

have to be converted into use practically as private docks or slips. With the above views in mind, I proposed the dredging. While this channel along here has shown a rather unexpected permanence so far, it is probable that here in future periodic dredging will be required, but this is not to be avoided and may safely be left to the city and private parties to do, their immediate interests being so concerned in it. In the report alluded to at outset of this, while it was out of place in it to go into the details of the construction of the various works proposed, I may here be allowed to recommend, as carrying out the principle on which are based the works proposed for the South Channel, *i. e.*, the extension of the tidal propagation, that these works be carried up in height only to the level of half tide or a little above.

All present works are carried up to 6 inches above mean high-water.
I remain, sir, very respectfully, &c.,

JAS. W. CUYLER,
Captain Engineers.

Maj. W. P. CRAIGHILL,
Corps of Engineers, U. S. A.

4.

UNITED STATES ENGINEER OFFICE,
Baltimore, Md., May 22, 1879.

MAJOR: Pursuant to your memorandum of April 24, ultimo, calling for a "complete report and estimates for a channel from Petersburg to the deep water below South Channel for 10 feet at mean low-water," I have now respectfully to submit the following on the Appomattox River improvement.

With the month of April, 1879, the operations under the previous detailed projects—all in pursuance of the general plan—as well as those inaugurated by myself, last January, which had for their object the securing permanently of the previous operations, were all brought to a final and complete close; with May 1, then, it became necessary to inaugurate new operations under a new detailed project; this latter having been submitted to and approved by you last March, was actually entered upon May 1; this date becoming thus a new departure entirely in the historical record of the improvement, a review of the conditions existing at it is a proper, almost necessary, introduction to the report called for.

Accepting as correct the three divisions of the "Petersburg Channel," the "Puddledock Channel," and the "South Channel," into which, according to Mr. Bird, the operations for the river improvement divide themselves naturally, very clearly the first named or upper one presents itself first for consideration in the progress of any such review.

The Petersburg Channel extends down from the wharves of the city of Petersburg to the abutment, where it passes into the Puddledock Channel, a distance of 11,055 feet, or 2.1 miles. Its course, to speak generally, lies in two curved branches of large radii of curvature, connected by a straight reach, or, better, by a very flat curve. It, of the three channels, naturally called for the most elaborate system of works to obtain and maintain the designed improvement, and it presented, probably of the three channels, the greatest obstructions to navigation, both because of the original lack of depth and width of channel-way and of its shifting and unstable character of bed. Its general condition, May 1, with the works as in it, is as follows:

The Lieutenant's Run training-wall—the upper work—has effectually turned the discharge of the run and secured the desired channel along its entire length, 805 feet. This channel is not quite wide enough; trimming it off by some dredging on northerly side is required. Such a channel would, it is believed, continue permanent, as no changes have been observed here, and no reasons for shoaling up would seem to exist. Four hundred and thirty feet below the end of this training-wall is the Magazine Rock, a ledge blasted out, and the channel opened for a width of 100 feet across to main north shore, as was supposed in July, 1877. This operation did not give a permanent success, as by November, 1878, the rock removed was replaced by a silting-up of sand, save a channel in center 30 feet wide by 9 feet deep, mean low-water being here referred to as the plane of reference as throughout this report. The floods and ice of the past winter washed out this sand, giving a channel 11 feet deep by 80 feet wide, but this is now again rapidly shoaling up. Further operations are needed to fix and maintain here the projected channel. One thousand one hundred and fifteen feet below the Magazine Rock a curved wing-dam, 360 feet in length, springs from the south shore, for the gradual contracting of the water-way, and from its lower end extends *up-stream*, along north bank, a wattle-work dike 650 feet long. This section, lying in the concave of the bend, and with the waters directed to a certain extent into it by the works above, maintains itself already well; some narrow bars occur and the channel needs widening, the broad flats, extending out from the south shore, having a tendency to

encroach upon it. Below this wing-dam, above referred to, the river makes a crossing to the south bank 720 feet in length, where, as was to be expected, shoals occur, demanding improvement, and 250 feet lower down begins the system of transverse jetties, so far applied. This system embraces 12 jetties, projected out as far as was designed for them, and 2—the lowest down-stream—incomplete as to length. They cover 3,900 feet of river line, and occupy the long straight reach connecting the 2 main curves of the river described above, and the abrupt beginning of the lower of these curves. Built as they were, to prevent the anticipated tendency on the part of the river to fill in its straight course, they have already largely secured their designed end. They cover two of the worst obstructions in this channel, if not in the river—Page's Bar and Hare's Bar—with a manifest decided improvement of both. In fact, for the river-space covered, excepting 4 isolated shoals, not extensive, the requisite depth is attained; the width is not as yet, nor is the channel made yet impressed with that character of fixity and permanence desired and projected for it; the results, though, do indicate clearly that to effect these objects the present works have only to be extended further in their details.

Below the jetties extends a stretch of 2,492 feet down to the "closure-dike," which may be said now to be almost a continuous shoal; a channel of projected depth, 60 feet wide, was dredged through this section in May, 1875, but no works have ever been put in it; it lies where the stream makes another crossing to north side to seek its old and natural channel to the north (west) of the Puddledock, now effectually closed by the closure-dike above mentioned. This, and the sudden widening from 140 feet in the jettied channel above to nigh 350 feet, naturally lead to the existing condition. It is just here that are found the main obstructions which the immediate commercial wants of Petersburg have necessitated removing by the temporary, and in this case expensive, method of dredging now to be resorted to for the immediate relief desired.

A straight reach, 900 feet in length, below leads into Puddledock Channel, terminating this Petersburg Channel; a channel of the depth, though not quite of the width, has already been found here, next to the main south bank. The closure-dike forming the north side of this reach—a critical work—was seriously wrecked just after completion last November, an event which ought not to have been unlooked-for, in view of the natural conditions then existing. It has now, it is believed confidently, been put out of all further danger, giving a regimen of permanency here.

From the above review the following works, with general estimates of cost therefor, are projected, reference being had to the annexed tracings for location and designation:

I. To widen present channel along Lieutenant's Run training-wall: dredging, 70 feet width by 4 feet depth (average), for length 805 feet = 8,300 cubic yards, at 25 cents per yard, \$2,075.

II. To extend down-stream to Magazine Rock, 430 feet, Lieutenant's Run training-wall, to guide waters into natural concave on north bank, and to gain desired contraction, with cross-dikes Nos. 1 and 2, to turn discharge of run into Stein's Upper Cut, arrest and bank up its deposits, and secure rear side of extension; sheet-pile and wattle-work, with "mat" protection on channel face; total cost, \$3,465.

III. Revetment of north bank opposite above extension, to give permanent side to new channel-way, and save present low and crumbling bank, 350 feet; fascine mats, secured by long pins, and grading of bank to regulate slope; cost, \$1,200.

IV. Longitudinal dike A, 170 feet, to close an indent made by freshet waters, arrest further enlargement, and keep alignment of new channel-way; sheet-pile work, mat protection, channel face; \$1,020.

V. Jetties B, C, D, E, 332 feet, sheet-pile and wattle-work; first three, from south bank, to maintain new channel-way as located, and prevent erosion of flats on this side; the fourth to contract duly at end of present curved wing-dam; total cost, with protection applied, \$1,103.

VI. Jetty F and training-wall G, with shore connections, 980 feet, sheet-pile and wattle-work; to secure crossing of channel, protect south bank, where sharp impingement now takes place, from further abrasion, contract duly, and rectify line of south shore, at beginning of present jetty system; total cost, \$5,400.

VII. Spurs H, I, K, from south bank, opposite heads of present jetties 3, 4, 5, to contract channel now too wide—145 feet about—to 125 feet width; as this south bank is high and firm, the pile-work of spurs must be connected with it by bulkheads of heavy timber, laid horizontally in trenches properly braced on rear (down-stream) side, with bank in front sloped and matted, in order to prevent any cutting round in-shore ends in seasons of high-water or ice-floes; 50 feet of sheet-pile work, and 100 feet of above-described bulkheads; cost, \$1,000.

VIII. Extend present jetties 10, 11, 12, 13, 14, and build main jetties 15, 16, 17, 18, 19, 20, 21, 22, with auxiliary jetties on south bank 1, 2, 3, 4, and such wattle cross-dikes as may be necessary to close sloughs and guts inshore (not able to be shown on tracing); 1,600 feet of wattle work, 900 feet sheet-pile work; to contract to a width

of 125 feet of channel-way, and continue and complete original projected jetty system; total cost, \$5,000.

IX. Continue and complete present dredging, undertaken to relieve pressing wants of the commerce of Petersburg, and located so as to fall within permanent jettied channel; the effects of the freshets of the past winter on the river in an incomplete condition of improvement; 24,000 yards, at 25 cents per yard, \$6,000.

X. Construct certain tide-gates (main and small gates), inclosure dike, to increase the tidal flow, and extend it the farther up-stream, in accordance with present plans; cost, \$900.

XI. Maintenance and repairs of works, wages at Petersburg, cost of necessary surveys and examinations from May 1, 1879, to July 1, 1880, \$2,400.

The above 11 separate items of work aggregate in cost.....	\$29,563
Of this sum there was available May 1, 1879, from appropriation of river and harbor act of June 18, 1878.....	6,800
Appropriation, as per river and harbor act of March 3, 1879.....	20,000
	<hr/>
	26,800

There remains, then, to complete the above project, to be supplied..... 2,763

This additional sum will place this, the Petersburg Channel, in the condition of improvement projected for it, which condition, it is believed, will be one of permanence. Of course, with works of the kind in this river, with a narrow water-way for navigation purposes, a sum will be necessary each year for inevitable maintenance and repairs; if supplied regularly, this sum should not exceed \$1,500 per year.

2. The Puddledock Channel next extends down to the South Channel, a distance of 9,200 feet = 1.76 miles. This is purely an artificial channel, formed by dredging through a swamp; it follows the course of a regular curve of large radius with its concavity towards the southeast or away from the old natural river, and connecting with the South Channel by a branch of a reverse curve of nearly corresponding radius; its dimensions, when completed in August, 1876, were 60 feet width at bottom, 100 feet width mean high-water, 10.5 feet depth; since that date, 3,341 yards have had to be redredged out, at connection with the South Channel, and 4,000 yards are now about to be redredged out at the upper end, or the connection with the Petersburg Channel, making a total of redredging of only 7,341 yards; this channel is found by examination to maintain a depth of 10.25 feet and more throughout its length, excepting at these two ends; the bottom width has narrowed about 15 feet, the slope up on both sides being regular and gradual; the only work built in this channel, besides the embankments raised on both sides, with the dredged stuff to render permanent the sides, and retain in the channel the high-waters, is a wattle-work longitudinal dike, extending up 350 feet from lower end on south or east bank to confine freshets to channel instead of spreading over a wide swamp here; the swamp through which the channel was made had much undergrowth upon it, with numerous stumps and roots matting closely together the coarse, compact gravel forming its substratum; save at a few points shown on tracing, there are no indications of caving banks; the embankments now in seem adequate, and already a good growth of willows and aquatic vines consolidate the new sides; three noteworthy freshets—February, 1875, November, 1877, and January, 1879—have discharged through the channel, without making any effect of consequence.

With this presentation of facts, the conclusion may be drawn that the operations of making this artificial channel, in a measure tentative and not favorably received at first, as may be seen from the early reports on the river improvement, has certainly yielded all the success so far that could have been expected from it, and entitled it to be classed as a permanent feature of improvement. Withal, the full test, to which this channel will be subject, as anticipated by the Board of Engineers of September, 1870, on the general plan of improvement for the river, has yet to come, when, with the permanent improvement of the Petersburg Channel, the entire discharge of the river must pass through its length, with a sectional area of only about 773 square feet, with a corresponding area of 1,377 feet at the city of Petersburg.

Holding this in view, I propose now to secure banks already caving by mats and riprap, first trimming to a regular easy slope from extreme high-water mark down, extending such protection from 50 to 100 feet above present caves. While it is not considered at all probable that the entire length of this channel will require such a protection, yet it is probable that other caves may show themselves, calling for prompt protection, and for this end, as well as to raise the embankments at some few points needing strengthening, to close, by rough hand-driven sheet-pile and wattle-work cross-dikes, certain guts and swamps, not now effectually closed, and to plant osiers and willows along new sides, I deem it, in a complete report and estimate, necessary to estimate for these purposes the sum of \$10,000. The tracings cannot definitely exhibit these works; even were it possible at date to so define them, they would be

isolated pieces of work, to be put in from time to time, as the occasion should point out.

The sum named, though, would, it is believed, render this channel permanent, necessitating no further dredging or any other operation to secure this end. Of course a certain small sum, here as elsewhere, would be required for annual maintenance and repair of works.

3. Lastly the South Channel remains to be considered. It extends down from the Puddledock Channel 11,000 feet = 2.08 miles, to the Point of Rocks, where naturally all projects having in view the improvement of the river terminate. Leaving the Puddledock in a bend somewhat abrupt but short, this channel follows down along the main or south bank, in a regular straight course, till near its other end, terminating there in a compound curve of radii respectively of 3,000 and 3,450 feet, easy and sweeping; this main bank is clearly defined by a line of steep firm bluffs, from the foot of which low land extends out from 30 to 60 feet only, with occasionally a swamp in the indents; the northerly side, on the contrary, consists for its entire length of low morass, cut through by many blind sloughs and secondary channels—one of these latter being the main channel of the river, on Coast Survey map of 1854—all communicating with the natural river (the channel) on the north (west) side of the new made channel of the Puddledock, and forming extensive widenings with attendant shoalings on this side.

This channel is in fact clearly the natural and the old channel of the river; its improvement by dredging above was completed in June, 1873, with these dimensions: 60 feet width mean low-water, 100 feet mean high-water, 10 feet depth; since that date but 12,004 yards have had to be redredged out; the examination of January last shows for the changes a slight shoaling throughout the length, reducing the depth to an average of 9.3 feet with a few narrow bars of about 8.4 feet, the curves of deep water continuing unchanged.

With several affluents of same size coming into the old river covered by the Puddledock Channel, all eventually finding their way into this channel, the natural volume of water in it is larger than in the two upper channels, and the characteristics of the tidal compartments of the river are much more clearly defined, the actual duration of the tidal influence, as well as the extent of its action in maintaining a fixed regimen, being both, by observation, found greater than above. With this presentation of existing condition—results so far having justified all reasonable expectation as to the permanency of the work already done—the works outlined on accompanying sheets are projected, holding in view the effect upon this channel of the improved river above. These works consist of 12 dikes, 13 jetties, and 13 spurs, built of sheet-piling and wattle-work, as at present located, as shown on sheets, and aggregating in cost as follows:

5,675 feet linear wattle-work, at 80 cents per foot.....	\$4,540 00
7,380 feet linear sheet-pile, at \$3 per foot.....	22,140 00
1,810 feet linear protection applied to above, at \$3.20 per foot.....	5,792 00
Add, for closing up interior channels or sloughs, not shown on sheets, as may be found necessary from time to time.....	3,000 00
Add cost of necessary surveys, &c., office expenses of same from May 1, 1879, to July 1, 1880.....	1,800 00
	<hr/>
Total cost.....	37,272 00

With those formulæ on which were based the contraction of the fair-way of the Petersburg Channel to 125 feet by the correspondent works, and making due allowance for the greater tidal action, 150 to 180 feet would result as the desirable fair-way width in this south channel; but while in the upper channel, owing to the great modifications to the flow of the tide from natural and artificial causes, in planning the works contracting the fair-way, the consideration of the active effect of freshets and land-floods upon the stream has had to exercise a controlling influence in the case of this channel, this gives place to the more important consideration of so arranging the works as to aid and extend upwards the tidal propagation, and putting the main reliance upon this factor for the securing of the permanent regimen; it is then upon this principle that the works herein are based, the system of transverse jetties, as such, giving place in consequence to that of longitudinal dikes or training-walls with the rigid closing (certainly at their upper ends) of all subsidiary channels or blind sloughs, the jetties used being located in straight reaches, where well-defined deep-water curves already are found, rather with a view of keeping the waters within these limits already marked out for themselves than to effect any calculated or arbitrary contraction of fair-way; so, too, the distance of 300 feet between consecutive jetties, found by experience to be the maximum distance apart for effective service in the Petersburg Channel, has not controlled in locating the present works, the natural conditions rather (such as the widenings on north side, due to sloughs or swamps, the entrance of secondary channels, &c.) indicating the locations proposed.

While, with the experience of the past, merely as a guide in any scheme of perma-

ment river improvement proposed for this particular channel, the simplest and least costly plan would be that of periodic reparation by dredging—an item of \$6,000 every three years probably covering this amply—two reasons point to the preferment of works of the class proposed: *first*, that, with the imposing of a new and improved regimen upon the two upper channels, the south channel will silt up at a far more rapid rate than heretofore, if left as it is; from the character of the country traversed by the river compartment proper, as experience abundantly shows, large quantities of material are being eroded and brought lower down; this material, a coarse sand, capable of being transported by a certain velocity of flow, with this velocity from any cause checked, is sure to be deposited, and, following the usual rule, to thus gain rapidly in density and compactness, beyond the power of the transporting causes to move; under proposed conditions, as above, this south channel must become then the final receptacle basin for all this moving matter, which would insure the change in its silting-up, above adverted to. And this statement serves to introduce the second objection to the periodic reparation plan, inasmuch as, while the causes—the yearly freshets and rises—for this movement of matter may be considered as of regular recurrence, the actual effects depending upon the magnitude and frequency of the moving causes, range between such wide limits as to make it impossible to foresee or guard against them seasonably; as, for example, the freshets of the fore part of the year 1875 necessitated the dredging out of 50,260 cubic yards in the then condition of the improvement; in the two years before, and till the close of the year 1877, scarce perceptible effects were produced from the same cause; the admittance of any such risks, as would even for the time entirely block the navigation proposed to be accommodated by the existing project of improvement, would seem, it is believed, inadmissible.

In conclusion, the following recapitulation is exhibited as to the figures of *cost* of proposed project:

1. Petersburg Channel	\$29,563 00
2. Puddledock Channel.....	10,000 00
3. South Channel	37,272 00
Grand total	76,835 00
Deduct balance of appropriation of June 18, 1878, on hand May 1, 1879	\$6,800 00
Deduct appropriation of March 3, 1879	20,000 00
	26,800 00
To be appropriated to complete project herein.....	50,035 00
Amount (estimated) required for completion of existing project, as per Appendix F, page 465, Annual Report of Chief of Engineers for 1878..	53,000 00
Deduct from this, appropriation of March 3, 1879.....	20,000 00
Balance required, as per figures previously existing	33,000 00
Additional sum required for project now proposed in detail.....	17,035 00

From the above figures it will be seen that the *original* estimate—the details of which are not in my hand—if covering the same object as that of project herein set forth, needs to be increased by this sum of \$17,035.

I have the honor, sir, to remain, very respectfully, your obedient servant,
 JAS. W. CUYLER,
 Captain of Engineers.

Maj. W. P. CRAIGHILL,
 Corps of Engineers, U. S. A.

F II.

IMPROVEMENT OF NEW RIVER FROM THE LEAD MINES IN WYTHE COUNTY, VIRGINIA, TO THE MOUTH OF GREENBRIER RIVER, WEST VIRGINIA.

The plan adopted for this river has been the formation of a channel-way 30 feet wide and 2 feet deep below the lowest water, suited for the keelboats now in use, but at the same time capable of utilization and adaptation at some future day, in a further improvement of the navigation for light steamboats, should means be provided therefor.

The ledges and detached bowlders have been blasted out under water, and the *débris* removed from the channel and built into the wing-dams and training-walls. The gravel shoals were excavated through and the materials placed in the hearts of the dams, &c. By these means sluices and chutes have been made, affording a good water-way, without insurmountably increasing the velocity and volume of the water in them. The work has been done altogether by hired labor, and the purchase of materials in open market.

Operations were confined to the section of the river above the crossing of the Virginia and Tennessee Railroad, under the personal supervision of Capt. J. W. Cuyler, Corps of Engineers, until September 13, 1878, when a very severe freshet occurred, causing a considerable loss of property, and doing some damage to the unfinished works. It was so late in the season that operations were not resumed on that section.

The appended report of Captain Cuyler gives a detailed description of them.

In August, 1878, it was decided to commence work at once on the section of the river immediately above the mouth of the Greenbrier, at Hinton, in West Virginia. These operations were placed under the immediate supervision of Assistant A. M. Scott, and vigorously continued until near the end of November. The report of Mr. Scott, appended hereto, gives the details of the work. This was resumed in June, 1879, under the direction of Col. W. P. Smith, assistant engineer. The working season is short, as the river must be low, the water clear and not too cold. June 3, a small force was at work on Greenbrier Shoals. June 18, a force was engaged upon the Blue Stone Shoals, and June 17, on Land Craft Shoals.

It is found necessary to increase the estimate for the completion of the work by the sum of \$56,160. The reasons for this are that the original estimate was approximate, being based on insufficient data, though the best then attainable; and actual experience has shown the quantities involved and the extent of the work to be done greater than previously supposed.

Money statement.

July 1, 1878, amount available.....	\$23,429 49
Amount appropriated by act approved March 3, 1879.....	12,000 00
	\$35,429 49
July 1, 1879, amount expended during fiscal year.....	19,125 01
July 1, 1879, amount available.....	16,304 48
Amount (estimated) required for completion of existing project.....	114,160 00
Amount that can be profitably expended in fiscal year ending June 30, 1881.	20,000 00

REPORTS OF CAPTAIN JAMES W. CUYLER, CORPS OF ENGINEERS.

1.

UNITED STATES ENGINEER OFFICE,
 Baltimore, Md., July 3, 1879.

MAJOR: Pursuant to your instructions to this effect, I respectfully submit herewith the annual report of operations, improvement of Upper New River, Virginia, for fiscal year 1878-79, in so far as these fell under my immediate charge.

For this report I adopt and submit, hereto attached, the report of operations for the season of 1878, after July 1, of date March 15, 1879. This latter report brings the record of operations up to October 15, 1878, when the operations under my immediate charge closed, and the entire work was transferred by your orders to a new locality, 84 miles down-stream.

The report of March 15, 1879, will be found to cover all the details of my operations, as also my general views on certain points, which may have a practical bearing in any further prosecution of the work, and which seemed clearly indicated to me by the experience of two seasons' work upon the river.

After October 15, 1878, I transferred to others, by your orders, the immediate charge of this particular work.

In this connection, I avail myself of the opportunity afforded me to express recognition of the valuable services rendered by my assistant in the office, Mr. William Costello, and by Messrs. Ranson and Gilliam, who acted as head overseers.

The plan adopted for this work was that of making a clear channel through all the obstructions in the river-bed, 2 feet deep below minimum low-water, 30 feet wide, for the now navigation of the stream—bateaux—to be later on enlarged to 3 feet depth and 90 feet width, for light steamboat navigation.

Original estimated cost of the work as now being carried on.....	\$100,000
Whole amount appropriated since adoption of present project.....	42,000
(First appropriation, August 14, 1876; last appropriation, March 3, 1879.)	
Amount expended to date.....	25,697

The original estimate is insufficient to carry out to completion the existing project. The reasons for this excess of cost are, firstly, that when the original estimate was made the data on which it was based were in themselves not sufficiently full to admit of a close estimate; and, secondly, because in the light of the actual experience had, both the quantities involved and the extent of the works are greater than at first estimated for by a considerable amount.

I estimate as the probable additional sum required for completion, \$56,160. This sum covers 128 miles of river to be improved under present project, at the rate of \$1,220 per mile, which the actual figures of the two working seasons show to be a safe estimate per mile at the lowest.

Amount, exclusive of former appropriations, required for entire and permanent completion, \$114,160.

While the nature of this work does allow of a permanent completion, this same nature involves an expenditure annually for maintenance and repairs; the probable sum of this, as nearly as can be estimated in this case, is \$4,000.

Amount that can profitably be expended during fiscal year 1879-'80, \$20,000.

No revenue collected and no statistics to show amount of commerce or navigation that would be benefited by completion; the completion would, it is confidently believed, create a considerable amount of both.

No abstracts of proposals or abstracts of contracts, the work being done entirely by the United States, with all purchases in open market.

I have the honor, sir, to remain, very respectfully, your obedient servant,

JAS. W. CUYLER,
Captain of Engineers.

Maj. W. P. CRAIGHILL,
Corps of Engineers, U. S. A.

2.

UNITED STATES ENGINEER OFFICE,
Baltimore, Md., March 15, 1879.

MAJOR: I have respectfully to submit the following report of operations on the Upper New River, Virginia, for the season of 1878, the period of time so covered extending from July 1, 1878, to which date my annual report of operations for 1877-'78 brought up the record to October 15, 1878, when all operations whatsoever were brought to a close.

After July 1, the work of completing the then working section, Falls Branch, by completing its two upper subsections, Bucks Falls and Egypt Falls, was continued, as previous to that date. The monthly reports set forth fully the difficulties and disappointments attending this work, all delaying the completion of it till August 20, far beyond the estimated date for completion. The length in river of this Falls Branch working section aggregated 1 mile, over which almost continuously work of some kind was done. Next, minor obstructions at Egypt Ford, $\frac{1}{2}$ mile farther up stream, and at Woolwine's Island, 1 mile beyond latter, were removed, and the work completed hereat (for localities, *vide* survey map of 1872). August 21, also, was begun the work at the Peak Creek section, $4\frac{1}{2}$ miles above the Falls Branch one. For a detailed description of this new section and the special difficulties of its work, I respectfully refer to the monthly reports. The position required a large amount of work of a preparatory nature; indeed, this was the main amount, and it was accomplished; no large amount of work in addition was required to complete the section, with a channel 30 feet wide in the lower

subsection of 2,900 feet of river length, and 20 feet wide in the upper of 3,600 feet, a total length of river of 6,500 feet covered by the obstructions. On the 13th September, while the above work was not entirely completed as above indicated, a freshet unprecedented—27 feet high at Peak Creek—unexpectedly and abruptly terminated the season's operations, by washing away and destroying the camp with its plant for the work, and greatly endangering the lives of all the working force. Though this flood ran out rapidly, the river until December, when winter froze it tight, kept much too high for any operations. After the flood, examinations were made at all the several working sections to determine the effects of the flood upon the works, the results of which have been submitted to you in a special report. The detail maps of the season's operations completed in the office, the property collected together and put in repair, and, finally, all boated down to Hinton, W. Va., at mouth of Greenbrier River, a distance of 84 miles, to which point, under your decision, operations were to be transferred in future as a base. Everything was closed up by October 15.

Appended are detailed exhibits expressed in figures; these show results satisfactory and gratifying in the improvement made over the corresponding figures of the season of 1877, due to a larger force, better organization, and adequate preparations, made in advance of beginning work, both as to the aggregates of work done and the several details of the same, the same general plan of operations being continued in both years. In no case did the preparations made the previous winter fail to meet their designed purpose.

The two bateaux built by informal contract drew but 5 inches of water, light, and with 5 tons load but 15 inches, answering entirely to the requirements of moving the force, stores, &c., from camp to camp, as also for reconnaissances, examinations, &c.; the craneboat, though she could not be used as much as was expected, owing to the obstructed channels rendering it impossible often to get her into position, lifted $2\frac{1}{2}$ tons on a draught of 6 inches of water, with her legs or spuds down. This device did admirably, a slight change, only practice pointed out, was needed in decreasing the outward spread from sides of boat of these spuds. The stone and gravel boats, drawing $6\frac{1}{2}$ inches light carried from 3 to 5 tons at a load on 16 inches of water, and, notwithstanding their weight, due to their solid construction, and the inevitable difficulty of handling such a style of boat in such a river as this, yet proved their efficiency, and went through a very trying (on them) season without any repairs being put on them; to make the plant on this line as perfect as it is possible to make it, they but require to be supplemented by a fleet of smaller boats—large strong canoes built with knees—carrying from $\frac{3}{4}$ to $1\frac{1}{2}$ tons on 12 inches of water, for use in the worst places.

The use of the churn-drill was introduced, but successfully only exceptionally; it was too unwieldy for one man to manipulate in such water, and experience confirmed that the jumper, with the 2-inch-diameter holes (for powder), first started with, was the best and cheapest system of drilling. Deeper holes, 3.75 feet (average) against 2.9 feet in 1877, were used, as it was found absolutely necessary to go below the grade of bottom as laid out, so as to get at completion the required depth; thus with an average charge (of powder), less than in 1877, 0.54 pound and 0.65 pound, more rock was moved per blast, 1 yard (cubic) against $\frac{2}{3}$ yard. Though considerable more labor was thus involved, yet the work per drill per day (average) increased from 9.75 feet, 1877, to 12.78 feet, 1878. Giant powder No. 2 was also introduced, and with such successful results as to indicate the advantage of using it almost exclusively in future work, provided proper arrangements be made, in Baltimore, in advance, to supply it regularly in small quantities at a time. With this, $1\frac{1}{2}$ -inch-diameter holes were used as ample, and only $\frac{1}{2}$ pound cartridges (average); by it so used the rock was so riven along the seams that it could be easily hoisted out in large blocks by the craneboat; larger holes or cartridges were disadvantageous as pulverizing the rock too much; of course, with this explosive, good judgment in its use is indispensable to produce good results; not unfrequently, however, in this work, if the rock is without seams or planes of stratification, the ordinary blasting-powder will do the desired work.

With the satisfactory results above noted accomplished, it may be further added that these were accomplished in the face of an unfavorable season for river work; it did not fairly open till the last part of June, and after July 1 comprised but 57 days on work proper, against 60 such days in 1877, beginning then July 23 and closing October 11. The appended plotted gauge-readings show, too, that the river in 1878 did not fall below— $6\frac{1}{2}$ inches on gauge, and the average stage for the season was not less than—3 inches, with three distinctly marked high freshets, entirely suspending operations for their continuance of 2 or 3 days, while in 1877 the stage was as low as—13 inches, with an average of— $8\frac{1}{2}$ inches, and but one freshet of note. The bearing on the work of this stage for 1878, higher by 6 inches all through, and about 4 inches above the ordinary summer low-water stage, is best appreciated in considering that, with a gauge-reading of +10 inches, work is very difficult, and with +18 inches absolutely impracticable, so that but small limits as to stage of river are afforded for advantageous working.