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called in by the proprietors last September, and explained the simple and inexpensive arrangements by which natural ventilation alone would bring in air at a temperature little exceeding that of air at the surface, and left the captains to carry out my suggestions. I have been recently informed, that by following these suggestions, the temperature has been reduced from 105° to 80°, and the cost from 18*l.* to 5*l.*

At nearly all collieries employing above 100 hands warm baths could be advantageously supplied from the pumping engine, which would enable the men to wash immediately on leaving work, and their clothes could be dried so that the filth of the collieries would not reach their homes. The arrangement would involve the construction of a "changing room," as it is called in Cornwall, a walled tank, and a drying room, which might be on the top of the boilers. In Cornwall this practice has been adopted in several instances, but in some of the large works in France and Belgium the best examples are to be found. Nowhere have I seen in this country arrangements to be compared with those at Anzin, Grand Hornu, Mariemont, St. Etienne, &c., for providing commodious dwellings, and enforcing a police of health and cleanliness, fully appreciated by the workmen, and esteemed of the highest advantage and importance by the managers of those mining establishments. The expenditure for surface works at mines in this country is small compared with that in Belgium, where the seams are thinner and more expensive to work. The outlay in dwellings, in warm baths and washhouses, would be no great addition to the cost of a large mine, and it might in all cases be made to return a fair profit for the capital expended, apart from the advantage which an improvement in the moral condition of the workmen always places in the hands of the employer.

SUPPLY OF WATER TO WASHINGTON AND GEORGETOWN, UNITED STATES.

In the latter part of the year 1852, the President of the United States directed the Engineer Department to make the necessary surveys, projects, and estimates for determining the best manner of affording to the cities of Washington and Georgetown an unfailing and abundant supply of water. The late Capt. F. A. Smith, of the corps of engineers, was ordered upon this duty, upon which he had just entered when he was suddenly removed by death. Lieut. Montgomery C. Meigs, of the same corps, was then, on the 3rd of November 1852, assigned to the service. He has made his report to the President, through General Joseph G. Totten, Chief-Engineer.

The present population of Washington is about 50,000, and of Georgetown 8000 inhabitants.

Three schemes are proposed by Lieut. Meigs:—1st. An aqueduct from Rock Creek to the Capitol, navy yard, and public buildings. 2nd. The Little Falls works. 3rd. The Great Falls project. After some brief and interesting remarks upon the history of the water works and supply of the States, the storage, and modes of filtering adopted, Lieut. Meigs proceeds with his report as follows.

Description of Rock-Creek Aqueduct.

I propose to erect, at a point shown upon the accompanying map of Rock creek, a dam of masonry. Its height will be, in the middle of the valley, 41 feet above its foundations. It will be built of rubble masonry, faced with large stones, roughly dressed, and laid in hydraulic mortar. The foundation and abutments are of sound gneiss rock, which is well calculated to resist the abrasion of water falling from such a height. The rock will be excavated under the site of the dam till all the loose and unsound stone is removed. The plan of the dam will be an arc of a circle of 282 feet chord, and 30 feet versed sine—adding to the inertia of the masonry the strength of the arch. The back of the dam will be embanked with earth, as usual.

To prevent the slow wear of the masonry and foundations caused by the constant flow of a thin sheet of water, 20 feet of the dam near the west end will be left as a waste-weir, 2 feet lower than the rest, and a channel will be excavated through the rock, which here rises within 10 feet of the lip of the dam, to carry off the ordinary flow of the stream. This weir will be regulated by stop-planks, in the usual way.

The water will flow in the channel prepared for it without injury to the dam, which will be exposed to wear for a short time only, during freshets. Wings 10 feet above the crest of the dam extend into the hill on each side, protecting the abutments from wash during floods.

The water will be raised at the site of the dam 37 feet, and a pond of about $2\frac{3}{8}$ miles in length will be formed, whose surface, at a level of $166\frac{4}{100}$ feet above high-tide in the Potomac, will contain $141\frac{1}{4}$ acres.

The upper part of this reservoir will be excavated to secure a depth of 5 feet near the shore, so as to prevent, as far as possible, the growth of aquatic plants.

The water contained in this pool, within 5 feet of the surface, will be about 231,000,000 gallons.

A greater reservoir, but at great cost, might be made above the termination of this one; but the character of the valley here changes, and, without much expense in excavating its head and borders, we should only obtain a wide shallow pool, which, by the heats of summer, would be rendered too warm for drinking, and which in time—filled with aquatic plants and the countless millions of infusoria—would become a stagnant lake, deleterious to the health of the neighbourhood, and unfit for use in the city.

From this reservoir, I propose to convey the water by a conduit of brick 6 feet in diameter and 9 inches thick, laid, wherever it is possible, entirely beneath the natural surface. Where raised upon embankments or masonry, it will be covered with a depth of at least 2 feet of earth, sufficient in this climate to protect it from any damage by frost.

I propose the circular form, because it gives the greatest waterway, with least friction on the sides and least expenditure of material. The diameter is determined by the necessity of allowing free passage to workmen and officers engaged in the periodical inspection and repairs.

This conduit will be capable of delivering much more than the minimum supply of Rock creek; but there is no good reason why, because we can get only 10 millions in dry seasons, we should not take 20 when they are to be had. The slope being 1 foot per mile, and the depth of water 5 feet, the discharge will be 26,732,300 gallons a day.

Waste-weirs will be erected in the proper places to relieve the conduit from the surplus caused by floods, and a gate-house near the dam will regulate the quantity admitted.

The route is very rough and rocky, requiring several deep cuts, four bridges, and one tunnel. Generally, however, the line has been so placed as to require but little excavation and embankment. To secure this result, and lighten the expense, we were obliged to make the line very crooked.

The most considerable bridge is at Piney branch, where the valley is 537 feet wide and 73 feet below the water-line of the aqueduct. I propose to cross this by a bridge of eight arches of 50 feet span—the arches to be, except at the heads where exposed to the weather, of brick; the piers of good rubble masonry; and the style of the whole work substantial and plain. Its magnitude and simplicity will give it a good effect, which will be little inferior, I think, to that of a more ambitious and decorated structure. The cost of this bridge will be $68,123.

I do not particularly describe the other three. They are designed in much the same style, but, being smaller, are less costly. They might all be replaced, with some reduction of cost, by pipes; but I have in these projects avoided the use of pipes in crossing valleys. They always occasion a loss of head, or else exceed in cost the bridges they replace. New York now regrets the unwise economy which, to save $100,000 in a work costing $12,000,000, choked the aqueduct at the great Harlem bridge, sacrificed 2 feet of head, and reduced to one-half the capacity of a work everywhere else able to pass 60,000,000 of gallons a day. At a much greater expense it is now proposed to raise the Harlem bridge, as it should have been at first, to the general grade of the aqueduct.

The conduit crosses the high ground near the Russian minister's country-seat by a tunnel, about 1500 feet in length, through hard gneiss rock; shortly afterwards it crosses Piney branch by the aqueduct bridge above described, and then, ascending the valley of a small brook, a tributary of Piney branch, turns, near the toll-gate on the 7th-street road, to the south, and, by a cut of 31 feet in depth, reaches a ravine between Mr. Stone's house and 7th-street road, where it is proposed to locate the receiving reservoir.

This reservoir will be formed by throwing a bank across the ravine. This bank will be 15 feet wide on the top—the interior sloping to the low-water level at an inclination of $1\frac{1}{2}$ to 1, and

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protected from wash by a paving of brick secured at the low-water line with broken stone. Thence to the bottom, the slope will be 3 to 1. The exterior slope will be 2 to 1, and will be sodded.

A bank, paved on the interior, will surround this reservoir.

It is usual, in other cities, to pave the bottoms of the distributing reservoirs, but for this I see no necessity; and indeed I do not know but it would be as well, in construction, if the soil proves to be a good compact gravel, to omit the paving on the borders, except on the exposed bank which forms the retaining dam. Nevertheless, I have estimated for the construction of the banks in the customary mode, leaving it to be determined, upon further consideration, whether the paving may be dispensed with.

The drainage of the surface water, which should not be allowed to flow from the fields into this reservoir, offered, owing to the form of the ground, a difficulty. It is provided for by a small sewer, 3 feet in diameter, outside the bank. Probably more careful study of the ground than I have had time to bestow may enable us to devise a less expensive arrangement. Certainly we are safe in estimating for this one.

The usual precautions of puddling, &c., have been provided for in estimating for this reservoir. A smaller one might be erected at much less expense; but the smaller the supply from the source the larger the reservoirs required for storage, and I have estimated for completing this work upon a liberal scale. The price of the embankment has been put at a high rate; but it must be made with extreme care, for the consequences to the city of a breach in these embankments, holding millions of cubic feet of water, at a height of 160 feet above it, would be disastrous. The water would probably seek a direct course to the Potomac, sweeping everything in its way.

A waste-weir gives escape to the surplus water, which is carried off by the drainage-sewer surrounding the reservoir.

The conduit is continued on the east side of the reservoir to its south-eastern corner, where a pipe chamber and mains enable us to draw the supply directly from the conduit, in case of accident, foulness, or cleansing of the reservoir.

The effluent mains and drainage-pipes will be contained in a brick vault, under the centre of the dam; so that the whole water of this reservoir can be drawn off for use in a great conflagration or any other extreme case. Its ordinary level will be $162\frac{64}{100}$ feet above high tide, which is $6\frac{78}{100}$ feet above the roof of the wings of the Capitol, and $70\frac{22}{100}$ feet below the top of the balustrade on the dome.

The mains which lead the water into the cities I have estimated to be 30 and 12 inches in diameter. These are sufficient for the present, and, unlike the aqueduct, are easily replaced by larger; or new ones can be laid beside them, as the wants of the cities increase.

All leading and important mains should be double, to prevent the interruption of the supply by accidents; but it is not necessary that they should all be of the same size. The twelve-inch main will afford enough for an economical use during the short time needed for repairs of the larger one.

A portion of Georgetown is at too great a height to be supplied by the natural flow of water from any source within reach.

I propose for this high service—supplying perhaps 1000 persons—to pump the water into a reservoir upon the heights of Georgetown. This reservoir will be of earth, the materials of the bank being supplied by the excavation of the centre. It will be about three-fourths of an acre in extent, and contain, when filled to a depth of 10 feet, about 2,500,000 gallons. The pump will be worked by a small turbine placed near the river in Georgetown, and driven by a pipe from the main with a head of 162 feet. The difference of level to be overcome being only 48 feet, the expenditure of a small quantity from the main will suffice to keep this reservoir full. The wheel and pump will be of sufficient power to raise the quantity needed for the daily consumption in 10 hours; so that the water necessary may be drawn from the mains at those hours of the night or day when it can be best spared.

The length of this aqueduct will be as follows.

From the head of retaining reservoir to dam ...	3·625 miles	
Conduit	3·8067	
		7·4317
Add length of mains to Pennsylvania		1·818
Total length to where pipes are common to all plans proposed, —nine and a quarter miles.		9·2497

Description of the Project for Supplying Water from the Great Falls of the Potomac.

The traveller ascending the bank of the Potomac from Georgetown to the Great Falls would conclude that a more unpromising region for the construction of an aqueduct could not be found. Supported by high walls against the face of jagged and vertical precipices, in continual danger of being undermined by the foaming torrent which boils below, the canal is a monument of the energy and daring of our engineers. The route seems occupied, and no mode of bringing in the water except by iron pipes secured to the rocks or laid in the bed of the canal seems practicable. Such were my own impressions; and though I knew that, in this age, with money, any achievement of engineering was possible, I thought the survey would be needed only to demonstrate by figures and measures the extravagance of such a work.

But, when the levels were applied to the ground, I found, to my surprise and gratification, that the rocky precipices and difficult passages were nearly all below the line which, allowing a uniform grade, would naturally be selected for our conduit; and that, instead of demonstrating the extravagance of the proposal, it became my duty to devise a work presenting no considerable difficulties, and affording no opportunities for the exhibition of any triumphs of science or skill.

Indeed, the nature of the country is such as to present less than the ordinary difficulties to be expected in such an undertaking. There are several tunnels of an average length of only 220 feet; but three bridges, and only one of these large enough to make its erection an object of ambition to an engineer. The line runs on the slope of the hills, which is generally moderate, and such as to afford choice of ground. It has been located so as to conform to the surface, and requires very light excavation and embankment. As will be evident from the accompanying map, it is a very direct line, of remarkably easy curves, much less crooked than the line we were compelled to adopt on Rock creek; though longer, with fewer bridges, and those, except in one instance, less costly. The distance in a right line from the beginning of the conduit to the north end of the Georgetown aqueduct is $11\frac{3}{4}$ miles; the length of the conduit is about 14 miles, including the reservoirs and the pipe, to this same point.

One great source of expense, however, is the number of small ravines which furrow the hill-sides, generally dry, sometimes containing small streams, but all liable, after heavy thunder-showers, to pour down torrents, requiring liberal culverts for their passage.

The elevation of the water in the Potomac opposite the fifteenth milestone on the canal, which is somewhat less than $\frac{3}{4}$-mile above Collin's Great Falls house, is, at low-water, 147 feet above high-tide at Washington. Our examination showed an average depth of less than 5 feet, a ledge of rock extending across the river and forming a natural dam.

In ordinary stages, the water is 2 or 3 feet higher. A dyke of rock thrown across the stream, 1541 feet in length, and 8 feet in height, will raise the water, at its lowest stage, to the level of (150). A brick conduit laid in a trench, and covered up with rock and earth, will conduct the water to the tail of the 18th lock on the canal. Here a large pipe-chamber will be constructed, serving as a waste-weir to relieve the conduit from the superabundant waters of great floods. Wastes will be put in at several points between this chamber and the head of the conduit at the dam to establish an equilibrium between the pressure within and without in floods, which may rise to a height, in some places, of nearly 20 feet above this conduit.

It may prove, upon further examination, a better and cheaper arrangement to carry a wall or dyke from the end of the dam along some islands near the Maryland shore, so as to make this part of the aqueduct an open canal; but the determination of this question must be left to the surveys for a final and definite location.

The height is not sufficient to cross over the canal, and any location between the canal and river below this point will be insecure and very expensive.

The water will, therefore, be conveyed by large iron pipes, under the canal, to a gate-house on the opposite side, where regulating-gates, worked by screws, will control the quantity to be admitted; while throttle-valves in the pipes, governed by a large float, will cut off the communication entirely when the river rises to a height likely to be injurious to the conduit.

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After leaving the gate-house, the water will be conducted to the receiving reservoir through a brick circular conduit 7 feet in diameter, 9 inches thick, covered always with at least 2 feet of earth. With a slope of 0·792 foot (a little over 9 inches) to the mile, the water running at 6 feet depth, this conduit will discharge 36,015,400 gallons in 24 hours. At a depth of 3½ feet, the discharge would be 17,734,300.

A small increase in the size of the conduit would very much increase the quantity of water. A conduit of 9 feet interior diameter, water 8 feet deep, would deliver 67,596,400 gallons a day. The quantity which can be supplied by the river being almost unlimited, it is difficult to decide upon the size of the conduit.

I have taken 7 feet diameter, because I considered it safe to construct one of that size, with an arch of 9 inches thickness; while a larger size would probably require a half-brick to be added to the arch, and thus considerably increase the cost. The difference in the excavation and embankment, however, would not be very great, and the increased expense by no means proportioned to the increased delivery.

There are two short tunnels near the pipe-chamber—one 215, the other 272 feet in length. They must be driven through hard gneiss rock, but offer no particular difficulty.

After leaving these tunnels, the line for about a mile is principally in rock; but the excavation is light, as will be seen by the profile upon the map. It crosses a ravine and small brook by an arch of 24 feet span, and soon after passes through two tunnels—one 115, the other 61 feet in length. The character of the rock is the same as in the first tunnel. At 5⅗ miles from the dam it crosses Mountain-spring brook by an arch of 50 feet span, and proceeds in easy cutting to the end of the seventh mile, where it meets the only serious obstacle on its whole course. This is the valley of the Cabin John branch. The bottom of the stream is 95 feet below the water in the aqueduct. This valley might be crossed by pipes; but the reasons given in describing the bridges on the Rock-creek line, and the experience of the Harlem bridge, on the Croton aqueduct, are sufficient, I think, to prove that a bridge, unless very costly, should be preferred.

The bridge proposed will be 482 feet in extreme length; its greatest height 101 feet; width, 20 feet; and will consist of 6 semicircular arches of 60 feet span, resting upon piers 7 feet thick by 20 feet long at the top, and of various heights, the highest being 52½ feet.

The piers will be of rubble masonry of large stones, which can be quarried within a quarter of a mile of the site; the ring-stones, at the ends of the arches, of well-cut stone; and the remaining part of the arches of brick.

This bridge will cost $72,409, and is the only large one upon the route.

The line then passes through favourable ground, being generally two-thirds of its depth below the natural surface. There are some ravines requiring embankments near the Little Falls, and the hill-side there is steep and stony.

Near the end of the tenth mile the line turns to the north-east, and, by a tunnel of 440 feet, reaches the valley of Little Falls or Powdermill branch. This is the last tunnel. The aggregate length of the whole five is 1103 feet, or less than ¼-mile.

A comparison with the tunnelling of the Croton aqueduct will show how favourable is the ground.

There are on the Croton aqueduct 16 tunnels; the shortest 116, the longest 1215 feet in length—longer than the whole of those upon this line.

The aggregate length of the 16 tunnels on the Croton is 6953 feet.

A dam across the valley of the Little Falls branch, 41 feet in height above its foundation, and 200 feet in length, floods 50·65 acres, making a reservoir of irregular shape, containing, above the level of 140 feet above high tide, 82,521,500 gallons. This is the receiving and settling reservoir. The water leaves it at a distance of 3000 feet from the point where it enters; and, in slowly passing across the pool, which deepens to 30 or 40 feet near the exit, it will deposit most of its sediment.

Powdermill or Little Falls branch is itself a valuable addition to the supply. The water is beautifully clear, and pleasant to the taste. During summer it never, I am informed, entirely fails; and at the time of our surveys I judge that it yielded as much as two or three millions of gallons a day.

An important advantage results from the formation of this reservoir, in hastening the time at which the water can be introduced into the cities. There are no tunnels or bridges on the line below this point; and the work, being light, except the construction of the distributing reservoir, the completion of which might be dispensed with for a short time, can be finished in a few months: so that, as soon as pipes are laid, and the dam on this stream completed, the two or three millions it affords in the autumn and winter can be introduced.

This could, without difficulty, be accomplished by the beginning of the next session of Congress.

The dam here is planned upon the model of the Croton dam, but with less cut stone, and in a less expensive but equally durable style.

The distance from the effluent gate-house of the receiving reservoir to the influent gate-house of the distributing reservoir is not quite two miles. The slope of the conduit, on leaving the receiving reservoir, is diminished to about 3 inches per mile. The two reservoirs are so near each other that their level is expected to remain nearly the same—145 feet above high tide.

The cutting on this portion of the line is almost entirely in clay, and the work is light, and offers no difficulties.

From the influent gate-house of the distributing reservoir the conduit is continued under the reservoir bank to an effluent gate-house and pipe-chamber at the end near Georgetown. An iron pipe communicating with the mains leading from the reservoir into the cities will afford the means of drawing a supply direct from the conduit when cleansing the distributing reservoir, or in case of interruption to its use during repairs.

The distributing reservoir is upon the thirteenth mile, making the whole distance from the dam to the end of the distributing reservoir, and including three-fifths of a mile in the receiving reservoir, less than 13 miles.

The distributing reservoir is near the Drover's Rest, above Georgetown. There is much land here suitable for the erection of a reservoir, and perhaps more exact surveys may induce a change in the location. The bank between the reservoir and the bluff will be constructed upon the same general plan as that proposed for the Rock creek line. The soil being clay, however, this bank will not require the heavy puddle-ditch in its centre there provided for. Its average depth is about 14 feet, its water surface is 36⅗ acres, and is 145 feet above tide. Contents at 14 feet depth, 167,530,000 gallons; within 5 feet of the surface it contains 59,783,000 gallons.

The two reservoirs will afford, supposing the conduit to be interrupted by floods or accident, or during the periodical examinations necessary for repairs, 142,304,500 gallons, without reducing the head below 140 feet; and in case of emergency, supposing the surface lowered to 131 feet above tide, they will yield 250,000,000 gallons, besides what will be supplied during this time by the flow of the Little Falls branch.

A pipe is inserted under the bank of this reservoir to drain it into the canal, for cleansing or necessary repairs. It is divided into two nearly equal parts by a bank rising nearly to the surface of the water, designed to assist, by allowing only the surface water to flow over it, in separating the turbid from the clear water, as explained in the remarks upon filtration submitted in the earlier part of this report. A communication-pipe and stop-cock are inserted in this division bank. The effluent pipe-vault is at at the south-east end towards Georgetown. It contains two pipes of 36 inches diameter.

The mains proposed are double, to guard against accidents, and admit of repairs without cutting off the supply entirely. One will be of 30 inches, the other, laid beside it, of 12 inches diameter. They follow the most direct route into Georgetown, down Bridge-street and Pennsylvania-avenue to the Capitol.

In the estimate I have provided for a small reservoir for high service in Georgetown, as in the project for the Rock-creek aqueduct. It will be supplied in the same way, by a force-pump, worked by a turbine with water drawn from the mains.

The estimate for the Great Falls aqueduct includes the mains, to the intersection of High and Bridge streets, in Georgetown, whence the pipes leading to the Capitol, Navy-yard, and principal public buildings are common to all the plans proposed.

A reduction might be made in these estimates by diminishing the size of the distributing reservoir; but this, I think, for reasons given above would be an unwise economy.

I have estimated throughout to do the work in what appears to me the best manner. We have within our reach, at a moderate expense, the finest supply of water ever offered to a city; and to

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build an imperfect work now, would only entail the necessity of enlarging it, at great expense, hereafter.

The mains leading from the reservoirs are, I think, enough for the present. In a few years it will be necessary to enlarge them. Then the 12-inch can be taken up and relaid in the distribution of the city, its place being supplied by one of 36 inches.

A separate estimate provides for the mains to the Capitol, the Navy-yard, the Arsenal, the Patent Office, the City Hall, the Mall, and the Observatory.

In comparing the estimates for the Rock-creek and the Potomac aqueducts, it will be seen that the cost of reservoirs is nearly the same—

Those for Rock-creek costing...	$260,403
Those for Potomac costing	266,291
The iron mains for Rock-creek will cost ...	451,063
For Potomac	398,726

The excess in cost of the Potomac line arises chiefly from the greater size and greater length of conduit.

The total cost of the Rock-creek aqueduct, including distribution to the public buildings, will be $1,255,863; of the Potomac, $1,921,244.

The former will deliver, when the creek can supply it, in the wet months of winter and spring, 26,732,300 gallons a day; but will sometimes, in hot weather and long-continued droughts, be reduced to 10,000,000.

The latter will always be capable of affording, in the hottest seasons, 36,015,400 gallons a day.

The height at which the water of the Great Falls can be delivered in the Capitol, 14 feet above the upper floor, is, I think, quite sufficient to secure the safety of the building, and of the invaluable collections therein contained; but should it be desired to have the power of pouring the water upon the roof itself, this can be done by a small turbine-wheel and force-pump, which, as for the high service of Georgetown, can be worked by water from the main.

Thus an iron tank on the roof might be kept constantly overflowing, and this store could be let loose at any moment, and its stream be directed upon any point required.

I say constantly overflowing. There would then be no danger of the tanks being frozen; and the surplus water conveyed away by a pipe, might escape in a fountain in the grounds.

Were it not for the great importance of protection to this building, it would be better to reduce the height of the reservoirs, in order to diminish the pressure upon the mains and service-pipes, which require to be made of great strength to resist the strain caused by such a head. The full head, however, has an advantage in permitting the use of much smaller leaden service-pipes in houses.

Description of the Project for Supplying Water from the Little Falls of the Potomac.

When I took charge of these surveys, I had formed an opinion that the nature of the ground between Georgetown and the Great Falls was such as would make any line of aqueduct thence enormously expensive.

I knew of the country only what can be seen in riding along the canal, whence it presents a series of ravines and precipices.

I knew also that Rock-creek was not a very large stream; and I turned my attention to the Little Falls of the Potomac.

There is a dam, built by the Chesapeake and Ohio Canal Company about four and a-half miles above Georgetown aqueduct. The fall of the river between this dam and Georgetown is 36 feet. The great size of the river, with the height of the fall, and the great water-power thus created, appeared to offer the means of raising, by machinery, the water necessary for a supply.

London, by steam power, pumps up 45,000,000 gallons daily.

The Great Falls route, proved, upon examination, much more favourable than I expected; and, fearing I would not be able to perfect all these projects during this session of Congress, I studied and completed first the design for the work from the Great Falls. That from Rock-creek was next taken up; and, time pressing, I have been obliged to make the estimate for this from the Little Falls with less exactness than the others.

The difficulties to be overcome are great. The Potomac, one of the great rivers of the continent, rises in floods sometimes 30 feet above its ordinary level. The people of Georgetown and Washington have seen proofs of its power in the wreck of their bridges and canals. Unlike the Mississippi and Ohio, which, when at their highest, move calmly and majestically, the Potomac, shut in between steep hills, and chafed by its rocky bed, resembles, at these times, a mountain torrent. Every new construction in such a river tends, by diminishing the space for its waters, to cause the next great flood to rise still higher. The engineers of the Chesapeake and Ohio canal have long fought it, replacing their guard-banks, destroyed by the floods, too often only to find the next freshet going beyond their calculations, and sweeping away the barriers placed in its course.

These difficulties, however, I believe, can be overcome; but they entail the necessity of very expensive constructions.

I regret that I have not more time at my disposal for a careful study particularly of this project. Perhaps it might safely be reduced in expense. It cannot be perfectly and fairly presented without detailed drawings, which I have not time to prepare; and doubtless, further and more deliberate study would enable us to improve it. For each difficulty I am obliged to seize the first and readiest solution. I have had but three months to survey, devise, project, and estimate three great works, either of which is well worthy the study of a year.

I propose, then, to bring the water of the Potomac, by a canal, about 100 feet wide and 6 feet deep, at the level at which the present Chesapeake and Ohio canal enters Georgetown, and located between this canal and the river, to a suitable place, about two miles above the Georgetown aqueduct, and there, by the proper machinery, to elevate it to such a height as will enable us, partly by a brick conduit, partly by iron pipes, to convey it to the cities.

For the construction from the end of the pumping-mains to the cities, I have adopted part of the project for the Great Falls aqueduct. I believe it is well adapted to the object, and it will have the advantage of being capable of extension, at a future day, to the Great Falls, when the wants of the cities increase to such an extent that the use of pumping machinery becomes too expensive.

One advantage of this plan is the security it will give to the Chesapeake and Ohio canal. To render ourselves safe, we must necessarily secure them. But the works for security must be high, and strong, and costly.

Part of the dam at present existing would be repaired, and a new location adopted for the rest of it. It would extend from the island shown on the map, in the middle of the river, to the head of High island. Under protection of this rocky island, a guard-lock and sluice-ways will be placed. A guard-bank, reveted on the exterior with masonry, will extend from this lock to the Maryland shore; and, a stop-lock being placed upon the Chesapeake and Ohio canal, the bank and wall will be connected with the high and rocky shore on the north-east side of the canal.

If these structures are high enough to overtop the highest floods, and strong enough to resist their pressure, they will render this portion of the work secure.

The highest flood known is that of April 1852. By marks then placed by Mr. W. H. Bryan, C.E., it reached, at the location of these works, a height of $17\frac{1}{10}$ feet above the top of the dam.

Our guard-bank, shutting out the river from the space between High island and the Maryland shore, will, by contracting its water-way, cause the next great flood to rise still higher—how much it is impossible for me to predict with exactness; but I believe that works rising 10 feet above the flood of 1852 will be safe from overflow. I have adopted this height in our project, keeping our banks and walls everywhere 10 feet above the flood of 1852.

The construction of a lock will be necessary in order to permit the passage of boats which occasionally will need to navigate the river, and for our own use when engaged in repairs of the dam.

The water will be admitted to the canal through ten sluices, 6 feet by 4 feet, in each of which are sliding-gates worked by screws. The gates are double, to guard against accidents; and there are grooves for stop-planks, to permit the gates to be taken out for repairs.

The sluice-ways and facing of the lock-walls are of cut stone; the rest of the work of heavy gneiss rubble masonry, laid in hydraulic mortar—the walls of great strength and thickness.

They have been carefully calculated, and are believed to be sufficient to resist the floods and ice.

The location alone of these works could be represented on the map. Slight drawings of them I have made; and I have sufficiently studied their details for the estimate.

High island forms a portion of our guard-bank. Below its

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foot a high embankment, 10 feet wide on the top, with slopes of 2 to 1, divides the canal from the river. It extends to within two miles of the Georgetown aqueduct. Its length is about two miles. Its top is kept 10 feet above the level of the highest recorded flood. Its exterior slope is protected from wash during floods by a thick covering of loose stone. In ordinary stages of the river it is not reached by the water.

The crossing of the stream known as the Little Falls branch presents a serious obstacle. To make our canal safe, it is necessary to shut out the floods, which here rise to a height of 6 feet above the surface of the water in the canal. Thence may result an upward pressure of a column of water 6 feet in height, tending to burst up the culvert. The flood, too, may come at a time when the Chesapeake and Ohio canal is empty: the upward pressure will then be that of a column of water 12 feet in height. The brook is too large to be passed in iron pipes, and a culvert of masonry will be needed. The river might be shut out of this culvert by sluice-gates; but if the brook should happen to be swollen at the same time as the river, it would then overflow into the canal, and might do serious damage. The sluice-valves, too, might be obstructed by the heavy stones brought down by this brook, which is sometimes a torrent. An open sluice, by admitting the river, would involve great danger to the works. The only complete solution seems to be, so to arrange the masonry in masses, leaving proper passages for boats on the canal, but connected by counter-arches, as to bring its whole weight to bear as one mass in resisting the upward pressure. This has been done.

The details of the pump-house I have not, for want of time much studied, but its general arrangement and size I have determined. For the machinery, I propose to use pumps of similar design to those for so many years in use in Philadelphia, but of greater size. They would be driven by turbine-wheels, upon the same principle as that so successfully applied by Mr. Graff at the Fairmount waterworks.

The quantity proposed to be raised by each pump would be 6,000,000 gallons, which would be raised to the height of 145 feet in twenty hours, allowing four hours a day for repairs, oiling, cleaning, &c.

I have procured an estimate from Mr. Geyelin, the designer and builder of the turbine and pump at Fairmount. It is appended to this report. In the development of our plans, the case has somewhat changed from that submitted to him, but it would not probably much alter the cost.

I propose to establish at once two sets of such machinery, each capable of raising 6,000,000 gallons a day.

The machinery must be in duplicate, to guard against accidents, and allow for repairs. Other wheels and pumps could be added as the wants of the cities increase. The water from the pumps will enter a stand-pipe—a vertical tube of wrought-iron boiler-plate, 6 feet in diameter, 160 feet high. It might be supported by stays of iron; but it will be better to surround it by a tower of masonry, with a spiral staircase between it and the masonry, to admit of frequent examination and repairs of leaks. The tower I would make circular in plan, and of brick; the stairs of cast-iron.

The stand-pipe is necessary to avoid the strain upon the pumps caused by pumping directly into the long mains leading to the reservoir. Air-vessels will assist in relieving the pumps, but will not alone be sufficient where the quantity of water to be raised is so great.

Two 36-inch mains will lead the water under the canal and up a small ravine to a pipe chamber on the hill. The aqueduct from the pipe-chamber shown on the general map is a part of that described in the Great Falls project, and needs no further remarks here.

Perhaps it would be better to shorten the canal, and locate the pumps higher up the river, so as to bring in, with considerable increase of cost, but with great advantages to the project, the settling reservoir at the Little Falls branch.

This project requires for its execution more skill and science than either of the others, and it bears a tempting aspect. The engineer who bridles and masters the Potomac will achieve fame.

The whole cost estimated, $1,597,415, would be not much less than that of the aqueduct from the Great Falls; and, that being far better, I should not have presented this to your notice, had not public attention been attracted to the Little Falls as a source of supply. My instructions were, to make surveys, projects, and estimates for determining the best means of affording to the cities of Washington and Georgetown an unfailing and abundant supply of good and wholesome water. I present all those which I have made—as well as those which I think are shown by our investigations not to be the best, as that from the Great Falls, which I believe to be the only one which will continue for many years to supply the wants of the metropolis and Georgetown.

Should the route from the Great Falls be adopted, and money be appropriated so as to be available early this season, I would advise the immediate commencement of the dam at the Little Falls branch, and the conduits and mains thence to the Capitol.

The water from this stream could then be introduced next winter; and the remainder of the work could be pushed through within the next year or eighteen months.

If the work is delayed by meagre appropriations, its expense will be much increased; and I hope, in that case, not to be held responsible for its cost above my estimate, which is based upon a steady and vigorous prosecution of the work.

The sum necessary to complete the work between the city and the settling reservoir on the Little Falls branch, not including the construction of the distributing reservoir, is about $700,000; but this would not allow us to commence the dam and tunnels on the line above, which should be among the first works undertaken.

In preparing these estimates, I have supposed the work to be substantially but plainly done. In the few bridges and buildings required, I have adopted a simple style, without much ornament, but suitable to the greatness and importance of their object. I have avoided all those expedients which, while they might somewhat reduce the cost, would impair the efficiency of the work.

There was only time to make a first location, and no doubt further surveys and more close examinations will show some changes to be proper. But the line we discovered from the Potomac is marked so plainly by the natural features of the ground, that I do not believe any great changes will be made.

The work, as located, can be built for the estimate, and will fulfil its purpose. Any changes will be made, not for greater security, but for economy; and will result, therefore, in diminishing, not increasing the cost of the work.

I have been particularly cautious not to lead Congress into error as to the cost. The prices adopted are liberal—the quantities carefully calculated. Wherever we had a doubt, we took the higher price. And I feel assured that the estimate is a safe one. Its preparation has involved a great deal of labour; and if it fails, it will be from some unforeseen contingency, which no care or foresight on our part could provide against.

Summary.

In conclusion, I have to recommend, as, in my opinion, the "best means of affording to the cities of Washington and Georgetown an unfailing and abundant supply of good and wholesome water," the construction of the aqueduct from the Great Falls of the Potomac.

The source is pure and unfailing; the quantity inexhaustible; the expense, when compared with its objects, moderate. Every dollar of capital expended will bring, for centuries, nineteen gallons a day of good and wholesome water into the cities.

In New York, each dollar of capital expended in the construction of the Croton delivers two and a half gallons a day.

In Boston, each dollar delivers two gallons only.

The Croton aqueduct cost $12,000,000; the Cochituate, $5,000,000. Buffalo has spent $400,000. Jersey city is spending $600,000. One district of Philadelphia (Spring Garden,) has expended $300,000.

I might multiply instances tending to show the sum estimated above for the supply of the metropolis, on a scale commensurate with its prospects, is moderate. But I fear that, while those not accustomed to the great expenditures common for such purposes may think it large, I shall be censured by engineers for making the estimate too small. The supply of 36,000,000 gallons by an aqueduct costing, exclusive of distributing-pipes, little over a million and a half, is so contrary to the experience of New York and Boston, that it may well excite surprise. The explanation is to be found in the shortness of the line—less than thirteen miles—and the favourable character of the ground on which it is located. A comparison of the tunnels with the Croton has been made above; and the same relation holds throughout. There are no deep cuts; no high walled embankments; no Harlem bridge, costing near a million itself. The most costly bridge on this line can be built for $72,500.

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The length of the Croton, from the head of the retaining reservoir to its termination in the distributing reservoir, is 45 miles.

The Cochituate, from the lake to the Beacon Hill distributing reservoir, is 20 miles in length. The Potomac aqueduct, to the end of the distributing reservoir, will be less than 13 miles.

Were I to recommend any change in this project, it would be to increase the diameter of the conduit. An increase of 2 feet, making a 9-foot conduit, would nearly double the quantity of water—delivering 67,596,400, instead of a little over 36,000,000 gallons.

The reservoirs would not require to be enlarged, and the increase of expense would fall chiefly upon the grading and embankment—which cost for the 7-foot conduit only $352,543, and would not be increased more than $100,000—and upon the conduit-trunk itself, which would cost about $250,000 more than the present one. The increase of cost to bring in 30,000,000 gallons more of water would thus be about $350,000, which is at the rate of 86 gallons daily for each additional dollar of capital expended.

The great supply obtained by the aqueduct from the Great Falls has the advantage of making it available for the numerous manufacturing purposes where a small steam-engine is too expensive, and heavy labour falls upon the mechanic in consequence.

It can be applied cheaply to the driving of lathes in the smaller workshops of a city. To the printing press, and to many other such uses, it is particularly adapted. I am informed that a newspaper of large circulation in Boston is printed upon a press driven by a small rotary pump, the power being supplied by a service-pipe from the street-main. The water is sold by the city at a fixed rate per gallon. The revolution of the pump measures the quantity, as in a gas-meter, and there is no waste. The cost is not greater than the wages of an engineer to attend a steam-engine—thus saving the expense of fuel and fireman, and the trouble and delay of getting up steam. The power is always at hand, and, on turning a cock, the machine is at once in action.

In a previous portion of this report, I made a comparison between the cost and advantages of the Rock-creek aud Great Falls lines. Perhaps it will be well to give in this place a summary relating to each of the three projects submitted.

The Rock-creek project is less costly than either of the others. Its supply is large enough for the present in winter; but it is liable to be diminished, at the time when a full supply is most needed, to about 10,000,000 gallons a day. The cost, complete, will be $1,258,863.

The Little Falls project offers the advantage of securing the Chesapeake and Ohio canal from damage by floods. It is less costly than the line from the Great Falls.

Its disadvantages are, that it requires the use of pumps and machinery; and I think the reasons I have elsewhere given in discussing the different modes of gaining proper height, are sufficient to justify my preference for a supply by the natural flow of the water.

The quantity to be thus raised is limited, also. The Potomac is a great river, but it diminishes in summer; and, though I have no doubt of its power at any season to supply the canal, and spare water enough to pump up twelve or fifteen millions of gallons, it may be doubted whether the power to raise thirty-six millions—the supply given by the Great Falls aqueduct—will be always available. And should this latter be constructed on the enlarged scale suggested of 9 feet diameter, capable of delivering 67,000,000 gallons a day, it will be still more decidedly superior.

This project is also deficient in reservoir space; and though we could add to it the Little Falls branch settling reservoir, it would be at the sacrifice of some of its advantages. The cost of the Little Falls work, as designed and estimated, will be $1,597,415.

The aqueduct from the Great Falls offers, I think, uncommon advantages. They are set forth in a previous portion of this report, and I shall only slightly recapitulate them here. Among them are: the simplicity and durability of the work; the purity and abundance of the source; the extent and capacity of the reservoirs, by which ample supplies are gained to guard against accidents and great emergencies, and which, allowing space and time for settling, secure the delivery of a supply clear and free from mud; the height at which it is delivered—14 feet above the upper floor of the Capitol; its adaptability to manufacturing purposes; the great quantity it will supply, while it takes from the river only what it delivers in the cities, not drawing off, as when machinery is used, seven or eight times as much to drive the wheels as those wheels and pumps raise for use. This enables us to use the water more freely than from either of the others. The streets, in hot weather, may be flooded every morning by hose. Every particle of dust or of offal prejudicial to health or comfort would thus be washed into the sewers. The most magnificent fountains could be kept constantly flowing; and the city of Washington, unrivalled in grandeur and beauty of plan, would, in a few years, refreshed by living streams, and beautified by sparkling jets and towering columns of water, become a place of summer resort and the admiration of our whole people.

What American looks upon the great public buildings of our capital but with a feeling of pride and pleasure? Let our aqueduct be worthy of the nation; and, emulous as we are of the ancient Roman republic, let us show that the rulers chosen by the people are not less careful of the safety, health, and beauty of their capital than the emperors who, after enslaving their nation, by their great works conferred benefits upon their city, which their treason almost forgotten, cause their names to be remembered with respect and affection by those who still drink the water supplied by their magnificent aqueducts.

The cost of this work will be $1,921,244.

For the discharge of the conduit I have used with confidence the formulæ of D'Aubuisson, as reduced to English units in his admirable work on hydraulics, so well translated by Mr. J. Bennett, C.E., of whose assistance I have had the advantage in conducting the Rock-creek survey.

The revetment and other walls submitted in these projects have been calculated by the formula of Poncelet; the thickness of the arches, by that of Peronnet; and for their thrust and equilibrium, I have used the tables of Captain Petit, of the French corps of engineers, contained in the Memorial du Génie.

In conclusion, I have to acknowledge my obligations to the gentlemen from whose reports I have derived information. Schramke's description of the Croton aqueduct, the reports of Messrs. McAlpine, Baldwin, Eddy, Jervis, Johnson, Chesbrough, and Graff, and of the Croton Board, the Cochituate Water Board, and the Watering Committee of Philadelphia, contain a body of valuable information upon this subject, of which I have freely availed myself.

METROPOLITAN BUILDINGS BILL.

A Bill has been prepared and brought into the House of Commons by Sir William Molesworth and the Lord Advocate. The following gentlemen have been nominated to form the committee on the bill:—Sir W. Molesworth, Lord J. Manners, Lord R. Grosvenor, Sir J. Shelley, Sir W. Clay, Sir J. Paxton, Mr. Alderman Cubitt, and Messrs. Brand, W. Williams, Jackson, and Locke.

The bill repeals the present bill and its amendments; it gives rules to be observed with respect to measurement, structure, and thickness of walls, buttresses, &c.; construction of roofs; as to close fires and smoke pipes; projections; interiors of buildings; separation of buildings; uniting buildings; &c.

District surveyors are henceforth to be appointed by the Commissioners of Works and Buildings, who may remove them. Assistant surveyors may be appointed in emergency.

The Commissioners of Works and Buildings may, for the purpose of superintending the district surveyors, and aiding in the execution of the act, appoint a person to be called the superintending architect of the Office of Works; the salary not to exceed 1200*l.* per annum.

Differences arising between building owners and adjoining owners are to be determined as follows:—

1. Where value of difference does not exceed 100*l.*, or by consent of parties, by two justices.
2. Where value exceeds 100*l.*, by arbitration, to be conducted as directed by the Companies Clauses Consolidation Act, 1845.

An appeal to the superior courts is given from the decision of justices, in respect of any point of law, or of the admission or rejection of any evidence. No such appeal to be made by any district surveyor, except with consent of justices before whom the case is tried. Appeals to be in the form of a special case.

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