities
1	Specimen A.	4.21	2.46	6.67
2	do B................	5.05	3.17	8.22
3	do C................	50.61	5.95	56.56

TABLE II.

Showing the weight, in grains, of the different constituents in one American gallon of the Charlottetown waters.

NO.	SPECIMENS.	A	B	C
1	Chloride of Sodium, [salt].........	0.722	0.631	
2	Other Salts of Soda..............	0.363	0.359	
3	Sulphate of Lime.................	1.813	2.650	} 50.61
4	Bi-Carbonate of Lime and Magnesia	1.101	1.020	
5	Silica, Alumina, and traces of Iron	0.211	0.389	
6	Organic Matter....................	2.460	3.171	5.95
	Total Weight of Impurities........	6.670	8.220	56.560

TABLE III.

Showing the weight of impurities, in grains, in one American gallon of the waters supplied to different cities.

NO.	NAME OF CITY.	SOURCE OF THE WATER.	MINERAL MATTER.	ORGANIC MATTER.	TOTAL Impurities
1	New York....	Croton River.........	4 11	0.67	4.78
2	Boston	Cochituate Lake or P'nd	2.37	0.83	3.20
3	Philadelphia..	Schuylkill River......	2.30	1.20	3.50
4	Chicago	Michigan Lake........	5.62	1.06	6.68
5	Montreal	Ottawa, & St. Law. R'vs	5.62	1.06	7 04
6	London, Eng.	Thames River.........	15.55	0.83	16.38
7	Paris, France..	Seine River...........	7.83	1.00	8 83
8	Charlottetown	Specimen A...	4.21	2.46	6.67

All the waters named in the last table, excepting Specimen A, were analyzed after settling in aqueducts, reservoirs, filters and distributing pipes, and they are much purer than the same waters would have been, if taken from their original sources.

Respectfully submitted,

S. DANA HAYES,
State Assayer and Chemist for Massachusetts.