

Thirty-eighth mile.—Elevation 2228.59 feet; slightly shoal for 1200 feet; fall 1.6 feet one shoal 150 feet long. Fall per mile 3.38 feet.

Thirty-ninth mile.—Elevation 2225.21 feet; one shoal 500 feet long; 1.3 feet fall; balance good water. Total fall 4.6 feet.

Fortieth mile.—Elevation 2220.61 feet; good navigation. Fall per mile 5.31 feet.

Forty-first mile.—Elevation 2215.30 feet; one shoal 800 feet long at Garrison's Ford. Total fall 2.18 feet.

Forty-second mile.—Elevation 2213.12 feet; good water. Fall per mile .9 foot.

Forty-third mile.—Elevation 2212.22 feet; at end Boone's Ford; quite wide, shoal for 2400 feet, and in it a fall of 1 foot in 200 feet. Total fall 4.76 feet.

Forty-fourth mile.—Elevation 2207.46 feet, Bull Run Falls; one fall 1.2 feet in 450 feet and rapids 1600 feet long; then a fall of 1 foot in 400 feet, and rapids for 300 feet with 1 foot fall; then water flows over 3 ledges and rapids for 1700 feet, full of bowlders; fall 9½ feet. Fall per mile 16.1 feet.

Forty-fifth mile.—Elevation 2191.36 feet; 1 foot fall in 450 feet; pool 1300 feet long; 3 ledges and rapids, Mallory's Falls for 1700 feet; fall 12 feet; then pool for 1800 feet. Total fall 15.98 feet.

Forty-sixth mile.—Elevation 2175.38 feet; 3 falls and rapids; De Priest's 1900 feet long; fall 14 feet; then rapids for 1400 feet; Bartlett's Shoals and Rapids, at end, 1750 feet long; 6 feet fall. Fall per mile 21.15 feet.

Forty-seventh mile.—Elevation 2154.23 feet; 1750 feet full of rock and some gravel, but good water; 6½ feet fall; one shoal 300 feet long, also some sand islands; balance pool. Fall per mile 10.45 feet.

Forty-eighth mile.—Elevation 2143.78 feet; good water. Total fall 1.3 feet.

Forty-ninth mile.—Elevation 2142.48 feet; good navigation for 2700 feet; then Dickinson's Shoals and Ford for 2600 feet; fall 5½ feet. Fall per mile 6½ feet.

Fiftieth mile.—Elevation 2135.98 feet; Dickinson's Rapids and Falls, a succession of heavy falls and rapids with three short pools. Fall for the mile 25.66.

Fifty-first mile.—Elevation 2110.32 feet; Surgener's Rapids and Falls; 3 falls and 3 short pools. Fall in the mile 22½ feet.

Fifty-second mile.—Elevation 2087.57 feet; 700 feet lower portion of Surgener's Falls; pool 1800 feet long; fall 2½ feet; ends in Dowling's Falls and Rapids. Fall in the mile 15½ feet.

Fifty-third mile.—Elevation 2071.82 feet; Grayson's Springs, Shoals, Rapids, and Falls; consisting of 4 shoals, 3 short pools, and 1 small fall at end. Fall in the mile 21.79 feet.

Fifty-fourth mile.—Elevation 2050.03 feet; fall ½ foot in 50 feet; shoal for 600 feet; fall 2½ feet; then the Gulf, consisting of rapids and two falls, in all 10 feet; very rough and full of bowlders. Total fall 11.65 feet.

Fifty-fifth mile.—Elevation 2038.38 feet; good water; Allen's Ferry. Fall per mile 10.80 feet.

Fifty-sixth mile.—Elevation 2027.58 feet; Early's Shoals, 500 feet long; fall 2.8 feet; pool 2500 feet long to beginning of Wilkinson's Falls. Total fall 1645 feet.

Fifty-seventh mile.—Elevation 2011.13 feet; Wilkinson's Rapids and Falls. Throughout this mile, water very swift, full of bowlders, loose rocks, and ledges entirely across the river. Fall per mile 28.05 feet.

Fifty-eighth mile.—Elevation 1983.08 feet; one shoal 800 feet long; fall 5 feet; one shoal 1100 feet long; fall 4 feet. Foot of Ewing's and Poplar Camp Mountains; limestone commences here. Total fall 16.40 feet.

Fifty-ninth mile.—Elevation 1966.68 feet; shoal for 2600 feet; fall 6 feet; balance good water. Total fall 9½ feet.

Sixtieth mile.—Elevation 1956.93 feet; a ledge for 50 feet, and a fall of 1½ feet in 300 feet, but deep water; remainder of mile good water. Total fall 3.45 feet.

Sixty-first mile.—Elevation 1953.48 feet; good navigation. Fall per mile 2.70 feet.

Sixty-second mile.—Elevation 1950.78 feet; shoal 900 feet long and 3 ledges; fall 3 feet; 2 other ledges, but good water over them. The survey is 62 miles and 566 feet, but for convenience the feet are included in the last mile. The estimate is made for a lock and dam at the Lead Mines; the channel, however, between the island and the left bank of the river can be cut out to the proper width and depth, if desirable. Fall per mile 6.92 feet; elevation at top of dam 1946.23 feet; elevation at foot of dam 1943.86 feet.

After a careful examination of the map and profile, it is considered possible to improve the river to and including the 43d mile by the usual methods of excavation and lateral dams, with the exception of Osborne's Falls, where locks and dams will have to be introduced. Slack-water navigation will also have to be made for the next 14 miles through the mountains; from the base of these to the terminus, 5 miles, but slight work will be required.

The improvement of this portion of the river must be considered as a whole. It is not possible to divide it into sections and treat such separately with regard to lateral means of transportation, by railway or otherwise, for no such means exist.

Perhaps the best method of improvement that can be used in the wide, and of consequence shoal portions of the river, is to build dams to concentrate a sufficient quantity of water into the channel, and then to reduce the grade and velocity by the use of low regulating-dams with sluices in them. At present this portion of the river is not used at all for transportation purposes. Only the ordinary canoe is seen, and it is merely used for ferrying and fishing. For keel-boat navigation a channel 2 feet deep and 30 feet wide, with tracking or towing paths at the falls and rapids, will answer all purposes.

Rock excavation, removing bowlders, sand, and gravel, and building lateral dams, will cost for the—

62 miles, at an average of \$1,200 per mile.....	\$74,400
20,300 linear feet of towing-path, at \$2.....	40,600
Total.....	115,000

The resources of the country are such, however, as to require a steamboat navigation. For this a channel 3 feet deep and 90 feet wide, with a grade always less than 1 foot in 400 feet, it is thought, will suffice. A channel less wide could be used, but the velocity would be much increased.

The locks and dams are to be of crib-work filled with stone, for which an abundance of material is found all along the river. The estimate for the locks is based on that of an 8-foot lift, with 4 feet depth on the miter-sills, costing \$11,500; and of the following dimensions: walls, 11½ feet wide and 17 feet high; chambers, 25 feet wide and 120 feet long; total length, including lower wings, 175 feet; total width, 48 feet.

The dam corresponding to a lock of the above description is estimated as having a width of 16 feet, a front 12 feet high, and a back 8 feet high, with supporting walls 8 feet apart longitudinally. Top covered with 3-inch plank, and at the crest an ice-breaker 3 inches thick and 6 feet deep. Estimated cost per linear foot, \$20. Each abutment is estimated as equal in cost to 55 linear feet of dam. The smaller dams are estimated at an average height of 6 feet, with a width at base of 12 feet.

The proposed locks and dams are shown in red on the maps. All shoals not otherwise marked are indicated to have sluice-ways cut through them.

Owing to the large rain-fall and extensive rises in the river during the progress of this survey, and the limited time to be devoted to it, it was found impossible to locate accurately the locks and dams mentioned as a part of the suggested system of navigation. Sufficient data, it is believed, however, was obtained to make the estimate submitted below, for a 3-foot navigation, nearly correct.

Table showing the estimated cost of each mile for 3-foot navigation.

First mile.....	\$13,800	Thirty-third mile.....	\$8,500
Second mile.....	4,400	Thirty-fourth mile.....	9,500
Third mile.....	7,000	Thirty-fifth mile.....	6,800
Fourth mile.....	4,300	Thirty-sixth mile.....	3,200
Fifth mile.....	15,300	Thirty-seventh mile.....	5,000
Sixth mile.....	36,500	Thirty-eighth mile.....	3,000
Seventh mile.....	8,700	Thirty-ninth mile.....	2,500
Eighth mile.....	700	Fortieth mile.....	0,000
Ninth mile.....	3,700	Forty-first mile.....	4,000
Tenth mile.....	59,600	Forty-second mile.....	0,000
Eleventh mile.....	12,300	Forty-third mile.....	13,200
Twelfth mile.....	10,400	Forty-fourth mile.....	48,300
Thirteenth mile.....	10,600	Forty-fifth mile.....	51,600
Fourteenth mile.....	15,700	Forty-sixth mile.....	43,400
Fifteenth mile.....	18,000	Forty-seventh mile.....	38,800
Sixteenth mile.....	10,600	Forty-eighth mile.....	00,000
Seventeenth mile.....	6,400	Forty-ninth mile.....	13,900
Eighteenth mile.....	10,500	Fiftieth mile.....	75,800
Nineteenth mile.....	00,000	Fifty-first mile.....	78,400
Twentieth mile.....	00,000	Fifty-second mile.....	44,100
Twenty-first mile.....	16,900	Fifty-third mile.....	44,400
Twenty-second mile.....	6,000	Fifty-fourth mile.....	35,000
Twenty-third mile.....	11,500	Fifty-fifth mile.....	00,000
Twenty-fourth mile.....	4,100	Fifty-sixth mile.....	57,800
Twenty-fifth mile.....	7,000	Fifty-seventh mile.....	81,800
Twenty-sixth mile.....	7,000	Fifty-eighth mile.....	50,500
Twenty-seventh mile.....	2,100	Fifty-ninth mile.....	13,200
Twenty-eighth mile.....	4,600	Sixtieth mile.....	2,500
Twenty-ninth mile.....	7,100	Sixty-first mile.....	0,000
Thirtieth mile.....	14,900	Sixty-second mile.....	21,100
Thirty-first mile.....	11,200		
Thirty-second mile.....	4,500	Total.....	1,101,700

The amounts in the following table are included in the table for estimated cost per mile.

Table showing the estimated cost of each lock and dam for 3-foot navigation.

[The abutments are regarded as a part of the dam, and included in its estimate, but the table shows the actual length of dam without abutments.]

No. of lock.	Location.	Lift of lock.	Cost.	Linear feet in dam.	Cost.	Total.
		Feet.				
1	Osborne's Falls, tenth mile	8	\$11,500	270	\$7,600	\$19,100
2	do	7	11,000	290	7,600	18,600
3	do	5	10,000	370	8,200	18,200
4	Bull Run Falls, forty-fourth mile	10	12,500	540	24,500	37,000
5	Mallory Falls, forty-fifth mile	7	11,000	700	15,600	26,600
6	do	5	10,000	670	13,300	23,300
7	De Priest's Falls, forty-fifth mile	8	11,500	450	11,200	22,700
8	do	6	10,500	350	8,300	18,800
9	Bartlett's Rapids, forty-seventh mile	10	12,500	890	22,200	34,700
10	Dickinson's Falls, fiftieth mile	10	12,500	590	15,400	27,900
11	do	6	10,500	510	11,200	21,700
12	do	9	12,000	430	11,300	23,300
13	Sergener's Falls, fifty-first mile	10	12,500	490	13,200	25,700
14	do	9	12,000	450	11,700	23,700
15	do	7	11,000	430	15,200	26,200
16	Dowling's Falls, fifty-second mile	9	12,000	450	11,700	23,700
17	Grayson Spring Falls	6	10,500	370	8,700	19,200
18	Grayson Spring Falls, fifty-third mile	7	11,000	330	8,400	19,400
19	do	10	12,500	370	10,500	23,000
20	The Gulf Falls, fifty-fourth mile	10	12,500	490	13,200	25,700
21	Wilkinson's Falls, fifty-sixth mile	8	11,500	300	8,200	19,700
22	do	9	12,000	660	15,700	27,700
23	Wilkinson's Falls, fifty-seventh mile	8	11,500	790	18,000	29,500
24	do	7	11,000	650	14,500	25,500
25	do	7	11,000	490	11,400	22,400
26	Wilkinson's Falls, fifty-eighth mile	8	11,500	340	9,000	20,500
27	do	5	10,000	400	8,700	18,700
28	At Lead Mines, sixty-second mile	6	10,500	450	10,100	20,600
	Total					663,100

STATEMENT OF FOREGOING ESTIMATE.

136,750 yards of rock excavation, at \$2 per yard	\$273,500 00
10,121 yards of bowlder excavation, at \$1.65 per yard	16,700 00
90,200 yards of loose rock and gravel, at 75 cents per yard	14,400 00
26,800 linear feet of small dams, at \$5 per foot	134,000 00
28 locks and dams	663,100 00
Total	1,101,700 00

A lock-and-dam navigation of 5 feet from the mouth of Wilson to the Lead Mines, overcoming a fall of 507 feet in 62 miles, will cost—

Locks and dams	\$1,524,000 00
38,000 yards rock excavation, at \$2	76,000 00
Total	1,600,000 00

SUMMARY.

Two-foot navigation	\$115,000 00
Three-foot navigation	1,101,100 00
Five-foot navigation	1,600,000 00

The counties traversed by the river within the limits of this survey are Grayson, Carroll, and Wythe, in Virginia, and Alleghany in North Carolina. These, with Ashe, a portion of Watauga, and Surrey, North Carolina, are dependent upon this river for a commercial outlet.

Alleghany County produces wheat, corn, oats, rye, buckwheat, potatoes, tobacco, hay, wool, butter, sheep, hogs, cattle, horses, &c. The growth of tobacco is a new industry, and the product small as yet. There has been some improvement in the mode of farming and in the yield of products since the census of 1870. The Peach

Bottom Copper Mine, located in this county, 8 miles from the Mouth of Wilson, 12 miles from Independence, and 3 miles south of the river, was worked before the late war, but is now idle. The Elk Creek Iron Furnace is located 6 miles from Mouth of Wilson. The ore used is found in extensive deposits on both sides of the river in Alleghany County, North Carolina, and Grayson County, Virginia, about 7 miles from Mouth of Wilson. Mine and furnace both idle. The Collins Iron Works, about 16 miles east of Mouth of Wilson, in this county, are now idle. There are deposits of iron, and indications of copper, asbestos, mica, and other minerals in various parts of this county, which only require capital and enterprise for their development.

The productions of Ashe County, North Carolina, are very similar to those of Alleghany. Ashe has a larger area of improved lands and more wealth; the quality of the soil is also better; hence the agricultural products are larger though the same in kind. Ore Knob is located in this county about 15 miles above the Mouth of Wilson, and 3 miles from the south fork of New River. This mine is extensively worked by a Baltimore company, Mr. James Clayton, the principal proprietor, managing it. Only the pure copper is shipped to market, and that over a very rough and mountainous road at great expense. By increased facilities for transportation, the sulphur and peroxide of iron, now worthless and waste products, could be utilized.

There is also another vein of copper at Elk Knob, about 35 miles southwest of the Mouth of Wilson, in Watauga County; this mine is said to be very rich in its copper deposits, and some work is about commencing there for the purpose of testing their extent.

Hilton Furnace is situated in the county of Grayson, 10 miles west of the Mouth of Wilson. Extensive deposits of iron ore are found on both sides of the State line, and said to be of the finest quality. Furnace not now in operation.

There are also valuable soapstone quarries in Ashe County. One quarry near Jefferson, about 20 miles southwest of Mouth of Wilson, furnishes the supply of soapstone for the furnaces at Ore Knob, of a very superior quality and as white as alabaster.

Surrey County, North Carolina, differs but little in its agricultural products from the other counties named, only in tobacco and sweet potatoes, which are extensively raised here. Nothing was ascertained about the mineral productions of this county.

There are extensive manufacturing establishments at Elkins and Mount Airy. At the former place, cotton and woolen establishments; at the latter, cotton, woolen, and tobacco factories, and also a factory for making ax-handles, &c., and another for boots and shoes. Mount Airy is about 50 miles east of Mouth of Wilson, and 20 miles south of New River at the nearest point. Elkins is about 45 miles southeast from Mouth of Wilson, and 34 miles south of New River. Dr. William Hampton has opened a valuable copper mine near the mouth of Little River, in Grayson County, Virginia, but as yet it is not worked. He has also a soapstone quarry near by.

Grayson, Carroll, and Wythe are reported to be better agricultural counties than those described above, and their mineral resources are wonderful. Cripple Creek, in Wythe County, is lined with iron furnaces. Snow Hill Branch, in the same county, has on it, near the river, large quantities of iron, zinc, and lead ores. It is deemed unnecessary, however, to give any further description of the resources of these counties, for the subject is thoroughly treated, as heretofore stated, by Colonel Abert and Maj. N. H. Hutton, in their reports, Appendix W of Annual Report of the Chief of Engineers of the United States Army for 1875, and Appendix T of Annual Report of same officer for 1873, to which attention is respectfully called.

I am indebted to Col. A. M. Davis, of Independence, Grayson County, Virginia, for much valuable information with regard to the resources of the counties in North Carolina.

Much credit is due J. M. Wolbrecht, transitman, M. Cooke, leveler, and J. D. Hoffman, draughtsman, for the efficient performance of their respective duties.

Respectfully submitted,
Col. WILLIAM P. CRAIGHILL,
Major Engineer Corps, U. S. A.

WM. PROCTOR SMITH,
Civil Engineer.

F 12.

IMPROVEMENT OF THE GREAT KANAWHA RIVER, WEST VIRGINIA.

The immediate supervision of this important work has been given by Lieut. Thomas Turtle, Corps of Engineers, with his usual zeal and ability. His report, appended hereto, gives a sketch of the inception and progress of the undertaking.

The season of 1878 was a very unfavorable one for work in the water, as there were 13 rises of the river to interrupt operations between May 20 and November 20. There was also an unprecedented run of ice in the freshet of January, 1879. The coffer-dams and other structures were very little injured, but the damage to individuals and companies on the river was great.

Much delay and annoyance were also caused by violent proceedings at the lock and dam near Paint Creek on the part of badly-disposed workmen, supported by lawless sympathizers, secret societies, &c. The local authorities seemed unable or unwilling to control this lawlessness, and nothing but the power of the United States, exerted through its court and officers, checked the trouble. Meantime, a practical suspension of operations necessarily took place at this locality until too late in the season to resume, except the rougher kinds of work, such as stripping quarries, &c.

At the date of this report, operations are in progress at three localities, numbered 3, 4, and 5, which are respectively near Paint Creek, Cabin Creek, and Brownstown. It is proposed to procure, as soon as possible, two other sites, to be called 6 and 7.

A table is given here, which gives important facts concerning the lock and dam at each of these sites.

Number of dam.	Kind of dam.	Distance from ferry at Charleston.	Miles.	Length of dam.	Feet.	Width of pass.	Feet.	Length of weir.	Shoals to be overcome by the lock and dam.	Depth of rock below low-water surface.	Feet.	Height of dam from rock.	Feet.	Lock, dimensions of, in clear.	Feet.	Lift of lock.	Feet.	Depth of miter-sill below low-water surface.	Feet.	Miter-sill above rock.	Feet.	Lock-wall, height of, from rock.	Feet.	Lock-wall, height of, above lower miter-sill.	Feet.	Height of pass weirs, sill to normal level of upper pool.	Feet.	Height of weir lockets, sill to normal level of upper pool.	Feet.	Height of weir lockets, sill to normal level of upper pool.	Feet.
3	Fixed.....	+21.45	560.0	248	210.0	Paint Creek Shoal, Windsor Shoal, Hunter's Shoal, Harvey's Shoal, and Staton's Run Shoal.	About 10	25	300x50	12	5	5	5	5	35	30	12.9	13.0	13.0	13.0	13.0	20	20	21	21	6.0	5.0	8.9(?)	8.3(?)		
4	Movable..	+15.24	468.0	248	210.0	Cabin Creek Shoal and Bouseman's Kippie.	About 10	19	300x50	7	5	5	5	25	20	7	5	5	5	5	25	20	21	21	6.0	5.0	8.9(?)	8.3(?)			
5	Movable..	+9.12	528.9	250	265.9	Catfish Shoal and Witcher's Creek Shoal.	About 8	17	300x50	7	5	5	5	23	20	7	5	5	5	5	23	20	21	21	6.0	5.0	8.9(?)	8.3(?)			
6	Movable..	-4.09	550.0	248	200.0	Island Shoal, Two Mile Shoal, and Elk Shoal.	9	19	300x50	8	5	5	5	25	20	8	5	5	5	5	25	20	21	21	6.0	5.0	8.9(?)	8.3(?)			
7	Movable..	-14.07	520.0	248	200.0	Peeled Maple, Newcomer, and Tyler Shoals.	8	18	300x50	8	4	4	4	25	21	8	4	4	4	4	4	25	21	21	13.0	13.0	8.9(?)	8.3(?)			

NOTE.—In column headed "Distance from ferry at Charleston," the sign + signifies above, the sign - below that point.

This table was prepared by Lieutenant Turtle, at my request; his letter transmitting it is also below, containing much other valuable information as to details which could not be put into the table.

LETTER OF LIEUTENANT THOMAS TURTLE, CORPS OF ENGINEERS.

CHARLESTON, KANAWHA COUNTY, WEST VIRGINIA,
June 10, 1879.

MAJOR: I submit the following information, as called for by a letter from you dated June 3, 1879.

Special advantages to be desired from each lock and dam:

Dam No. 3 will permit all the coals from Cannelton to Paint Creek, inclusive, and from tributary streams between those points, to reach the pool below Paint Creek Shoals at all seasons of the year, from which point the coals can at all times reach the pool at Charleston through locks Nos. 4 and 5 if the water be low, and through the passes of dams Nos. 4 and 5 without detention if the river be sufficiently high.

Dam No. 4 will permit all coals from the foot of Paint Creek Shoal to Cabin Creek, inclusive, and from Kelly's Creek, to reach the pool above Witcher's Creek Shoal, either through the lock or through the pass, according to the stage of the river. From this pool the coal can at all seasons reach the Charleston pool through lock No. 5 if the river be low, and through the pass without detention if the river be sufficiently high.

Dam No. 5 will permit all coals between Cabin Creek and the head of the Charleston pool, inclusive, and from Witcher's Creek and Field's Creek, to reach the Charleston pool at all seasons, through the lock if the water be low, and through the pass without detention if the river be sufficiently high.

The Charleston pool is an important point to reach. This pool is about 10 miles in length, with sufficient water throughout nearly its entire extent for the harboring of heavily loaded boats at the lowest stage of the river. From this pool boats can run out to the Ohio, drawing 5 feet on an average of 210 days in the year, and can run out drawing 6 feet on an average of 159.7 days in the year; this according to an average of 6 years. This compares favorably with the Ohio River at Pittsburgh. (See Report of Chief of Engineers, 1877, Part I, page 644.) On an average (22 years) the Ohio River at Pittsburgh is 155.9 days above 6 feet.

The Ohio at Pittsburgh is 80 days per year below the 3-foot stage, while the Kanawha at Charleston is but 53 days below that stage. I assume that the table in the Report of the Chief of Engineers referred to gives the draught of water which boats can take from Pittsburgh.

Dam No. 6 will increase the depth upon the miter-sill of the lock of the Elk River Navigation Company near the mouth of Elk River to 5.95 feet at low-water; at present it is but 1.45 feet. This dam will raise the level of the Charleston pool $3\frac{1}{2}$ feet at low-water at Charleston, and will give the required depth of 7 feet upon the miter-sill of lock No. 5 at all times.

Dam No. 7, with dam No. 6, will give access to the Coalsmouth pool from the Charleston pool at all seasons. At present at close stages towboats take partial tows from the Charleston pool to below Tyler Shoal, and there make up full tows. With these two dams this may be avoided. Dam No. 7 also will increase the depth of water on the miter-sill of the Coal River Navigation Company to 7.39 feet. At present there is but 0.67 foot on this miter-sill at low-water. On this account the transit through this lock and from Coal River to the Kanawha, in times of low water, is completely crippled.

Dam No. 3, without any dredging above, will give a depth of 7 feet to the foot of Harvey's Shoal, 4.55 miles above. It will give a depth of 6 feet to the same point without dredging. Without dredging above, this dam will give 5 feet depth to Staton's Run Shoal, 5.64 miles above. For this depth the channel across Harvey's Shoal would be quite narrow. Without dredging above, this dam will give 4 feet depth to the foot of Lykens Shoal, 6.08 miles above. The channel across Staton's Run Shoal would be quite narrow. With the contemplated dredging at Staton's Run and Harvey's Shoals, dam No. 3 will give 7 feet depth of water to the foot of Lykens Shoal, 6.08 miles above Charleston.

At extreme low water the river boats up to this time go no higher up than Brownstown, at the head of the Charleston pool. When the reading of the Charleston gauge gets lower than 3 feet (and $1\frac{1}{2}$ above low water), boats cease running above Brownstown. This period is for an average of 53 days in the year.

The draft of water from Charleston to the Ohio, at extreme low water, is now but $1\frac{1}{2}$ feet.

No. 5 will probably be completed for use this season. No. 4, in the season of 1880 No. 3, in the season of 1881.

If money be furnished as rapidly as required, two other dams can probably be placed in use in the season of 1883, provided this season be not lost to the construction.

Very respectfully,

THOMAS TURTLE,
First Lieutenant of Engineers.

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

The sites for lock and dam No. 3 were acquired in the autumn of 1877. It was determined to carry on the work by hiring labor and purchasing materials in open market. A force was organized, such buildings erected as were necessary, and operations commenced in February, 1878, at lock No. 3. Delays occurred from freshets and the labor troubles in 1878. At the close of the fiscal year ending June 30, 1879, the quarries are being successfully operated, the coffer-dam is complete and the laying of the masonry of the lock is rapidly proceeding, a considerable quantity of stone being ahead, cut, and a large force of cutters being engaged steadily to keep up the supply. A good quarry is opened on the abutment side, and arrangements are made for the building of the abutment and half of the dam, as well as for procuring the materials for the remainder of the dam. Not more than half of a dam can be built at one time, as the whole river cannot be obstructed at once.

Lock 4 was completed by the close of the working season of 1878. It is now ready to receive its gates, which will be of wood. The timber for them is in store and they will be ready by the time the dam is completed. The iron-work for the movable dam was received during 1878, and stored. The abutment is nearly done. The coffer-dam now in place incloses a space next the lock and includes 204 feet of the pass. The work here, as at 3 and 5, is continued without cessation, night as well as day.

At the end of June, 1879, the setting of the steps on the slope from the top of the bank to the lock had begun. The placing of the pass was well along. The laying of the stone, the setting of concrete, and the placing of the timbers were commenced and the excavation within the coffer completed. Timber and lumber had been ordered for the second section of the coffer-dam.

Lock No. 5 was completed in August, 1878. The iron for the gates reached the site in October, 1878. They should have been in place October 22, 1878, but the contractors failed to perform their agreement. Their time was extended by the Secretary of War to August 1, 1879.

The contractor for dam No. 5 abandoned his work in October, 1878, after many delays. It was then taken in hand by the United States, labor being hired and material and machinery purchased in open market. The abutment and pier were finished by the contractor, and the coffer dam for the pass completed, but it was frequently injured by freshets. Pumping began for the first time in July, 1878, and excavation in the coffer July 20, but freshets occurred frequently thereafter in 1878. The excavation of rock for the trenches for the anchor disks began October 2, 1878. The setting of anchor-rods and disks, and the laying of concrete, began November 5, 1878. During June, 1879, quarrying, stone-cutting, and the breaking of concrete were in progress. All the anchor disks were in place at the end of June, with about three-fourths of the concrete. Thirteen of the longitudinal timbers were in place. The paving of the floor of the pass had been commenced. The placing of boxes had been begun, crib-logs, for the next section of the coffer, had been ordered.

The dam at Two-mile has needed and received some repairs during the year. The survey of the river below has been extended to the Ohio, except that soundings are needed for about 6 miles of the lower part. Some other local surveys have been made at particular points. These surveys have led to a new location of the locks and dams below Charleston, and have enabled the number to be reduced by one. As No. 1 of the series belonged rather to the central water line than to the special improvement of the Kanawha, that may be also omitted.

An appropriation of \$150,000 was made March 3, 1879. As this should be applied to commencing work at one or two new sites, and the first step was the acquisition of the sites, it was found that the money was not applicable thereto. It became necessary to obtain the passage of an act amendatory of the river and harbor act, which was passed by Congress and approved by the President in June, 1879. The new sites will be obtained as soon as possible, and work upon them begun.

Money statement.

July 1, 1878, amount available.....	\$460,080 44	
Amount appropriated by act approved March 3, 1879.....	150,000 00	
		\$610,080 44
July 1, 1879, amount expended during fiscal year.....	216,854 68	
July 1, 1879, outstanding liabilities.....	10,000 00	
		226,854 68
July 1, 1879, amount available.....		383,225 76
Amount (estimated) required for completion of existing project.....	2,610,000 00	
Amount that can be profitably expended in fiscal year ending June 30, 1881.	200,000 00	

REPORT OF LIEUTENANT THOMAS TURILE, CORPS OF ENGINEERS.

CHARLESTON, KANAWHA COUNTY, WEST VIRGINIA,
June 18, 1879.

MAJOR: I submit the following annual report of progress in the improvement of the Great Kanawha River for the fiscal year 1878-'79.

CONDENSED HISTORY OF THE PRESENT IMPROVEMENT.

A survey of the Great Kanawha River from the Great Falls to the mouth was directed to be made by the act of June 10, 1872. This survey was placed in charge of Major Craighill, Corps of Engineers. The services of Mr. E. Lorraine were obtained for this purpose. Mr. Lorraine submitted a report dated December 9, 1872, based upon the surveys made by Mr. Gill in 1838 and by Mr. John A. Byers in 1856 and upon measurements and reports on the improvement of the river by reservoirs by Charles Ellet, jr. In this report by Mr. Lorraine two plans for the improvement of the river were discussed; one being by open, or sluice, dams and a reservoir on Meadow River, a tributary of the Gauley; the other being by locks and dams throughout. The method recommended was that of an open-dam navigation from the mouth to the foot of Paint Creek Shoal, with locks and dams from that point to the Great Falls. In the open-dam portion the water-ways were to be 120 feet wide and 6½ feet deep. For this navigation the Meadow River reservoir was to furnish the additional water necessary at those times when the natural discharge of the Kanawha was insufficient. The locks upon the slack-water portion were to be 240 feet long and 40 feet wide. (Report of Chief of Engineers, 1873, page 835.)

This project was assumed by the Board of Engineers on the water-line from the Ohio River to Richmond, Va., as the method to be adopted for the improvement of the Kanawha. (Report of the Chief of Engineers for 1874, part 2, page 86.)

Major Craighill, in his report on the water-line from the Ohio River to Richmond, Va., dated January 13, 1875 (Report of Chief of Engineers for 1875, part 2, page 631), sets forth that the aspects of the question had somewhat changed since Lorraine's report in 1872. The 1874 board on the water-line, in their report, looked to the advantages of larger locks on the canal than 120 by 20 feet, and these larger locks on the

anal would necessitate larger locks on the slack-water portion of the Kanawha than those theretofore recommended. The shippers of coal and salt said that sluices would not accommodate their trade, and that locks 240 by 40 feet were too small. The sluice-dam method was experimental and dependent for success upon a reservoir. Major Craighill, in this report, states that he "inclines now to the opinion that the ordinary lock and dam system will finally be adopted for the whole length of the river, and with locks larger than those proposed by Mr. Lorraine, on the system of movable dams, will be used."

REVISED ESTIMATES WERE MADE FOR LOCKS 60 FEET BY 50 FEET.

An appropriation of \$300,000 for the permanent improvement of the river was made by the act approved March 3, 1875.

A Board of Engineers was convened by special order No. 59, Headquarters Corps of Engineers, dated April 30, 1875. (Report of Chief of Engineers 1875, part 2, page 90 and following.) This Board, following the suggestions of Major Craighill's letter, considered three systems for the improvement of the river; the first being by locks and fixed dams throughout; the second by locks and movable dams throughout; and the third being by a combination of the two or by locks and movable dams from its mouth to a certain point, with locks and fixed dams above that point. The Board recommended that "movable dams be adopted from the mouth of the river to Paint Creek, the first fixed dam being at that point, and that the dams above that point be fixed dams, unless it should be deemed advisable hereafter to make the whole or a part of them movable."

The movable dams were to be formed by Chanoine wickets, and the dimensions of the locks were to be 50 feet in width and 300 feet long in the clear.

The lock near Brownstown, No. 5 of the series, was placed under contract in August, 1875, and was completed under this contract (ready to receive the gates) in August, 1878. The gates are now under contract.

Dam No. 5 (movable), connected with this lock, was placed under contract in March, 1876. This contractors being financially unable to proceed further, voluntarily abandoned the work at the end of October 1878, after completing the abutment and the pier, and placing a coffer-dam for and commencing the navigable pass; from that time the work has been carried on by the United States by hired labor.

Lock No. 4, below Cabin Creek Shoal, was placed under contract in October, 1875, and under this contract was completed (ready to receive the gate) in November, 1878. Dam No. 4 (movable), connected with this lock, was placed under contract May 1, 1877. The contractors for this work abandoned it in December of the same year, after partially completing the abutment. The work has since been carried on by the United States by hired labor.

Work for lock No. 3, at the foot of Paint Creek Shoal, was begun in February, 1878, to be carried on by the United States with hired labor. The dam to be connected with this lock is to be a fixed dam. The coffer-dam for this lock is placed, a large quantity of the excavation therefor has been made, and considerable stone is prepared and masonry is about to be commenced.

The season of 1878 was a very poor one for this work on account of the frequent rises in high-water. From the 20th of May to the 20th of November, that portion of the year in which work in the river must be performed, there were thirteen rises to a gauge-reading of over 6 feet, which is almost the limit at which operations in this stream can be carried on. There were two remarkable freshets in the year, one on September 12-14, 1878, the other in January, 1879. In the former the gauge at Charleston read 40.132 feet above low-water, being 5.24 feet below the memorable rise of September 29, 1861. The New River was considerably higher in the flood of last September than it was in 1861, but the Gauley, Elk, Coal, and Ohio Rivers were lower than in the earlier year, so the freshet of 1878 was the lower on the Kanawha, from Coalburg to the mouth.

The freshet of January last was remarkable from the unprecedented run of ice. The maximum quantity of water flowing, as indicated by the Hinton gauge, would correspond to a reading of the Charleston gauge of about 25 feet. With this discharge of the stream, the ice gorged below Charleston, backing the water up to a gauge reading of 36.67 feet. The loss to the coal operators was very considerable; many barges, both full of coal and empty, were carried away or sunk; one towboat was sunk and then torn to pieces by the ice; two steamers were sunk at the mouth of Elk River, and the Keystone Bridge across that stream was thrown down. The damage at the United States works was comparatively light; two flatboats were broken in two and others injured somewhat; one engine was injured incidentally and the crib at the head of the river wall, lock No. 5, was overturned.

The organization has been the same throughout the year as that given in the last annual report.