IN THE SENATE OF THE UNITED STATES.

APRIL 15, 1864.—*Resolved*, That one thousand extra copies of the Report of the Washington Aqueduct be printed; five hundred for the use of the Interior Department and five hundred for the use of the Senate.

Mr. MORRILL, from the Committee on the District of Columbia, presented the following supplemental report of the Engineer of the Washington Aqueduct, which was ordered to be printed.

SUPPLEMENTAL REPORT OF THE CHIEF ENGINEER OF THE WASHINGTON AQUEDUCT.

DEPARTMENT OF THE INTERIOR,
Office of the Washington Aqueduct, February 22, 1864.

SIR: The Senate having, on February 2, 1864, passed the following resolution, to wit: "*Resolved*, That the Committee on the District of Columbia be instructed to inquire into the subject of the Washington aqueduct, and the necessity for further appropriations therefor; and into the subject of sewerage in the city of Washington, with power to send for persons and papers."

And the committee having expressed a desire to make a thorough investigation of the manner in which all past appropriations have been expended; and also of the details and explanations of the estimates, submitted in the last annual reports from your department, of the amount required for future expenditures, in order that they may form an intelligent opinion as to the necessity for any further appropriations by Congress, I have, under your instructions, prepared the following

SUPPLEMENTAL REPORT,

in addition to, or in further explanation of the last annual report from this office, dated October 1, 1863, in relation to such matters as may come within the scope of the investigations under the aforesaid resolution.

It is assumed that the general objects of the investigation are to ascertain, first, whether the past appropriations have been expended in accordance with the directions of Congress, as expressed in the laws passed in relation to the Washington aqueduct; second, whether these expenditures have been made in a manner best calculated to secure, with reasonable economy, the objects for which the work was undertaken by the government; and, third, whether any, and, if so, what amount of further appropriation is now required for the proper protection, prosecution, and completion of the work.

1. LAWS OF CONGRESS RELATING TO THE WASHINGTON AQUEDUCT.

The first enactment by Congress in relation to this work will be found on page 92, volume 10, Statutes at Large, in the general appropriation bill passed April 31, 1852, which reads as follows:

"To enable the President to cause the necessary surveys, projects, and estimates to be made for determining the best means of affording the cities of Washington and Georgetown an unfailing and abundant supply of good and wholesome water, report thereof to be made to Congress at its next session, the sum of five thousand dollars, or so much thereof as may be found necessary."

The second enactment will be found on page 206, volume 10, Statutes at Large, in the general appropriation bill, passed March 3, 1853, which reads as follows:

"To be expended under the direction of the President of the United States, for the purpose of bringing water into the city of Washington upon such plans and from such places as he may approve, one hundred thousand dollars: *Provided*, That if the plan adopted by the President of the United States should require water to be drawn from any source within the limits of Maryland, the assent of the legislature of that State shall first be obtained."

The third enactment will be found on page 664, vol. 10, Statutes at Large, in the general appropriation bill, passed March 3, 1855, which reads as follows:

"For continuing the work on the Washington aqueduct, two hundred and fifty thousand dollars."

The fourth enactment will be found on page 86, vol. 11, Statutes at Large, in the appropriation bill for certain civil expenses, passed August 18, 1856, which reads as follows:

"For paying existing liabilities for the Washington aqueduct, and preserving the work already done from injury, such sums of money as shall be necessary, not exceeding two hundred and fifty thousand dollars."

The fifth enactment will be found on page 225, vol. 11, Statutes at Large, in the appropriation bill for certain civil expenses, passed March 3, 1857, which reads as follows:

"For continuing Washington aqueduct, one million dollars."

The sixth enactment will be found on page 323, vol. 11, Statutes at Large, in the appropriation bill for certain civil expenses, passed June 12, 1858, which reads as follows:

"For the completion of the Washington aqueduct, eight hundred thousand dollars; and in addition thereto, so much of the appropriation of two hundred and fifty thousand dollars 'for paying existing liabilities for the Washington aqueduct, and preserving the work already done from injury,' contained in 'An act making appropriations for certain civil expenses of the government for the year ending thirtieth June, eighteen hundred and fifty-seven,' approved eighteenth August, eighteen hundred and fifty-six, as may not be required for said purposes."

The seventh enactment will be found on page 435, vol. 11, Statutes at Large, passed March 3, 1859, entitled "An act to provide for the care and preservation of the works constructed by the United States for bringing the Potomac water into the cities of Washington and Georgetown, for the supply of said water for all governmental purposes, and for the uses and benefits of the inhabitants of said cities." No appropriation is made in this act, and it is too lengthy for insertion here. Some of its provisions have been amended and repealed; but many of them are important, and remain in force. It creates the office of "Engineer of the Potomac water works," and specifies the manner in which the inhabitants of Washington and Georgetown may be supplied "with Potomac water from the aqueduct mains or pipes now laid, or to be laid, in the streets and avenues by the United States," and provides: "That the cities of Washington and Georgetown, respectively, shall have power to establish a complete system of sewerage in aid of the execution of this act."

The eighth enactment will be found on page 106, vol. 12, Statutes at Large, in the appropriation bill for sundry civil expenses, passed June 25, 1860, which reads as follows:

"For the completion of the Washington aqueduct, five hundred thousand dollars, to be expended according to the plans and estimates of Captain Meigs, and under his superintendence: *Provided*, That the office of engineer of the Potomac water works is hereby abolished, and the duties shall hereafter be discharged by the chief engineer of the Washington aqueduct."

The ninth enactment will be found on page 620, vol. 12, Statutes at Large, entitled "Joint resolution transferring the supervision of the Potomac water works to the Department of the Interior," passed June 21, 1862, and which reads as follows:

"*Resolved, &c.*, That the supervision of the Potomac water works be, and the same is hereby, transferred from the War Department to the Department of the Interior; and all unexpended money which has been heretofore appropriated, and all money which may be hereafter appropriated, for the completion of said water works, shall be expended under the direction and supervision of the Secretary of the Interior."

The tenth and last enactment will be found on pages 804 and 805, vol. 12, Statutes at Large, entitled "An act amendatory of an act entitled 'An act to provide for the care and preservation of the works constructed by the United States for bringing the Potomac water into the cities of Washington and Georgetown, for the supply of said water for all governmental and other purposes, and for the uses and benefits of the inhabitants of the said cities,' passed March 3, 1863."

No appropriation is made in this act, and it is too lengthy for insertion here. It provides for some details and omissions that were wanting in the act to which this is an amendment, with reference to levying and collecting taxes and water rents by the corporation, for the purpose of laying down water-pipes and erecting fire-plugs throughout the city of Washington; and provides that the revenue thus created "shall constitute a fund exclusively for the maintenance, management, and repair of the system of water distribution."

It may be proper to remark in this place, that some further legislation appears to be necessary, or the existing laws more rigidly enforced, with reference to the proper control of the distribution of the water throughout the city, in order to prevent unnecessary waste.

The aggregate appropriations made by Congress in the foregoing enactments may be recapitulated as follows:

April 31, 1852	$5,000
March 3, 1853	100,000
March 3, 1855	250,000
August 18, 1856	250,000
March 3, 1857	1,000,000
June 12, 1858	800,000
June 25, 1860	500,000
Total	2,905,000

By reference to the foregoing legislation it would appear that, up to June 25, 1860, Congress had never *in terms* restricted the expenditure of the appropriations to any particular plans, specifications or estimates, further than may be inferred from the first enactment, which authorizes the President "to cause surveys, projects, and estimates to be made for determining *the best means of affording the cities of Washington and Georgetown an unfailing and abundant supply of good and wholesome water;*" and from the second enactment, which provides that the amount therein appropriated shall "be expended under the direction of the President of the United States, *for the purpose of bringing water into the city of Washington upon such plans and from such places as he may approve,*" &c.

The eighth enactment, passed June 25, 1860, is more specific, and provides that the amount of five hundred thousand dollars therein appropriated shall "be expended *according to the plans and estimates of Captain Meigs, and under his superintendence*," &c. It appears by reference to the report of Captain Meigs, (supposed to be dated October 1, 1861—see page 84, message and documents, 1861-'62, part 2,) that the bill was approved and signed by the President, though in returning it to Congress he accompanied it with a message, with some remarks upon the conditions attached to this appropriation.

On referring to this message, (see "Congressional Globe, part 4, appendix, 1st session 36th Congress, 1859-'60,") and perusing it carefully, I deem it so important, as constituting a component part of the past history of this work, that I have appended a full copy to this report.*

It may be proper to state, in this connection, that the civil appropriation bill which contained the objectionable item referred to in the President's message was passed by Congress at the close of the session; and, consequently, if the President had vetoed it on account of these objections, the entire bill would have failed to become a law.

A perusal of the report of Captain Meigs, above referred to, and also of the inscriptions upon the aqueduct structures, and property connected therewith,† appear to indicate that Captain Meigs felt justified in the belief that he would remain in charge of the work until it was fully completed, in accordance with his plans and specifications.

The annexed letter to the Secretary of the Interior, dated August 27, 1863,‡ would also seem to indicate that, in the opinion of General Meigs, the plans, as designed by him, ten years since, for the work, are the best that can be devised, and that any departure from them will "require special legislation to legalize it."

The following clause in the joint resolution passed June 21, 1862, to wit, "and all unexpended money which has been heretofore appropriated, and all money which may be hereafter appropriated for the completion of said water works, *shall be expended under the direction and supervision of the Secretary of the Interior*," seems to repeal or annul the restrictions previously placed upon the expenditure, both with reference to "the plans and estimates of Captain Meigs," as well as to "his superintendence," and leaves the Secretary of the Interior responsible alone to Congress for the manner in which the work is conducted, and the money expended.

2. Propriety of past and proposed expenditures.

In the exercise of the authority, and acting under the responsibility, imposed upon him by Congress, the Secretary has directed and approved some changes, both in the theory of working the aqueduct and in some of the plans which were being executed when the work came under his supervision; some of which involve increased expenditures of money, and all of which, it is believed, will, when fully understood, meet with the approval of Congress.

These changes are explained in the following extracts from the last annual reports of the Secretary of the Interior and the chief engineer of the Washington aqueduct:

Extract from the last annual report of the Secretary of the Interior, in relation to the Washington aqueduct.

"The work on the Washington aqueduct has progressed, in pursuance of the act of Congress transferring the same to this department, with but slight exceptions, and the water of the Potomac river has been this day introduced into the reservoirs. The walls and banks of the distributing reservoir were designed, by

---

* See Appendix A, page 22.
† See Appendix B, p. 24.
‡ See Appendix C, p 26.

the engineer who projected the aqueduct, to be protected by broken stone, and a contract was made and the work commenced on that plan; but it appeared to me to be so unsubstantial and insufficient for the purpose that I caused an inquiry to be made as to the manner of protecting similar embankments in other localities, and found that, with but few if any exceptions, the walls were lined with solid stone masonry, laid in the best of cement. Influenced by the example and experience of others and by the advice of eminent engineers, I directed a thin dressing of broken stone to be placed upon the interior walls for a foundation, and the whole to be faced with solid stone-work of about the same thickness as the contemplated riprap or broken stone wall. According to the original plan of the aqueduct, the water from the Potomac is conducted into a receiving reservoir formed by a dam across a stream called Powder Mill or Little Falls branch, about nine miles below the head of the conduit, whence it is conveyed about two miles further down to a distributing reservoir, divided into two equal sections, or basins, by an embankment designed chiefly for filtering purposes. It is thus always intermingled with the water from Powder Mill branch. The latter stream drains a considerable extent of country, and is subject to frequent and heavy freshets, which render its water unfit for immediate use. At times this stream is clear, while the water of the Potomac is rendered impure, by reason of heavy rains, nearer its source. It is, therefore, important that the aqueduct should be so constructed as to afford an adequate supply of water from whichever of these sources may, for the time, be most free from impurities, and to exclude that which may be unfit for use. For this purpose, the engineer in charge proposes to connect the conduit above the receiving reservoir with that below it, so that the water from the Potomac may be brought directly into the distributing reservoir without being adulterated by that of Powder Mill branch. He also proposes to construct a gate-house in the dividing wall of the distributing reservoir, so as to admit of the use of the water from either section, as may become desirable. By means of these improvements, the requisite supply of water may be drawn from whichever of four distinct sources may be the purest and best, viz: the Potomac river, Powder Mill branch, or either section of the distributing reservoir; but without some such arrangement, 'an unfailing and abundant supply of good and wholesome water' cannot at all times be obtained. Under these circumstances, I have deemed it necessary to order these changes in the original plan, and have made the estimates of appropriations for the completion of the work to conform thereto. For information in detail in reference to this subject I invite attention to the full and able report of the chief engineer.

"Certain parties having, from time to time, made claim to heavy damages for the diversion of the water from the Potomac river, my immediate predecessor, with a view to settle and end this claim, entered into an agreement of arbitration with the claimants. Pursuant to this agreement, the arbitrators met from time to time, and finally submitted their award, by which they adjudged in favor of the claimants upon each and all of the plans and modes submitted to them, being three in number, for the construction of the dam across the Potomac, and also $12,000 for their own fees as arbitrators, and $761 84 for the expenses of arbitration. The sums being so large, I did not feel justified in applying the existing appropriation for the completion of the aqueduct to the payment thereof, preferring to submit the whole matter to Congress for its determination. It appears from the report of the experienced engineer in charge of the work, as must be obvious to every observer, that an ample supply of water for the use of the cities of Washington and Georgetown, for many years to come, can be obtained from the Potomac by the erection of a tight dam, extending from the Maryland shore to Conn's island, to a height which will give a head of six feet of water in the aqueduct, and yield a daily supply of about 65,000,000 gallons, which is thirty-three and one-third per cent. more than was used in the city of New York in the year 1861, when its population was over 800,000. In view of this fact, I have instructed the engineer to construct a dam of cut stone, with

a base sufficient to bear a superstructure of the required height for the full capacity of the aqueduct, whenever it may be called into requisition.

"It is difficult to conceive how a dam of this character can work any injury to the proprietors of the water right claimed at the Great Falls. At the utmost, it could only raise the water to a level at the head of the island, while at ordinary stages and at low water (the only time when any value can properly be placed upon the right) it would not increase or diminish the flow of water in the main channel on the west side of the island; and it surely cannot be pretended that the parties claiming the water right can lawfully divert the ordinary flow of the water on the east side of the island. A dam of the east channel that would raise the water to a height sufficient to fill the aqueduct would be a great advantage to the claimants, for the reason that it would enable them to avail themselves of the power by the erection of but one dam, while one that would only back the water to the head of the island must be a matter of total indifference to them; because, in the very nature of things, it can work them no detriment whatever.

"If this view shall be taken of the case by Congress, I recommend that a reasonable sum be appropriated to pay the expenses of the arbitration, and that the estimate of the cost of the dam across the main channel be diminished to the estimated cost of the dam over the east channel, thus leaving the greater expense of the dam to be provided for as the exigencies of the cities of Washington and Georgetown, by the increase of their population, may require."

Extract from the last annual report of the chief engineer of the Washington aqueduct.

COST OF COMPLETION

"The original estimate of the cost of this work, as submitted to Congress by the President, February 21, 1853, was	$1,921,244 00
"The above estimate being for a seven-feet conduit, and the plan having been afterwards changed to a nine-feet conduit, the engineer in charge, in his annual report for the year ending September 30, 1856, adds for additional cost of nine-feet conduit	350,000 00
	2,271,244 00
"Or, in round numbers"	2,300,000 00
"It appears, from the foregoing financial statement, that there had been expended, under the supervision of the War Department, up to June 18, 1862, the date of transfer	$2,675,832 53
"The engineer's 'report of operations on the aqueduct during the year ending September 30, 1862,' gives the amount expended from June 17 to September 30, 1862	9,215 80
"Also the estimated cost of completing the aqueduct	220,008 00
"Making a total cost of	2,905,056 33
"Or an increase over the original estimate, of	605,056 33

"The present estimate of the cost of completing the aqueduct will be found to embrace several items which have not appeared in former estimates, as well as a considerable increase in the cost of some of the original items, all of which produce a material increase in the aggregate cost of the work, and should be fully explained here.

"The original estimate of the cost of the dam at Great Falls, and the work

connecting it with the Maryland shore, was $50,043. The plan upon which this estimate was based may be understood by the following extracts from the specifications:

"'The dam will be an embankment of rubble stone, with a top width of twenty feet; a slope on the upper side of one to one, and on the lower side of five to one. It will be made of large stones, the spaces filled with smaller ones, so as to form a compact mass; eight and a half feet from the upper slope, and laid parallel to it, there will be three feet in thickness of spalls and gravelling. Care will be taken to place on the outer surface of the bank stone sufficiently large to resist the action of high freshets.'

"'For thirty feet above the upper edge of the dam all materials will be removed for a depth of four feet below the level of the water in the pool, to form a boat channel that can be used in replacing any of the stones carried away by high freshets.'

"This dam was located on a diagonal line, about three thousand feet in length, extending across the Maryland channel, the head of Falls island, the lower portion of Conn's island, and the main or Virginia channel, to a point on the Virginia shore about one-half of a mile above the feeder at the head of the aqueduct.

"That portion across the head of Falls island, about six hundred feet in length, has been completed.

"My own views as to the propriety of carrying out the above plan were submitted to the department at considerable length in a communication dated October 16, 1862. They have undergone no change, but have rather been confirmed by subsequent observation and experience.

"The location seems to be a very unnatural one, and was evidently adopted from other than engineering considerations. I do not consider the structure a suitable one for a work of this kind, neither as regards stability nor imperviousness.

"In the communication above referred to it is recommended that the location of the dam be changed 'to the form of an arc, extending from the mouth of the aqueduct to a point on the Virginia shore below the mouth of the old canal, which happens to be almost directly opposite.' And it is also recommended that the plan be changed to 'a dam of the most substantial masonry.'

"The Great Falls Manufacturing Company claim to be the owners of the right to use the whole or a large portion of the water flowing in the Potomac river in the vicinity of the Great Falls, by virtue of riparian rights acquired by them in the purchase of the adjacent shores and islands. This claim has always been resisted by the government. In the summer of 1858 a jury was summoned to assess the damages that would be sustained by this company by reason of the diversion of so much water as would be required to supply the aqueduct. Their verdict amounted to $150,000. An appeal was taken by the United States, by which the verdict was set aside.

"On the 20th of November, 1862, an agreement was entered into between the Secretary of the Interior and the Great Falls Manufacturing Company, by which the whole question of damages was submitted to the arbitration and decision of five commissioners mutually agreed upon by the parties.

"These commissioners made a personal examination of the locality in question; and, after receiving a large amount of oral and written testimony on both sides of the case, made four alternative awards upon as many different plans and locations for the proposed dam, which were submitted to them on the part of the government. As no action has since been taken by the Secretary of the Interior in relation to this matter, and as this item has not appeared in former estimates, the question of damages for land or diversion of water by reason of the construction of the dam will not be considered or provided for in the present estimate.

"As a question of engineering, however, I do not hesitate to recommend the adoption of the location and plan which contemplates the ultimate construction of a cut-stone dam of solid masonry entirely across the river, of sufficient height to secure a full and permanent supply of water for the aqueduct. Inasmuch, however, as many years may elapse before a supply equal to the full capacity of the aqueduct, or 85,000,000 gallons daily, will be required, the present estimate only provides for the construction of that portion of the dam extending from the Maryland shore to Conn's island, to a height which will give a head of six feet of water in the aqueduct, or a daily supply of about 65,000,000 gallons. This dam will be so located and constructed as to admit of an additional height of two feet, and an extension to the Virginia shore, whenever Congress shall think proper to make the necessary appropriation.

"The theory upon which the works have been planned, and thus far constructed, is as follows: The water drawn from the Potomac at Great Falls is to be conducted in the first instance through a circular conduit nine feet in diameter, a distance of about nine miles, and discharged into the receiving reservoir, (which contains about fifty acres of water surface,) and there allowed to intermingle with the water collected in the reservoir from the surface drainage of the surrounding country. It is then to be drawn through another nine-feet conduit, a distance of about two miles, to the head of the distributing reservoir, near Drovers' Rest, which contains a water surface of about forty-two acres, and then either discharged into the distributing reservoir and drawn from thence for general distribution by means of large cast-iron mains, or carried past the distributing reservoir through a seven-feet conduit which connects directly with the same cast-iron mains at the lower end of the reservoir.

"It will be observed, that by this theory of working the aqueduct there can never be but one direct source of supply, to wit, the receiving reservoir; and but two qualities or degrees of purity to the water supplied, to wit, that which is drawn directly from the receiving reservoir, and that which is allowed a short time for rest or settlement in the distributing reservoir. The distributing reservoir is divided into two sections, very nearly equal in size, by an embankment, the top of which was to be left two feet below the ordinary surface of the water in the reservoir, so that the water in the lower section would be drawn from the surface of the upper section. A culvert, with a stop-gate, was to be built through the bottom of the dividing bank for the purpose of draining the water from the upper section into the lower one, and from thence through a waste-pipe in the effluent gate-house, whenever it should be necessary for purposes of cleaning or repair.

"The experience of the last four years has shown that the water collected in the receiving reservoir from the drainage of the surrounding country (and which has thus far been the only source of supply) is, during a great portion of each year, so muddy and full of sediment that it is often considered unfit for ordinary uses. It has also been observed that very often, when the water in the reservoir is in this impure state, the water in the Potomac is comparatively clear and pure; and *vice versa*. These differences are occasioned by showers or heavy rains falling in the localities adjacent to the respective streams or sources of supply, and are, of course, unavoidable.

"It has, therefore, been deemed both advisable and important that every available means should be adopted in the arrangement and working of the aqueduct, by which the water would be rendered as clear and pure as possible. With this object in view, it is recommended that the conduit above the receiving reservoir be connected with the conduit below the reservoir, so that the Potomac water may be brought directly into the distributing reservoir without adulteration with the waters collected from other sources in the receiving reservoir. It is also recommended that the dividing bank in the distributing reservoir be built to the full height of the outside banks, so as to separate the water in the different sections; and that, instead of the proposed culvert, a gate-house be so constructed

in this division bank that, in connexion with the effluent gate-house, the water may be drawn at pleasure from either section; and also so arranged that the lower section may be supplied with water from the surface of the upper section.

"By means of this improvement in the distributing reservoir, and the connection of the conduit through the receiving reservoir, we shall always be able to select a supply of water from whichever of four separate and distinct sources may, for the time being, be the purest and best. To illustrate, suppose that, at any time, both sections of the distributing reservoir are full of good clear water, and that a sudden shower or heavy rain should cause the water either in the Potomac or receiving reservoir, or both, to be too muddy for immediate use. The water from above would then be shut off temporarily from the distributing reservoir, and the supply would be drawn from the upper section until it became exhausted; after which the draught would commence from the lower section, while the upper one would be replenished either from the Potomac or receiving reservoir—from either of which the water may also at any time be supplied directly to the distributing mains.

"It is believed that by the adoption of these simple expedients, we shall at all times secure a supply of water of the greatest degree of purity attainable, unless we resort to the expensive process of filtration, which is now being successfully adopted on a large scale in some of the most important water works in Europe, and will, undoubtedly, soon be adopted to a great extent in this country.

"The original plans and 'specifications for the completion of the distributing reservoir, near Drovers' Rest,' required that the interior slopes or water faces should be faced with broken stone in blocks not exceeding three inches nor less than one and a half inch cubes, to be spread evenly on the surfaces to a depth of eighteen inches. Believing that this plan would not afford the banks proper protection from the action of the water, and finding that my opinions were concurred in by the most experienced engineers in the country, I took the responsibility, on the 18th of May last, while acting as consulting engineer of the aqueduct, of recommending the following amendment to the specification, which being approved by yourself, on the 30th of July, is now in force:

"AMENDED SPECIFICATIONS FOR THE COMPLETION OF DISTRIBUTING RESERVOIR NEAR DROVER'S REST.

"All interior slopes shall have a uniform inclination of two feet base to one foot vertical. They will be faced with small broken stone or clean hard gravel to an average depth or thickness of six inches. Upon this foundation will be laid a rubble slope wall averaging fifteen inches in thickness, and varying from twelve to eighteen inches, according to location and circumstances, at the discretion of the engineer. The foundation of the slope wall will be one foot below the bottom of the reservoir. The stone will be laid at right angles to the slope, and will be sufficiently large to extend through the wall, and to resist the action of the water. The face of the wall to be well wedged and pointed, either with pinners and spalls, or with clean hard gravel, as the engineer may direct, so as to prevent the water from displacing any portion of the wall or the broken stone underneath.

"The top of the wall will be connected with a pavement rounded over the upper front angle, and extending across the top of the division bank, and five feet back on the top of the outside banks. The pavement to be from six to ten inches thick, as the engineer may direct, and composed of field or quarried stone, of good quality and uniform size, compactly laid on their ends, and well bedded to a uniform surface in broken stone or clean hard gravel.

"The top of the banks, from the outer edge of the paving, will be finished with a slope of one in twenty, inclining from the reservoir, so as to shed the water into the surface drains prepared for that purpose."

"Although this change will somewhat increase the present cost of the work, it is believed that it will result in a great saving of future expense.

"It has also been thought advisable to construct eight shafts upon the top of the conduit for purposes of ventilation, in order to allow of the escape of impure air, and the passage of a current of pure air over the surface of the water in the conduit.

"No allowance has been made in former estimates for the cost of fencing the reservoirs and conduits, and the government lands connected with the aqueduct. This item is included in the present estimate.

"The following is now submitted as the estimated cost of completing the aqueduct in accordance with the foregoing recommendations, from and after October 1, 1863:

Potomac dam of solid masonry from the Maryland shore to Conn's island	$54,000 00
Temporary dam for procuring three feet head of water during construction of permanent dam	2,000 00
Completion of head of conduit and cut-stone masonry connected therewith	5,000 00
Completion of tunnels	6,550 00
Completion of conduit	4,844 00
Completion of bridges	31,751 00
Completion of gate-houses	26,560 00
Completion of earthwork and water facings in distributing reservoir	87,720 00
Completion of central gate-house in dividing bank of distributing reservoir	20,500 00
Completion of high service reservoir	8,900 00
Connection of conduit through the receiving reservoir	99,200 00
Ventilators to conduit	2,800 00
Fencing reservoirs, conduit, and government lands connected therewith	25,000 00
Engineering, superintendence and repairs, for the ensuing two years	40,000 00
Land and law expenses	20,000 00
Constructing common roads	3,500 00
	438,325 00
Add ten per cent. for contingencies	43,832 50
Total amount	482,157 50
Deduct balance on hand	80,773 88
Appropriation required	401,383 62
If we add to the above the estimated amount required to complete the Potomac dam to its full length and height, say	145,050 00
And the amount of former appropriations	2,900,000 00
We shall then have	3,446,433 62
Or, in round numbers	3,500,000 00

Which amount will represent the total cost of this great national work when fully completed in the most permanent and substantial manner, and upon a plan which will make its full capacity available for all coming time.

"This amount cannot be considered as extravagant when compared with the cost of supplying other cities with water by means of artificial works, as will be seen by an examination of the following valuable table of statistics of water supply for various cities throughout the United States, compiled by Mr. Samuel McElroy, an eminent civil and mechanical engineer of Brooklyn, New York:

Statistics of water supply, compiled from various authorities.

Locality.	Cost of works.	Cost of water rights.	Daily supply controlled.	Daily supply used, 1859.	Daily supply used, 1861.	Annual expenses, 1859.	Annual expenses of extensions, 1861.	Annual expenses of administration, 1861.	Annual receipts, 1859.	Annual receipts, 1861.	Miles of distribution.	Population, 1860.	Power.
			Gallons.	*Gallons.*	*Gallons.*								
Albany	$921,892	$100,000	12,000,000	2,500,000	3,000,000	$17,963	.....	.....	$78,490	.....	46.5	62,368	Gravity.
Baltimore	3,503,355	236,958	18,440,000	.....	8,000,000	.....	$28,959	$8,269	.....	$180,371	136	212,419	Do.
Boston	5,500,000	211,930	20,000,000	15,000,000	18,181,000	29,088	40,058	33,918	316,290	347,138	131.25	177,481	Do.
Buffalo	530,000	.....	.....	3,000,000	.....	19,000	.....	.....	50,000	.....	.....	81,131	Steam.
Brooklyn	5,300,000	126,200	33,000,000	.....	4,445,000	.....	*21,336	41,748	.....	†261,679	137	266,664	Do.
Chicago	1,000,000	.....	.....	3,877,910	4,841,520	35,000	54,727	24,823	123,600	131,035	95.3	109,263	Do.
Cincinnati	1,359,000	.....	.....	4,618,000	4,855,500	51,000	104,206	46,446	180,000	158,497	85	161,044	Do.
Cleveland	526,000	.....	.....	710,984	881,600	8,623	3,431	9,406	13,824	17,375	24.38	36,054	Do.
Detroit	683,000	.....	.....	2,142,000	.....	13,097	.....	.....	48,779	.....	.....	45,619	Do.
Hartford	427,000	.....	1,500,000	785,000	.....	7,771	.....	.....	26,000	.....	.....	29,152	Do.
Jersey City	850,000	.....	6,000,000	2,000,000	.....	18,000	.....	.....	69,245	.....	.....	29,226	Do.
Louisville‡	817,457	.....	4,000,000	.....	640,627	.....	.....	11,338	.....	12,445	25.95	69,740	Do.
Mobile	300,000	.....	.....	250,000	.....	10,200	.....	.....	33,500	.....	.....	29,259	Gravity.
New Orleans	1,400,000	.....	.....	6,000,000	.....	25,000	.....	.....	140,000	.....	.....	168,823	Steam.
New York	§14,000,000	173,955	.....	40,000,000	43,000,000	.....	146,140	38,152	759,250	765,954	280.25	814,287	Gravity.
Philadelphia	3,000,000	236,958	31,570,784	19,638,000	20,728,985	79,000	159,835	79,154	551,000	533,980	337	568,034	Water and steam.
Pittsburg	900,000	.....	.....	4,075,000	.....	26,000	.....	.....	69,000	.....	.....	100,000	Steam.
Richmond	654,000	.....	.....	2,000,000	.....	18,000	.....	.....	32,000	.....	.....	37,910	Water.
St. Louis	1,880,000	.....	.....	8,000,000	.....	.....	.....	.....	.....	.....	.....	151,780	Steam.
Troy	216,000	.....	.....	1,468,000	.....	12,141	.....	.....	23,770	.....	.....	39,285	Gravity.

* In part. † Assessed. ‡ Supply just introduced. § About.

"From this table it appears that, although the Washington aqueduct will furnish a supply of double the amount furnished by any of the water works named, its cost will be much below the average of those of even one-half the capacity.

"The original estimate of the cost of the Washington aqueduct was made in 1853, or ten years since, and at a favorable time for the accomplishment of such a work. There is no reason to doubt that the estimate was ample for the completion of the work upon the plans then proposed, provided the appropriations had been made by Congress, so as to have allowed of the uninterrupted prosecution of the work to completion.

"The excess of the estimate of October 1, 1862, over the original one, (to wit, $605,056 33,) may be accounted for in a great measure by the unavoidable consequences growing out of the periodical delays and suspensions of the work for the want of funds; such, for instance, as deterioration and waste of materials, tools, machinery, and fixtures; extra allowances to old contractors for damages, and extra prices to new ones for the completion of old and unfinished work; cost of engineering, superintendence, office expenses, repairs, &c., &c.; all which must necessarily amount to a very large per-centage on the final cost of the work.

"When to this is added the extra cost of the additions and improvements recommended in this report, and provided for in the present estimate, the discrepancy of $1,146,433 62 between the present and original estimates cannot be regarded either as unexpected or unreasonable in a work of this character and magnitude."

In submitting further explanations, and stating additional reasons for the changes already adopted, and those recommended in the foregoing and present reports, reference will first be made to the change in the location and character of the dam in the Potomac river above the Great Falls, which is designed to turn the Potomac water into the aqueduct. (See the annexed map.) In this connexion I desire respectfully to refer to the annexed "Report of S. Seymour to the Hon. John P. Usher, Assistant Secretary of the Interior, in relation to the proposed dam at the Great Falls of the Potomac," dated October 16, 1862.*

Reference is also made to the annexed extracts from the testimony of Messrs. James Slade, of Boston, Massachusetts, Samuel McElroy, of Brooklyn, New York, and Marvin Porter, of Davenport, Iowa, civil engineers of ability and experience, upon the same subject, taken in December, 1862, and January and February, 1863, before the commissioners appointed to examine and decide the question of damages sustained by the Great Falls Manufacturing Company, by reason of the diversion of a portion of the water from the Potomac to supply the aqueduct; also to that of John G. Stone, a former superintendent upon the Chesapeake and Ohio canal. †

It is respectfully submitted that it is unnecessary to add anything more upon this subject in order to justify the change in the plan and location of the dam at Great Falls, from an "embankment of rubble stone," as designed and was being constructed by Captain Meigs, to a dam of solid masonry, as adopted by the Secretary of the Interior.

The amount expended, up to the 1st instant, on the permanent dam, is $3,700. And it is estimated that a further amount of $49,000 will be required to complete the dam from the Maryland shore to Conn's island, to a height which will give a head of from five to six feet of water in the aqueduct, and a daily supply of from fifty to sixty million gallons of water.

Another change in the original plans is recommended by the Secretary of the

---

* See Appendix D, p. 26.
† See Appendix E, p. 30.

Section of Embankment of Rubble Stone

10 5 0 10 20

Scale for Sections

Section of Masonry Dam

WASHINGTON AQUEDUCT.

MAP OF THE POTOMAC RIVER AT GREAT FALLS.

To Accompany Supplemental Report of CHIEF ENGINEER.

Dated Feb. 22nd 1864.

Scale for Map

1000 500 0 1000 2000

Bowen & Co lith Philada

WASHINGTON AQUEDUCT.

MAP OF

THE

RECEIVING RESERVOIR.

TO ACCOMPANY SUPPLEMENTAL REPORT OF

CHIEF ENGINEER.

Dated Feb. 22nd 1864.

Scale.

300 0 500 1000 1500 2000 Ft.

Bowen & Co. lith. Philada.

Interior, and provided for in the estimates of the chief engineer, to wit: the extension of the conduit from a point above tunnel No. 4, around the lower portion of the receiving reservoir, to the effluent gate-house, so as to enable the water from the Potomac river to be brought in its pure state into the distributing eservoir, without adulteration with the waters collected in the receiving reservoir, from the surface drainage of about four thousand acres of the surrounding country. (See the annexed map of the receiving reservoir.) In addition to the reasons given for this change, in the foregoing extracts from the reports of the Secretary of the Interior and the chief engineer of the aqueduct, I have to state that since the introduction of the Potomac water into the receiving reservoir, December 5, 1863, the water supplied to the city from the receiving reservoir has been unusually impure and muddy, although the weather has not been unusually rainy; whereas, previous to that time, the water in this reservoir, during intervals of dry weather, would be reasonably clear. I can account for this circumstance in no other way than from the fact that it has been necessary, since the introduction of the Potomac water, to keep the water surface in the reservoir from two to seven feet lower than before, in order to allow the Potomac water to flow into it; thus affording the winds and waves, and also the strong current, discharged from the upper conduit, an opportunity to stir up the sediment which has been for some years accumulating upon the immense shoreline which surrounds it, as well as upon the uneven and, in many places, shallow surface of the bottom. It will be remembered that the elevation of the present dam at Great Falls, and the bottom of the waste-way of the reservoir, are the same, to wit, 145 feet above *datum* line of the aqueduct, or the level of mean tide in the Potomac, so that, if the water in the reservoir is kept at or above that elevation, no water, except at high stages, can flow into it from the Potomac. And, in order to obtain any considerable quantity of water from the Potomac with the present height of the dam, the surface of the reservoir must be kept, at least, from two to three feet below the bottom of the waste-passage; whereas, during several months previous to the introduction of the Potomac water, it had been kept from three to five feet above that level, by means of a temporary dam across the passage. These considerations incline me very strongly to the opinion that it will be necessary to shut the Potomac water entirely off from the reservoir, and to raise the water in the reservoir to its previous height until the Potomac dam can be completed, and a connection made between the conduit above and the conduit below the reservoir. In view of this contingency it is quite as important that the proposed connection in the conduit be made, as it was in the first instance that the works should be completed from the Potomac, at Great Falls, to the receiving reservoir.

The experience thus far, with reference to this reservoir, certainly goes very far towards proving the fallacy of Captain Meigs's theory with reference to it, as stated in Ex. Doc. No. 82, H. R., 34th Congress, 1st session, to wit: "The water enters this reservoir by a tunnel, at a distance of half a mile from the point at which it leaves it; and during its passage through this deep pool, time is afforded for it to deposit most of its impurities."

As an illustration of the comparative degree of purity of the water in the Potomac, and the water as it is drawn from the receiving reservoir, I procured samples of each on the 20th instant, which show a very marked difference in favor of the Potomac water. The weather had been clear and cold during several weeks preceding that date, and the surface of the reservoir was frozen at the time to a depth of several inches. The water at the mouth of the upper conduit appeared quite clear; but the shade, as it approached the effluent gate-house, grew visibly darker and more turbid.

No expenditure has been made on account of this proposed change; but an item providing for its cost will be found in the annual report, amounting to $99,200.

Another change has been in part adopted, and is now, to some extent, being carried out, with reference to the distributing reservoir near "Drovers' Rest," to wit: First, in the substitution of slope wall for riprap facing on the interior slopes, and extending the same from the bottom of the reservoir to and over the top of the slopes. Second, in the construction of the dividing bank to the full height of the exterior banks, and the substitution therein of a central gate-house, for the culvert, as heretofore contemplated. Third, in the excavation of the whole, or a portion of the bottom of the reservoir, to an additional depth of thirteen feet. (See the annexed plan of the distributing reservoir.) With reference to the first change, I beg leave, in addition to the reasons assigned in the foregoing extracts from the reports of the Secretary and chief engineer, to refer to the annexed communication, addressed on the 18th May, 1863, to the Secretary of the Interior, while I was acting as consulting engineer of the aqueduct, and containing a correspondence upon the subject with Messrs. James P. Kirkwood and Alfred W. Craven, of New York, and James Slade, of Boston, all of whom hold positions in the first rank of American engineers in connection with works of this kind.*

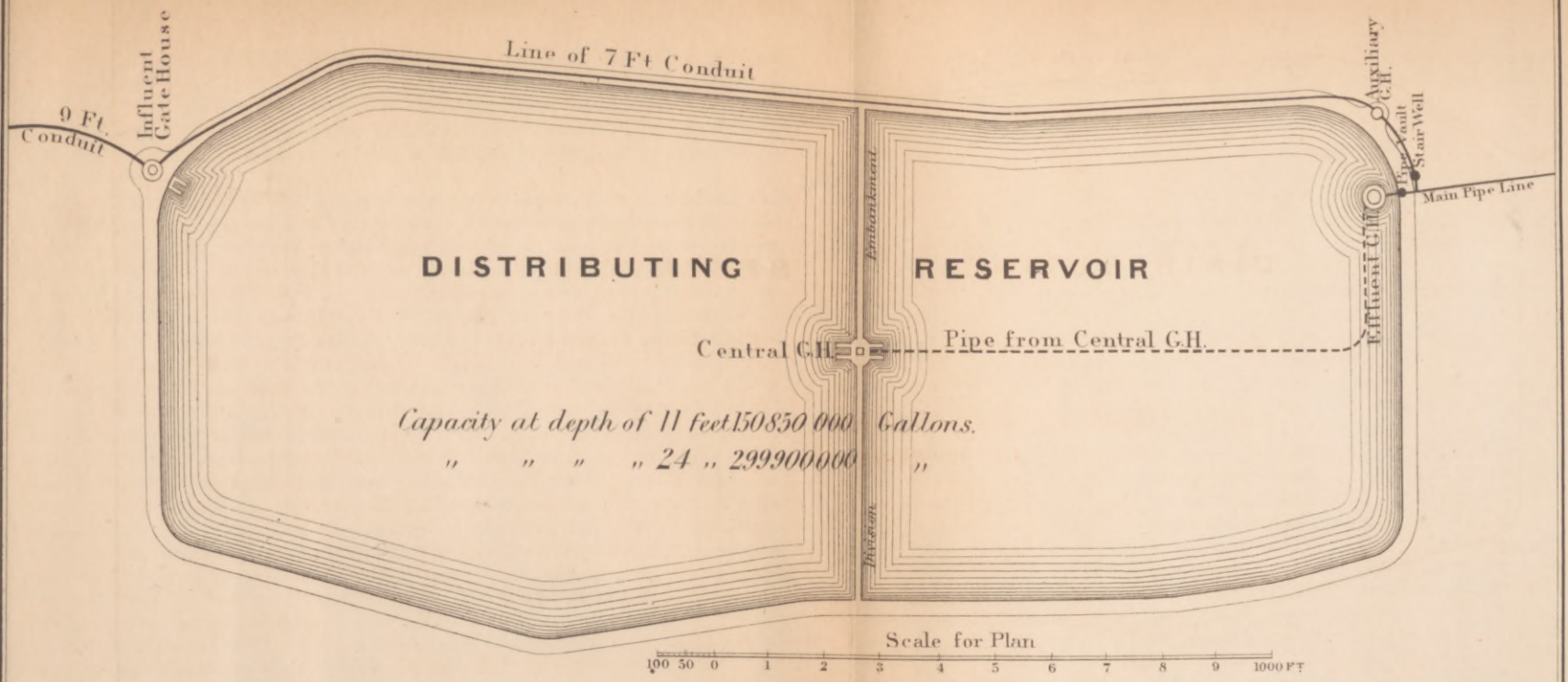
It is proper to state that the change in the plan of finish for the water facings involves not only the character of the walls, but also the extent of surface to be covered by them; and that the increase of cost is not so much on account of the quality, as the additional quantity of work proposed to be done. The original plan contemplated that the slopes should be covered with broken stone, or riprap, eighteen inches thick only, from a point one foot above the surface at the flow-line, to a point seven feet below the surface, making a vertical height of eight feet—thus leaving the upper angle and slope of the banks, and also that portion of the slope below the foot of the riprap, (which will frequently be left bare by the drawing down of the water,) exposed to the action of frost and the waves. The aggregate increase in the cost chargeable to this change in the plan is estimated at $32,308, of which $23,888 is chargeable to the additional quantity required to cover the entire slopes, and $8,420 to the change in the character of the work from riprap to slope wall. There has been expended up to the 1st instant, on the slope walls built according to the present plan, $11,525; and the amount required to complete them is estimated at $49,375.

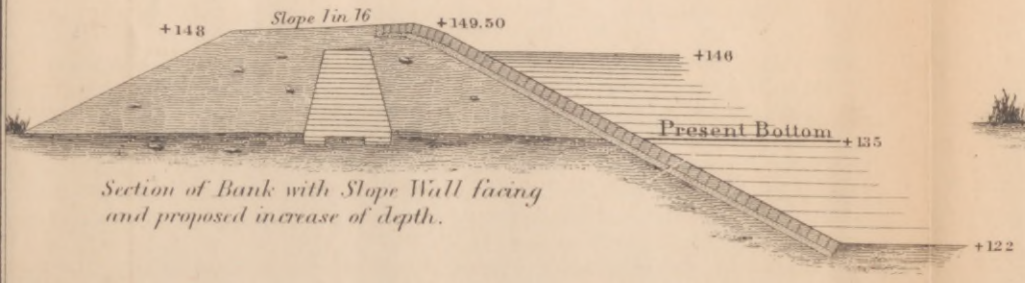
The reasons for the change in the elevation of the dividing bank, and the substitution therein of a gate-house for the culvert, are fully stated in the foregoing extracts from the annual reports of the Secretary and chief engineer. The design is to secure additional purity to the water at a very small comparative expense. Nothing has been expended on account of this proposed change excepting the purchase of some bricks for the small conduit leading from the central to the effluent gate-house, which can be used for other purposes if the improvement be abandoned. The additional cost of this improvement, including a slight change in the effluent gate-house to admit of the water being drawn with greater facility from the surface, at different elevations, is estimated at twenty-three thousand nine hundred dollars.

The change proposed in the elevation of the bottom of the distributing reservoir is not referred to in either the annual report of the Secretary or chief engineer, and will therefore be fully explained here.

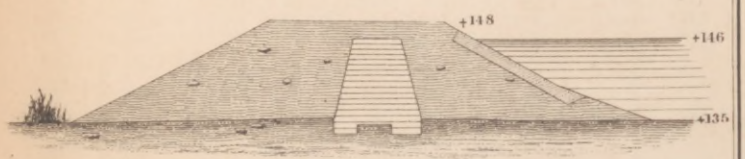
The level of the bottom of the reservoir, as established by Captain Meigs, and as now being graded, is two feet above the bottom of the conduit, which discharges into it at the influent gate-house, and fifteen feet above the centre of the discharge-pipes or mains which lead from it at the effluent gate-house; and it is only eleven feet (or ten feet as shown in the plan of Captain Meigs) below the flow-line or surface of high water in the reservoir—making the capacity of the reservoir, which contains an area of forty-four acres of water sur-

* See Appendix F, p. 37.





Section of Bank with Slope Wall facing and proposed increase of depth.



Section of Bank as originally designed with partial rip rap facing.

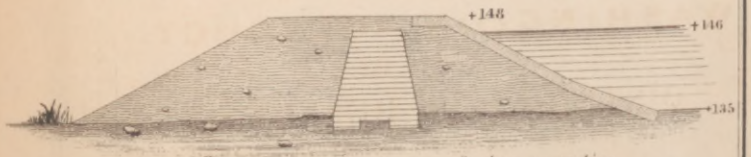
WASHINGTON AQUEDUCT.

PLAN OF

DISTRIBUTING RESERVOIR

TO ACCOMPANY SUPPLEMENTAL REPORT OF CHIEF ENGINEER.

Dated Feb. 22nd 1864.



Section of Bank with rip rap facing on entire slope.

10 5 0 10 20 30 40 50

Scale for Sections.

Bowen & Co. lith. Philada.

face, equal only to one hundred and fifty million eight hundred and fifty thousand gallons; whereas, if the bottom was excavated to the lowest depth at which water can be drawn through the discharge-pipes, we should have a depth of twenty-four feet of water and a capacity of two hundred and ninety-nine million nine hundred thousand gallons, or double the amount of its present capacity.

The additional cost of this improvement is estimated at two hundred and twenty-three thousand one hundred dollars. I have been unable to find in the reports on file in this office any reasons given for the adoption of the present level for the bottom of the reservoir, and therefore suppose it to have been done merely for purposes of economy. The advantages of the proposed change appear to be obvious, and may be briefly stated as follows: First. Double storage capacity in the reservoir; and second, greater purity as well as coolness in the water, on account of its additional depth. I am so thoroughly impressed with the importance of adopting every available expedient within the limits of reasonable economy which will be calculated to improve the purity of the water, that, in case Congress should make an adequate appropriation, I would recommend that at least one section of the reservoir should now be excavated to the full depth, even if it involved the entire suspension of work upon the remaining section until Congress should feel justified in providing for its completion in the same manner. In that case, the storage capacity of this completed section would be substantially the same as that of the entire reservoir when completed upon the present plan, and the quality of the water would be greatly improved. The same object, however, would be more thoroughly accomplished by completing the upper section (the water facings of which are now far advanced) to a depth of eleven feet, and the lower section (upon which the slope wall has not been commenced) to the full depth of twenty-four feet.

The estimated cost and storage capacity of each section, when completed to different depths below the flow line, will be found in a subsequent part of this report.

An additional reason for carrying out this improvement at the present time is, that in all probability the use of the receiving reservoir for storage and purifying purposes will have to be abandoned for the reasons hereinbefore stated; and, in that event, the full capacity of the distributing reservoir for both purposes should be brought into immediate requisition. Experience will also probably demonstrate the inability of the conduit above the reservoir to sustain the pressure of any considerable head above the crown of the arch; in which case, the water in the reservoir must be kept at an elevation which will give only seven feet depth above the present bottom, and a capacity of only ninety-four million five hundred thousand gallons.

I beg leave, in this connection, to call your attention to the annexed "Paper in relation to the receiving and distributing reservoirs, prepared by Mr. J. J. R. Croes, principal assistant engineer," which will be found to contain many details and much valuable information not embraced in this report.*

With reference to the items of ventilating shafts upon the top of the conduit, and the fencing of the reservoirs, conduit, and government lands connected with the aqueduct, which have not been included in former estimates, I have nothing additional to say.

The above, I believe, embraces all the material changes in and additions to "the plans and estimates of Captain Meigs," together with the information and explanations relating thereto, to which you will desire to call the attention of the committee.

I desire to add, in this connection, that the plans designed by Captain Meigs for the aqueduct, were probably the best that could be devised at the time, from

* See Appendix G, p. 39.

the lights and experiences then available for reference. The changes since adopted, and now recommended, should, in the language of the annual report, be regarded "as only the natural results of experience and observation on this and other works of a similar character during a period of ten years which has elapsed since the commencement of the work; and should, therefore, not be regarded as reflecting any discredit upon the plans as originally adopted."

The history of this work would differ materially from that of any other public improvement in the country, if the experience and observation of each succeeding year of its construction and use did not develop the expediency of some changes in the original plans and estimates, which, if adopted, would prove advantageous to the work. It seems, therefore, but just to assume that Congress will indorse these improvements, when convinced of their utility; and that it will hold any person in whose charge the work may be placed responsible for their incorporation in the plans and estimates, so that this great national work, when fully completed, will not be inferior in any respect to those of a similar character in this or any other country.

The other items in the estimate, it is supposed, are sufficiently explained in the engineer's annual report. They are for the completion of unfinished mechanical structures, in order to render them more useful, and to protect them from injury on account of exposure to the elements.

It may be proper, however, to remark, with reference to the "high-service reservoir," in Georgetown, which stands apart from the main line of works, that I find in the report of Captain Meigs, dated February 12, 1853, (see 32d Congress, 2d session, Ex. Doc. No. 48, page 23,) the following allusion to it: "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, a thousand people—to pump 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 in 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 the reservoir full. The wheel and pump will be of sufficient power to raise the quantity needed for the daily consumption in ten 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 estimated cost (see page 49 of same report,) was $18,928.

It appears that the plan was subsequently changed, as the present elevation is 80 feet above the flow-line of the distributing reservoir, and the capacity is only 1,880,000 gallons. A Worthington pump has also been substituted for the proposed turbine. The expenditure on account of this work, as nearly as can be ascertained, has been $40,000, exclusive of land. The roof is yet to be completed, and some leakages, which have prevented its successful use up to the present time, have to be repaired. The estimated cost of all which is $8,920.

A statement of the "mains laid by the United States" in connection with the Washington aqueduct, will be found appended to this report. *

It is estimated that from eight to ten million gallons of water have been distributed daily during the past two years, and that nearly double that quantity, or say fifteen million gallons, will be required during the next two years; this is more than can be relied upon, with any degree of certainty, in the present condition of our works at Great Falls.

The question of damages to the Great Falls Manufacturing Company by reason of the construction of the dam, and the diversion of a portion of the water from

* See Appendix H, page 48.

the Potomac river, will, undoubtedly, receive a thorough examination by the committee; and it is to be hoped that their investigations will lead to a final settlement of this long-pending and vexatious question. The present *status* of the case is stated in the Secretary's report, and in the annual report of the chief engineer. The agreement for submission to arbitrators, the testimony taken in the case, the award of the commissioners, together with a map of the premises showing the alternative plans and locations of the dam, have all been placed in the hands of the committee.

Although the present estimates do not contemplate the immediate construction of the dam entirely across the river, yet it is to be hoped that Congress will see the propriety, as well as economy, of providing the right of way for the whole distance, so that no further controversy can ever arise in relation to the matter.

A map of the entire line of the aqueduct is attached to this report, which will show the relation of all the changes, herein discussed, to the whole work, and also the location of the government mains in the cities of Georgetown and Washington.

3. Necessity for further appropriations.

With reference to the question of "the necessity for further appropriations" for the protection and prosecution of the work, I have to say that, in the present disturbed condition of the country, and the consequent heavy draught upon its resources, it is not to be expected that Congress will make any further appropriations than may be necessary for the proper safety and protection of the work already done, and the completion of such portions as will secure to the departments of government, and the inhabitants of the cities of Georgetown and Washington, (who have now become entirely dependent upon this means of supply,) the requisite quantity of the purest and healthiest water attainable by the expenditure of a reasonable amount of money.

The amount of the present appropriation unexpended at the beginning of the present month does not exceed $18,000. This will not be sufficient for purposes of ordinary repairs during the next fiscal year. The work of completing the distributing reservoir is now progressing slowly; but it should be suspended at once unless a further appropriation be made immediately.

The following is a summary of all the items, with their cost, embraced in the present estimates for the completion of the work:

1.	For the completion of the Potomac dam to Conn's island, to a height giving from five to six feet head of water in the conduit.	$49,000
2.	Completion of masonry at the feeder and head of conduit.....	1,485
3.	Completion of gate-house at Great Falls	3,480
4.	Trimming, plastering, arching, and lining in tunnels that appear defective.....	5,125
5.	Completing the paving, coping, and railing of stone arch bridges, to prevent injury from exposure.....	27,565
6.	Repairs to roof of effluent gate-house at the receiving reservoir,	400
7.	Completion of influent and auxiliary gate-houses, and pipe vault, at the distributing reservoir	9,240
8.	Completion of high-service reservoir in Georgetown.....	8,920
9.	Connecting the conduit above with the conduit below the receiving reservoir	99,200
10.	Completing the distributing reservoir to the full depth of twenty-four feet, with slope-wall facings, including the effluent and central gate-houses, with connecting conduit complete, giving a storage capacity of 299,900,000 gallons.....	332,970
11.	Constructing ventilators upon the conduit	2,800

12. Fencing conduit, reservoirs, and government lands connected therewith	20,000
13. Engineering, superintendence, and repairs for the ensuing two years	35,000
14. Land and law expenses	10,000
	605,185
15. Add ten per cent. for contingencies	60,518
Total amount	665,703
Deduct balance on hand 1st February, 1864	18,000
Appropriation required to complete	647,703
NOTE.—The increase of appropriation required by the present, over the estimate contained in the annual report, is accounted for by the additional cost of completing the distributing reservoir to the depth of twenty-four instead of eleven feet, which amounts, with ten per cent. added, to	245,410
By deducting which will leave a balance of	402,293

It will be observed that no provision is made in the above estimate for the settlement of the land question at Great Falls, nor for the completion of the Potomac dam to its full height entirely across the river.

The following additional summary is given of the cost (exclusive of ten per cent. for contingencies) of completing certain portions of the distributing reservoir in the manner specified:

16. For completing the whole reservoir to a depth of eleven feet, including the central gate-house, the conduit connecting it with the effluent gate-house, and the raising of the dividing bank to its full height, giving a storage capacity of 150,850,000 gallons	$109,870
17. For completing the upper division to a depth of eleven feet, including a coffer-dam around the site of the central gate-house, so as to admit of its future construction, and the raising of the dividing bank to its full height, giving a storage capacity of 86,120,800 gallons	41,800
18. For completing the upper division to a depth of twenty-four feet, including the central gate-house, connecting conduit, and dividing bank, as in item 16, giving a storage capacity of 172,530,000 gallons	163,854
19. For completing the lower division to a depth of twenty-four feet, including a coffer-dam, and the raising of the dividing bank, as in item 17, giving a storage capacity of 127,370,000	171,700
20. For completing the upper division to a depth of eleven feet, and the lower division to a depth of twenty-four feet, including the central gate-house, connecting conduit, and dividing bank, as in item 16, giving a storage capacity of 213,500,000 gallons	230,436

If Congress shall concur in the opinion that any further appropriations should be expended with a view only of improving the *quality* of the water, so far as it can be done, by drawing a full supply directly from the Potomac, without adulteration with the water collected from other sources in the receiving reservoir, this result can only be accomplished by the completion of the Potomac

dam to Conn's island and the construction of the connecting conduit around the lower end of the receiving reservoir.

If, in addition to this, it shall be thought advisable to bring into use, for storage and purifying purposes, the cheapest and most available portion of the distributing reservoir, this object will be attained by the completion of the upper or western division of the reservoir to its present depth of eleven feet. In doing this, however, provision should be made for the completion of the influent and auxiliary gate-houses and pipe-vault connected with the distributing reservoir.

If, in addition to the foregoing, it shall be thought proper to repair and complete the high-service reservoir at Georgetown, which is very much needed, and also to provide an adequate amount for engineering, repairs, and contingencies, the items, as numbered above, making up the appropriation, will be aggregated as follows:

1. For Potomac dam	$49,000
9. For new conduit around the receiving reservoir	99,200
17. For completing upper section of the distributing reservoir to a depth of eleven feet	41,800
7. For completing influent and auxiliary gate-houses and pipe-vault at the distributing reservoir	9,240
8. For completing high-service reservoir at Georgetown	8,920
13. For engineering, superintendence, and repairs, say	20,000
	228,160
15. Add ten per cent. for contingencies	22,816
Total amount	250,976
Deduct balance on hand 1st Feb., 1864	18,000
Appropriation required	232,976

4. Sewerage in the city of Washington.

The subject of "sewerage in the city of Washington," also embraced in the Senate resolution, will be found referred to in the following extracts from the annual reports of the Secretary of the Interior and of the chief engineer of the Washington aqueduct:

Extract from the report of the Secretary of the Interior.

"The report of the engineer will not fail to arrest the attention of Congress in another important particular.

"The immense volume of water which the aqueduct will soon furnish will afford an ample supply for fountains at all appropriate places, and for cleansing the streets and sewers of the city—keeping them at all times in a healthful and agreeable condition. But in order to the accomplishment of this most desirable object, the present system of expenditure for the repairing of streets and the construction of sewers must be abandoned, or modified to such an extent as to place it under one control. I can perceive no good reason why the government should take upon itself the exclusive management and repair of one or more of the streets and avenues of the city, while all are equally necessary to the convenience and comfort of the citizens of the United States visiting or residing in the city of Washington. The great width of its numerous streets and avenues quite discourages any attempt to completely pave them; nor is it desirable that it should be generally done, when we consider the increased amount of heat that would be radiated from their exposed surfaces, and the clouds of dust that would be constantly sweeping over them.

"It is believed that this may be avoided to a great extent by allowing, in

some instances, the adjoining proprietors to extend the sidewalks into the streets, so as to reduce the latter to a proper width for pavement or concrete, and to afford space for grass plots in front of their dwellings, and in other streets by making a park of proper width through the middle for the cultivation of trees and plants and the erection of fountains. By the adoption of such a course the streets and avenues of the city would be reduced to such width as to admit of their being thoroughly paved at a reasonable cost, and the beauty and comfort of the city immensely increased. But neither this nor any other great improvement can be expected under the present law. They should be so modified as to require a uniform and perfect system of sewerage throughout the city, and to superintend this, and to improve and repair the streets, commissioners should be provided, one to be appointed by the government, and one or more by the corporate authorities of the city—the money appropriated by Congress to be expended in such proportion to the sum provided by the city as should be prescribed by law, and the obligation imposed upon the city to raise by taxation, annually, such sum as might be deemed by the commissioners necessary for the objects to be accomplished."

Extract from the report of the chief engineer.

"DRAINAGE AND SEWERAGE."

"The introduction, by artificial means, of a large supply of water into towns and cities for the use and comfort of the inhabitants must, as a matter of course, create a necessity for a revolution in the system of drainage and sewerage previously in use; and on that account, as well as on account of the intimate relations which naturally exist between the two improvements, they are generally placed under the same general direction and superintendence. This has not been the case in the present instance. The drainage facilities for the cities of Georgetown and Washington are, at present, only intended to accommodate the discharge of water falling on the surface which is naturally tributary to this drainage, together with the sewage of the cities; and they are found in many instances to be much too limited for even these purposes.

"The introduction, by means of the aqueduct, of from twenty to fifty million additional gallons of water daily into these cities, and the necessary discharge of a large portion of it into the drains and sewers now in use, will at once create a necessity for an entire remodelling of the present system of drainage upon a much larger and more extensive scale. This may not be so important in Georgetown, on account of the greater irregularity of the surface and declivity of the streets, as in the city of Washington, where the ground is more level, and the drainage more sluggish.

"At the present time a very large portion of the drainage and sewerage of Washington is discharged into a shallow, open sewer, of about one hundred and fifty feet in width, (sometimes called a canal,) which stretches its filthy surface through the heart of the city, and within a stone's throw of the Capitol of the United States, the President's House, the Treasury Department, and all the principal hotels on Pennsylvania avenue, breeding disease and pestilence along its borders. The accumulated filth and excrement of the city is constantly held in a state of semi-solution in this hotbed of putrefaction, by means of the ebb and flow of the tides, over a surface of more than a million square feet. And whatever portion of it ultimately finds its way into the Potomac river is spread out in thinner proportions over several hundred acres of flats immediately in front of the city, the surface of which is exposed to the action of the sun at intervals during the day, and the miasma from which contaminates every breath of air which passes, from that direction, through or over the city.

"All this may be remedied by the adoption of the most simple and natural expedients. A portion of the canal, say twenty or twenty-five feet in width, should be walled in and arched over, and a flood-gate inserted at its junction

with the river; this portion should be used exclusively for purposes of sewerage and drainage, while the remaining longitudinal section should, by the adoption of a proper system of flood and stop gates and locks, be kept constantly filled, to the level of high tide, with pure Potomac water. The water thus held in the canal, together with the water from Tiber creek and the surplus water from the aqueduct, should, when necessary, be allowed to flush through the main sewer at low tide, and thus keep it entirely free from sediment and deposit. By this arrangement the open canal would not only be ornamental, but exceedingly useful for commercial purposes.

"By the construction of a breakwater in the Potomac from the foot of Mason's island a few thousand feet down the stream, and so located as to divert the main current from the Virginia to the Maryland shore, and the removal of a portion of the north end of the solid causeway in the present Long bridge, at the foot of 14th street, so as to admit of a channel fifteen hundred or two thousand feet in width, the main channel of the Potomac would be brought immediately in front of the city of Washington, with a depth of water from twenty to thirty feet, into which the drainage from the main sewers of the city would be discharged and completely removed by the action of the current.

"The commercial advantages resulting to the city from both these improvements would be almost incalculable, while a fruitful cause of sickness and discomfort would be permanently removed. The cost of the improvements would be comparatively moderate, and should be borne proportionately by the government, the corporation of Washington, and the owners of the property which would be benefited by the improvements."

Should Congress deem it proper to refer the matter of sewerage and drainage to the Department of the Interior for examination, in connection with the Washington aqueduct, I should take pleasure in making a thorough examination of the subject, and in presenting such plans and estimates for the same as, I should hope, would meet with the approval of the Secretary and of Congress. A joint resolution, looking to that object, has already been introduced into the Senate at its present session, and referred to the Committee on the District of Columbia.

A bill has also been introduced in the House of Representatives, and referred to the same committee of the House, "To provide for the improvement of the Potomac river, opposite the city of Washington," which is a matter intimately connected with the sewerage of the city. As neither of these measures contemplate any appropriations of money by Congress, it is to be hoped that they will receive early and favorable action.

5. Want of a collection and proper arrangement of all laws and reports relating to the Washington aqueduct.

I desire to say, in conclusion, that during my connection with the Washington aqueduct, and particularly while preparing this report, I have felt the want of a connected, synoptical arrangement of all the laws, reports, and other published and important matter connected with this work, from its first inception to the present time; and I have no doubt that the committee, as well as Congress, have felt, and will continue to feel, the same want.

I would, therefore, respectfully, but earnestly, recommend that some provision be made for the publication of all such matter in a convenient form for reference at an early day.

All which is respectfully submitted.

S. SEYMOUR,
Chief Engineer of the Washington Aqueduct.

To the Honorable
JOHN P. USHER,
Secretary of the Interior.

APPENDIX

TO THE

SUPPLEMENTAL REPORT OF THE CHIEF ENGINEER OF THE WASHINGTON AQUEDUCT, DATED FEBRUARY 22, 1864.

A.

PRESIDENT'S MESSAGE IN REFERENCE TO THE CONDITIONS ATTACHED TO THE APPROPRIATION PASSED JUNE 25, 1860.

To the House of Representatives:

I have approved and signed the bill entitled "An act making appropriation for sundry civil expenses of the government for the year ending the 30th June, 1861."

In notifying the House of my approval of this bill, I deem it proper, under the peculiar circumstances of the case, to make a few explanatory observations, so that my course may not hereafter be misunderstood.

Amid a great variety of important appropriations, this bill contains an appropriation "for the completion of the Washington aqueduct, $500,000, to be expended according to the plans and estimates of Captain Meigs, and under his superintendence; provided, that the office of engineer of the Potomac water works is hereby abolished, and its duties shall hereafter be discharged by the chief engineer of the Washington aqueduct." To this appropriation, for a wise and beneficial object, I have not the least objection. It is true I had reason to believe, when the last appropriation was made of $800,000, on the 12th June, 1858, "*for the completion of the Washington aqueduct*," this would have been sufficient for the purpose. It is now discovered, however, that it will require $500,000 more "*for the completion of the Washington aqueduct*," and this ought to be granted.

The Captain Meigs to whom the bill refers is Montgomery C. Meigs, a captain in the corps of engineers of the army of the United States, who has superintended this work from its commencement, under the authority of the late and present Secretary of War.

Had this appropriation been made in the usual form, no difficulty could have arisen upon it. This bill, however, annexes a declaration to the appropriation that the money is to be expended under the superintendence of Captain Meigs.

The first aspect in which this clause presented itself to my mind was, that it interfered with the right of the President to be "commander-in-chief of the army and navy of the United States."

If this had really been the case, there would have been an end to the question. Upon further examination, I deemed it impossible that Congress could have intended to interfere with the clear right of the President to command the army, and to order its officers to any duty he might deem most expedient for the public interest. If they could withdraw an officer from the command of the President, and select him for the performance of an executive duty, they might, upon the same principle, annex to an appropriation to carry on a war a condition requiring it not to be used for the defence of the country unless a particu-

lar person of its own selection should command the army. It was impossible that Congress could have had such an intention, and therefore, according to my construction of the clause in question, it merely designated Captain Meigs as its preference for the work, without intending to deprive the President of the power to order him to any other army duty for the performance of which he might consider him better adapted. Still, whilst this clause may not be, and I believe is not, a violation of the Constitution, yet how destructive it would be to all proper subordination, and how demoralizing its effect upon the *morale* of the army, if it should become a precedent for future legislation. Officers might then be found, instead of performing their appropriate duties, besieging the halls of Congress for the purpose of obtaining special favors and choice places by legislative enactment. Under these circumstances, I have deemed it but fair to inform Congress that, whilst I do not consider the bill unconstitutional, this is only because, in my opinion, Congress did not intend, by the language which they have employed, to interfere with my absolute authority to order Captain Meigs to any other service I might deem expedient. My perfect right still remains, notwithstanding the clause, to send him away from Washington to any part of the Union to superintend the erection of a fortification, or on any other appropriate duty.

It has been alleged, I think without sufficient cause, that this clause is unconstitutional, because it has created a new office, and has appointed Captain Meigs to perform the duties.

If it had done this it would have been a clear question, because Congress have no right to appoint to any office, this being specially conferred upon the President and Senate. It is evident that Congress intended nothing more by this clause than to express a decided opinion that Captain Meigs should be continued in the employment to which he had been previously assigned by competent authority.

It is not improbable that another question of grave importance may arise out of this clause. Is the appropriation conditional, and will it fall provided I do not deem it proper that it shall be expended under the superintendence of Captain Meigs? This is a question which shall receive serious consideration, because upon its decision may depend whether the completion of the water works shall be arrested for another season. It is not probable that Congress could have intended that this great and important work should depend upon the various casualties and vicissitudes incident to the natural or official life of a single officer of the army. This would be to make the work subordinate to the man, and not the man to the work, and to reverse our great axiomatic rule of "principles not men." I desire to express no opinion upon the subject; should the question ever arise it shall have my serious consideration.

JAMES BUCHANAN.

WASHINGTON, *June* 26, 1860.

B.

MEMORANDUM OF INSCRIPTIONS ON STRUCTURES CONNECTED WITH THE WASHINGTON AQUEDUCT.

1. In the gate-house at Great Falls:

"Washington Aqueduct,
Projected by Captain Montgomery C. Meigs,
U. S. Corps of Engineers, Chief Engineer.
Begun November 8, 1853, by Franklin Pierce,
President of the United States.
This stone is erected in the unfinished gate-house
at the Great Falls of the Potomac,
June 10, A. D. 1858, James Buchanan
being President of the United States.
Captain M. C. Meigs, Chief Engineer of the Washington Aqueduct.
The assistant engineers have been
W. H. Bryan, C. Crozet, C. G. Talcott, A. L. Rives,
W. R. Hutton, E. T. D. Myers.
Cost of the work as estimated, 1853, $2,300,000.
Actual cost when finished, $
Dei gratia.
Esto perpetua."

2. On waste-weir No. 1:

"Waste-weir No. 1.
Washington Aqueduct,
Captain M. C. Meigs, Chief Engineer."

3. On bridge No. 1:

"Washington Aqueduct,
Captain M. C. Meigs, Chief Engineer.
Anno Domini 1857.
Bridge No. 1."

4. On bridge No. 2:

"Washington Aqueduct,
Captain M. C. Meigs, Chief Engineer.
Anno Domini 1857.
Bridge No. 2."

5. On culvert No. 12:

"Washington Aqueduct,
A. D. 1856.
Captain Montgomery C. Meigs, Chief Engineer.
No. 12.
May, 1856."

6 On bridge No. 3:

"Washington Aqueduct,
Chief Engineer,
Captain Montgomery C. Meigs,
U. S. Corps of Engineers.
Division Engineer,
Charles G. Talcott, C. E.
Bridge No. 3.
June 9,
A. D. 1858."

7. On Cabin John bridge (on the east abutment:)

"Union Arch.
Chief Engineer, Captain Montgomery
C. Meigs, U. S. Corps of Engineers.
Esto perpetua."

(On the west abutment:)

"Washington Aqueduct,
Begun A. D. 1853. President of the U. S.,
Franklin Pierce. Secretary of War,
——— ———. Building A. D. 1861.
President of the U. S., Abraham Lincoln.
Secretary of War, Simon Cameron."

(On one of the arch stones:)

"M. C. Meigs,
Chief Engineer.
Washington Aqueduct.
A. D. 1858.
Fecit."

8. On sluice tower at receiving reservoir:

"Washington Aqueduct,
Built by order of the Congress of the United States, for bringing water into Washington.
Begun A. D. 1853, on the 8th day of November.
Water delivered in Washington
from this reservoir A. D. 1859,
on the 3d day of January.
From the Potomac river A. D. ——, on the —— day of ——.
151 feet above 0 of the Washington Aqueduct, or 150 feet above ordinary high water at Washington. A. D. 1858.
Captain M. C. Meigs, Chief Engineer."

9. At the distributing reservoir the *rise* of each of the thirty-nine iron steps leading down into the pipe-vault is composed of the letters

"M. C. MEIGS."

10. On bridge No. 6, across Rock creek, (two inscriptions, one on each side:)

"Washington Aqueduct.
A. D. 1859.
Chief Engineer, Captain M. C. Meigs,
U. S. Corps of Engineers.
Division Engineer, E. T. D. Myers, C. E.
Iron Founders, A. & W. Denmead & Sons."

11. On waste-weir No. 3, between the two reservoirs:

"Washington Aqueduct,
Waste-weir No. 3.
Dec., 1858.
Captain M. C. Meigs, Chief Engineer.
W. R. Hutton, C. E., Division Engineer."

12. In addition to the above:

"Washington Aqueduct, M. C. Meigs,"

is stamped upon nearly every piece of iron or brass connected with the derricks and machinery used for the construction of the work, and the hoisting gear of all stop-cocks and water-gates.

C.

LETTER FROM GENERAL M. C. MEIGS TO THE SECRETARY OF THE INTERIOR, DATED AUGUST 27, 1863.

QUARTERMASTER GENERAL'S OFFICE,
Washington, August 27, 1863.

DEAR SIR: I enclose copy of a letter received to-day from Lewis Baker, a person unknown to me.

I have no further connection with the water works than a natural desire that they shall be well and economically completed. The office contains complete plans of every detail of my designs, which Congress, by a law, directed to be followed in completing the work. None of the work can need to be taken up. That portion from the receiving reservoir to the city, which has been in use for several years, without costing a dollar for repairs beyond filling up washes of the new embankments, is exposed to a greater head or pressure of water than any other portion of the conduit or work. It is built precisely like the rest of the work not yet brought into use. One portion of the conduit about culvert 18 was put hastily into a fresh embankment in wet weather to avoid interruption by a lawsuit. The embankment settled and this portion of the work cracked. These cracks were being repaired when I left the work. No other part of the work can need any but ordinary repairs.

On the Croton and other aqueducts annual repairs of cracks caused by settlement are necessary. On the part of the Washington aqueduct in use no such repairs, after the first month's use, have been needed or made within my knowledge.

Before introducing water from the Great Falls, the whole interior of the conduit ought to be carefully inspected, and all shrinkage or settlement cracks should be carefully pointed with cement. If this is done well, no repairs will be needed to the conduit for years. If the plans prescribed by law are followed (see act of 1860, chap. 211, page 106, vol. XII) with reasonable skill and ordinary fidelity, the work will be durable, substantial, and satisfactory. Any change will involve additional expenditure, and require special legislation to legalize it.

Having made all the designs and plans of this work *ab initio*, having devoted many years of labor to its construction, I desire to see it completed as designed, and am willing to remain responsible for its success, if so completed.

From any change I anticipate ill results—if not to the work, at least to the treasury.

I am, very respectfully, your obedient servant,

M. C. MEIGS,
Quartermaster General, late Chief Engineer Washington Aqueduct.

THE SECRETARY OF THE INTERIOR.

D.

REPORT OF S. SEYMOUR TO THE HONORABLE J. P. USHER, ASSISTANT SECRETARY OF THE INTERIOR, IN RELATION TO THE PROPOSED DAM AT THE GREAT FALLS OF THE POTOMAC.

WASHINGTON, *October* 16, 1862.

SIR: In obedience to your request, I accompanied Mr. Hutton, the chief engineer, over the Washington aqueduct, on the 9th instant, to the High Falls of the Potomac, and spent several hours in examining with him the topography

of the country and the flow of water, both at the falls and at the head, and down both sides of Conn's island.

Mr. Hutton explained to me very frankly and fully the plans that have been adopted with reference to obtaining an adequate supply of water for the Washington aqueduct from the Potomac at that point. As my views differ in many respects from those of Mr. Hutton, as well as from the plans heretofore adopted and approved by him, I will proceed to explain them to you, and to make such suggestions for your consideration as, in my opinion, the importance of the subject demands.

The conduit of the Washington aqueduct is considerably larger than any other now in use for a similar purpose in this country. It is a circle of nine feet diameter in the clear, and has an inclination of nine and one-half inches per mile. The transverse sectional area is $63\frac{62}{100}$ square feet. Assuming that the available area for water-way is only fifty square feet, and that the average velocity of the current will be only two miles per hour, it will then discharge nearly *one hundred million gallons* every twenty-four hours.

Although this quantity of water may be much greater than will be required for many years, yet it is unquestionably expedient that a full supply at the fountain head should be secured for all time.

It is proposed to divert a sufficient quantity of water from the Potomac at the Great Falls for the supply of the aqueduct, by means of a dam across the branches or channels of the river running each side of Conn's island. The specification for this dam reads as follows: "The dam will be an embankment of rubble stone, with a top width of (20) twenty feet, a slope on the upper side of one to one, and on the lower side of five to one. It will be made with large stones, the spaces filled with smaller ones, so as to form a compact mass ($8\frac{1}{2}$) eight and one-half feet from the upper slope, and laid parallel with it, there will be three feet in thickness of spalls and gravelling. Care will be taken to place on the outer surface of the bank stone sufficiently large to resist the action of high freshets," &c.

The Great Falls of the Potomac affords one of the finest natural water-powers for manufacturing purposes in the country, and perhaps in the world. The government, therefore, in appropriating any considerable portion of this water to its own use should do so in a way to inflict as little injury as possible to the rights of the owners of the remaining water, or, in other words, the dams, and other structures that may be required for the purposes of the aqueduct should be so planned and constructed as to be permanent and imperishable in their character, to permit of no unnecessary waste of the water, and to allow, as far as practicable, the convenient and unobstructed use of the remaining water by the legitimate owners for manufacturing or other purposes. From the examination and reflection that I have been able to give the subject, I am fully convinced that the above objects will not be fully accomplished by the present plans.

A large island, containing about (200) two hundred acres, (known as Conn's island,) divides the waters of the Potomac a little above the Great Falls.—By far the largest portion of the water flows upon the Virginia side of this island, and it is upon this side that water for manufacturing purposes can be taken from the river to the best advantage.

The aqueduct enters the river from the Maryland shore at a point nearly opposite the foot of Conn's island, and therefore draws the water in the first instance from that portion of the river which flows upon the Maryland side of the island.

Unfortunately, however, in my opinion, there are two facts existing which will prevent the water that naturally flows upon this side of the island from fully supplying the aqueduct, except in cases when the river is above low-water mark—these are, first, that during stages of extreme low water there is apparently not a sufficient quantity running in the Maryland channel (exclusive of

the waste water from the Chesapeake and Ohio canal) to fill the aqueduct; and, second, that the level of the water at the head of the island during low stages is, as I am informed by Mr. Hutton, only five feet above the bottom of the mouth of the conduit, which fact shows that, whatever might be the quantity of water running in the Maryland channel, there is not sufficient head, (after allowing one-half of a foot as a necessary inclination for the requisite velocity of current,) to fill the aqueduct above its centre line.

It will therefore be seen that, should the dam across the Maryland channel, immediately below the mouth of the aqueduct, be constructed sufficiently high to raise the water to the crown of the conduit, it would only cause the water to set back and flow down the Virginia channel. To obviate this the present plan contemplates the construction of an additional dam across the Virginia channel of the same height.

If there was sufficient elevation at the upper end of the island to fill the aqueduct, the deficiency of water, if any, in the Maryland channel might be remedied by deepening the head of the channel, and thus diverting a portion of the water from the Virginia side of the island; but as it is, this is evidently impracticable. If the grade line of the aqueduct had been depressed four or five feet there would have been no necessity for constructing a dam across the Virginia channel. Why this was not done is not apparent to me.

I consider both the location and plan of the present dam as highly objectionable. The line of the dam is quite oblique to the channel, and forms an acute angle of, say, about (50°) fifty degrees, with the Maryland shore, looking up the river, and on that account will have a tendency to throw the flood wood over towards the entrance of the aqueduct, and upon that portion of the dam nearest to it. The dam is also required to be much longer, on account of this obliquity, than it would be if located directly across the river.

The effect of raising the water four or five feet at the upper end of the island, by means of perfectly tight and permanent dams intersecting it upon each side, would, in my opinion, be to endanger the safety of the island itself during high floods.

The only apparent motive for the present location is to reach a piece of land owned by the government on the Virginia side of the river, with a view perhaps of evading the question of damages to the owners of the water-power below that point. Were this question of damages entirely settled and out of the way, I should, so far as I can judge without having made a critical examination of the Virginia shore, consider the most natural location of the dam to be in the form of an arc, extending from the mouth of the aqueduct to a point on the Virginia shore below the mouth of the old canal, which happens to be almost directly opposite.

The plan of the dam is, in my opinion, open to at least two very serious objections, to wit: Want of stability, and a want of that degree of compactness which is necessary to prevent the wastage of a large amount of water by filtration. Both of these objections should, in my opinion, weigh very seriously with the government, as well in regard to the question of ultimate economy in the use of the water as in the question of present damages for the diversion of a much larger amount from the Virginia channel than they actually use, and the risks taken by the owners of manufactories below on account of the danger of the carrying away of the dam during high floods.

I observed at the head of Conn's island a large amount of floatsome, piled several feet in height, and composed of large trees and timbers, some of which appeared to be portions of the Harper's Ferry railroad bridge, in parts of sections firmly bolted together. Much of this was evidently deposited during the unusually high flood of last spring, and a much larger quantity undoubtedly passed down the river alongside of the island. The water during that flood was, as I am informed, only about two feet above the top of the riprap dam, which

is now completed some six hundred feet in length across a portion of the Maryland channel. This portion of the dam shows very little damage from the flood, on account of the abundance of water-way both in the Virginia channel and those portions of the Maryland channel (several hundred feet in width) at each end of the dam. If these channels had been obstructed by a similar dam, extending entirely across the river, I am quite confident that scarcely a vestige of them would have remained after the waters had subsided.

If this first objection to the plan should prove to be well founded, then the question may, of course, be considered as disposed of without discussing the second objection. But admitting, for the sake of the argument, that the dams will stand permanently, I submit in the greatest confidence that they will, in low stages of water, pass a much larger quantity through them than they will divert to the aqueduct. I know of several instances where, at the present time, living streams are running, and have been running for years, through rock embankments of from fifty to one hundred feet base, and when culverts were dispensed with by my own direction as an unnecessary expense.

My experience and observation, therefore, force me to the irresistible conclusions, with reference to the dam as now proposed to be constructed—first, that it will not during low stages of water produce sufficient head to fill the conduit; and, second, that in stages of high water, when no dam is needed, it will be carried away by the floods. I would therefore advise the construction of a dam of the most substantial solid masonry.

If it should be determined that the water naturally flowing upon the Maryland side of Conn's island will be sufficient, at all stages, to afford a full supply for the aqueduct, and that, in obtaining this supply, it is inexpedient to interfere in any manner with the natural flow of the water in the Virginia channel, this result may at any time be accomplished by extending a wing dam from the head of the island up the river to a point giving sufficient head, and locating it in such a manner as to produce the same natural division of the water as is now secured by the island. This expense, however, or any other, for the purpose of obtaining a greater head than four feet, may very well be deferred so long as it is found that one-half the capacity of the upper end of the conduit, in addition to the present reservoir below, affords the required supply. Should the plan of the dam be changed from loose, or riprap, to solid masonry, and the location extending across the river below the island be adopted, then it will only be necessary to extend the dam to a point opposite the lower end of Conn's island, and there connect it temporarily with the island in order to secure all the water flowing down the Maryland channel, and to raise it sufficiently high to furnish a supply for present purposes, equal to one-half the capacity of the conduit.

The above suggestions and recommendations are submitted to the department with much hesitation, for the reason that they differ so materially from the views of the present chief engineer, and from the plans heretofore recommended by Captain Meigs and adopted by the government.

The following extract from the specifications shows, however, that Captain Meigs did not regard the proposed dam as an entirely permanent structure:

"For thirty feet above the upper edge of the dam all materials will be removed for a depth of four feet below the level of water in the pool to form a boat channel that can be used in replacing any of the stones carried away by high freshets."

The following extract from a paper prepared by the same engineer in April, 1858, also shows that he had not, in his own opinion, selected the best site for the dam with reference either to its cost, or the damages to the proprietors of the water-power:

"The plan of this dam, shown upon the drawings in the office, may possibly be modified, as negotiations are now in progress with the owners of the water-

power on the Virginia shore which may result in the acquisition of a better site for the dam than the only one heretofore available, and in the revision of the location so as to reduce the cost of the dam, and at the same time to construct one which will render the water-power more available to the proprietors."

There is, perhaps, no subject connected with the profession of civil engineering, the investigation of which has occupied more time and attention, and involved the expenditure of larger amounts of money, than the one involving the stability and imperviousness of structures required to resist the action and pressure of water. Amounts almost fabulous have frequently been expended by engineers of acknowledged reputation, and upon plans apparently unexceptionable, without accomplishing the desired result.

The vast destruction of property by the unprecedented floods of the past few years in different parts of the country, and the failure of structures that had withstood the action of the water for a quarter of a century, and were supposed to be impregnable, should admonish engineers to use the greatest caution in the recommendation of plans and specifications for structures that are to be at all exposed to the action or pressure of water.

If, in the face of these facts and experiences, it shall now be found that a promiscuous mass of loose augular rocks, interspersed with a thin section of spalls and gravel, will successfully withstand the floods of the Potomac, and at the same time be impervious to water, the fact may well be regarded as an engineering paradox.

In a matter involving so large an expenditure of money, and results so important both to the government and the cities of Georgetown and Washington, I would respectfully recommend the department, before proceeding further under the present plans, to avail itself of the best experiences, and the advice of the best engineering talent in the country. The time and expense required to do this will be trifling in comparison to the importance of the questions and results involved.

I will also take the liberty of calling the attention of the department to what I regard as a serious defect in the plan of completing the large distributing reservoir near Drovers' Rest. The present plan contemplates the interior slopes "to be faced with broken stone." It has been found that this facing will not answer the purpose, and consequently it has been necessary, in the reservoirs of the Croton aqueduct, to substitute a solid slope wall, either pointed or laid throughout with hydraulic cement.

I have the honor to be, very respectfully, your obedient servant,

S. SEYMOUR,

Consulting Engineer, 411 *Pennsylvania Avenue.*

To the Honorable
J. P. USHER,
Assistant Secretary of the Interior.

E.

EXTRACTS FROM TESTIMONY TAKEN BEFORE COMMISSIONERS IN RELATION TO THE DAM AT GREAT FALLS.

Testimony of James Slade, Esq.

Question. What is your general experience and practice as a scientific engineer, so far as your experience and knowledge have been applied to departments of engineering, and in what special departments of civil engineering have you been employed?

Answer. I have been the city engineer of Boston somewhere about seven

years, having charge of the water works principally about six years of that time. I made the original surveys for the water works of the city of Baltimore, and the plan that was adopted, and during the construction of the water works the city government passed an ordinance authorizing the commissioner to employ me as consulting engineer, and I was such for nearly three years. I was engaged upon the construction of the Boston water works from the foundation of the reservoir, having that in charge as resident engineer, and superintended the laying of two great mains. I was engaged there some two years. I was also engineer of, and made plans for the construction of the Hartford water works. I took exception with the commissioners in regard to plans of engines, and we parted on that. I also made surveys and plans with reference to the extension of the water works in Cohoes, and was consulting engineer. I also made estimates and calculations for the water-power company in Cohoes, as to their water-power, giving Mr. Young a detailed estimate of what they had there. I was consulted by the contractors of the Brooklyn water works on several points; also, in reference to the water works of St. John's, New Brunswick, I do not know how many times, and although I did not visit there myself I sent on my assistants. Three of the commissioners came on to Boston to see me, and I proposed an improvement there which they adopted, and which operated as they desired. I learned them how to get a supply of very excellent water. I have acted as consulting engineer on various matters for many years past. I was resident engineer upon a dam built near Island Ann, Boston, of which Colonel Boardman was chief engineer. I was engaged on the construction of the Albany water works, from very near the commencement down to the introduction of water, or until a few days of that event, when I resigned my position.

Mr. Stanton.—Question. What would be the character of the riprap or rubble dam as to tightness?

Answer. Such as is now constructed, some 600 feet in length, I should consider so imperfect that I should not like to trust it as a dam in case of a freshet.

Question. There is no sluice-way mentioned in the plan, I believe. Have you formed any estimate of what the construction of such a sluice-way would cost?

Answer. I have not. A riprap dam could not be made to hold the water. The circular dam, in my opinion, would be by far the best adapted to the wants of both parties. It would be much less liable than the others to break away. The tendency of the water on the circular dam would be to consolidate it, and it would certainly give more overfall than a straight one. The water would not rise so high upon it, and it would be less liable to break away in case of freshet. It would require an increase of length in the bulkhead; that is, I mean something more than they now have. The construction of that circular dam would not be of so much injury to the company as either of the others. I cannot form any idea of what it would cost to put the dam there.

Mr. Bradley. It makes no provision for bulkhead upon the main land. They would have to put up a bulkhead for their own protection, which would only be required in case of a flood.

Mr. Childs. Do you mean to say it would not be safe to erect large mechanical works with that kind of dam—rubble or riprap?

Answer. It would not be safe to have a rubble dam there. I should not be disposed to trust anything below it. The low dam mentioned in the plan would be much more likely to stand than the high one.

Mr. Walker.—Question. With the knowledge you have of this matter, do you think that the manufacturing capitalists of New England would deem it secure to invest a large amount of capital in works with a rubble dam like this proposed by the government?

Answer. I think they would not certainly.

Mr. Stanton.—Question. Would it not be necessary for the dam to be entirely tight in order to secure it at all?

Answer. I judge it would. A solid stone wall might be made of the rubble-stones, provided they were cemented and made tight in that way. A large mass of ice coming down the Potomac would carry away the smaller stones and tend to destroy the rubble dam. The specifications, however, which you now show me, describe a different dam from the one I am testifying upon, and different from that now erected.

Question. What proportion of the weight of such stone as is described there is sustained by the water: one half, or do you know the specific gravity of that kind of stone?

Answer. I do not know exactly, but suppose it must be something near the same as granite. Granite weighs something like 170 pounds to the cubic foot, and the water weighs 62½ pounds.

Question. Would you advise the building of a riprap dam, such as is described, across the Virginia shore to this point?

Answer. I would not. I cannot conceive any object to be attained by building a dam of masonry on one side and riprap on the other.

Question. Could the stones of the riprap settle, all being separate, horizontally, or could they settle perpendicularly?

Answer. They could settle some, possibly. A dam twenty-five feet high, or thereabouts, might settle two or three inches. There would be liability to looseness in the substructure in the riprap, and spaces. There would be flows all through the rock structure of the dam all the time. You cannot pile rough stones up in any possible manner without having spaces between them.

Testimony of Samuel McElroy, Esq.

Question. Please state what experience and study you have had as a civil engineer, more especially with reference to water-courses and the construction of dams, or to the taking of water, either for a mill-power, canals, or aqueducts; and also more especially to steam-power as well as water-power.

Answer. I have been employed as an assistant engineer of the Erie canal enlargement; also as an officer of the engineer corps of the navy, and as such engaged on the plans, erection, and operation of steam machinery; was principal assistant engineer of the New York navy yard, for several years in charge of the prominent structures there; was associate engineer in surveys for the Niagara ship-canal, and on surveys and plans for the Rochester water-works; have been connected with the Albany, Hamilton, and other water-works; was chief engineer of the Brooklyn water-works at the time the plans and specifications were prepared and the work put under contract; have also been engaged in the measurement of rivers for the determination of tidal currents, and in the preparation of papers for prominent magazines of the country on hydraulic engineering, which I have made a special study; have also been in charge of railroads as chief engineer.

Question. Have you had personal observation and more or less examination of the site of the Great Falls on both sides of the river, including the existing canal of the Potomac company, and the works of the Washington aqueduct, as connected with the river at that place?

Answer. Yes, sir.

Question. Sufficiently to enable you to speak of special localities designated on the map, to be made the subject of inquiry in the examination of witnesses?

Answer. So far as general examination will permit.

Question. I now ask your attention to the dam projected next above, which is marked A on the map. What would be the effect of the dam constructed on that oblique line, proceeding in a straight line of solid masonry from the Mary-

land bank to Conn's island, and from Conn's island, in riprap, to the Virginia bank? What would be the effect of that dam upon the water-rights and water-power of the company, first as to the diversion of water?

Answer. The same effects in general as described for the lower dam, with this exception: If we assume that the crest of the dam is flowing, the waste would be in proportion to the length, which would be in the proportion of about 1,200 on the Virginia to 1,510 on the Maryland side, in length; but I do not think that the riprap dam on the Virginia side would be tight. It would involve, I think, two contingencies to the company; one is, the construction of the wing-dam to Conn's island, in order to catch the water which is wasted through the riprap dam; and the other, the construction of a hydraulic canal from the mouth of the present canal to the dam. In order to secure the water from the line A, I think they would need both of those structures.

Question. What proportion of leakage or wastage would the portion of it which is riprap involve?

Answer. If a channel above the dam were not to be blasted out across Conn's island, as described in these specifications, so that the crest of dam on Conn's island is about the same level as Conn's island itself, I doubt very much whether any water would be thrown on the Maryland side, except the spill of the dam on that side. I think the dam would operate as our railroad riprap culverts do, and waste the flow of the river—certainly a large portion of it.

Question. What is the operation of ordinary railroad riprap culverts?

Answer. They are put in for the purpose of passing streams under railroad embankments, particularly for torrent streams.

Question. Are they, or not, a substitute for culverts of masonry?

Answer. Yes, sir.

Question. I understand that in your experience ripraps have been used for passing mountain streams under railroads, &c., as substitutes for culverts; that is, on the same principle as French drains, as they are called.

Answer. Very much so.

Question. Are they not subject to being stopped up by silt flowing into them?

Answer. No, sir; they always clear themselves. The floods keep them clean.

Question. In that event are not the stones loosely thrown together?

Answer. They are packed as closely as they can be made with an ordinary dump. They are dumped in—all sizes.

Question. Have you looked at the specifications of this riprap dam?

Answer. Yes, sir.

Question. Is that such a dam as is made under railroad embankments for mountain streams?

Answer. As far as its tightness is concerned, I think it would come under the same general law. It is more carefully made, however, and has the addition of a short layer of smaller stones; but the relative tightness would be a mere question of spaces.

Question. In these ripraps of which you spoke are the spaces filled in with smaller stones so as to form a protection of three feet of thickness of gravelling upon them?

Answer. If the relative sections are compared, I think the relative tightness is in favor of the culvert. As I understand it, this dam is but twenty feet across the head. The culverts to which I have made reference are in all cases a great deal longer. The structure should be made very tight, so as not to settle. It would not do to fill up on a shaky foundation.

Question. So that work of this description would afford only a medium obstruction to the passage of the water?

Answer. Yes, sir.

Question. In ordinary times would the water flow through almost as fast as the supply?

Answer. That is a matter that would depend upon the velocity of approach more than anything else.

Question. My object is to see what the effect of this riprap dam "A" would be in preventing the flow of water to the company's grounds as they now stand, and if it is so opened as to operate more efficiently in passing water than the ripraps under the railroads. I want to know to what extent it would impair the value of this water privilege by shutting off the water. Have you any memorandum of the velocity of the stream there?

Answer. No, sir. The cases to which I refer are mainly in torrent streams, which are small streams in warm weather, and in the spring are torrents. And the relative level at the dam you speak of would, of course, depend upon the quantity of water coming down the river and the velocity of approach. The water would pile up on the upper stream side.

Question. You spoke of the accumulation of rocks in riprap as a substitute for culverts under embankments of railroads; have you special knowledge of such substitutes?

Answer. Yes, sir; there is one case in the New York and Erie railroad, near Hornersville, in which there is an embankment of about fifty feet in height, in which the base line of the culvert, that is, riprap work, is about 200 feet in length, which passes a creek.

Question. Does that riprap work constitute the foundation in the bed of the creek, or river, upon which the entire embankment rests?

Answer. Yes, sir; there is another case of much larger character than this on the Cascade creek, in a gorge crossing, where the base is several hundred feet—nearly seven hundred feet in length.

Judge CURTIS. Question. In this case the riprap work is carried up much above the level of the water, I suppose?

Answer. Yes, sir; the stream banks up.

Question. In that case the water would be run over the dam. Of course, in the case of these culverts, it would run under?

Answer. That would depend upon the quantity of delivery and force of velocity of approach.

Question. How much interstitial space must you allow for the delivery of the water?

Answer. In those cases tunnels were built to aid the free discharge in case the water did not go through, but were not used. The riprap is carried up to meet extraordinary currents, but in the ordinary current the water flows through without any trouble.

Question. Did I understand you that the flood cleanses them from silt?

Answer. Yes, sir; it has that effect.

Question. Have you had any experience of the percolation or leakage through rubble-stone dams?

Answer. The percolation of water through riprap dams? I have built a number of culverts to allow the escape of water.

Question. Describe the nature of one of these substitutes.

Answer. We would take the common stone and throw it in indiscriminately, making it pretty broad and pretty high, covering that with brush and leaves and then earth, and building the railroad bank right over it.

Question. What was the magnitude of the structures?

Answer. All heights, from five feet to, on the New York and Erie railroad, enormous heights and consequent breadth of base. One of them is over fifty feet, and another of them, at the cascade, of the height of 186 feet, where they built the whole bottom with loose rock, which allows all the water to flow through. There is more than one saw-mill above the railroad, and the stream is large. To guard against accidents that might arise, they built a tunnel through the permanent hill outside, but the water has never yet come up to the tunnel.

Testimony of Marvin Porter, Esq.

Marvin Porter, being duly sworn, doth depose and say, in answer to interrogatories proposed by the counsel for the claimants, as follows:

1st interrogatory. What is your name, residence, and occupation?

Answer. My name is Marvin Porter; my residence, Davenport, Iowa; my occupation, civil engineer.

2d interrogatory. How long have you been civil engineer, and what experience have you had in that capacity?

Answer. I have been engaged in civil engineering about twenty-four years, during which time I have had charge of one division on the Genesee Valley canal; the enlargement of the Erie canal, between Lockport and Rochester; in locating a portion of the Erie railroad; location and construction of the Canandaigua and Elmira railroad, and the Canandaigua and Niagara Falls railroad; and the Niagara Falls and Lake Ontario railroad; and two divisions of the Burlington and Bellows Falls railroad.

3d interrogatory. Have you made the subject of hydraulic engineering your study?

Answer. I have, so far as obtaining water for canals, and determining the flow of water in canals.

16th interrogatory. Suppose the dams proposed by the government were to be built of riprap, what would be the effect on the waste of water?

Answer. It is very doubtful whether, in a low stage of the water, it would flow over the dam. It would probably all waste through the dam before it could be brought to the crest of the dam. I have frequently, in constructing railroads where the embankment was from 50 to 60 feet in height, across a stream of 15 feet wide, and water in ordinary stage 6 inches in depth, formed an embankment of rock for the first 30 or 40 feet in height. With a base 196 feet it would pass all the water through it without injury to the embankment, even in high stages of the water. I have also passed water through an embankment where the base would be 50 feet, where the water in high stage would be from 5½ to 6 feet above the bed of the stream embankment made in the same way as the dam of the government appears to be, of riprap. This method is frequently resorted to by engineers to save the expense of constructing culverts.

The present riprap dam already constructed at Great Falls by the government is no better than those which we make for embankments I have described. The character of the work is the same; that is, the stone are thrown in haphazard and filled up as best it can be done afterwards.

FEBRUARY 2, 1863.

Met pursuant to adjournment.

Marvin Porter recalled.

1st question. Have you made an examination of dam No. 1 on the Chesapeake and Ohio canal? And if so, state what is its condition.

Answer. I have examined dam No. 1 of the Chesapeake and Ohio Canal Company, and find it more or less injured where the current strikes it directly; and that portion of the dam from the mouth of the feeder to the angle in the dam, and also about one-half of that portion between the angle and the island in the river has been partially carried away from the lower side of the dam, the stone being thrown up in an irregular manner by the action of the water evidently, and many of them deposited in the bed of the river below. The water does not rise to the top of the dam in this part of it, but passes through, showing the lines of the inner angle of the dam. The same may be said of some portion of the dam on the westerly side between the island and the Virginia shore.

1st cross-interrogatory. When did you make the examination?

Answer. On Saturday, the 31st day of January.

The following testimony of Mr. John G. Stone, a former superintendent upon the "Chesapeake and Ohio canal," was taken in the same case, to show the instability of the feeder dams constructed of "riprap" on the Potomac river.

Witnesses for the United States.

John G. Stone, being duly sworn, doth depose and say, in answer to interrogatories proposed by Joseph H. Bradley, esq., counsel for the United States, as follows:

1st interrogatory. What is your name, residence, and occupation?

Answer. My name is John G. Stone; my residence, Georgetown, D. C.; my occupation, a wood merchant.

2d interrogatory. Were you at any time, and for how long a period, and in what capacity, employed on the Chesapeake and Ohio canal?

Answer. I was employed on said canal in the spring of 1832, as a volunteer rodman under Mr. Purcell and Mr. Cruger, civil engineers of that company, during the location of the canal, and afterwards as assistant engineer in the construction of the work; and, after the completion of the work, as division superintendent, under Mr. Fisk; and afterwards, as general superintendent; so that, with an intermission of one or two years, I was employed there for about twenty-five years.

Cross-examination by J. B. Stewart, Esq., counsel for the claimants.

1st cross-interrogatory. What is the special office of the dams on the canal?

Answer. They form feeders to supply the canal with water.

2d cross-interrogatory. State specifically how each dam was built.

Answer. The first and second dams were built with riprap stones. The third dam is the Harper's Ferry dam, built by the government; it is partly now a masonry dam. Dam No. 4 was built of timber filled in with stone, and replaced by a masonry dam. Dam No. 5 is the same, a crib dam filled in with stone, and is now being replaced by a masonry dam. Dam No. 6 is a crib dam filled in with stone. Dam at Cumberland, called No. 8, is a masonry dam.

3d cross-interrogatory. Why were dams Nos. 1 and 2 built differently from the others?

Answer. I don't know any reason why, except that the riprap dams answered the purpose to raise the water a few feet, and the other dams were stronger and answered the purpose better to resist the water at a greater height.

4th cross-interrogatory. Were all these dams built across the river?

Answer. I am not certain about the Seneca dam; all the others are.

5th cross-interrogatory. To operate as canal feeders, how are dams 1 and 2 arranged as to the line of the current?

Answer. Dam No. 1 inclines up the river a little to an island, and then goes from the island straight across the river. Dam No. 2 inclines up the river.

6th cross-interrogatory. How were dams Nos. 1 and 2 repaired, and how often?

Answer. Dam No. 1 has never been repaired since it was rebuilt with large stone. Before that it was repaired whenever the water would get extremely low in the river each year. Dam No. 2 would be repaired in the same way whenever the water would get extremely low.

7th cross-interrogatory. Were not dams 4 and 5 rebuilt of masonry to make them hold water and stand freshets?

Answer. They were. The timbers were rotten—the dams required repairing, and the canal board concluded to rebuild them of masonry instead of having to repair them constantly.

8th cross-interrogatory. How long after you repaired dam No. 1, as you have stated, did you continue as general superintendent?

Answer. I am not certain, but think it was about three or four years.

9th cross-interrogatory. Do you know whether that dam has been repaired since you were superintendent?

Answer. I do not; I don't think it has. I have passed there repeatedly.

F.

COMMUNICATION FROM S. SEYMOUR, ESQ., TO THE SECRETARY OF THE INTERIOR, IN REFERENCE TO THE SPECIFICATIONS FOR THE COMPLETION OF THE DISTRIBUTING RESERVOIR.

WASHINGTON AQUEDUCT OFFICE,
Washington, May 18, 1863.

SIR: The specifications for the completion of the distributing reservoir, near Drovers' Rest, require the interior slopes to be faced with broken stone, as shown by the drawings. "Riprap will be composed of sound, hard, and durable stone, in blocks not exceeding three inch nor less than one and a half inch cubes, to be spread evenly on the surfaces, which will first be trimmed to the proper slopes."

I have always entertained the opinion that this finish would not be sufficient to protect the banks from the action of the water during high winds, and have incidentally stated my convictions in two communications to the department—one dated October 16, 1862, and the other dated April 24, 1863.

Not feeling entirely willing, however, to take the responsibility of recommending a change in the specifications, in opposition to the views of the chief engineer, without first consulting other engineers of skill and experience in such matters, I addressed, under date of 11th instant, a communication, of which the following is a copy, to James P. Kirkwood, esq., the chief engineer of the Brooklyn water works, Alfred W. Craven, esq., chief engineer and commissioner of the Croton aqueduct, and James Slade, esq., city engineer of Boston, and engineer of the Boston water works.

WASHINGTON AQUEDUCT OFFICE,
Washington, May 11, 1863.

DEAR SIR: The present specification for the receiving reservoir of the Washington aqueduct requires that the interior slopes "shall be faced with broken stone in blocks not exceeding three inch nor less than one and a half inch cubes, to be spread evenly on the surfaces."

The water surface of the reservoir will be about fifty acres, and will be very much exposed to high winds.

Will you be good enough to inform me whether, in your opinion, this finish will afford an adequate and suitable protection to the banks, and oblige

Yours, very respectfully,

S. SEYMOUR,
Consulting Engineer Washington Aqueduct,
411 *Pennsylvania Avenue.*

JAMES P. KIRKWOOD, Esq.,
Civil Engineer, &c., New York.
ALFRED W. CRAVEN, Esq.,
Chief Engineer Croton Aqueduct.
JAMES SLADE, Esq.,
City Engineer, &c., Boston.

The following are copies of replies received from Mr. Kirkwood and Mr. Craven. Mr Slade's reply has not yet been received:

30 UNION SQUARE, NEW YORK,
May 14, 1863.

DEAR SIR: I have only to-night received your note of the 11th.

The broken stone which you mention as specified for the water faces of your receiving reservoir is frequently applied on a bed for stone paving. I have never known loose stone of any size used by itself on the water slopes of any reservoir, and I presume that I have seen the best in this country, and some of the best in Great Britain. Such a reservoir as you describe wants to be very carefully paved to protect its banks from the effects of high winds.

Very respectfully,

JAMES P. KIRKWOOD.

S. SEYMOUR, Esq.

—

CROTON AQUEDUCT DEPARTMENT,
OFFICE OF THE CHIEF ENGINEER,
May 15, 1863.

SIR: Owing to my absence from the city your note did not reach me until this morning.

In reply to your question, I beg to say that, with slopes of ordinary inclination and banks of ordinary materials, I should think a common facing of broken stone inadequate as a protection; but without more specific data than are contained in your letter, I do not feel justified in giving an opinion on the question proposed.

I am, very respectfully, your obedient servant,

A. W. CRAVEN.

S. SEYMOUR, Esq.,
Chief Engineer, &c., Washington.

Inasmuch as the opinions expressed by these gentlemen correspond with my own, as well as with those of every practical engineer with whom I have conversed, I therefore respectfully recommend that the specifications be changed to something like the following:

The interior slopes or water faces of the reservoir will be faced with broken stone six inches thick, upon which will be laid a rubble wall of one foot in thickness, to be composed of stone extending through the wall, laid at right angles with the slope, and sufficiently large to resist the action of the water.

The face of the wall to be well wedged and pointed with pinners or spalls so as to prevent the water from displacing any portion of the wall or the broken stone underneath. The top of the wall will be connected with a pavement rounded over the upper front angle and extending three feet back on the top of the bank, the pavement to be six inches thick, and composed either of small field or quarried stone of uniform size compactly laid on their ends and well bedded to an uniform surface in broken stone or clean, hard gravel. The top of the bank from the outer edge of the pavement will be finished with a slope of one in ten inclining from the reservoir, so as to shed the surface water away from the reservoir into drains prepared for that purpose.

I suggest the above as merely a modification of the present specification, with a view of greatly increasing the permanency and value of the work, without adding materially, if anything, to its present cost. Were the work to be started anew, I would recommend, as a proper finish for the water faces, a thickness of at least eight inches of broken stone, and a slope wall eighteen inches thick, aid in mortar.

The interior slopes of the reservoir should have a uniform inclination of two to one, if the plan of facing above is adopted.

I have the honor to be, very respectfully,

S. SEYMOUR, *Consulting Engineer.*

Hon. J. P. USHER,
Secretary of the Interior.

WASHINGTON, *May* 21, 1863.

P. S.—Since writing the foregoing I have received a letter from Mr. Slade, of which the following is a copy:

BOSTON, *May* 19, 1863.

DEAR SIR: Yours of the 11th has been received. The facing for the reservoir, made of stones as you describe, will be totally inadequate, unless, indeed, they are laid up in full beds of cement, which, as I understand, is not intended, the waves will wash it down in a short time. I should not allow any stone in it of less than six inches depth, and the larger the better.

Yours, truly,

JAMES SLADE.

S. SEYMOUR, Esq.,
Consulting Engineer, Washington.

G.

PAPER IN RELATION TO THE RECEIVING AND DISTRIBUTING RESERVOIRS, PREPARED BY MR. J. J. R. CROES, PRINCIPAL ASSISTANT ENGINEER, W. A.

DEPARTMENT OF THE INTERIOR,
OFFICE OF THE WASHINGTON AQUEDUCT,
Washington, D. C., February 20, 1864.

SIR: In accordance with your instructions, I have the honor to submit for your consideration the following notes on the receiving and distributing reservoirs:

RECEIVING RESERVOIR.

The object proposed in the construction of the receiving reservoir at Powder Mill branch was twofold: first, to give storage capacity in case of accidents occurring to the aqueduct; secondly, to furnish a large area in which the water might have opportunity to remain comparatively quiet and deposit its impurities.

The first object is, to some extent, accomplished, the capacity being, above the bottom of the aqueduct, one hundred and sixty-three million gallons. The experience of the past four years has shown that the hopes entertained of the purification of the water were not well grounded, and for the following reasons:

Four or five streams are constantly discharging into the basin, each draining a hilly country, and consequently swollen and muddied by every rain. The hill-sides sloping up from all sides of the reservoir discharge their surface water into it. Every shower, therefore, brings in a supply of turbid water, which continues running for some days from the streams. The water, for the most part, is shallow; the area, compared with the length of shore-line, small, and the banks unprotected from the wash of the waves. In a broad sheet of deep water, these reasons would not count for so much; but here is an area of fifty-three acres, with a shore-line of fifteen thousand feet, and a width varying from two hundred to five hundred feet. The wind, sweeping down through the gorges of the hills, dashes the waves against the shores unprotected from their action and stirs up the mud.

The theory that the water from the aqueduct, entering the reservoir some three thousand six hundred feet from the outlet, would diffuse itself over this area, and deposit its sediment in the passage, is good, but, unfortunately in this case, the object is entirely defeated by the mountain streams and the immense unprotected shore-line. This might have been foreseen, and means taken to bring the water directly to the city from the Potomac without passing through this basin when muddied by the streams, and also to protect the shores with stone.

But, independently of this consideration, a due regard to the liability to accidents would demand that some provision for a separate supply should be made. Should the dam, for instance, give way, there would be no means of procuring water in the city, the conduit discharging the water from the river directly into this reservoir. Such an accident, though not very probable, is by no means impossible. There are now, and have been for some time, two streams passing through the dam, but as yet doing no damage.

At present the conduit passes through a rock tunnel, six hundred and twenty-six feet in length, to reach the upper end of the reservoir. Midway in this tunnel a large chamber is excavated, and a waste-weir built, to lead off the water from which a drift, three hundred and fifty feet long, is tunnelled through the rock, and walled and arched with masonry.

From where the conduit line would diverge to form the connection with the conduit below the reservoir, the line, as constructed, has cost $37,000. To have built it directly to form such connection would have cost, at the prices then paying, $61,000—a difference of $24,000. Now, the same work, with the necessary additional gate-house, is estimated to cost $99,200, or, altogether, $75,200 more than it should have done at first. The necessity for it is actually no greater now than it was then. Only it is more obvious, after the experience of a few years.

DISTRIBUTING RESERVOIR.

The distributing reservoir at "Drovers' Rest" is, in form, nearly a rectangle 2,250 feet long, and about 850 feet wide at the flow line, having forty-four acres of water surface, a depth of water of eleven feet, and capacity of 150,850,000 United States gallons. It is divided into two parts by an embankment running across it—the upper or western division having an area of twenty-five acres, and the lower or eastern nineteen acres.

The inner slopes, as originally designed, were to be partially covered with a riprap of small, broken stone.

Three changes are proposed in the plans for this structure.

The first, now carrying into execution, relates to the slope facings.

The second relates to the division embankment and the drainage arrangements.

Both of these changes are discussed in the annual report of the chief engineer, and recommended by the Secretary of the Interior in his report.

The third change relates to the increase of the capacity of the reservoir.

With regard to the first proposed change, the original specifications for the water facings of this reservoir require that the slopes be covered to a thickness of eighteen inches, with small stones (three-inch cubes) beginning one foot above the present water level, and ending seven feet below the same.

By this plan that portion of the bank above the riprap is left unprotected from the action of the waves, and the lower portion of the slopes is also left without protection.

The question to be considered is, whether by this means sufficient security is afforded to the embankments.

The requisites of a slope facing are: first, that it should protect the banks from washing; second, that it should have sufficient weight to prevent the

saturated earth-bank from sliding inwards in case the water in the reservoir is drawn down suddenly; third, that the materials of which it is composed should be sufficiently weighty, and so disposed as to prevent their being displaced by the action of the waves.

A reference to the experience of some other reservoirs will show the necessity of extending the facings to the top and bottom of the bank, and making them of heavier stones than were called for by the original plan.

On the reservoirs of the Brooklyn and New York water works, the waves, in an ordinary high wind, wash up from ten to fifteen feet on the slopes, frequently dashing over the top of the bank. On the 23d of April, 1859, the waves in one division of the Ridgewood reservoir, in Brooklyn, twelve acres in area, washed to the top of the embankment, a vertical height of nine feet, cutting out the earth and gravel between and behind the stones with which the bank was faced, and causing many of them to settle backwards from six to eight inches. This wall was composed of stones not less than twelve inches in thickness, laid upon the earth embankment, with the joints well squared and fitted together, but without the backing of broken stone used in the wall now laying at the "Drovers' Rest" reservoir. The damage caused by the waves was so great that it was necessary to relay a large portion of the wall, and fill all the joints with cement and concrete.

I specify the day above mentioned, as it was the one on which the waves ran highest during that season, but like injury was done to the wall every day for several weeks, until the water was drawn off and the wall repaired, as stated. The original design terminated the wall just above flow-line; after this, however, it was carried to the top of the bank and coped. It was about this time that the wall on the New Croton reservoir was beginning to be laid. The effect produced by the failure of the Ridgewood wall was such, that the plans were changed on the Croton reservoir, involving great additional expense.

These facts show the necessity of extending the slope facing to the top of the bank for protection; and as the water will frequently be lowered in the reservoir, it is no less essential that it should be carried further down the slopes than was originally contemplated.

The wind, sweeping over the large area, would dash the waves against the wall with sufficient force to dislodge such small stones and roll them to the bottom; while in winter, the ice, especially when the water was falling, would very effectually destroy a riprap wall of "stones broken into cubes of not more than three nor less than one and a half inches."

In September, 1859, the water being drawn rapidly from the Detroit reservoir, the saturated earth of the embankments slid forward, carrying with it the water facings.

In December, 1863, one of the mains of the Jersey City water works having burst, the reservoir at Belleville was suddenly emptied, and a like result ensued. These reservoirs were lined with brick walls, laid in cement, and supposed to be water-tight. They were sufficiently so to prevent the water in the bank from running out through them; but no facing of ordinary cheapness has yet been discovered which will prevent water from penetrating the bank to some depth. Had these been heavy stone walls, instead of light brick ones, the accidents would probably not have occurred.

While a dry wall, allowing the water to run out more freely, is preferable in such a case, any wall at all which is not carried down to the foot of the slopes and there well bedded but adds to the danger.

It is very evident that a riprap facing to the slopes, covered in its turn with stones sufficiently large to resist the action of the waves, and so laid as not to be affected by the anchor ice, is preferable to a facing of small stones entirely. The large stones prevent the small ones from being washed from their places, while

the small ones prevent the earth from being washed from the banks through the joints of the large ones, as happened on the Ridgewood reservoir.

It has been urged, in opposition to this change of plan, that the cost will be greater, and that, moreover, it will not be carrying out the original designs of the Washington aqueduct, and therefore should not be made on any account—that is to say, a plan devised eleven years ago must be adhered to, because it *was* made then, notwithstanding experience has clearly demonstrated, within those eleven years, that the plan is faulty in many respects. That economy which looks to a diminution of first cost, regardless of future expense in repairs, is a very false economy.

Experience and reason showing that the slopes should be covered from top to bottom, I propose further to show that the additional cost of putting on the present wall instead of riprap is slight in itself, and very small in proportion to the advantages to be gained.

The price for which A. A. McGaffey agreed in 1858, when labor was cheap, to furnish and lay the riprap was $1 50 per cubic yard. It was then expected that a considerable portion of the material could be obtained from the excavation in the reservoir. Under his contract no work was ever done on the wall.

In September, 1862, S. L. Rodgers & Co. agreed to furnish and lay the stone for $1 70 per cubic yard. These contractors soon found that it was impossible for them to do the work at this price, and made repeated applications for an increase of compensation.

I am convinced that they could not have laid this work for anything near their contract price, and they would have thrown up the contract for this reason, had it not been annulled in August, 1863, for their inefficiency and delays in the prosecution of the work. Nothing was done by them on the slope wall, except the furnishing of a small proportion of the stone.

The items to be examined in estimating the cost of the riprap work are the price of stone in the quarry, cost of quarrying, cost of breaking, cost of carting, and cost of spreading stone on the slopes.

There being no stone in the immediate vicinity of the reservoir suitable for this work, it is necessary to procure materials from quarries on the canal bank, the nearest of which is about one mile distant from the reservoir, and one hundred feet below its level. The least price charged by the owners for stone from these quarries is believed to be twelve cents per yard. The stone is of a nature difficult to quarry, and the quarries contain much that is unfit for the work, and which has to be removed. The cost of quarrying is at the minimum one dollar per yard.

Then the stones must be broken by hand into three inches cubes, costing seventy cents per yard.

A horse, cart, and driver, costing $2, will make ten trips per day, averaging half a yard per trip, making the cost of hauling forty cents per yard. The stone being dumped on the edge of the bank, two men can adjust twenty yards per day, making the cost of spreading fifteen cents per cubic yard.

We have, therefore, the following as the cost of the riprap facing:

Price of stone in the quarry, per cubic yard	$0 12
Cost of quarrying	1 00
Cost of breaking	70
Cost of carting	40
Cost of spreading	15
Total	2 37
Add 20 per cent. for superintendence, profits, &c	47
Total cost	2 84

For slope wall, with riprap backing, the cost of the preparation of the stone is somewhat less, but that of quarrying and laying the same is increased. The cost is as follows:

Price of stone in the quarry	$0 12
Cost of quarrying	1 25
Cost of carting	40
Cost of preparing and laying stone	1 04
	2 81
Add 20 per cent for superintendence, profits, &c	56
Total cost	3 37

The contract price is actually $3 per yard, which, from the above calculation, seems by no means to be exorbitant.

The quantity of slope facing was estimated on October 1, 1862, by the then chief engineer at ten thousand yards (under the original plan,) of which the cost, estimated at the above prices, would be—

8,800 cubic yards riprap, at $2 84 per yard	$24 992
1,200 cubic yards slope wall around gate-houses, at $3 per yard	3 600
Total	28 592

As stated above, it would be necessary to cover the whole slope with stone. Supposing the work done in this style, and the contractors allowed the price calculated above, which is considered barely a paying one at present prices for labor, the cost would be—

17,000 cubic yards riprap, at $2 84 per yard	48 280
1,400 cubic yards slope wall, at $3 per yard	4 200
Total	52 480
The cost of the slope wall, as building under the present contract, will be, 20,300 cubic yards, at $3 per yard	60 900
An increase of	$8 420

By no means a large amount when we consider the great superiority of the plan involving the greater cost. The quantity of wall is greater than that estimated for the riprap, it being made heavier on the more exposed portions of the embankment.

With respect to the above estimate of cost of riprap, it must be borne in mind that prices both of labor and materials have advanced fully fifty per cent. since July, 1862, when S. L. Rogers & Co. made their bid.

The second change in plan requires some explanation also.

The theory of the reservoir, as planned by Captain Meigs, is this: The water will be introduced at one end, fill the west basin, and there having time and space to settle, will flow in a thin sheet of pure water over the division embankment, left for that purpose, a little below the ordinary flow-line, and be drawn to the city from the other end of the eastern division. Communication between the two basins is had by a culvert through the division bank about twenty-five feet below flow-line. This culvert to be closed ordinarily by a stop-cock.

If ever the water in the receiving reservoir falls to the level of 144 feet above the *datum* line, this overfall will cease to work. If ever it is found advisable to reduce the pressure on the conduit, as the overfall requires a head on the conduit of at least two and a half feet, the same will be the effect. In such

case, instead of passing pure water to the eastern division, we must open the culvert and pass the lowest and, therefore, most impure water. Practically, this will be the case nine-tenths of the time. The daily supply to the city will in a few years reach thirty millions of gallons. In this case the upper basin will hold only three days' supply, and the water from the aqueduct coming in at the bottom of the reservoir, will tend to keep the lower stratum of water in continual agitation, and prevent the deposit of sediment called for by the plan. When passed through the culvert, it will probably reach the second basin in a worse state than it entered the first.

With the present arrangements at the effluent gate-house, it is impossible to draw surface water to the city, and at the same time to waste any of the impure water at the bottom of the reservoir. The supply of surface water to the pipes is regulated by stop-plank; the drain pipes being on a level with and close to the service pipes, the stop-plank must all be removed to enable bottom water to be drawn off, and this will also allow it to enter the service pipes.

The advantage of having an arrangement for separate drainage and supply is obvious. The experience of other cities affords many examples of it, of which one may be here cited.

In Albany, during the summers of 1854 and 1855, the water was very impure and offensive. The construction of the gate-house at the reservoir was such that all the supply to the city was drawn from the bottom. Investigation showed that at the reservoir "the water taken from the surface emitted no odor, and tasted sweet, but on going to the waste-weir, through which the water taken from the bottom of the reservoir was flowing, a *most nauseous odor* revealed itself." The stop-plank arrangement for regulating the supply is, at the best, an awkward and inconvenient one.

Besides, the present plan gives no separate drainage to the western division of the reservoir. If from any cause the water there should become very impure, while that in the eastern was still serviceable, or if there should be a leak making it necessary to draw off the water, the eastern division would also be necessarily emptied, causing a great loss of water and of time. The original plan of Captain Meigs contemplated a separate drainage into the canal from this basin. It is unfortunate that this idea was abandoned.

In considering the improvements which might be made on this reservoir, the plan suggested by the shape of the reservoir and the natural conformation of the surrounding ground would be, to have the influent gate-house at the north, and the effluent at the south end of the division bank, with separate inlets to each division, and an independent drain from each leading directly to the canal, while the service pipes would also run directly down the hill to the river road, and along that to the city. But as the gate-houses are already partly built, this cannot now be done, so the best adaptation must be made of the existing structures. The fact that the central drainage trench projected in the original plan has been partially excavated makes it cheaper to avail ourselves of it. We wish to secure a separate discharge from the western division at any level, an overfall communication between the two basins, an independent discharge at any level from the eastern basin, and separate drainage from each basin.

To accomplish these objects it is proposed to carry up the division bank to the height of the other banks, and build in its centre a gate-house having an inlet to the western division, an overfall for the surface water to pass to the eastern division, and four gate-openings—one leading to the eastern division at a lower level, and the other three for drawing service or drainage water from various heights into a central well or bay, whence a culvert will lead to the effluent pipe-vault, where by an arrangement of stop-cocks the water can be turned either to the city, or into the drain channel.

A wall with gate openings at various heights should also be constructed in the effluent gate-house, which can easily be done. All of which is estimated to cost less than $30,000, with an incalculable gain to the city in the purity of the

water, and the advantageous arrangements for drawing. The working of this arrangement is so very lucidly explained in the annual report of the chief engineer, (page 6,) that it is needless to dwell longer on it.

The third proposed change appears fully as important as the others. It consists in deepening the reservoir, so as to give greater storage capacity. It is proposed to excavate the bottom to a depth of twenty-four feet below flow-line, or thirteen feet below the present bottom. The lower slopes to be paved with a rough wall, where the slope wall is already built, a berm ten feet wide to be left at the base. This will give an additional capacity of 149,050,000 gallons, making the whole capacity 299,900,000 gallons. This will require about 460,000 cubic yards of excavation, and 15,000 cubic yards of slope wall, and is estimated to cost $223,100 in addition to the cost on the present plan.

While the capacity is thus greatly increased, an object greatly to be desired, and one much sought after now by all the large cities, (New York has just completed a reservoir holding 944,000,000 gallons,) I do not consider this as the chief benefit to be derived from the change. I have already mentioned the probability that the flow-line will in practice be necessarily lowered from 146 feet above datum. I must again speak of it in this connection, as I consider the subject a very important one. At the influent gate-house, the bottom of the conduit is two feet below the ordinary bottom of the reservoir; the crown of the arch is therefore four feet below the assumed flow-line. Experience goes to show that a masonry conduit like this one cannot be safely trusted to bear such pressure. On the Croton aqueduct, which is as well constructed as any in the country, and has stood for twenty years, it has been considered dangerous for several years to put a head of water on the crown of the arch. Whenever it is done, leaks break out in fresh places.

The danger arises, not from the upward pressure, tending to lift the arch, but from the lateral pressure, which tends to split the conduit longitudinally, opening cracks at the top and bottom. No difficulty is to be apprehended where the masonry is below the natural surface of the ground, but only in embankments, where the weight of the superincumbent earth may not be sufficient to hold the masonry together in certain contingencies.

Fig. 1.

The Croton aqueduct is of the section shown in Fig. 1. Of this the assistant engineer says: "The stone masonry outside of the brick-work was intended to be strong enough to resist the pressure of the water without the weight of the outside bank; but it does not prove to be so. The consequence is, that when a rain and thaw loosen the earth of the bank, and a sharp frost shrinks the bank, taking the weight from the masonry, it causes cracks, if the water stands more than three inches above the spring-line of the arch."

Fig. 2.

The section of the Boston aqueduct is shown in Fig. 2. Of late years it has been run under a head. The engineer, in his report for 1863, says: "The difficulty resulting from cracks in the brick aqueduct is a serious one, and from the additional duty imposed on the aqueduct by using it as a pipe, under a head, is liable to increase with the increase in the consumption of water, unless measures are taken to strengthen those portions of the aqueduct resting upon embankments by concrete foundations and backing of the same material as high as the top of the invert."

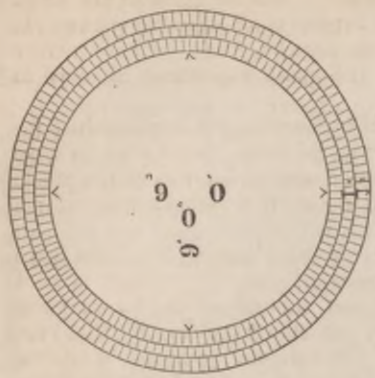


FIG. 3.

The section of the Washington aqueduct is shown in Fig. 3. The masonry not being sufficient to withstand the thrust of the water without support from the bank, any shrinkage relieving the pressure of the earth will cause the ring to open at top and bottom when full of water. This has already occurred in some instances.

For size and form this conduit is as yet an experiment. While able, according to calculation, to bear much more pressure, some slight defect in materials or workmanship, not to be guarded against even by the careful supervision and inspection exercised over the construction of this work, may destroy the value of some portion of the conduit. The fact that cracks have already occurred, goes to prove the soundness of this opinion, and to show that we will not always be able to carry the proposed height of water in the reservoir.

Suppose, then, that the water must be drawn down to the level of the crown of the arch. This will reduce the depth of water in a large portion of the reservoir to seven feet. This depth is not sufficient to insure purity of water, especially in this latitude, where the heat of the summer sun is so intense.

Shallow reservoirs are condemned by engineers in this country and abroad. An eminent English engineer says: "If shallow reservoirs are exposed to the heat of the sun in summer, they give rise to vegetable and animal life." Another says: "I do not know exactly what depth is required in a reservoir to prevent vegetation. I have known considerable vegetation in *ten feet water*." The engineer of the Philadelphia water works, in his report for January, 1859, says: "By raising the banks of the Kensington reservoir seven feet, sufficient additional depth would be obtained to add materially to the purity of the water. Much of the difficulty here has been on account of the want of depth of water in the reservoir." The depth of this reservoir was fourteen feet.

The same engineer, in his report for 1860, speaking of the subsiding reservoir for the 24th ward works, says: "The depth of water is of the greatest importance in purifying by subsidence;" and recommends the construction of additional subsiding reservoirs. In his report for 1862 he says of the Fairmount reservoirs, that "when full, they only contain fourteen feet of water, a depth insufficient in our climate," and recommends an increase of depth. The water in the Corinthian avenue reservoir, twenty-seven feet deep, he says is better than that in any of the others. "On account of its greater depth and capacity, th water has time to deposit many of its impurities, and to decompose others, as well as escapes that degree of overheating in the sun's rays which encourages the growth of confervæ and animalcules, and the putrescent decomposition of organic matter."

The chief engineer of the Jersey City water works, in his report for 1856, says: "The advantage of keeping a large supply of water in the distributing reservoir is seen in the improved quality of the water by being allowed to stand for a considerable length of time before it is used. There is a marked difference between the appearance of the water when it is used in the city almost as soon as it is pumped, and as it appears after being allowed to settle for

several days in the reservoir before distribution." Similar remarks are found scattered through the reports of water-works engineers all over the country, to quote which would require more space than can here be given. I have merely made these few extracts at random to show the great importance attached to the subject by others.

With the supposed reduction of depth in this reservoir, the opportunities for deposition of sediment are certainly diminished, the water being kept in more rapid motion, as the quantity *in transitu* bears a larger proportion to the whole mass. At this level the reservoir will contain ninety-four and one-half million gallons, a small quantity for storage.

I have said before that increased storage capacity is sought in all the large cities. The report of the water-works engineers all over the country abound with complaints of deficiency in this respect, and recommend the construction of larger reservoirs. Large sums of money are annually expended for that purpose, much of which might have been saved by the adoption of proper measures in the first place. The reservoir at "Drovers' Rest" is now in better condition for making such improvements than it ever will be again. The gate-houses require but little alteration, the pipes, as before stated, being below the proposed new grade of the bottom; and the surplus material can be more advantageously disposed of now than at any future time.

It is difficult to understand why it should have been originally designed to be so shallow, except from motives of economy. For the reasons given above, it appears that it would be very mistaken economy to build it so.

In the estimates of the cost of the completion of the Washington aqueduct, submitted to the Secretary of the Interior by the late chief engineer, in 1862, the item for the distributing reservoir is	$30,499
In the estimate submitted by the present chief engineer, in 1863, the corresponding item is	87,720
Increase of estimated cost	57,221
To which add amount paid for said work from October 1, 1862, to October 1, 1863	28,534
Total increase of estimated cost	85,755

So very remarkable a discrepancy requires an explanation.

A portion of the difference arises from the change of plan for slope facings.

In 1862, the estimate provided for 8,800 cubic yards rip rap at $1 70	14,960
" " " 1,200 cubic yards slope wall, at $3	3,600
Total	18,560
The estimate of 1863 was for 20,300 cubic yards wall, at $3	60,900
Increase	42,340

This leaves still for the earthwork, &c., a difference of $43,415.

When the work on the reservoir was resumed in 1862, cross-sections were taken of the embankments, and the quantity requisite to finish them was taken as the basis of the estimate of work to be done. The bottom, whence the material was to come, was not cross-sectioned, and, consequently, neither engineers nor contractors knew how much was to be taken out.

The estimate of 1862 called for cubic yards excavation.....	26,200
When the present chief engineer took charge in July, 1863, the bottom was carefully cross-sectioned, and it was found that the amount of excavation required to comply with the specification, was.....c. y.	66,200
Add excavation done, Oct. 1, 1862, to Oct. 1, 1863 ..c. y.	64,509
Total which was to have been done October 1, 1862.....c. y.	130,709
Under estimated October 1, 1862 .....c. y.	104,509

This shows that the above increase of $43,415 in the estimate of the cost of the reservoir earthwork is not due to any change of plan, or alteration in the actual quantity of work to be done.

All of which is respectfully submitted.

J. J. R. CROES,
Principal Assistant Engineer W. A.

SILAS SEYMOUR, ESQ.,
Chief Engineer and General Superintendent, W. A.

H.

WASHINGTON AQUEDUCT.—MAINS LAID BY THE UNITED STATES.

In the effluent screen well at the distributing reservoir are laid four 48-inch mouth-pieces for the supply of the city. Of these, one is now furnished with a 12-inch discharge, for draining the reservoir; another is capped in the pipe-vault; a third is reduced to 30 inches in the vault; and the fourth to 12 inches.

At the end of the seven-feet conduit around the reservoir is the auxiliary gate-house, in which is a 48-inch mouth-piece. The pipe on leaving the gate-house is reduced to 30 inches, and leads to the pipe-vault, a distance of about one hundred and fifty feet, where it is connected by vertical pipes with the 30-inch and 12-inch pipes above mentioned.

In the vault are four stop-cocks, viz:

One 48-inch; closing connection between reservoir and 30-inch main.

One 30-inch; closing connection between auxiliary gate-house and 30-inch main.

One 12-inch; closing connection between auxiliary gate-house and 12-inch main.

One 12-inch; closing connection between reservoir and 12-inch main.

Leaving the vault, the 12-inch and 30-inch mains run parallel about three thousand three hundred feet across the country to Foundry branch, where is a chamber containing a blow-off pipe from each main of its own size, and a 12-inch connecting pipe betweeen the two mains. There are here two 30-inch and three 12-inch stop-cocks, so arranged that the portion of either main between the reservoir and this point can be emptied, while the portion below is supplied from the other main. Three hundred feet east of this chamber is the lowest point outside of the city on the pipe line. The pipe is here only fifteen feet above the *datum* line, making a fall of one hundred and fifteen feet from the vault at the reservoir. From here the mains follow the road along the canal for about one thousand feet to College pond, which is crossed by an arch of one hundred and twenty feet span, composed of two 30-inch pipes. From here the 30-inch and 12-inch mains are continued along the river road and Bridge street, in Georgetown, about five thousand two hundred feet, to Rock creek, where both are enlarged to 48 inches diameter, and form an arch of two hundred feet span

across the creek. In the west abutment of this bridge is a duplex water engine, which forces water through Green, West, and High streets, to the high-service reservoir, on the corner of High and Road streets. The force main is 12 inches diameter for fifteen hundred and fifty feet, and is then reduced to 10 inches for three thousand five hundred and thirty-eight feet. The water surface in the reservoir, when full, will be two hundred and twenty-five feet above the *datum* line.

At the east end of the Rock Creek bridge the pipes are again reduced respectively to 30 inches and 12 inches. The 30-inch main follows Pennsylvania avenue to the circle, then deflects to the left and passes through "K" street, Massachusetts avenue, and New Jersey avenue to "B" street north, where it runs eastwardly for one hundred and two feet, terminating in a dead end; a distance in all of about fifteen thousand feet. The 12-inch main, starting from Rock creek, follows the line of Pennsylvania avenue and Eighth street east to the navy yard wharf. It passes around the Capitol square by "A" street north and First street east. Total length about twenty-four thousand four hundred and ten feet

From the corner of "B" street north and New Jersey avenue, a 20-inch main runs through the reservation, (connecting at Pennsylvania avenue with the 12-inch main, Maine avenue and "B" street south,) to a point opposite the south door of the Smithsonian Institute. Length five thousand one hundred and thirty-seven feet.

The branches from the 20-inch main are—

1st. A 12-inch pipe down Four-and-a-half street, seven thousand eight hundred and seven feet long. At the penitentiary gate this is reduced to an 8-inch pipe, which runs two thousand and forty-seven feet to the United States arsenal.

2d. A 12-inch pipe, nine hundred and thirty-eight feet long, to the fountain in the Smithsonian grounds.

3d. A 6-inch pipe, three hundred and forty feet long, to the south door of the Smithsonian building.

From the 30-inch main branches a 12-inch pipe at Twenty-fourth street, which runs down that street two thousand five hundred and sixty-seven feet to the Observatory gate, is there reduced to a 4-inch pipe, which runs six hundred and eighty-nine feet through the Observatory grounds, and, again reduced to two inches, runs one hundred and forty-two feet further.

The branches from the 12-inch main are—

1st. A 4-inch pipe at Seventeenth street, leading to the fountain in the President's grounds, nine hundred and eighty-six feet. This, reduced to two inches, then runs one hundred and one feet further.

2d. At Eighth street west, a 12-inch pipe runs up Eighth street, down F and up Seventh streets, for two thousand four hundred and seven feet, supplying the Post Office and Patent Office. This, reduced to ten inches, runs up Seventh street nine hundred and eighty-seven feet.

3d. A 12-inch pipe up Four-and-a-half street to Judiciary square, one thousand one hundred feet.

4th. At foot of Capitol hill, a 12-inch pipe to the fountain in the square, two hundred and forty-nine feet.

5th. In A street north and New Jersey avenue, a 12-inch pipe, three hundred and fifty-nine feet long, connects with the 30-inch main in B street.

Besides the stop-cocks on branch pipes at all intersections, there are on the 30-inch main stop-cocks at each end of the Rock Creek bridge, and on K street, near Thirteenth, opposite the square.

On 12-inch main, there are cocks at Twenty-first street, Eighth street, New Jersey avenue, corner of A and First streets, and navy yard wharf.

On the Patent Office branch, there is a stop-cock on the corner of F and Eighth streets.

Summary of lengths of mains laid by government, with branch lines.

	2″.	4″.	6″.	8″.	10″.	12″.	20″.	30″.	48″.
Pipe vault to College pond						4,597		4,597	
Across College pond, double								375.4	
To Bridge 6						5,131.9		5,131.9	
Across Bridge 6, double								281.6	551.2
To the Circle						1,634		1,634	
To navy yard, by Pennsylvania avenue						22,774			
To B st., by K st. and N. Jersey avenue								13,627	
From B street north to B street south							5,137		
Down 4½ street to U. S. arsenal				2,047		7,807			
To Smithsonian fountain						938			
To door of Smithsonian Institute			340						
Connection 20″ and 12″, Pennsylv'a av						38			
24th street, from Pennsylvania avenue to Observatory gate						2,567			
In Observatory grounds	142	689							
17th street and President's grounds	101	986							
To Post Office and Patent Office					987	2,407			
From B to A streets north						359			
4½ street, from Pennsylvania avenue to Judiciary square						1,100			
Branch to Capitol fountain						249			
In Georgetown:									
1st. From pump, Bridge 6, to Green st						1,550			
2d. To 7th and High streets					3,538				
3d. To centre of reservoir						342			
Total feet	243	1,675	340	2,047	4,525	51,493.9	5,137	25,646.9	551.2
Total miles	0.046	0.317	0.064	0.387	0.857	9.752	0.973	4.857	0.104

Total pipe laid by United States ..... 17.357 miles.

TOPOGRAPHIC MAP OF THE SWANN LAKE AND AQUEDUCT of the BALTIMORE CITY WATER WORKS

Surveyed and drawn by A. FAUL, Asst. Engineer under the direction of CHAS. P. MANNING, Chief Engineer.

1852.

Bowen & Co. Phila.