

as great as the means provided by Congress would permit; but the fact must be recognized that that progress has been comparatively slight, and not at all satisfactory either to the people for whose benefit the work is being prosecuted or to the officer in charge.

The estimated cost of the improvement is \$7,684,200, but this estimate is based upon the supposition that funds are provided as rapidly as they can be judiciously expended. With annual appropriations of \$200,000, as have prevailed, it is my belief that the improvement will occupy at least a century and will cost \$20,000,000. But enlarged operations will leave more unfinished works at the end of each year and subject the government to greater loss from their destruction by the failure of appropriations for the following year, for it is rarely advantageous to entirely complete any work in one season. In our revetments we sometimes protect the bottom of the bank first and then leave it, returning to it the following season when the river has usually saved us the expense of grading it to a gentle slope by hand; but if we leave it too long the river cuts in behind it and our work is destroyed.

In contracting a wide part of the river the object of the works is to create deposits from the river, and these always require considerable time; but until the deposits are secured the works are in a precarious condition, and require constant watching and repairs; the want of \$1,000 at the opportune moment may result in an expense of \$50,000. The only security against failure and waste of the public money is to be found in the command of abundant means, not only for the current expenses of extensive works, but to insure their continuation at the proper time in future. The least amount that can be profitably expended during the fiscal year ending June 30, 1881, is \$500,000. To give an idea of the demands upon the annual appropriations for this district, I append copies of some of the petitions received during the year. The demands of the city of Saint Louis have already been referred to, while the great and overwhelming demands of general navigation need no mention.

Copy of petition of September 27, 1878, signed by 43 residents of Monroe County Illinois, Appendix B.

Copy of letter from Common Council of Alton, Ill., December 10, 1878, Appendix C.

Copy of petition of February 5, 1879, signed by 219 citizens of Saint Genevieve, Mo., Appendix D.

Copy of letter from Mayor and Common Council of Cape Girardeau, Mo., without date, received June 17, 1879, Appendix E.

It is to be remarked that the works referred to in the petitions marked D and E have nothing to do with the evils complained of. The interests represented by these petitions are mainly local, but many of them could be protected in carrying out the main scheme of general improvement, while now it is altogether impossible to give heed to them.

It is not intended to commence any new work during the fiscal year ending June 30, 1880, except possibly at Alton or Maple Island.

The allotments made from the undistributed part of the appropriation of March 3, 1879, were—

Horsetail Bar	\$70,000	
Kaskaskia Bend	1,000	
Repairs and contingencies	1,000	
Unallotted	5,000	
		\$147,000

The specific allotments by Congress were—

Illinois to Missouri	15,000	
Kaskaskia Bend	8,000	
Dickey Island to mouth of Ohio	30,000	
		53,000
		200,000

The estimate of \$500,000, already given, for the fiscal year ending June 30, 1881, is intended to cover the completion of the works now in progress, and to commence improvements much needed at several points, for which detailed estimates cannot be given in advance of the actual commencement of each particular work.

All work during the year has been done by hired labor and the purchase of material in open market, with the usual satisfactory results. It is intended to pursue the same system the coming year.

The work is located in the collection-district of New Orleans.

Amount of revenue collected at the port of Saint Louis for the fiscal year ending June 30, 1879, was \$1,136,417.85.

Construction account.

Name of work.	Expended previous to July 1, 1878.	Expended during year ending June 30, 1879.	Total cost to June 30, 1879.	Required to complete.	Total estimated.
Piasa Island Dam	\$32,333 30	.....	\$32,333 30	\$8,877 43	\$41,210 73
Alton Dam	33,623 92	.....	33,623 92	6,376 08	40,000 00
Sawyer Bend protection	93,815 57	\$2,988 06	96,803 63	45,407 99	142,211 62
Venice Dikes	36,341 85	.....	36,341 85	3,658 15	40,000 00
Arsenal Island protection .....	.....	9,673 85	9,673 85	.....	9,673 85
Closing Cahokia Chute	26,403 26	76,746 63	103,149 89	1,450 11	104,600 00
Horsetail Bar, dike 1	40,549 53	.....	40,549 53	.....	.....
Horsetail Bar, dike 2	21,911 58	1,688 68	23,600 26	.....	.....
Horsetail Bar, dike 3	82,692 54	.....	82,692 54	.....	.....
Horsetail Bar, dike 4	41,290 11	.....	41,290 11	37,195 34	347,502 86
Horsetail Bar, dike 5	31,753 73	5,180 14	36,933 87	.....	.....
Horsetail Bar, training-wall, &c.	20,398 16	64,843 05	85,241 21	.....	.....
Fort Chartres Dam	36,812 86	.....	36,812 86	9,750 00	46,562 86
Turkey Island	24,463 85	.....	24,463 85	8,101 61	32,565 46
Kaskaskia protection	4,514 31	30,923 55	35,437 86	6,562 14	42,000 00
Liberty Island Dam	5,053 91	.....	5,053 91	.....	5,053 91
Liberty Island protection	35,116 97	10,012 43	45,129 40	.....	45,129 40
Devil's Island, dike 1	65,871 17	.....	65,871 17	.....	.....
Devil's Island, dam 1	49,848 58	.....	49,848 58	17,601 95	150,000 00
Devil's Island, dam 2	16,678 30	.....	16,678 30	.....	.....
Cairo protection	30,092 95	55,051 53	85,144 48	87,355 52	172,500 00
Total	729,566 45	257,107 92	986,674 37	232,336 32	1,219,010 69

Property and material account.

Class of property.	Balance July 1, 1878.	Dr.	Cr.	Balance June 30, 1879.
Office furniture	\$264 05	\$28 00	\$120 00	\$172 05
Instruments and survey material	850 00	764 50	525 30	1,089 20
Pile-drivers	9,914 97	1,328 47	6,896 00	4,347 44
Barges	24,358 60	16,287 22	14,765 81	25,880 01
Two towboats, one tug, one launch, and expenses.	41,769 16	36,413 68	50,472 32	27,710 52
Small boats	58 19	314 07	227 00	145 26
General expenses of property	19,660 94	1,776 15	.....	21,437 09
Material and quarry privileges	2,079 33	213,377 36	212,544 46	2,912 23
Tools and appliances	258 61	3,213 42	2,827 40	644 63
Quarters for workmen, shops, &c	4,135 67	734 38	790 00	4,080 05
Totals	103,349 52	274,237 25	289,168 29	88,418 48

Engineer Office, United States Army, in account with United States.

Dr.		Cr.	
To appropriations, allotments, &c., prior to July 1, 1878	\$1,242,636 28	By expenses of office	\$53,832 90
To appropriation for improvement of Mississippi River between the Illinois and Ohio Rivers, approved March 3, 1879	200,000 00	By general engineering	32,596 52
To allotment for surveys	500 00	By surveys	90,349 17
To miscellaneous receipts and for fuel sold to officers	90 52	By constructions	986,674 37
To unpaid percentage	900 17	By balance on account of property	88,418 48
To liability for labor, material, &c	7,989 74	By cash on hand and in Treasury	200,245 27
	1,452,116 71		1,452,116 71

Abstract of proposals for four model barges for improvement of Mississippi River between the Illinois and Ohio Rivers, opened at Engineer Office, United States Army, Saint Louis, Mo., at 12 m. July 20, 1878, in accordance with advertisement dated July 8, 1878.

No.	Name of bidder.	Address.	Price per barge.	Price for four barges.	Remarks.
1	Salem T. Lamb	New Albany, Ind	\$2,650 00	\$10,600 00	
2	James Mack	Cincinnati, Ohio	2,700 00	10,800 00	
3	Bernard W. Nadal	Louisville, Ky	2,815 00	11,260 00	
4	Eberman, McFall & Co	California, Pa	3,000 00	12,000 00	Not in duplicate.
5	Covington Dock Company.	Covington, Ky	3,150 00		Bid for only one or two.
6	McCaskey & Kerr	Freedom, Pa	3,300 00		Bid for only two.
7	D. G. Stuart & Co	Madison, Ind	3,300 00	13,200 00	
8	Saint Louis Sectional Dock Company.	Saint Louis, Mo	3,375 00	13,500 00	
9	William Knox & Son	Marietta, Ohio	3,600 00	14,400 00	
10	John Young	Mason, W. Va.		14,700 00	
11	Alfred Cutting	Metropolis, Ill	3,900 00	15,600 00	

The contract was awarded to Salem T. Lamb for \$10,600.

Money statement.

July 1, 1878, amount available	\$256,307 62	
Miscellaneous receipts	56 92	
Amount appropriated by act approved March 3, 1879	200,000 00	\$456,364 54
July 1, 1879, amount expended during fiscal year	256,119 27	
July 1, 1879, outstanding liabilities	8,889 91	
July 1, 1879, amount available		265,009 18
		191,355 36
Amount (estimated) required for completion of existing project		6,289,600 00
Amount that can be profitably expended in fiscal year ending June 30, 1881		500,000 00

A.

REPORT OF MR. D. M. CURRIE, ASSISTANT ENGINEER.

SAINT LOUIS, Mo., July 7, 1879.

COLONEL: I have the honor, respectfully, to submit the following report of operations for the improvement of the Mississippi River between the Illinois and Meramec rivers, during the fiscal year ending June 30, 1879, to the duty of conducting which I was assigned by your order dated July 18, 1878:

Work was carried on under your direction during the year as follows:

Repairing revetment and cross-dikes at Sawyer Bend.

Constructing dam across Cahokia Chute.

Repairing and extending revetment on west shore of Arsenal Island.

Repairing dike No. 5, and constructing training wall and hurdles at Horsetail Bar.

SAWYER BEND.

The current had cut away the bank between the cross-dikes so as to leave their shore connections narrow salient points, which would readily yield to a slight additional attack. One dike at the upper end of the protection had its connection with the shore severed, and a short section of the bank there had been revetted to check the erosion, but had not fully succeeded in doing so.

The revetment below the cross-dikes had been somewhat damaged by the action of the current at points which were filled in the original grading.

Four of the cross-dikes having been repaired during the spring of 1878, were in good condition at the beginning of the fiscal year. The others were repaired by revetting the salient points mentioned in the preceding paragraph, and by raising those which needed it to the top of the bank, for the stone had disappeared from the upper part of a few of them, whether by the action of the current or other causes is not known.

The revetment at the upper end of the cross-dikes was raised to the top of the bank and extended up-stream about 200 feet. That below the cross-dikes was repaired, restoring it as nearly as practicable to its original condition.

DAM ACROSS CAHOKIA CHUTE.

When work was resumed at the beginning of this season Cahokia Chute was the principal branch of the river, and contained the only channel navigable at low stages of water. These conditions, having existed for several years, were apparently well established.

When the stage of the Upper Mississippi is higher than that of the Missouri its clear water remains distinct from the turbid water of the Missouri to some distance below the mouth of the chute. Such relative stages prevailed and excluded the Missouri water from the chute when turbid water would have lent material aid in the construction of the dam by depositing its sediment.

The above are the principal causes which rendered the construction of a dam across Cahokia Chute difficult. The fact that it was the only practicable channel for navigation at low stages made it necessary to commence the construction of the dam at a high stage, and push it fast enough to cause a navigable channel to be opened in Arsenal Chute before the low-water season. Those who have attempted to turn the principal branch of a large silt-bearing river from a chute in which it has become well established will readily understand the difficulties to be overcome. The difficulties arising from the clear water were of a negative character, as explained in the preceding paragraph.

Another cause contributed to make the construction of Cahokia Dam difficult, namely, the condition of Arsenal Chute. A broad, flat bar of sand or gravel, whose crest was everywhere above low-water, extended from the head of Arsenal Island to the Missouri shore. The water spread over the bar with nearly equal depth from side to side, and with a current insufficient to scour. This bar proved tenacious, and did not begin to yield until the head of water at Cahokia Dam became greater than the fall between the upper and lower openings of the chute.

Owing to the great depth of water (30 feet) and strong current near the Illinois shore, piles were not considered an efficient means of holding brush in position while being sunk. Therefore, mattresses or rafts of brush were constructed and sunk there without the use of piles.

Temporary "ways" having been constructed on Arsenal Island, below the west end of the dam, 100 feet long by 30 feet wide, a grillage of grub plank was laid spaced from 6 to 8 feet between lines of plank. The plank were nailed together at the intersections, and two holes having been bored through at each intersection, the ends of a small line were passed through and temporarily made fast to a stake driven near by, at about the height of the top of the mattress when finished. The brush was then placed in alternate layers parallel with and at right angles to the length of the mattress, the first or bottom layer being parallel with it. When all the brush was placed a grillage was laid on top, with intersections and holes corresponding to those at the bottom. The ends of the lines were then taken from the stake and passed through the holes and the stake drawn out. The next step was to heave a sufficient strain on the lines to thoroughly compress the brush in the mattress. The compression was then secured by driving a small pin into the hole by the side of the line. The line used was $\frac{3}{4}$ inch diameter at the marginal and $\frac{1}{2}$ inch diameter at the interior intersections. Of the four mattresses constructed, one was 24 by 80 feet, two 24 by 96 feet, and one 30 by 96 feet; all of these were about 2 feet thick when completed.

The mattress having been launched was taken in tow ahead of the boat, with a barge on each side containing stone to be used in sinking it, and after being brought into the exact position laterally, and slightly above it transversely, the lines to be used in lowering were adjusted by passing their bights through toggles attached to the mattress and drawing taut. The mattress having been loaded as heavily as the

lines would bear, an active man stood at each line, and under the direction of the foreman slacked away until it rested on the bottom. Sufficient stone was then placed to secure it in position and the lines withdrawn. The mattresses were placed with their length parallel with the current.

Before removing the lines ranges were set on the sand bar above to mark the position of a line drawn through an edge of the mattress to direct the location of the next one so that there would be no vacant space between them.

The plan of the apron of the dam did not differ essentially from that of similar works which have been constructed under your direction during the past five or six years. The plans of some of those works having been described in former reports, a repetition here may seem superfluous. Still it is repeated with the hope that sufficient has been added to make it interesting.

A line of piles was driven 50 feet below the center line of the dam, and another 65 feet below, making 15 feet between these two lines. The piles were 10 feet apart in each line. When the piles had been driven in both lines on a section as long as the loaded length of a brush-barge, a mat of brush about 2 feet thick was formed on them in alternate courses, parallel with and across the current. The heaviest course was laid parallel with the current with the tops down stream and butts just above the upper line of piles. The brush being 30 feet to 35 feet long, the tops extended 15 feet to 20 feet below the lower line of piles. The top or sinking course was laid across the current parallel with the lines of piles and filled the space between them. The brush in this course was laid as shingles are placed on a roof to completely cover the lower courses and bind the whole together. The barge was moved on when a section of mat was completed and another section formed in the same way. The mat when finished was loaded with stone distributed as equally over the surface of the sinking course as practicable, care being taken to load it so the ends of the course parallel with the current would sink nearly together.

The process of forming and sinking went on until a continuous mat extended from side to side of the chute. This will hereafter be called a *tier* of brush.

Frequent reference will be made to the lines of piles; therefore they are designated by numbers, beginning with No. 1, 65 feet below the center line of the dam, and proceeding up stream to No. 6, 10 feet above it.

The first tier of brush having been completed, the third line of piles was driven 20 feet from the second, and with 15-foot spaces between piles. The second tier of brush was then placed in the same manner as the first, with the butts of the brush in the course parallel with the stream just above the third line of piles, and the tops lapping on the first tier. The fourth line of piles was then driven 20 feet from the third line, with 10-foot spaces between piles, and the third tier of brush was placed as the preceding tiers had been. Then the fifth and sixth lines of piles were driven, and the fourth tier of brush was placed with tops up stream and butts above the fourth line of piles. This tier and a part of the third properly formed the foundation of the dam. The fifth line of piles being driven chiefly for support to the large body of brush that was to be placed in the dam, was not filled out, but extended across the deep water where such support would be needed.

The spaces between piles in the fourth, fifth, and sixth lines were made short, to furnish needed support for this same body of brush.

The next step was to bring the profile of the dam as near the same level as practicable. This was done by placing a mat between the fourth and sixth lines of piles. The thickness of the mat was regulated by the depth of the water. But it was not practicable to level it with a single mat, therefore short mats were placed in the deep water to level up the inequalities before the commencement of the long one. In this way the profile was brought so nearly to the same level that there was no more than 2 feet difference in depth of water from one end of the dam to the other.

The dam having been raised to about 5 feet above low-water with brush and stone, the use of brush was discontinued, and the construction of the dam was continued with stone alone. This condition was reached October 23, and from that date to the last of the month leveling the profile was continued by placing stone on the low places, which were found only near the Illinois shore and near the west end.

The shaking of the piles near a point about 500 feet from the east abutment late in the afternoon of October 31 indicated that a scour had commenced under the brush. During the night a breach was formed extending eastward from the point above mentioned a distance of 200 feet. There was 18 feet of water in the deepest part of it on the morning of November 1. A pile stood erect about the middle of the breach. That pile had been driven about 15 feet, therefore the scour could not have exceeded that depth.

November 2 the pile still stood erect in the middle of the breach, showing that the scour had not increased much, if at all. A barge-load of stone was placed in the breach near each side to prevent its widening in either direction. Eight hundred cubic yards of riprap had now been placed in the breach, in addition to that with which the brush was loaded when placed, probably as much more.

Monday, November 4, the pile was gone from the middle. The overfall and current remained about the same. Work was done that day on each side of the breach to secure the ends of the uninjured portions of the dam against the scouring force of the strong current that was passing around them into the breach.

Tuesday, November 5, the increased current and smooth-flowing water showed an increased depth in the breach. The overfall had decreased until it was scarcely perceptible. Barges made fast to any of the clumps of mooring piles above the dam and allowed to swing freely in the current pointed directly to the breach, although there was from 3 to 5 feet of water over the whole length of the dam except about 100 feet out from the Illinois shore, and about 150 adjoining the breach on the west. The steamer A. A. Humphreys passed through, sounding, found 31 feet, then came back into the breach and found 36 feet. Soundings taken from the side of a barge that was lying in the breach gave 32 feet. The discrepancies between these soundings could be satisfactorily explained by supposing that no two of them were exactly on the same point, and all of them may have been correct. Still it is doubtful whether any of them were so, although they were carefully taken by experienced leadsmen with a heavy lead (11½ pounds) and small line. It is known, however, that the true depths did not exceed those given.

After passing through the breach soundings were taken across the chute. Fortunately soundings on the same line were taken October 30, before the breach occurred. Sections made from these soundings show a decided increase of depth in front of the breach and a corresponding decrease each side of it.

A few days later a longitudinal scour was developed close above the dam along its entire length. This scour of course exposed a face composed of the movable material of the river-bed to the action of the current, while the water rolling over the dam and the eddies caused by the torrent pouring through the breach were scouring below and gradually bringing the deep water nearer to the dam, thus threatening the formation of other breaches by tunneling under the brush, when the ridge of sand would become too narrow to resist the pressure. To protect against this and to keep the breach within its original limits occupied until about the middle of November, without any special effort being made to fill the original breach.

The dam commenced settling at several points; at but one, however, was any considerable damage sustained. About 120 feet adjoining the breach on the west settled 10 feet.

While these protective works were in progress efforts were being made to procure a more economical material than the riprap of ordinary size to be used in filling the breach. To this end proposals were received and accepted from the owners of quarries at Grafton, Ill., for furnishing stone containing not less than 2 cubic feet. At the same time experiments were made with the ordinary riprap inclosed in open crates containing about a cubic yard. They were placed in the deep water of the breach with one end of a small cord attached while the other end was kept on board the barge, but they rolled beyond the limits of the base of the dam. An experiment was then made with a close box filled with riprap and sand, containing about 21 cubic feet, placed in the same way. It remained in position. The cost, however, was a few cents per cubic yard in favor of the larger stone, which determined its use. The first barge was received November 17, when the work of closing the breach may be said to have commenced. The maximum depth of water was about 35 feet, and the width of the breach was about 200 feet. The dam had been strengthened from the breach to each end, so that we were ready to commence filling the breach on the arrival of the large stone.

The large riprap ranged in size from about 2 cubic feet to 37 cubic feet. It was used in conjunction with the riprap of ordinary size.

The large stone was placed first in the deepest part and the small stone then placed above it. In this way the small stone was retained in the desired position.

The depth of water was decreased to 20 feet by the 30th of November, and to 12 feet by December 7. The difference in elevation between the upper and lower pools was measured on each of these dates; on the former it was 2.1 feet at the west end of the dam, and 2.2 feet at the east end; on the latter date the head was measured only at the west end of the dam, and was 2.45 feet.

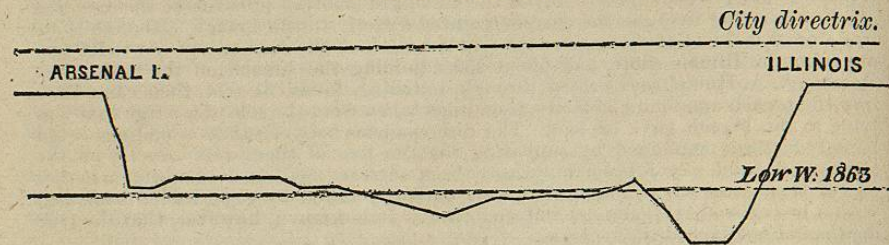
The work continued until the ice commenced forming a gorge above the dam, December 15. There was then only about 4 feet of water in the breach. Its width remained about 200 feet, though its location had changed. About 100 feet on the west had been raised to the surface of the water, while the stone had been washed off the top of the dam about the same distance eastward from the breach.

To check the erosion from the eddies below, it became necessary to place additional riprap on the brush in the lower side of the apron both ways from the breach to the east shore and a distance of about 300 feet to the westward.

Until the strong current was thoroughly broken, care was taken to work as equally on each end as practicable.

Soon after the brush had been placed in the foundation of the dam, the depth of water above it was discovered to be increasing near the east shore and toward the west shore. The increase of depth at the first-named point was from 3 to 5 feet, and at the latter about 2 feet.

CAHOKIA CHUTE.



Horizontal scale 1 inch to 500 feet.
Vertical scale 1 inch to 50 feet.

A cross-section of the dam accompanies this report which shows the mode of construction. This section is made for a depth of water about 16 feet at a stage 9 feet above low-water, or the same as the elevation of the top of the dam. A cross-section of the chute on center line of the dam is also transmitted.

After the close of operations, Cahokia dam was visited on the 30th of December. The ice had formed a gorge above the dam and another about 2 miles below. The latter backed the water at the dam so that the overfall was reduced to a foot or less. In the mean time the small stone on top of the dam had been carried away to a distance of about 200 feet.

The ice-gorge broke February 4, 1879, carrying the stone off the top of the dam in several places. After the ice had gone, the depth of the water in the breach was about 10 feet.

Work on the dam was resumed February 10, and continued until it was completed, April 12, the general elevation of its crest being about 9 feet above low-water.

The bar across the head of Arsenal Chute yielded during the winter, enlarging the water-way on that side and diminishing the pressure on the dam. Still the current in the breach was strong enough to roll small stone dropped from a barge and distribute them over a broader base than desired; therefore large stone was again used in connection with them.

ARSENAL ISLAND.

In obedience to your verbal instructions the old revetment on the west side of Arsenal Island was repaired and extended 125 feet up stream, and down stream as far as the action of the current had eroded the bank to the proposed shore-line, a distance approximately 3,500 feet.

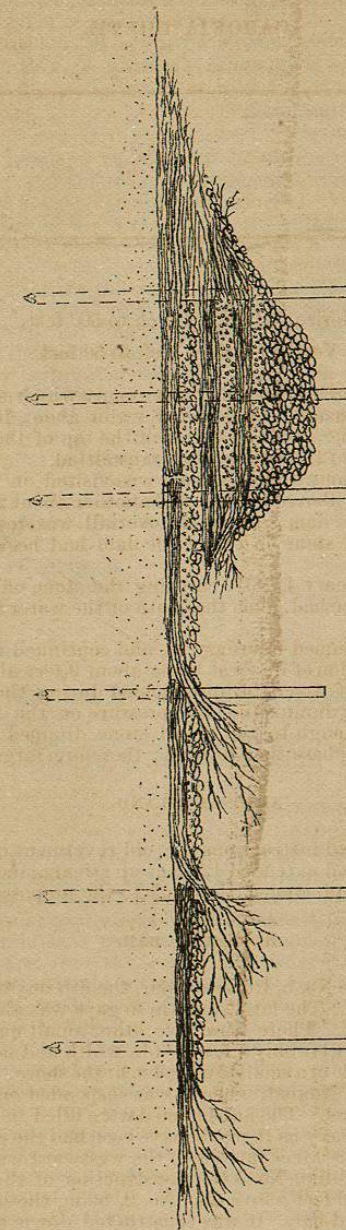
HORSETAIL BAR.

Work was resumed on dike No. 5, Horsetail Bar, the 6th day of August, with a view to filling several small gaps. The largest of these gaps was about 200 feet wide with a maximum depth of 18 feet. There were two other small gaps between the larger and the eastern shore; these were only a few feet in width and needed to be raised 4 or 5 feet. All of them were outside of a small towhead near the shore. Work on this dike continued until the 24th day of August, when it was suspended on account of the small depth of water in the channel. The gaps named were filled to the desired height, but the dike was not made as heavy as it would have been had the channel remained navigable. Another gap about 300 feet further to the westward was not filled.

After the close of work at dike No. 5 the construction of the training-wall was resumed at a point about 2,250 feet above dike No. 2, being the intersection of the line of the wall with the dry sand-bar. It was constructed down to dike No. 2, the dike being extended 200 feet to connect with it; then the wall was extended about 2,750 feet below, toward the outer end of dike No. 3, before the work stopped on account of ice.

In this distance the wall crossed the best channel for navigation, which had a maximum depth of 22 feet. Above dike No. 2, the wall was raised to about 14 feet above low-water, while below the dike it was left about 10 feet above at the close of the fall season.

During the winter the ice broke through the wall just below dike No. 2, making a



CAHOKIA DAM
Cross Section

AM. PHOTO-LITHO. CO. N.Y. (OSBORNES' PROCESS)

gap about 800 feet long with a maximum depth of 20 feet, which extended about 200 feet, while deeper water was found on both sides of the wall opposite the gap; on the channel side 30 feet, and behind the wall 43 feet, so near that stone would slide into it before taking its natural slope. After resuming work in the spring of 1879, the wall was extended up-stream about 600 feet to a willow bar, and below dike No. 2 it was raised to about 14 feet above low-water.

The wall was then extended 350 feet down stream, under instructions contained in your letter dated May 5, 1879, of which the following is a copy:

ENGINEER OFFICE U. S. ARMY,
Saint Louis, Mo., May 5, 1879.

SIR: With a view to reducing the cost of the training-wall at Horsetail Bar, you are requested to employ the following experimental construction at some suitable point in prolongation of the line already commenced.

Drive two rows of piles about 5 feet apart, the distance between the rows being equal to about half the depth of the water, and place a brush foundation as heretofore, except that the body of the brush should project towards the channel, and there should be but little projection towards the shore. Place vertically against the piles on the channel side of each row a sheathing made of cottonwood boards in panels. These panels should be about 16 feet long in one direction, and long enough in the other direction to reach from the bottom to the surface of the water at a 12-foot stage.

They may be made by laying four pieces of 3 by 4 inch scantling of a length suited to the depth of water, parallel to each other, and nailing upon them cottonwood boards 16 feet long. After being sunk they should be spiked to the piles.

Place a revetment of riprap on the channel side of the outer row of sheathing. Brace the two rows of piles together by cross-pieces of 5 by 5 inch scantling at intervals of 10 or 12 feet. Fill the space between the two rows of sheathing with sand dredged from the bed of the river at some point not very close to the training-wall, and cover the top with a thin layer of riprap.

Very respectfully,
By command of Colonel Simpson,

O. H. ERNST,
Captain of Engineers.

Mr. D. M. CURRIE,
Assistant Engineer.

The 350-foot section built was left unfilled in accordance with verbal instructions received through Captain Ernst subsequent to the date of the above letter.

Eight lines of hurdles were constructed in the rear of the training-wall in accordance with instructions contained in your letter dated March 10, 1879, of which the following is a copy:

ENGINEER OFFICE U. S. ARMY,
Saint Louis, Mo., March 10, 1879.

SIR: With a view to securing the full benefit of the deposits which may be expected during the coming high-water in the rear of the training-wall at Horsetail Bar, you are requested to connect that portion of the wall which has been completed with the Illinois shore by a series of continuous hurdles, made as follows:

Drive a row of light piles, 8 to 10 inches in diameter at the butts, 5 feet apart, sinking them 6 to 8 feet into the bed. Interweave with these piles courses of willow-brush. The brush should be from 20 to 30 feet long and from 2 to 3 inches in diameter at the butt, with most of the branches cut off. The smaller branches at the end may be woven together about the main stalk. Two pieces of brush are then bound together end to end, having an overlap of 6 feet, four withes being used for fastening, thus making a single rod from 35 to 55 feet long. Beginning at the training-wall, this rod is placed on the up-stream side of the first pile, on the down-stream side of the second pile, the up-stream side of the third, and so on, until it comes to an end. In continuing the course with a new rod, it will be better to fasten it to the end of the old in the same manner as the two were made into one; but if the practical difficulties are great, the new one may simply be laid in prolongation of the old one, with an overlap of 6 feet. The courses will be sunk by the weight of men as low as possible, but at all events at least 3 feet below mean stage of water, or say 6 feet above low-water. The most flexible rods should be selected for the lower courses. Having carried one course through, another is laid on the opposite sides of the piles, and then a third on the same sides as the first, and so on, until the height of the hurdle is equal to that of the training-wall or a little greater.

After the wattling has been completed, pieces of brush should be pushed vertically into the voids, until the latter are all completely filled. They should be driven down into the bottom, if possible. The branches are left on the top, and should project 4 or 5 feet above the wattling.