Worcester, Mass. -- City council, committee on an additional supply of water.

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REPORT

OF A

COMMITTEE OF THE CITY COUNCIL

ON AN

Additional Supply of Water,

FOR THE

CITY OF WORCESTER.

WITH

REPORT, PLAN AND ESTIMATES,

BY

PHINEHAS BALL,

CIVIL ENGINEER.

Printed by order of the City Council.

WORCESTER:

EDWARD R. FISKE, PRINTER.

1863.

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REPORT.

THE Committee to whom was referred the petition of Stephen Salisbury and others, asking that immediate measures be taken by the City Council "to procure an abundant supply of water for the use of the inhabitants, and for the protection of the city against fire," submit the following report:—

At the commencement of the year, the supply of water in Bell Pond was so small that it had become necessary to cut off most of the water-takers, and there was great and well-founded apprehensions for the safety of the city against a sweeping conflagration, to which it was at any time liable, and against which the Aqueduct, at that time, furnished no adequate protection. Fortunately, owing to the skill and good judgment of our water commissioner, Mr. Phinehas Ball, this immediate danger is now past. By the improvements in and about Bell Pond, the supply of water in the Acqueduct available for present and future use, has been more than doubled. Previous, however, to these improvements, the Committee had commenced the investigations with which they were charged, and they did not think it advisable, nor were they authorized, to abandon them.

In compliance with the vote of the City Council, they secured the services of Mr. Ball as a person whose scientific skill and practical experience, and whose extensive knowledge of the topography of the country, best fitted him to obtain and impart such information upon the subject as would command the confidence of the community.

Starting with the assumption, that if an adequate supply of pure water could be obtained within a reasonable distance from the city, at an elevation sufficient to deliver it by gravitation to the highest part of the city, such a source of supply would have vast advantages over any scheme that depended upon pumping or artificial aid, the Committee instructed Mr. Ball to look, first, for such a supply. Of the probable sources that have, from time to time been considered, the one nearest the city first attracted our attention, because if that would furnish the required quantity of water, and of sufficient purity, of course its proximity to the city would decide the question in its favor.

The decided and unanimous opinion of all the mill owners, and of every unprejudiced person at all acquainted with the characteristics of East or Lynde Brook, has long pointed to that stream as the true source of supply for our city. In his report, made in 1854, Mr. Inches referred to it, and intimated, without having made any actual surveys, that it might be sufficient for the city for a few years' use. In 1860 and 1861, Committees of the City Council caused partial measurements and computations to be made of the water flowing through Lynde Brook, and of the means of storing it for use. The water shed was not surveyed, nor was the flow of the water gauged with much accuracy. Although the Committee was convinced that an ample supply of water could be obtained from this source, the surveys and estimates were so imperfect and limited, that they did not receive the full confidence of the public.

Mr. Ball was directed to examine carefully and thoroughly the water shed of Lynde Brook, ascertain its character, extent and peculiarities, compute the flow of water through its channel, determine the practicability of making a reservoir capable of storing the water, estimate the cost of bringing it into the city, and the probable consumption and revenue to be derived from it. His able and full report, with the accompanying plans, is herewith submitted. By his very carefully conducted surveys, certain facts relating to the stream are now well established which before were merely conjectural. Mr. Inches supposed its water shed to be 2,000, and the Committees of 1860 and '61 estimated it 2,500 acres. It is now ascertained to be 1870 acres. The amount of water in a river valley available for use, and which is not soaked into the ground nor evaporated in the air, is estimated, under ordinary circumstances, at about one-half the aggregate rain fall. It is sometimes placed as low as four-tenths. We now learn what we should expect from the rocky and mountainous character of the country forming this water shed, that 48 per cent. of the rain falling upon it during the summer months passes into the stream, while during the winter, when the ground is frozen, 90 per cent. can be saved.

It is asserted by Professor Silliman as a basis of calculation, beyond question reliable, that the springs and streams of a limited district like this, represent, in their aggregate, only the annual rain fall—less the amount lost in soakage and evaporation. Adopting and following his calculations and method of reasoning, we arrive at these results. On each superficial acre of ground are 43,560 square feet, upon which a rain fall of 48 inches (the aggregate annual rain fall in Worcester for the last twenty years) will precipitate an aggregate of 173,907 cubic feet of water. A cubic foot weighing 62.5 pounds, this is equal to 10,869,187 pounds. As the imperial gallon holds 10 pounds of water, this weight corresponds to 1,086,918 gallons. It having been established by Mr. Ball that 65 per cent. of this quantity will flow into the stream and can be stored, we have an amount of water from each acre available for use of 706,496 gallons, and on 1,870 acres, which is the extent of the water shed of Lynde Brook, 1,321,147,520 gallons, or

3,619,956 imperial gallons a day, which is equal to about 4,223,000 wine gallons for the 365 days of the year.

This, it will be said, is mere theory that will not be sustained by facts, and cannot be reduced to practice. To test its accuracy, and to ascertain the amount of water that flowed through the channel of Lynde Brook, a wier was constructed in May last, near the outlet of the stream, and a person has been employed during the season to take daily observations of the height of the water upon it.

Lynde Brook, like all other streams in a hilly and rocky country, is liable, after sudden and heavy rains, to swell rapidly, and to subside almost as soon. Observations and measurements made at certain hours in the day would therefore be less reliable to determine the actual flow of water through the channel, than in streams less susceptible to such sudden changes. Aware of this peculiarity of the brook, and to avoid all possibility of careless and willful errors in the measurement, an ingenious self-registering gauge, regulated by clock work, so arranged as to be entirely secure from being tampered with, was contrived by Mr. Ball and applied to the weir. By means of the measurements thus separately and independently taken, compared with each other and verified, the amount of water that flows through this brook has been positively determined. The result is from May 9 to November 1 of this year, an average flow of 3,111,800 gallons per day. During this time only 24,11 inches of rain fell, being about five-tenths of the average rain fall of the year. Although these experiments were made at a season when the evaporation and soakage were the greatest, they show that 48 per cent, of the rain fall upon the water shed flowed into the channel of the brook.

Can this large amount of water be stored so as to be available for use as wanted? Without going over the calculations of the engineer, it is sufficient to state his conclusions: That a Reservoir can be built in a valley at the outlet of the stream, a place formed as by nature for the purpose, by constructing a dam 38 feet in height and only 400 feet long, and by raising the road as stated by the engineer, which will flow an area of 132 acres, much of which will be covered to the depth of 38 feet. This basin will contain 710,000,000 gallons of water, or about 2,000,000 per day for one year.

There can be no doubt that a much less amount of water, per capita, will be required in Worcester than in our large commercial cities. We have a large population sparsely settled, which will never need any other supply that can be more easily and cheaply obtained from the wells and springs with which our city, particularly in the suburban districts, is so abundantly supplied, and we have no shipping which consumes so much in all seaport towns. These facts and figures would seem to settle the question of the capacity of Lynde Brook to supply the present and prospective wants of the city, and when to these considerations we add the further one, that the wastage from Kettle Brook, ascertained to average 2,000,000 gallons per day, can, with a trifling expense, be turned if necessary into Lynde Brook, thus swelling the

supply to over 6,000,000 gallons per day, there cannot remain a doubt upon the subject in any reasonable mind.

By reference to the analysis of the water of Lynde Brook, made by Professor Jackson in 1860, it will be seen that it is of very pure quality, containing but little more than half as much foreign matter as the Cochituate. With proper precautions in preparing the bottom and sides of the Reservoir, and in preventing rank vegetation at the water line, there can be no doubt that the water of such great depth will remain pure.

The city of Hartford has, until now, been supplied with water pumped from the Connecticut. Its water works have been in operation since 1856. The quantity of water consumed in that city since 1861, was 1,098,850 per day, the income from which was sufficient to pay the interest upon the cost of the works and the expense of operating and maintaining them. Finding it necessary to increase the supply, particularly for the higher portion of the city, Professor Silliman and other able engineers, advised as the most reliable, economical and best plan for obtaining such supply, to bring it by gravitation a distance of five miles, from a small rivulet, rather than to enlarge their works and increase the machinery to force it from the river flowing directly by the city. The height necessary to force the water was 175 feet. To force the water from Lake Quinsigamond into Bell Pond, it is necessary to overcome an elevation of 309 feet. The annual cost of pumping in Hartford was estimated at $8,869, representing a capital of $147,816. The cost of pumping from Lake Quinsigamond was estimated by Mr. Inches at $13,945, representing a capital of $232,000, or, adding 25 per cent. according to Mr. Ball's estimate for present prices, $17,430, representing a capital of $290,000.

The experience of other cities, the great saving in the first cost of construction, and the far greater economy in the annual expense of maintaining an Aqueduct conveying water by gravitation from Lynde Brook over the expensive works necessary to force water from Lake Quinsigamond, compel your Committee to give the decided preference to the former scheme.

The well established facts that Henshaw Pond will furnish but about one-third as much water as Lynde Brook; that it is 3,850 feet more distant from the city, and that every mill owner between Leicester and Norwich may and probably will claim damages for the diversion of its water, furnish equally strong reasons for preferring Lynde Brook to Henshaw Pond as a source of supply for our city.

The objection most often urged against Lynde Brook, and in fact the only objection that does not apply with still greater force to every other scheme that has been proposed, is that in some seasons during the summer months, for days and even weeks together, it is entirely dry. The fact is undoubtedly true. During the last summer, for ten days, not enough water ran in the channel of the brook to be measured, and yet during the dryest month, June, it furnished a daily average of 546,528 gallons. With such a supply, and with a Reservoir capable of storing

700,000,000 gallons, filled full as it will be every spring, this does not seem to be a very serious objection. The country adjacent to and supplying Lynde Brook is so hilly and rocky that the rain passes rapidly into the stream. There are few or no swamps and little level land to soak it up and retain it. The water, instead of being held in the ground and furnished by a slow and steady supply, is poured at once into the Reservoir and made ready for use. We do not rely the less upon our rain-water Cisterns because they are not daily supplied by fresh showers. It is only necessary to make them of sufficient capacity to furnish a constant supply. Had the present City Council been governed by this consideration, the recent improvements upon Bell Pond, which are of such acknowledged value, would not have been made. The little run of water, whichhas more than doubled the supply in the present Aqueduct, improving its quality almost as much as the quantity, for two entire months this very year did not furnish a gallon.

If the people shall be satisfied with the result of the present investigation, and shall demand "that immediate measures be taken to introduce a further supply of water" from this source, the Committee would recommend, that for the present, and until the growth and development of the city and its increasing wants shall require a greater supply, the dam for the Reservoir be raised only to the height of 24 feet, which will flow an area of 45 acres, and hold 230,000,000 gallons of water. The city will have acquired all necessary rights, and can, at any time when it becomes necessary, raise the dam to any desired height. The plan is for a main pipe 16 inches in diameter, which will be ample for all time. It is recommended to carry it as far as Thomas Street, where it will intersect with the main pipe of the present Aqueduct, coming direct from Bell Pond. By placing the distributing Reservoir as proposed near the school house at Parkhurst's, which is on a level with Bell Pond, by which arrangement the Bell Pond Reservoir will be always sure of a full supply, it is believed that the city will have a system of water works for the daily supply of its inhabitants, and especially for its protection against fire, that will scarcely admit of improvement.

There are questions of damages to the mill owners that will require serious consideration if the work shall be undertaken, but which cannot, in this case, and probably can never be calculated or adjusted in advance, whatever scheme may be adopted. From whatever source the water is taken these claims must be met. They will undoubtedly be less here than if either of the other projects which have been considered shall be adopted, and it is thought and hoped that the protection which Hydrants would furnish to some of the mills situated upon the route, would be full compensation for any real or supposed damage caused by the diversion of the water.

The estimates have been made with great care by the engineer, based upon present prices of labor and materials, with the usual allowance for contingencies. They contemplate everything necessary for the introduction of the water into the city to connect with the present system of

distribution. As this shall hereafter prove insufficient, and new streets and new sections of the city shall require the water for consumption or protection, the pipes can be extended when the necessity arises, in the same manner and by the same rules as gas or sewerage are now supplied.

The Committee have not thought it necessary or proper for them to recommend to the Council any specific action. In furnishing the facts and estimates contained in their report and in that of the engineer, they have discharged their duty. They have endeavored to obtain the fullest and most reliable information possible, which, with that already in possession of the public in previous reports, will enable every citizen to form an intelligent opinion upon the comparative merits of the various schemes that have from time to time been proposed. Of the urgency of the demand for more water, of the probable revenue to be derived from it, and of the effect of an ample supply of it upon the health and growth and prosperity of the city, the public can judge as well as the Committee.

One other consideration deserves attention. The quantity of water furnished by Lynde Brook, and the means of storing it, will hereafter be known. In its present natural state it is of little value to the mill owners below, because in times of high water when the streams are full, they have enough without it, and when they are low, this, from its peculiar character, is lowest of all, and does them little good. Stored away in a large Reservoir as proposed for the city, it would furnish a large, permanent and valuable supply. Profiting by the information furnished by this investigation, it is probable they will before long take measures to secure it for their own use, if it shall not be expedient to take it for the use of the city.

D. WALDO LINCOLN,
HARRISON BLISS,
CHARLES A. WHEELER,
PHILIP L. MOEN,
GEORGE S. BARTON,
RUSSELL R. SHEPPARD,
} COMMITTEE.

REPORT OF PHINEHAS BALL, CIVIL ENGINEER.

TO THE JOINT SPECIAL COMMITTEE ON WATER FOR THE CITY OF WORCESTER, APPOINTED BY THE CITY COUNCIL, FEB. 9TH, 1863.

GENTLEMEN,—By your solicitation the following Report is presented upon the subject of fully supplying the city with water, illustrated by the accompanying maps, profiles and plans.

The first question that engages the attention is, whether the demand for an increased and permanent supply of pure water for all purposes for which a city like Worcester needs water, is of that public and general character to make the necessary outlay therefor, one of prudence for the city in its corporate capacity, as it would be, for that of any individual moved by the same motives and for the same purposes. If the demand be limited to a small number of parties, localities and individuals, and if the amount needed be small in quantity, then the demand is of such a private nature as to relieve the public of any duty in making any further outlays to supply such want. The water question here is one which is complicated by many side questions, arising from a great variety of causes.

Some of these complications arise from personal and private motives, but most come from the very general feeling, especially among our rural population, that the income derived from the sale of water, will not be near proportioned to the interest upon the necessary outlay, and hence must impose a heavy additional burden upon the great mass of tax payers for the more direct benefit of a few individuals, business firms and corporations.

That the demand is confined to a small area of our city, or to that which has been familiarly known as the "Center District," is apparent. In population the demand covers about two-thirds of the entire inhabitants, or about 15,000.

But that it exists to a large extent, that it is a want deeper than that of a few individuals, is shown by the repeated efforts made during the past ten years, by men of all parties, to increase the supply to such an extent as to meet all the varied wants of the city. This effort being the fifth or sixth which has engaged, in some form, the consideration of the municipal government of the city, during that period of time.

For some portions of the "Center District" private parties have from time to time attempted by small aqueducts to do on a limited scale, what the city has been asked several times to do for all. There are three separate private aqueducts, partaking somewhat of a public character, in that they supply water to various takers, under certain restrictions, along those portions of the city which they reach; besides several others of a more private nature which merely supply a single corporation, block or dwelling.

First, the Allen, or Spring Water, as the proprietors now call it, supplying some thirty-seven different parties, almost wholly on Main street. This aqueduct has not far from two miles of pipe, its source being near Adams' Square, and about one hundred and twenty feet above Lincoln Square. The water is of an entirely unexceptionable character for drinking and other purposes.

Second, the Paine Spring Aqueduct, the source of which lies at the foot of Laurel Hill, on the east side of Hanover street, and some twenty-five feet above Union street, at Wm. A. Wheeler's foundry. This supplies parties on School, Union, Main, Thomas, and Summer streets. The late Agent states that some forty-one different proprietors are furnished either partially or wholly, and that it is used by some one hundred and twenty-five to one hundred and thirty different families, shops, &c. The amount of pipe laid is about one mile. The water was once quite soft and pure, but now much complaint is made of its hardness.

Third, that of the Rice Aqueduct, supplying parties in the neighborhood of Grafton and Franklin streets, to the number of sixty-one families, including two steam engines, which are estimated equal to twenty-four families.

The State Lunatic Hospital has one of its own, which was originally laid with a two-inch cast iron pipe, in 1845 or 1846. The pipes at present are so corroded and filled with concretions as to limit, at times, their supply, to very stinted measures. They have this year rebuilt the dam at the Hermitage, on the Green brook in a most substantial manner, with a view of laying a four inch cement and iron pipe early next year, and when the work is all completed, as is now contemplated by the Board of Trustees, the institution will be amply supplied, and independent of all other parties. The amount used at the institution is from fifteen to eighteen thousand gallons per day.

Since the introduction of an additional supply into Bell Pond last spring, there have been constant and increasing applications for water from the City Aqueduct. These have been supplied in all cases where it was deemed prudent so to do, without prejudice to previous takers.

All the means of supply conveyed at present in any manner into the city for public use, are taxed to their full extent, and still have additional calls for furnishing more water. To this statement the present City Aqueduct forms no exception. The pond will supply about the present number of takers during all those seasons which are as favorable as the past one has been. But a careful and attentive study of it

during the past summer leads to the conclusion that it will fail even the present number of takers, in a season of great drouth.

The consumers of water from the City Aqueduct are restricted in its use by ordinance, in such a manuer, that the Aqueduct Commissioner may cut them off when the amount in Bell Pond has been reduced to such an extent as to be only sufficient for the use of the Fire Department, in case of need, for the extinguishment of fires. The uncertainty of feeling thus produced among the consumers, not so much, by the wise provision of the ordinance, as by the fact, that in years past, the ordinance at times has had to be either fully or partially enforced, has led consumers to make various provisions to meet such contingency, and on very many of the premises supplied there is to be found a well, and a rain water cistern, with all the equipages of force pump, aqueduct, cisterns, connections, and the like, kept constantly in repair to meet such an emergency. Thus admitting by these extra provisions the need and the demand for a reliable supply, and were such a supply ample, those furnished would be saved the vexatious care of keeping the extra implements in order, and all the extra expenses attendant thereon from first to last.

Perhaps in some instances wells would be retained to supply water for drinking purposes. But in all the central portion of the city, where the wells are very generally impure and hard, and each year increasing the difficulty, say along Main street from Lincoln Square to the City Hall, and east, including Summer street, were the supply ample and reliable no long time would elapse before most of the wells and cisterns would be entirely abandoned.

Statistics have been collected of the number of buildings and their occupancy in the central portion of the city, as nearly correct as the limited time which has been allotted to the subject would permit. The results of these investigations have been condensed into the following table, which needs these explanations:

Column A, includes that portion of the city lying east of Lincoln street to the Green Brook Valley, and north of Belmont street to Paine's woods.

B. West of Lincoln street as far north as the house of F. W. Paine, and northerly of Lincoln Square to Grove Mill, and south-westerly of Salisbury's Pond to Highland street.

C. East of Summer street to Chandler Hill, and north of the Hospital to Belmont street.

D. That portion of the city southerly of the Hospital and easterly of Summer street, along Shrewsbury street, known as East Worcester.

E. Southerly of the Worcester Railroad from the Bloomingdale road following the line of settlement down Mill Brook, until it touches said road below Plymouth street.

F. East of Main street to Summer street, and south of Lincoln Square to Front street, including all Main street and the west side of Summer street, and the north side of Front.

G. South from Front Street, to the Junction and Jackson street, and west from the Western Railroad to Main Street.

H. West of Main street to the valley of the Agricultural Grounds; south from Highland street to the Oread.

Under the head of buildings is included dwellings, blocks and machine shops, and under the head of tenements has been given the number of families, as near as could well be ascertained without personal inquiry at each separate block or dwelling, and among shops, has been intended to include each individual firm carrying on in any block or building mechanical business. These remarks sufficiently indicate the principle upon which the table has been formed.

Description of Enumeration.	East of Lincoln Street.	West of Lincoln Street.	East of Summer Street.	East Worcester to Summer St.	South of Western Railroad.	Between Main & Summer Sts.	South of Front Street.	West of Main Street.	
	A.	B.	C.	D.	E.	F.	G.	H.	Totals.
Number of Buildings,	60	67	234	134	221	503	371	538	2128
" " Tenements,	86	131	348	273	363	767	624	825	3417
" " Stores,	.....	.....	2	9	17	208	44	11	291
" " Offices,	.....	.....	.....	.....	.....	130	5	5	140
" " Saloons,	.....	.....	.....	3	.....	26	7	.....	36
" " Hotels,	.....	.....	.....	.....	1	4	1	.....	6
" " Bakeries,	.....	.....	.....	.....	.....	1	1	1	3
" " Stables,	23	19	36	9	27	67	65	103	349
" " Depots,	.....	.....	.....	.....	.....	.....	.....	.....	4
" " Gas House,	.....	.....	.....	.....	.....	.....	.....	.....	1
Engine & Hook & Ladder Houses,	1	.....	.....	1	.....	5	1	1	9
Shops, Foundries and Manufact's,	.....	1	4	4	12	185	55	13	274
Wire and Rolling Mills,	.....	.....	.....	.....	.....	.....	.....	.....	2
School Houses and Churches,	.....	.....	3	3	3	10	9	6	34
Halls, public and private,	.....	.....	.....	.....	.....	.....	.....	.....	10

Amount of pipe now laid in City Aqueduct, ...27,780 feet—5 1-4 miles.
Number of hydrants now supplied, ...112.
" " parties now taking water, ...146.
" " private aqueducts, 3; miles of pipe in same, about.....4.
" " parties supplied, mostly families, about, ...112.

It will be noticed that the number of places supplied by all aqueducts combined amount to but a very small fraction of the number of occupied premises in the entire district. The outer limit of the district would not demand any further supply for some years to come, hence, the present demand is included in the center portion, which includes about three-fourths of all the buildings and nearly all the business. On personal examination of the premises in this district, which are supplied by the present aqueducts, public and private, and those which are not, there are scarcely any data upon which to predicate the conclusion that those which are now unsupplied would not be, were the means sufficient, as well as those which now are.

Another consideration is the demand for an increase of water for the extinguishment of fires. The present Aqueduct is efficient only within a certain range, and much more limited than most are aware,

who are not practically conversant with the fact. There being no place in the city where over three hydrants can be effectively used at the same time, in most places only two, and in some only one. This may be owing as much to the smallness of the pipes laid, as the deficiency of water, but there stands the fact. Taking all that portion of the city covered by Mill Brook, the two steamers are at present quite as effectual as the Aqueduct.

That portion of the city lying west of Main street is quite insufficiently protected from fire by the present Aqueduct. The smallness of the pipes laid for mains in Main street, and the elevations of a larger portion of this section above Main street, renders the extreme end of the pipes quite inefficient for much else save supplying water, in moderate quantities, for the hand engines. These pipes only cover portions of Pleasant, Elm, Chestnut and Bowdoin streets, and away from these localities, especially in very dry weather, there is practically no water for fire purposes that can be obtained within any available distance of the densely settled portion of Chatham, Chandler, Austin and William streets, and the northerly portion of Harvard street, and some sections lying adjacent.

If the main pipe in Main street were much larger than at present, the amount of water furnished on the streets where the present pipes now lay would be very much increased, as there then would not be that loss of head, at present occasioned by traveling long distances in too small pipes.

Should the project be adopted of supplying the city with water from any of the sources hitherto examined in the town of Leicester, and the main pipe be brought down Main Street, say as far as Thomas street, and that portion of pipe now lying in Main street from Myrtle street to Thomas street, be taken up and relaid in Chandler or Austin street, then the southern portion of the city would be quite amply protected, as compared with its present protection.

Then again, if the additional supply be brought from the west, and the distributing reservoir be placed, as is proposed, at an elevation equal to that of the Bell Pond Reservoir, then the present pipes on Main, Summer and Front streets, by the arrangement of proper stop cocks, and with good management, will be twice as efficient for fire purposes as at present, for the reason that they will be supplied with water from opposite directions at the same time.

This subject claims the most serious attention in connection with the demand for a further supply of water, as a single fire in these unprotected sections, at some unfortunate time, might destroy more property than enough to defray the expenses of the completion of the present project, and that, too, in the face of the very best and highest efforts of an efficient fire department; for a well manned, drilled and equipped fire department, in case of need, without water, is just as efficient for protection, as a large army well drilled and equipped, but without ammunition; and no fault-finding with the management of the one, or the generalship of the other, can either supply the one with water, or the other with ammunition.

For manufacturing purposes, all the present supplies of pure water combined, are totally inadequate to be relied upon to any extent. The amount of steam used in the various work-shops enumerated in the center district amounts to about 1150 horse power, not including the vast amount of steam power at Nathan Washburn's Rolling Mill, the water for all of which is mainly drawn from Mill Brook. This brook having become and having to remain the great common sewer for the City, the water is very impure and unfit for any purpose for which pure water is needed. On inquiry of those who use its water, there has been scarcely one who is fully satisfied with its quality. Most of this might and would be supplied at once, at reasonable rates, were the supply ample and pure. The proprietor of the Rolling Mill has stated that he would pay largely to the city to be only insured a supply for all his works at such times as his present machinery and sources fail to supply him. For other than steam purposes large amounts of water are wanted,

The demand for water for these purposes will be illustrated by a single application which has been made to the Aqueduct department this present year. Early in the season application was made by Messrs. Messinger & Wright, the lessees of the Fox Woolen Mill estate, for a supply of water for washing light colored woolen goods in process of manufacture;—their present supply comes from Mill Brook. On examination of their premises and the uses for which water was desired, it was found that it was utterly impossible to finish with certainty, the light shades of goods in marketable style with the turbid waters of the brook. Their application seemed so reasonable and the favor to them so manifestly for the best interest of the city that permission was granted to use water to the extent alone of washing their white goods. This is but a single example, and shows that if the city is to keep pace with her other sister cities in material prosperity, she must also furnish the same facilities towards that end as do all the others. Some may reply, that the waters of Mill Brook should be kept pure; that the stream should not be allowed to be used as common sewer. The reply to this statement is, that sewerage is just as necessary for a city as a supply of water, and any system of sewerage for the city which shall supercede Mill Brook, will be more expensive than the present project; and then after it is completed, into what shall its sewerage be discharged?

The next inquiry is, what amount of water will be sufficient to constitute a full supply? The usual mode of estimating is to allow a certain number of gallons to each individual enumerated in the population. At the time the Cochituate water works were projected, the engineers assumed that 28½ gallons per day to each individual would be a sufficient allowance. This was assumed because the practice of supplying cities with water, up to that time, had found that quantity to be sufficient. Assuming our population to be supplied as 15,000, this data would give 427,500 gallons. But this is probably too low. It may be sufficient for all purposes of use but will not include waste. Tables have been prepared showing the amount of water used in Boston and Hartford, which will be readily understood by inspection.

CITY OF BOSTON.

Supply, Income, &c., since the commencement.

	Amount consumed per day.	Annual income to Jan. 1, of each year.	Water takers.—Total number Jan. 1, of each year.	Total No. of fixtures supplied as far as registered.	Gallons consumed per day per individual.	Income per 1000 gallons in cents.
1848	Works opened Oct. 25.					
1849	3.680.000		5.200			
1850	5.837.900	$72.043.20	12.108		42¾	4.61
1851	6.883.800	98.367.90	13.463		42	6.42
1852	8.125.800	161.299.72	16.076		56	6.05
1853	8.542.300	179.486.25	16.862	31.594	57¼	6.29
1854	9.902.000	196.352.32	18.170		63	6.00
1855	10.346.300	217.007.51	19.193		63½	7.05
1856	12,048.600	266.302.77	19.998		72	6.42
1857	12.726.000	282.651.84	20.806		73	6.22
1858	12.847.000	289.328.83	21.602	47.888	72½	6.44
1859	13.175.000	302.409.73	22.414	52.744	72	6.54
1860	17.238.000	314.808.97	23.271	59.218	97½	5.31
1861	18.189.304	334.544.86	24.316	64.526	99½	5.54
1862	16.600.000	365.323.46	25.486	75.216	89	6.17
1863		373.922.88	26.289	77.843		

CITY OF HARTFORD.

Date.	Total number of gallons used per annum.	Average No. of gallons consumed per day.	Daily consumption per individual.	Total annual receipts.	Average revenue pr 100 galls in mills.	Current expenses including interest.	Annual cost of pumping.	No. of assessments.
1856	104.914.656	345.114	.....	$7.039.06	6.7	$18.940.72	.....	1041
1857	190.456.203	521.797	.....	16.112.07	8.4	28.570.35	.....	2232
1858	242.354.674	661.245	.....	21.821.75	9.2	29.385,56	.....	3151
1859	286.648.604	785.338	.....	26.000.51	9.0	30.271.80	.....	.....
1860	327.417.801	897.035	.....	30.038.44	9.1	31.166.73	.....	.....
1861	401.080.335	1.098.850	.....	33.259.06	8.2	32.227.41	.....	.....
1862	491.644.749	1.346.971	51	37.010.90		33.772.22	$5.777.17	5643

The foregoing tables conclusively show that when once water is introduced, that its use increases from year to year, and probably by the same laws that govern the increase of business, comfort and refinement.

In Boston, it is to be remarked, that in 1853, when the takers were 16,862 the fixtures supplied were 31,594; and that in January 1, 1863, while the takers had increased 9427, the fixtures supplied had increased 46,294, or nearly five times as fast as the number of takers, showing that from year to year old takers are constantly adding to their fixtures as business necessity, domestic comfort or luxury add the motive, and increased prosperity the means of making the extension. The same results are constantly going on here with the present City Aqueduct, and would be very much more increased with a full supply of water.

An estimate is here given of the amount required to furnish a full supply to the entire center district as now occupied.

		Total gallons.
3417	Families at 150 gallons per day,	512,550
291	Stores at 100 " " "	29,100
140	Offices at 50 " " "	7,000
33	Saloons at 300 " " "	9,900
6	Hotels at 1,500 " " "	9,000
3	Bakeries at 500 " " "	1,500
6	Stables at 1000 gallons and 340 at 100 each,	40,000
4	Depots and gas house,	7,000
274	Shops and foundries at 200 each,	54,800
5	Railroad companies using at present	43,000
	For manufacturing purposes and steam, say	200,000
	Total,	913,850

In the above estimate Bell Pond has been assigned to the fire department, for watering streets, and a portion of the usual wastage.

The present project contemplates building a Retaining Reservoir on Lynde Brook, on the farm of Mr. Edwin Waite, in Leicester, and a Distributing Reservoir near the school-house in Valley Falls district, at the same elevation as the present one on Chandler Hill, and the laying of so much main pipe as shall be necessary to convey the water from the storing reservoir to the distributing, and thence along the main road to the city, and connect this main with the present City Aqueduct at Thomas street, and then supply from the present pipes all which they will be able to distribute, and lay distributing pipes only so fast as the public interests and the income to be derived from the sales of water shall warrant. Hence the whole amount of water stated above cannot be used at once. The amount of pipes already laid is nearly 5¼ miles. From the pipes as now laid, may be supplied nearly as follows:

		Total gallons.
900	Families, 150 gallons per day,	135,000
125	Stables, six at 1000 gallons and 119 at 100,	17,900
279	Stores, 100 gallons per day,	27,500
200	Shops, 200 " " "	40,000
135	Offices, 50 " " "	6,750
31	Saloons, 300 " " "	9,300
6	Hotels, 1500 " " "	9,000
5	Railroads,	43,000
500	Horse-power of steam, 50 gallons,	25,000
4	Depots,	4,000
	Gas House,	3,000
3	Bakeries,	1,500

For manufacturing purposes,	60,000
Public halls and buildings,	5,000
Watering streets,	40,000
Total,	426,950
Add for waste, say	23,050
Total estimate in gallons,	450,000

Thus much for demand and supply. Now the main question must be touched, that of "Will it pay?" This is the question that is vital to the enterprise. From this stand point viewed negatively comes many a nay against the project, even where the enlightened judgment admits the demand and the necessity. The amount of water estimated above which may be furnished from the present pipes is, say 450,000 gallons. Taking the average annual income of Boston as 6.06 cents per thousand gallons, this would give an annual income of $9,953. Taking the average of Hartford, a city in circumstances and population more nearly like our own and the income would be $13,114; which would be the interest of $150,000, and $4,140 to pay current expenses.

Aside from a direct income from the sale of water, there is an income which the public derive from the use in water for protection against fire. In Boston, in 1853, after five years trial with their aqueduct, it was estimated that the direct saving in city expenses in maintaining the fire department alone, derived from the aqueduct, was over $51,000 per annum; that is, it cost that sum less to maintain the fire department with the aqueduct than it would without it. In the city of Hartford, the water board there assess the hydrants thirty dollars per annum each, as the value which the public should pay for the benefits derived from the use; and this amount is reported each year as a part of the legitimate income of their water works. The last year, their hydrants being 149, the reported amount of income therefrom is given at $4,470. If hydrants are equally valuable to us as to the city of Hartford, then the value of these to the public when the present project shall be completed, would be for 126 hydrants, 16 new ones being added, $3,780. Apart from the protection to individual property in cases of emergency, when it is considered that the rates of insurance are directly affected with every increase of facility for extinguishing fires when they occur, the assessment of thirty dollars per hydrant seems not to be erroneous but just. In consulting the Board of Engineers upon this matter, their conclusion is that although as the city increases, the expenses of the fire department will increase; still if an abundant supply of water be introduced, and proper hydrants located over various parts of the city as the works are extended, that the expenses of the fire department will not increase as fast with the water as without it.

The past season careful surveys in detail have been made of the basin

of Lynde Brook, Henshaw Pond, and all of that portion of Kettle Brook above the mill of Samuel L. Hodges, in Cherry Valley.

The basin of Lynde Brook above the outlet of the intervale, on the farm of Mr. Edwin Waite, contains 1,870 acres; that of Henshaw Pond 590 acres; that of Kettle Brook as above, 4,200 acres. Thus it will be seen that the basin of Lynde Brook is 3,169 times as large as Henshaw Pond Basin, and that of Kettle Brook only about 2¼ times larger than that of Lynde Brook.

In general terms the water drained from any basin is directly proportional to its area, and the amount of rain falling thereon.

Climate, soil, and geological structure each add their varying influence. The soil of some basins may be so loose and absorbent, so circumstanced in structure as to retain or convey away most of the rain falling thereon and furnish waters to supply springs in other basins than its own. Or a basin may receive the waters of large springs drawing supplies from districts far beyond its own water shed line.

The contour of all the water sheds above named are rough, broken, and hilly, quite uniform in character and all their general features. Their levels so nearly correspond with each other, their soils so impervious, that it is highly probable that no one of them receives the waters of large springs supplied from the waters of the others, or *vice versa*. Hence estimates of the amount of water drained from any one of them based upon the area and the amonnt of rain fall will be quite reliable.

When the estimates were made for supplying the city of Boston with water from Lake Cochituate, it was then assumed that the amount of water which the Lake would furnish would be equal to 40 per cent. of the annual amount of rain fall. Since the construction of the Aqueduct, careful measurements have been made of the amount of water supplied the city from the Lake, and of the annual amount of wastage, and also the annual rain fall at the Lake. Taking these items as they are stated in the annual reports of the Water Board and the Chief Engineer, making no allowance for the difference in the height of the Lake between the beginning and the end of the year, the percentage of rain fall drained off from the Basin for the ten years named has been as follows:

	Inches of Rain.	Per cent. drained off.		Inches of Rain.	Per cent. drained off.	
1851	43.97	55.3	1858	48 66	43.5	AVERAGE FOR THE 10 YEARS—
1852	47.93	46.4	1859	49.02	80.5	54.04 PER CENT.
1853	55.86	38.4	1860	55.44	37.3	
1854	43.15	53.8	1861	46.44	68.8	
1857	63.10	77.3	1862	49.69	39.2	

The following table, showing the connection between the rain fall and the percentage drained off from any area, has been derived mainly from an English work on Hydraulic Engineering, by Samuel Hughes.

The last seven experiments were made in this country, the others in England.

NAME OF DRAINAGE AREA.	Inches of Rain fall per annum.	Per cent. drained off.
Bann Reservoir, (Moorland)	72	66
Greenock, (Flat Moor)	60	68
Bute, (Low Country)	45.4	53
Glencorse, (Pentland Hills)	37	60
Belmont, (Moorland) 1843,	65.4	80
1844,	50	67
1845,	55	75
1846,	49.8	67
Rivington Pike,	55.5	44
" " Stevenson's Report, 1847 and 1848,	63.6	63
Turton and Entwistle, 1836,	46.2	89
" " " 1837,	48.2	81
Ashton,	40	39
Bateman's Evidence on the Drainage Area of Longdendale:		
First half of 1845 very dry,	21.2	64
Second " 1845,	38.6	71
First " 1846,	22.5	78
Oct., Nov. and Dec., 1846,	10.2	85
Mr. Hawkesley's Experiments on an area of 100 sq. miles,		43
Mr. Stirrat's three years' Experiments at Paisley,		67
Eaton Brook, Madison Co., N. Y., 6,800 acres,		66
Madison Brook, " " " 6,000 "		50
Albany Water Works, First Station, 2,600 acres, May to Oct., 1850,		41½
Albany Water Works, First Station, 2,600 acres, Nov. to April, 1850,		77.6
Albany Water Works, First Station, 2,600 acres, May to Oct., 1851,		82.5
Albany Water Works, Second Area, 8.000 acres, July to Dec.,		33.6
Albany Water Works, Second Area, 8,000 acres, Dec. to June,		53.6

The difference in the percentage in the different years may be accounted for in the differing circumstances under which the rain fell. If during the summer months the rain descends in frequent, gentle and light showers, with an atmosphere in a suitable condition to aid rapid evaporation, the amount of rain so falling, though large in the aggregate, will aid the supply but very little, because it will mostly be carried off again by evaporation. But if the amount falling comes down in occasional powerful showers these will fill the small streams abundantly, and supply an increased amount of water in the larger streams over the small frequent showers. That is to say, more water will be collected in the streams from a single heavy shower in which two inches of rain falls in the course of two hours, than in six gentle showers furnishing the same amount of rain, with a fair and windy day intervening between them.

And so in the collections of water usually stored up in the form of ice and snow upon the surface of the ground during the winter months. If large accumulations of snow and ice are carried off suddenly in connection with strong south winds and rain, as is quite frequently the case in this climate, and that too when the surface of the ground is frozen, the water collected by the streams will be very much larger than if the snow should be melted away by genial suns accompanied by dry northerly winds. These are some of the varying circumstances which from year to year effect very materially the amount of water collected from any supply district.

These views are borne out by some investigations which have been made at Lake Cochituate. Thus, in 1853, with a rain fall of twenty inches from the first day of June to Oct. 24, there was collected of that amount only 15 per cent., or three inches of the rain falling during that time. and for the remainder of the year 0.486 per cent.

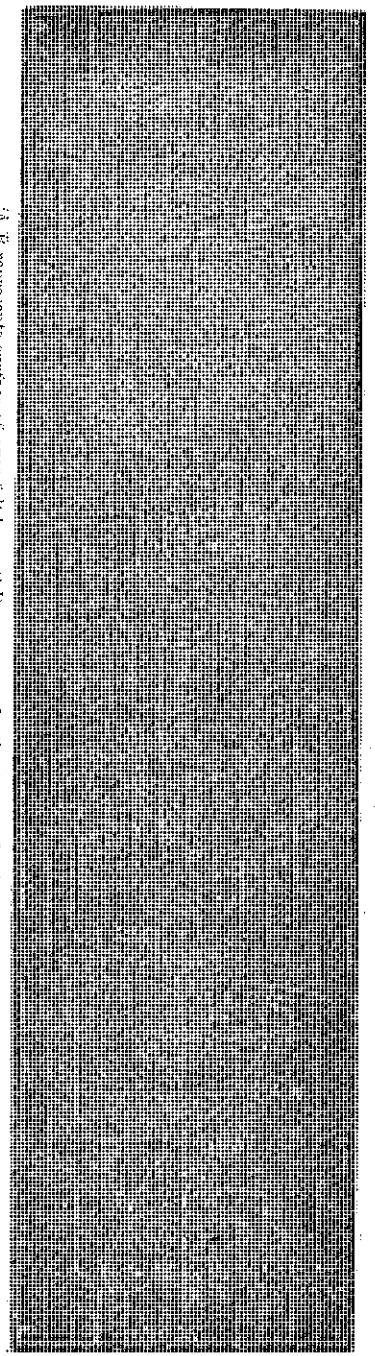
These views are corroborated by the results of the gaugings of Lynde Brook the past season.

An estimate is here given of the amount of water annually drained from these basins, from data derived from the experiments just given. The percentage is assumed at 65, in consideration of the steep hilly character of their contour and the impervious nature of their soil, aided by the result of the gauging of Lynde Brook from May 8th to Nov. 1st. The average annual amount of rain fall is taken at 46.92 inches, being the amount given as the average of twenty-one years' observations at the hospital here.

	Acres.	Gallons drained off per annum.	Gallons per day.
Lynde Brook,	1,870	1,547,686,800	4,240,238
Heushaw Pond,	590	488,307,600	1,337,911
Kettle Brook, above Kent, and from which water may be turned into Lynde Brook,	3,200	2,648,248,000	

A weir was constructed on Lynde Brook and finished on the 19th of March last, which was unfortunately washed away by the very severe freshet of the 26th of March, only six days after its completion, it having proved quite too small to carry so large a quantity of water as then came down the stream. The average amount of water passing down the stream in these six days was 4,845,960 gallons per day, not including but a very small portion of the freshet. From March 26th the stream continued so high that the weir was not reconstructed until the 8th of May afterwards, at which time the gauging recommenced and has been carried forward systematically ever since: Shortly after the weir was constructed, a self-registering water gauge, moved by clock work, was devised and applied to the weir, which has been of great benefit in the observations taken during the season, as showing the rapidity with which the stream rises and falls, and also by what small showers the stream is suddenly effected.

A Profile is here added, reduced from the one made by the gauge from July 16th to the 23d. The length of the weir is 10 feet. The Profile shows the varying height of the water flowing over the over-fall bar. It will readily be understood by careful inspection, without further explanation.



A B represents surface of over-fall bar. C D represents depth of water flowing over same at times named.

The results of the gauging of the Brook, from May 8th to Nov. 1st, have been calculated and arranged in the following table.

Date.	Time in hours	Number of gallons estimated by the gauge.	Rain fall in gallons, estimated from the rain gauge kept at the Hospital.	Inches of rain fall.	Per ct. of rain fall drained off each month.	Average number of gallons gauged per day.
May.	546	53,730,140	79,420,800	1.56	67	2.361,768
June.	659	15,006,770	60,074,700	1.18	24	546,528
July.	548	131,165,510	448,523,700	8.81	29	5,744,472
August.	757	123,328,550	293,755,000	5.77	42	3, 10,008
September.	708	56,951,030	130,331,500	2.56	43	1,930,536
October.	720	140,153,000	215,352,500	4.23	65	4,671,766
Total.	3,938	520,335,000	1,227,458,200	24.11		3,111,800

Time, 164 1-12 days. Average amount of flow as estimated by the gauge, 3,111,800 gallons per day; an amount largely in excess of any present want of the city. Percentage of rain fall drained off from July to November 1st, 48, nearly. Inches of rain fall during this time, 24.11; being 0.36 of an inch less than the usual average for those months for the last 21 years, as registered at the hospital. The percentage of rain fall given as drained off in each month is not strictly correct, as each succeeding month is effected more or less by the month next preceding.

The drought of June so far affected the stream as to reduce the flow so low from June 26th to July 9th, that no water could be registered by the gauges for that time, the amount being only nominal. This gives a good starting point, and the percentage shows a steady and remarkable increase from July onward, as cold weather advances.

A survey has been made around the basin of the Waite Intervale, on the farm of Mr. Edwin Waite, and the adjoining lands, to ascertain the feasibility of constructing a storing reservoir on the brook at this point. Were a dam built so as to raise the water some thirty-eight feet above the bed of the brook at the outlet on the Waite farm, and the road leading from Samuel L. Hodges to Edwin Waite's raised as per profile, the area flowed would be one hundred and thirty-two acres. The amount of water which this reservoir would contain is estimated to be 710,000,000 of gallons, or nearly 2,000,000 of gallons per day for one year. Some doubt may be expressed whether this large amount of water could ever be obtained from the water shed in question.

The Paxton Reservoir on Kettle Brook has an area of one hundred and eighteen acres nearly, and from an estimate based upon information derived from the owners, and the surveys made for raising the same in 1854, the reservoir will hold 450,000,000 gallons, and is filled to overflowing in all ordinary years, from an area of 1450 acres.

The amount of annual wastage at the Paxton Reservoir is undetermined by any series of actual observations, but from information derived from the proprietors, there is enough wasted each year to fill

the reservoir, were it much larger than at present. Hence there can be no doubt but that the contemplated reservoir on Lynde Brook would be filled every year if constructed, as its water shed is nearly one-third larger than that of the Paxton.

Then again, the valley of Lynde Brook is so located as regards Kettle Brook, that the wastage of Kettle Brook may be turned into it at Kent's Mill, just above the Waite Reservoir. The pond at Kent's Mill would lie nineteen and one-half feet above the reservoir on Lynde Brook, when raised the thirty-eight feet before stated. The area from which wastage may be collected in this storing reservoir from the Kettle Brook valley is 3200 acres, 1750 of which lies below the Paxton Reservoir, and is but very partially improved by the mill owners upon the stream.

The amount of wastage which may be collected from this water shed and added to the amount which can be collected on Lynde Brook is entirely undetermined by any series of actual observations which can lead to any certain results. But estimating the drainage of each portion of this shed to be sixty-five per cent. of the rain fall, this gives the amount for each portion of the shed as follows:

1750 acres below Paxton Reservoir, 1,448,370,000 gallons per annum, and the amount drained from the reservoir for 1450 acres as 1,199,878,000 gallons annually, or enough to fill the reservoir two and two-thirds times. The amount drained off below the reservoir is about an average of 4,000,000 of gallons per day. Considering the fact that most of the amount of the water which reaches the streams seaches them in the winter and spring freshets, and heavy rains in the summer months, and the smallness of all the reservoirs along the brook, it is adjudged that at least 730,000,000 of gallons are wasted from this area annually, or an amount equal to 2,000,000 of gallons, which might be added to the Lynde Brook collection.

There have been no additional surveys made of the Henshaw pond, as regards the basin for forming reservoir, &c. This was surveyed in 1856, as reported by Mr. Inches. The original pond contains 33.86 acres, and when flowed twenty feet will contain 108.56 acres, and hold 529,750,000 gallons of water. The original pond cannot be drawn from as a reservoir to any extent; the amount available for use must be stored above its present surface. On June 29th, when no water was flowing down Lynde Brook, a careful measurement was made of the flow of water from the outlet, and ascertained to be 27,600 gallons in twenty-four hours, which amount was probably much reduced before the commencement of the rains, July 9th. This fact, though showing an advantage in favor of the pond, still not large enough to warrant the conclusion that the pond could be relied upon to any extent as a source of supply, by reason of some inexhaustible spring flowing into it. The relations between Henshaw Pond and Lynde Brook as regards water supply may be thus stated:

First. They are equal in quality of water furnished, and soil for building storage reservoir.

Second. The land damages will be about equal on each for reservoirs of equal size.

Third. They can each be connected with Kettle Brook. The expense of the two connections being rather in favor of Henshaw Pond. The waste water obtained from Kettle Brook would be about eight per cent. the largest at Henshaw Pond.

Fourth. The expense of building the necessary dams and their fixtures, to collect, store and obtain an equal amount of water at each would be not far from equal.

Fifth. On Lynde Brook, from its own basin, about three times as much water can be collected as at Henshaw Pond.

Sixth. The water from Lynde Brook can be brought to the city with 3,850 feet, or about three-fourths of a mile, less pipe than the Henshaw Pond.

The question of damage to mill owners upon the stream is one which has to be met in whatever direction the city chooses to go to obtain water. Lynde Brook seems to be as favorable as any in this respect. The number of mills upon the Kettle Brook stream which will be damaged at all, if any, are thirteen in number. These all lie upon the stream between Kettle Brook, at the junction of Lynde Brook therewith, and the junction of Mill Brook with the Blackstone River, below South Worcester. The outlet at the reservoir being one hundred and forty-three feet above the distributing reservoir by the school house, gives ample means of placing hydrants along the road to protect the six mills in Valley Falls against fire, which would be a partial offset for damages. If the large storing reservoir proposed be constructed, and its connection with Kettle Brook be made, the full supply of the city may be drawn from the surplus waters of these two streams, leaving the minimum summer supply for the mills.

ESTIMATE OF RESERVOIR ON LYNDE BROOK.

Earthwork of dam and raising road,	$5800
120 feet 16 inch waste pipe, at $2.50,	300
One 16 inch gate,	133
Gate house,	925
Roll way,	275
Grubbing and clearing ground in basin,	800
Cost of Waite Farm to west side of reservoir,	8000
10 acres above Waite Farm at $40,	400
Amount,	$16,633

PIPE FROM STORING RESERVOIR TO CITY.

7680 feet 12 inch pipe to distributing reservoir, at $2.05 per ft.,	$15,744
2 gates, " " at $102,	204
6 hydrants, at $40,	240
Outlets along line,	15
Land damages, 1 2-3 acres before reaching Leicester road, say	600
250 feet 6 inch pipe and gate at reservoir,	201
Distributing reservoir, 300 ⋈ 100,	2770
Land damages, say,	1100
19,036 feet 16 inch main pipe to Thomas street, at $2.70 per ft.,	51,397
4 16 inch gates and stop cocks, at $133,	532
10 hydrants along line at $40,	400
Outlets along line, say,	300
Amount,	$73,903

SUMMARY.

Cost of storing reservoir,	$16,633
Pipe and fixtures between reservoir and distributing reservoir, and main pipe to Thomas street, and fixtures,	73,903
Total,	$90,536
Engineering and contingencies, say,	$8,000
Total,	$98,536

The kind of pipe estimated is the protected wrought iron pipe, which experience has proved to be preferable in many respects to cast iron. It produces no discoloration of the water, is affected by no concretions, or rust, and is very much more economical in its cost than cast iron. The foregoing estimates are based upon propositions from responsible parties, at prices for which they will contract for the work as therein stated, which propositions are herewith enclosed.

The estimate for the reservoir has been made for flowing twenty-four feet of the basin surveyed, which would cover about forty-five acres, and hold 230,000,000 of gallons of water. This is adjudged to be sufficient for the present wants of the city, as the dams may be raised at any time when the wants of the city increase so as to create the demand.

Many of our people still regard with favor the idea of pumping water to supply the city from Lake Quinsigamond. To show the increased expense to the city of so doing, the following estimate of the first cost of the pumping apparatus and the necessary pipes to convey the water into Bell Pond, has been taken from the elaborate report of M. B. Inches, Esq., civil engineer, upon the subject in 1854, that the same

may be compared with the first cost of the project of bringing water by gravitation from Lynde Brook.

Engine and fixtures, - - - - -	$80,000
Raising main 24 inch, 6035 feet, at $8,00,	48,280
Raising dam at lake, - - - - -	1,100
Total first cost, - - -	$129,380
Add contingencies, say 10 per cent, - -	12,938
Total cost, - - - - -	$142,318

To which must be added, to briug the estimate to the present value of all materials and manufactured articles, at least twenty per cent., and thus the cost would amount to $170,781. To this must be added all flowage damages at the lake, and all land damages for laying and rights of maintaining the pipe, which when settled for could not be less than on Lynde Brook.

The annual cost of pumping one million gallons per day from the lake into Bell Pond appears by the same report to be $13,945, to which must be added at least twenty-five per cent. to meet present high prices, which would make the annual cost at the present time $17,430, to which add the interest of $170,781, and the annual cost at the present time wonld be $27,676. So that under these circumstances one million of gallons per day, pumped from Lake Quinsigamond would cost the city the same as that which should be brought to the present distributing pipes by gravitation by an aqueduct which should be constructed with a cost of $450,000, or four and one-half times as much as the expense of bringing it by the aqueduct contemplated from Lynde Brook. This may not be fair to bring the cost of construction and pumping up to the present inflated standard. This has been done because the estimates in this report are at present prices, and is so done for comparison. Taking the annual cost of pumping as given for 1854, and the interest on the cost of construction, and the annual cost at that time of one million gallons per day, would be $22,584, which is over three and one-half times the amount of the present project. And then the aqueduct estimated from Lynde Brook is capable of delivering at least two millions of gallons in twelve hours at the City Hall, which adds to the favor of the present project, and doubles the disparity between the cost of pumping from the lake and bringing the same by gravitation as above estimated.

All which is respectfully submitted,

PHINEHAS BALL,

Civil Engineer.

Worcester, Nov. 24, 1863.

Boston, Dec. 3d, 1860.

W. D. Cheever, Water Commissioner,
Worcester,

Dear Sir:—I have completed the analysis of the sample of water you sent me, and now report results.

One Imperial English gallon (or five quarts) of the water, weighing 70,000 grains, yields on analysis two grains of a gray brown solid matter, consisting of the following ingredients, in proportions:

	Grains.
Organic vegetable matter, mostly crenicæid,	0.50
Silica, with a little Alumina,	0.33
Chloride of Calcium, (muriate of lime,)	0.40
Sulphate of Soda,	0.18
Carbonate (originally Crenate) of Lime,	0.40
Magnesia,	0.06
Per Oxide of Iron, (originally Crenate of Iron),	0.20
and a trace of Oxide of Manganese.	
	Grs. 2.07

This water is good wholsome drinking water, and is suitable for all domestic uses. It is also excellent for supplying locomotive and other steam boilers, since it does not form an adhesive crust, when evaporated to dryness, and no crust at all, unless it is dried off entirely, and the deposite is easily re-dissolved on adding more water to the boiler.

I have no doubt that the people of Worcester will be as well pleased with this water as we in Boston are with that from Cochituate lake.

By referring to the analysis made by Profs. Horsford, Silliman and myself in the report of the Cochituate Water Board, you will perceive that the Worcester water contains but little more than half as much foreign matter as the Cochituate. Respectfully, your ob't serv't

CHARLES T. JACKSON, M. D.,

State Assayer, &c., &c.