McAlpine, W. J.

REPORT

MADE TO

The Staten Island Water Supply Company,

FOR SUPPLYING THE VILLAGES OF

V BRIGHTON, EDGEWATER, and PORT RICHMOND,

STATEN ISLAND,

WITH PURE AND WHOLESOME WATER,

BY

HON. WILLIAM J. McALPINE,

ENGINEER.

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ALEXANDER J. HAMILTON, *Sec'y and Treas'r.*

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Hon. WILLIAM J. McALPINE.

NEW YORK, SEPTEMBER 4th, 1879.

HON. H. G. STEBBINS,

President Staten Island Water Supply Co.

SIR:—I have examined the subject of supplying the villages of New Brighton, Edgewater, and Port Richmond, with water.

I have been furnished with copies of the estimates therefor, made by Mr. Radford, and with tracings of his maps showing his proposed distribution of the water through the streets of these villages.

I have also been furnished with the monthly fall of rain at Stapleton, for the years 1870 to 1878, both inclusive, kept by Dr. Keutgen for the U. S. coast survey, and I have obtained the rain fall at Fort Hamilton on the opposite side of the river, for the years 1839 to 1854.

And I have examined the district from which Mr. Rand proposed to collect and store the water for the supply of the villages, and his proposed sites for the storing and distributing reservoirs and the routes of the force and supply mains to and from them.

I have made no new surveys, but have tested approximately the correctness of those heretofore made by the gentlemen named, with the contour map of the U. S. Coast Survey.

The source of supply selected by Mr. Rand and Mr. Radford is from Clove Brook, on which at an elevation of about 100 feet above tide level, he proposed to erect an earthen dam of about 30 feet height, which would flow the water back over some 70 acres of surface, and give a storage capacity of about 170,000,000 of gallons of water, supplied from a water shed of about 900 acres.

The examination of the subject will be presented under the following general heads:

First. From what source can a supply of water of suitable quality and in sufficient quantity be obtained?

Second. What quantity of water is required for the present and ultimate supply of these villages, for domestic, mechanical, fire and municipal purposes? And;

Third. What are the best plans for obtaining and distributing the water under sufficient head throughout the villages?

At the risk of repeating information which your Board already knows, but some of which may not be so well known to many of your citizens, I will recall to your recollection the principles which govern all fresh water supplies.

All of the fresh water which is found either above or below the surface of the ground, was primarily, and most of it is now obtained from the ocean.

The atmosphere passing over the salt water of the ocean, is constantly carrying on a process of natural distillation and absorption of pure fresh water, and driven by the winds over the land, this watery vapor is there cooled and condensed, and is precipitated upon the earth in the form of dew, rain and snow.

A large portion of the water which is thus discharged upon the earth, passes off again to the ocean, either through the superficial water courses or those subterraneous ones which are not visible. A portion of the rain which falls upon the land, is evaporated from the exposed water surfaces of lakes, ponds, rivulets, and rivers, to be again discharged thereon with the ocean derived waters, and all of the water which flows back to the sea, is again subsequently evaporated, transported, and discharged upon the earth, having kept up this ceaseless operation for ages.

"All of the rivers run into the sea, yet the sea is not full; unto the place from whence the rivers come, thither they return again."

The visible flow of the rain-water over the surface of the land, is familiar to all, but the (so-called) mystery of the existence and flow of the waters from the same source beneath the surface, is not so well known to everyone, but is equally simple.

The rain-drops which fall upon the surface of common soils penetrate generally to a depth of less than a foot, and when the rain has continued long enough to fully saturate this upper stratum, that which subsequently falls, flows off superficially to the rivulets.

Wherever soil is very porous, the rain-drops continue their descent in it, until they reach an impervious stratum of earth or rock, and then continue to fill the interstices of the porous soil to repletion.

Before any water can flow *through* the soil, it must have a head sufficient to overcome its friction in passing between the particles of earth. Hence, all subterranean streams (however small) must have a surface slope similiar to that which we observe in the superficial water courses, but with more descent on account of the greater amount of friction which the water encounters in the former.

In the interior configuration of the earth below the surface, there are numerous places where dishes or pockets of water-tight earth or rock are overlaid with pervious soils like gravel. The rain water descends through the latter and fill up these basins to the upper rim, after which the subsequent inflow of water passes over the brim and discharges itself (still subterraneously) through the surrounding pervious soils.

There are large districts, like those along the whole Atlantic coast line, where sand and gravel of considerable porosity exists backward from the edge of the sea, or its bays and entering water-courses. In these cases the rain which falls upon the surface, sinks to just such a depth as will give it the necessary superficial slope to overcome its friction in passing between the particles of sand and gravel.

Hence, throughout these districts (and in all similar cases inland) the surface of fresh water will always be found at the level and edge of the sea and its entering water-courses, or inland at the edge of rivers and lakes, and will also be found at a higher and higher level above the sea, on the slope mentioned, as you proceed downward.

Sea water is three per cent. heavier than rain water, and when perfectly undisturbed, the latter will be found floating above the former, and when it rises landward upon the slope described, it displaces an amount of sea water below, nearly equal to its own depth above tide level.

Thus in such coast districts there exists a body of fresh water of a wedge form, with its upper surface rising above the sea level and its lower surface on almost the same slope, but descending below the level of the sea, and giving a double depth of fresh water, exactly in proportion to its distance landward.

In many cases I have found that the surface slope of the fresh water in the very porous shore sand, was at the rate of two feet to the mile at the end of the dry season in September, and at the rate of three feet per mile at the end of the wet season, in May.

This slope will always be exactly in proportion to the porosity of the soil. Along the southern slope of the whole length of Long Island, my measurements showed surface water slopes, for miles back from the sea (bays, etc.), of from four to eight feet per mile, indicating a mixture of more or less loam or clay in the soil. Here, as elsewhere, the slope was greater at the end of the wet than at the end of the dry season.

The above remarks have been applied to the Atlantic sea coast districts because the lands adjacent to the sea, are more homogeneous than is often found elsewhere; but the same principles apply wherever porous earth exists.

The French engineers have found large bodies of fresh water by deep borings in the deserts of Sahara, and Gen.

and by some other circumstances, all of which are different in the same months of different years, but they will not materially affect the general results which we now desire to arrive at.

Having applied these proportions to the rain-fall at Stapleton, for each month of each year, to the area of nine hundred acres of water shed,* we obtain the aggregate quantity of water available for use for each year, and therefrom an available monthly mean. The difference between the supply which the rain of each month affords and this mean is carried into a column of "surplus" or "deficiency," as the case may be.

By inspection of these two columns we assume that the reservoir was empty at a particular month, and the last column is made up by adding the surplus of each month or deducting the deficiency successively until the month selected to begin with is reached, when the reservoir will, of course, be found empty. The largest sum in any place in this last column shows exactly how large the reservoir should have been to retain all of the surplus waters of that year.

The tables are made up for all of the years noted, in the same manner, and show a similar result for each year.

In this case, however, the same method is applied to the whole period from 1870 continuously, so as to show how large a storage must be provided to bridge over the *years* of small and irregular rain-falls by the surpluses of preceding years, and thus show how a greater average supply can be obtained than if the storage was arranged only for the years separately considered.

SUMMARY OF THE TABLES.

YEAR.	INCHES RAIN FALL.	IN GALLONS. MEAN DAILY SUPPLY.	MAXIMUM STOR. REQUIRED. For the Year.	MAXIMUM STOR. REQUIRED. For the Period.
1870.	38.38	1,586,250	111,562,560	150,000,000
1871.	53.45	2,019,166	80,100,000	132,000,000
1872.	45.	1,612,500	44,100,000	103,000,000
1873.	53.09	2,010,000	105,245,000	178,658,000
1874.	49.68	1,937,500	115,350,000	198,000,000
1875.	45.	1,610,000	64,725,000	111,825,000
1876.	46.09	1,885,000	164,700,000	186,900,000
1877.	42.90	1,751,250	146,587,500	147,225,000
1878.	58.62	2,300,000	156,375,000	150,000,000
		Mean, 1,955,740		Mean Daily Supply, 1,750,000

* Since the above was written I have been furnished with the result of a careful compution of this water shed, which is found to be twelve hundred acres. This increase is equivalent to adding one-third to the quantity of water which can be furnished from this district. That is, ultimately, to *more than two millions of gallons a day.*

The tables show that if a reservoir of eighty millions of gallons capacity, had been built in 1869 (the year of least rain-fall), there would have been a supply equal to a daily average of more than 1,600,000 gallons ; and if the storage had been increased to a hundred and fifty millions the average daily supply for the whole period of nine years would have been nearly 1,750,000 gallons.

They also show that until the demand for water exceeds a million of gallons a day, a reservoir of thirty-five millions capacity, would have been sufficient to have bridged over the dry years of the period.

But whenever the demand exceeds a million of gallons daily, it may be supplied by increasing the storage as herein provided for.

It may be remarked that if there should ever be a season or succession of seasons dryer than those of which we have any record, the plans herewith submitted, will assure a supply of at least a million and a half daily.

In these calculations the allowance for filtration and evaporation from the reservoir, has not been deducted, because the rain-fall on the water shed will be enough greater than that assumed in the tables, to provide for those losses.

ON THE QUALITY OF THE WATER FROM THE PROPOSED SOURCE.

In the preliminary part of this paper we have seen that the atmosphere performs the office of natural distillation of pure fresh water, even from the briny sea. It is then in its most pure condition, but is also in a state of readiness to absorb everything objectionable to its purity with which it comes in contact.

The rain water discharged through the pure atmosphere of an open country, falls upon the ground also nearly pure, but thereafter it is in constant contact with deleterious matters. On the surface of the earth it meets with decaying animal and vegetable matter, and there and below the surface with earthy salts, minerals, etc., all of which render it more or less impure, in proportion to the soluble character of the substances and the length of time it remains in contact with them.

A clever French writer (Tissandierre) says: "An engineer fairly versed in analyses can tell from an examination of the water of a district what its geology is ; *or, if he knows its geology he can describe its water.* Even a layman need not long doubt."

"According to the nature of the soil, therefore will be the nature of its waters."

The district under discussion has only the ordinary amount of vegetation upon it. This vegetation when growing is an absorbent of all that is noxious to water, in either the atmosphere or the earth, from which it derives a part of its nutriment, and hence during the spring and early summer, vegetation has the effect of preventing to a certain extent, the contamination of the water which passes over and through it. But in the autumn, when the annuals are decaying, they give out matter seriously deleterious to the waters therefrom.

Animal life, even the most minute, depends primarily upon the extent of vegetable growth, and with its decay, its life also ceases, and further adds to the deterioration of the water at that season of the year.

The water shed is now occupied as farms and gardens, and hereafter will be taken up as villas, so separated as to produce nothing seriously detrimental to the waters collected from the district.

The soil contains so small a quantity of the earthy salts and mineral matters, that the water from this source will be but slightly affected thereby.

A consideration of the whole of the circumstances, leads to the conclusion that the water from this district, is now superior to any other in this section of the country, and that it is likely to remain so in the future.

The analyses of the water at various times show that it is above the general character for domestic purposes, of those waters which are supplied to other cities, and which is not there considered objectionable by the sanatist or consumer.

In this connection it is proper to compare the quality of the water which it is proposed to furnish, with that which is now the only potable water accessible, viz.: from the wells sunk amid the denser population of the villages.

Both are primarily from the same source, but the latter is from the beginning, while falling through the air, contaminated by the gases of effete matter, which is observed upon every vacant lot and yard of the village, and from combustion carried on in the thousand and one houses, is thus rendered impure. When the water reaches the ground it encounters these decaying animal and garbage wastes upon the surface, and when it passes below, it enounters solutions of these and other substances which have been carried into the soil, and, worst of all, the overflow or leakage of privies, cesspools, and defective drains, and similar matters from stables, cow-yards, and pig-styes.

All of the wells sunk in such extremely contaminated soils, will absorb all of their impurities, and when the idea is strongly presented, will render all of such well waters disgusting and abhorrent.

The water herein proposed to be supplied, is entirely free from each of these contaminations, and will be gratefully received by all persons of any degree of refinement, or those who care for the health of their wives and children.

Cistern water is liable to only the first of these objections, added to the soiling from dirt-covered roofs, and the deprivation of nature's curative process, by the oxidation of impurities in contact with the atmosphere, and its beneficial aeration.

The water stored in the reservoirs of other cities, have frequently become impure in the heat of the late summers, and this has caused a popular, but not well-founded prejudice against such stored waters.

The fouled reservoir waters referred to, have been rendered so by the sudden development of animalcular or ephemeral marine vegetation, which, following a law of nature, has an existence as short as its generation has been sudden.

When a body of water has been exposed to the heat of midsummer for a considerable time, this minute life is suddenly developed, and almost as suddenly dies, and in its latter condition seriously contaminates the water.

The first considerable reduction in the temperature of the air or the operation of a brisk wind, destroys all of this contamination by condensing or driving off the gases therefrom, and then the water stored in the reservoir, becomes even better purified than before.

A reservoir performs the office of a filter better than any mechanical contrivance. In the first place, by its quiescence, all foreign matter heavier than water, sinks to the bottom below the decomposing effects of the warmer water near the surface, and that which is lighter, rises to the surface, and is quickly dissolved into gases, which are driven off by the wind.

There is, however, a provision in the plan of the works, by means of which no inconvenience will be experienced from the fouling of the stored waters, viz.: in the plan of its aeration and agitation when being delivered into the distributing reservoir, and also in the provision by which the supply may be obtained from either of the reservoirs when one of them is thus temporarily fouled.

SECOND.—THE QUANTITY OF WATER WHICH MUST BE SUPPLIED.

A method in common use for determining the quantity of water which should be furnished to a city, is to apply a certain rate per head to the whole population. The result is considered as representing the whole demand for domestic uses, mechanical purposes, street sprinkling, and for the extinguishment of fires.

The daily supply of water to New York is equal to 100 gallons a head, applied to its whole population, and that for other large cities is nearly as great.

It is well known that the waste of water by the takers, and what is far greater, by the careless supervision over the pipes, is in many of these cities, equal to that actually consumed by the takers. In smaller places, where the supervision is better, the consumption for all purposes ranges from 25 to 40 gallons per capita.

The actual quantity of water required for all domestic uses, does not exceed ten gallons a day for each person. On ships of war the supply of water used to be, one gallon to each of the crew and two to the officers, with which the latter had all of their clothes washing performed.

The mechanical and all other purposes do not require more than that used for domestic purposes, and a supply equal to 30 gallons a head for the whole population, is ample where the works will be, as in this case, under careful control.

An average supply of a million of gallons a day, would be very liberal for a population of 30,000, and the plans of all of the works herewith furnished, are based upon that quantity; but they are all so arranged that whenever the demand becomes greater than a million, the various parts of the work may be enlarged thereto without any loss of the first expenditure.

THIRD.—THE PLANS PROPOSED FOR THE WORKS.

Herewith are presented the following drawings:

1. Of the plan of constructing an earthen dam for the STORING RESERVOIR, with its GATE-HOUSES, WASTE-WEIR, conduit pipes, and the public road-crossing.
2. Of the plan of constructing the DISTRIBUTING RESERVOIR, with its GATE-HOUSE, INLET, OUTLET and WASTE-PIPES, and the FILTERING and AERIFICATING APPARATUS.
3. Of the plans of the PUMPING ENGINE and its DUPLICATE, the BOILERS therefor, the PUMP-WELL, and its inlet and waste-pipes, and of the ENGINE and BOILER-HOUSES and coal sheds.
4. A map showing the system of the DISTRIBUTION by FEEDING-MAINS, extending through the villages, and the capacity of these pipes to deliver large quantities of water throughout, in case of large conflagrations.
5. Specifications describing in great detail the manner of performing every part of the work.

THE STORING RESERVOIR.—The earthern dam as at first built is to give a capacity of storage for one hundred millions of gallons, but the base of the works are arranged for its ultimate enlargement to hold two hundred millions.

This dam is provided to be built, so as to prevent any leakage whatever through, under or around the ends, and with an ample, constantly self-acting waste, to provide against any overflow from an excessive rain discharging into a full reservoir.

The water face of the dam is to be protected by a heavy stone pavement, and over its top will be carried the public road securely railed.

The Gate-house is to be built of stone masonry, lined, if advisable, with timber and plank, with gates which will permit the water to be drawn from near the surface of the lake, at the middle of its depth, and from near its bottom.

A house will be built over the well in which will be placed the machinery for opening the gates and raising the screens.

The effluent and waste-pipes are to be of heavy cast iron, encased in masonry, and extended through the earthen dam with protections against leakage thereat. The *outlet gate-house* will be of stone, within which will be placed the water gates, by means of which either the supply or the waste water may be turned through either or both of the cast-iron pipes.

The lake is to be thoroughly cleaned from all decayed or vegetable matter and muck or soil, and its bottom made perfectly clean, and is to be surrounded by a high picket fence.

The Distributing Reservoir is to be made of earth, with a clay puddled lining and water facings of pavement, and also surrounded by a high picket fence. Its capacity as first built, will be for seven millions of gallons, and arranged to be deepened to hold ten millions.

Its Gate-house will be of stone masonry, and provided with gates and water screens and suitable machinery to operate them.

The inlet, outlet, and waste-pipes will be of cast-iron, enclosed with masonry and protected against leakage.

The Filtering apparatus will be placed in the middle of the reservoir, to which the Force-main will be extended, with branches and gates arranged to deliver the water from the Pumping Engine directly into the Reservoir, or into the Filter, or into the Aerificator.

The Filter is to be made reversible, so as to cleanse itself whenever desired.

The Pumping Engine is to be condensing with a power sufficient to elevate a million of gallons of water in twenty hours from the storing into the distributing reservoir.

The Duplicate is to be non-condensing with half of the above-mentioned power.

The Pump-well is to be of strong, substantial masonry, and of the same depth as the water in the Storing Reservoir, to which it will be connected by an extension of the two cast-iron outlet pipes. Suitable screens will also be placed in it.

A neat and suitable Engine and Boiler-house will be built of brick masonry.

The FORCE-MAIN will extend from the Pumping Engine to the Distributing Reservoir, and also directly to the *Distributing pipes* at two or more places.

It will be provided with the necessary water gates and two check valves.

THE DISTRIBUTION.

The supply mains will be of such size, that when a draft of water equal to a million of gallons a day is being withdrawn from the reservoir and distributed throughout the *ultimate pipe district*,* the pressure of the water in every part of the pipes laid in streets, which are less than 100 feet above tide, shall be not less than equal to 50 feet above the level of the surface of any such streets. That is, that if a hose pipe should be attached to any of the hydrants in such streets, and it should be carried up the side of a very high building, the water will rise in such hose pipes to a level of not less than 150 feet above tide. Whenever the demand for water elsewhere in the whole district, should happen to be less than is hereinbefore assumed, the water will rise in such a hose to a greater elevation than 150 feet; and of course, during the night, when the consumption of water throughout the several villages will often be only nominal, the water in such a hose pipe would rise to nearly its elevation in the reservoir.

The system of supply will be by larger feeding mains extending from the distributing reservoir to and through certain streets to the extreme ends of each of the said villages; and, by frequent cross-feeding mains connecting the same, and by smaller intermediate pipes through such other streets of the said villages whenever the demand for water is sufficient to pay for the use of the required intermediate pipes.

It will be observed that the feeding mains are all required to be laid down in the proper streets therefor, without regard to the revenue from the water takers, and also that they must all be of sufficient size to distribute all of the water which will be required, when the population of the villages has increased to several times the present numbers.

The feeding mains above referred to, will be arranged as follows: Starting from the distributing reservoir and running to Castleton Avenue, the pipe will be of sufficient size to deliver at the rate of a million and a half gallons a day.

From this place, pipes will be extended along that Avenue to the right and left, each of sufficient size to carry half that of the above mentioned quantity of water in each direction.

Along Richmond Terrace and its continuation along the shores, a line of feeding mains will be laid, which, in connection with the cross mains from the Castleton Avenue main,

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* By which is meant the district which will ultimately embrace the 30,000 water takers consuming a million of gallons a day.

will each be sufficient to supply one-fourth of the quantity at the supplying end, and diminishing in size to the *west* end at Mariner's harbor, and at the *south* end of Edgewater, in each place with pipes sufficient to supply one-tenth of the said million and a half of gallons daily.

The main in Castleton Avenue westerly will be reduced in size but sufficient to convey one-sixth of the water to Columbia Street, and the one running easterly will be reduced to convey one-fourth of the water to Ferry Street, and the same quantity to near the foot of Arietta Street, where it will unite with the shore main, and will be extended down Bay Street, starting with a capacity equal to the delivery of one-fifth of the quantity, and diminishing to one-tenth at the south end. The cross supply mains and the intermediate pipes will increase the above mentioned capacities of the feeding main whenever a larger quantity is demanded, as for the extinguishment of fires.

The water gates are so arranged as to make nine separate water districts,from each of which the supply of water can be shut off without interrupting the supply to any of the other districts, whenever it hereafter becomes necessary to connect with additional pipes, or to make repairs.

In case of a large conflagration in any part of either of the said villages, the supply to all of the other parts can be throttled down by means of these valves, to the barely necessary consumption, and thereby very largely increase the quantity of water which can be delivered at the place where such conflagration is going on.

In all ordinary cases, the quanitity of water which can be drawn from the hydrants for fire purposes, and without diminishing the usual consumption of the citizens during the day time, will be equal to that of four of the medium-sized steam fire engines in New York, and in an exigency a supply equal to that from ten to fifteen such engines can be availed of, in less than half an hour.

The water for fire purposes, will be delivered generally from the hydrants under 150 to 200 feet head (above tide water), and can be thrown to a vertical height from a nozzle at the hydrant, of 100 to 140 feet, and at the end of a straight laid hose of 500 feet, of more than two-thirds of those elevations.

The hydrants will be placed on four inch pipes leading from the street mains, and the nozzles will be of the size and thread of those of the fire engines of the villages.

The water pipes will all be laid at such depth below the surface of the ground as will protect them from frost.

The trenches will be filled with rammed earth, and the surface of the streets thus disturbed, will be restored to as good a condition as before their removal.

Mem.—The above described arrangement is based upon the location of the Distributing Reservoir at near the head of Bard Avenue.

If the location of this reservoir is changed, the feeding mains will also be changed so as to accomplish the same object, and also to connect the force main with certain of the feeding mains leading to Port Richmond, as well as with the general system of the feeding mains.

I have been informed that you desired an opinion from me, whether the introduction of an ample supply of water would require also immediately a thorough system of sewerage through the villages.

There is no necessary connection in your case, between the two public improvements. The porous character of the most of the soil through the villages, permits of the use of cesspools with less objection than would exist when the soil is water-tight, because leakages therefrom entering the soil, is acted upon something like that of earth closets in common use.

For this same reason, however, the use of wells in such soil for domestic supply, is much more objectionable than it would be elsewhere.

A complete system of sewerage is necessary in every large population, to preserve the health and add to the comfort of the community, and its importance is only second to that of a supply of wholesome water, and in such abundance and under such head as to be effective for the extinguishment of the largest conflagrations.

The plans which are herewith presented, will fully accomplish these purposes, and will undoubtedly have the effect of so enhancing the desirableness of residences on your beautiful slopes, as to cause a very rapid increase of your population by new and useful citizens.

As a brief summary of the foregoing report (which I have not the leisure to condense), I beg to state—

That the plans herein proposed, will furnish the villages of New Brighton, Edgewater, and Port Richmond, with an abundance of pure and wholesome water, for a population of more than thrice that of the present, and at such elevations and with such pressure as will enable you almost instantly to check the beginning of a great many fires, which without the aid of these works, would almost certainly destroy more property than the whole cost thereof, and in the unhappy event of one of these great conflagrations, which seem to occur periodically in every one of our American communities, these works when built will serve *to lessen* the destruction of property again equal to their cost. Respectfully,

WM. J. McALPINE, *Engineer.*