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A HISTORICAL AND DESCRIPTIVE ACCOUNT OF THE JERSEY CITY WATER WORKS.

BY A MEMBER OF THE INSTITUTE.

Jersey City, 30th Sept., 1856.

HENRY MEIGS, Esq., Rec. Sec'y of the American Institute:

Dear Sir—In compliance with your request, I have much pleasure in furnishing you an account of the legislative proceedings, preliminary examinations, construction and cost of the Jersey City water works, with a short description of the works themselves, and some account of their present management and future prospects.

It may be proper to state by way of introduction, that a large proportion of the lands lying within the chartered limits of Jersey City, are a part of what was formerly an extensive marsh, the soft mud of which reaches in some parts to a depth of seventy feet, or more, and over which the high spring tides regularly ebbed and flowed. From this marshy soil, no water fit for domestic use could be obtained; nor was it found by boring the underlying rocky strata to the depth of 300 feet; and in that part of the city which in its natural state was above the reach of tide, the formation is of such character that water found by sinking wells was poor in quality, and the supply small and uncertain.

In consequence of this peculiarity of the site upon which the city is built, the want of good water began to be felt almost as soon as it was occupied, and became more pressing and inconvenient with every addition to the population; the few public wells which afforded water fit for household purposes being, at some seasons, surrounded from early dawn till a late hour in the evening, with crowds waiting to secure a small portion of the scanty supply which they furnished: and it became a trade to transport water in casks from Bergen hill, and sell it in the streets

of the city to consumers who were unable to obtain their supply from the public wells.

This scarcity was so severely felt in the autumn of 1850, that an application was made to the Legislature at its session in the succeeding January, for the passage of "An act for the appointment of Commissioners in relation to supplying the townships of Hoboken, Van Vorst, and the city of Jersey City, with pure and wholesome water."

The Legislature passed the law as desired, and it was approved 18th March, 1851. The commissioners named in it were Edwin A. Stevens, Edward Coles, Dudley S. Gregory, Abraham L. Van Boskerek and John D. Ward; and it was made "their duty to examine and consider all matters relative to supplying the said townships of Hoboken, Van Vorst, and Jersey City, with a sufficient quantity of pure and wholesome water for the use of their inhabitants, and the amount of money necessary to effect that object." These commissioners entered upon the performance of the duties assigned to them in June, 1851, electing John D. Ward, President, and Edward Coles, Secretary, and shortly afterwards engaging the services of William S. Whitwell as engineer.

They first considered a plan which was proposed for obtaining water from a small reservoir which had been excavated by the New Jersey Railroad and Transportation Company, at the side of their road where it passes through Bergen hill; a report in favor of this as the source of supply having some time before been made to the municipal government of the city.

Another plan brought to their notice was, to pump the water required directly from Hackensack river, after building a dam at some point not far from Snake hill, and extending embankments each way from the dam across the meadows to the high ground, to prevent the salt water below from being carried at any time by the tide and mixed with the fresh water above.

It was supposed by some that a good supply could be obtained by converting the Western slope of Bergen hill into a gathering ground, and collecting the water from the net work of underground drains, into a canal extending along the foot of the hill, from which it was proposed to raise it by a steam engine to a reservoir upon the summit.

It was also proposed to take water from the Passaic river above the falls at Paterson, and conduct it to Jersey City in pipes; and another proposition was to take it at the Dundee

dam between Paterson and Acquackanonk, and raise it to the required height by water power furnished by the river.

Rockland lake, and Greenwood lake or Long pond, were also proposed as sources of supply, both of which are sufficiently elevated to render pumping unnecessary. But to each of these, and sundry other projects, which were brought to the notice of the commissioners, objections were found sufficiently serious to cause their rejection, and the plan of raising the water by a steam engine, directly from Passaic river, at Belleville, was, after extensive and careful examinations, surveys and estimates, considered by the board the one best adapted to furnish to the inhabitants of Hoboken and Jersey City a permanent supply of pure and wholesome water at a reasonable cost.

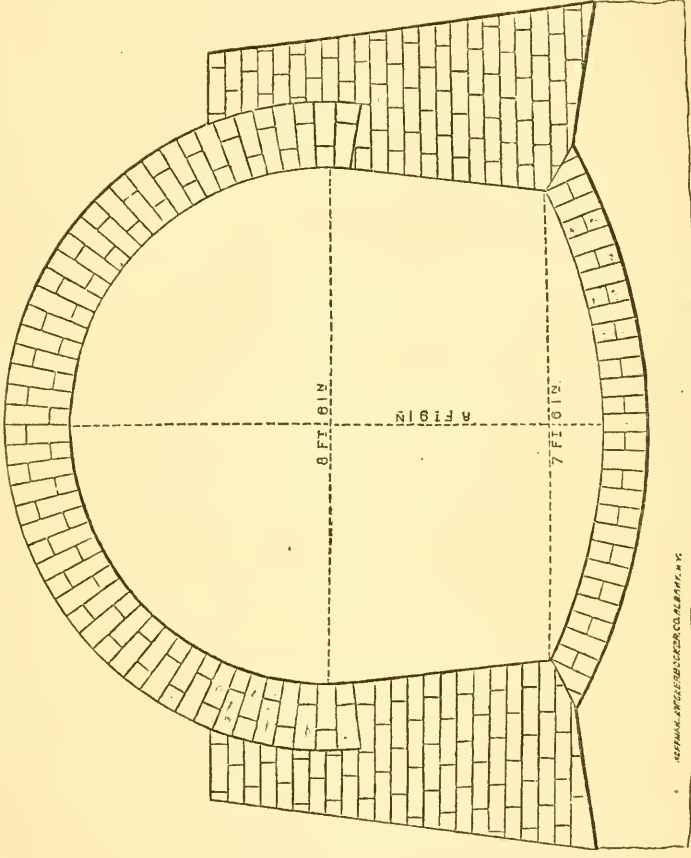
The commissioners, as directed by law, made a report of their proceedings to the legislature in January, 1852, and presented a copy of the same to the municipal authorities of Hoboken and Jersey City, the township of Van Vorst having, during the year preceding, been annexed to and made part of the latter corporation. In their report the commissioners, after describing and discussing the merits of the various plans which had received their consideration, recommended the construction of works in conformity with the plan approved, the estimated cost of which was \$653,359.

The people of Hoboken, however, after seeing and deliberating upon the commissioners' report concluded that it would be inexpedient for them, at that time, to be concerned in the construction of works so large and expensive as those proposed; and declined uniting with the citizens of Jersey City in asking the legislature to grant authority for that purpose. The citizens of Jersey City, though disappointed at the determination of their neighbors to withdraw from any share in the prosecution of the enterprise, were not discouraged, but determined if assistance could not be obtained, to proceed with the work alone. At their request the legislature passed "An act to authorize the construction of works for supplying Jersey City, and places adjacent, with pure and wholesome water;" and for that purpose to borrow, on the credit of the city, the sum of \$600,000 at a rate of interest not exceeding six per cent per annum, and for a term not exceeding fifty years. The construction of the works was, by the act, placed under the direction of five commissioners, three of whom, (J. D. Ward, D. S. Gregory, and M. B.

Bramhall,) were named in the act, one was directed to be elected at the next ensuing charter election, and the president, for the time being, of the board of aldermen, was constituted a member *ex-officio*. This board was first regularly organised on the 28th April, 1852. The members constituting it at that time were John D. Ward, Dudley S. Gregory, Moses B. Bramhall, Thomas A. Alexander, then recently elected, and David S. Manners, then president of the board of aldermen, commissioner *ex-officio*. Of this board John D. Ward, was elected president; and as the law under which they acted required that before any work could be undertaken, they should obtain a loan for at least one-half the estimated cost of the whole, the attention of the commission was first necessarily directed to the financial part of its duties, and inquiries were instituted to ascertain where and on what terms the requisite amount of money could be obtained. The result of their inquiries was a conclusion to advertise for proposals for a loan of \$300,000, or one-half the sum required for the works, for twenty-five years at an interest of six per cent per annum, payable half yearly. When the bids for this were opened on the 9th June, it was found that the sum of \$1,421,000 was offered at rates varying from $1\frac{1}{2}$ to $3\frac{3}{10}\frac{9}{10}$ per cent premium. The average rate of premium on the bids accepted was 2,006 per cent. The commissioners being thus furnished with the means of proceeding, engaged Wm. S. Whitwell, the engineer employed in making the preliminary surveys and examinations, to direct and superintend the construction of the works.

Contracts were soon after entered into for the principal part of the iron pipes required, for the stop-cocks and fire hydrants, for excavating and refilling the trenches for water pipes in the streets, and for the construction of the distributing reservoir on Bergen hill; and the contractors entered almost immediately upon the execution of the work which they had undertaken. Contracts for the pumping engine, and pipes for the rising main, for the engine house, the inlet conduit, and the receiving reservoir at Belleville were made during the succeeding winter.

The number of contracts entered into, and the progress made by the contractors in executing them, admonished the commissioners that the remainder of the loan which they were authorized to contract would be required at no very distant day to enable them to meet their engagements; they therefore on the



AS PER PLAN AND SECTION DRAWINGS

Inlet Conduit, Jersey City Water Works.

10th December, 1852, invited proposals for the further sum of \$300,000. These were opened on the 19th January following, and found to amount to \$976,000, at rates of premium varying from $2\frac{1}{2}$ to 5 per cent, and the average rate on the bids accepted was 4.266 per cent—the amount received for 300 bonds of \$1000 each being \$312,798.80. Such parts of the work as could be executed during the winter without injury were carried on without interruption, and such as were necessarily suspended during the severe weather were resumed as early as the return of the warm season permitted, and prosecuted regularly until their completion.

In June, 1854, the steam engine was first started, and the several parts of the works were so far completed that a small quantity of water raised by it reached the distributing reservoir, when the failure of a valve chamber of the large pump caused a suspension of its operations for some weeks; and it was not until the latter part of August that the water commissioners were able to commence the regular distribution of Passaic water to their tenants, which since that time they have regularly continued.

These works take water from the Passaic river at Belleville and raise it to the height of 157 feet, into a receiving reservoir on Belleville ridge, from which it flows through iron pipes to the distributing reservoir on Bergen hill, and thence through distributing pipes to all parts of Jersey City, and will no doubt soon be furnished to the citizens of Hoboken, as negotiations are now in progress between the municipal authorities of that city and the water commissioners intended to effect that object. The works comprise,

First. The inlet conduit and pump-well which receive the water from the river.

Second. The engine house, pumping engine and boilers, pump, and rising main through which the water is raised to the reservoir.

Third. The receiving reservoir.

Fourth. The pipes which conduct the water from the receiving to the distributing reservoir.

Fifth. The distributing reservoir.

Sixth. The distributing pipes which conduct the water from the reservoir to the consumers.

The inlet conduit, the bottom of which is four feet below ordinary low water in Passaic river, is about 375 feet in length, and of the form and dimensions shown by the annexed drawing. It

has sliding gates and wire screws at its mouth, which are placed in proper vertical grooves in the masonry, and these are protected by a small brick gate-house erected over them, which in its turn is protected by a row of piles driven a few feet in front of it, and parallel with the course of the river. The pump-well, into which the water is received from the conduit, is divided into two parts by a wall through its centre, making each, twenty-six feet nine inches, by sixteen feet three inches. Large arched openings are formed in the lower part of this wall, for the passage of the water, and it is carried up through the engine-house to the same height as the beam walls, dividing it into two equal and similar engine rooms. The pump-well was sunk to the red sandstone rock which underlies that region, and which, though somewhat loosely stratified, was found sufficiently firm to sustain the weight of the pump, together with the water which it contains, and the plunger loaded to the extent required to raise the water into the receiving reservoir. The foundation for it was prepared by simply levelling and smoothing that part of the rock on which the pump stands.

The engine house, which is a handsome brick structure, 127 feet in length, including the boiler house, and 39 feet in breadth, was built and fitted for receiving two Cornish pumping engines, with steam cylinders of 80 inches diameter, and stroke of 11 feet, each intended to work a pump with a stroke of 11 feet, and plunger $34\frac{1}{2}$ inches in diameter. But one of these is yet erected; the present demand for water not requiring half the power of the one now in operation. But as the consumption is constantly increasing, the time may not be far distant when it will become necessary to provide the means for increasing the supply.

The Rising Main, which at present passes out through the side of the engine house, in the rear, is 36 inches in diameter, and 2305 feet in length. It is taken through the embankment of the receiving reservoir at its northwest angle, on a level with the bottom, from which it rises with an easy curve to the height of the top water line, in order that the amount of work to be performed by the pumping engine may remain constant whether the reservoir be full or empty (a condition necessary to its good performance); and also to guard against the possible injury which might be caused by the current if a failure in the lower part of the main should occur, and its mouth within the reservoir be so placed as to permit the water to re-enter and flow back through it. This latter contingency is to some extent guarded against

by a set of self-acting stop valves, placed in the main near its lower end; and it is also furnished with two stop-cocks of the ordinary form, which may be closed when required.

The Receiving Reservoir.—This is situated on Belleville ridge, about 3,000 feet from the bank of the river. Its form is that of a parallelogram; the length is 390 feet, the breadth 318 feet, the depth 19 feet, and it is intended to contain 16 feet water, or about 10,334,229 imperial gallons. Nearly half its depth was excavated, and the remainder was obtained by raising an earthen embankment, with a puddle wall in the middle of its breadth, to the top water line, which is 157 feet above ordinary high water in the Passaic.

The embankment is twelve feet wide on the top, and has a slope of one foot vertical to two feet horizontal on the outside, and one vertical to one and a half horizontal on the inside. The outside slope is sodded to the top, and the inside is faced with bricks laid in cement, as high as the top water line. A small gate house at the southeast angle encloses the gates and screens of the outlet pipes, of which there are two, one of 20 inches, and one of 36 inches diameter. The smaller one only is used at present, the larger, extending no further than the outside of the embankment, to be used when the demand for water shall render a larger supply necessary than the 20 inch will convey to the distributing reservoir. A similar provision exists at the opposite angle, a 36 inch pipe being laid through the embankment, to which another rising main may be attached whenever such addition shall become necessary.

The Connecting Pipes between the Receiving and Distributing Reservoirs.—These are 20 inches in diameter, cast in the usual form, with spigot and faucet joints, and were laid in the ordinary way wherever the ground was sufficiently solid, but at least three-fourths of them were laid upon a marsh so wet and soft, and containing so many stumps and roots, that any attempt to lay them in a trench would have proved impracticable.

In that part of the line they were therefore laid upon the surface, and have a covering of earth forming a low embankment, which is composed partly of marsh mud and partly of gravel, taken from Belleville ridge.

For short distances, near the solid ground at each side of the marsh, two rows of piles were driven and capped to serve as a foundation for the pipes; but the largest proportion of them were laid upon a bed formed by cutting away such portions of the

stumps as projected much above the surface, and levelling up the lower parts with such materials as could be obtained from shallow ditches excavated at the sides. In this way the bed was raised from 4 to 6 inches above the general level of the marsh; on this was laid a flooring, of two inch hemlock plank, about eight feet in width, and in some parts of double thickness, the planks crossing each other at right angles. The pipes laid upon this have remained in good condition, notwithstanding a trifling settlement of the line in some parts. At Hackensack river a narrow bridge about 1000 feet in length was built, upon which a box, made of timber six inches in thickness, strongly bolted and trussed, was laid to receive the pipes, which are furnished with what is technically termed a slip joint near each end of the bridge, for the purpose of preventing the lead joints from being destroyed by the contraction and expansion of the iron, caused by changes of temperature. As the Hackensack is a navigable river, it was of course necessary to provide for the passage of vessels through the bridge. This was done by sinking about 60 feet of the box and pipes, opposite to the draw in the adjacent turnpike bridge, to 12 feet below low water, which places the whole completely out of reach of the keel of every vessel that navigates the river.

The diameter of the pipes used for this inverted syphon, is 24 inches, the larger size being adopted to compensate for the obstruction to the flow, caused by the four changes of direction which the water receives in passing through the syphon. The distance between the two reservoirs is nearly six miles, and the difference of level of the water in them is generally about 25 feet. With this head, the 20 inch pipe will deliver into the distributing reservoir a little more than 2,000,000 imperial gallons in twenty-four hours, the quantity that would be raised by working the engine eight strokes per minute for twelve hours, a rate at which it may be worked if a proper stand pipe is erected. This addition to the works will, no doubt, indeed, *must*, be made as soon as the increased demand for water requires more than can be raised by working the engine constantly at the present rate of $4\frac{1}{2}$ to 5 strokes per minute, a rate which, with the present arrangement, cannot be exceeded with safety, because the water being sent from the pump directly into the rising main, the friction and inertia of a column 2305 feet in length must be overcome, and the whole set in motion at each separate stroke. This slow rate of working, however, is favorable to economy, the duty obtained

having been as high as 60,000,000 or 65,000,000 lbs. of water raised one foot with 90 lbs. of Cumberland coal.

The Distributing Reservoir.—This is situated on Bergen hill, about two miles from the Jersey City ferry. Its form is oval, being 897 feet in length, and 722 feet in breadth, with an average depth of about 15 feet. The top water line is 128 feet above ordinary high water in the harbor of New-York, and extends over an area of nearly twelve acres. The average depth of water, when filled, is about 12 feet. The upper or northern part is principally formed by excavation, and the lower or southern part by an embankment which, on the lowest ground has a breadth at its base of something more than 100 feet, and is about 20 feet in height. The slope of the embankment on the outside is 1 perpendicular to $1\frac{1}{2}$ horizontal, and on the inside 1 perpendicular to 2 horizontal. The inside is protected by a slope wall of stone extending from the top water line to a level 11 feet below it, or 14 feet below the top. The outside is sodded, and the top, which is 16 feet in width, has a gravelled walk of 10 feet bordered by sods at the sides, which on the inside reach to the stone wall.

The capacity of this reservoir is about 45,000,000 imperial gallons, and of this and the receiving reservoir together 55,334,229—a quantity sufficient to supply a population of 100,000 persons with 30 gallons each for nearly 19 days.

At the southeasterly side is the gate-house, through which the influent and effluent pipes pass, and in which are placed stop-cocks for regulating the flow of the water; and near to this, within the reservoir, is the screen-house, a low brick structure, without a roof, in which are fixed wire screens, for preventing fish and floating substances from entering the effluent, or distributing pipes, and being carried to the mouths of the service pipes where they would become troublesome to the water-tenants. A 36 inch influent pipe is laid through the embankment at this reservoir, as was done at Belleville, and also a 26 inch effluent pipe in addition to the one now used, and arrangements made for connecting new lines of influent and effluent pipes when required, without interfering at all with the operation of those already in use. Provision is also made for taking the water into the city without allowing it to pass into the Bergen hill reservoir—an arrangement which will permit alterations, or repairs to be made in that, when necessary, without interrupting the regular supply to consumers.

Distributing Pipes.—Of these there are now laid about 19 1-5 miles, of the following sizes and lengths, to wit:

Of 26 inches diameter,.....	3,420 feet.
“ 20 “	8,472 “
“ 16 “	1,411 “
“ 12 “	12,124 “
“ 6 “	69,195 “
“ 4 “	6,778 “

101,400 feet, or

19 miles, 1080 feet. And there are used in the rising main, connecting pipes and distributing pipes, 143 stop-cocks, varying in size from 36 inches to 4 inches, and in the streets of Jersey City are fixed 186 fire hydrants, from any one of which, by attaching a hose of sufficient strength, the water may be thrown over the highest buildings yet erected within the city limits. And if the same proportions are hereafter adhered to in laying down distributing pipes, which have hitherto been observed in that department of the work, the same effective head will be retained as the city is extended, and fire engines continue to be an entirely useless apparatus, so that the municipal government may not only be saved the expense of purchasing others, but with perfect propriety may dispose of most of those now on hand, and place the proceeds of the sales in the city treasury.

The quality of Passaic water, as received by the consumers, after resting as it does in the reservoirs, is excellent; and careful analyses have shown that it is superior to the water furnished to the people of Albany, New-York, or Philadelphia; and experience has shown that it is well suited for domestic use, and for all manufacturing or other purposes where pure and wholesome water is required, and the quantity which may be brought to the distributing reservoir is only limited by the power of the machinery employed to raise, and number and dimensions of the pipes to deliver it; and as these may be increased indefinitely, it may be safely said that the water supply in Jersey City is inexhaustible.

The actual cost of constructing the works made up from the statement of receipts and expenditures contained in a semi-annual report of the water commissioners, to the mayor and common council of Jersey City, on the 1st July, 1854 (after the steam engine had been actually at work), was \$594,885.78, or a little more than \$5,000 below the original estimate; although vari-

ous parts had been made larger and more complete than was originally contemplated; the length of pipes had been increased from about $19\frac{1}{2}$ miles to $25\frac{1}{2}$; the engine house had been built and fitted to receive two pumping engines, instead of one; the Belleville reservoir was enlarged to contain four or five times the quantity proposed, besides other extensions of the plan. Some parts of the works and grounds were not, at that time, in a completely finished state, and the expenditures required for their completion, together with the additions and extensions which have been called for, during two years which have elapsed since the introduction of the water, had, on the 1st July, 1856, increased the cost to \$640,828.04 as appears from the subjoined statement furnished from the books of the water commissioners. This excess of expenditure, over the original estimates, is sufficiently accounted for by the construction of works of greater extent and more efficient character than were at first supposed necessary, but which the rapid growth of Jersey City, and the almost absolute certainty that Hoboken would require to be supplied from them, appeared to render necessary and proper.

Summary of cost of the works, 1st July, 1856.

Pumping engine and pump,	\$37,323 07
Engine house, inlet conduit, dock, &c., &c.,	92,593 96
Rising main, check valves, stop cocks, &c.,	37,652 00
Belleville reservoir,	35,946 63
Bergen hill reservoir,	53,416 27
Connecting pipes between reservoirs,	127,500 00
Distributing pipes,	189,571 34
Pipe bridge and syphon,	9,315 14
Land,	38,005 00
Engineering expenses,	19,499 63

\$640,828 04

The works continue in effective operation completely realizing the wishes and expectations of their projectors and the citizens generally, who are not backward in availing themselves of the advantages which are afforded by an abundant supply of excellent water. The income derived from the sale of water, is steadily increasing; the receipts for the present year are estimated by the water commissioners, at \$47,669.53, and the expenditures, including interest on the whole water debt, \$58,212.00, leaving a deficiency of \$10,542.47 to be provided from other sources; of this

about \$5,000 will be supplied by a small tax of fifty cents per lot, levied equally on all grounds improved, or unimproved within the city limits (the collection of which is to cease when the receipts from water rents are sufficient to pay the current expenses), the balance will be raised by an addition to the general tax. And it is confidently believed, that within two years, the receipts will exceed the expenditures, and enable the commissioners to make investments in securities to form a sinking fund, out of which to pay the water debt as the bonds severally become due.

The law authorising the construction of waterworks, made it "the duty of the commissioners to cause all such surveys and examinations to be made as would enable them to decide upon and recommend a suitable plan for a general system of sewers for the whole district proposed to be supplied with water." These surveys and examinations were made as directed, and after mature consideration a plan was drawn up and submitted to the municipal government for its consideration.

That body, after careful examination and inquiry, adopted the plan, and by an ordinance directed that all sewers hereafter authorised in the city, shall be constructed under the direction of the water commissioners, and in conformity with the plan submitted and adopted. This contemplates a canal at the foot of Bergen hill, in rear of Jersey City, to be connected at one end with Hudson river, and at the other with the Morris canal, and into which water from the river will be admitted and retained by gates at high water level; the sewers are to be made in the streets, running from the canal to the river, with lateral branches in the cross streets; and each main sewer to have a fall in its whole length of four and a half feet. With this arrangement the water in the canal will be let into the sewers at the time of low water in the river; and as at spring tides there will be a difference of level of six feet between the water in the canal and that in the river and bay, all the sewers may be perfectly cleansed as often as required; and, in the language of the late Nicholas Dean, Esq., "*will leave Jersey City nothing to desire in the important matters of public health and individual convenience.*"

I remain your very obedient servant,

W.