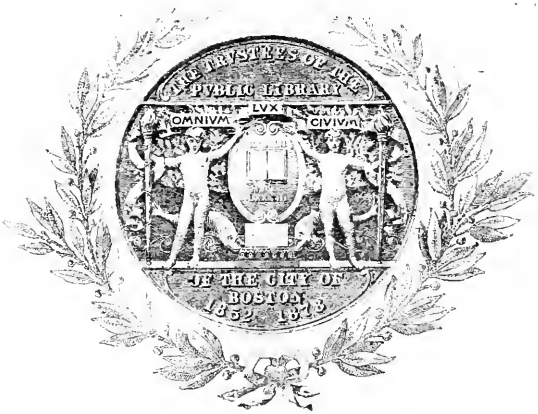
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REPORT

OF THE

COMMISSIONERS

APPOINTED UNDER THE ORDER OF THE CITY COUNCIL,

AUGUST 26, 1844,

TO

REPORT THE BEST MODE AND EXPENSE OF BRINGING

THE

WATER OF LONG POND

INTO THE

CITY OF BOSTON.

BOSTON:
1844.
JOHN H. EASTBURN, CITY PRINTER,
No. 18 State Street.

BOSTON, NOVEMBER 9, 1844.

HON. MARTIN BRIMMER,

Mayor of the City of Boston.

SIR,

The undersigned, Commissioners appointed under the order of the City Council of August 26, "to report the best mode and the expense of bringing the water of Long Pond into the City," having performed the duty assigned to them under their appointment, have the honor herewith to communicate to you their report.

Very respectfully, your ob't serv'ts,

P. T. JACKSON,
NATHAN HALE,
JAMES F. BALDWIN,
} *Commissioners.*

REPORT.

The Commissioners appointed under an order of the City Council, to "report the best mode, and the expense of bringing the water of Long Pond into the City," respectfully submit the following

REPORT:

In determining the best mode of bringing the water from the proposed source to the City, it seemed to the Commissioners necessary to consider the purposes for which it is to be used, and the amount of regular supply required to serve those purposes. Presuming it to be the desire of the City Council that the water proposed to be introduced into the City, shall be sufficient to afford an ample supply to all the inhabitants, as well for domestic purposes, as for the protection of the City against fire and for cleansing the streets, and also for various economical and manufacturing uses,—particularly the feeding of steam engines,—it seemed necessary to base their calculations on some assumed amount of population to be supplied. It is presumed that since the subject was last under the consideration of Commissioners for a similar investigation, the population of the City has increased in a ratio of not less than 25 per cent., and that the present number of inhabitants is

near 110,000. It may be assumed therefore, that by the time the proposed introduction of water into the City can be accomplished, the population will not be far from 125,000. Presuming also that it will not be the intention of the City Council, to limit the supply of water to the wants of the existing population, and taking into view the very great and uninterrupted increase of the City, not only within the period of seven years already referred to, but for the last fifty years, in which last period the number of inhabitants has more than twice doubled, it has been deemed reasonable to assume, as the basis of our computation of the amount of daily supply, such a quantity as will be sufficient for all the public, domestic and manufacturing uses of 250,000 inhabitants; or for double the population the City may be expected to contain, at the date of the completion of the proposed works.

The next question for consideration is, what measure of supply shall be assumed, as sufficient to meet all the wants of this number of inhabitants. On this point your Commissioners conceive it will be satisfactory, to adopt the conclusion which was arrived at, after a careful inquiry into the rate of supply which had been deemed sufficient in a large number of other cities, by the Commissioners who were appointed under an order of the City Council in 1837. They refer in their report, to the water works of the City of Philadelphia, as those which afforded as liberal a supply of water, as those of any city within their knowledge, and they state that the quantity, as appeared from the official report of the preceding year, amounted to an average of 28½ wine gallons, to each inhabitant within the limits of the distribution.

The Commissioners are the more disposed to adopt this ratio, as the measure of the proposed supply, because as far as their knowledge extends, it has been generally regarded as fully sufficient. At this ratio, the supply of 250,000 inhabitants will require 7,125,000 gallons of water per day. This is equal to 950,000 cubic feet, or very nearly a regular flow of eleven cubic feet a second, through every hour of the day.

The next point of inquiry which has engaged the attention of the Commissioners, was to determine whether the water of Long Pond is sufficient, to afford a constant supply to this amount. As the order of the City Council, which defines the duty of the Commissioners, demands only a report of the best mode of bringing the water of Long Pond to the City, without reference to the quantity, it might at first view appear that the foregoing computations as to the quantity required, are irrelevant to the objects of our commission. In our opinion, however, a definite conception of the quantity required to be regularly supplied, for meeting the purposes in view, constitutes an important element, in the calculations for determining the best mode of bringing the water to the City. For the same reason, it is important to determine the extent of the permanent supply of water, which the pond is capable of affording; that the works may be adapted to the purpose of bringing it to the City, without being of greater magnitude, and consequently more expensive than is necessary.

This involves an inquiry of great difficulty, arising from the embarrassments to the exact measurement of the flow of the water, while it is subject to the

uses of the proprietors of the mills at the outlet, and more especially from the great variableness of the flow, in different parts of every season, and also the great inequality between one season and another. The Commissioners have given as much attention to this inquiry, with the aid of a careful engineer, as the period which has elapsed since their appointment would allow, and they have also availed themselves of the observations and calculations, which were made by the Commissioners whose report is above referred to. The unusual drought of the past season, arising from the small quantity of rain which fell during a period of two or three months, was favorable for determining what may be regarded as the minimum flow of water in any ordinary season. It may perhaps be proper to regard it as a season of extraordinary drought, not likely to be often surpassed, though it would be unsafe to assume that even severer droughts may not occur hereafter.

It is perhaps superfluous to remark, that all natural streams of water vary greatly in the amount of their discharge, according to the contingency of a dry or wet season,—the condensation of vapor and the fall of rain and snow, being the ultimate source of supply to them all. In our climate, as the summer and autumn months are usually comparatively dry, and as a greater amount of water during the heat of summer escapes by evaporation, the running streams are in general comparatively low in the autumn, and a uniform flow of water through the year can be preserved only by retaining, by artificial means, the supply afforded in the more rainy parts of the year. The minor streams and ponds, which serve as feeders to the rivers, are themselves fed in part from

springs proceeding from a greater or less depth in the earth; but even these depend for their supply upon the rain, and gradually diminish, during the continuance of every dry season—some of them, however, being far more sensibly affected by changes of the weather than others. Happily for those who reside under our climate, the rain is never so long withheld, that any of the considerable streams are entirely dried up, though there is no one which is not subject to great fluctuation, from the alternations of wet and dry seasons.

Long Pond is of course not exempt from the effects of these alternations, though it is not subject to them in any unusual degree. In the winter and spring, it receives very large accumulation of water from the snow and rain, which never fail to fall at those periods of the year, in greater or less abundance, and from the small streams and springs which are fed from those sources. It is thus raised, without the aid of any artificial dam, to a considerable height above the level of the outlet. The stream, which at these periods flows from the pond, is consequently large, compared with its dimensions after a period of comparatively dry weather in summer. This stream, between its outlet and Concord river, is occupied by two mills, a woolen and carpet factory, belonging to Mr. William H. Knight. For the supply of these mills, the water has been usually retained to a certain height, during a part of the summer, by a dam at the outlet; but in every spring, a large surplus is supposed to escape. This dam has been recently increased in height by Mr. Knight, and it is his intention hereafter, as he has informed the Commissioners, to retain the water in the spring, at a height of five

and a half feet above the outlet,—having acquired a right to do so, by a purchase of a tract of meadow land, which will be necessarily flooded by the operation.

This description is necessary, for presenting a distinct idea of the productiveness and capacity of this pond. The pond is estimated to cover a surface of 600 acres, but its extent has not been accurately ascertained by any survey, known to the Commissioners. When raised to a height of five and a half feet, it will cover a still larger surface. The water thus accumulated will serve to afford, under suitable regulations, a discharge for several successive months, far larger than it would afford, in its natural state, during the dry portion of the year. The pond was drawn down in part, at an early period of the last spring, to avoid the damage which would have been occasioned to the adjoining meadow, which had not then been purchased by the proprietor of the mills. In consequence, before the end of summer, all the water which had been accumulated by artificial means was exhausted, so that the discharge from the pond had been reduced, before the first visit of the Commissioners to it, on the 30th of August last, to what may be denominated its natural summer discharge. There had been then a very little rain for several successive weeks, and the stream, in common with all the neighboring water-courses, was low. The dry weather continued, with the exception of light rains, for several succeeding weeks, in which period the supply of the pond was reduced nearly as low as at any period of which any information has been obtained. During this period, a measurement was made under the direction of the Commissioners, of the periodical discharge from the pond. For this measurement,

Mr. Knight afforded every facility, by consenting to the interruption of the mills, so far as was necessary for adjusting the apparatus. These measurements exhibited a discharge, during the thirteen days ending September 24th, equal to an average of 5.1 feet a second, during the day and night, although the works were kept running only during the day. But during the last thirteen days of this period, the surface of the pond was gradually reduced about 0.01 foot per day, or 1⅔ inches in the the thirteen days, which is equal to a draft of 3.2 feet a second. This shows that during the period mentioned, the quantity of water running into the pond from streams or springs, amounted to no more than 1.9 feet per second, beyond the quantity lost by absorption and evaporation. But by carrying this calculation back to the commencement of the observations on the 30th of August, we find that the discharge was equal to 5½ feet a second, without any depression of the surface of the pond, between that date and the 12th of September. By carrying it forward a day and a half, to the 26th, we find that the pond recovered, in consequence of a rain of twenty-four hours, the full quantity of water which it had lost in the preceding thirteen days. The result, therefore, of the measurements, which have been made the present season, is that the minimum produce of the pond, independent of what is obtained by reducing the quantity accumulated in it during a period of thirteen days, was 1.9 feet a second, but with the exception of those thirteen days, the average of any equal or longer period exceeded five feet a second. The supply since the 15th of October, and it is presumed through the

other parts of the year, has been much larger than this last amount.

Observations were made under the direction of the Commissioners appointed in 1837, by which it appeared that in the autumn of that year, which was a remarkably dry season, the discharge of the pond, in the last five days of September, averaged only 1.83 feet per second; and the average of the months of August, September and October, was 4.93 feet. The produce of the pond in these three months, after deducting from the amount of discharge the quantity obtained by reduction of the pond, was equal to an average of 3.71 per second, and for four months 5.62 per second.

The above computations of the natural discharge of the pond, during a season of drought, or during a a long continued absence of rain, are not to be considered as affording a measure of the constant supply, which the pond is capable of affording. The accumulation of water, in those seasons of the year which never fail to afford an adequate supply, is a much surer source on which to rely, than the immediate produce of springs and rivulets, the amount of which will always fluctuate with the changes of the weather. According to the observations above referred to, the discharge of the pond from July 27, 1837, to July 27, 1838, including the dry season of the former year, was estimated to be equal to an average of 15.36 feet a second; and from November 1837, to November 1838, embracing a part of the same year, with a portion of the succeeding year, in which there was more rain, the discharge amounted to an average of 21.82 feet a second. These estimates of the discharge from the pond, within the

two periods here mentioned, taken in connexion with such other information as it has been practicable to obtain, relative to the flow of the stream for some years past, and to the mill power at the outlet, seem to justify the inference, that the amount of that flow will, every year, equal an average of at least twelve feet a second, for the whole year. It remains to be shown, how the surplus of one portion of the year can be made to supply the deficiency of another, so far as to secure a regular discharge equal to twelve feet a second, through every part of the year,—or a certain supply of eleven feet, after a liberal allowance for leakage and waste.

The pond, as has been observed, forms a natural reservoir, covering an estimated surface of 600 acres. It is possible that it may fall short of this estimate, but if we add to it Shakum and Dug Ponds which communicate with it, and which may be held in reserve if necessary, there is no doubt that the three embrace an area of more than 600 acres.

The Commissioners propose, in the mode of constructing an aqueduct which they recommend, for conducting the water to the City, that it shall be so placed, that when filled to a sufficient height, to afford a supply of eleven feet a second at Corey's Hill, the surface of water in it shall be seven inches above the present flume at the outlet, and 3 feet and 10 inches above the bottom of the aqueduct. The present dam, as has been stated, was designed to raise the water to a height of five and a half feet, or four feet and eleven inches above the proposed water line in the aqueduct; and the proprietor of the water has acquired the right to flow all, or nearly all, the land, below this level. There appears to be no

room to doubt, from the facts above stated, that water enough will flow into the pond every winter and spring, to fill it to this height, if it should be necessary, and that if the dam should be closed to this height, a considerable surplus will flow over it, during a portion of every year. There will thus be held in reserve, with a dam of this elevation, 128,502,000 cubic feet of water, to be drawn upon at pleasure during the dry months of the year, or those in which the flow into the pond may be less than the required draft upon it. This quantity will be sufficient to sustain a continued draft of 12 feet a second for a period of 124 days, or seven feet a second for 212 days.

It has been seen that the produce of the pond, independently of any draft upon its accumulated resources, during the past summer, was estimated to exceed 5 feet a second, with the exception of a short period, and that in 1837, which was also a dry season, the produce was computed to be equal to an average of 5.62 feet during the four dry months. These facts afford the principal data for calculating the quantity of water which must be held in reserve for ensuring a continued supply, and the height to which the dam must probably be raised for the purpose. Further observations will be necessary for determining the most suitable limit to the height of this reservoir. A very large reserve may be obtained by a foot or two less of depth than that assumed above. If raised to a height of $3\frac{1}{2}$ feet only, the quantity accumulated will be 91,476,000 cubic feet. This is adequate to sustaining a draft of 12 feet a second for 88 days, or to making up a deficiency of 7 feet a second, for 151 days.

Upon the evidence of these facts and computa-

tions, the Commissioners are of opinion that although the supply of water, running into the pond from tributary sources, is liable to be reduced, for short periods in seasons of extreme drought, to a flow of less than two cubic feet a second, it may safely be relied on for producing every year an average of at least 12 feet; and also for retaining, by means of a dam and gates at the outlet, such a quantity of water, as will ensure a regular supply equal to that amount, through the whole year. Whether it will be necessary for this object, to retain the water to the maximum height to which the present proprietor of the water proposes to raise it for the supply of his mills, or whether the object may be attained by means of a dam of considerable less height, is a question which may be safely left, to be determined hereafter, especially as the maximum quantity of water cannot be required for a number of years to come.

The raising of the pond to the greatest height above proposed, would probably have little injurious effect upon the banks, or upon the adjoining lands, with the exception of the tract of meadow already mentioned. It is surrounded, for the most part, with a gravelly beach, entirely free from all vegetable substances. In some small part, bordering upon streams flowing into it, there are collections of mud, which if it be found necessary for preserving the purity of the water, may be removed. Should it be found necessary permanently to flow the meadow, it would be a question for future consideration whether it would be expedient to remove the peat, of which it is formed. Whatever may be the height to which it may be found expedient to raise the surface of the pond, there can be no difficulty in surround-

ing it with a well defined margin, by excavating the parts imperfectly flowed, so that the part covered with water shall be permanently covered, and vegetation prevented. The injurious effects upon the water, from the decay of vegetable matter, in consequence of the flowing of an increased surface, would be but temporary, and all inconveniences from this source, may be obviated by raising the pond at once, in anticipation of the period of the completion of the works.

Having from the foregoing considerations adopted the conclusion, that on a liberal estimate of the probable wants of the City, a supply of water of not less than 7,000,000 gallons per day ought to be provided, and that Long Pond may be safely relied upon to produce a constant supply to this extent, with as great a degree of certainty as calculations of this nature will admit of, it remains next to consider the best mode of introducing this water into the City, and of placing it at such an elevation, that it may be advantageously distributed throughout all parts of the City, for the purposes for which it is designed.

Before determining upon the character and dimensions of the work which should be recommended for this object, two of the Commissioners visited New York for the purpose of examining the recently erected Croton Water Works, for the supply of that City. By the kind attention and assistance of Hon. James Harper, the Mayor of the City, and of James A. Coffin, Esq., President of the Board of Water Commissioners, and also of Horatio Allen, Peter Hastie, and E. French, Esqrs., Engineers, the two latter resident Engineers at the City, and at Sing Sing, they were afforded the fullest opportunity for examining every part of this magnificent work, which

the time they could devote to the inquiry admitted; and all their inquiries in regard to the principles of the work, the method of conducting it, the choice of materials, and the cost of the various parts of it, were freely and most satisfactorily answered. The result of their examination, while it has deeply impressed them with the skill with which that work has been conducted, and particularly with its strength and apparent durability, has satisfied them that the leading principles on which it is constructed are well adapted to the object proposed here. The Croton Water Works are of much greater magnitude, and had much greater obstacles to encounter, than those which are proposed for the use of this City. They are adequate to the supply of a million and a half of inhabitants;—the aqueduct is of more than double the length of that proposed by us,—and it traverses a very uneven and rocky country, in which frequent tunnelling through extensive ledges of rock and high embankments were necessary. For retaining the water of Croton river, and forming a reservoir five miles in length, covering an area of 400 acres, a part of which is 55 feet deep, a dam was required to be erected, of 40 feet in height above low water in the river: an aqueduct bridge has been built over the Sing Sing Kill, more than 70 feet in height, and supported by an arch of hydraulic stone masonry, of 88 feet span; a much larger bridge yet unfinished, but rapidly advancing, is to be erected over Harlem river, 1450 feet in length, on 8 arches of 100 feet in height, and 80 feet span, and 6 arches of 50 feet span,—the top of the parapets to be 114 feet above the ordinary high water line of the river, and 149 feet above the lowest foundation of the piers. There

are also two very capacious reservoirs in the City, of the most thorough construction, one of a capacity of 20,000,000 of imperial gallons, and the other of 150,000,000. All these works are of massive masonry, of superior workmanship, exhibiting great architectural skill, and consequently of great cost. The water is conveyed from the Croton dam to Harlem river, through an uninterrupted conduit of hydraulic brick and stone masonry, 7 feet 5 inches in width, and 8 feet 5½ inches in its greatest height. The aqueduct is laid on a bed of concrete, formed of hydraulic cement, sand and broken stone; it is lined throughout with brick laid in cement, the covering consists of an arch of the same materials, and the sides are supported by walls of stone masonry laid in cement.

The works proposed, for bringing the water of Lond Pond to this City, will require no construction bearing any comparison for magnitude or cost, with those above enumerated. The Commissioners recommend the construction of an aqueduct, from Long Pond to a reservoir, of sufficient capacity to contain a day's supply, to be formed on Corey's Hill in Brookline,—a distance of about sixteen miles. They propose that the aqueduct shall be of brick, laid in hydraulic cement, of an oval form, five feet in width, and six feet four inches in height, in the interior, and broader in the lower section than in the upper. They recommend this form of the structure, as well adapted to give it strength, and these dimensions, as sufficient to afford sufficient capacity, and also to admit of its being easily entered for the purpose of examination and repair, should it become necessary. They propose that the brick work shall

be eight inches in thickness, and that the whole structure shall be covered with an embankment of earth, four feet in depth, in every part. They propose that the conduit shall be laid with an inclination from a level, of three inches in a mile,—which inclination is computed to be sufficient, to admit of the flow of the proposed supply of water, viz. 11 feet a second, by filling the aqueduct to a depth of three feet and ten inches; leaving a space of two and a half feet in height empty.

The dimensions thus proposed are considerably larger than those of the aqueduct recommended by the Commissioners of 1837. The reasons for recommending a work of these greater dimensions are, that the calculations are based on the supply of a greater number of inhabitants than those of 1837;—it has been deemed an important object to form a structure of greater height, to admit of its being more readily entered for the purpose of examination; and it was deemed also desirable to deliver the water at as great an elevation as is practicable, at the reservoir on Corey's Hill, for the purpose of obtaining the power of a more satisfactory distribution in all parts of the City. This increase of the dimensions of the work adds something to the estimate of the cost, but the advantages gained by it are believed to be sufficient, to justify the increase of cost.

A line has been surveyed between the termini above described, on which it is ascertained that there is no formidable obstacle to the construction of the work. There will be several places of deep cutting, none however exceeding 36 feet in depth, and several large embankments will be required for sustaining the level. The heavy excavations will be

mostly through earth, consisting apparently in great part of sand or gravel, of easy excavation, and there are no indications of rock to any great extent on the line. No measures however have been taken to ascertain, by any examinations under ground, the character of the excavations. There are two valleys to be crossed, which are too low to admit of the line of the aqueduct being sustained over them, without incurring an excessive cost. One of these is at the crossing of Charles River near Newton Lower Falls, and the other is near Lime Grove, beyond Brighton Village. It is proposed to suspend the brick aqueduct at the crossing of these valleys, and to convey the water across them by means of a double line of iron pipes, each of 30 inches diameter, to be laid near the natural surface of the earth, and to be covered with earth to a depth of four feet. The length of the two proposed sections of pipes is 2,470 feet, and it is computed that in consequence of the diminished area of the section of water passing through the pipes, compared with that in the brick aqueduct, there will be a loss of level, at the two valleys, amounting to about fifteen inches.

It is proposed that the water shall be taken from the pond at a height, after it is introduced into the aqueduct, of 124.86 feet above the marsh level; and allowing about four feet for the inclination of the aqueduct, and 15 inches for fall at the two valleys crossed by iron pipes, that the surface of water at the reservoir on Cory's Hill, when it is filled to its usual height, shall be 119.61 feet. Corey's Hill is the nearest point of land to the City, which can be approached by such an aqueduct, as that above described, and which is of sufficient elevation for the

site of a reservoir. It is at a distance of about four miles from the State House. From that reservoir, the water must be conveyed to the City, and distributed, by means of iron pipes.

To effect a more satisfactory distribution, and to insure an unfailing supply of water for all emergencies, it is recommended that there shall be three or four reservoirs of moderate dimensions; one to be situated on Beacon Hill,—another on Fort Hill,—the third on Dorchester Heights in South Boston,—and a fourth on Copp's Hill in the North part of the City, if a suitable site can be obtained for the purpose. These reservoirs may perhaps be dispensed with, by adopting pipes of larger dimensions for the introduction of the water from Corey's Hill; but it is believed that the object of maintaining an uninterrupted delivery of the water, at a high level, will be most effectually and most economically attained, by their aid.

It is computed that for the distribution of the proposed quantity, of seven millions of gallons per day, it will be necessary to lay two iron pipes, of 30 inches diameter, each, from Corey's Hill to a part of Tremont Street near the Roxbury boundary;—that a branch from one of them, of perhaps 12 inches diameter, shall be carried from this point, in the most direct and eligible course, to Dorchester Heights, for the supply of South Boston; that one of them shall be continued through Tremont Street to Boylston Street; that branches shall be carried thence to the reservoirs on Beacon Hill, Fort Hill, and Copp's Hill;—and that such other branches shall be laid, for the conveyance of water to all parts of the City, as shall be found, on a careful study of

the best system of distribution, to be necessary. It is proposed that the water should be delivered at the reservoir on Beacon Hill, at the height of 111.61 above the marsh level; 4.68 feet above the level of the State House floor; and 60 feet above the foot of the columns, in the Piazza in front of Tremont House. The proposed level of the reservoir will be 19.81 feet above the level of the sidewalk, at the corner of Mount Vernon and Temple Streets, and 34.62 feet above the summit of Somerset Street, opposite to Somerset Court.

The most extensive and costly works of stone masonry, which are proposed in this plan of construction, are the Beacon Hill reservoir,—an arched passage way, for carrying the aqueduct over a public highway in Brighton,—and a structure with two arches for carrying the iron pipes, with a proper covering of earth for their protection from frost, across the Charles River.

This is the general outline of the plan of a work, which the Commissioners recommend as, in their opinion, best adapted for bringing the water of the pond into the City,—and on which they have made an estimate of cost, exhibited in a tabular statement, which is presented as a part of this report. This estimate including an allowance for contingencies, amounts to $2,118,535 83.

The largest item of the estimate consists of the sum of $440,155 for the cost of the proposed brick structure, from the pond to Corey's Hill, which they have computed at the rate of $16 for each thousand of brick, laid in hydraulic cement. It is well known that the price of bricks, in this market, is extremely variable, according to the extent of the demand; and

that the wages of mechanics and laborers are subject to material changes, from year to year, from causes which cannot be foreseen. It is therefore impossible to estimate with any degree of certainty, what a work of this description will cost, in any future year. It is believed, however, that in the estimate here given, a sufficient allowance has been made for the different items, to cover the cost of the work, in any probable state of prices; or at least that the probability that the work may be done at a less cost than this, is greater, than that it will cost more.

Another item of nearly equal magnitude consists of the cost of iron pipe, for conducting the water across the two vallies, and from the reservoir on Corey's Hill to the reservoir in the City, amounting to $366,501. This is estimated at the rate of 2½ cents a pound. A similar remark, to that made above, may be applied to the cost of this article. The price of pig iron has varied in England during the last year, from 37*s.* 6*d.* to 80*s.* per ton, and in this country from 20 to 35 dollars. It is therefore very difficult to foresee at what price any manufacture of iron may be obtained, at a future day. The rate of our estimate is higher than it would be necessary to pay, if the pipes were to be contracted for at the present time. The lead to be used for the joints is estimated at 4 cents a pound, a price higher than the average value of the article for two or three years past.

The quantity of excavation, and embankment, is computed upon the line of the survey of 1837, without any allowance for a probable improvement of it, by further examination. In the absence of any satisfactory evidence as to the character of the earth

to be removed, in the deep cuts, the whole excavation and embankment, including the embankment for covering the brick aqueduct, except where it is covered by replacing the excavated earth, is estimated at the price of 17 cents per cubic yard. The filling of the cuttings, by replacing the excavated earth, is estimated at 10 cents per yard.

In the computation for the cost of distributing the water in the City, the Commissioners instead of attempting a detailed estimate, founded on a digested plan of distribution, and embracing a measurement of the streets, and the assignment of the particular size and extent of pipes in each, have taken the estimate which was made for this object, by the Commissioners of 1837, without any deduction from this part of it, for the reduced cost of iron and lead, since that date,—and have added to the amount, an increase of 25 per cent. for the increased population now to be supplied. This result it was thought would serve as an approximate estimate, sufficiently accurate for the purpose now in view, and nearly as correct as could be made at the present time. If it is erroneous, it is presumed that it errs on the safe side, by allowing too large rather than too small a sum.

The amount allowed, for the cost of a reservoir on Beacon Hill, can hardly be called an estimate, as it was impossible to assume for the basis of it, any definite dimensions, or form of construction, without knowing what suitable site could be obtained for the purpose. The sum given in the table, embraces the amount of the estimate made by the Commissioners of 1837, for a reservoir which should hold 750,000 gallons, together with an additional allowance for an increased cost of land. It was thought safe to assume,

that for this cost, a lot of land suitably situated may be obtained, and a reservoir may be erected, of perhaps less lateral extent, but of greater depth, which will serve the purposes of the aqueduct then proposed.

The only remaining item of the estimate, of sufficient magnitude to require particular remark, is that which is given for the cost of water rights. The compensation which will be demanded for the diversion of the water of Long Pond, from the uses to which it is now appropriated, to the important one of supplying the inhabitants of the City with water for domestic uses, presents perhaps the most difficult question which has yet been considered. In estimating the water rights, which will be thus invaded, at $100,000, the Commissioners would not be understood as rating their actual value for manufacturing purposes, independently of the property which may be injured by withdrawing the water, at near so high a price.

The supply of the City with water for the domestic purposes of its inhabitants, it is presumed will be regarded by the Legislature of the State, as one of those public objects, which justify the taking of private property at a valuation to be determined, when not adjusted by agreement with the parties, in such manner as shall be provided by law. For property taken under such circumstances, the City will expect to pay, not only a full, but a liberal rate of compensation. Such a rate, according to the estimate which shall be made of the actual value of the water to its present owners, they will doubtless be ready to offer. Were the title to compensation vested in a single claimant, it might have been more easy to ascertain

what price would be demanded for it. In the present state of ownership, of the water of Concord river, the estimate of the claims of the several parties, presents a complicated question.

The exclusive right to the use of the water for manufacturing purposes, from the outlet of the pond, to its union with Concord river, as has been stated, is owned by Mr. Knight of Framingham. From this point the whole of the water of Concord river, including that of Long Pond, is held by the proprietors of the Middlesex Canal, for the purpose of feeding the canal, with the exception, however, of a certain reservation for the use of Billerica Mills. Whether that corporation has a right to use it for any other purpose, and in such a manner as to divert it from the Billerica Mills, or from the other mills on Concord river below Billerica, is a question which may be raised, but which it does not belong to the Commissioners to settle. The surplus of water, beyond what the Middlesex Canal is competent to use or dispose of, belongs to the proprietors of Billerica Mills, and to those of three other privileges on Concord river.

It is perhaps not important for the present purpose, to know whether the right of disposing of the water of this river, for any other use than that of supplying the canal, belongs to the Middlesex Canal Company or not, because if they are entitled to compensation for a diversion of the water, the other claimants are not, and if they are not entitled to it, the other claimants probably are.

So far as the value of the water depends upon the actual quantity, and upon the regularity of the supply, the explanation which has been given above,

will serve to show in what manner, in the opinion of the Commissioners that quantity must be estimated; and also such data for the estimate, as can be at present obtained. The maximum supply which, in their opinion, can be held in reserve by artificial means, for regular and permanent use, is computed not far to exceed the quantity already named, of twelve feet a second. It might probably be increased somewhat beyond this amount, but with more or less hazard of a failure, in the constancy of the supply. The statements above given also show, that the minimum supply, in periods of drought, without the aid of improvements yet to be made, and which when made, must be subject to the control and pleasure of the proprietor of the falls at the outlet, is less than two feet a second, and that sometimes during several successive months, it does not exceed five feet a second.

The height through which this water falls, at the two mills of Mr. Knight, as measured by our Engineer, is 12.89 feet. The damage which would be occasioned by the taking away of a water power, created by a fall over such a height, of the quantity of water here described, is not to be estimated merely by the amount of power produced, independently of the value of existing works, of which it has become a necessary appendant. The buildings and machinery would be rendered comparatively useless, if deprived of the water power, unless a substitute of some other power, were provided in its place. The most obvious mode of computing the value of the water power, in this case, would therefore be, to compute the amount of capital which would be required to provide an equivalent in steam power, and

afford a sufficient income to maintain it in permanent operation. In this mode, it is evident, a full equivalent for the water power could be provided, by the substitute of steam power. In addition however to the loss of the water power, he would sustain an injury from the taking away of the water required by him in a running stream, for the washing of wool, used in the manufacture carried on by him. The only mode therefore in which he could be adequately compensated for being deprived of the water would probably be, to pay him such a sum of money, as would be equivalent to the purchase of another water power, and the removal to it of his buildings and machinery, or perhaps the erection of new buildings with a proper allowance for the value of the old for other uses.

The proper estimate of the damage to the Canal Company, must depend upon the question whether the water is likely to be actually wanted for the purpose of sustaining the navigation of the canal. If it is not wanted for this purpose, it is not apparent in what way the company would sustain an injury, unless they have a right to appropriate it to other uses. If it is wanted by them for the purpose of feeding the canal, the most suitable mode of estimating the damage would probably be, to ascertain the cost of providing a substitute, for such quantity of water as the canal would be deprived of, during the seasons in which they would suffer from a deficiency, by an equal quantity to be held in reserve for that use, in an artificial reservoir, to be formed in the vicinity of Concord river, or on some of its tributary streams. Such a supply it is believed might be provided for, at a moderate cost.

Should it be decided that the Canal Company has an unlimited right to dispose of the water of Concord river, including that of Long Pond, for manufacturing purposes, or should it be abandoned by them, and in consequence become the property of the owners of the mill privileges, from the canal to the mouth of Concord river, there seems to be but one rule by which to estimate the proper value of the power which can accrue from it, at the several falls over which it flows. The height of the several falls is ascertained to be 11.11 feet at the Billerica Mills; 25.31 at Whipple's Mills; 8.39 at the Massasoit Mills, and 11.21 at the Middlesex Mills.

By a rule which has been adopted by the proprietors of the Locks and Canals at Lowell, for computing the amount of mill power, 25 feet of water per second, on a fall of 30 feet, is assumed to be a mill power; and if the fall be less than 30 feet, the quantity of water to be increased in proportion to the diminution of fall; one foot in height to be deducted in all cases for loss of head, and not to be included in the computation of the proportion. The highest price at which such a mill power has been sold at Lowell, is $14,336, and this is regarded as a high price for water power. If then a water power, measured at 25 feet a second falling 36 feet, is worth $14,336, what is the value of a power arising from 12 feet of water a second, upon falls of 11, 25, 8, and 11 feet respectively? It is not intended to intimate, that these mathematical proportions will indicate the exact value of the water in question, to these mill privileges, but they show the principle by which the amount of power may be computed, and its value estimated, for the purpose of comparison

with the estimate, which has been put on proportionate amounts of water power, in other situations.

The computations and estimates, in this report, are based chiefly on the surveys which were made, under direction of the Commissioners of 1837. Some additional surveys have been made for obtaining such further information as was deemed necessary, particularly a revision of the level of the whole line, and the determination of certain other levels. For the purpose of indicating the route recommended in this report, and of explaining the form and dimensions of the proposed aqueduct, the Commissioners refer to the engraved plan which accompanied the report of 1837, impressions of which have been prepared, with some alterations, and with the addition of a section of the proposed aqueduct. The profile, exhibited on this plan does not correspond exactly with that of the work recommended, but it may aid in rendering the description given in this report more intelligible.

Which is respectfully submitted.

P. T. JACKSON,
NATHAN HALE,
JAMES F. BALDWIN, } *Commissioners.*

Boston, *November* 9, 1844.

ESTIMATE

Of the cost of an Aqueduct for conveying the water of Long Pond, lying in the towns of Framingham, Natick and Wayland, to Boston, and for distributing the same through the City, by a Conduit of brick masonry, of an oval shape, 5 by 6.33 feet diameter, and by iron pipes, with necessary Reservoirs, &c. &c.

1844.	Dolls.	Cts.	
Nov. Guard Gates, Building, &c. at Long Pond, - - - - - - - -	6,000	00	
Brick Conduit from Long Pond to Corey's Hill, in Brookline, 84,428 f.=15 miles 5228 feet, or 15.9893 miles, including 1624 feet along side of Reservoir, and excluding two pipe sections of 2470 feet; say 16 miles.			
1,719,358 bricks to a mile, laid in hydraulic cement, 8 inches thick. 1,719,358 by 16 miles=27,509,728 a $16 per m=	440,155	65	
For forming bottom for laying brick and for puddling where necessary, say	10,000	00	
Two Pipes, each for Charles River and Brighton valleys, both equal to 2692 f. including slopes and laps, and being double lines=5384 feet. Pipes 30 inches diameter - - - - -	51,862	22	
Excavation and embankment from Long Pond to Reservoir on Corey's Hill, including earth and rock excavations and back-filling over brick work and valley pipes, - - - - - -	180,674	00	
Bridges and culverts from Long Pond to Corey's Hill, - - - - - -	29,785	00	
Reservoir on Corey's Hill, 1624 f. long 120 f. wide, 10 deep, - - -	30,715	00	
Amount carried forward, - - -			749,191 87

1844.			Dolls.	Cts.	
Amount brought forward,					749,191 87
Two 30 inch pipes from Reservoir on Corey's Hill to Tremont road,	10,810 f.				
Excavation and back-filling,		8,911 95			
Bridge across Creek,		4,507 60			
Double line of 30 inch pipes laid,		219,435 60			
			232,855	15	
One 30 inch main pipe, from Tremont road to Boylston street, 9614 feet, bridge and earth work,			102,127	46	
One 20 inch pipe from Boylston street to Mount Vernon street, 2310 feet,			11,998	50	
One 12 inch pipe from Tremont road to South Boston Reservoir, say 12,000 ft.			28,701	69	
3 Waste Weirs with Ventilators,			3,000	00	
4 Intermediate Ventilators,			1,000	00	
Pipes and stop-cocks for drawing off water in the 2 valleys,			700	00	
Waste or discharging pipes and stop-cocks at Corey's Hill,			500	00	
Branch pipes with gates or stop-cocks for letting water into and from Reservoir on Corey's Hill,			1,500	00	
Damages for land to be taken around Long Pond and for the line of Aqueduct and for Reservoir on Corey's Hill; also for line of pipes to Boston and South Boston,			21,600	00	
Water rights,			100,000	00	503,982 80
					1,253,174 67

DISTRIBUTION.

Reservoir on Beacon Hill or Mount Vernon,			77,339	00	
Ditto on Fort Hill,			6,224	00	
Ditto at South Boston,			10,000	00	
Mains and service pipes for distributing water through the City, per estimate of 1838,		463,363 00			
To which, add 25 per cent. for increase of population,		115,841 00	579,204	00	672,767 00
					1,925,941 67
Agents and Engineers, Clerks, Office Rent, and Contingencies, 10 per cent,					192,594 16
					$2,118,535 83


Long Pond
NEEDHAM
NEWTON
BRIGHTON
BROOKLINE
CAMBRIDGE
BOSTON
PLAN AND PROFILE
of the
AQUEDUCT
from Long Pond in Natick
to
BOSTON.