

least depth in the fairway is 15 feet, and the removal of 5,000 cubic yards would make a channel 18 feet at low tide, with 130 feet bottom width. This cut deepens very slowly from scour, except at the lower end where there are over 40 feet depth of water. The material in the bottom is a very hard clay, nearly black in color, said to be "Triassic," which cannot be profitably dredged with our machines without the aid of blasting. A map is submitted showing the present condition of this work, and also the low tide widths before the several enlargements were made, since 1870.

The greatest depth of cutting was 654 feet. This work was first publicly advocated by Captain Stansbury, United States Engineers, in 1853. It was begun during the war, in aid of military operations, by General B. F. Butler, and was so far completed that some small vessels passed through. At the close of the war the owner of the land closed it by a causeway across the upper end. The flood of 1870 washed out this causeway, and the United States having then undertaken the improvement of the river, decided to open it to navigation. A contract was made with the American Dredging Company, of Philadelphia, for a certain amount of work, and it was widened to about 135 feet; subsequently a slide from the right bank diminished this to 120 feet. In 1875 contracts were made with R. T. Hieston and M. Meehan, who left it about 180 feet wide. In September, 1878, a contract was made with M. C. Heggarty, for widening on the left bank, and, following him, a force employed by the month widened it on the right bank, leaving it of the dimensions stated above.

The cubic yards excavated since 1870 and the cost are:

	Cubic yards.	
By American Dredging Company .....	59,472.0	\$19,625 76
By M. Meehan, below water .....	17,212.3	8,261 87
By R. T. Hieston, above water .....	18,674.8	4,271 84
By M. C. Heggarty, above and below .....	30,799.9	7,299 25
By monthly force, above and below .....	6,598.0*	1,533 73
Totals .....	132,757.0	40,992 45

In the last annual report the results of a survey of 2 miles of the river below the cut-off, including the Varina Shoal, are given, showing that in that distance the river was essentially as it was found by the Coast Survey in 1852-'53, except that the channel through Varina Shoal was probably narrower. In December last an examination was made of 1,700 feet on each end of the bend cut off, adjoining the cut, and of the river above the gap for 3,300 feet. The following statement gives the conditions as compared with 1852-'53 and 1874.

Year.	Main river for 3,300 feet above cut-off.				Bend for 1,700 feet below upper end of cut-off.				Bend for 1,700 feet above lower end of cut-off.			
	Mean width at low tide.	Mean depth of channel.	Mean depth of river.	Mean area.	Mean width at low tide.	Mean depth of channel.	Mean depth of river.	Mean area.	Mean width at low tide.	Mean depth of channel.	Mean depth of river.	Mean area.
1852-'53 .....	Feet. 526	Feet. 35.8	Feet. 20.9	Sq. ft. 10,993	Feet. 586	Feet. 33.1	Feet. 20.7	Sq. ft. 12,130	Feet. 993	Feet. 18.5	Feet. 12.7	Sq. ft. 12,611
1874 .....	504	36.8	19.2	9,667	544	31.0	17.0	9,248	959	17.1	12.5	11,988
1878 .....	496½	35.5	20.8	10,323	541	25.6	13.5	7,304	906	15.3	10.9	9,875

As the high-tide line only is given on the map of 1852-'53, the width assumed for low tide in that year may be too much, which would make the areas for that year too large.

It will be seen, however, that the river above the cut-off has suffered very little injurious change since 1852-'53; but there has been a marked diminution in width, depth, and area in the bend cut-off, especially at the upper end. It would be interesting to know if the shoaling diminished regularly from the upper to the lower end of the bend, or if it is confined to the parts adjacent to the cut-off. I think this cut-off has had no injurious effect on the river above and below it, and the projected cut-offs at Jones Neck and Bermuda Hundred may be undertaken with confidence

\*32 cubic yards in 1876.

that the results will be satisfactory. Dutch Gap Cut-off saves 5½ miles of navigation. The other two would save about 8 miles. The area of the cut-off at low tide before the recent enlargement, or when the survey was made, was about 2,600 square feet. The diminution in area of the bend has been 4,826 square feet at the upper and 2,736 square feet at the lower end.

Cubic yards of material moved in 1878.

Locality.	Solid rock.	Soft and decomposed rock and bowlders.	Hard clay.	Sand and mud.
Gillies Creek Shoal (above Rocketts Reef) .....		525		
Rocketts Reef .....	975	1,794		
Firebrick Channel (below Rocketts Reef) .....	10	2,020		
Drewry's Island Channel .....	249½	26,490		
Warwick Bar .....				18,695
Dutch Gap Cut-off .....			37,366	
Total .....	1,234½	31,279	37,366	18,695

Total excavations of all kinds, cubic yards..... 88,574½  
Wing-dams built, linear feet..... 4,976

All the material excavated was deposited as revetment on the wing-dams, but is insufficient in amount to fully protect them.

FRESHETS.

September 15, 1878, a rise of 9.83 feet above high tide.  
November 18, 1878, a rise of 9.25 feet above high tide.  
December 12, 1878, a rise of 9.12 feet above high tide.

An ice-gorge, unusual in this vicinity, occurred in January, 1879. The river closed with ice on the 3d, and remained so until the 10th, when the Old Dominion steamship Wyanoake cut the way to her wharf; at this time the ice on the channel is reported to have been 6 inches thick. Rain had fallen on the 8th and 9th, and after the ship arrived broken ice began to come from above in large quantities. The rise in the river was not serious, amounting to only 5 feet at the Belle Isle Works; but owing to a gorge of ice 11 miles below the city, the river at Rocketts rose rapidly, and on the 11th was fully 15 feet above high tide. The registering gauges were removed on the 9th, so that the extreme height cannot be given with precision. There was no considerable current at any time during this rise. Another rain fell on the 12th, which brought down more ice; but in the mean time the river had fallen several feet at Rocketts, and the latter rise was not so great as on the 11th. The river was packed with ice from Richmond Bar to the lower end of Kingsland's Reach, 11 miles below; it was then clear by way of Dutch Gap Cut-off to Varina, 16 miles below the city, where another gorge or pack occurred, of more limited extent. The bend cut-off at Dutch Gap was also much obstructed. On the 15th the Old Dominion Steamship Company attempted to break through the pack with their iron ships Wyanoake and Richmond, the former from above, the latter from below. The Richmond, a screw ship of full model, failed to make a serious impression from below, and abandoned the effort. The Wyanoake, a sharp-built side-wheel ship, spent the 15th, 16th, and 17th in the pack, and broke through on the 18th, and was met by her companion ship, Old Dominion, in the ice at Varina. The latter came on to the city the same day without serious impediment. This steamship company is entitled to great credit for this long-continued effort to clear the channel. The ice was probably 8 feet thick in places, and may have been more, for some of it left on the dikes was nearly 9 feet thick on the 22d.

The river turns a sharp elbow in Kingsland's Reach, where the ice seems to have first gorged seriously, and at the point is 550 feet wide and 30 feet deep; a third of a mile above it is 1,100 feet wide with a narrow channel, 13 feet deep at low tide before the gorge.

The shoal is underlaid with rock, which at the channel is generally 20 feet below low tide, but near the right bank is within 5 or 6 feet of the surface in places. The ice closed the river for one-third of a mile below the narrow point mentioned, and at

the lower end the depth of water was 20 feet. In 1870 the flood made a breach across this elbow, and this breach was enlarged by the succeeding flood of 1877, but ordinary freshets were not high enough to reach its level. During this ice-gorge a part of the river escaped through this breach and further enlarged it. The main body of water probably passed under the ice, and scoured away 4 or 5 feet in depth of the shoal, for a considerable width over its entire length, which is about one-third of a mile. The breach, which is now only a few feet above high tide, should be closed by a levee, and proper dikes should be built to maintain the present excellent channel, which was 17 feet deep at low tide in March last. The accompanying map shows the river at this point, the breaches in the levee, and the position of the proposed works. An estimate of the cost is included elsewhere in this report.

As the current was very gentle during the existence of the pack, the wing-dams suffered less damage than in the preceding freshets of November and December, nor were many of the channel buoys moved; some of the piles which extended above the level of the dams were bent down stream, and a few of the outer piles were carried away. The dams, built to but little above the level of high tide, were at least 14 feet under water at the height of the rise, and were therefore but slightly injured. The effect of explosives was tried at the lower end of the gorge, but with no beneficial effect. The tide-gauge house on Richmond Bar was carried away and destroyed; the clock had been removed. About 20,000 feet, board measure, of lumber belonging to the improvement was lost.

The examination of the shoals below Varina, made in May, 1879, shows that the channels have not lessened in depth for 25 years past, and the cost of deepening them is a comparatively easy matter.

The rise and fall in the lower part of the river is much less than it is at Richmond. At the mouth of the Chickahominy the rise and fall is 1.9 feet, while it is 3.865 feet on Rocketts Reef, and for several miles below. The mean high tide at Richmond is 3.463 feet above our assumed zero, and the channel is to be 15 feet below this zero. If the depth below zero is made the same on the lower part of the river, a deeper draught can be carried from the city at high tide than can be carried over the shoals below at high tide, and so moderate is the cost of deepening the channel through the lower shoals, that it seems to me advisable to make the depth below Dutch Gap at low tide the same that it is above at high tide. In that case vessels loaded for the full depth at high tide at Richmond could approach within 15 miles of the city at any stage, and at high tide proceed to the city. In the other case, vessels will be limited to the low-tide depths, or to 1.9 feet over, and must stop at every shoal until high tide.

The range of tide at Richmond is affected by the discharge from above the falls, *e. g.*:

Date.	Mean low tide above zero for the month.	Mean range of tide for the month.	Mean high tide for the month.
April, 1877	1.022	2.931	3.953
May, 1877	0.297	3.283	3.542
June, 1877	-0.565	3.847	3.282
July, 1877	-0.829	4.062	3.234
The mean for 12 months was	-0.402	3.865	3.463

This mean does not include freshets, for tides over 5 feet above zero are excluded from the computation. It will be seen that low tides varied 1.851 feet and high tides only 0.719 feet. By this compensation the mean of high tides is maintained at more nearly the same level. In the remarkably low stage of July, 1877, the high tide was only 0.229 below the mean for the year. But the discharge of fresh water has little effect in raising the river in the lower reaches. The great flood of November, 1877, rose 25.12 feet above high tide at Richmond; but only 1.82 feet on Harrison's Bar, 37 miles below.

The estimates heretofore submitted have included nothing for the shoals below Varina, except a small item for Harrison's bar. There are three shoals below City Point which have about 15 feet at low tide, but do not have 18½ feet at high tide. These are Harrison's Bar 14½ feet, Swan Point 16 feet, and Goose Hill Flats 15 feet. There are but two considerable shoals between City Point and Dutch Gap with less than 18½ feet at high tide—Varina, and Curle's Neck. There are two other points

which may have less, but they are inconsiderable in extent. An estimate is submitted for deepening all these shoals to 18½ feet at low tide.

No estimate is made for dikes or other works of the kind below Varina. Such works will probably be needed in places to maintain the deepened channel; but I am not sure that occasional dredging will not be cheaper than the interest on the cost of such works. The first cost of dredging will be light, and the experience gained by watching the changes which may afterward take place, would enable one to locate such works more judiciously in the future, should they be found necessary. For a further improvement to a much greater depth than 18½ feet, which the river is undoubtedly capable of, such works would certainly be needed.

No estimate is submitted for closing the breaches in several dikes near Dutch Gap Cut-off, which formerly prevented the overflow of large areas. This work, if done, would increase the volume and velocity of the tidal wave above, and is important for the maintenance of the channel. For the same reason, the restoration of the basin at the head of tide, above the ship-lock, is a work which will commend itself in the near future. This basin has been reduced at least 12 acres, in the past 26 years, by an accumulation of sand, which now shows itself at low tide, diminishing by so much the quantity of ebb and flow, and the evil is increasing. It will require the excavation of 100,000 cubic yards to reduce the shoal to 4 feet below low tide, and would cost about \$20,000. This sum is not included in the estimates.

THE COST OF COMPLETING THE WORK.

A revised estimate is submitted for the completion of the work according to the plan, and for deepening the channel below Dutch Gap to 18½ feet at low tide, with a width of 200 feet. The plan of contraction by wing-dams is adhered to as far as Varina, and a small estimate added for connecting their outer ends as may be found necessary in the immediate future. The cost of excavation is put at the prices which similar work on this river has cost in the past. The additional work for the deeper channel below Dutch Gap is the only considerable increase over the estimate submitted last year. The item for connecting the outer ends of wing-dams has been covered heretofore by the larger percentage allowed for contingencies, but it is impracticable to foresee how far this work may become necessary. An additional amount of dredging is estimated for, but at lower prices. In this item we cannot foresee how much will be scoured by reason of the wing-dams; and, on the other hand, it is impossible to say how much stone must be purchased for the protection of the works. Hitherto we have depended upon material dredged from the channel near Richmond for revetment. Perhaps the amount saved by scour will pay for the stone needed.

This estimate is submitted with the supposition that the prices for labor and materials will remain as at present, and that full appropriations are made so as to avoid the increase in expense attending intermittent and incomplete operations.

Richmond Dock to Rocketts Reef.

24,000 cubic yards decomposed rock, &c., at 35 cents	\$8,400
300 cubic yards solid rock, at \$7	2,100
	\$10,500

Across Rocketts Reef.

3,000 cubic yards solid rock, at \$7	21,000
2,379 cubic yards soft rock and cobble-stone, at \$2	4,758
	25,758

Rocketts Reef to lower end of Drewry's Island.

60,000 cubic yards decomposed rock, &c., at 35 cents	21,000
800 cubic yards solid rock, at \$10	8,000
1,000 linear feet timber wing-dams, at \$1.50	1,500
1,000 linear feet connecting dike, at \$4	4,000
	34,500

Goode's Rocks to Richmond Bar.

2,800 cubic yards solid rock, at \$7	19,600
5,000 cubic yards soft rock cobble-stone, &c., at \$2	10,000
800 linear feet of timber wing-dams, at \$1.50	1,200
	30,800

Richmond Bar and Randolph's Flats.

100,000 cubic yards sand and gravel, at 20 cents	20,000
500 linear feet timber wing-dams, at \$1.50	750
2,000 linear feet connecting dike, at \$4	8,000
	28,750

*Warwick Bar.*

30,000 cubic yards sand and mud, at 20 cents.....	\$6,000	
4,000 linear feet timber wing-dams, at \$1.50.....	6,000	
1,000 linear feet connecting dike, at \$4.....	4,000	
		\$16,000

*Kingsland's Reach.*

15,000 cubic yards embankment in levee, at 18 cents.....	2,700	
800 linear feet sheet-pile dike and filling, at \$4.50.....	3,600	
840 linear feet crib wing-dams, at \$4.....	3,360	
630 linear feet pile wing-dams, at \$2.50.....	1,575	
10,000 cubic yards dredging, at 20 cents.....	2,000	
		13,235

*Dutch Gap Cut-off.*

Completed larger than original plan.

*Varina or Aiken's.*

48,000 cubic yards sand and mud, at 20 cents.....	9,600	
3,000 linear feet timber wing-dams, at \$2.50.....	7,500	
		17,100

Total work estimated for heretofore, except Harrison's Bar.....	176,643	
Add for contingencies 10 per cent.....	17,664	

Total..... 194,307

*Channel below Varina, 200 feet by 18½ feet.*

At Curle's Neck, 40,000 cubic yards, at 20 cents.....	8,000	
At Harrison's Bar, 50,000 cubic yards, at 25 cents.....	12,500	
At Swan Point, 6,000 cubic yards, at 25 cents.....	1,500	
At Goose Hill Flats, 55,000 cubic yards, at 25 cents.....	13,750	
At other points, 10,000 cubic yards, at 20 cents.....	2,000	
	37,750	
Add 10 per cent. for contingencies.....	3,775	
		41,525

Total..... 235,832

To make this lower channel 400 feet wide will cost \$45,000 additional.

## COMMERCIAL STATISTICS.

The following extract is from the report of R. E. Blankenship, Esq., chairman of the city committee on the improvement of James River, for the year ending December 31, 1878:

"The tonnage on the river is larger than in previous years by some 18,000 tons, but the actual number of vessels shows a slight reduction, which is positive evidence that larger vessels are seeking this port."

Steamers.....	590
Sail.....	839

The number of vessels the previous year was—steamers 570, sail 903.

The collector of this port has kindly furnished the following letter:

CUSTOM-HOUSE, COLLECTOR'S OFFICE,  
Richmond, Va., June 14, 1879.

DEAR SIR: In reply to your letter of 12th instant, I have the pleasure to inclose herewith a statement showing the duties received on imports, the number and tonnage of vessels engaged in the foreign and coastwise trade, and the value of imports from and exports to foreign countries.

In addition to the vessels engaged in the coastwise trade reported in the statement, hundreds of vessels engaged in that trade are not required to enter or clear at this office, and consequently we have no record of their tonnage.

Yours respectfully,

H. D. WHITCOMB, Esq.,  
Assistant Engineer.

CHARLES S. MILLS,  
Collector.

## STATEMENT INCLOSED.

Duties on imports received from June 1, 1878 to May 31, 1879.....\$15,189 53

## Vessels engaged in foreign trade:

	Vessels.	Tonnage.
Entered.....	48	15,499
Cleared.....	132	42,761

## Vessels engaged in the coasting trade:

Entered.....	446	413,057
Cleared.....	505	468,429
Value of imports.....		\$185,838 50
Value of exports.....		3,068,520 00

The city of Richmond has aided the work by furnishing dredges and other machinery at actual cost of current repairs, and proposes to do some dredging in June and July.

Mr. George R. Talcott has been employed as assistant engineer since October 1. Mr. A. L. Johnston and Mr. Walter Izard have assisted on surveys and in office-work for a part of the year.

The amount which can be profitably expended on this work during the year is \$150,000.

The work is in the collection-districts of Richmond, Petersburg, and Norfolk.

Very respectfully, your obedient servant,

H. D. WHITCOMB,  
Assistant Engineer.

Col. WM. P. CRAIGHILL,  
Major, Corps of Engineers, U. S. A.

## F 10.

## IMPROVEMENT OF APPOMATTOX RIVER, BELOW PETERSBURG, VIRGINIA.

When the first appropriation was made for this river by the United States after the civil war, it was found that the city of Petersburg was engaged actively in the work of its improvement. The principal feature of the plan adopted by the city was the cut made through the Puddledock Swamps. Though not approved by the United States Engineers, it had progressed so far that it was considered better for the United States to carry it through. In connection with it, much dredging was necessary in the South Channel, below the Puddledock Cut, and in the channel from Petersburg to the upper end of the Puddledock Cut, in order to accommodate the actual commerce on the river. Mr. Bird states that at the close of the war there was "only 6½ feet navigation," meaning thereby 3½ feet at low-water and 6½ feet at high-water. Soundings made within a few days show that 8¼ feet may be found at low-water and 11¼ at high in the channel to Petersburg, except for a very short distance in the Petersburg Channel, where there are found only 6 feet at low-water and 9 feet at high. A few days of dredging would remedy this trouble temporarily, and the completion of the proposed arrangement of wing-dams and training-walls would remedy it permanently.

There has never been subject to the control of the engineer a sufficient amount of money to conduct the necessary operations in the best and most economical manner. In consequence the annual process has been chiefly an effort by resorting to the use of the dredge promptly to remove the obstacles to navigation to be annually expected in the unfinished state of the river, and next, or simultaneously, by the use of the available funds, to make a step forward, as great as possible, in the plan of permanent improvement.

The channel from Petersburg to the deep water below is naturally divided into three parts. In that division called the South Channel, which

is a natural channel, nothing has as yet been done but to dredge. A channel was cut previous to June 30, 1873, with a width of 60 feet at bottom and a depth of 10 feet at mean low-water. Up to this time it has stood unexpectedly well, though there is some deposition in it. The next division, the Puddledock Channel, above the South Channel, is altogether an artificial cut through a swamp. In August, 1876, this cut had been made 100 feet wide, with a depth to permit the passage of vessels drawing 10½ feet. In connection with the dredging, embankments were made for the new channel, which were planted with willows. A deflector had been also built at the upper end, to turn a portion of the fluvial current from its original channel into the new cut. Thereafter attention was confined almost exclusively to the third division, from the Puddledock Cut up to Petersburg. Some rock was removed near Petersburg, but the main work has been dredging and the construction of wing-dams and training-walls to contract the water-way to 125 feet.

The report of Capt. J. W. Cuyler, who has lately had the immediate supervision of the work, details the operations of the year ending June 30, 1879. He has also prepared, at my request and carrying out my ideas and instructions, a report with estimates for a permanent channel from Petersburg to the deep water below, to give 10 feet at mean low-water. This report is also appended.

In the last annual report it was stated that the sum of \$53,000 yet remained to be provided to complete the estimate.

Deducting the appropriation of March 3, 1879, \$20,000, there would be left still the sum of \$33,000 to be appropriated. A revision of the estimate increases this amount by \$9,000, or \$42,000.

The work is located near the port of entry of Petersburg. Amount of revenue collected at this port, \$700.48.

The amount of internal revenue collected during the year, \$1,259,036.26. No foreign vessels entered or cleared from this district. The number of vessels engaged in the coastwise trade using this improvement are as follows:

Entrances, 388; 426,401 tons.  
Clearances, 264; 346,564 tons.

#### Money statement.

July 1, 1878, amount available.....	\$30,005 19
Amount appropriated by act approved March 3, 1879.....	20,000 00
	\$50,005 19
July 1, 1879, amount expended during fiscal year.....	29,964 05
	20,041 14
July 1, 1879, amount available.....	20,041 14
Amount (estimated) required for completion of existing project.....	42,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1881.	30,000 00

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

1.

UNITED STATES ENGINEER OFFICE,  
Baltimore, Md., July 1, 1879.

MAJOR: I respectfully submit below the annual report of operations, improvement of Appomattox River, Virginia, for fiscal year 1878-79 pursuant to your instructions to this effect.

The operations of the year have been in immediate continuation of those undertaken the previous year as specified in the corresponding annual report, being concentrated upon the "Petersburg Channel," a stretch of river of 11,000 feet, equaling 2.1 miles.

The work has been carried on entirely by hired labor and purchases in open market,

under the immediate superintendence of Mr. H. D. Bird, up to October 10, 1878, and since that date under my own.

During July, August and September, 1878, the operations were principally directed towards the needed repairs and finishing up of the system of transverse jetties, thirteen in number, built during the previous year, with the view of placing these in a condition of thorough completion. Six hundred and ninety-three linear feet of jetty was thus built. A fourteenth jetty 300 feet below No. 13, 130 feet in length, composed of wattle-work, to be extended by the sheet-pile work, was also built. A large amount of material was also collected and duly placed, and with October, 1878, the most critical of the several works of the improvement—the lateral dike extending down from the deflector of 1874 to the abutment at the upper end of the Puddledock Channel, and closing the old natural river channel to the north, and turning it into the artificial Puddledock Channel, was commenced. This dike, 605 feet in length, an elaborate construction of sheet-piling and cap and brace pieces, was completed by December, when a season of unusual storm and freshets, involving a scour at bottom from an average depth of 9 feet down to 17 feet, necessitated extensive repairs, with a remodeling of the details to gain additional required strength for the structure. The two breaks, 80 feet in length each, were effectually repaired with February, 1879, an entire suspension of operations occurring from December 25 to January 23, by reason of the closing of the river by ice. In this same above interval, the longitudinal dike at Hare's bar, opposite jetties Nos. 11 and 12, a sheet-pile construction, 630 feet long, serving as a guide wall in a concave bend, as also a revetment to the main bank, was built.

The monthly examinations demonstrating that with all works put in the stream there followed unflinchingly a very threatening scour, it was decided as the next first step to arrest this scour by the application of a protection composed of mats of fascines laid with a regular slope from the works outwards and duly loaded with stone, and as the season stopped operations of any other kind, this particular work was at once taken in hand. The up-stream faces for an average length of 55 feet of 12 of the jetties, the 2 breaks above referred to in the closure-dike, 100 feet each in length, and the down-stream 460 feet of the Lieutenant's Run training-wall were thus protected by May 1, 1879, with results entirely satisfactory.

In this last-named work a serious break, 85 feet in length, caused by collision of a vessel, was repaired in April, 1879, and the whole lower 300 feet of this wall strengthened by driving additional brace-piles in rear and putting in corresponding braces.

With May 1, 1879, the details of the project of Captain Phillips, United States Engineers, of date June 28, 1878, having been filled, the new project I submitted to you in March, 1879, then approved by you, was undertaken. This had for its object the completion of the system of transverse jetties, by extending these down to the closure-dike, with 8 main jetties on north bank and 4 secondary ones on south; under it jetties Nos. 22 and 21 and Nos. 4 and 3 south bank, aggregating 500 feet (84 feet wattle-work, 416 feet sheet-piling), were built by June 12, 1879, when the near exhaustion of the appropriation of June 18, 1878, compelled an entire suspension of operations and closed the record for the year.

In August, 1878, owing to the unfinished state of the works of improvement, detached bars had formed in this, the Petersburg Channel, which, in order to meet the current commercial necessities of the city of Petersburg, had to be removed with the dredging out of 5,003 cubic yards. For the same cause, only in a greater degree, owing to the greater severity of the past winter, these bars formed again by March, 1879, calling for further immediate relief by the temporary expedient of dredging, which accordingly was again begun and carried on to June 7, 1879, with the removal of 10,245 cubic yards, removing thus the worst immediate obstacle to navigation, when it, too, was brought to a close for lack of funds.

To sum up for the year: *In general*, the river has been placed in better condition for navigation than probably it ever was before, and this, too, notwithstanding the drawbacks and temporary obstructions incident to a project in progress of execution. The works at date all stand in a thorough and secure condition. *Specially*, the success of the plan adopted has been established, requiring but the extension of it to accomplish effectually the desired end.

In this connection, several points of importance left to the test of experience to solve, have thus been determined. The average depth of scours, 7 feet, and its inside limit to 6½ feet, high-water, have been clearly indicated, as also the total uselessness of riprap merely thrown in as *à pierres perdues*. The maximum distance of 300 feet between consecutive jetties for their effectiveness seems also to have been well established, as also the further contraction of the fairway to 125 feet width (as was judged probable in the last annual report) from present width of from 140 to 150 feet. The work has been done at prices altogether satisfactory. Mr. H. D. Bird has continued the resident engineer at Petersburg, and in this connection I take occasion to express my indebtedness to him for valuable information and zealous co-operation.

1. The general plan of this work of improvement as laid down in report of Board of

United States Engineers of dates September 30, 1870, and November 19, 1870, and which has been followed out to date with certain modifications of details, was to make a channel "12 feet deep at high-water, 60 feet wide at bottom" (vide Annual Report Chief of Engineers, 1874, part 1, pages 50-54) from the city of Petersburg down to the natural deep water at Point of Rocks, 6.12 miles.

Original estimated cost.....	\$242,600
Total amount appropriated (first appropriation March 3, 1871, last appropriation March 3, 1879).....	260,000
Total amount expended to date.....	240,000

The original estimate is insufficient to carry out to completion the present working project.

The reason for this excess of cost is that in the light of the experience had, many works, especially for the lower or south (so-called) channel, not provided for at all, have now to be constructed, and that the depth of channel-way proposed is increased 1 foot or to 13 feet mean high-water, equaling 10 feet mean low-water. These facts, and a more detailed revision of the original figures of cost, account fully for the admitted excess noted.

Probable additional sum required for completion of project now being worked out.....	\$31,643
2. Amount exclusive of former appropriations required for entire and permanent completion.....	41,643

With works of the nature of those of this improvement, while an "entire and permanent completion" can and will be attained, a certain sum will be required for maintenance and repairs, guarding against collisions, freshets, &c.; with such a sum provided regularly, *annually*, so as to keep up in condition the completed work, it is estimated that there would be required only..... \$3,200

3. Amount that can be profitably expended during fiscal year 1880-'81..... 42,000

4. The work is located in the collection-district of Petersburg.

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

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

2.  
UNITED STATES ENGINEER OFFICE,  
Baltimore, Md., May 10, 1879.

MAJOR: I have respectfully to submit for your consideration a recommendation I propose as to the direction to be given to the new jetties about now to be constructed on the Appomattox River improvement. Heretofore the jetties have been projected out into stream at right angles to general shore line. I propose now to give a slight *up stream* direction to the jetties from the in-shore ends, *i. e.*, a departure of about 8 feet up stream at outer end, equivalent to about an angle of  $4\frac{1}{2}$  degrees in the distance or usual length of jetty face.

At this outer end extends downstream, parallel in direction to the general current, or a shade in-shore of this, a "slant"; at the elbow formed by this "slant" and jetty face I project, upstream, making about an equal angle with both, a short "spur." The intent of the upstream direction of jetty face is to produce to a certain extent slack water along the face, and so prevent the scour which, as experience in the case of the present jetties conclusively shows, does take place to a dangerous extent along nearly the entire face, *i. e.*, to 6 feet water (mean high-water).

It is true that the general objection to this upstream direction is that in freshets the waters passing over top of jetty and being concentrated in to the shore might erode this shore injuriously below jetty, and necessitate here a shore protection or apron of mats and stone, but such protection would be little if any more, either in cost or extent, than the protection heretofore necessitated, and might not have to be put in at all. So, too, in special cases where the banks are bad, or where sloughs or "guts" run in back of the jetties, indicating the necessity of turning away from rather than concentrating upon the shores the waters, this upstream alignment is objectionable, but as I made a careful examination of the banks, having this in view, on my late visit to the Appomattox, I think I am able to decide the exceptions to such alignment and the perpendicular projection instead. The wrecks yet extant of the old jetties, the first attempt at jettifying the stream made many years ago, show that the engineer gave a decided downstream direction to his jetties, and all accounts concur in representing that the waters had a raking scour, which soon destroyed the

work, though it should be considered in this connection that this work itself was flimsy and inadequate save as shore protection. The "spur" receives the first force of the current, and acts as it were to break it. At present, or till further experiment settles this point, I propose only a length of 8 feet for it. The "slant" keeps the water from running in on lower side of jetty (as it does in case of present jetties), and so prevents the evident swirl or long curve in which the water runs, eroding, in lieu of depositing, between consecutive jetties, adding to the scour near outer end of lower jetty, where the outgoing path is to make a crossing, checking and distorting the main flow. In brief, the intent of the slant is to seek to keep in jettied channel-way the water after the jetty head is passed, so protracting down stream to a greater distance the direct effect of the jetties, and acting the part of a longitudinal training-wall without the expense of such a regular work. For the present, I believe a length of 16 or 20 feet all needed to be given them. This can be added to later if experience demands it. The extra expense attendant on these changes of detail is not great, and is worth being incurred, if only to test the proposed plan as compared with the present one, in my opinion.

The accompanying sketch exhibits the general idea with the objects hoped to be gained, only, of course, exaggerated as to dimensions, effects produced of filling in between jetties, &c.

I find from a study of the report of Chief of Engineers for 1876, and from the improvement of the Vistula River in Europe, a jettied stream, that the general features of these details have met with success, as illustrated by the report quoted on the Wisconsin River. While in this latter case, the surface slope, as also the range between high and low water, is much greater than in case of the Appomattox, and the shifting sands in bed of river, from the very nature of the country traversed, as well as the two factors above stated, are infinitely in excess, all of which facts would make towards the greater success of the proposed plan, still, it is believed, that this modification may be applied to the Appomattox with advantage.

As incidentally applying to the question considered by you as to the solution of the correct distance between jetties to be fixed upon, I may say, that in case of Vistula River, the details proposed lengthened considerably the distance apart.

I remain sir, very respectfully, &c.,

J. W. CUYLER,  
Captain Engineers.

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

3.  
UNITED STATES ENGINEER OFFICE,  
Baltimore, Md., June 23, 1879.

MAJOR: In my report touching the complete improvement of the Appomattox River, Virginia, lately submitted to you, will be found, in the details of work proposed for the Petersburg Channel, an item of \$2,000 (about) for dredging, in improving the present channel along the Lieutenant's Run training-wall by widening it on its northerly side. In view of the, as I think, proven lack of success as to permanency of dredging as a means of improvement of this river, and of my own general views, oft previously expressed to you, adverse to dredging as a method to be adopted, I may perhaps explain now the insertion of such an item in the project proposed.

The *locale* of this proposed dredging is just at the connection of the course of the river with the so-called harbor of Petersburg. Should the improvement meet its end, a commerce must develop which will necessitate an extension of this harbor, already limited in area and inconveniently situated. Such an extension must find place on this northerly side of the river along the proposed dredging. It could not find place by docks, &c., on southerly side, where is the training-wall, a permanent public work, already forming a defined and good channel.

To project out, then, jetties from the north bank, in place of dredging, would firstly involve the purchase by the United States of the necessary river-front, now held by private parties, for the purpose of dockage. In possible view of this very harbor extension, I need scarcely point out that this purchase would be an expensive one to the United States.

But, apart from this consideration, the more important one presents itself against the construction of any works here having in view the making of a permanent, fair-way by a contraction of the water-way, that not only is this needed absolutely for harbor-room, but, as may be seen by inspecting the map, the course of the river here is in a bend quite sharp. Any jetties, or even longitudinal training-walls, if rightly located, must so seriously obstruct navigation as to hamper the commerce of the city just where it can least bear hampering. At best, any such permanent works would