Pittſburgh New Water Works.

REPORT

OF THE

Board of Examiners

AND

HYDRAULIC ENGINEERS,

With Estimates of Cost of Work.

Submitted March, 1871.

PITTSBURGH:
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1871.

Extracts from the Journal of the City Councils.

FEBRUARY 28th. 1870.

Mr. C. W. Batchelor called up a resolution offered by him January 31st, 1870, to wit:

Resolved, That the Water Committee be, and they are hereby authorized and instructed to engage the services of a competent Hydraulic Engineer, and his assistants; and Councils shall, in joint convention convened for this purpose, elect three citizens who are not members of these Councils, and who shall serve without pay, to be known as Water Commissioners.

The Chief Engineer, Water Commissioners, and Superintendent of City Water Works shall constitute a Board of Examination to take into consideration the subject of new Water Works to supply the city with pure water; make a careful and thorough examination of the various plans suggested, and report the result of their deliberation to these Councils.

The Water Committee shall cause a warrant to be drawn on the Treasurer for expenses of Board of Examination, and have the same charged to Water Extension Fund.

Read three times, and passed.

Joint Session, March 28th, 1870.

Councils then went into joint session for the purpose of electing three citizens as Water Commissioners, as required by resolution of Councils.

The following named gentlemen were nominated and elected:

Messrs. FELICIAN SLATAPER, J. K. MOORHEAD, and GEORGE A. BERRY.

Report of the Board of Examiners.

To the Select and Common Councils of the City of Pittsburgh:

GENTLEMEN,—We are pleased to have reached the period when we can make a final report to you, upon the important matter committed to our charge by the joint action of your bodies.

By the experience of all large cities in providing for new water works, the necessity to make provision for a liberal supply of water at the outset has become a matter of fact and economy; and we believe that an *abundant* supply of *pure* water is worthy of almost any expenditure. Liberal as provision was thought to have been made by many of the cities east and west of us, at the time of the establishment of their works, they have nearly all found it necessary, at certain seasons, to husband their resources; and their reports show that the consumption of water each year is greater in proportion than the increase in population.

In presenting these facts, the Board desire to impress upon the minds of the councils, that, in undertaking any new works, they should be sure to have it done on such a scale as will insure an abundant supply for a largely increasing population, and increased demand.

The engineers selected by the Water Committee commenced their labors on the 8th day of June last, and from that date until the present time have been assiduously at work in making their surveys, examinations, and plans for supplying the city with an abundance of good pure water. During their investigations and explorations, your Board of Water Commissioners and Examiners have on various occasions given

their personal attention to the examination of sites and such other matters as appeared proper and pertinent to the matter in hand.

On the 25th day of last month, Messrs. Chesbrough and Lane presented us with their report, together with estimates in detail of the cost of the proposed work, on the several different plans, the cost of reservoirs, and their several locations; description of the pumping engines, their cost, &c., &c., together with maps and plans of the work, all of which we herewith lay before councils, together with the report and analysis of the water, by Professor Wuth. Since receiving their report, your Board have endeavored to fully understand the subject, and for that purpose have not only examined all statements, facts, plans, &c., submitted to them, but have made personal examinations on the ground of the different locations for reservoirs, pumping works, &c.

The engineers at the commencement very summarily, and as we think very properly, disposed of the plan or idea of supplying the city by gravitation (as Col. Roberts had previously done in his able report), as being too expensive if not entirely impracticable.

They next proceeded to settle the question of the elevation of the different reservoirs, an exceedingly important point for the very broken and hilly ground of our city. In doing this they have fixed upon three different levels or planes from which different portions of the city shall be supplied,—the lower service will be about 200 feet above high water, supplying an area of $5\frac{1}{4}$ square miles; the middle one, about 330 feet above high water, supplying an area of $8\frac{6}{10}$ square miles, and the high one will be about 500 feet above high water, supplying an area of $7\frac{8}{10}$ square miles.

Having settled this, as your Board believe very properly and judiciously, their next inquiry was as to where the supply of water should be obtained, and where to fix the location of the pumping works and reservoirs—the Allegheny, Monongahela, Kiskiminitis, and Youghiogheny Rivers were all looked to, and examined for the supply of water; and unlike most cities where it is difficult to find sufficient elevations for the location of reservoirs, our city presented so many, as to make

it a very laborious task to examine them all, make comparisons, and determine on the best.

They first introduce the plan of a reservoir at Shade's Run; and whilst this location would have advantages over that of Negley's Run, on account of being further up the river, and more free from impurities that flow into the stream from oil refineries, &c., yet the fact of that location requiring a dam of 170 feet in height, that would retain a pressure of more than 120 feet of water unavailable, being below the bottom line of the basin, or the discharging main, together with the great cost of constructing the reservoir, viz: $454,091, and the additional distance and unfavorable route for laying the mains into the city, and the danger of a leak or breach in the dam, which might destroy its use for months, induces us to justify the engineers in, as they say in their report, "looking for a more favorable location for the low service reservoir."

They next propose what they designate as

"THE ALLEGHENY RIVER PLAN."

On this plan, the pumping works would be located just above Negley's Run, and the water taken from near Nine Mile island, and carried in a conduit six feet in diameter to the pumping well.

The ground selected on what they have termed "Brilliant Hill," for the low service reservoir, appears to be well adapted to the purpose. The flow line of this reservoir would be 206 feet above high water—an elevation sufficient to supply the Allegheny City Reservoir if ever required. It would contain from forty to fifty million gallons, with a depth of twenty feet. The area of water surface being about eight acres. This reservoir would supply the whole of the lower plane of the city, as shown on the map.

From this reservoir the water would be pumped into one immediately above, located on the ground of James McCully and Casper Negley, being about one-half on each side of Hiland Avenue extension. It is proposed to construct it with a division in the centre. The flow line of this middle service reservoir would be three hundred and thirty-six feet (336) above high water. It would have a water surface of 17¾ acres,

and capacity to hold 104,000,000 gallons. This appears to your Board of Examiners to be a most admirable location, the ground is well adapted to the purpose, the construction of the reservoir will not be expensive, and the streets and lanes to be used in extending the pipes for distribution are exceedingly favorable.

The owners of the ground are also disposed to accommodate the city at rates that are not deemed exorbitant.

Mr. Casper Negley proposes to sell twenty-five acres at sixteen hundred dollars per acre.

James McCully, Esq., informed members of the Board that he would sell to the city what land they want of him at a reasonable rate, and said he would leave a proposition to that effect, but it has not yet been received.

This reservoir would supply the middle plane of the city, including what is known as the East Liberty plateau. From this level it is proposed to pump the water into a reservoir to be located on Herron's Hill, by a water pressure engine located at the junction of Ellsworth avenue and Neville street, or some point on Centre avenue—an ingenious and economical device that, it is believed, will answer the purpose admirably.

The Herron's Hill reservoir will command the highest habitable portion of the city, its flow line being five hundred and thirty feet above high water. It is proposed to construct it with an area of water surface of two acres, and its capacity about ten million gallons.

The estimated cost of this plan, in its entirety, is $2,294,178.00.

"THE MONONGAHELA RIVER PLAN"

Is next introduced by the engineers, and is the only rival of the Allegheny River plan.

The proposition is to take the water out of Pool No. 2, of the Monongahela Navigation, above the mouth of Turtle creek, and conduct it through a brick conduit six feet in diameter, to the pumping works near the mouth of Four Mile run, a dis-

tance of seven and nine-tenth miles. From this point the water would be pumped through a force main to the lower service reservoir situated on ground formerly known as Camp Howe, being a part of the Craft estate.

This is an excellent site for a reservoir, the ground is well adapted for the purpose, its construction would not be expensive, and the elevation is just what is wanted, the flow line of water being two hundred and seven feet above high water (207), or just one foot above the lower service reservoir at Brilliant Hill, on the Allegheny River plan. The area of water surface here would be 15⅔ acres, and the capacity ninety-two million gallons (92,000,000).

This reservoir will supply the lower plane of the city, the same as would be supplied by the one at Brilliant Hill.

For the supply of the middle plane, it is proposed to pump the water into a stand pipe one hundred and ninety-five feet high, from which it will flow into a middle service reservoir located on Wilkins' Hill, near the residence of William Coleman, Esq., the flow line of which will be 379½ feet above high water, and the capacity sixty-four millions of gallons—area of water surface 11⅛ acres—from this the supply for the high service will be taken to the water pressure engine at the junction of Ellsworth avenue and Neville street, or some point on Centre avenue, and from thence to Herron's Hill, being exactly the same as the Allegheny River plan from that junction.

The total estimated cost of constructing the works upon this plan is $2,748,973.00. In giving the cost of the Allegheny and Monongahela plans, there is no estimate for the cost of lands.

The engineers say in their report, very properly, that two absolute requisites must be kept in mind in seeking a supply of water for the present and *prospective* population and industry of Pittsburgh, viz: purity and abundance.

The first requisite will be fully complied with by taking the water from either river.

Let us for a moment examine the second. The Allegheny River takes it rise in this State; passing into the State

of New York, its course at first is nearly due north; the fall from the New York State line to Pittsburgh is about 3¼ feet per mile, consequently the current is rapid, the water clear, pure, and abundant. Col. Roberts, in his preliminary report, page 16, says of it: "In ordinary low water the flow is not less than one hundred thousand cubic feet per minute; and in an extremely low stage, such as occurs only once in ten or more years, there are about eighty thousand cubic feet, or, taking the lowest quantity, six hundred thousand gallons per minute." He considers the source of supply abundant for any future city that could reasonably be anticipated at the head of the Ohio River.

Again, in a pamphlet published by order of the Board of Trade, written by Col. Roberts, in reply to Col. Ellet, on the improvement of the Ohio River, page 24, speaking of the quantity of water in the Ohio River being sufficient for a lock and dam navigation, he says: "At the very beginning of the proposed slackwater navigation at Pittsburgh, the quantity of water at the *extreme lowest known* stage by measurement was *thirteen times greater* than *the flow of the Monongahela*, at the same time; so that there may readily be, in very dry times, a scarcity on the Monongahela, but not on the Ohio." From this we learn that the flow of the Allegheny was twelve, to one in the Monongahela.

Of the abundance of water in the Allegheny, no one doubts; so there is no necessity for pursuing this branch of the subject further. We would only remark in this connection that the rapidity of the current is a great purifier of the water.

The Monongahela River flows from West Virginia, its sources are directly south of our city; it therefore runs nearly due north, along the foot or base of the mountains. It is a dull sluggish stream; the fall from West Virginia State line to Pittsburgh, a distance of 90.6 miles, being only 74.6 feet, or about 10 inches per mile.

In the report of the Monongahela Navigation Company of 1839, Col. Roberts, who was then engineer of the company, and speaking of the supply of water for the improvement,

states that on the 30th of August, 1838, the quantity of water passing Brownsville was 12,420 cubic feet per minute, *all the tributaries from that point to the mouth of the Youghiogheny were dry at their outlets.* September 19th, it was again measured, and the quantity was reduced to 4,500 *cubic feet* per minute. In his preliminary report on the water works, before referred to, he says: "In its very lowest stages, the natural flow of the Monongahela has been known to be less than two thousand cubic feet per minute, which would furnish only about twenty-one and a half million gallons per day.

The engineers, whose report is herewith submitted, say, "That for *present* purposes, and the wants of the near future, either stream would furnish an ample supply." They state afterward, however, that measurements taken in a very dry season showed the flow to be not much, if any, more than twenty million gallons per day; and then add that even this would be claimed for the purpose of lockage. It would be necessary to construct compensating reservoirs to supply the locks.

In addition to the foregoing testimony, it is well known to members of your Board, that during many low water seasons, since the construction of locks and dams on the Monongahela River, the water has sunk below the comb or weirs of the dams, and has remained so for weeks, and some seasons for months, frequently becoming so low as to suspend the navigation entirely. When this is the case, the entire flow of the river is not sufficient to keep the pools full, the evaporation and leakage through the locks and dams, together with the insensible escape of water through the gravel from the higher to the lower levels, more than absorbs it all; upon these artificial pools are numerous coal boats laden from five to eight feet deep, and during these seasons of low water they frequently become grounded, and in some cases have been injured.

Now, suppose that during such a stage of water, that would continue for six to ten weeks, the minimum flow of twenty-one and a half millions of gallons per day, which is all absorbed as before stated by evaporation, leakage, &c., should be pumped out of the pools into the city water basin, what

would be the effect upon the pools, coal boats, &c.? The leakage and evaporation would not cease, because the city wanted the water, and the effect of the double drain upon the supply, either being fully equal to it, would be to reduce the river to its normal condition, and not only destroy all navigation upon the river, but also the value of the laden boats upon its waters.

When the water is at this low stage of course little or no *current* exists; and that great purifier that is constantly acting upon the water in the Allegheny River is entirely lost to the Monongahela. The effect must be evident to all, these pools of ten to fourteen miles in length receiving all the offal and filth usually cast, and naturally being drained into the river, must not only become stagnant, but impure and offensive.

The engineers say that the supply of water might be kept up by compensating reservoirs, so as to supply the city and the navigation also.

The Navigation Company at one time considered the construction of reservoirs to keep up the supply of water for navigation purposes, and the Schuylkill navigation is now supplied during low water by three reservoirs.

In the report of the Monongahela Navigation Company, presented January, 1855, in speaking of the low water of 1854, they say, viz:

"In July, the effects of the drought began to be felt; and on the 27th of that month, the water became so low that the large packet steamers ceased to run during the period of nearly three months, and were not able to resume their trips until the 17th of October. * * * * The water during the greater part of that time not only ceased to run over the dams, but by evaporation and leakage became almost literally dried out of the pools."

Again, in the report of the year 1856, they say: "From the 14th of May until the 1st of December, a period of more than six months, there was at no time a sufficiency of water to float coal boats. * * * Below Dam No. 4, the water was gauged by the President of the Company on the first day of October, 1856, and the quantity passing found to be 1,492 cubic feet per minute. Mr. Charles Stewart, the engineer of

the Company, gauged it at Brownsville bar, on the 8th day of October, and the quantity passing per minute was 1,365 cubic feet." Being less than fifteen million gallons per day.

In their report of January, 1859, when discussing the system of reservoirs for the Ohio River, recommended by Charles Ellet, Esq., they say:

"The location and construction of one or more of these reservoirs on the upper Monongahela, would add greatly to the value of this improvement, * * * drawing off the water during the Summer months, would give us a never-failing supply."

Your Board therefore believe it would be unwise to take the water from the Monongahela River, with the abundant flow, and pure water of the Allegheny River at your command.

The sites selected, and herewith recommended for the three reservoirs, are admirably adapted to that purpose, being away from any present, or probable thoroughfare of travel, always opens to a free circulation of air; free from any proximate contamination, and in a remarkably safe and secure position, the lands being on an elevation, such as commands fine views of the rivers and city in our vicinity, and the spot will afford, when finished, a very pleasant place of resort for our citizens: we would recommend that, in securing the sites for the reservoirs, additional ground to the amount required for reservoirs, be obtained and improved, so as to make for our citizens places of resort and recreation, as is now done in many cities.

In view of the probable early consolidation of the south side boroughs with this city, and the demands that may be made to be supplied with water from a common source, we would in addition recommend the early purchase of a portion of the land that was designed in the original surveys for the Monongahela River system, for a distributing reservoir on the high ground on Craft's Hill, near Four Mile run; said ground to be used in the future for a smaller equalizing or storage reservoir, for all that section of the city situated along the banks of the Monongahela River.

One important additional advantage the location of the water works will have on the Allegheny River is, that should our city in future years think it advisable to extend their source of water supply to the best fountain head, and purest water, viz: the Kiskiminitis, as seen in the report of the chemist, Mr. Wuth, all that will be required to be done, without in any way interfering with the present proposed construction, or loosing the use of any parts, will be the construction of a conduit of proper size, from the Kiskiminitis to the pump well of the engine house, on the bank of the Allegheny River, as then in use. As to the probable cost of such extension, we have thought at present not necessary to enter into any examination: but the assurance that it can at any time in the future be done at reasonable cost, when so required by the large increase and extension of the city, will be a source of satisfaction to our citizens.

The Engineers have recommended engines known as "double cylinder, with beam and fly wheel:" we have full faith in their recommendation without any special personal knowledge on the subject; but as so much depends on the character, quality, and capacity of the engines and pumps, in the economical working and certain supply of water, and as a mistake in this matter would be hard to remedy, and involve great expense, your Board would recommend to councils, a thorough examination of all the modern improvements in engines and pumps, before making a selection.

We take pleasure in commending the skill, ability, and zeal displayed by the Engineers in the prosecution of their laborious task: we believe they have most fully and thoroughly investigated the whole subject; that they have left no available site unexplored, nor any promising point unsurveyed,—but that they have laid down in their report a good, if not the very best system, that the ground is susceptible of.

In conclusion, therefore, we unanimously recommend the adoption of what they have designated as the "ALLEGHENY RIVER PLAN," with the addition suggested by us of a small storage reservoir on Craft's Hill.

We decide in favor of the "ALLEGHENY RIVER PLAN" for the following reasons:

First—*Abundance of water.*

Second—*Its purity and greater clearness.*

Third—*The ability to extend this system of supply to any possible requirements for a century to come.*

Fourth—*Less cost for the construction of works.*

All of which is respectfully submitted.

BOARD OF EXAMINERS,

J. K. MOORHEAD,
FELICIAN SLATAPER,
GEO. A. BERRY,
Board of Water Commissioners,

E. S. CHESBROUGH,
Chief Engineer,

JOSEPH FRENCH,
Sup't. Water Works.

ENGINEERS' REPORT.

PITTSBURGH, February 24, 1871.

To Gen. J. K. Moorhead, Geo. A. Berry, Esq, and F. Slataper, Esq., Water Commissioners.

GENTLEMEN: In accordance with the previous appointment and notification of the Water Committee, through their Chairman, Henry Lloyd, Esq., we came to this city on the eighth of June last, and were instructed by the Board of Water Commissioners, organized on that day, "to proceed to examine all reports and surveys heretofore made and in possession of the councils and City Engineer, the location of the grounds and sites for reservoirs in the vicinity, and make such surveys and instrumental explorations as he (the Chief Engineer) may deem necessary."

It was previously understood, in the letter of the Chief Engineer to Mr. Slataper, who acted in behalf of the Water Committee, stating on what terms and conditions he would perform the duties of the office,—which terms and conditions were accepted by the Committee,—that Mr. Lane was to be Associate Engineer, hence the joint character of this report.

Immediately after receiving our instructions, and in company with some of the Commissioners, members of the Water Committee, and a few prominent citizens, we visited the most important points in and near the city, mentioned in previous proceedings relative to the new water supply. We also examined considerable portions of the Monongahela and Allegheny rivers in the vicinity where it had been proposed to take the water.

One of the most important steps in a proceeding of this kind is to ascertain what information previously obtained is acces-

sible and reliable. Besides the State, County, and City maps and railroad surveys, we found much in the office of the City Engineer to assist us.

The preliminary report of Col. J. Milnor Roberts, dated December 12th, 1868, together with the maps and profiles of surveys made under his directions, forms, by far, the most important source of information placed in our hands, and renders unnecessary much labor and investigation of a general nature we might otherwise have thought it important to undertake. We have carefully considered the facts upon which Col. Roberts bases his opinion, that it would be a useless expenditure of money to construct at present gravitation works, by which a supply could be obtained without pumping engines, from the Youghiogheny or the Kiskiminitis, or from intermediate collecting reservoirs, and agree with him in that conclusion.

We have almost from the first been convinced that, under existing circumstances, the practical issue was not between pumping and gravitation works as *modes* of supply, but between the Allegheny and Monongahela Rivers as *sources* of supply. Hence our labors have been almost exclusively directed to the development of such projects as would most efficiently and economically furnish the city with an abundance of water from either of those streams, endeavoring to investigate carefully everything that seemed to have an important bearing on the question thus restricted.

One of the most important results of our surveys was the determination of the general elevation of the different parts of the city. Although much information in this respect had been obtained by our predecessors, we found it necessary to add considerably to it. We have thus been enabled to determine, quite satisfactorily to our own minds, upon a judicious arrangement of different services, or heights above the river at which the water should be supplied.

These consist of a low service including all the business portions of the city, a middle service including the East Liberty valley, and an upper service including the highest portions of the city, and will be described more minutely below.

The present corporate limits of Pittsburgh cover an area of about twenty-one square miles, extending from the junction of

the two rivers along the left bank of the Allegheny eight miles, and from the same point eight and one-fifth miles up the right bank of the Monongahela. The distance between the two rivers at the eastern limits of the city is four and a half miles. This whole area is extremely diversified, as will be readily understood from the following statement condensed from the results of our surveys.

The area of that portion situated below a plane one hundred and twenty feet above high water, is five and one-sixth square miles; the area of that portion betwen the planes of one hundred andtwenty feet and two hundred and fifty feet above high water is eight and six-tenths square miles; the area of that portion above the plane of two hundred and fifty feet above high water is seven and six hundredths square miles. There are several points, or hills, within the city limits higher than four hundred feet above high water, and two above five hundred feet—Herron's Hill five hundred and thirty feet, and Coleman's Hill five hundred and forty feet.

There will be frequent reference to the terms high water and low water, in this report; to define clearly what is meant by these terms, the following explanation is given: The base or datum line assumed for our levels, as zero, is low water in the Allegheny river at its junction with the Monongahela, indicated by the pier marks on the channel scale of the St. Clair street Suspension bridge. This datum line is that adopted for levels in the city of Allegheny and the city of Pittsburgh. Extreme high water mark is thirty-two feet above low water. In speaking of heights or levels in this report, the term low water signifies the datum as above explained; and by the expression high water, an elevation of thirty-two feet above that plane is indicated. Our principal contour lines were run at the heights of one hundred and twenty, two hundred and fifty, four hundred, and four hundred and seventy feet above high water. The heights on the plans and profiles accompanying this report are marked at the elevation above low water, unless otherwise expressly stated.

To determine the location of the reservoirs and how many it would be best to build, and at what elevation, a survey of the whole area of the city has been so far completed as the time

would permit. The elevation of all the streets now laid out, and all the roads now in use, have been taken or collated from notes in the office of the City Engineer, and contour lines have been run at elevations as above stated. These contour lines have been completed in all the city except the Twenty-second Ward and a small portion of the northern part of the Twenty-first Ward. Enough information has been collected to enable us to decide intelligently upon the proper location of the reservoirs.

From the information thus obtained, it has been determined that a plan of works which would afford facilities of water supply to the whole city should have three reservoirs, at different elevations, sufficiently high to afford the proper head in each district for extinguishment of fires, but not so high as to require entirely new distribution pipes and the renewal of the house-plumbing in those parts already supplied with water. There are objections to an excessive head of water; where the supply is constant, it leads to great and almost uncontrollable waste of water; there is, besides, the constant expense of pumping the water higher than necessary.

Any new reservoir for the Water Works of this city, it is conceded, must be located from three to six miles farther from the densely populated portion of the city than the present reservoirs. It would thus be free from the deleterious influences of the gases and vapors floating in the atmosphere of great cities, and would also be near the pumping works. For it has been assumed at the outset that the main design in building new water works, next after increasing the capacity of the present works, is to furnish the city pure water free from city drainage or the drainage from manufactories or refineries. To do this, whether the water be taken from the Allegheny or the Monongahela, it will be necessary to locate the principal pumping works near the eastern boundary of the city. A reservoir located four or five miles from the point where the most of the water is used, must necessarily be twenty-five or thirty feet higher than if located directly in the midst of the district, in order to overcome the friction of the water in the pipe mains.

The elevation recommended for the low service reservoir is about two hundred feet above high water. A reservoir

situated at this height will afford to the whole of that part of the city lower than one hundred and twenty feet above high water, comprising the whole of the business part of the city, a head of at least fifty feet at all times, and in the lower portions of the district, a head of about one hundred and fifty feet, besides an allowance sufficient to overcome the friction in the pipe mains from the reservoir to the city. This elevation may seem too great when compared with that of the present low service reservoir, or with that of the reservoirs in some of our large cities. There are but few large cities that afford any choice of sites for reservoirs—the highest is usually selected. A reservoir at the elevation proposed will afford about the same head of water in this city as is given by the present works in the neighboring city of Allegheny, or by the works in the borough of Birmingham. The flow line of the reservoir in Allegheny is one hundred and eighty-five feet above high water; that of the reservoir of the Birmingham Water Works is also one hundred and eighty feet above high water. The data in reference to these reservoirs are stated to show that there will not be required any great change in the present pipe system, if the height recommended—two hundred feet above high water—is adopted for a low service reservoir.

Of the whole area of the city lying between the levels of one hundred and twenty and two hundred and fifty-feet above high water, by far the larger portion is situate at the height of about two hundred feet above high water. This is the general elevation of the East Liberty valley or plateau. A reservoir that would afford a head of about one hundred and thirty or forty feet in the greater part of this district is considered high enough, and accordingly the height fixed for the reservoir to supply this district is three hundred and thirty or forty feet above high water.

For the third, or high level reservoir, a height of five hundred feet would answer very well. It should, however, be twenty-five or thirty feet higher, so as to command the most elevated portions of the city.

In our plans, we propose to make every possible judicious use of the existing City Water Works. Of course the present pumping works, after the completion of the new, would be no

longer needed; and we do not see how any important use could be made of the low reservoir near the High School. Some of the force mains might very advantageously be taken up and relaid elsewhere.

Having assumed the general heights of the different services, our next step was to ascertain the best reservoir sites. On a surface so extensive and widely diversified as that of Pittsburgh of course many reservoir sites exist, but owing to the necessary restrictions of height, capacity, cost, and safety, the choice was narrowed down to a few. We have examined and estimated upon thirteen sufficiently for comparison, and have carefully developed and planned six. The necessary limits of this report will only permit a description of the more important ones.

Our attention was early called to Shade's run. This is a small brook running into the Allegheny river one and one-fourth miles above Negley's run. It drains a water shed of three hundred and seventy-five acres. This brook divides into two branches twelve hundred feet from the river; the distance from this point to the source of each is about one-half mile. The quantity of water flowing in summer is very small. The sides of the run rise precipitously; the lowest point along the crest of the water shed toward East Liberty is four hundred and thirty feet above high water.

The fact that there is a deep pool in the river opposite this run, and within several miles above it only one manufactory (the Acid Works at Sandy Creek), the drainage from which would not at all affect the purity of the water in the river, has induced the belief, among many citizens of sound judgment, that this would be the best location for the new water works. To understand thoroughly its adaptability to this purpose, it has been carefully surveyed.

The following is the approximate estimate of the cost of building a low service reservoir in this Run:

Clearing and Grubbing			$ 4,000
768,000	cubic yards	of embankment, at 42c	322,560
52,000	do	puddle, at 75c	39,000
11,500	do	stone facing of dam, at $1.50	17,250
Masonry in culvert, influent and effluent chambers, gates, screens, &c			30,000
			$412,810
Add for contingencies, &c., 10 per cent			41,281
Total			$454,091

The great expense of building a reservoir here, and the risk in so very high an embankment of leakage, by the use of improper materials, or by unfaithful work, have led us to endeavor to find a location for a low service reservoir where the construction would be less expensive, and which could be more readily connected with the pumping works for a high service reservoir.

Other reservoir sites above this were examined and estimated upon, but were not at suitable heights for the middle and high services.

The two plans we have worked out complete, for comparison and estimates of cost, are,

1st. THE ALLEGHENY RIVER PLAN.

2d. THE MONONGAHELA RIVER PLAN.

1st. The Allegheny River plan:

In this plan it is proposed to locate the principal pumping works, above Negley's run, and below Shade's run, at some suitable point hereafter to be selected; there are two or three within a short distance of Negley's run. The one selected on which to base our estimates of cost, is situate eight hundred feet above the mouth of Negley's run.

The water is to be taken from the river near Nine Mile Island, and conducted through a brick conduit, six feet interior diameter, to the pump well. It is here to be pumped into a reservoir, located on the hill at the west of Negley's run, called Brilliant Hill. The length of the force mains from the

engine house to this reservoir is twenty-three hundred and twenty-five feet; it is proposed to make the mains thirty-six inches internal diameter, and to lay two lines, one from each of the two pumping engines.

The pumping engines will be described farther on in this report.

The proposed location of the pumping works at Negley's run, is six and one-half miles above the location of the pumping works of the present city water works. The flow line of this reservoir is to be two hundred and thirty-eight feet above our datum line, or two hundred and six feet above high water; but as low water in the river here is twelve feet above the datum line, the extreme lift of the water at this pumping station will be two hundred and twenty-six feet.

There is ground here on which the reservoir can be built at a lower level, if so desired. The site chosen is high enough to command the reservoir in Allegheny, if it should ever be thought advisable to supply that city from these pumping works.

This Brilliant Hill reservoir is to be built in two compartments, and large enough to hold about fifty million gallons. The site surveyed, and on which the present estimates are based, will hold forty-four million gallons, with a depth of twenty feet of water. The area of the water surface is eight acres.

From this reservoir the water to supply the whole of the lower plane of the city (all that part below one hundred and twenty feet above high water), would flow through a cast iron pipe main, thirty-six inches interior diameter. This large supply main is to be laid in Butler street through Lawrenceville, and thence to pass into Liberty street at Thirty-third street, and to continue in Liberty street to Twentieth street; from here the supply could be taken by the pipes now in use, or by new pipes of less diameter than thirty-six inches, and connected with the existing mains.

From near the Sharpsburg bridge to Negley's run, a distance of one and a half miles, Butler street is not graded. The cost of grading the street, or opening it, is not included in the estimate of the cost of the works. The most of the work on

the street is light, and it is assumed that it will be paid for in the usual way. It is proposed to pass Haight's run, the only point where the work is expensive, by building a culvert of ten foot span, and taking the main across this valley, by laying it down the slope and over the culvert, and up the slope on the other side. The expense of the short culvert required for this purpose, and the necessary grading and embankment, is included in the estimate. When it may become necessary to grade this street across the run, the culvert can be lengthened at each end, and the pipe mains raised to the grade of the street.

Provision has been made in the plan of the masonry of the effluent chamber of the Brilliant Hill reservoir, for laying a second supply main from this reservoir when it may become necessary on account of increased demand for water in the city.

For the supply of that portion of the city situate above the plane of one hundred and twenty feet above high water, and below two hundred and fifty, which we have called the middle level, it is proposed to pump the water from the low level reservoir at Brilliant Hill into a reservoir to be located on the property of Mr. Casper Negley and Mr. James McCully, on Hiland avenue. The length of this pumping main will be about one thousand feet, and its internal diameter twenty-four inches. The flow line of the middle level reservoir is to be one hundred and thirty feet above the low service reservoir, or three hundred and thirty-six feet above high water. The reservoir is to be built in two compartments, and to contain, when full at twenty feet depth of water, one hundred and four million gallons. The area of the water service is seventeen and two-third acres.

The distribution main from this reservoir is to be laid in Hiland avenue as far as to Penn avenue (where it will be connected with the main at present being laid in this avenue), and in Penn avenue to Ellsworth avenue, thence to continue in Ellsworth avenue to Neville street. This main in Hiland avenue, from the reservoir to Penn avenue, will be thirty inches interior diameter; in Penn avenue to Ellsworth ave-

nue, twenty-four inches diameter; and in Ellsworth avenue, from Penn to Neville street, twenty inches diameter.

At the junction of Ellsworth avenue and Neville street, a water pressure engine is to be located to pump the water into a high service reservoir to be located on Herron Hill. The flow line of this reservoir is to be five hundred and thirty feet above high water; this reservoir is to be built with but one compartment, and to contain, at the depth of twenty feet, ten million gallons. The area of its water service is two acres. The pumping main for this high service district will be forty-nine hundred feet long and twelve inches interior diameter. It is proposed to connect the reservoir with the distribution pipes now laid and hereafter to be laid in this elevated portion of the city, by a distribution main twelve inches diameter, to be laid in Madison avenue and Wylie avenue.

The waste water from the pumping engine located at the junction of Neville street and Ellsworth avenue, is to be conducted by a twelve inch main laid in Boundary street to Second avenue, near Four Mile run, and there connected with the pipe now laid in that avenue.

The difference in level between the low service and the middle service (one hundred and thirty feet) will be sufficient to overcome the friction in the mains from Hiland avenue reservoir to the proposed water pressure engine at Neville street (the length of these mains is three and one-third miles), and furnish a pressure of forty pounds per square inch to pump the water into the reservoir on Herron Hill.

The quantity of water at present required on this high level district has been assumed to be one-half million gallons per day. There are no manufactories in this level, and the consumption of water there will be very much less per inhabitant than in the district where these are located. It is assumed that one half million gallons per day will be sufficient for a population of at least ten thousand, affording to each inhabitant fifty gallons per day. This, probably, is as large a population as will be required to be supplied from this reservoir in many years.

For supplying the high level on Wilkins avenue, and that district in the Twenty-second Ward situate above the plane of

two hundred and fifty feet above high water, and lying directly south of East Liberty valley (this includes the heights where the Pennsylvania Female College is located), the water can be conveyed directly from the high service pumping engine at Neville street, in a cast-iron pipe of six or eight inches interior diameter.

The chief advantage in the use of the water pressure engine will be a saving in the expense of attendance: it does not, like steam pumping engines, require an engineer or fireman. There is not claimed for it, in this case, any saving in power; and, in fact, no other saving than what results from doing all the pumping by steam, at two points very near each other, rather than at three points widely apart.

The distribution main in Penn avenue, twenty inches diameter, now being laid, and which it is understood the Water Committee propose to lay the whole length of this avenue to the east line of the city, will serve the double purpose of a distributing main and a connecting main between the middle level district and the low service district. The large quantity of water (over one hundred million gallons) which the middle level reservoir will contain, will thus always be at command on the low service distribution, in case of any temporary stoppage or disabling of the pumping machinery at the main pumping station.

The method of constructing the reservoirs is about the same for all; a general description will, therefore, be sufficient. The embankments enclosing the reservoir are to be built of earth, deposited in layers of less than one foot in thickness and thoroughly compacted. These embankments are to be carried up to the height of twenty-four feet above the bottom of the reservoir; their width at top is to be twenty feet, and the slopes or inclinations of their sides to be one and one-half horizontal to one vertical on the inside of the reservoir, and one and three-fourths to one on the outside. The whole of the bottom of the reservoir and the inner slopes to be lined with clay puddle. This puddle is to be covered with concrete five inches thick. The inner slopes of the reservoir are to be paved with a stone paving one foot thick, laid in mortar. The water is to be conducted to the reservoir and drawn from it

through chambers of masonry fitted with screens and valves, admitting the supplying of the city from one division while the water is pumped into the other.

The proposed forms of the reservoirs, and the methods recommended for their construction, are shown on the drawings accompanying this report. The above general description applies to all the reservoirs, except that the reservoir on Herron hill is to be built with but one compartment; and in this case the chambers of masonry are dispensed with, and the pipes are conducted through the banks.

The question may be asked, Why a larger reservoir than the one proposed is not recommended to be built on Herron Hill? The answer to this query is, that the area of the top of the hill is small, and the ground slopes away so rapidly on all sides that the construction of a reservoir larger than this would be very expensive, as will be seen by an examination of the plan, or the proposed site of the reservoir. Besides this, the quantity of water that will be used daily from this reservoir is small, when compared with the whole quantity used in the city. The reservoir as proposed will certainly contain more than a week's supply for the high level district, which is considered sufficient for all purposes.

The estimated cost of the works by this plan is, exclusive of lands and land damages, two million two hundred and ninety-four thousand four hundred and seventy-eight dollars ($2,294,478).

2. THE MONONGAHELA RIVER PLAN.

The water is to be taken from Pool No. 2 of the Monongahela river, and conducted through a brick conduit six feet internal diameter and seven and nine-tenths miles long, to the pumping works, which are to be located on Second avenue, just above Four Mile run. This location is very nearly opposite the pumping works of the Birmingham Water Works. The water is to be pumped through a force main twenty-three hundred feet long, into a reservoir to be located on the hill near J. Arthur's residence. The site for this reservoir is on Arthur and Craft's Hill, the west side of Four Mile run, at the junction of Bouquet and Frazier streets. It is proposed to

build it in two compartments; the whole to contain, at a depth of twenty feet, ninety-two million gallons. The area of the water surface is fifteen and two-thirds acres. The flow line is to be two hundred and seven feet above high water.

The distribution main from this reservoir is to be thirty-six inches interior diameter, and to be laid in Second avenue, as far as to Grant street, in Grant street to Liberty, and in Liberty street as far as Twentieth street. It will here be connected with the twenty inch main, now laid in Liberty street, by a twenty inch main to be laid from Twentieth to Thirtieth street; it will also be connected at other points with the pipes in the streets through which it is laid.

The district to be supplied by this main, called the low service district, is that part of the city situate below the height of one hundred and twenty feet above high water.

As the water surface of this Arthur and Craft's Hill reservoir is only one foot higher than that of Brilliant Hill reservoir, the head of water furnished in the lower or business portion of the city will be almost precisely the same from either reservoir.

For the supply of the middle level district, it is proposed to pump the water from the Arthur and Craft's Hill reservoir into a stand pipe, to be located on the north side of this reservoir. The height of the stand pipe is to be one hundred and ninety-five feet. The water will flow from it through a main thirty inches in diameter, to be laid in Bouquet and Atwood streets to Fifth avenue, where it would connect with the main at present laid in this avenue. This thirty inch main is to be laid in Fifth avenue, as far as to Neville street; from the junction of Neville street and Fifth avenue there is to be a twenty inch main continued through Fifth avenue to Wilkins, in Wilkins to Shady Lane, in Shady Lane to Edgerton avenue, and in Edgerton avenue to the reservoir, to be located on Wilkins' Hill. The flow line of this reservoir will be three hundred and seventy-nine and one-half feet above high water, and its capacity sixty-four million gallons. The area of its water surface will be eleven and one sixth acres. This reservoir will be connected with the main now being laid in Penn

avenue, by a thirty inch distribution main, to be laid in Edgerton and Park avenue, to Penn avenue.

For the supply of the high level district the water will pass from the main in Fifth avenue, through a twenty inch main, to be laid in Neville street, to the engine to be located at the junction of Ellsworth avenue and Neville street. From this point the plan for the supply of the high level district is precisely the same as that recommended for the first mentioned, or Allegheny River plan, except that the twelve inch main which takes the water, used to drive the water-pressure engine, into the low level distribution district, will in this plan be located northerly through Neville street, and down the valley of Liberty run to Liberty street. The length of the main is the same as the length through Boundary street to Second avenue, in the other plan. A repetition of the description of the high service plan is unnecessary.

The general description of the construction of the reservoirs given in the other plan applies to this also.

The total estimated cost of the works, if built on the plan here described, will be, exclusive of lands and water rights, ($2,748,973) two million seven hundred and forty-eight thousand nine hundred and seventy-three dollars. If the building of the conduit is dispensed with, and the water taken from Pool No. 1, directly in the rear of the engine house, the cost will be ($2,032,673) two million thirty-two thousand six hundred and seventy-three dollars.

The detailed estimates of the cost of both plans are given in the Appendix to this report.

In making the surveys and calculations for the works on the Monongahela Plan, the reservoir for the supply of the high service district was first located on Ewart's Hill, south of Centre avenue, and the pumping main was designed to be laid in Bouquet and Atwood streets, to Fifth avenue, and thence directly to the reservoir, located between Bayard street and Centre avenue. There is an excellent site here for a reservoir. A reservoir could be built here at a very reasonable expense, to hold forty-two million gallons. The area of its water surface would be seven and five-eighth acres. If the reservoir for the supply of the middle level district were located here,

the stand pipe at the Arthur and Craft's Hill reservoir could be dispensed with, and the water pumped directly through the force main, sixty-eight hundred feet in length, into this reservoir. The water surface would be four hundred and fifty-six feet above high water. The general level of the middle service district is about two hundred feet above high water. With a reservoir located at the height here proposed, there would be afforded a head of about two hundred and fifty feet over the whole district, which is too great, and would involve a needless expense for pumping the water. It was this that led us to look for a reservoir on a lower level to supply this district. With a reservoir located at a lower level, though the first cost is somewhat increased, the annual expense for pumping will be very much less, and there will be a large annual saving.

The cost of the construction of the works by this plan could be very greatly diminished, as is shown by the estimates, by taking the water for the present from Pool No. 1, directly in the rear of the location of the engine house, above Four Mile run.

Soundings were taken in this pool on September 17th, 1870, from the Four Mile run up to Patterson's run, above City Farm.

A detailed report of these soundings has been made to you.

The general depth of water in the main channel varied from ten to about twenty-five feet. Soundings were taken entirely across the river or pool, at this proposed location of the pumping works, on November 17th, 1870. The depth within fifty feet of the right bank was fifteen feet; from this point the depth gradually increases to seventeen feet in the centre of the pool, and thence decreases to the depth of ten feet at one hundred and twenty feet from the left bank of the river.

If the pumping works were located here, it would be necessary to construct the pump well and influent conduit from the river low enough to take the water at the level, it would be, when this pool might be drawn off for making repairs to the locks or Dam No. 1, of the Navigation Company. The lift of the lock is eight feet.

By taking the water from this Pool—No. 1,—and omitting

the building of the Wilkins' Hill reservoir, and the laying of the principal mains that would be required to connect with this reservoir when built, and making use of the present upper reservoir of the old water works (capacity two and one-fourth million gallons,) for a reservoir on the middle level, the cost of the works on this plan would be, exclusive of land and water rights ($1,763,917), one million seven hundred and sixty-three thousand nine hundred and seventeen dollars.

We believe that the selections of reservoir sites, made for both the Monongahela and the Allegheny projects, meet all the requirements of capacity, height, and safety. In this last respect we had some fears with regard to the low service reservoir at the mouth of Negley's run, as there are indications of a tendency to slide, on the slope of the bluff immemediately below the site, but, on boring, it was found that the bottom of the reservoir would be in rock, which in some spots crops out on the brow of the hill.

The straight lines and angles proposed for the outlines of most of the reservoirs on our plans could be changed to varying lines and curves, without material, if any, increase of cost, should it be desired as a matter of taste. This would be particularly appropriate if the city should determine to ornament to any extent the grounds around the reservoirs.

We have not made any plans or estimates of the cost of a dam across the Allegheny river, and of other works connected therewith, to pump up the supply for the city by water power; because we are satisfied the city has no authority at present to construct a dam, and do not consider it certain such authority could be obtained. If such a dam and connecting works were built, it would still be necessary to erect steam pumping works to be prepared against occasional stoppages of the water wheels by high water, and possible accidents. If, after a few years of trial with the steam pumping works, it should be found that the increased demand for water was great, and all legislative objections to the dam could be removed, there would be scarcely anything to throw away or abandon in the reservoirs, or pumping works on the Allegheny; for they would all be needed, the reservoirs constantly, and the engines occasionally. A few years' delay in this mat-

ter would be attended with decided advantages, by giving not only more time for consideration, but would probably furnish experience of importance in the arrangement of such works, especially in connection with other public interests.

If the Ohio river is to be improved by slack water navigation, it is not impossible that the Allegheny will be too. In that case any dam the city would build, simply with reference to water power, might lose much of its value by back water from a dam below.

Whenever the daily consumption shall equal thirty, or even twenty million gallons, the economic advantages of pumping by water would undoubtedly be very great, as clearly shown by Col. Roberts.

In estimating the cost of such works as we would recommend for present use, we have provided for main pipes sufficiently large for a daily consumption of twenty-four million gallons, and two engines for the low service, each capable of raising twelve million gallons daily. With such engines, and reservoirs as large as are proposed, there would be no difficulty in keeping up an average supply of fifteen million gallons daily; for in case of repairs being needed, the reservoirs and one engine would keep up that supply from thirty to fifty days. The engine houses are intended to be large enough to admit a third engine, when the reliable pumping capacity could be increased at once to twenty-four million gallons and upwards, as might be deemed best.

We are aware that a forcible objection can be made to the proposed arrangement of separate engines and buildings for the lower and middle service, while a single building, enclosing the necessary machinery, would be cheaper at first to construct and afterwards to operate under all ordinary circumstances. It may be that, upon further investigation, this arrangement will be considered the best; but the greater apparent safety of the other has led us to adopt it for the purposes of this report.

The kind of engine recommended is what is call the double cylinder, with beam and fly-wheel. It is more expensive in first cost than the kinds commonly used, but the results obtained by it in England, and the greatly increased favor which

Double Cylinder Engines have received during the last few years for other purposes in this county, have led us to select it for the estimate. We must confess a little perplexity in the matter, however. If civil and mechanical engineers generally agreed on this question, it would be easier to convince the public of the wisdom of choosing a particular form, but in the midst of the great diversity that exists, there will necessarily be doubt with regard to the propriety of our choice.

While we have our own preference as above expressed, all the light we have been able to get on the subject satisfies us that far less depends upon the kind of engine than upon the skill with which the different parts are arranged and constructed, the perfection of the boilers and proper management in working the whole machine when in use.

For the preparation of the engine plans, we are indebted to G. M. Copeland, Esq., who was the superintending mechanical engineer of the pumping engines recently built by the Knap Fort Pitt Foundry Company, of this city, for the new Water Works of St. Louis. Mr. Copeland's general description of the engine accompanies this report.

In seeking a supply of water for a city of the present and prospective population and industry of Pittsburgh, two absolute requisites must be kept in mind—one is purity, and the other abundance. There should be no doubt with regard to either. Professor Wuth's analysis herewith presented, shows that nothing could be desired in respect to purity, except the removal of sedimentary matter, which would nearly, if not quite, all subside in the large reservoirs. The Professor, it will be seen, makes a very slight theoretical difference in favor of the Allegheny, which is also, as is well known, a clearer water than that of the Monongahela.

According to analysis, no important cities in this country are supplied with as good water as the Pittsburgh streams furnish, except Brooklyn and Boston; and none in Europe, that we know of, except Glasgow. With regard to abundance, there can be no doubt that, for present purposes, and the probable wants of the near future, either stream would furnish an ample supply.

The Allegheny would undoubtedly be sufficient for all time to come, but according to measurements taken by officers of

the Monongahela Slackwater Navigation Company, that stream falls so low in very dry seasons as not to discharge much, if any, over twenty million gallons a day. But even this would be claimed at such times by the company for lockage purposes. It would be necessary, in order to avoid litigation, to construct compensating reservoirs to supply the locks. Where these reservoirs should be located, and what would be their probable cost, we have not thought it necessary to ascertain. If it should be considered important to determine this question accurately, we think it would require at least a year longer.

We have estimated for conduits from the proposed pumping works on both rivers to such points above as are supposed to be beyond the reach of pollution from sewage for a long time to come. We do not believe, however, that it would be necessary for several, and perhaps many years to build either. On the Allegheny, in case no satisfactory arrangement by purchase or otherwise with owners of existing works above Negley's run could be made, it would probably be advisable to build an intercepting sewer at an estimated expense of about thirty thousand dollars, but of the immediate necessity of this we are not certain. It is a question that may be safely left for future determination, for in any event a remedy will be at hand.

Besides the possibility of contamination of the water of either river from the drainage of towns that may spring up along their banks, and which may be provided against in one of the ways already suggested, there will naturally arise the inquiry, What is to be done with the oil that may be wasted into the Allegheny above points over which the Legislature has given the city no control; that is, more than five miles above the point at which the water may be taken, if that river should be adopted as the source of supply?

In the first place, it may be answered, that the water to be used by the city should be taken from a deep pool, so far below the surface as not to be affected by floating substances. In the next place, it is not probable that the wasteful modes of handling and refining oil, which have hitherto prevailed, will long be practised in the future.

The least daily flow ever noticed in this river, as stated by Col. Roberts, is eight hundred and sixty-four million gallons.

It would seem impossible for such a stream to be seriously affected above the immediate influences of the city by any manufactories or other establishments to be erected along its banks. They could at least be controlled by legislative action sufficient to maintain the purity of the stream as is already done to a considerable extent in Great Britain.

It will be seen by what has been thus far presented, that of the two main schemes which have occupied our attention, the Monongahela would probably cost about four hundred and fifty-four thousand dollars more than the Allegheny, if the proposed conduits above the pumping works should be built. But if the conduits should not be built, then the probable cost of the Monongahela plan would be $6,825 less than the Allegheny. This difference might at first be increased $268,756 by omitting for a few years the construction of the Wilkins reservoir, and the laying of the distributing main from it; but ultimately this, or its equivalent, would have to be built to make the reservoir capacity of the Monongahela plan as great as that of the Allegheny; and in the meanwhile the Monongahela works would be less efficient and safe in case of serious accident to the pumping machinery, or a leak requiring repairs in the low service reservoir. The site of the low service reservoir on the Monongahela is remarkably fine, and the capacity of the reservoir itself is more than double that of the Allegheny low service. But the Allegheny middle service reservoir is also exceedingly well situated, and larger than the Monongahela low service, and would of course supply a greater extent of the city in case of serious accident to the works below.

The advantage of the Monongahela plan over the Allegheny consists in a less probable cost of from $6,825 to $275,581 in the first construction of the works.

The advantages of the Allegheny plan over the Monongahela are, the smaller probable cost in the future if conduits should have to be constructed to avoid impurities from drainage; the avoidance of possible litigation with the Monongahela Slackwater Navigation Company, or the construction of compensating reservoirs; the possibility of greatly reducing the annual expense of pumping by the use of water-power, should the supply demanded be largely increased; and the greater

clearness of the water, which, though of no practical value for many purposes, is certainly more grateful to the eye.

In view of the above statements, we feel it to be our duty to recommend the Allegheny river as the source of supply. We believe that the general plan we have worked out would be, on the whole, as judicious as any other that could be selected. In justice to ourselves, however, we would state that, owing to the general expectation that as early a report as possible should be made, on the one hand, and our desire to avoid all useless expenditure on the other, we have not worked out many details as thoroughly as we otherwise would. But this can easily be done by those to whom the construction of these important works may hereafter be confided.

We have been faithfully assisted in our labors by Messrs. Chas. MacRitchie, John Nichol, C. A. Cooper, and G. L. Miller; and our thanks are due for the constant and cheerful manner in which Messrs. H. J. Moore, City Engineer, and W. H. Kennedy, Engineer in charge of City Surveys, have communicated all desired information in their offices.

Respectfully submitted,

E. S. CHESBROUGH,
Chief Engineer.

MOSES LANE,
Associate Engineer.