1898

The work resulted in removing 4,253 snags, 32 drift piles, 2 steamboats, and 1 barge wreck, and cutting down 14,856 trees.

The bottom of the snag boat *J. N. Macomb*, after continuous service since 1874, had become so pitted and corrugated with rust that it could no longer be operated with safety. Proposals were solicited by advertisement in February last for renewing this. But one bid was received and that was unsatisfactory in several respects. Authority was given to the officer in charge to do the work by hired labor. At the end of the fiscal year the work was nearly finished. It is expected that the boat will be ready for service at the commencement of the next low-water season.

An annual appropriation, not to exceed $100,000, for carrying on this work was made by the act of August 11, 1888. Under this appropriation the two snag boats will patrol the river and remove obstructions where necessary.

Amount drawn under section 7, act of August 11, 1888	$88,917.74
June 30, 1898, amount expended during fiscal year	88,915.27
July 1, 1898, balance unexpended	2.47
July 1, 1898, outstanding liabilities	2.47
July 1, 1898, amount available for fiscal year ending June 30, 1899	100,000.00

(See Appendix Y 1.)

2. Mississippi River, between Ohio and Missouri rivers.—The original condition of the navigable channel of this portion of the Mississippi River before the work of improvement was begun was such that the natural depth at low water was in many places from 3½ to 4 feet. The channels were divided by islands, which formed sloughs and secondary channels, through which a great deal of the volume of the flow was diverted, to the detriment of navigation.

The first work for improvement began in 1872, and was continued for a number of years as appropriations were made, the works consisting of dikes and dams of brush and stone, erected with a view to confining the low-water volume to a single channel, and of revetments to hold and preserve the banks where necessary or advisable to do so.

The present project is a continuation of the plan adopted in 1881. It also contemplates confining the volume of the river at low water to a single channel, its approximate width to be, below St. Louis, about 2,500 feet, the natural width being in many cases from 1 to 1½ miles. The method principally employed is the closing of sloughs and secondary channels and building up of new banks out to the line desired, using the solid matter brought down by the river and which is collected by means of hurdleworks. The banks, both new and old, are revetted where necessary.

The object of the improvement is to obtain eventually a minimum depth, at standard low water, of 6 feet from the mouth of the Missouri to St. Louis, and of 8 feet from St. Louis to the mouth of the Ohio.

The original estimate of the cost of the improvement, as revised in 1883, is $16,397,500.

The total amount expended to June 30, 1897, was $7,070,814.39, exclusive of $180,000 allotted by acts to projects for improvement between the Illinois and the Missouri rivers, including Alton Harbor.

The amount expended during the fiscal year ending June 30, 1898, is $868,793.96. This includes $288,585.47 expended during the year for dredge plant, portable jetties, and for operating the same. The total

amount thus far expended for what is termed temporary channel improvements is $437,769.90, the most of which has been for plant that is now on hand and available for future work. The approximate value of this plant is $343,000.

The result of the expenditure of this amount has been the partial improvement of the whole reach of the river from St. Louis to Cairo. During last year there was at all times throughout this reach a navigable channel 5 feet or more in depth, notwithstanding that the river reached a low-water stage of 1.2 feet below the standard low water.

The work done during the last year in the line of permanent improvement consisted in repairs to existing contraction works and revetment, and a further extension of the same in localities where work had been commenced.

New work was commenced above the head of Arsenal Island, to preserve the head of the island and to force the channel nearer the Missouri shore; at the lower end of the Ste. Genevieve Bend, to hold the bank in that locality and limit the oscillations of the river; at Hamburg Chute, to prevent about one half the low-water discharge of the river going through it, and by concentrating the water on the west side of the island increase the depth in the navigable channel; at the head of Devils Island, to prevent erosion of the bank and hold the river in proper alignment; at the lower end of the island near Minton Point, to contract the width of river bed and improve a shoal crossing at that point; near Commerce, to correct excessive width in the river and improve shoal crossings; and behind Bird Island near Buffalo Island, to shut off the flow of one-half the river and concentrate it over a shoal crossing. At all places where work was done before the last low-water season the effect was manifest in an improved condition of navigation.

Repairs and additions were made to works already in existence at Twin Hollows, Illinois; Chesley Island, Missouri; Michaels Landing, Missouri; Sycamore Landing, Illinois; Moro Island, Illinois; opposite Chester, Ill.; Anchor Landing, Missouri; Wagners Landing (Liberty Bend), Illinois; and Doolans Slough.

Opposite to Chester, Ill., the balance of the allotment of $30,000, made by river and harbor act of June 3, 1896, was expended in raising the revetment to the height of 20 feet above low water.

The $22,500 allotted by the river and harbor act of August 5, 1886, for continuing improvement at Cape Girardeau, Missouri, and Montana (Minton) Point, Illinois, from the general appropriation of that year for work in this reach of the river, was expended during the year in building contraction hurdles in the vicinity of Minton Point and improving a shoal crossing just above Cape Girardeau.

Work for the temporary improvement of the channel by means of portable jetties and dredging appliances was done at the following localities: Riverside, Harrisonville, Platin Rock, Grand Tower Bend, 76 Landing, Juden Creek, and Buffalo Island.

The jetties varied in length from 450 feet to 2,230 feet. The total length built and removed during the season was 9,345 feet, at an average cost of $3 per foot, including all expenses.

By means of these temporary expedients a gain in depth of channel varying from 6 inches to 3 feet was effected.

The two steel-hulled hydraulic dredges mentioned in last annual report as being under contract and to be completed about the middle of last October were not finished in time for last season's low-water work. They were delivered, one January 31, 1898, the other April 15,

1898. The tests made show that they are fully up to the required capacity of 1,000 yards each. They will be available for work during next low-water season.

With these appliances to aid the work put in place for the permanent improvement of the channel, it is confidently expected that at least 6 feet depth will be maintained during future low-water seasons between St. Louis and Cairo.

The funds now available will be expended in carrying out the original project and in the temporary work required by the river and harbor act of June 3, 1896.

The sum asked for the fiscal year ending June 30, 1900, will be applied to a continuance of the same work.

To prevent the suspension of this important work for lack of funds, the river and harbor act of June 3, 1896, makes provision for three years' work from July 1, 1897, to be paid for as appropriations are made by law, at the rate of $673,333.33 annually.

July 1, 1897, balance unexpended		$782,518.93
Amount appropriated by deficiency act approved July 19, 1897		325,000.00
Amount appropriated by sundry civil act approved July 1, 1898		673,333.33
		1,780,852.26
June 30, 1898, amount expended during fiscal year		868,793.96
July 1, 1898, balance unexpended		912,058.30
July 1, 1898, outstanding liabilities	$3,223.64	
July 1, 1898, amount covered by uncompleted contracts	56,234.98	
		59,458.62
July 1, 1898, balance available		*852,599.68
Amount (estimated) required for completion of existing project		8,219,166.68
Amount that can be profitably expended in fiscal year ending June 30, 1900		673,333.33

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of June 4, 1897.

(See Appendix Y 2.)

3. Harbor at St. Louis, Mo.—St. Louis Harbor is about 18 miles long and divided into two nearly equal parts by the Eads Bridge. The upper part, included between the bridge and the northern limits of the city, is about 10 miles in length.

Three miles above the Eads Bridge is the Merchants Bridge. The lower part of the harbor, included between Eads Bridge and the River Des Peres, is 8 miles long. The channel in this part of the harbor has sufficient depth and accessible landings at all points. Good depth exists above the Merchants Bridge.

Congress, by act approved September 19, 1890, appropriated $182,000 for improvement of this harbor.

The navigable reach between the Eads Bridge and Merchants Bridge was at that time obstructed by a number of middle bars. The project adopted for improvement of the harbor under the appropriation of 1890 consisted in a contraction of the waterway between those bridges to a width of about 2,000 feet, in order to concentrate the flow upon the bars, and thus cause scour to the depth desired. The contraction

* Of this balance special allotments have been made by Congress, as follows:

Bank protection at Cairo, Ill., act of July 5, 1884 (balance)	$8,600
Bank protection on east side of Mississippi River opposite mouth of Missouri River, act of June 3, 1896	50,000
Total	58,600

Y 2.

IMPROVEMENT OF MISSISSIPPI RIVER BETWEEN OHIO AND MISSOURI RIVERS.

The object of the improvement is to obtain eventually a minimum depth at standard low water of 6 feet from the mouth of the Missouri River to St. Louis, a distance of 16 miles, and of 8 feet at the same stage of water from St. Louis to the mouth of the Ohio River, 178 miles, the natural depth being in many cases from 3½ to 4 feet. The channel is divided at a number of points by islands forming sloughs and secondary channels behind them, through which a large portion of the volume of the flow is diverted, to the detriment of navigation.

The initial point of the work for the lower portion is St. Louis, the programme being to make the work continuous, proceeding downstream from that city.

The first work for improvement began in 1872 and was continued for a number of years, as appropriations were made, the works consisting of dikes and dams of brush and stone, erected with a view to confining the low-water volume to one channel, and of revetments to hold and preserve the banks where necessary or advisable.

Under these appropriations work of this character was done at the following localities between the mouth of the Ohio and the mouth of the Illinois River, viz: Piasa Island, Alton Harbor, Sawyer Bend, St. Louis Harbor, Arsenal Island, Horsetail Bar, Carroll Island, Fort Chartres, Turkey Island, Kaskaskia Bend, Liberty Island, Devils Island, and in the vicinity of Cairo, Ill.

The present project is a continuation of the plan adopted in 1881, and contemplates a reduction of the river to an approximate width of 2,500 feet below St. Louis, the natural width being in many cases from 1 to 1½ miles. The method employed is the building up of new banks out to the line desired from the solid matter brought down by the river, and which is collected by means of hurdles. The banks, both new and old, are revetted when necessary. Other means are also used occasionally for completing or hastening the depth required.

A hurdle, as the term is here used, is one of many silt-arresting devices that have been experimented upon in this country and elsewhere. The hurdles consist, essentially, of a row or of parallel rows of piling, the piles driven either singly or in clumps, the piling being connected lengthwise of the hurdle by wattling of fine brush or by curtains composed of brush and lodged against the upstream side of one of the rows of piles, the whole forming a permeable dike through which the silt-laden current can pass, though with greatly diminished velocity, resulting in deposits of silt above and below the hurdles.

These deposits are generally soon overgrown with willows or cottonwood, and after they arrive at sufficient height they can be revetted on their river fronts.

To guard against loss by scour of the piles, a broad, flexible mattress is first sunk on the line of the hurdle. Through this mat the piles and clumps of piles are driven.

During the past year the hurdles have been constructed of clumps of piles, three piles and upward to each clump. These piles are driven so that when their upper ends are drawn together by means of a wire rope they form a sort of pyramidal structure, the horizontal distances of the piles from each other at the surface of the river bed being 8 to 10 feet, depending mainly upon the depth of water.

The wire ropes are made on the work. They are composed of 14 to 18 strands of No. 14 galvanized iron wire. They are drawn taut by

means of the pile-driver machinery. At each turn of the rope around the upper end of the clump of piles a spike is driven as an additional guard against the rope slipping, though the wire itself generally binds or cuts into the piling sufficiently to prevent any slip. This method of drawing the upper ends of the piles together appears to be better than the old one of bolting them.

The tops of the piles are generally at an elevation of 20 feet above extreme low water, excepting that in the curtain or wattling row the top of one pile of the clump is at an elevation of about 25 feet above that stage, in order to intercept drift at high stages and prevent it from crossing the line of hurdles and dragging the top of the latter with it.

The curtain or wattled row is braced by vertical diagonal braces heeled against a row of clumps spaced at such distances below as to make the angle of the braces about 45 degrees.

The heel of the braces is held by a clevis passing around one of the piles of the lower clump, with its pin through the brace. At top the brace is bolted to one or more of the piles in the upper clump.

The piling of the hurdle row is so spaced as to represent an equivalent of one pile to the linear foot of hurdle. The piles are driven by means of the hydraulic jet as well as by the hammer, the latter weighing 2,400 pounds, and sometimes by both combined.

The completed curtain, or the wattling, whichever may be used, is generally carried finally to a height of 20 feet above extreme low water. The mattress is from 60 to 135 feet in width, depending upon the depth of water and consequent length of piles, as well as upon liability of the bed to suffer from scour. It is fabricated upon floating ways, in place, by wattling brush upon poles spaced about 5 feet apart and in any length desired. Continuity is obtained by lapping the poles and fastening them together with spikes and wire. When additional strength is required wire cables are used across and in direction of the length of the mattress. The brush is spiked to the poles at the edges of the mattress and at other points, about one spike to every third pole. In sinking the mat a little less than 1 cubic yard of broken rock is required to a cord of brush.

The piles used in the hurdles run in lengths from 25 to 60 feet, and their average penetration in the bottom is about 15 feet. They are driven with the large end down.

At the shore end of the hurdle the bank is revetted for about 300 feet, of which 200 feet is below the axis of the hurdle.

In constructing the shore revetment a mat about 120 feet or more in width, its inner edge at the surface of standard low water, is sunk. The bank is then eventually graded to a slope of one-half and covered with riprap. Where necessary to grade the bank by artificial means, the grading is done by the hydraulic method, or by means of shovels, etc.

Since the adoption of this project work has been done at the following localities, by methods substantially as above described, viz: Piasa Island, Alton Harbor, St. Louis Harbor, Cahokia Chute, Arsenal Island, Horsetail Bar, Carroll Island, Twin Hollows, Pulltight and Beards Island, Chesley Island, Jim Smiths, Sulphur Springs, Foster Island, Lucas, Cornice Island, Calico Island, Michaels Landing, Rush Tower, Fort Chartres, Crooks Landing, Turkey Island, Ste. Genevieve, Liberty Island, Hamburg, Minton Point, Cape Girardeau, Powers Island, Buffalo Island, and vicinity of Cairo.

Since last annual report work looking to the permanent improvement of the river has been carried on in the following localities: Arsenal Island, Twin Hollows, Illinois; Chesley Island, Missouri; Michaels

Landing, Missouri; Osborne Fields, Illinois; Danby Landing, Missouri; Sycamore Landing, Illinois; Ste. Genevieve, opposite Chester, Ill.; Anchor Landing, Missouri; Wagner Landing, Illinois; Hamburg Slough, Devils Island, vicinity of Minton Point, Powers Island, and Buffalo Island.

Work in the nature of portable jetties and dredging for the temporary improvement of the channel was done in the following localities: Riverside, Harrisonville, Platin Rock, Grand Tower Bend, Seventy-six Landing, Juden Creek, and Buffalo Island.

Arsenal Island.—The head of this island is on the Illinois side of the river and nearly opposite the old arsenal grounds in St. Louis, Mo. Work has been done for the protection of this island from time to time between 1877 and 1885. The work of this latter year left the head protected with a rock revetment to about the 16-foot stage. For several years during high-water stages more or less erosion has taken place above this revetment. There being many other places where work was more urgently required than here to the full extent of the available funds, this revetment was not carried up to the full height of the bank. The high water of 1897, impinging against the head of the island with more than usual force, succeeded in getting behind the revetment and washed the bank away for about 900 feet. About 35 acres were washed from the head of the island. The tendency of the whole river seemed to be in that direction and to form a bar on the Missouri side. To remedy this it was necessary to reestablish the shore upon the Illinois side and to force the river over to the Missouri shore. Four hurdles aggregating 4,400 feet in length and about 1,700 feet apart were built out from the Illinois shore, as shown upon plate herewith. These serve to check the sediment carried by the river and cause a deposit in the locality which in time will be sufficiently high to be revetted and held permanently. This work was commenced September 17 and finished December 1.

During the high water of this year the main current was well over to the Missouri side with no tendency to erosion of the Illinois shore.

The material used and work done at this and other localities mentioned in this report are given in the tables devoted to these subjects to be found in the report of Assistant D. M. Currie, herewith. The expenses incurred are shown in the table of cost of works during the fiscal year.

Twin Hollows, Illinois (14 miles below St. Louis).—The revetment on the east side of the river in this locality was built in 1882 and years following. In 1894 some repairs were made. A decided tendency to erode above and behind this revetment during recent high waters has made it necessary to do considerable repair work here. On account of the limited supply of stone that could be made available for this work, the revetment for a distance of 4,077 feet was repaired only to a height of about 12 feet. The work was done between October 23 and November 26.

Chesley Island, Missouri (19 miles below St. Louis).—Prior to 1894 considerable work had been done at the head of this island and in the chute behind it. During that year some repairs had been made to the revetment. The high waters of recent years impinging upon the head of the island have worn it back into a concave shape, 150 feet in length by 50 feet in width, leaving the old low-water protection mattress undisturbed. The new bank was revetted with stone November 27 to 30.

Michaels Landing (27 miles below St. Louis).—In my last annual report mention was made of the fact that a breach had been made in hurdle No. 1 of this series, and that hurdle No. 2 was in the process of construction behind it. This hurdle was completed July 19. The stone

dike for the shore connection at the west end of this line and the revetment of Osborne Towhead at the outer end were completed July 31. A large quantity of drift having lodged against this line it was sunk, thus adding much to the strength of the hurdle. No attempt was made to close the large gap of 750 feet in hurdle No. 1. The checking of the water, drift, etc., by No. 2 seems to result in a shoaling of the water between the two hurdles.

Osborne Fields.—The river bank in this vicinity was revetted in 1893 and 1894, but never completed to high water. There has been a gradual erosion of the upper part of the bank, and as opportunity offers rock is placed upon this. Between August 16 and September 17 about 4,700 linear feet of this bank was covered with stone. Five hundred linear feet had eroded back of the low-water protection. This was regraded and covered with stone to a 10-foot stage.

Danby Landing, Missouri (39 miles below St. Louis).—In 1895 the eroding bank just below this landing, for a distance of 4,750 feet, was protected to the height of the 16-foot stage. Subsequent high waters graded the bank back and threatened to get back of the revetment. Between September 18 and October 5 repairs were made to this at the point where the most damage had been done. It will be necessary to carry this revetment to the top of the bank whenever funds can be spared for the purpose.

Sycamore Landing, Illinois (46 miles below St. Louis).—The revetment of the Illinois shore near Sycamore landing was begun in 1892. A protection mattress 5,500 feet in length was placed and stone carried above to the foot of the abrupt bank at the level of a 10-foot stage. The stone work was raised in the fall of 1893 to about the 18-foot stage for a distance of 3,750 feet down from the upper end. The lower end not being raised to the required height has been subjected to high water erosion. About 1,500 feet of this revetment was repaired between October 6 and 21. It will be necessary to do other work in this locality.

Turkey Island, Illinois (52 miles below St. Louis).—In 1895 a low-water protection mattress was placed on the west side of this island for a distance of 5,250 feet and high-water protection carried up to heights varying from 5 to 15 feet. Between October 21 and November 4 this was repaired and all parts brought up to at least a 10-foot stage. About 2,200 feet of bank was covered with stone in whole or in part. These repairs, like others that have been mentioned, were limited to what was urgently necessary, by reason of the fact that funds could be expended in relieving the immediate necessities of navigation to better advantage elsewhere.

Ste. Genevieve, Ill. (57 miles below St. Louis).—The work done in this locality is shown upon Plate III, which accompanied my last annual report. (See Chief of Engineers Report, 1897, p. 2014.) The work of the present year consisted of repairs to hurdles and revetment about the head of Moro Island. Hurdle No. 12 had been damaged some by heavy pour of water around its outer end. About 200 feet was broken down by this process. This was repaired and the head strengthened. The hurdle was further strengthened against a large accumulation of drift on its upper side.

In hurdle No. 15, which closes the chute to the east of the island, two gaps had been made by ice and high water of the preceding spring. The larger of these was 200 feet in width, with 25 to 30 feet depth at a 15-foot stage; the smaller was 60 feet wide with a maximum depth of 20 feet. These gaps were closed and the hurdle strengthened and put in good repair.

The head of Moro Island and the west side for a distance of 5,700 feet had been revetted to a 10-foot stage in 1895. Subsequent high waters eroded the upper portion of this bank back so as to finally permit a large volume to pass between it and the low-water protection. The bank was carried away for a length of 3,000 feet. The maximum recession was 400 feet. To prevent further erosion and to restore the shore line to the old position and to the low-water protection, five short strong hurdles were built out, about 650 feet apart, extending from the bank to the old mattress, sloping between the ends down and out from the 25-foot level to the 15-foot level. The protections for the shore ends were made unusually strong, as the main current of the river strikes directly against this point. These hurdles were built between August 5 and September 28.

Ste. Genevieve, Mo.—At the lower end of the Ste. Genevieve reach and upon the Missouri side it was found necessary to hold a soft sand bank for a distance of 5,600 feet in order to preserve a proper alignment for the river channel. This was done by placing in front of it a good substantial low-water revetment and revetting the bank above this with stone to the height of the 10-foot stage. It is contemplated to extend this to the top of the bank as soon as it may be graded back by high water.

The lower end of this low-water mattress for a distance of 1,600 feet was made of lumber 1 inch thick, 4 to 6 inches wide, and 12 to 16 feet long. Lumber in this shape is easily handled and readily woven into a strong flexible mattress. The remainder of the mattress used in this protection was made of brush woven in the usual way and made very strong, to resist a very strong current found along this shore. Because of this current the work of making and sinking this mattress was very difficult. At one time 300 feet broke away from its moorings and was carried down the river. It was subsequently caught by one of the Government towboats and used at the works in Hamburg Chute, 60 miles below. Work in this locality was closed for the season October 22.

Chester, Ill. (73 miles below St. Louis).—The river and harbor act of June 3, 1896, contained a mandatory clause directing "that $30,000, or so much thereof as may be necessary, shall be expended in removing the bar in front of Chester, Ill., and protecting the west bank of the Mississippi River opposite Chester." In my last annual report I mentioned that in compliance with this law 3,310 feet of this bank had received a low-water protection and that the bank above the low-water line had been protected with stone to the height of the 10-foot stage, which was then the foot of the perpendicular portion of the bank. Subsequent high water having graded this bluff back, the revetment of the slope was continued up to the 20-foot stage. The work was done between October 23 and November 23. The full amount of the appropriation is now expended.

Anchor Landing (80 miles below St. Louis).—In this vicinity a second revetment was placed against the bank in 1895. The total length of mattress work was 7,250 feet and the stone work, or high-water revetment, was carried up to a 16-foot stage. The first revetment was made ineffective by the water getting in behind it.

Between the 22d and 29th of September repairs were made to this new revetment below the landing by taking stone from the old, which was then exposed. Later in the season, November 11 to 13, the stone work above the landing was repaired with stone brought from the quarry at Little Rock.

Wagner's Landing (84 miles below St. Louis).—This locality is the

Liberty reach, in which, as mentioned in my last Annual Report, 6,850 feet of bank were reveted. The work done here during the season consists in repairs to this over a length of about 3,900 feet. The revetment was placed in as good a state of repair as time and funds available would admit.

Hamburg, Ill. (120 miles below St. Louis).—In this vicinity there was a reach of river difficult to navigate at low water. The water was divided into two channels by Hamburg Island, and where these joined below the island the width of the river bed is excessive. It is a region of troublesome sand bars and shoals. During the higher stages of the river the Illinois shore to the east of the island was subject to erosion and much valuable land was destroyed.

The first step looking toward the improvement of this reach for low-water navigation was evidently to close the chute between Hamburg Island and the Illinois shore. This was effected by the construction, during July and August, of two permeable hurdle dams. One, 2,860 feet in length, was located across the head of the chute; the second is 6,600 feet below this and about 700 feet below the caving bank on the Illinois shore. This is 1,225 feet in length.

In the first hurdle, designated No. 5 in the series projected for this reach, the piles were driven in three rows, 18 feet apart, with the piles of the middle row 6 feet apart, and in the other rows 12 feet apart for a length of 575 feet from the Illinois end. From this point the usual form of a double row of 3-pile staggered clumps was used to the bar line at the head of the island. A single row of 3-pile clumps was jetted across the dry bar to connect the head of the island with the double row of clumps.

The Illinois end of the hurdle was protected by a shore mattress 325 feet long, with revetment to the top of the bank, 22 feet above low water. The island end of the hurdle was well protected by reveting the bank with rock to prevent scour. Curtains were placed in front of the hurdle to a height of 8 feet above standard low water.

The second of these hurdles, No. 6, was constructed as a double row of 3-pile clumps driven after the construction of the foundation mattress 112 feet wide, reenforced in deep water near the island end by a third row of clumps. The clumps were brought into contact by a longitudinal stringer dropped between the clump rows, fastened by wire. The shore mattress at each end was 300 feet in length. The above-water revetment on the island end was placed the full length of the mattress and to the height of the bank. On the Illinois end, owing to the favorable position and hardness of the bank, the grading and revetment were carried only to 220 feet below the head of the shore mattress. Curtains were placed in front of the hurdle to the height of the 8-foot stage.

These two hurdles were finished on the 1st day of September.

The closing of this chute, even by these permeable structures, had a marked effect during the fall low-water season in increasing the depth of navigable water through the channel on the west side of the island.

The spring high water has caused extensive filling to take place about the head of the chute. A small break is reported in the middle of the upper hurdle and erosion has taken place around the island end of the lower. These are not regarded as serious and can be remedied at little cost. This work is shown upon Plate III herewith.

Devils Island (124 miles below St. Louis).—The reach of the river mentioned above extends down to the Devils Island country—a reach that has always given more or less trouble to steamboat men during

low water. Considerable work has been done in this region in former years, commencing as far back as 1874. A dam was built, closing the chute between Picayune Island and the Illinois shore, and one closing the chute between this island and Devils Island. These have subserved the object for which they were built. The contraction works, formerly built near Minton Point and opposite Cape Girardeau, are now practically destroyed.

Rapid erosion has taken place of the newly formed land above the heads of these islands, and it was feared that if not stopped it would result in the destruction of the dams. To stop this erosion and at the same time put some sort of limit to the river in that direction, and get it into shape for passing the town of Cape Girardeau, it was deemed necessary to undertake work of considerable magnitude in this vicinity.

A hurdle 1,200 feet in length was built across the old head of Devils Island Chute. A mattress 200 feet wide protected this from scour, and extended with a width of 120 feet upstream 1,650 feet as a low-water protection to the shore, and down along the west side of Devils Island for a distance of 4,320 feet. The total length of this mattress was 7,070 feet.

Riprap-stone protection above low water extended to heights varying from 14 to 8 feet. This it is hoped will prevent further erosion in this locality until it can be returned to and placed in a more completed state.

At the lower end of the bend in which this revetment is placed it is necessary to contract the width of the river and throw the channel nearer to the Missouri shore. A very bad low-water crossing is here, on which it is desired to increase the depth of water.

With this object two hurdles, Nos. 9 and 11, were built. The upper one is 900 feet in length and the lower 1,200 feet. They are 2,000 feet apart. The upper hurdle, No. 9, having to withstand the pressure of large quantities of drift, is composed of three rows of 3-pile clumps, connected by longitudinal stringers, while the lower one, not being so much exposed, is composed of two rows of clumps. Both hurdles were suitably protected against excessive scour at their outer ends, and the bank at the shore ends riveted. Work in this vicinity was closed for the season September 20.

These two hurdles, being a part of the works designed for the improvement of the Mississippi River at Cape Girardeau and Minton Point, they were constructed in part from the unexpended appropriation of $22,500 made by the river and harbor act of August 5, 1886. This appropriation is now entirely exhausted.

Powers Island (145 miles below St. Louis).—In my last Annual Report mention was made that the work of improving the river in this vicinity had been commenced by the building of a strong hurdle dam in Doolans Slough, which separates Powers Island from the Missouri shore. This dam is successfully accomplishing the object for which it was constructed. Across the head of the slough and for some distance down there has been a large deposit of sediment, which has nearly closed the chute at low water. The improvement in navigation through this reach was very marked at low water last season.

The spring floods of 1897 caused a very heavy deposit of drift above the dam and some settlement of the rock revetment at its ends. The drift was sunk in place by putting a board mattress over it and weighting it down with stone, thus adding greatly to the strength of the dam. The revetment at the ends was repaired. The work was begun July 20 and finished August 10. The dam at last reports was in good condition.

The width of the river below Commerce is excessive at almost all points, and will need more or less rectification and bank protection throughout the whole distance—35 miles—to the mouth of the Ohio.

At Commerce Island a hurdle is in process of construction, extending down the river across the heads of the chute and passing just outside of Allen Towhead. It is 2,850 feet in length, and in consequence of its exposed position made of great strength. This work was commenced May 11. At the end of the fiscal year it was nearly completed. Its location is shown on Plate IV.

Buffalo Island (154 miles below St. Louis).—In this vicinity there will be required extensive contraction works in order to properly rectify the river and insure good permanent low-water navigation. The first hurdle of the projected series was commenced March 23, 1898, and at the end of the fiscal year was practically finished. It is a strong hurdle dam designed to close the chute between the Illinois shore and Blackbird Island.

During a part of the last low-water season the main channel of the river was through this chute.

The dam is 3,050 feet long.

It is not expected that the new hurdles constructed during the year will be all that is required to rectify the river in their respective localities. They are only a commencement of a series which it will be necessary to construct in order to hold the river permanently. Their locations are so chosen as to give the best results with the money expended and minimize the amount of work to be done during next low-water season by the temporary expedients for improving the channel that are now at our command.

TEMPORARY EXPEDIENTS.

Work of a temporary character for the relief of navigation was done during the season in the following localities: Riverside, Harrisonville, Platin Rock, Stanton Towhead, Old River near Chester, Seventy-six Landing, Grand Tower Bend, Juden Creek, and Buffalo Island.

Riverside Landing is the most important shipping point in the Mississippi River between St. Louis and Cairo, by reason of the fact that it is the eastern terminus of the Mississippi River and Bonne Terre Railroad, from which its trains of loaded cars are transferred on large ferryboats to and from St. Louis. On the approach of the low-water season of last year a large shore bar began to develop above the incline at this place, which threatened to move down and close it out entirely. To prevent this, dredge No. 2 was set at work to keep a channel open inshore through this bar.

At Bushberg, a short distance above Riverside, the main channel is deflected from the Missouri across to the Illinois shore and returns again below Riverside. Within a distance of 6 miles the river channel in this vicinity makes four crossings from one side to the other.

With the view to increasing the volume of water through the cut made by the dredge, a portable jetty, 1,100 feet in length, was constructed on the upper side of the bar, inclining outward into the main channel. The towboat *Gen. Abbot* gave occasional assistance with her wheel at the lower end of this cut.

When the dredging was commenced, August 21, the soundings along the line of the proposed cut indicated a minimum depth of 3½ feet with the water at a 10-foot stage on the St. Louis gauge. When work was discontinued, October 12, there was a cut 100 feet wide and nearly 4,000

feet long with a minimum depth of 4 feet with the water at a 3-foot stage on the St. Louis gauge.

Although this cut was not used by the steamers passing up and down the river the results obtained were satisfactory in so far that the landing at the Riverside incline was kept open and available during the whole season.

Dredge No. 2 worked a few days during October at the crossing near Riverside, removing a reef that had moved down with the channel. It was then taken into "Old River." This was the bed of the river near Chester, Ill., prior to the Kaskaskia cut-off. It makes a fine winter harbor for the Government floating plant, and has been used as such for the past three winters. The entrance to this is gradually shoaling up. Last fall it was necessary to dredge a channel through the shoal at the lower end in order to get the boats in. This was done by dredge No. 2 during the month of November. A cut was made 120 feet wide, 3 feet deep, and 1,750 feet long. The work closed December 4, 1897.

The material taken from this was silt and stiff clay, mixed with sand. It was deposited through the discharge pipes at a distance of 500 feet from the cut.

A description of this dredge is given in my last annual report. The machinery during this last season worked in a very satisfactory manner and fully up to expectations. No special effort was made to ascertain the amount of material removed. If such had been done the results could only have been approximated. The cost per cubic yard can not therefore be given.

Jet dredge No. 1.—This dredge was in commission from August 20 to the end of November and did good service jetting sand reefs and improving the channel at Stantons Towhead, Grand Tower Bend, and Buffalo Island. In its work the dredge was materially assisted by the towboats *Abbot* and *Casey*. These boats have each been provided with two heavy spuds—one on each side of the bow—which can be let down when the boat is on a bar or reef. When the wheel is worked with the boat thus anchored, a strong current is induced which carries the sand down stream. When either of these boats could be spared from their regular towing work they were used in connection with dredge No. 1 to deepen the channel through shoals.

Portable jetties.—As the river began to approach its low stage the necessity for concentrating the water at some of the shoal places became apparent. Before the season was over jetties had been built in the following localities: Riverside, Harrisonville, upper and lower crossings; Platin Rock, Seventy-six Landing, Juden Creek, and Buffalo Island.

The jetties varied in length from 450 to 2,230 feet. The total length built and removed during the season was 9,345 linear feet. The jetty party took the field during the latter part of August and was withdrawn early in December. It was in the field ninety-seven days, of which thirty-nine were employed in construction, twenty-three in removal, nineteen in towage from place to place, and sixteen were lost (Sundays, rain, etc.).

The cost of putting this length of jetty out and replacing it in store was but $3 per linear foot. This includes the proportional expenses for plant, repairs, deterioration, towage, office, engineer depot, etc.

The jetties materially improved and maintained the channel at each of the crossings where they were placed, giving a navigable depth of 5 feet or more, although the river reached a stage of 1.2 feet below the standard low water.

Hydraulic dredges Nos. 3 and 4.—In my last annual report a descrip-

tion is given of these two dredges. At that time they were under construction. The contract was entered into with The Bucyrus Company, South Milwaukee, Wis., March 17, 1897, and by its terms both dredges should have been completed on or before October 10, 1897. This time came and neither one of them was ready for delivery. The time for delivery was extended to April 20, 1898. Dredge No. 3 was delivered January 31, 1898, and dredge No. 4 was delivered April 15, 1898. Both these dredges were subjected to an efficiency test of sufficient duration to fully demonstrate that all their machinery and parts were equal to the requirements of the specifications, and that in respect to workmanship and material the terms of the contract were fully complied with. During these efficiency tests it was shown that one battery of these boilers (there are six boilers on each dredge) could, if necessary, be made to furnish all the steam required for both pumps. With 115 pounds of steam each engine developed 305 horsepower, driving the pump disks at 200 revolutions per minute, and delivering the material through 500 feet of discharge pipe. No barge measurements for capacity were attempted, but from cross sections made ahead of the nozzles and in rear of them, it was estimated that at least 1,200 cubic yards of sand per hour were going through the pumps.

During the test of dredge No. 3, and while the nozzles were being purposely crowded ahead with the discharge pipes, carrying about 30 per cent of sand, both pipe lines turned completely over. The water in the river was running at a rate of about 4 miles per hour.

The primary cause of this accident was water in some of the pontoons, which ran to the lowest corner and brought it below the water surface, where it was caught by the swift current, when one pontoon started over and the whole line had to go. The lines were righted with some little trouble, and to prevent a recurrence of the accident, lashed together during the remaining time of the test.

It is not expected that dredging will be done in a current so swift as 4 miles an hour, or that the pipes will be often loaded so heavily with sand. To provide against a possibility of this kind, however, steps have been taken to have all the pontoons widened by putting upon the sides a triangular-shaped piece, rounded at the outer angle. This is being done at the engineer depot by Government employees.

A number of other slight alterations and additions are being made to these dredges, which were not foreseen and provided for in the contract for their construction, all of which will add greatly to economy and facility of operation.

The utility of the swivel joint in the discharge pipes where they leave the dredge, and the system of pontoon supports so arranged as to swing under the pipes was fully demonstrated during the test of dredge No. 4. By properly adjusting the pontoons to the current, which was about 3 miles per hour, no difficulty was experienced in throwing the discharge pipes 670 feet apart at their outer ends without the aid of any other force than that of the river current. With experience in handling, this distance can be increased to 800 feet, or, in other words, the material can be delivered by this means 400 feet on either side of the dredged channel.

This device is certainly a great step in the direction of economy, both of time and money in these dredging operations. By it the pipe lines can be easily swung out of the way of passing river craft and back into position again without stopping the dredge pumps. Each line of pontoons is maneuvered by two wire cables that pass along their sides and to each of which they are made fast at one point. The action is like the well-known boom rudders used by loggers to throw booms

across narrow streams for the purpose of catching timber as it floats down.

Model barges.—During the year eighteen model barges were obtained by contract for use upon the works. These barges were of the same dimensions and capacity as those heretofore in use. Contract was entered into with David S. Barmore, Madison, Ind., to furnish twelve of these and with the Cincinnati Marine Railway Company, Cincinnati, Ohio, to furnish six.

By the terms of the contracts the barges should have been finished and delivered on or before May 15, 1898. Owing to high water in the Ohio River the contractors were unable to do this. The time for completing Mr. Barmore's contract was extended to June 15, 1898, and for the Cincinnati Marine Railway Company's contract to July 14, 1898.

At the end of the fiscal year the construction of all the barges was finished, but two from each of the contractors remained to be delivered.

Under existing contracts 502,018 linear feet of first-class piles and 460,992 linear feet of second-class piles were paid for.

There were 32,981.6 cubic yards of stone purchased during the year under existing contracts.

The two steel-hulled hydraulic dredges, Nos. 3 and 4, the piles and the stone above mentioned, were paid for from the $325,000 appropriated by the deficiency act of July 19, 1897, and authorized to be contracted for by the river and harbor act of June 3, 1896.

During the year 81,978.4 cubic yards of stone were obtained by hired labor from Government quarries at Little Rock, Mo., at an average cost of 58.2 cents per yard loaded on barges. In addition to these amounts 10,571.1 cubic yards were purchased in open market.

There were also obtained by hired labor 30,522 cords of brush, at an average cost of $1.30 per cord loaded on barges.

The plant pertaining to this work was kept in good state of repairs during the year and rendered efficient service.

In consequence of want of barges at times during the season of active work the cost of brush and stone was much higher than it would otherwise have been. The 18 new barges now being delivered will remedy this to a certain extent during the coming season.

The dredging operations during the low-water season, when revetment and other work is in progress, will tax the capacity of our towboats and tenders beyond their limit. It will be necessary during the coming season to construct at least one new towboat and two tenders.

Mr. D. M. Currie has continued to discharge the duties of principal assistant engineer upon the works, and Mr. William S. Mitchell and Mr. John O. Holman in charge of the parties in the field. The procuring of brush and quarrying of stone by hired labor was done by parties in charge of Mr. E. D. Libby, assistant engineer. The engineer depot, at which a large part of the supplies for the work of the district is assembled and distributed, and repairs to tools and additions and repairs to floating plant are made has been continued in charge of Supt. C. D. Lamb. All these gentlemen, together with the office force connected with the work, have satisfactorily discharged their several duties. For further details concerning the operations of the year reference is invited to appendixes herewith.

ESTIMATES.

The original estimate of the cost of the improvement of the Mississippi River between the mouth of the Ohio and the mouth of the Missouri River, as revised in 1883, is $16,397,500.

The aggregate amount of funds appropriated and made available for this work to June 30, 1898, is $8,178,333.32.

The total appropriations to date amount to $8,358,333.32. Of this amount $180,000 was allotted by acts and projects for improvement between the Illinois and the Missouri rivers, including Alton Harbor, leaving a balance of $8,178,333.32, as stated above, to be applied to the project for the general improvement of the river between the mouth of the Missouri and the mouth of the Ohio River.

Of this amount, there was on hand June 30, 1898, an available balance of $179,266.35, exclusive of outstanding liabilities. The amount that has been expended upon the project to this date is, therefore, $7,999,066.97.

The amount expended during the fiscal year ending June 30, 1898, is $868,793.96.

The river and harbor act approved June 3, 1896, provides:

> That any balance of former appropriations now available and the money hereby appropriated and authorized to be expended for the said section of said river between the mouth of the Missouri River and the mouth of the Ohio River, or so much thereof as may be necessary, shall be expended in the construction of suitable dredge boats, portable jetties, and other suitable appliances, and in the maintenance and operation of the same, with the view of ultimately obtaining and maintaining a navigable channel from St. Louis to Cairo not less than 250 feet in width and 9 feet in depth at all periods of the year, except when navigation is closed by ice.

In the $7,999,066.97 above mentioned, is included what has been expended for dredge plant, portable jetties, and appliances for temporary improvement of the channel, and for operating the same. This amounts to about $431,599.94. Of this, $287,382.49 was expended during this fiscal year. The present value of the plant pertaining to this temporary work is now estimated at approximately $287,290.45.

The available balance includes the unexpended balances from special allotments made by Congress, as follows:

For bank protection at Cairo, Ill., act of July 5, 1884	$8,600
For bank protection on east side of Mississippi River opposite to mouth of Missouri River, act June 3, 1896	50,000
Total	58,600

In view of facts connected with this item of $50,000 appropriated for the bank protection on the east side of the Mississippi River, to be expended at the discretion of the Secretary of War, as set forth in my letter of May 20, 1897, to the Chief of Engineers, and other papers connected therewith, I respectfully recommend that such action be taken in the premises as will make the sum available for any purpose for which the appropriation from which it was withdrawn was available.

As the matter now stands this $50,000 is tied up indefinitely, doing no good, while the general improvement of the river is greatly in need of funds to carry it forward.

The balance of the estimate for the original project not appropriated June 30, 1898, is $8,219,166.68.

It is estimated that the sum of $800,000 can be profitably expended during the fiscal year ending June 30, 1900, in the work of the original project and in the temporary work required by the river and harbor act of June 3, 1896.

This work is in the collection district of New Orleans. The nearest port of entry is St. Louis, Mo., at which place the customs collected during the fiscal year ending June 30, 1898, amounted to $1,000,632.43. The amount of internal revenue collected was $8,394,365.65.

Money statement.

July 1, 1897, balance unexpended		$782,518.93
Amount appropriated by deficiency act approved July 19, 1897		325,000.00
		1,107,518.93
June 30, 1898, amount expended during fiscal year		868,793.96
July 1, 1898, balance unexpended		238,724.97
July 1, 1898, outstanding liabilities	$3,223.64	
July 1, 1898, amount covered by uncompleted contracts	56,234.98	
		59,458.62
July 1, 1898, balance available		*179,266.35
Amount (estimated) required for completion of existing project		8,219,166.68
Amount that can be profitably expended in fiscal year ending June 30, 1900		800,000.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of June 4, 1897.		

List of appropriations.

By act of—		By act of—	
June 10, 1872	$100,000.00	August 11, 1888	$300,000.00
March 3, 1873	200,000.00	September 19, 1890	400,000.00
June 23, 1874	200,000.00	July 13, 1892	525,000.00
March 3, 1875	200,000.00	March 3, 1893	658,333.33
August 14, 1876	200,000.00	August 18, 1894	758,333.33
June 18, 1878	240,000.00	March 2, 1895	758,333.33
March 3, 1879	200,000.00	June 3, 1896	275,000.00
June 14, 1880	250,000.00	June 4, 1897	673,333.33
March 3, 1881	600,000.00	July 19, 1897	325,000.00
August 2, 1882	600,000.00		
July 5, 1884	520,000.00	Total	8,358,333.32
August 5, 1886	375,000.00		

Abstract of proposals for model barges for improving Mississippi River between mouths of Ohio and Missouri rivers, received in response to advertisement of August 2, 1897, and opened September 1, 1897, by Maj. Thos. H. Handbury, Corps of Engineers, at St. Louis, Mo.

No.	Name and address of bidder.	Number bid on.	Price each.	Amount.	Remarks.
1	Ed. J. Howard, Jeffersonville, Ind	6	$4,000	$24,000	
2	Cincinnati Marine Railway Co., Cincinnati, Ohio.	6	3,597	21,582	
3	Elizabeth Marine Ways Co., Elizabeth, Pa	12	5,975	71,700	
4	David S. Barnmore, Madison, Ind	6 to 12	3,800	22,800 to 45,600	
5	Godfrey Marine Ways Co., Lyons, Iowa	2	3,578	7,156	Bid defective.

Acceptance recommended of bid No. 2 for 6 barges.
Acceptance recommended of bid No. 4 for 12 barges.

*Of this balance special allotments have been made by Congress, as follows:

Bank protection at Cairo, Ill., act of July 5, 1884 (balance)	$8,600
Bank protection on east side Mississippi River opposite mouth of Missouri River, act of June 3, 1896	50,000
Total	58,600

1899

REMOVING SNAGS AND WRECKS FROM MISSISSIPPI RIVER; IMPROVEMENT OF MISSISSIPPI RIVER BETWEEN THE OHIO AND MISSOURI RIVERS, OF HARBOR AT ST. LOUIS, MO., AND TO PREVENT THE MISSISSIPPI RIVER FROM BREAKING THROUGH INTO CACHE RIVER AT BEECHRIDGE, ABOVE CAIRO, ILL.

This district was in the charge of Maj. Thomas H. Handbury, Corps of Engineers, to March 21, 1899, and of Capt. Edward Burr, Corps of Engineers, since that date. Division Engineer, Col. Henry M. Robert, Corps of Engineers.

1. Removing snags and wrecks from the Mississippi River below the mouth of the Missouri River.—Before this work was inaugurated, and for many years afterwards, the navigation of the river was very much interfered with by numerous snags, logs, etc., which had lodged in the channel, and to which new additions were made with each rise in the river. A large number of wrecked flatboats, barges, steamboats, and all manner of river craft are found in the navigable channels, and menace life and property.

For the removal of these obstructions appropriations were made as early as 1824. The project adopted consisted of building boats suitable for removing the snags, logs, rack heaps, etc., and operating them whenever the stage of water was favorable and funds were available.

The amount expended upon this work on the reach of the river below the mouth of the Missouri prior to 1879 can not now be definitely ascertained, for the reason that during much of the time appropriations were made at irregular intervals in lump sums, to be applied to several streams as their needs or the terms of the law might require. From March 3, 1879, when the first specific appropriation was made, up to June 30, 1898, there had been expended $1,371,846.10. This expenditure made great improvement in the navigation of the river and lessened the danger to boats. During the fiscal year ending June 30, 1899, the sum of $88,923.15 has been expended.

Two steel snag boats were employed in removing the obstructions to navigation between the mouth of the Missouri River and New Orleans, and during the year removed 3,300 snags and 34 drift piles. Thirty thousand six hundred and ninety-five trees were felled, and 12,395 miles were run.

The renewal of the steel plating of the hull of the snag boat *J. N. Macomb*, which was begun during the previous fiscal year by hired labor, was completed August 22, 1898.

An annual appropriation, not to exceed $100,000, for carrying on this work was made by the act of August 11, 1888. Under this appropriation the two snag boats will patrol the river and remove obstructions where necessary.

For recapitulation of commercial statistics reference should be made to report upon improving Mississippi River between Ohio and Missouri rivers.

Amount drawn under section 7, act of August 11, 1888	$88,923.15
June 30, 1899, amount expended during fiscal year	88,923.15
July 1, 1899, amount available for fiscal year 1899–1900	100,000.00

(See Appendix Y 1.)

2. Mississippi River, between Ohio and Missouri rivers.—The original condition of the navigable channel of this portion of the Mississippi River before the work of improvement was begun was such that the natural depth at low water was in many places from 3½ to 4 feet. The channels were divided by islands, which formed sloughs and secondary channels, through which a great deal of the volume of the flow was diverted, to the detriment of navigation.

The first work for improvement began in 1872, and was continued for a number of years as appropriations were made, the works consisting of dikes and dams of brush and stone, erected with a view to confining the low-water volume to a single channel, and of revetments to hold and preserve the banks where necessary or advisable to do so.

The present project is a continuation of the plan adopted in 1881. It also contemplates confining the volume of the river at low water to a single channel, its approximate width to be, below St. Louis, about 2,500 feet, the natural width being in many cases from 1 to 1½ miles. The method principally employed is the closing of sloughs and secondary channels and building up of new banks out to the line desired, using the solid matter brought down by the river and which is collected by means of hurdleworks. The banks, both new and old, are revetted where necessary.

The object of the improvement is to obtain eventually a minimum depth, at standard low water, of 6 feet from the mouth of the Missouri to St. Louis, and of 8 feet from St. Louis to the mouth of the Ohio.

The original estimate of the cost of the improvement, as revised in 1883, is $16,397,509.

The total amount expended to June 30, 1898, was $7,939,608.35, exclusive of $180,000 allotted by acts to projects for improvement between the Illinois and the Missouri rivers, including Alton Harbor.

The amount expended during the fiscal year ending June 30, 1899, is $674,260.71. This includes $89,525 expended during the year for dredge plant, portable jetties, and for operating the same. The total amount thus far expended for what is termed temporary channel improvements is $500,756.65, the most of which has been for plant that is now on hand and available for future work. The approximate value of this plant is $262,431.

The result of the expenditure of this amount has been the partial improvement of the whole reach of the river from St. Louis to Cairo. During last year there was at all times throughout this reach a navigable channel 5 feet or more in depth and, excepting for a few days, of 6 feet or more, the river reaching a low-water stage of 0.7 foot below standard low water.

The work done during the last year in the line of permanent improvement consisted in repairs to existing contraction works and revetment, and a further extension of the same in localities where work had been commenced, in addition to new works in localities where no work had heretofore been done.

New works were constructed at Lucas for the further contraction of the river to improve shoal crossings; at Osborne Field and at Danby Landing in extending the revetment to the 16-foot stage; at the lower end of Ste. Genevieve Bend in extending the Missouri revetment downstream and raising it to the 16-foot stage; at the lower end of Kaskaskia Island in revetting the bank to a 16-foot stage to prevent further erosion; at Horse Island, opposite Chester, Ill., in placing a subaqueous mattress to stop erosion of the bank; at Seventy-six Landing to close the chute east of Lacours Island for the improvement of a shoal crossing; at Commerce Island to close the chutes between the channel and the Missouri shore; at Burnham Island in revetting the bank to the 8-foot stage to stop erosion; at Goose Island to reduce the excessive width of the river, and at Buffalo Island to contract the river and close the chute east of Blackbird Island.

Repairs were made to existing works at Osborne Field, Danby Landing, Ste. Genevieve Reach, Hamburg, Devils Island, Commerce Island, and to the bank protection above Cairo.

Work for the temporary improvement of the channel by means of portable jetties and dredging appliances was done at Harrisonville and Platin Rock (Lucas Reach), Ste. Genevieve Bend, Seventy-six Landing, and Philadelphia Point. By means of these temporary expedients a gain of from 6 inches to 3 feet in channel depth was effected. The jetties varied in length from 250 feet to 1,360 feet. The total length placed and removed during the season was 2,710 feet, at an average cost of $8.14 per foot, including all expenses.

With the present appliances for temporarily assisting the works for the permanent improvement of the channel, it is confidently expected that a navigable channel depth of at least 6 feet will be maintained between St. Louis and Cairo during future low-water seasons.

The funds now available will be expended in carrying out the original project and in the temporary work required by the river and harbor act of June 3, 1896.

The sum asked for the fiscal year ending June 30, 1901, will be applied to a continuance of the same work.

To prevent the suspension of this important work for lack of funds, the river and harbor act of June 3, 1896, made provision for three years' work from July 1, 1897, to be paid for as appropriations should be made by law, at the rate of $673,333.33 annually.

The funds thus provided will be exhausted by June 30, 1900, and it is earnestly recommended that a similar provision be made for the future prosecution of this improvement.

Recapitulation of commercial statistics.

	1895.	1896.	1897.	1898.
	Tons.	*Tons.*	*Tons.*	*Tons.*
Receipts and shipments at St. Louis	812,185	1,244,175	1,046,035	906,168
Transferred by ferries at St. Louis	2,809 791	2,529,786	3,042,674	4,033,871
Shipped from landings between St. Louis and Cairo	26,715	75,513	69,815	53,785
Total	3,648,691	3,849,474	4,158,524	4,993,824

July 1, 1898, balance unexpended		$912,058.30
Amount appropriated by sundry civil act approved March 3, 1899		673,333.33
		1,585,391.63
June 30, 1899, amount expended during fiscal year		674,260.71
July 1, 1899, balance unexpended		911,130.92
July 1, 1899, outstanding liabilities	$45,443.05	
July 1, 1899, amount covered by uncompleted contracts	164,026.55	
		209,469.60
July 1, 1899, balance available		[1]701,661.32
Amount (estimated) required for completion of existing project		7,545,833.35
Amount that can be profitably expended in fiscal year ending June 30, 1901:		
For works of improvement	$850,000.00	
For maintenance of improvement	150,000.00	
		1,000,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of June 4, 1897.

(See Appendix Y 2.)

[1] Of this balance special allotments have been made by Congress, as follows:

Bank protection at Cairo, Ill., act of July 5, 1884 (balance)	$7,400
Bank protection on east side of Mississippi River, opposite mouth of Missouri River, acts of June 3, 1896, and March 3, 1899	100,000
Total	107,400

Y 2.

IMPROVEMENT OF MISSISSIPPI RIVER BETWEEN OHIO AND MISSOURI RIVERS.

The object of the improvement is to obtain eventually a minimum depth at standard low water of 6 feet from the mouth of the Missouri River to St. Louis, a distance of 16 miles, and of 8 feet at the same stage of water from St. Louis to the mouth of the Ohio River, 178 miles, the natural depth being in many cases from 3½ to 4 feet. The channel is divided at a number of points by islands, forming sloughs and secondary channels behind them, through which a large portion of the volume of the flow is diverted, to the detriment of navigation.

The initial point of the work for the lower portion is St. Louis, the programme being to make the work continuous, proceeding downstream from that city.

The first work for improvement began in 1872 and was continued for a number of years, as appropriations were made, the works consisting of dikes and dams of brush and stone, erected with a view to confining the low-water volume to one channel, and of revetments to hold and preserve the banks where necessary or advisable.

Under these appropriations work of this character was done at the following localities between the mouth of the Ohio and the mouth of the Illinois River, viz: Piasa Island, Alton Harbor, Sawyer Bend, St. Louis Harbor, Arsenal Island, Horsetail Bar, Carroll Island, Fort Chartres, Turkey Island, Kaskaskia Bend, Liberty Island, Devils Island, and in the vicinity of Cairo, Ill.

The present project is a continuation of the plan adopted in 1881, and contemplates a reduction of the river to an approximate width of 2,500 feet below St. Louis, the natural width being in many cases from 1 to 1½ miles. The method employed is the building up of new banks out to the line desired from the solid matter brought down by the river, and which is collected by means of hurdles. The banks, both new and old, are revetted when necessary. Other means are also used occasionally for completing or hastening the depth required.

A hurdle, as the term is here used, is one of many silt-arresting devices that have been experimented upon in this country and elsewhere. The hurdles consist, essentially, of a row or of parallel rows of piling, the piles driven either singly or in clumps, the piling being connected lengthwise of the hurdle by wattling of fine brush or by curtains composed of brush and lodged against the upstream side of one of the rows of piles, the whole forming a permeable dike through which the silt-laden current can pass, though with greatly diminished velocity, resulting in deposits of silt above and below the hurdles.

These deposits are generally soon overgrown with willows or cottonwood, and after they arrive at sufficient height they can be revetted on their river fronts.

To guard against loss by scour of the piles, a broad, flexible mattress is first sunk on the line of the hurdle. Through this mat the piles and clumps of piles are driven.

At the shore end of the hurdle the bank is revetted for about 300 feet, of which 200 feet is below the axis of the hurdle.

In constructing the shore revetment a mat about 120 feet or more in width, its inner edge at the surface of standard low water, is sunk. The bank is then eventually graded to a slope of one-half and covered with riprap. Where necessary to grade the bank by artificial means, the grading is done by the hydraulic method, or by means of shovels, etc.

Reference should be made to the report of the Chief of Engineers for 1894, Appendix X, pages 1577 et seq. for information relating to the development of the various forms of construction used and for a résumé of the various types used between 1872 and 1894, and to the reports of the Chief of Engineers for 1895 (p. 2059), 1896 (p. 1717), 1897 (p. 2012) and 1898 (p. 1698), Appendixes W, W, W and Y, respectively, for minor changes in the forms of construction.

During the past year the general types of construction in use in recent years have been followed. Hurdles have been constructed of one, two, or three rows of clumps of piles, the number of piles in each clump being two or more, with stringers of pile timber placed between adjacent rows of clumps to solidify the structure. Owing to the increasing scarcity of suitable and available brush the use of lumber for mattress construction has become greater. Common cull lumber, 1 inch thick and from 4 to 6 inches wide, is found to make an excellent substitute for brush, excepting for that portion of hurdle mattresses through which piles are driven and at points where special strength is required. The cost of the lumber mattress is slightly less than of brush at present prices, the increased cost of material being offset by decreased cost of labor, and lumber permits of more rapid construction on account of greater facility in handling the material. At present lumber is used for the downstream portion of hurdle mattresses, for the offshore portion or the whole of revetment mattresses, and entirely for mattresses for sinking drift above hurdles.

Since the adoption of this project work has been done substantially according to the methods referred to above at the following localities: Piasa Island, Alton Harbor, St. Louis Harbor, Cahokia Chute, Arsenal Island, Horsetail Barr, Carroll Island, Twin Hollows, Pulltight and Beards Island, Chesley Island, Jim Smiths, Sulphur Springs, Foster Island, Lucas, Cornice Island, Calico Island, Michaels Landing, Osborne Field, Rush Tower, Danby Landing, Fort Chartres, Crooks Landing, Turkey Island, Ste. Genevieve, Kaskaskia Island, Liberty Island, Hamburg, Devils Island, Minton Point, Cape Girardeau, Commerce Island, Burnham Island, Powers Island, Goose Island, Buffalo Island, and vicinity of Cairo.

Since last annual report work looking to the permanent improvement of the river has been carried on in the following localities:

Lucas (Foster Island and Calico Island), Osborne Field, Danby Landing, Ste. Genevieve Reach and Bend, Kaskaskia Island, Horse Island (Chester), Seventy-Six Landing, Hamburg, Devils Island, Commerce Island, Burnham Island, Goose Island, Buffalo Island, and above Cairo.

Work for the temporary improvement of the channel by the use of portable jetties and dredging appliances was carried on at Harrisonville and Platin Rock (Lucas Reach), Ste. Genevieve Bend, Seventy-Six Landing, and Philadelphia Point.

PERMANENT IMPROVEMENT.

Lucas, Ill., (30 miles below St. Louis).—Much difficulty was experienced at this locality during the last low-water season on account of shoal and badly located channels and crossings. The local project had not provided a sufficient contraction of width and the projected works had not all been constructed to their full projected lengths. A new local project has been adopted providing for a further extension of the Illinois system of hurdles in order to contract the river to the generally projected width of 2,500 feet, with minor rectification of the irregular Missouri shore should it be subsequently deemed necessary. Work

upon the projected extensions shown on Pl. III herewith was begun in April, 1899, and is still in progress. Hurdles Nos. 14 and 16 were constructed; Hurdles Nos. 9, 11, 13, and 15 were repaired and extended at both their inshore and channel ends, and the mattresses for Hurdles Nos. —4, —3, and —2 were made and placed, the aggregate new work being equivalent to 5,150 feet of hurdle.

Osborne Field, Ill., (36 miles below St. Louis).—The Illinois bank between Osborne Field and Durfee Landing was protected during the seasons of 1892–93 and 1893–94 by the customary type of revetment to a length of 8,770 feet, carried up to a 16-feet stage. Having been completed only to the foot of the bluff bank and not to high water, the work suffered somewhat during the high waters of 1896 and 1897, in both of which years slight repairs were made. In the spring of 1898 the revetment was again broken during high water, and during the past year the work was again thoroughly repaired.

Danby Landing, Missouri (39 miles below St. Louis).—The protection of the caving bank at and below Danby Landing for a length of 4,750 feet was begun in 1895 and continued as the abrupt bank was graded by subsequent high waters. In the fall of 1897 some repairs were made at the lower end of the work where the current threatened to get behind the revetment. During the past year the work was thoroughly repaired and extended to the foot of the bluff bank, 16 feet above low water.

Ste. Genevieve, Ill. (57 miles below St. Louis).—The work done in this locality is shown upon Pl. III, accompanying the Annual Report for 1897 (see Report of the Chief of Engineers, 1897, p. 2014). During the past year repairs were made to hurdle No. 15, which closes Moro chute and had been broken at its island end during the spring freshets of 1897. Repairs were also made to Nos. 0, 1, 2, 3, 4, and 5 of the series of short hurdles built to protect the west side of Moro Island and rebuild the eroded bank. The aggregate length of hurdle built was 500 feet.

Ste. Genevieve, Mo. (60 miles below St. Louis).—During the previous fiscal year it became necessary to protect the soft and rapidly-caving sand bank of the Missouri shore at the lower end of Ste. Genevieve Bend in order to preserve a proper alignment for the river channel. This was done by placing in front of it a good substantial low water revetment and revetting the bank above this with stone to the height of the 10-foot stage. During the past year this protection was extended downstream 2,350 feet, making the total length 7,950 feet, and was raised to 16 feet above low water.

Kaskaskia Island (71 miles below St. Louis).—In the spring of 1881 the Mississippi broke through into the Kaskaskia River at the head of what is now Kaskaskia Island. This cut-off shortened the distance from the head to the foot of the island by 6.5 miles, and, rapidly widening and deepening, soon became the main channel of the river. Since the occurrence of the break the banks of the cut-off have been caving at most points at a more or less rapid rate, and during the high water of the spring of 1898 the bank at the lower end of the island was eroded to a line at which it was desirable to hold it for the preservation of Chester Harbor and of a good channel alignment. Five thousand seven hundred feet of the bank at the lower end of the island was therefore protected by the usual revetment, which, by grading the bank, was carried up to the 16 feet stage or to the top of the bank, where it did not stand that high.

Horse Island, Missouri (Chester, 72.7 miles below St. Louis).—As a result of the erosion of the bank at the lower end of Kaskaskia Island

during the high water of 1898, the Missouri bank at Horse Island, opposite Chester, Ill., and immediately across Old River from the Kaskaskia work, was subjected to a very strong current during the high water of this year and began to cave rapidly. A continuation of this caving would affect adversely the present favorable channel alignment and conditions at and in the harbor of Chester and endanger the existing protection of the Missouri bank at Clearyville, below. It was decided to protect this point at once, and operations were begun in May, resulting in the placing of 4,058 feet of subaqueous revetment and stopping the erosion. On account of the strong current and high stage of the river during the execution of this work, it was more than usually difficult.

Seventy-six Landing, Illinois (91.6 miles below St. Louis).—The width of the river in this locality is excessive, and a shoal crossing exists that gave some trouble during the past lower water season, although the difficulty was removed readily by the use of a portable jetty. To contract the river to the projected width, hurdle No. 1 of this series, 1,900 feet long, was constructed from the Illinois shore to above the head of Lacours Island. This hurdle was strengthened by a stone buttress and connected with the head of the island. The head of the island was protected by a heavy revetment.

Hamburg, Ill. (120 miles below St. Louis).—In this vicinity there was a reach of river difficult to navigate at low water. The water was divided into two channels by Hamburg Island, and where these joined below the island the width of the river bed is excessive. It is a region of troublesome sand bars and shoals. During the higher stages of the river the Illinois shore to the east of the island was subject to erosion and much valuable land was destroyed.

The first step looking toward the improvement of this reach for low water navigation was evidently to close the chute between Hamburg Island and the Illinois shore. This was effected by the construction, during July and August, of two permeable hurdle dams. One, 2,860 feet in length, was located across the head of the chute; the second is 6,600 feet below this and about 700 feet below the caving bank on the Illinois shore. This is 1,225 feet in length. For a description of these hurdles see Report of the Chief of Engineers for 1898, page 1703.

The closing of this chute, even by these permeable structures, had a marked effect during the fall low water season in increasing the depth of navigable water through the channel on the west side of the island, and the high water of 1898 caused an extensive fill about the head of the chute. Both hurdles were, however, broken during that high water, and by the fall of 1898 the opening in the upper hurdle had widened to 400 feet. The break was closed and the hurdle repaired, but the hurdle was again broken at the other end by ice during the past winter. Repairs by sinking drift and closing this break are in progress.

Devils Island (124 miles below St. Louis).—The reach of the river mentioned above extends down to the Devils Island country—a reach that has always given more or less trouble to steamboat men during low water. Considerable work has been done in this region in former years, commencing as far back as 1874. A dam was built closing the chute between Picayune Island and the Illinois shore and one closing the chute between this island and Devils Island. These have subserved the object for which they were built. The contraction works formerly built near Minton Point and opposite Cape Girardeau are now practically destroyed.

Rapid erosion has taken place of the newly-formed land above the heads of these islands, and it was feared that if not stopped it would

result in the destruction of the dams. To stop this erosion and at the same time put some sort of limit to the river in that direction and get it into shape for passing the town of Cape Girardeau it was deemed necessary to undertake work of considerable magnitude in this vicinity.

A hurdle, No. 1, 1,200 feet long was built across the old head of Devils Island chute in the fall of 1897. The Illinois bank was revetted for a distance of 1,650 feet above this hurdle and the island bank for a distance of 4,320 feet downstream from the hurdle. Two hurdles, Nos. 9 and 11, were built at the lower end of the island during the same season. For a description of these and other works in this reach, see Report of the Chief of Engineers for 1898, page 1703.

Hurdle No. 1 was broken during the high water of 1898, but was reestablished and extended to the head of the island, which had been cut away. The revetment of the Illinois bank was repaired. The downstream revetment was extended 3,100 feet to the end of the caving bank and raised to the 4-foot stage. The revetment on the head and west face of the island was raised to a 15-foot stage. The channel end of Hurdle No. 9 was strengthened and drift was sunk above Nos. 1, 9, and 11.

During the spring high water of 1899 Hurdle No. 1 was again broken. This break will be repaired and all accumulated drift will be sunk.

Commerce Island, Missouri (143 miles below St. Louis).—Below Commerce, Mo., the width of the river is excessive, and numerous islands draw off the water into chutes and side channels. Of these side channels the most important was Doolans Slough, which is located between Powers Island and the Missouri shore, and carried off about one-half of the low-water flow. This slough was closed in the summer of 1896 by an unusually heavy permeable dam, fully subserving the purpose of its construction. Other chutes were closed by the construction of Hurdle No. 5 of the Commerce series, 2,850 feet long, which was begun in the spring of 1898 and completed in July. During the past spring the closing of the sloughs upon the Missouri side was completed by the construction of a hurdle (No. 1) 900 feet long, from above the head of Commerce Island to the Missouri shore. A good connection was made to the island at its head, which was protected by the usual revetment. The accumulated drift upon Hurdle No. 5 was sunk in August, 1898, and again in June, 1899. The effect of the work done in previous years has been very marked upon the shoals in this reach.

Burham Island, Illinois (145 miles below St. Louis).—To stop the erosion of the bank of this island a subaqueous plank mattress 3,910 feet long was placed nearly opposite Hurdle No. 5 of the Commerce series in the fall of 1898. For a length of 1,000 feet at the upper end and 2,040 feet at the lower end the bank above the mattress was revetted with stone to a stage of 8 feet above low water (4 feet above standard low water). In the center section the bank was too bluff for the reception of stone and the revetment will be carried up as the bank is graded back by the action of the river.

Goose Island, Illinois (148 miles below St. Louis).—At Goose Island, opposite the lower end of Powers Island, the width of the river is excessive. During the summer and fall of 1898 Hurdles Nos. 3 and 5 of the series intended to contract the river at this point were constructed, with lengths of 1,100 and 2,100 feet, respectively.

Buffalo Island (154 miles below St. Louis).—To close side channels and reduce excessive width in this reach, the construction of Hurdle No. 8 of the series, 3,050 feet long, was commenced in the spring of 1898, and completed early in the present fiscal year, closing the channel

between Blackbird Island and the Illinois shore and directing the entire flow into the west channel. During the present year Hurdles Nos. 2 and 5 of the same series, 1,100 and 1,700 feet long, respectively, were constructed.

Cairo protection.—For description of this work reference is made to the Annual Reports of the Chief of Engineers for 1876 to 1881, inclusive, and for 1885 and 1887. Two small breaks having been made in the revetment between the spur dikes at Eliza Point, slight repairs were made in the fall of 1898.

Plates I and II, accompanying, show the river from the mouth of the Missouri to the mouth of the Ohio, and the relation of the various works of improvement to each other and to the section of the river affected by each. The improvement in accordance with the adopted general project is extensive and progressive. While it is practically continuous for 60 miles below St. Louis, it is not complete at any point, and in the lower section work has been confined to such points as give the greatest trouble to navigation and return the greatest relief for the money expended. It is not expected that the contraction works constructed in new localities in the past and preceding year will be all that are required to rectify the river in their respective localities. They are only the commencement of certain series which it will be necessary to construct to hold the river permanently. Their location has been so chosen as to give the best results with the money available and to minimize the amount of work to be done during the following low-water seasons with the expedients now available for the temporary improvement of the channel.

TEMPORARY EXPEDIENTS.

Work of a temporary character for the relief of navigation during the low-water season of the summer and fall of 1898 was done at Harrisonville and Platin Rock (Lucas Reach), Ste. Genevieve Bend, Seventy-six Landing, and Philadelphia Point.

Dredge No. 3 was in commission from July 21 to November 30, 1898; dredge No. 4, from August 15 to November 23, 1898, excepting from October 17 to November 2, during which period it was laid up for repairs. Dredge No. 2 was operated by the crew of No. 4 while the latter was repairing.

At Harrisonville and Platin Rock (Lucas Reach) the channel makes four crossings from one bank to the other within a distance of 6 miles, and during the past low-water season much difficulty was experienced in navigating this shoal and badly located channel.

At Harrisonville several shoal channels developed at low water, none of which carried sufficient depth. On September 8 operations were begun with dredge No. 4 looking toward filling up the minor channel and thus diverting a larger flow through the main crossing, which latter would have been much obstructed by the presence of the dredge in deepening it. After two days' operation a gain of 2 feet in depth, from 6 feet to 8 feet, was found in the channel and operations were suspended.

At Platin Rock the channel crossed at low stages almost straight across the river. An attempt was made with dredges Nos. 3 and 4 to open a channel on the Missouri shore, avoiding this crossing and the one above. A depth of 8 feet was obtained, but the steamers used the regular channel, which had about the same depth. No. 3 worked in this locality from August 23 to November 23, and No. 4 from August 17 to September 6. The Platin Rock crossing was deepened by No. 3 early in September, but the cut was obliterated by a rise in the river about

the 20th of the month. When the river again fell to a 5-foot stage, dredge No. 3, between October 3 and October 10, opened a channel downstream of this crossing and with the aid of a portable jetty, placed to prevent the waste and direct the flow of the water, this channel attained a depth of 7 feet and maintained a depth of 6 feet for the remainder of the season.

Toward the lower end of Ste. Genevieve Bend a shoal developed promptly with the approach of the low-water season, with no well-defined channel. With the aid of dredge No. 3. a channel depth of 12 feet was gained on August 22 and a good depth was maintained throughout the season.

At Seventy six Landing a shoal crossing threatened to appear and the piling for a portable jetty was driven for about 1,000 feet, running from near the head of Lacour Island toward the Missouri shore. A rise of the river removed the necessity for completing the jetty. The piling caught such drift as to serve as a deflector for the current and the channel remained good.

In the latter part of September a shoal developed at Philadelphia Point. The towboat *Abbot* opened a channel through this shoal by working over it several days with her wheel and water jets. A portable jetty was placed upon the Illinois side of the channel and assisted in maintaining it in good condition through the season.

In addition to the work noted above the dredges were used to open a channel to the railroad incline at Crystal City, to open a channel to the hurdle closing Moro Island chute to enable work to be carried on at that point, and at the end of the working season to deepen the channel into the winter harbor for the plant belonging to the work.

For details relating to portable jetties and dredging appliances reference is made to the Annual Reports of the Chief of Engineers for 1881, 1882, 1889, and 1895 to 1898, inclusive.

PLANT.

The plant belonging to this appropriation has been maintained in efficient working condition during the year.

Contract was entered into on October 17, 1898, with Mr. Ed. J. Howard, of Jeffersonville, Ind., for the construction of a steel-hulled towboat to be completed July 27, 1899, at a cost of $67,750. On January 31, 1899, a contract was executed with the same builder to furnish three steel-hulled steam tenders, to be completed October 7, 1899, at a cost of $18,150 each. June 22, 1899, bids were opened for the construction of 60 flatboats, and award of contract to Mr. Ruell C. Arnold, of Leavenworth, Ind., at a cost of $19,140, has been recommended.

Under formal contracts 314,133 feet of first-class pile timber and 283,402 feet of second-class pile timber were purchased during the year. In addition to this, there were purchased in open market 93,294 feet of first-class and 128,213 feet of second-class piling. Also, 21,795.6 cubic yards of riprap stone, under formal contracts.

By hired labor there were obtained at the Government quarries at Little Rock, Mo., 131,244.8 cubic yards of stone at an average cost of 72.38 cents per cubic yard loaded on barges. In addition to these amounts, 11,953.1 cubic yards were purchased in open market. From various points 9,911.2 cords of brush were obtained at an average cost of $1.45 per cord loaded on barges.

Mr. D. M. Currie has continued to discharge the duties of principal assistant engineer upon the works, and Mr. William S. Mitchell and

Mr. John O. Holman in charge of the parties in the field. The quarrying of stone by hired labor was in charge of Mr. E. D. Libby, assistant engineer. The engineer depot, at which a large part of the supplies for the work of the district is assembled and distributed, and repairs to tools and additions and repairs to floating plant are made, has been continued in charge of Superintendent C. D. Lamb. All these gentlemen, together with the office force connected with the work, have discharged their several duties intelligently and faithfully. For further details concerning the operations of the year attention is invited to the appendices herewith.

ESTIMATES.

The original estimate of the cost of the improvement of the Mississippi River between the mouth of the Ohio and the mouth of the Missouri River, as revised in 1883, is $16,397,500.

The aggregate amount of funds appropriated and made available for this work to June 30, 1899, is $9,524,999.98.

The total appropriations to date amount to $9,704,999.98. Of this amount $180,000 was allotted by acts and projects for improvement between the Illinois and the Missouri rivers, including Alton Harbor, leaving a balance of $9,524,999.98, as stated above, to be applied to the project for the general improvement of the river between the mouth of the Missouri and the mouth of the Ohio River.

Of this amount, there was on hand June 30, 1899, an available balance of $701,661.32, exclusive of outstanding liabilities. The amount that has been expended upon the project to this date is, therefore, $8,823,338.66.

The amount expended during the fiscal year ending June 30, 1899, is $674,260.71.

The river and harbor act approved June 3, 1896, provides:

> That any balance of former appropriations now available and the money hereby appropriated and authorized to be expended for the said section of said river between the mouth of the Missouri River and the mouth of the Ohio River, or so much thereof as may be necessary, shall be expended in the construction of suitable dredge boats, portable jetties, and other suitable appliances, and in the maintenance and operation of the same, with the view of ultimately obtaining and maintaining a navigable channel from St. Louis to Cairo, not less than 250 feet in width and 9 feet in depth at all periods of the year, except when navigation is closed by ice.

In the $8,823,338.66 above mentioned is included what has been expended for dredge plant, portable jetties, and appliances for temporary improvement of the channel, and for operating the same. This amounts to about $500,756.65. Of this, $89,525 was expended during this fiscal year. The present value of the plant pertaining to this temporary work is now estimated at approximately $262,431.

The available balance includes the unexpended balances from special allotments made by Congress, as follows:

For bank protection at Cairo, Ill., act of July 5, 1884	$7,400
For bank protection on east side of Mississippi River, opposite to mouth of Missouri River, acts of June 3, 1896, and March 3, 1899	100,000
Total	107,400

The balance of the estimate for the original project not appropriated June 30, 1899, is $6,692,500.02.

It is estimated that the sum of $1,000,000 can be profitably and economically expended during the fiscal year ending June 30, 1901, in the permanent improvement of the river, in accordance with the original project and in the work of temporary improvement, with a view of

obtaining a navigable channel from St. Louis to Cairo not less than 250 feet wide and 9 feet deep at all periods of the year, in accordance with the requirements of the river and harbor act of June 3, 1896. Of this amount it is estimated that $150,000 will be expended upon the operation and maintenance of dredges, portable jetties, and other appliances for the temporary improvement of the river.

This work is in the collection district of New Orleans. The nearest port of entry is St. Louis, Mo., at which place the customs collected during the fiscal year ending June 30, 1899, amounted to $1,226,039.15. The amount of internal revenue collected was $14,380,819.15.

Money statement.

July 1, 1898, balance unexpended		$912,058.30
Amount appropriated by sundry civil act approved March 3, 1899		673,333.33
		1,585,391.63
June 30, 1899, amount expended during the fiscal year		674,260.71
July 1, 1899, balance unexpended		911,130.92
July 1, 1899, outstanding liabilities	$45,443.05	
July 1, 1899, amount covered by uncompleted contracts	164,026.55	
		209,469.60
July 1, 1899, balance available		[1] 701,661.32
Amount (estimated) required for completion of existing project		7,545,833.35
Amount that can be profitably expended in fiscal year ending June 30, 1901:		
For works of improvement	$850,000.00	
For maintenance of improvements	150,000.00	
		1,000,000.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of June 4, 1897.		

List of appropriations.

By act of—		By act of—	
June 10, 1872	$100,000.00	September 19, 1890	$400,000.00
March 3, 1873	200,000.00	July 13, 1892	525,000.00
June 23, 1874	200,000.00	March 3, 1893	658,333.33
March 3, 1875	200,000.00	August 18, 1894	758,333.33
August 14, 1876	200,000.00	March 2, 1895	758,333.33
June 18, 1878	240,000.00	June 3, 1896	275,000.00
March 3, 1879	200,000.00	June 4, 1897	673,333.33
June 14, 1880	250,000.00	July 19, 1897	325,000.00
March 3, 1881	600,000.00	July 1, 1898	673,333.33
August 2, 1882	600,000.00	March 3, 1899	673,333.33
July 5, 1884	520,000.00		
August 5, 1886	375,000.00	Total	9,704,999.98
August 11, 1888	300,000.00		

[1] Of this balance special allotments have been made by Congress as follows:

Bank protection at Cairo, Ill., act of July 5, 1884 (balance)	$7,400
Bank protection east side of Mississippi River, opposite mouth of Missouri River, acts of June 3, 1896, and March 3, 1899	100,000
Total	107,400

United States Engineer Office in account with the United States, from the establishment of the office in 1870 to June 30, 1899—Continued.

June 30, 1899.	By construction, between Illinois and Missouri:		
	Piasa Island Dam	$37,910.41	
	Piasa Island Dam, cutting channel	3,116.86	
	Alton Dam	33,740.05	
	Alton Dike	126,652.74	
			$201,420.06
	By construction, between Missouri and Ohio		8,149,319.85
	By surveys and gauges		173,555.32
	By amounts withdrawn for office, Chief of Engineers.		1,920.50
	By property on hand		668,746.45
	By material on hand		82,424.50
	By appropriations unexpended:		
	Mississippi River, Missouri to Ohio	$911,130.92	
	St. Louis Harbor	31,237.97	
	Beach Ridge, Ill	35,243.20	
			977,612.09
	Total		10,254,998.77

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

ST. LOUIS, MO., *June 30, 1899.*

CAPTAIN: I have the honor respectfully to submit the following report of operations for the improvement of the Mississippi River between the Ohio and Missouri rivers during the fiscal year ending June 30, 1899:

These operations comprise the construction, extension, and repair of works designed to permanently improve the navigation of the river and expedients for its temporary relief, including the construction, repair, and care of the plant, together with procuring material used therein; caring for and reading the gauges established along this section of river, and making such local and special surveys and examinations as were required.

The works for the permanent improvement, consisting of hurdles and bank protection, were carried on in accordance with approved projects at the following localities: Lucas, Ill.; Osborne Field, Illinois; Danby Landing, Missouri; Ste. Genevieve, Ill.; Ste. Genevieve, Mo.; foot of Kaskaskia Island, Illinois; Chester, Ill.; Seventy Six, Ill.; Hamburg, Ill.; Devils Island, Illinois; Commerce Island, Missouri; Burnham Island, Illinois; Goose Island, Illinois; Buffalo Island, Illinois, and Cairo, Ill.

Work in nature of temporary expedients, including portable jetties and dredging, was carried on at several localities, as follows: Dredging at Harrisonville; dredging and portable jetty at Platin Rock; dredging at Ste. Genevieve and at entrance to the winter harbor in Old River, near Chester, Ill.; portable jetty at Seventy Six, and portable jetty at Philadelphia Point after the channel had been opened by the steamer *Abbot*, using for that purpose its wheel and jet pumps.

LUCAS, ILL.

The work at Lucas was in construction, repair, and extension of several hurdles of the series projected for that locality, as follows: Nos. —4, —3, —2, 14, and 16 were partly constructed, and Nos. 9, 11, 13, and 15 were repaired and extended. In the aggregate the work was equivalent to the construction of 5,150 feet new hurdles, in which the quantities of work were 6,860 linear or 970,225 square feet of mattress fabricated and sunk; piles driven, 5,683; stringers placed, 174; drift mattress fabricated and sunk, 500 linear, or 7,000 square feet; curtains fabricated and placed, 1,639 linear or 10,555 square feet; revetment placed, 477 linear or 18,992 square feet; buttresses built, 1.

OSBORNE FIELD, ILLINOIS.

The bank from Osborne Field to Durfee Landing, which during the seasons of 1893 and 1894 was protected by subaqueous mattress and revetment above to the foot of the bluff bank, was repaired and extended to the contour 16 feet above standard low water during the years 1898 and 1899. In the fiscal year 1899 1,829 linear or 96,318 square feet of mattress was fabricated and sunk, 4,950 linear or 246,760 square feet of revetment was placed, and 2,500 cubic yards of earth was excavated.

DANBY LANDING.

The revetment at Danby Landing was repaired and extended up to the foot of the bluff bank, contour 16 feet above standard low water, in which 175,850 square feet of revetment was placed upon 4,925 linear feet of bank.

STE. GENEVIEVE, ILL.

The work at Ste. Genevieve, Ill., was in repair of Hurdle No. 15 of the series between Turkey and Moro islands, which had been broken during the preceding high-water season, and the repair of the series of Hurdles Nos. 0, 1, 2, 3, 4, and 5 built to protect the river front of Moro Island.

The work was done between September 26 and November 7, working at intervals as the stage of river and dredging gave depth sufficient to float the plant to the gap in Hurdle No. 15. In the repairs of No. 15, 447 piles were driven, 12 stringers were placed, 670 linear or 73,450 square feet of mattress was fabricated and sunk. In the Moro Island series, 38 piles were driven, and 7 stringers and 10,000 square feet of revetment was placed.

STE. GENEVIEVE, MO.

The protection placed at Ste. Genevieve, Mo., during the fiscal year 1898 was raised to the contour 16 feet above standard low water and was extended 2,350 feet downsteam, in which 277,500 square feet of mattress was fabricated and sunk, 7,500 cubic yards of earth was excavated in grading, and 6,790 linear or 272,700 square feet of revetment was placed.

KASKASKIA ISLAND.

The bank was protected to a distance of 5,700 feet upstream from the foot of Kaskaskia Island to the top of the bank at the lower end where the bank was not above the 16-foot contour, and to that contour above standard low water when the bank was higher, in which the following quantities of work were done: Mattress fabricated and sunk, 6,559 linear or 763,905 square feet; revetment placed, 231,900 square feet; earth excavated in grading, 17,640 cubic yards; piles driven, 74, and stringers placed 14.

CHESTER.

At Chester part of the river face of Horse Island was protected by a subaqueous mattress placed upon a distance of 4,058 feet, located as shown upon the accompanying plate No. 1, and covering the portion attacked by the strong current developed since the point of Kaskaskia Island was cut away. In this work 4,434 linear or 618,905 square feet of mattress was fabricated and sunk.

SEVENTY-SIX, ILL.

Hurdle No. 1, 1,900 feet long, was built at this locality to close the chute east of Lacours Island, and the head and 520 feet of the river front of the island was protected, in which the quantities of work done were as follows: Piles driven, 1,894; stringers placed, 98; mattress fabricated and sunk, 302,150 square feet; revetment placed, 30,035 square feet; earth excavated in grading, 600 cubic yards; buttresses built, 2.

HAMBURG, ILL.

The work at Hamburg, Ill., was the repair of the break in Hurdle No. 5, which occurred during the spring of 1898, as mentioned in the Annual Report for that year; also the repair in part of another break which occurred in the same hurdle during the spring of 1899. These breaks were about 400 feet and 650 feet long, respectively, located as shown on plate No. 2. In these repairs 613 piles were driven, 34 stringers were placed, 1,425 linear or 167,750 square feet of mattress was fabricated and sunk, and 2,950 linear or 164,900 square feet of drift mattress was fabricated and sunk.

DEVILS ISLAND, ILLINOIS.

The work at Devils Island comprised repair and extension of hurdles and bank protection.

Hurdle No. 1 was extended to reestablish its connection with the head of the island, and drift was sunk above Nos. 1, 9, and 11 during the first half of the year. A break which occurred in No. 1 during the spring of 1899 has not been repaired. In these repairs 931 piles were driven, 49 stringers were placed, 735 linear or 87,200

square feet of foundation mattress was fabricated and sunk, and 2,700 linear or 123,140 square foot of drift mattress was fabricated and sunk.

The bank protection placed during the preceding year was extended 3,100 feet downstream to the lower end of the caving bank by subaqueous mattress, and revetment above to the contour 4 feet above standard low water. The revetment previously placed on Swift Sure was repaired, and that on the head and west face of the island was extended to the contour of 15 feet above standard low water. In the bank protection 3,190 linear or 421,425 square feet of mattress was fabricated and sunk, and 228,135 square feet of revetment was placed upon 7,000 feet in length of bank.

COMMERCE ISLAND, MISSOURI.

The work at Commerce Island, Missouri, comprised the completion of Hurdle No. 5 of the series projected for that locality, which was in progress at the close of the fiscal year 1898, and the construction of Hurdle No. 1 of same series, designed to close the chute between the island and the Missouri shore. The work done aggregated: Foundation mattress fabricated and sunk, 1,715 linear or 223,070 square feet; piles driven, 1,420; stringers placed, 93; drift mattress fabricated and sunk, 6,397 linear or 238,885 square feet; revetment placed, 49,715 square feet.

BURNHAM ISLAND, ILLINOIS.

The river front of Burnham Island was protected in part by placing a subaqueous mattress to a distance of 3,910 feet downstream from the shoulder of the island, and placing revetment above to the contour of 4 feet above standard low water upon the upper 1,000 feet and lower 2,040 feet of this distance. In this work 3,910 linear or 459,200 square feet of mattress was fabricated and sunk and 27,350 square feet of revetment was placed.

GOOSE ISLAND.

At Goose Island Hurdles Nos. 3 and 5 of the series projected for that locality were built in the usual form, each having foundation mattress, piling in three rows of three pile clumps, with stringers between consecutive rows to secure contact; protection at the shore and river ends, and curtains upon a distance of 1,650 feet from shore on No. 5. In length they were built 1,100 feet and 2,100 feet, respectively. In these hurdles 4,420 linear or 525,800 square feet foundation mattress was fabricated and sunk, 3,694 piles were driven, 229 stringers were placed, 1,650 linear or 19,800 square feet of curtains fabricated and placed, and 45,340 square feet of revetment was placed.

BUFFALO ISLAND, ILLINOIS.

The work at Buffalo Island, Illinois, comprised the completion of Hurdle No. 8 and the construction of Hurdles Nos. 2 and 5. No. 8, which was in process of construction at the close of last fiscal year, was completed by driving piles as additional support at points which had been weakened by scour, sinking drift above it, and extending the shore protection at both ends of the hurdle. Hurdle No. 2, 1,100 feet, and No. 5, 1,700 feet, long, were built in the usual form of three rows of three pile clumps with foundation mattress 120 feet wide, tee head and shore ends protected, and stone dike connecting shore protection with piling. In these hurdles Nos. 2, 5, and 8, 3,657 piles were driven; 232 stringers were placed; 4,023 linear or 483,125 square feet of foundation mattress and 561 linear or 22,962 square feet of drift mattress were fabricated and sunk; and 119,765 square feet of revetment was placed.

CAIRO PROTECTION.

Two small breaches were made in the bank protection between the spur dikes at Eliza Point, and they were repaired by placing revetment to cover them, 375 feet by 29 feet and 227 feet by 45 feet respectively, between the 10-foot and 29-foot contours and by constructing a spur dike 60 feet long and 4 feet high. In this work 1,268 cubic yards of stone was expended.

TEMPORARY EXPEDIENTS.

Harrisonville.—At Harrisonville several shoal channels developed upon the approach of low water, leaving the depth in the best insufficient for the requirements of navigation. Relief was obtained by dredging one and partly filling the others with material dredged from the river bed. The dredged channel remained in good navigable condition during the remainder of the season.

Platin Rock.—At Platin Rock a persistent shoal developed, for the improvement of which dredging was done at different times in three separate channels, designated, respectively: Missouri Shore, Middle Bar, and Crystal City crossing. In connection with the last a jetty was placed to prevent waste of water. The combined effect of the jetty and dredging fixed the channel in the Crystal City crossing and maintained it in good condition throughout the remainder of the season. A part of the jetty near the shore end was pushed over during a temporary rise, and the panels were so bedded in sand that they could not be removed. That part of the jetty was left to act permanently as a contraction work.

Ste. Genevieve Bend.—At Ste. Genevieve Bend, a shoal developed promply upon approach of low water, but yielded to the vigorous attack with the dredge and gave no further trouble during the season.

Seventy-Six.—At Seventy-Six the piling was driven and the stringers placed preparatory to the construction of a jetty upon the approach of low water, but on account of a temporary rise the jetty was not completed. The piling caught fine drift, which gave such efficiency to the jetty that it deflected the current and contracted the waterway sufficiently to open the channel and keep it so during the navigable season.

Philadelphia Point.—Upon the approach of low water, during the last half of September, a shoal developed at Philadelphia Point, which was at that time the most serious obstruction to navigation on this section of the river. The *Abbot* opened a channel through the shoal by working several days with its wheel and water jets, when a jetty was placed there, which further improved the channel and maintained it in good condition to the close of the navigable season, about the middle of November.

Procuring material.—The brush and part of the stone required was procured by hired labor.

On account of the scarcity of suitable brush, sound cull lumber was used to a large extent in making mattresses, with cost no greater than that for brush and for mattresses through which no piles were to be driven, about equal to it in efficiency. Of the stone required much the larger portion was procured by hired labor, which experience has shown to be in the interest of economy and advantageous to the Government, although the cost per yard may be in excess of that at which small quantities of stone may be purchased from contractors selling only the by-product accumulated while quarrying for other purposes.

PLANT.

The plant was constructed, repaired, and equipped for service as required.

The towboat *W. R. King* and three tenders, Nos. 8, 9, and 10, all with hulls of steel, were under process of construction by contract with Mr. Ed. J. Howard, of Jeffersonville, Ind., and are still unfinished.

Towboats *Gen. H. L. Abbot*, *Gen. Gillmore*, and *Gen. T. L. Casey*, dredges Nos. 2, 3, and 4, tenders, barges, quarter boats, pile drivers, derricks, small boats, panels for portable jetties, sections of portable buildings, engineer depot, and tools and appliances all received the current repairs required.

SURVEYS.

The local surveys required in connection with the several localities at which works for the improvement were in progress were made. A survey with borings to determine the practicability of improving the west chute at Grand Tower was resumed and the field work completed. A survey was made at Wittenberg. Examinations and surveys at Beech Ridge and at Wagners Landing required by the river and harbor act approved March 3, 1899, were in progress at the close of the fiscal year.

GAUGES.

As heretofore, since 1891, the gauges established along this section of river have been read during the fiscal year for the purpose of collecting data for future use in studying the effect of improvement upon the physical phenomena of the river. The readings of the several gauges have been compared by making check hydrographs, and, after eliminating errors, they have been filed for future reference.

DISCHARGE OBSERVATIONS.

Three discharge observations, one at Chester, Ill., December 7, 1898, with stage of river on Chester gauge 1.1 feet, 2.9 feet on St. Louis gauge and falling; another at St. Louis, December 23, with stage of river 6.3 feet, rising during day to 7 feet on St.

Louis gauge; the third at St. Louis, January 12, 1899, with river at 4.1 on St. Louis gauge. The discharges per second obtained were 60,600 cubic feet at Chester, 95,800 cubic feet at St. Louis December 23, 1898, and 72,150 cubic feet at St. Louis January 12, 1899.

RESULTS.

The condition of the river during the fiscal year was generally favorable to navigation, due in part to the elimination of several noted shoals by the extension of the works for the permanent improvement, in part to temporary expedients for the relief of navigation, and also in part to the favorable stages and gradual changes from high to low stages. The extreme range on St. Louis gauge, as furnished by the Weather Bureau, was from —0.7 foot in February to +25.6 feet in April. The range during the low-water season of navigation, August to December, on the St. Louis gauge fluctuated between 12 feet and 0.3 foot above the low water of 1863. The highest and lowest stages on same gauge for each month were as follows: 6.4 feet and 12 feet for August; 4.5 feet and 12 feet for September; 3 feet and 9.9 feet for October; 5.5 feet and 9.1 feet for November; and 0.3 foot and 9.3 feet for December, showing that the fluctuations were not excessive, and that there was no long period of extremely low stages.

FORMS OF CONSTRUCTION.

No radical changes were made in the forms of construction during the year. The form used in hurdles still comprises foundation mattress with piles driven through it in one, two, or more rows, singly or in clumps of 2, 3, or 4 piles to each clump, with stringers between adjacent rows. In height they are still built to the stage of 20 feet above low water, with at least one pile in each clump of the upper row extending to the 25-foot stage, and drift was sunk above each hurdle when collected in sufficient quantity. The shore and river ends were protected substantially as in the form in vogue for several years with bank protection, and tee head with buttresses, respectively, except that during the last half of the year buttresses were built below instead of above the hurdle, and a row of pile clumps extended downstream to prevent destruction of the river end of the hurdle by eddies. On account of the small available supply of brush the portion of the mattress below the piling was built of lumber. In bank protection a subaqueous mattress was placed to protect the zone below low water, and after the bank was brought to a suitable grade, either artificially or otherwise, a revetment of stone was placed above to the 20-foot contour. The mattress was usually made of brush, but on account of the scarcity of suitable brush, cull lumber 1 inch thick by 4 to 6 inches wide and in length not less than 12 feet was adopted as sufficient.

For the development of forms of construction reference is made to the Report of the Chief of Engineers, 1894, Appendix X, pages 1577 and following, for résumé of forms used between 1872 and that date, and to the Reports of the Chief of Engineers for the fiscal years 1895, 1896, 1897, and 1898, Appendices W W W and Y, respectively, for minor changes in forms adopted since 1894.

REPORTS OF ASSISTANTS IN LOCAL CHARGE.

Quantities of work done shown in tables herewith and other details comprised in this report were obtained from the reports of assistants in local charge, as follows:

Works for improvement and portable jetties between St. Louis and Red Rock Landing, from the report of Mr. W. S. Mitchell, assistant engineer; between Red Rock Landing and Cairo, from the report of Mr. John O. Holman, assistant engineer; procuring stone by hired labor, from the report of Mr. E. D. Libby, assistant engineer; to procuring brush, from the report of Mr. E. C. Wiley, master of dredge; construction, repairs, and outfitting plant at engineer depot, from the report of Mr. C. D. Lamb, superintendent; operations of dredges Nos. 3 and 4, from reports of their masters, Mr. William M. Penniman and Mr. E. C. Wiley, respectively; surveys and examinations, from the report of Mr. William M. Penniman, master of dredge.

TABLES.

Quantities of work done are shown in detail in the following tables:

Table of work done for year ending June 30, 1899.

LUCAS WORKS.

	Hurdle —4.	Hurdle —3.	Hurdle —2.	Hurdle 9.	Hurdle 11.	Hurdle 13.	Hurdle 14.	Hurdle 15.	Hurdle 16.	Total.
Length of hurdles projected, linear feet	400	700	1,000	1,200	1,400	1,750	2,700	2,800	400	11,850
Length of hurdles built, linear feet	150	250	50	200	300	500	2,700	600	400	5,150
Piles, number	65	75	43	90	248	1,528	2,951	430	253	5,683
Piles, penetration, feet	1,265	1,348	861	1,553	4,787	28,127	54,375	8,058	4,867	105,246
Stringers, number				8	2	40	90	16	12	174
Cables, do	18	25	11	45	92	479	1,157	194	115	2,136
Foundation mattress, linear feet	507	830	150		855	1,171	2,573	500	274	6,860
Do, square feet	70,280	130,640	24,000		134,785	178,936	369,944	28,760	32,880	970,225
Drift mattress, linear feet								500		500
Do, square feet								7,000		7,000
Curtains, linear feet					50		759	570	260	1,639
Do, square feet					200		3,505	4,840	2,010	10,555
Revetment, linear feet							120	120	237	477
Do, square feet							1,680	1,900	15,412	18,992
Grading, approximate, cubic yards										
Buttresses, number							1			1

Table of work done for year ending June 30, 1899.

	Osborne Fields.	Danby Landing.	Ste. Genevieve, Ill.	Ste. Genevieve, Ill. Moro Hurdles 0,1,2,3,4.	Ste. Genevieve, Mo.	Kaskaskia Island.	Chester, Ill. (Horse Island).
	Bank protection.	Bank protection.	Hurdle 15.	Hurdles.	Bank protection.	Bank protection.	Bank protection.
Lengths of work projected, feet							
Equivalent lengths built, do	4,900	4,925	400	100	6,790	5,700	
Piles driven, number			889	38		74	
Piles driven, penetration, feet			7,431	476		1,274	
Stringers placed, number			12	7		14	
Foundation mattress fabricated and sunk, linear feet			670				
Do, square feet			73,450				
Drift mattress fabricated and sunk, linear feet							
Do, square feet							
Bank-protection mattress fabricated and sunk, linear feet	1,829				2,350	6,559	
Do, square feet	96,318				277,500	763,900	
Curtains placed, linear feet							
Do, square feet							
Stone revetment placed, linear feet	4,900	4,925		300	6,790	5,700	
Do, square feet	246,750	175,850		10,000	272,700	231,900	
Grading, linear feet	2,500				3,000	5,000	
Do, cubic yards	2,500				7,500	17,600	
Buttresses built, number							
Mattress, linear feet							4,434
Do, square feet							618,905

Table of work done for year ending June 30, 1899—Continued.

	Seventy-six.	Hamburg.	Devils Island.				
	Hurdle 1.	Hurdle 5.	Hurdle 1.	Hurdle 9.	Hurdle 11.	Total.	Bank protection.
Equivalent lengths built.....feet..	1,900	400	755	260	.....	1,015	.....
Piles driven.....number	1,894	613	562	369	.....	931	.....
Piles driven, penetration.....feet..	36,114	11,185	10,040	5,875	.....	15,915	.....
Stringers placed.....number..	98	34	22	27	.....	49	.....
Foundation mattress fabricated and sunk.....linear feet..	2,560	1,425	475	260	.....	735	.....
Do.....square feet..	302,150	167,750	58,600	28,600	.....	87,200	.....
Drift mattress fabricated and sunk.....linear feet..	.....	2,950	1,060	400	1,240	2,700	.....
Do.....square feet..	.....	164,900	90,210	33,930	59,000	123,140	.....
Bank-protection mattress fabricated and sunk.....linear feet..	.....	.....	.....	.....	.....	.....	3,100
Do.....square feet..	.....	.....	.....	.....	.....	.....	421,425
Stone revetment placed.linear feet..	938	.....	240	.....	.....	240	7,000
Do.....square feet..	30,035	.....	25,500	.....	.....	25,500	228,135
Buttresses built.....number..	2	.....	1	1	2	.....	.....
Earth excavated in grading, cubic yards.....	600	.....	.....	.....	.....	.....	.....

	Commerce Island.			Burnham Island.	Goose Island.		
	Hurdle 1.	Hurdle 5.	Total.	Bank protection.	Hurdle 3.	Hurdle 5.	Total.
Equivalent lengths built:.....feet..	900	200	1,100	.....	1,100	2,100	3,200
Piles driven.....number.	1,012	408	1,420	.....	1,265	2,429	3,694
Piles driven, penetration.....feet..	18,214	7,333	25,547	.....	21,718	47,049	68,767
Stringers placed.....number.	54	39	93	.....	79	150	229
Foundation mattress fabricated and sunk.....linear feet..	1,715	.....	1,715	.....	1,550	2,870	4,420
Do.....square feet..	223,070	.....	223,070	.....	186,000	339,800	525,800
Drift mattress fabricated and sunk.....linear feet.	697	5,700	6,397	.....	.....	.....	.....
Do.....square feet..	27,910	310,975	338,885	.....	.....	.....	.....
Bank-protection mattress fabricated and sunk.....linear feet..	432	310	742	3,910	.....	.....	.....
Do.....square feet..	37,115	12,600	49,715	469,200	.....	.....	.....
Curtains placed.....linear feet..	.....	.....	.....	.....	.....	1,650	1,650
Do.....square feet..	.....	.....	.....	.....	.....	19,800	19,800
Stone revetment placed.linear feet..	.....	310	310	3,040	300	312	612
Do.....square feet..	.....	12,600	12,600	27,350	27,124	18,216	45,340
Buttresses built.....number..	2	.....	2	.....	1	1	2

	Buffalo Island.				Cairo protection.	Portable jetties.		
	Hurdle 2.	Hurdle 5.	Hurdle 8.	Total.	Bank protection.	Platin Rock.	Seventy-six Landing.	Philadelphia Point.
Equivalent lengths built....feet..	1,100	1,700	238	3,038	.....	1,360	250	1,100
Piles driven.....number..	1,249	2,110	298	3,657	.....	227	64	158
Piles driven, penetration.....feet..	22,953	39,670	5,322	67,945	.....	4,678	1,150	4,132
Stringers placed.....number..	77	132	23	232	.....	64	4	60
Foundation mattress fabricated and sunk.....linear feet..	1,685	2,338	.....	4,023	.....	.....	.....	.....
Do.....square feet..	196,125	287,000	.....	483,125	.....	.....	.....	.....
Drift mattress fabricated and sunk.....linear feet..	.....	.....	561	561	.....	.....	.....	.....
Do.....square feet..	.....	.....	22,962	22,962	.....	.....	.....	.....
Bank-protection mattress fabricated and sunk.....linear feet..	.....	.....	.....	.....	.....	.....	.....	.....
Do.....square feet..	.....	.....	.....	.....	.....	.....	.....	.....
Curtains placed.....linear feet..	.....	.....	.....	.....	.....	.....	.....	.....
Do.....square feet..	.....	.....	.....	.....	.....	.....	.....	.....
Stone revetment placed, linear feet.....	300	321	811	1,432	602	.....	.....	.....
Stone revetment placed, square feet.....	15,300	28,890	75,575	119,765	21,215	.....	.....	.....
Buttresses built.....number..	1	1	.....	2	.....	.....	.....	.....
Panels placed.....do....	.....	.....	.....	.....	.....	163	.....	183

PLATES.

For further information reference is made to plates Nos. I and II, which make up the map of the river between the Ohio and Missouri rivers, and shows the location and extent of the several works of improvement comprised in this report; and to plate No. III, showing revised project from Fosters Island to Calico Island, which includes Lucas Works.

Very respectfully, your obedient servant,

D. M. CURRIE,
Assistant Engineer.

Capt. EDW. BURR,
Corps of Engineers, U. S. A.

REPORT OF MR. C. D. LAMB, SUPERINTENDENT UNITED STATES ENGINEER DEPOT.

ST. LOUIS, MO., *June 30, 1899.*

CAPTAIN: I have the honor to submit the following report of operations at the United States Engineer Depot during the fiscal year ending June 30, 1899:

The employees on the work at the beginning of the year included 9 machinists, 35 carpenters, and 70 laborers.

This force was retained throughout the year, and the number of carpenters was increased during the spring to 65, on account of the large amount of repairing necessary on barges, quarter boats, pile drivers, and flats.

The work done is divided, as heretofore, between construction, equipping for service, extraordinary repairs, and ordinary repairs, the latter item including watching, care of property, and handling of supplies of all kinds.

CONSTRUCTION.

Tools and appliances.—A derrick with a 54-foot boom was made and set up on pile-driver No. 16 for use in handling piles, pontoons, and portable jetties.

Six double blocks, 10 treble blocks, 8 quadruple blocks, and 66 snatch blocks were made for exceptionally hard usage. These blocks are extra heavy, with turned sheaves and steel pins. They cost about as much as the heaviest blocks of the size sold by the trade, but they are much stronger and better made than any blocks in the market.

One hose expander, 12 coal boxes, 2 iron and 4 wooden spuds were made for use on the steamers.

A large number of patterns were made for castings of all kinds. These include sheaves of various kinds, winch heads, quarter brasses, and parts of machinery needed for repairs.

EQUIPPING FOR SERVICE.

Dredge No. 4.—The pontoons for carrying the pipes were enlarged by the addition of water-tight compartments on each side similar to those built for No. 3 during the last fiscal year.

Machine shop.—A pipe and bolt threading machine was set up and connected. It will thread bolts up to 2 inches and pipe to 4 inches in diameter, and has been in almost constant use since its purchase.

Engineer depot.—A band sawing machine was set up in the cabin used as a sawmill, and all curved and beveled timbers are now cut to the exact shape desired without hand labor. This machine has already saved its cost, as the modeled top timbers and hood ends of a barge can be sawed to the shape for fully $100 less than if hewed out with a ship ax.

EXTRAORDINARY REPAIRS.

Steamer Gen. T. L. Casey.—The boat was laid up at the depot during March and extensively repaired.

The old wooden head was torn away and a new one of iron put on in its place. The head block was a hollow beam made of two channels each 14 inches deep, bent to shape, riveted back to back, and filled with wood. The chocks and deck beams under the knees were also made of iron. The deck under the boilers and parts of the deck frame and outriggers were renewed, new stacks were made and set up, the furnace was entirely rebuilt, and the machinery thoroughly repaired.

Barges.—No. 118 was docked during the fall and almost entirely rebuilt. The sides, deck frame, and stems were renewed, and the bottom calked.

Office and survey boats.—Nos. 3 and 4 were towed to the depot during the fall season and pulled out on the ways. The rotton rake and bottom plank, gunwales, and outriggers were torn away and renewed, the hull calked, and cabin painted.

Pile drivers.—Pile drivers Nos. 4, 9, 16, 17, 18, 21, 23, and 24 were pulled out during the year and entirely repaired. Their deck frames, rakes, and parts of the bottom and gunwales were renewed, the leads and machinery repaired, and the seams calked.

Ways.—The old ways built during 1893 became unserviceable, and were entirely rebuilt during the winter. The 11 way pieces are of 10 by 12 inch oak set 12 feet apart on cypress piles, many of which were driven to the bed rock.

The upper ends of the ways are located about 100 feet from the wall at a 30-foot stage, and they extend out 225 feet to the zero stage, about on the city wharf line.

The piles were driven about 8 feet apart to a depth of 18 feet whenever possible. The bed rock was found at a —15-foot stage at the outer ends of the ways, and at —9-foot stage 100 feet to the west.

The slope of the new ways is about 7–½ to 1 as against 4–½ to 1 on the old ways. We should be able to dock the two smaller towboats without difficulty, or the *Gen. Abbot*, by the addition of two more way pieces.

The ways have been in constant use since they were rebuilt; 9 quarter boats and 18 pile drivers have been pulled out and repaired, and 2 tenders, 4 barges, and 1 pile driver, docked last fall, have been launched.

The cost of this docking, if done by private parties, would have been about $3,500, while it has cost us less than $1,500, a saving of about half the entire cost of rebuilding the ways.

ORDINARY REPAIRS.

Steamer Gen. H. L. Abbot.—A pair of spuds 16 inches in diameter, 32 feet long, of ½-inch flange steel, was made to replace the wooden spuds of the same size. They will be handled by lines running from the capstan through double bracket blocks on the masts.

A new set of circle irons was made, and the wheel entirely rebuilt with 12-inch less diameter than before.

The main engines were equipped with a new set of bronze packing rings, with babbitted recesses, cast, turned, and filled in our shop.

The rivets in the boilers over the fire box were cut out and replaced with a larger size. The outriggers were calked, the wheel tightened, the slack of the chains taken up, and all repairs made necessary to keep the boat in good condition.

Steamer Gen. T. L. Casey.—A new pair of bronze packing rings was made for the cylinders; a break in the knuckle was repaired by the use of a side dock, the boilers were repaired, and various small repairs made as required.

Steamer Gen. Gillmore.—No work was done on the boat during the year except such as was necessary to keep it in a serviceable condition. The condition of the hull is so bad that no extensive repairs upon the boat are justified.

Dredge No. 2.—A new elbow was fitted to the suction pipe. The dredge was prepared for service and sent out in October.

Four sleeves were fitted to the main shaft. These sleeves were made in two parts, of best phosphor bronze. They weigh about 80 pounds each, and cost, finished, about 25 cents per pound.

Dredge No. 3.—The four pump runners or discs were repaired at different times during the season. Four main pump shafts of best open-hearth steel were purchased, and one was turned to fit No. 3, leaving three now on hand in the rough.

Two pairs of steel flange couplings and 18 bronze sleeves were made for the main shafts.

Two 26-inch piston heads, each with two cast-iron packing rings, were fitted to the main engines.

Dredge No. 4.—This dredge was equipped and sent out for service during August. Two of the pump runners were repaired and 13 bronze sleeves made for the main shafts.

The piston and cylinder head of one pump were broken during November, and they were replaced by those made here from the rough castings purchased. A new piston head was also made for the other engine, and a set of cast-iron packing rings for both.

Tenders.—No. 1 was pulled out in the fall to avoid danger from ice. It was launched in April after the hull was calked and the furnace rebuilt.

No. 2 was on the ways at the beginning of the year. It was calked and launched in July and pulled out in the fall with No. 1.

The heads, wheels, and machinery of Nos. 3 and 4 were repaired in the fall and again in the spring.

No. 5 was docked at the close of the fall season and extensively repaired during the winter. The deck frame, head, furnace, and wheel were entirely renewed and the machinery thoroughly overhauled. The new head is like that on Nos. 3 and 4,

being made with a box beam of 7-inch channels, riveted back to back, and filled with 4-inch by 7-inch nosing. The boiler beams and some of the outriggers on the head are made of 5-inch channel beams.

Small repairs were made upon the head, wheel, and boiler of No. 7 in the fall and again during the spring.

Barges.—Nos. 114, 116, 117, and 121 were pulled out on the bank at the close of the fall season and were extensively repaired during the spring. The top sides, stems, and deck frames were entirely renewed and some new plank put in the bottoms. No. 119 remained on the bank during the year and is used to hold up the chains and blocks for the ways. No. 118 was repaired last year, and the remaining barges in this lot, Nos. 114 to 126, will need repairs during the fall and winter.

The 16 barges, Nos. 1 to 9, 11, and 25 to 30, built from 1881 to 1885, are in such bad condition as to be only suitable for use as store boats or with quarters. The only work done on these barges during the year was a little calking and small repairs upon the fastenings.

No. 112 was sunk during the fall season. No. 103 is used as a derrick barge, and Nos. 142 and 143 for dredges Nos. 1 and 2, leaving 64 barges suitable for carrying material.

All of these were calked during the fall, and all were towed to the depot and repaired during the spring, except Nos. 101, 126, 129, and 204.

Quarter barges.—Repairs were made upon the bow of No. 6, and 45 iron beds were set up in the cabin.

Small repairs were made wherever necessary upon Nos. 11 and 28, which were used for carrying stores and supplies from the depot to the works below.

Quarter boats.—The rebuilding of the ways made it possible to dock the quarter boats, and all, except No. 5, were pulled out and thoroughly repaired. The rakes and parts of the bottom were renewed and all the seams calked.

New iron beds similar to those on the other boats were set up on Nos. 9 and 10 during the fall, and the cabins of Nos. 1, 4, 9, and 10 were painted.

Office and survey boats.—The hulls of Nos. 1 and 2 were calked in the spring and the cabins painted. Water tanks were put up in the kitchens and wire beds in the crews' quarters.

Nos. 3 and 4 were pulled out on the ways in the fall, and the rakes and bottoms repaired and calked.

Pile drivers.—The 28 pile drivers, with marine boilers, large jet pumps, and hoisting engines, have been kept in serviceable condition throughout the year. These drivers are numbered 1 to 6, 9, 12 to 14, 16 to 18, and 21 to 35. All were repaired during the year except No. 33, and all except Nos. 2, 13, and 33 were pulled out on the ways, their rakes and bottoms repaired and calked, new wells put in the hold, and the machinery thoroughly overhauled.

New leads were set up on Nos. 4, 18, 21, 28, 30, and 34.

The 7 drivers of the old pattern, with small boilers and crab frames, have all been dismantled, except No. 15.

The boilers of Nos. 7 and 19 are in use on derrick barge No. 103; those of Nos. 10 and 20 are used in the machine shop and sawmill, while the boilers of Nos. 8 and 11 are stored at the depot.

The hull of No. 7 was repaired as a machine shop. No. 11 is also available for such use, or for a driver, if desired; but the other hulls were built in 1890 and are not worth repairing.

Derrick boats.—No. 1 was towed to the depot in the spring, the hull and machinery repaired, and the sheer legs straightened.

Derricks.—The 2 derricks on barge No. 103 were repaired and strengthened during the fall. They were both supplied with a sheer leg back of the mast to take the weight of the stiff legs and hold the mast in place.

Small boats.—The additional plant needed during the fall was repaired and calked during the summer. It included 21 flats, 6 yawls, and 24 skiffs.

At the close of the fall season all the small boats were stored at the depot, except a few flats and skiffs used at the winter harbor.

Nearly all the small boats remaining in a serviceable condition were repaired and sent out for use in the spring.

The plant sent out included 130 flats, 13 yawls, and 85 skiffs.

The 40 flats and 8 skiffs condemned during the spring were destroyed.

Portable jetties.—The portable jetties were all repaired in the fall and loaded upon barges; 627 were sent out for use and returned at the close of the season, and all were again piled on the bank. They were overhauled during the winter, and 452, which showed rust, were painted with red lead.

About 700 gates, each 10 feet long, are now in good condition. Fifty of this number are 10 feet, 525 14 feet, and 125 are 18 feet wide.

Ways.—The old ways were repaired at intervals during the fall, but no repairs have been needed upon the new ways during the spring.

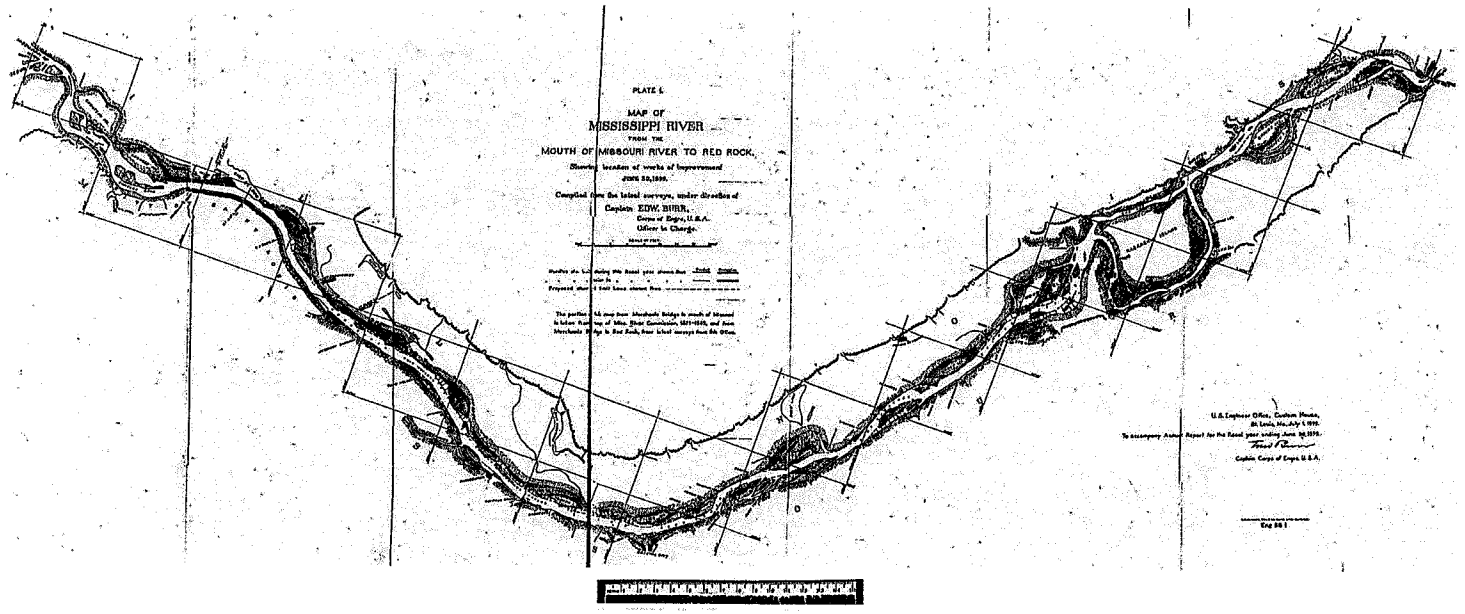


PLATE 5.
MAP OF
MISSISSIPPI RIVER
FROM THE
MOUTH OF MISSOURI RIVER TO RED ROCK.
Showing location of works of improvement
JUNE 30,1899.
Compiled from the latest surveys, under direction of
Captain EDW. BURR,
Corps of Engrs, U.S.A.
Officer in Charge.
U.S. Engineer Office, Custom House,
St Louis, Mo., July 1, 1899.
Captain, Corps of Engrs, U.S.A.

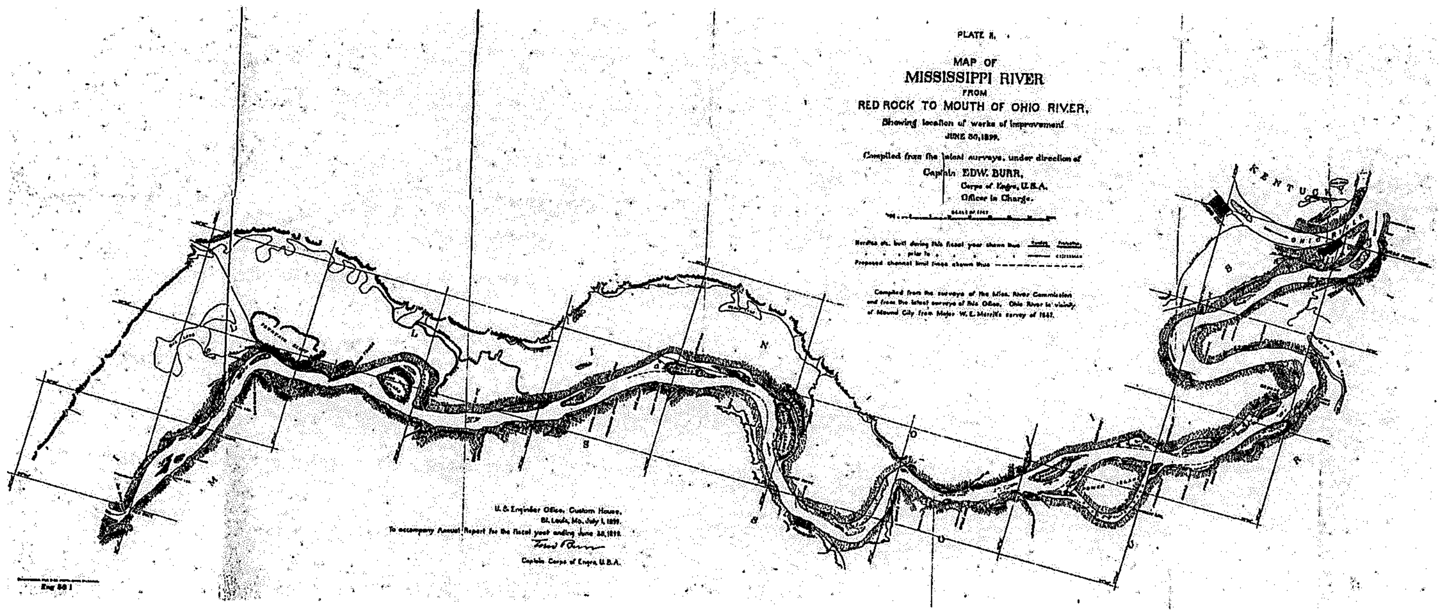


PLATE 8.
MAP OF
MISSISSIPPI RIVER
FROM
RED ROCK TO MOUTH OF OHIO RIVER,
Showing location of works of improvement
JUNE 30, 1899.
Compiled from the latest surveys, under direction of
Captain EDW. BURR,
Corps of Engrs., U.S.A.
Officer in Charge.
KENTUCKY
OHIO RIVER
U.S. Engineer Office, Custom House,
St. Louis, Mo., July 1, 1899.
To accompany Annual Report for the fiscal year ending June 30, 1899.
Captain Corps of Engrs. U.S.A.

MISSISSIPPI RIVER,

FROM BUSHBERG TO CORNICE ISLAND,

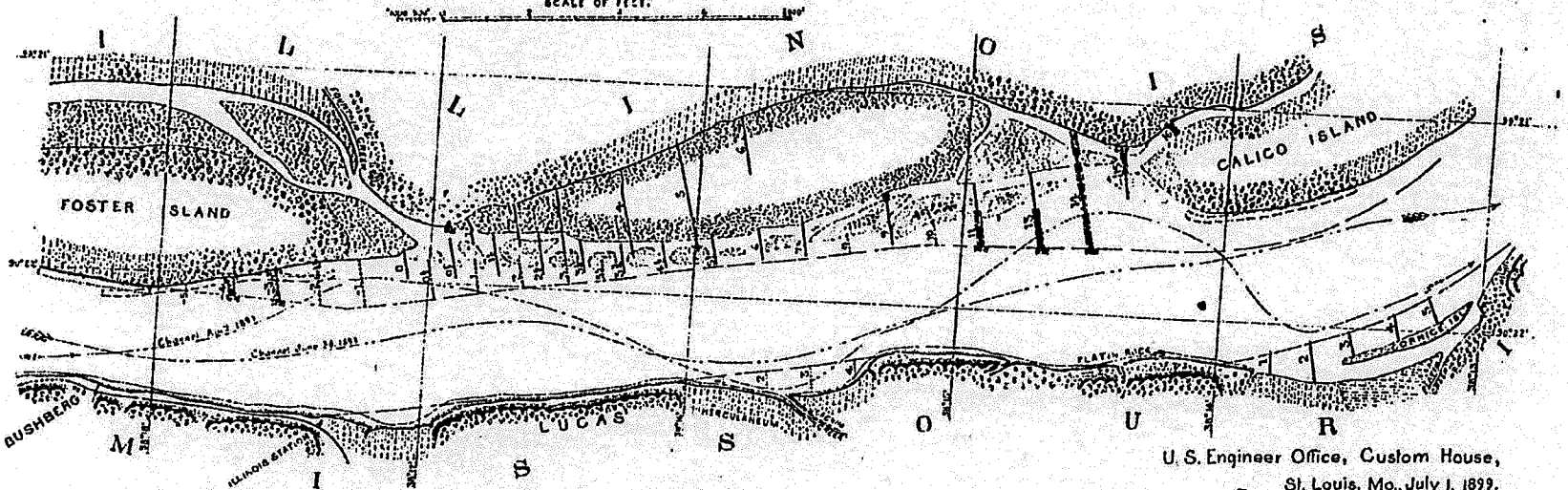
SHOWING WORKS OF IMPROVEMENT AT LUCAS'

JUNE 30, 1899.

PLATE III.

FROM SURVEY OF APRIL 18 TO 22, 1899.

SCALE OF FEET.



Hurdles etc. built during this fiscal year shown thus — Hurdles — Protection.

" " " prior to " " " " " " ——— ▭▭▭▭

" " projected shown thus ..... ▭▭▭▭

Proposed channel limit lines shown thus —— —— —— —— ——

U. S. Engineer Office, Custom House,
St. Louis, Mo., July 1, 1899.

To accompany Annual Report for the fiscal year ending June 30, 1899.

Thos. W. Symons

Captain Corps of Engrs, U. S. A.

GUNZ-HOWELL, WEIL & CO. PHOTO-LITHO. BALTIMORE.

Eng 56 1

1900

2. Mississippi River, between Ohio and Missouri rivers.—The original condition of the navigable channel of this portion of the Mississippi River before the work of improvement was begun was such that the natural depth at low water was in many places from 3½ to 4 feet. The channels were divided by islands, which formed sloughs and secondary channels, through which a great deal of the volume of the flow was diverted, to the detriment of navigation.

The first work for improvement began in 1872, and was continued for a number of years as appropriations were made, the works, consisting of dikes and dams of brush and stone, erected with a view to confining the low-water volume to a single channel, and of revetments, to hold and preserve the banks where necessary or advisable to do so.

The present project is a continuation of the plan adopted in 1881. It also contemplates confining the volume of the river at low water to a single channel, its approximate width to be, below St. Louis, about 2,500 feet, the natural width being in many cases from 1 to 1½ miles. The method principally employed is the closing of sloughs and secondary channels and building up of new banks out to the line desired, using the solid matter brought down by the river, and which is collected by means of hurdleworks. The banks, both new and old, are revetted where necessary.

The object of the improvement is to obtain eventually a minimum depth, at standard low water, of 6 feet from the mouth of the Missouri to St. Louis, and of 8 feet from St. Louis to the mouth of the Ohio.

The original estimate of the cost of the improvement, as revised in 1883, is $16,397,500.

The total amount expended to June 30, 1899, was $8,613,869.06, exclusive of $180,000 allotted by acts to projects for improvement between the Illinois and the Missouri rivers, including Alton Harbor.

The amount expended during the fiscal year ending June 30, 1900, includes $62,317.64 expended during the year for dredge plant, portable jetties, and for operating the same. The total amount thus far expended for what is termed temporary channel improvements is $533,489.53, much of which has been for plant that is now on hand and available for future work. The approximate value of this plant is $232,846.24.

The result of the expenditure of this amount has been the partial improvement of the whole reach of the river from St. Louis to Cairo. During last year there was at all times throughout this reach a navigable channel 5 feet or more in depth and, excepting for a few days, of 6 feet or more, the river reaching a low-water stage of −2.52 feet below standard low water.

The work done during the last year in the line of permanent improvement consisted in repairs to existing contraction works and revetments and a further extension of the same in localities where work had been commenced, in addition to new works in localities where no work had heretofore been done.

For the permanent improvement of the river, new works were constructed at the mouth of the Missouri River, for the protection of the Illinois bank, under special statute allotment of $100,000; at Lucas, for the further contraction of the river, to improve shoal crossings; at Danby Landing, in extending the existing revetment upstream; at Horse Island, opposite Chester, in raising the existing revetment to

higher levels, and at Devils Island in extending the existing revetment and raising it to higher levels.

Repairs were made to existing works at Twin Hollows, Chesley Island, Calico Island, Michaels Landing, Osborne Field, Danby Landing, Ste. Genevieve, Kaskaskia Island, Liberty, Hamburg Island, and Devils Island.

Work for the temporary improvement of the low-water channel by means of portable jetties and dredging appliances was carried on at Sulphur Springs, Turkey Island, Ste. Genevieve Bend, and at the entrance to the winter harbor in Old River. By means of these temporary expedients a gain of from 6 inches to 3 feet in channel depth was effected at these points. But one portable jetty was constructed. It was placed at Turkey Island middle crossing, and was 1,200 feet long.

With the present appliances, and such others as may be developed for the temporary improvement of low-water channels, it is expected that a navigable depth of at least 6 feet will be maintained between St. Louis and Cairo during all low-water stages that the river is open to navigation, and until the projected depth is obtained throughout by the extension and completion of the works for the permanent improvement. There can be no doubt of the ultimate success of this permanent improvement and of its value to the commercial interests involved.

To prevent the suspension of this important work for lack of funds, the river and harbor act of June 3, 1896, made provision for three years' work from July 1, 1897, to be paid for as appropriations should be made by law, at the rate of $673,333.33 annually. The last of these annual appropriations was provided by the act of March 3, 1899, and was practically exhausted by June 30, 1900. By suspending all operations during the last half of this fiscal year sufficient funds were reserved to provide for emergencies and for urgent low-water operations during the present season. To the amount thus reserved $100,000 was added by allotment from the act of June 6, 1900, but the total of funds available is sufficient only for two months' work with a partial force, and for the care of the large plant of the work until such time as further appropriations may be expected. The loss to the Government and to the commerce of the Mississippi River by the interruption of work for this important improvement can not be even approximately stated. The improvement not only makes no progress, but actually retrogrades, and navigation interests are decreasing from failure to obtain and maintain such channels as are necessary for economical transportation. It seems now certain that the procuring of satisfactory channels at all seasons of open navigation is merely a matter of providing funds in sufficient quantities to do the work economically. The local officer states that $150,000 is required annually for temporary low-water operations alone.

The sundry civil act approved March 3, 1899, requires that from the appropriation made by that act for improving the Mississippi River from the mouth of the Ohio River to the mouth of the Missouri River the sum of $10,000 "shall be expended for the protection of the bank on the Missouri side and to deepen and to straighten the channel at Wittenberg, in Perry County, in the State of Missouri." Captain Burr, the local officer, reports that a careful examination and survey of the

locality in which the work is proposed to be done under this allotment of $10,000 have been made and fail to show that any work is necessary for the protection of the bank on the Missouri side or for straightening the channel at any point in the neighborhood of Wittenberg; the Missouri bank requires no attention, and the channel is in a good and satisfactory condition. I recommend, therefore, that the provision requiring the expenditure of funds at this locality be repealed, and that authority be given for use of the amount on the general work for improvement of the Mississippi River between the mouth of the Ohio and the mouth of the Missouri.

Recapitulation of commercial statistics.

	1896.	1897.	1898.	1899.
	Tons.	*Tons.*	*Tons.*	*Tons.*
Receipts and shipments at St. Louis	1,244,175	1,046,035	906,168	669,815
Transferred by ferries at St. Louis	2,529,786	3,042,674	4,033,871	5,036,730
Shipped from landings between St. Louis and Cairo	75,513	69,815	53,785	30,716
Total	3,849,474	4,158,524	4,993,824	5,737,261

July 1, 1899, balance unexpended		$911,130.92
September 11, 1899, transferred from appropriation for preventing break in Mississippi River at Beechridge, Ill		9,587.48
March 17, 1900, transferred from appropriation for preventing break in Mississippi River at Beechridge, Ill		12,714.84
January 17, 1900, redeposited by Maj. Thos. H. Handbury, Corps of Engineers, to credit of appropriation		5.84
Allotted from appropriation in sundry civil act approved June 6, 1900		100,000.00
		1,033,439.08
June 30, 1900, amount expended during fiscal year		541,560.84
July 1, 1900, balance unexpended		491,878.24
July 1, 1900, outstanding liabilities	$7,457.43	
July 1, 1900, amount covered by uncompleted contracts	42,841.01	
		50,298.44
July 1, 1900, balance available		[1]441,579.80
Amount that can be profitably expended in fiscal year ending June 30, 1902, for works of improvement and for maintenance, in addition to the balance available July 1, 1900. Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867, of section 7 of the river and harbor act of 1899, and of sundry civil act of June 4, 1897.		750,000.00

(See Appendix Z 2.)

3. Harbor at St. Louis, Mo.—St. Louis Harbor is about 18 miles long and divided into two nearly equal parts by the Eads Bridge. The upper part, included between the bridge and the northern limits of the city, is about 10 miles in length.

Three miles above the Eads Bridge is the Merchants Bridge. The lower part of the harbor, included between Eads Bridge and the River

[1] Of this balance special allotments have been made by Congress, as follows:

Bank protection at Cairo, Ill., act of July 5, 1884 (balance)	$7,400.00
Bank protection on east side of Mississippi River, opposite mouth of Missouri River, acts of June 3, 1896, and March 3, 1899	52,487.76
	59,887.76

TABLE No. 2.—*Summary of expenses for operating U. S. snag boats H. G. Wright and J. N. Macomb in connection with work of removing obstructions in Mississippi River during fiscal year ending June 30, 1900*—Continued.

Application.	1900.						
	January.	February.	March.	April.	May.	June.	Total.
Office expenses	$4.00	$980.43	$4.92	$184.70	.....	$79.33	$2,528.41
Expenses of U. S. snag boat H. G. Wright:							
Crew	4,239.00	2,087.49	1,766.50	1,403.33	$1,422.00	1,757.50	22,760.98
Outfit	.....	.....	.....	161.92	1,098.74	61.22	1,321.88
Fuel	753.00	603.60	63.00	136.00	11.00	484.00	5,188.82
Subsistence	384.46	369.13	157.60	139.33	266.78	791.23	5,495.12
Supplies	.....	.....	4.50	578.64	466.98	37.56	1,337.68
Repairs	.....	10.00	.....	2,115.45	1,663.89	366.14	4,325.21
Miscellaneous	.....	9.90	.....	.....	8.70	16.10	35.52
Expenses of U. S. snag boat J. N. Macomb:							
Crew	2,122.50	2,160.50	1,993.33	1,425.00	1,425.00	1,421.51	22,604.34
Outfit	.....	.....	.....	10.08	24.65	1,604.86	1,642.34
Fuel	1,077.50	1,005.00	1,106.00	76.50	.....	18.79	7,972.06
Subsistence	873.53	104.79	405.01	24.49	316.12	462.40	5,343.73
Supplies	.....	.....	.....	29.54	76.42	962.15	1,154.29
Repairs	.....	.....	.....	388.72	973.79	929.64	4,604.81
Miscellaneous	.....	.....	.....	.....	7.50	16.10	40.10
Total	9,453.99	7,330.84	5,500.86	6,673.70	7,762.07	9,028.53	86,365.29

Z 2.

IMPROVEMENT OF MISSISSIPPI RIVER BETWEEN OHIO AND MISSOURI RIVERS.

The object of the improvement is to obtain eventually a minimum depth at standard low water of 6 feet from the mouth of the Missouri River to St. Louis, a distance of 16 miles, and of 8 feet at the same stage of water from St. Louis to the mouth of the Ohio River, 178 miles, the natural depth being in many cases from 3½ to 4 feet. The channel is divided at a number of points by islands, forming sloughs and secondary channels behind them, through which a large portion of the volume of the flow is diverted, to the detriment of navigation.

The initial point of the work for the lower portion is St. Louis, the programme being to make the work continuous, proceeding downstream from that city.

The first work for improvement began in 1872 and was continued for a number years, as appropriations were made, the works consisting of dikes and dams of brush and stone, erected with a view to confining the low-water volume to one channel, and of revetments to hold and preserve the banks where necessary or advisable.

Under these appropriations work of this character was done at the following localities between the mouth of the Ohio and the mouth of the Illinois River, viz: Piasa Island, Alton Harbor, Sawyer Bend, St. Louis Harbor, Arsenal Island, Horsetail Bar, Carroll Island, Fort Chartres, Turkey Island, Kaskaskia Bend, Liberty Island, Devils Island, and in the vicinity of Cairo, Ill.

The present project is a continuation of the plan adopted in 1881 and contemplates, below St. Louis, the reduction of the width of the river to about 2,500 feet, the natural width being in many cases from 1 to 1½ miles. Where the width and alignment of the river are satisfactory, these conditions are to be maintained by protecting the banks from erosion when necessary. In contracting the width of the river

permeable dikes or hurdles are employed to collect and hold the solid material brought down by the river and thus to build out to the adopted line new banks which are protected by revetment where necessary. Other means are also used occasionally for completing or hastening the result desired.

A hurdle, as the term is here used, is one of many silt-arresting devices that have been experimented upon in this country and elsewhere. The hurdles consist, essentially, of a row or of parallel rows of piling, the piles driven either singly or in clumps, the piling being connected lengthwise of the hurdle by wattling of fine brush or by curtains composed of brush and lodged against the upstream side of one of the rows of piles, the whole forming a permeable dike through which the silt-laden current can pass, though with greatly diminished velocity, resulting in deposits of silt above and below the hurdles.

These deposits are generally soon overgrown with willows or cottonwood, and after they arrive at sufficient height they can be revetted on their river fronts.

To guard against loss by scour of the piles, a broad, flexible mattress is first sunk on the line of the hurdle. Through this mat the piles and clumps of piles are driven.

At the shore end of the hurdle the bank is protected against scouring or caving by a revetment 300 feet long, of which 200 feet is placed below the axis of the hurdle. The channel end of the hurdle is constructed with a tee head to hold drift and to break somewhat the eddy or whirl at that point. It is also protected by an ample mattress and where necessary is strengthened against damage by ice and drift by a buttress of brush and stone. The drift collected upon the upper face of the hurdle is sunk from time to time when necessary to further strengthen the work.

In constructing the shore revetment a mat about 120 feet or more in width, its inner edge at the surface of standard low water, is sunk. The bank is then eventually graded to a slope of one-half and covered with riprap. Where necessary to grade the bank by artificial means the grading is done by the hydraulic method, or by means of shovels, etc.

Reference should be made to the Report of the Chief of Engineers for 1894, Appendix X, pages 1577 et seq., for information relating to the development of the various forms of construction used and for a résumé of the various types used between 1872 and 1894, and to the Reports of the Chief of Engineers for 1895 (p. 2059), 1896 (p. 1717), 1897 (p. 2012), and 1898 (p. 1698), Appendixes W, W, W and Y, respectively, for minor changes in the forms of construction.

During the past year the general types of construction in use in recent years have been followed. Hurdles have been constructed of one, two, or three rows of clumps of piles, the number of piles in each clump being two or more, with stringers of pile timber placed between adjacent rows of clumps to solidify the structure. Owing to the increasing scarcity of suitable and available brush the use of lumber for mattress construction has become greater. Common cull lumber, 1 inch thick and from 4 to 6 inches wide, is found to make an excellent substitute for brush, excepting for that portion of hurdle mattresses through which piles are driven and at points where special strength is required. The cost of the lumber mattress is slightly less than of brush at present prices, the increased cost of material being offset by

decreased cost of labor, and lumber permits of more rapid construction on account of greater facility in handling the material. At present lumber is used for the downstream portion of hurdle mattresses, for the offshore portion or the whole of revetment mattresses, and entirely for mattresses for sinking drift above hurdles.

Since the adoption of this project work has been done substantially according to the methods referred to above at the following localities: Piasa Island, Alton Harbor, mouth Missouri River, St. Louis Harbor, Cahokia Chute, Arsenal Island, Horsetail Bar, Carroll Island, Twin Hollows, Pulltight and Beards Island, Chesley Island, Jim Smiths, Sulphur Springs, Foster Island, Lucas, Cornice Island, Calico Island, Michaels Landing, Osborne Field, Rush Tower, Danby Landing, Fort Chartres, Crooks Landing, Turkey Island, Ste. Genevieve, Kaskaskia Island, Horse Island (Chester), Clearyville, Liberty Island, Seventy-six Landing, Hamburg, Devils Island, Minton Point, Cape Girardeau, Commerce Island, Burnham Island, Powers Island, Goose Island, Buffalo Island, and vicinity of Cairo.

Since the last annual report work for the permanent improvement of the river has been carried on in the following localities:

Opposite mouth Missouri River, Twin Hollows, Chesley Island, Lucas, Calico Island, Michaels Landing, Osborne Field, Danby Landing, Ste. Genevieve, Kaskaskia Island, Horse Island (opposite Chester), Liberty, Hamburg, and Devils Island.

Work for the temporary improvement of the low-water channel by the use of dredging appliances and portable jetties was carried on at Sulphur Springs, Turkey Island, Ste. Genevieve Bend, and at the entrance of the winter harbor.

PERMANENT IMPROVEMENT.

Mouth of the Missouri River.—The acts of Congress of June 3, 1896, and March 3, 1899, each made an allotment of $50,000 for the protection of the Illinois bank below the mouth of the Missouri River, this sum of $100,000 being withdrawn from the appropriation for the general improvement. This bank was wearing slowly, but in no immediate need of attention. At other points on the river the banks were caving rapidly and the money could have been applied to much greater advantage elsewhere. Beginning at Gillams Landing the bank was protected by a subaqueous mattress for a distance of 10,030 feet downstream. For 6,000 feet of this distance the bank was revetted to the 8-foot stage (St. Louis gauge) and to the 5-foot stage for the remaining 4,030 feet.

Twin Hollows, Ill. (14 miles below St. Louis).—This revetment was placed in 1882 and years following and from time to time slight repairs have been made to it. During the high water of 1899 some breaks occurred and 2,500 linear feet of the revetment was repaired and placed in good condition.

Chesley Island, Mo. (19 miles below St. Louis). The Chesley Island revetment was placed in 1882 and during the past year was repaired where necessary, particularly in the 1,000 feet at the lower end.

Lucas, Ill. (29 miles below St. Louis).—Much difficulty was experienced at this locality during the last low-water season on account of shoal and badly located channels and crossings. The local project had not provided a sufficient contraction of width and the projected works

had not all been constructed to their full projected lengths. A new local project has been adopted providing for a further extension of the Illinois system of hurdles in order to contract the river to the generally projected width of 2,500 feet, with minor rectification of the irregular Missouri shore should it be subsequently deemed necessary. Work upon the projected extensions shown on Plate III accompanying the last annual report was begun in April, 1899, and during that fiscal year hurdles Nos. 14 and 16 were constructed and hurdles Nos. 9, 11, 13, and 15 were repaired and extended. During the past fiscal year hurdles Nos. —4, —3, —2, and —1 were constructed and completed excepting as to the channel end of hurdle No. —1. Work was also don upon hurdles Nos. 0, ½, 5½, 6, 7, 11, 13, 14, and 16. The total construction was 4,960 feet of hurdle. No difficulties were experienced in this reach during the low-water season.

Calico Island (30 miles below St. Louis).—The Calico Island protection was placed in 1891 and 1892, and was damaged at its upper end for about 350 feet. It was repaired by a subaqueous mattress and by such bank revetment as was required.

Michaels Landing (36 miles below St. Louis).—Hurdle No. 2 of this series was constructed in 1897, with a stone dike as a shore connection. This dike having settled somewhat, it was raised to a stage of 23 feet (St. Louis gauge) by the use of 1,140 cubic yards of stone.

Osborne Field, Ill. (36 miles below St. Louis).—The Illinois bank between Osborne Field and Durfees Landing was protected during the seasons of 1892–93 and 1893–94 by the customary type of revetment to a length of 8,770 feet, carried up to a 16-foot stage. Having been completed only to the foot of the bluff bank and not to high water, the work suffered somewhat during the high waters of 1896 and 1897, in both of which years slight repairs were made. In the spring of 1898 the revetment was again broken during high water, and subsequently thoroughly repaired. During the high water of 1899 damages again occurred, and during the past year repairs were made along 3,000 linear feet of revetment.

Danby Landing, Mo. (39 miles below St. Louis).—The protection of the caving bank at and below Danby Landing for a length of 4,750 feet was begun in 1895 and continued as the abrupt bank was graded by subsequent high waters. In the fall of 1897 some repairs were made at the lower end of the work where the current threatened to get behind the revetment, and in 1899 the work was thoroughly repaired and extended to the foot of the bluff bank, 16 feet above low water. During the past year the bank above this work began caving, and the protection was extended 700 feet upstream by a subaqueous mattress. Additional work is necessary at this point for the protection of that already placed.

Ste. Genevieve, Ill. (57 miles below St. Louis).—Hurdles Nos. 2, 3, and 4 of this series were constructed in 1891–92 from a special appropriation for the preservation of the landing for Ste. Genevieve at Little Rock, Mo. They had subsequently been broken, and, not having been repaired, a considerable body of water was diverted from the main channel to the great detriment of the latter at the Turkey Island crossing, where some difficulty was experienced during low water. In connection with the temporary low-water work hurdle No. 2 of this series was rebuilt for a length of 850 feet. A break having occurred

in hurdle No. 15 for a length of 250 feet, it was also repaired and closed.

Ste. Genevieve, Mo. (60 miles below St. Louis).—In 1898 it became necessary to protect the soft and rapidly caving sand bank on the Missouri shore at the lower end of Ste. Genevieve Bend in order to preserve a proper alignment for the river channel. This was done by placing in front of it a good, substantial, low-water revetment and revetting the bank above this with stone to the height of the 10-foot stage. In 1899 this protection was extended downstream 2,350 feet, making the total length 7,950 feet, and was raised to 16 feet above low water. During the past year repairs were made to the lower 1,000 feet of this revetment.

Kaskaskia Island (71 miles below St. Louis).—In the spring of 1881 the Mississippi broke through into the Kaskaskia River at the head of what is now Kaskaskia Island. This cut-off shortened the distance from the head to the foot of the island by 6.5 miles, and, rapidly widening and deepening, soon became the main channel of the river. Since the occurrence of the break the banks of the cut-off have been caving at most points at a more or less rapid rate, and during the high water of the spring of 1898 the bank at the lower end of the island was eroded to a line at which it was desireable to hold it for the preservation of Chester Harbor and of a good channel alignment. Five thousand seven hundred feet of the bank at the lower end of the island was therefore protected by the usual revetment, which, by grading the bank, was carried up to the 16-foot stage or to the top of the bank, where it did not stand that high. During the past year repairs were made upon 3,000 feet of the bank protection.

Horse Island, Missouri (Chester, 72.7 miles below St. Louis).—As a result of the erosion of the bank at the lower end of Kaskaskia Island during the high water of 1898, the Missouri bank at Horse Island, opposite Chester, Ill., and immediately across Old River from the Kaskaskia work, was subjected to a very strong current during the high water of this year and began to cave rapidly. A continuation of this caving would affect adversely the present favorable channel alignment and conditions at and in the harbor of Chester and endanger the existing protection of the Missouri bank at Clearyville, below. It was decided to protect this point at once, and operations were begun in May, 1899, resulting in the placing of 4,058 feet of subaqueous revetment and stopping the erosion. In the fall of 1899 this work was repaired where necessary and the revetment was extended up the bank to a height of 20 to 24 feet above low water, excepting the 200 feet at the upper end, which was raised to a height of from 15 to 20 feet.

Liberty, Mo. (82 miles below St. Louis).—Before improvement the Liberty reach was, during low water, one of the most troublesome between St. Louis and Cairo, and its improvement by the construction of a series of hurdles on the Missouri bank was begun in 1896. The result of this work was a marked and prompt improvement in navigation. Hurdles Nos. 7 and 10 of this series having been broken near their shore ends, the necessary repairs were undertaken and were in progress on No. 10 at the close of the fiscal year.

Hamburg, Ill. (120 miles below St. Louis).—In this vicinity there was a reach of river difficult to navigate at low water. The water was divided into two channels by Hamburg Island, and where these joined

below the island the width of the river bed is excessive. It is a region of troublesome sand bars and shoals. During the higher stages of the river the Illinois shore to the east of the island was subject to erosion and much valuable land was destroyed.

The first step looking toward the improvement of this reach for low-water navigation was evidently to close the chute between Hamburg Island and the Illinois shore. This was effected by the construction, during July and August, of two permeable hurdle dams. One, 2,860 feet in length, was located across the head of the chute; the second is 6,600 feet below this and about 700 feet below the caving bank on the Illinois shore. This is 1,225 feet in length. For a description of these hurdles see Report of the Chief of Engineers for 1898, page 1703.

The closing of this chute, even by these permeable structures, had a marked effect during the fall low-water season in increasing the depth of navigable water through the channel on the west side of the island, and the high water of 1898 caused an extensive fill about the head of the chute. Both hurdles were, however, broken during that high water, and by the fall of 1898 the opening in the upper hurdle had widened to 400 feet. The break was closed and the hurdle repaired, but the hurdle was again broken at the other end by ice during the winter of 1898–99. Repairs by sinking drift and closing this break were in progress at the beginning of the year and were then completed. Weakness having developed in this hurdle (No. 5) in the spring of 1900, it was repaired and strengthened to prevent the threatened break.

Devils Island (124 miles below St. Louis).—The reach of the river mentioned above extends down to the Devils Island country a reach that has always given more or less trouble to steamboat men during low water. Considerable work has been done in this region in former years, commencing as far back as 1874. A dam was built closing the chute between Picayune Island and the Illinois shore and one closing the chute between this island and Devils Island. These have subserved the object for which they were built. The contraction works formerly built near Minton Point and opposite Cape Girardeau are now practically destroyed.

Rapid erosion has taken place of the newly formed land above the heads of these islands, and it was feared that if not stopped it would result in the destruction of the dams. To stop this erosion and at the same time put some sort of limit to the river in that direction and get it into shape for passing the town of Cape Girardeau it was deemed necessary to undertake work of considerable magnitude in this vicinity.

A hurdle, No. 1, 1,200 feet long was built across the old head of Devils Island chute in the fall of 1897. The Illinois bank was revetted for a distance of 1,650 feet above this hurdle and the island bank for a distance of 4,320 feet downstream from the hurdle. Two hurdles, Nos. 9 and 11, were built at the lower end of the island during the same season. For a description of these and other works in this reach see Report of the Chief of Engineers for 1898, page 1703.

Hurdle No. 1 was broken during the high water of 1898, but was reestablished and extended to the head of the island, which had been cut away. The revetment of the Illinois bank was repaired. The downstream revetment was extended 3,100 feet to the end of the caving bank and raised to the 4-foot stage. The revetment on the head and west face of the island was raised to a 15-foot stage. The channel end of Hurdle No. 9 was strengthened and drift was sunk above Nos. 1, 9, and 11.

During the spring high water of 1899 Hurdle No. 1 was again broken, and during the past year this break was closed and the hurdle strengthened by drift sinking, as were also Hurdles Nos. 9 and 11 of the same series.

The bank protection at Swift Sure, the upstream portion of the work, was extended upstream 700 feet and the revetment on the face of Devils Island was raised to higher stages.

Cairo protection.—For a description of this work reference is made to the Annual Reports of the Chief of Engineers for 1876 to 1881, inclusive, and for 1885, 1887, and 1899. Some apprehension as to the safety of this work was caused by the erosion of the accretions above it at Eliza Towhead, but a careful examination at low water failed to indicate any change in its condition.

Plates I and II, accompanying, show the river from the mouth of the Missouri to the mouth of the Ohio, and the relation of the various works of improvement to each other and to the section of the river affected by each. The improvement in accordance with the adopted general project is extensive and progressive. While it is practically continuous for 60 miles below St. Louis, it is not complete at any point, and in the lower section work has been confined to such points as give the greatest trouble to navigation and return the greatest relief for the money expended. It is not expected that the contraction works constructed in new localities in the past and preceding year will be all that are required to rectify the river in their respective localities. They are only the commencement of certain series which it will be necessary to construct to hold the river permanently. Their location has been so chosen as to give the best results with the money available and to minimize the amount of work to be done during the following low-water seasons with the expedients now available for the temporary improvement of the channel.

TEMPORARY EXPEDIENTS.

Work of a temporary character for the relief of navigation during the low-water season of the summer and fall of 1899 was done at Sulphur Springs, Turkey Island, Ste. Genevieve Bend, and at the entrance to Old River, at Chester, Ill.

Dredge No. 4 was in commission from September 7, 1899, to November 29, 1899, and dredge No. 2 was operated at intervals by the crew of dredge No. 4, in connection with the work at Old River.

At Sulphur Springs and at Turkey Island the conditions were somewhat similar. With an excessive width of river, a diagonal reef was formed in each case, over which the channels were variable and of insufficient depth. Dredging was resorted to in each place, and with the progress of the low-water season redredging was necessary as new channels developed. The results were generally satisfactory as to depth but not to the extent obtainable by permanent works.

In Ste. Genevieve Bend a shoal developed at the approach of low water, but after once being dredged, a good depth was maintained during the season.

At Turkey Island a portable jetty 1,200 feet long was placed, but while its effect was beneficial, the assistance of dredges was necessary.

For details relating to portable jetties and dredging appliances reference is made to the Annual Reports of the Chief of Engineers for 1881, 1882, 1889, and 1895 to 1898, inclusive.

PLANT.

The plant belonging to the appropriation has been maintained in efficient working condition during the year.

Mr. Ed. J. Howard, of Jeffersonville, Ind., delivered on December 5, 1899, the steel hulled towboat built under his contract of October 17, 1898, at a cost of $67,750. Of the three steel hulled steam tenders built by the same contractor, at a cost of $18,150 each, under his contract of January 31, 1899, two were delivered on April 19, 1900, and the third on June 11, 1900. Contract was entered into on July 17, 1899, with Mr. Ruell C. Arnold, Leavenworth, Ind., for the construction of 60 flatboats and is as yet not completed.

Under formal contracts 241,796 feet of first-class pile timber and 117,660 feet of second-class pile timber were purchased during the year; also 25,522.2 cubic yards of riprap stone, under formal contracts.

By hired labor there were obtained at the Government quarries at Little Rock, Mo., 50,114 cubic yards of stone at an average cost of 87.5 cents per cubic yard loaded on barges. In addition to these amounts, 7,733.5 cubic yards were purchased in open market. From various points 948.8 cords of brush were obtained at an average cost of $2.74 per cord loaded on barges.

Mr. D. M. Currie has continued to discharge the duties of principal assistant engineer upon the works, and Mr. William S. Mitchell and Mr. John O. Holman in charge of the parties in the field. The quarrying of stone by hired labor was in charge of Mr. E. D. Libby, assistant engineer. The engineer depot, at which a large part of the supplies for the work of the district is assembled and distributed, and repairs to tools and additions and repairs to floating plant are made, has been continued in charge of Superintendent C. D. Lamb. All these gentlemen, together with the office force connected with the work, have discharged their several duties intelligently and faithfully. For further details concerning the operations of the year attention is invited to the appendixes herewith.

ESTIMATES.

The original estimate of the cost of the improvement of the Mississippi River between the mouth of the Ohio and the mouth of the Missouri River as revised in 1883 is $16,397,500.

The aggregate amount of funds appropriated and made available for this work to June 30, 1900, is $9,624,999.98.

The total appropriations to date amount to $9,804,999.98. Of this amount $180,000 was allotted by acts and projects for improvement between the Illinois and the Missouri rivers, including Alton Harbor, leaving a balance of $9,624,999.98, as stated above, to be applied to the project for the general improvement of the river between the mouth of the Missouri and the mouth of the Ohio rivers.

Of this amount there was on hand June 30, 1900, an available balance of $441,579.80, exclusive of outstanding liabilities. The amount that has been expended upon the project to this date is therefore $9,364,899.50.

The amount expended during the fiscal year ending June 30, 1900, is $541,560.84.

The river and harbor act approved June 3, 1896, provides:

That any balance of former appropriations now available and the money hereby appropriated and authorized to be expended for the said section of said river between

the mouth of the Missouri River and the mouth of the Ohio River, or so much thereof as may be necessary, shall be expended in the construction of suitable dredge boats, portable jetties, and other suitable appliances, and in the maintenance and operation of the same, with the view of ultimately obtaining and maintaining a navigable channel from St. Louis to Cairo, not less than 250 feet in width and 9 feet in depth at all periods of the year, except when navigation is closed by ice.

In the $9,364,899.50 above mentioned is included what has been expended for dredge plant, portable jetties, and appliances for temporary improvement of the channel and for operating the same. This amounts to about $533,489.53. Of this $62,317.64 was expended during this fiscal year. The present value of the plant pertaining to this temporary work is now estimated at approximately $232,846.24.

The available balance includes the unexpended balances from special allotments made by Congress, as follows:

For bank protection at Cairo, Ill., act of July 5, 1884	$7,400.00
For bank protection on east side of Mississippi River, opposite to mouth of Missouri River, acts of June 3, 1896, and March 3, 1899	52,487.76
Total	59,887.76

The balance of the estimate for the original project not appropriated June 30, 1900, is $6,592,500.02.

It is estimated that the sum of $1,000,000 can be profitably and economically expended during the fiscal year ending June 30, 1902, in the permanent improvement of the river, in accordance with the original project and in the work of temporary improvement, with a view to obtaining a navigable channel from St. Louis to Cairo not less than 250 feet wide and 9 feet deep at all periods of the year, in accordance with the requirements of the river and harbor act of June 3, 1896. Of this amount it is estimated that $150,000 will be expended upon the operation and maintenance of dredges, portable jetties, and other appliances for the temporary improvement of the river.

It is believed that the importance of this improvement is conceded, and that therefore no argument as to its desirability or necessity is required. Such being the case, the only question at issue is its successful and economical prosecution to a proximate completion. The work is of great magnitude and cost, and is of such a character that, unless pressed with such appropriations as its magnitude warrants, satisfactory results either as to progress or economy can not be expected. Successful results from the partial execution of the projected improvement will be of no great value to through traffic, the most important class of navigation, until extended throughout the full length of this reach. Uncompleted works suffer damage and depreciation by inability to protect and complete them on account of partial or complete failure of appropriations, and the large plant required for their prosecution entails a considerable loss by its care and depreciation during each suspension of operations, as was the case during the last half of the past fiscal year.

In order that the work can be intelligently and economically carried forward, ample appropriations for a term of years should be provided, as is now done in the case of important contract works, and an appropriation of $1,000,000 per annum for five years is earnestly recommended for this purpose.

This work is in the collection district of New Orleans. The nearest port of entry is St. Louis, Mo., at which place the customs collected during the fiscal year ending June 30, 1900, amounted to $1,511,005.21. The amount of internal revenue collected was $14,641,090.91.

Money statement.

July 1, 1899, balance unexpended		$911,130.92
September 11, 1899, transferred from appropriation for preventing break in Mississippi River at Beechridge, Ill		9,587.48
March 17, 1900, transferred from appropriation for preventing break in Mississippi River at Beechridge, Ill		12,714.84
January 17, 1900, redeposited by Maj. Thos. H. Handbury, Corps of Engineers, U. S. A., to credit of appropriation		5.84
Amount appropriated by sundry civil act approved June 6, 1900		100,000.00
		1,033,439.08
June 30, 1900, amount expended during fiscal year		541,560.84
July 1, 1900, balance unexpended		491,878.24
July 1, 1900, outstanding liabilities	$7,457.43	
July 1, 1900, amount covered by uncompleted contracts	42,841.01	
		50,298.44
July 1, 1900, balance available		[1]441,579.80
Amount that can be profitably expended in fiscal year ending June 30, 1902, in addition to the balance available July 1, 1900:		
For works of improvement	$850,000.00	
For maintenance of improvement	150,000.00	
		1,000,000.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867, of section 7 of the river and harbor act of 1899, and of sundry civil act of June 4, 1897.		

LIST OF APPROPRIATIONS.

By act of—	
June 10, 1872	$100,000.00
March 3, 1873	200,000.00
June 23, 1874	200,000.00
March 3, 1875	200,000.00
August 14, 1876	200,000.00
June 18, 1878	240,000.00
March 3, 1879	200,000.00
June 14, 1880	250,000.00
March 3, 1881	600,000.00
August 2, 1882	600,000.00
July 5, 1884	520,000.00
August 5, 1886	375,000.00
August 11, 1888	300,000.00
September 19, 1890	400,000.00
July 13, 1892	525,000.00
March 3, 1893	658,333.33
August 18, 1894	758,333.33
March 2, 1895	758,333.33
June 3, 1896	275,000.00
June 4, 1897	673,333.33
July 19, 1897	325,000.00

[1] Of this balance special allotments have been made by Congress, as follows:

Bank protection at Cairo, Ill., act of July 5, 1884 (balance)	$7,400.00
Bank protection east side of Mississippi River, opposite mouth of Missouri River, acts of June 3, 1896, and March 3, 1899	52,487.76
Total	59,887.76

By act of—Continued.	
July 1, 1898	$673,333.33
March 3, 1899	673,333.33
June 6, 1900	100,000.00
Total	9,804,999.98

List of contracts in force.

Articles.	Name of contractor.	Date of approval.	Date of beginning work.	Date of expiration.
8 tenders	Ed. J. Howard	Feb. 7, 1899	10 days after notice.	Sept. 6, 1899.
6,000 piles, more or less	T. J. Moss Tie Co.	Feb. 16, 1899	15 days after notice.	When delivery is completed.
20,000 cubic yards stone, more or less.	Jno. A. Lohrum	Feb. 25, 1899	do	Do.
6,000 piles, more or less	Fred. Hartweg	Feb. 28, 1899	do	Do.
20,000 cubic yards stone, more or less.	Emeline E. Burke	Mar. 8, 1899	do	Do.
60 flatboats	Ruell C. Arnold	July 27, 1899	10 days after notice.	July 29, 1900.

COMMERCIAL STATISTICS.

Receipts and shipments at St. Louis, Mo., during the years 1896–1899.

Articles.	Receipts.				Shipments.			
	1896.	1897.	1898.	1899.	1896.	1897.	1898.	1899.
Barbed wire, ores, and metals (pig and manufactured)	*Tons.* 30,336	*Tons.* 25,449	*Tons.* 15,424	*Tons.* 2,001	*Tons.* 2,277	*Tons.* 2,513	*Tons.* 2,240	*Tons.* 2,049
Cement	9,342	4,747	1,915	1,131	.....	.....	.....	.....
Coal and coke	50,820	22,490	24,850	36,350	99,588	117,280	69,555	.....
Cotton and cotton products	2,822	1,803	2,221	2,623	10	1,776	1,115	1,825
Groceries and dairy products	14,449	18,311	23,592	19,395	9,919	9,492	11,886	10,353
Hay, seed, grain, flour, meal, etc	55,148	34,694	54,934	41,335	350,180	230,221	218,889	90,889
Live stock and products	27,474	24,153	21,579	22,122	10,233	9,130	5,790	6,346
Lumber	173,891	103,165	129,376	36,572	5,457	4,480	3,945	724
Merchandise and sundries	300,741	327,993	228,321	291,793	85,213	81,895	78,199	82,505
Vegetables and fruit	6,383	13,513	4,191	9,848	2,076	2,810	1,856	3,169
White lead, oils, etc	44	90	25	152	2,575	1,975	2,077	1,128
Wines and liquors	50	30	24	9	4,911	4,721	3,677	4,217
Wool	206	232	113	279	1	12	24	.....
Total	671,765	576,670	506,585	466,610	572,410	469,355	399,583	203,205

Transferred by ferries across the river at St. Louis.

	Tons		Tons.
1896	2,589,786	1898	4,033,871
1897	3,042,674	1899	5,036,730

Shipments down the river from landings between St. Louis and Cairo during the years 1896–1899.

Grain, including flour, meal, etc., and coal:	Tons.
1896	75,513
1897	69,815
1898	53,785
1899	30,716

1901

An annual appropriation, not to exceed $100,000, for carrying on this work was made by the act of August 11, 1888. Under this appropriation the two snag boats will patrol the river and remove obstructions where necessary.

For recapitulation of commercial statistics reference should be made to report upon improving Mississippi River between Ohio and Missouri rivers.

Amount drawn under section 7, act of August 11, 1888	$86,710.05
June 30, 1901, amount expended during fiscal year	86,710.05
July 1, 1901, amount available for fiscal year 1901–2	100,000.00

(See Appendix Y 1.)

2. Mississippi River between Ohio and Missouri rivers.—The original condition of the navigable channel of this portion of the Mississippi River before the work of improvement was begun was such that the natural depth at low water was in many places from 3½ to 4 feet. The channels were divided by islands, which formed sloughs and secondary channels, through which a great deal of the volume of the flow was diverted, to the detriment of navigation.

The first work for improvement began in 1872, and was continued for a number of years as appropriations were made, the works consisting of dikes and dams of brush and stone, erected with a view to confining the low-water volume to a single channel, and of revetments, to hold and preserve the banks where necessary or advisable to do so.

The present project is a continuation of the plan adopted in 1881. It contemplates confining the flow of the river to a single channel having an approximate width below St. Louis of 2,500 feet, the natural width in many places being from 1 to 1½ miles. This result is to be accomplished by closing sloughs and secondary channels and by building out new banks where the natural width is excessive, using for this purpose permeable dikes or hurdles of piling that collect and hold the solid matter that is carried in suspension or rolled on the bottom by the river. The banks, both old and new, are to be revetted or otherwise protected where necessary to secure permanency. Pending the completion of the permanent improvement, the low-water channel is to be improved each season by the use of dredges and other temporary expedients.

The object of the improvement is to obtain eventually a minimum depth, at standard low water, of 6 feet from the mouth of the Missouri to St. Louis, and of 8 feet from St. Louis to the mouth of the Ohio.

The original estimate of the cost of the improvement, as revised in 1883, is $16,397,500.

The total amount expended to June 30, 1900, was $9,155,433.03, exclusive of $180,000 allotted by acts to projects for improvement between the Illinois and the Missouri rivers, including Alton Harbor.

The amount expended during the fiscal year ending June 30, 1901, includes $42,718.52 expended during the year for dredge plant, portable jetties, and for operating the same. The total amount thus far expended for what is termed temporary channel improvements is $576,208.05, much of which has been for plant that is now on hand and available for future work. The approximate value of this plant is $225,526.27.

The result of the expenditure of this amount has been the partial improvement of the whole reach of the river from St. Louis to Cairo. During the past year there was at all times during open navigation a

channel depth of 5 feet or more throughout this reach, and, excepting for a few days, a depth of 6 feet or more. The river reached a low-water stage of 3.4 feet below standard low water.

The work done during the past year in the line of permanent improvement consisted in repairs to existing contraction works and revetments and a further extension of the same in localities where work had been commenced, in addition to new works in localities where no work had heretofore been done.

For the permanent improvement of the river new works were constructed or extended opposite the mouth of the Missouri River, at Osborne Field, Rush Towhead, Penitentiary Point, Ste. Genevieve, Mo., Horse Island (opposite Chester), Liberty, Ill., Devils Island, and Buffalo Island for the protection of caving banks and at Ste. Genevieve, Ill., for the improvement of a shoal crossing.

Repairs were made to existing revetments at Danby Landing, Liberty, Mo., and to Cairo protection, and to existing hurdles at Liberty, Mo.

Dredging for the improvement of the low-water channel was carried on at Sulphur Springs, Crystal City, Stantons Towhead, Winter Harbor in Old River, Manskers, and Bainbridge. Buoys were maintained on all shoal crossings during the low-water season.

With the present appliances and such others as may be developed for the temporary improvement of low-water channels, it is expected that a navigable depth of at least 6 feet will be maintained between St. Louis and Cairo during all low-water stages that the river is open to navigation, and until the projected depth is obtained throughout by the extension and completion of the works for the permanent improvement. There can be no doubt of the ultimate success of this permanent improvement and of its value to the commercial interests involved.

To prevent the suspension of this important work for lack of funds, the river and harbor act of June 3, 1896, made provision for three years' work from July 1, 1897, to be paid for as appropriations should be made by law, at the rate of $673,333.33 annually. The last of these annual appropriations was provided by the act of March 3, 1899, and was practically exhausted by June 30, 1900. By suspending all operations during the last half of the previous fiscal year sufficient funds were reserved for emergencies and for urgent low-water operations during the past season. To the amount thus reserved $100,000 was added by allotment from the act of June 6, 1900, but the total of all available funds, after deducting allotments for specific localities, was sufficient for only three months' work with a limited force after reserving sufficient funds for the care of the large and valuable plant belonging to this work until other appropriations become available. All operations were suspended during the last half of the fiscal year, and there appears no probability of resuming them during the next fiscal year. The total loss of time by reason of the failure of appropriations will therefore be at least two years. The loss to the Government and to the commerce of the Mississippi River by the interruption of work on this important improvement can not be even approximately stated. The care and depreciation of plant will alone cost the Government more than $100,000 for each year's suspension, with absolutely no return. The improvement not only makes no progress, but actually retrogrades, and navigation interests are decreasing from failure to obtain and maintain such channels as are necessary for economical transportation. It seems now certain that the procuring of satisfac-

tory channels at all seasons of open navigation is merely a matter of providing funds in sufficient amounts to do the work economically. The local officer states that $150,000 is required annually for temporary low-water operations alone.

The sundry civil act approved March 3, 1899, requires that from the appropriation made by that act for improving the Mississippi River from the mouth of the Ohio River to the mouth of the Missouri River the sum of $10,000 "shall be expended for the protection of the bank on the Missouri side and to deepen and to straighten the channel at Wittenberg, in Perry County, in the State of Missouri." Captain Burr, the local officer, reports that a careful examination and survey of the locality in which the work is proposed to be done under this allotment of $10,000 have been made and fail to show that any work is necessary for the protection of the bank on the Missouri side or for straightening the channel at any point in the neighborhood of Wittenberg; the Missouri bank requires no attention, and the channel is in a good and satisfactory condition. I recommend, therefore, that the provision requiring the expenditure of funds at this locality be repealed, and that authority be given for use of the amount on the general work for improvement of the Mississippi River between the mouth of the Ohio and the mouth of the Missouri.

Recapitulation of commercial statistics.

	1897.	1898.	1899.	1900.
	Tons.	*Tons.*	*Tons.*	*Tons.*
Receipts and shipments at St. Louis	1,046,035	906,168	669,815	757,590
Transferred by ferries at St. Louis	3,042,674	4,033,871	5,036,730	5,218,967
Shipped from landings between St. Louis and Cairo	69,815	53,785	30,716	52,640
Total	4,158,524	4,993,824	5,737,261	6,029,197

July 1, 1900, balance unexpended	[1]$491,875.11
March 26, 1901, transferred from appropriation for preventing break in Mississippi River at Beechridge, Ill	1,044.56
Redeposited, canceled, and disallowed vouchers:	
July 28, 1900	21.71
August 10, 1900	.84
December 20, 1900	13.00
	492,955.22
June 30, 1901, amount expended during fiscal year	336,841.01
July 1, 1901, balance unexpended	156,114.21
July 1, 1901, outstanding liabilities	4,083.97
July 1, 1901, balance available	[2]152,030.24
July 1, 1901, amount covered by uncompleted contracts	12,249.60
Amount that can be profitably expended in fiscal year ending June 30, 1903, for works of improvement and for maintenance, in addition to the balance available July 1, 1901	673,333.00
Submitted in compliance with requirements of sundry civil act of June 4, 1897, and of section 7 of the river and harbor act of 1899.	

(See Appendix Y 2.)

[1] $3.13 less than amount stated in previous annual report.

[2] Distributed under subheadings as follows:

For bank protection at Cairo, Ill., act of July 5, 1884	$2,571.70
For revetting bank opposite mouth of Missouri River, act of March 3, 1899	30,872.84
For from mouth of Ohio River to mouth of Missouri River, act of June 6, 1900	96,336.10
For protection of bank on Missouri side and to deepen and straighten channel at Wittenberg, Mo., act of March 3, 1899	10,000.00
Amount covered by uncompleted contracts	12,249.60
	152,030.24

Y 2.

IMPROVEMENT OF MISSISSIPPI RIVER BETWEEN OHIO AND MISSOURI RIVERS.

A concise statement of the project for and history of this work will be found in the Annual Report of the Chief of Engineers, United States Army, to which this report is an appendix, as well as on page 2631 of the Report of the Chief of Engineers, United States Army, for 1900.

Reference should be made to the Report of the Chief of Engineers, United States Army, for 1894, pages 1577 et seq., for information relating to the development of the various forms of construction and for a résumé of the various types employed between 1872 and 1894 and to the Reports of the Chief of Engineers, United States Army, for 1895 (p. 2059), 1896 (p. 1717), 1897 (p. 2012), 1898 (p. 1698), and 1900 (p. 2632) for minor details as to forms of construction.

During the past year the types of construction in use in recent years have been followed. Lumber was used entirely for mattress construction for both hurdles and bank protection with a marked increase in economy and rapidity of construction. A disk sand anchor that was developed for use as moorings in mattress and hurdle construction and for dredges and channel buoys has proved very efficient. A simple and economical form of grader, consisting of an ordinary scraper operated by a derrick scow, was employed by a contractor in bank grading preparatory to the placing of the stone revetment. Descriptions of all these appliances will be found in the technical appendixes to this report.

Since the adoption of this project work has been done substantially according to the methods referred to above at the following localities: Piasa Island, Alton Harbor, mouth Missouri River, St. Louis Harbor, Cahokia chute, Arsenal Island, Horsetail bar, Carroll Island, Twin Hollows, Pulltight and Beards Island, Chesley Island, Jim Smiths, Sulphur Springs, Foster Island, Lucas, Cornice Island, Calico Island, Michaels Landing, Osborne Field, Rush Tower, Danby Landing, Fort Chartres, Crooks Landing, Turkey Island, Ste. Genevieve, Kaskaskia Island, Horse Island (Chester), Clearyville, Liberty Island, Seventy-six Landing, Hamburg, Devils Island, Minton Point, Cape Girardeau, Commerce Island, Burnham Island, Powers Island, Goose Island, Buffalo Island, and vicinity of Cairo.

Since the last annual report work for the permanent improvement of the river has been carried on in the following localities:

Mouth of the Missouri River, Osborne Field, Danby Landing, Rush Towhead, Penitentiary Point, Ste. Genevieve, Horse Island (opposite Chester), Liberty, Devils Island, Buffalo Island, and Cairo Protection.

Dredging for the betterment of the low-water channel was carried on at Sulphur Springs, Crystal City, harbor in Old River, Manskers, and Bainbridge.

PERMANENT IMPROVEMENT.

Mouth of the Missouri River (16 miles above St. Louis).—The object of this work is stated on page 2633 of the Report of the Chief of Engineers for 1900. The protection begun the previous year was

extended up the bank to stages varying from 17 to 20 feet above low water of 1863, and the subaqueous protection was extended 1,000 feet downstream, and the bank protected to about the 13-foot stage.

Osborne Field, Illinois (Rush Tower Reach, 37 miles below St. Louis).—A summary of operations upon this work will be found on page 2634 of the Report of the Chief of Engineers for 1900. The bank continued to cave below the existing protection, and the latter was extended downstream 3,030 feet by a subaqueous mattress, the bank above it being protected to 13 feet above low water of 1863.

Danby Landing, Missouri (40 miles below St. Louis).—A summary of the operations at this point will be found on page 2634 of the Report of the Chief of Engineers for 1900. A bad crossing exists at this locality and additional regulation is necessary. A middle bar crowds the low-water flow strongly along the Missouri bank and causes a scour to a greater depth than existed when the protection was placed. Several breaks have occurred progressively downstream with the movement of this bar. During the last low-water season five such breaks took place within a distance of 1,200 feet and were repaired.

Rush Towhead, Illinois (42 miles below St. Louis).—The channel through Fish Bend Cut-off having attained a sufficient width, the protection of the face of Rush Towhead was undertaken to prevent further widening and to hold the bank in line with that of Penitentiary Point below. Two thousand four hundred and thirty-five linear feet of subaqueous mattress was placed and the bank was revetted to the 13-foot stage above low water of 1863.

Penitentiary Point, Illinois (44 miles below St. Louis).—The protection of the bank at Penitentiary Point has been under consideration for several years, but has been deferred to enable the limited appropriation to be applied to more urgent work elsewhere. The caving had progressed to such an extent as to threaten an increased pressure against the head of Fort Chartres series of hurdles on the Missouri side, 3 miles below, and the holding of the bank became necessary. Six thousand three hundred and fifty linear feet of subaqueous mattress was placed and the bank was revetted to the 14-foot stage above the low water of 1863.

Ste. Genevieve, Ill. (55 miles below St. Louis).—A summary of the operations at this point will be found on page 2634 of the Report of the Chief of Engineers for 1900. For the further improvement of the Turkey Island crossing an additional series of three hurdles was projected, but only one could be constructed on account of lack of sufficient funds. Hurdle No. —2 was built to a length of 850 feet and finished with a stone buttress and inclined T-head. It produced a marked improvement in the crossing, over which a good depth of water was found all season.

Ste. Genevieve, Mo. (60 miles below St. Louis).—The reach from Little Rock Landing, Missouri, to the head of Kaskaskia Island is now the most troublesome and difficult section of the river between St. Louis and Cairo. The conditions now existing and only partially remedied are due to the Kaskaskia Cut-off of 1881, and although much work has been done, a large additional expenditure will be necessary to secure good navigation. The Illinois series of hurdles was built between 1891 and 1896, and the Missouri series between 1894 and 1896, both series being designed to contract the river to a width of 2,500 feet. In 1897 and 1899 the bank below the Missouri series was protected for

a distance of 7,950 feet. These works have not been sufficient to produce the full result desired, and, moreover, the river was slowly returning to its natural condition by the abrasion of the ends of the hurdles. To hold the accretion on the Missouri side, the bank was protected last season for a distance of 6,900 feet, beginning above Hurdle No. 12 and extending downstream to within supporting distance of the protection placed in 1897.

Horse Island, Missouri (opposite Chester and 72 miles below St. Louis).—A summary of the operations at this point will be found on page 2635 of the Report of the Chief of Engineers for 1900. A slight cave under the mattress was repaired and the revetment extended 1,300 feet downstream to the end of the existing mattress.

Liberty, Mo. (82 miles below St. Louis).—The bank protection extending from Anchor Landing to Bishops Landing was repaired by securing its head where undermining was in progress and by raising 2,200 feet of the revetment to stages of 18 and 21 feet above low water. It was intended to continue raising this revetment during the present season, and it is feared that the suspension of operations on account of the failure of appropriations will result in material loss at this point. The repair of Hurdle No. 10, which was in progress at the beginning of the year, was completed. In closing the break 495 linear feet of new hurdle was constructed.

Liberty, Ill. (85 miles below St. Louis).—The Liberty (Mo.) series of hurdles deflects the current to the Illinois shore at Wagners Landing. Six thousand eight hundred and fifty linear feet of this bank was protected in 1896, the same season in which the hurdles were built. The caving continued downstream from this protection, and the bend having become for a portion of its length as deep as appeared desirable, the 1896 protection was last season extended downstream by 6,575 feet of subaqueous mattress, above which the bank was revetted to the 14-foot stage. Five thousand five hundred linear feet of the 1896 protection was extended up the bank to the 19-foot stage. As funds become available this work should be extended downstream about 5,000 feet, or to a total length of 18,500 feet.

Devils Island, Illinois (125 miles below St. Louis).—A summary of the operations at this point will be found on page 2636 of the Report of the Chief of Engineers for 1900 and on page 1703 of the Report of 1898. The bank protection at Swift Sure, immediately above the head of Devils Island chute, was extended by a subaqueous mattress upstream 5,350 feet to the foot of Hamburg Towhead and bank revetted to a stage 9 feet above low water. The total length of this protection above and below the chute is now 15,100 feet.

Buffalo Island, Missouri (152 miles below St. Louis).—The caving of the bank from Anita Towhead to the head of Buffalo Island, a distance of 4 miles, if allowed to continue, would affect adversely the result sought to be gained by the series of hurdles on the Illinois side opposite Buffalo Island. While funds were not available to protect the full length of this bank, a beginning was made near the foot of Anita Towhead and the protection carried 5,000 feet downstream to 1,100 feet below Philadelphia Point by a subaqueous mattress and the bank revetted to the 8-foot stage.

Cairo Protection, Illinois (178 miles below St. Louis).—A description of this work will be found in the reports of the Chief of Engineers from 1876 to 1881 and for 1885, 1887, and 1891. The continued cav-

ing back of the face of Eliza Towhead exposed the head of the 1884 mattress, and a small break in the bank resulted. A subaqueous mattress 466 feet long was placed to cover the break and the bank upstream from it, and a liberal amount of stone was used to secure the upstream end of this mattress. The bank above the mattress was revetted to the 14-foot stage.

Plates I and II,[1] accompanying, show the river from the mouth of the Missouri to the mouth of the Ohio and the relation of the various works of improvement to each other and to the section of the river affected by each. The improvement in accordance with the adopted general project is extensive and progressive. While it is practically continuous for 60 miles below St. Louis, it is not complete at any point, and in the lower section work has been confined to such points as give the greatest trouble to navigation and return the greatest relief for the money expended. It is not expected that the contraction works constructed in new localities in the past and preceding year will be all that are required to rectify the river in their respective localities. They are only the commencement of certain series which it will be necessary to construct to hold the river permanently. Their location has been so chosen as to give the best results with the money available and to minimize the amount of work to be done during the following low-water seasons with the expedients now available for the temporary improvement of the channel.

TEMPORARY EXPEDIENTS.

Dredging for the temporary relief of navigation during the low-water season of the summer and fall of 1900 was carried on at Sulphur Springs, Crystal City, Stantons Towhead (Ste. Genevieve Bend), Manskers, and Bainbridge. Dredge No. 4 was in commission from July 25, 1900, to November 8, 1900, and dredge No. 3 from August 3, 1900, to November 1, 1900. A rather rapid fall of the river in the early part of August developed several shoal crossings, of which Bainbridge was the worst, with 5 feet of water. This condition lasted but a few days, and was relieved by a rise in the river, after which a good stage prevailed almost uniformly to the end of the working season. The two dredges were continued in commission, ready for service, but were worked only intermittently at the localities mentioned and in opening the channel into the winter harbor occupied by the floating plant of this district.

No use was made of portable or other temporary or semipermanent structures during the year. It was proposed to adapt for the temporary improvement of shoal crossings the floating curtain employed in the early eighties for permanent work, but no occasion for its use arose.

For details relating to portable jetties and dredging appliances reference should be made to the reports of the Chief of Engineers for 1881, 1882, 1889, and 1895 to 1898, inclusive.

The buoying of shoal crossings was systematically undertaken during the past season. The value of buoys for marking low-water channels became evident from the small number placed during the season of 1899, although difficulty was experienced in keeping them in position by any anchor that depended upon weight alone for its holding

[1] Not printed.

power in the shifting bed of the river. During the past season these buoys were moored to disk anchors, 10 inches in diameter, jetted about 12 feet into the sand. This type of mooring proved successful, although the scour was sufficient in a few instances to release the buoys. Ordinary oil barrels moored by one end were used for buoys, and the principal losses were due to their being run over at night by steamboats.

The records of this office are deficient in some respects as to the physical data necessary to determine fully the effect of the improvement upon the regimen of the river. To make good a part of this deficiency a series of discharge measurements at St. Louis, Mo., was carried through the flood and low-water seasons of 1900. Unfortunately for the completeness of this series, the freshet of 1900 was much below the average magnitude, although this fact did not affect the prime object of the measurements, which was the determination of the relations of stage and discharge at and near low water. A special report upon these measurements by Mr. W. S. Mitchell, assistant engineer, is attached hereto.

PLANT AND MATERIAL.

The plant belonging to this improvement has been maintained in efficient working condition during the year. It is designed for the execution of work by hired labor, on the basis of an expenditure of $750,000 per annum upon the permanent improvement, but with an apparent tendency to make appropriations in smaller amounts and to apply a considerable proportion of them to temporary work it will be necessary to diminish the quantity of plant by omitting to replace worn-out items.

Under his contract of July 17, 1899, for the construction of 60 flatboats, Mr. Ruell C. Arnold, of Leavenworth, Ind., delivered 24 boats on August 10, 1900, and 27 boats on December 23, 1900. The remaining 9 boats were delivered on July 1, 1901, completing the contract.

Under formal contracts 42,941 linear feet of first-class and 49,207 linear feet of second-class pile timber were purchased during the year; also 15,709.80 cubic yards of riprap stone.

By hired labor there was obtained at the Government quarries at Little Rock, Mo., 46,330 cubic yards of riprap stone, at an average cost of $0.7859 per cubic yard loaded on barges. Eight thousand two hundred and eighty-six cubic yards of stone were purchased in open market. Under written proposals and acceptances 4,277,487 feet B. M. of common or cull lumber were purchased for construction of mattresses.

Mr. D. M. Currie has continued in charge of the duties of principal assistant engineer and Assistant Engineers William S. Mitchell and John O. Holman in field charge of construction work. The quarrying of stone by hired labor was in charge of Assistant Engineer E. D. Libby. Assistant Engineer C. D. Lamb had charge of the engineer depot, where are received and distributed most of the supplies of this district and are made the necessary repairs and additions to tools and plant. All of these gentlemen, together with the office force connected with the work, have been many years in the service, and have discharged their duties with marked efficiency and faithfulness to the interests of the Government. For further details concerning the operations of the year, attention is invited to the report of Mr. D. M. Currie, assistant engineer, attached hereto.

ESTIMATES.

The original estimate of the cost of the improvement of the Mississippi River between the mouth of the Ohio and the mouth of the Missouri River as revised in 1883 is $16,397,500.

The aggregate amount of funds appropriated and made available for this work to June 30, 1901, is $9,624,999.98.

The total appropriations to date amount to $9,804,999.98. Of this amount $180,000 was allotted by acts and projects for improvement between the Illinois and the Missouri rivers, including Alton Harbor, leaving a balance of $9,624,999.98, as stated above, to be applied to the project for the general improvement of the river between the mouth of the Missouri and the mouth of the Ohio rivers.

Of this amount there was on hand June 30, 1901, an available balance of $139,780.64, exclusive of outstanding liabilities. The amount that has been expended upon the project to this date is therefore $9,485,219.34.

The amount expended during the fiscal year ending June 30, 1901, is $335,760.90.

The river and harbor act approved June 3, 1896, provides:

> That any balance of former appropriations now available and the money hereby appropriated and authorized to be expended for the said section of said river between the mouth of the Missouri River and the mouth of the Ohio River, or so much thereof as may be necessary, shall be expended in the construction of suitable dredge boats, portable jetties, and other suitable appliances, and in the maintenance and operation of the same, with the view of ultimately obtaining and maintaining a navigable channel from St. Louis to Cairo, not less than two hundred and fifty feet in width and nine feet in depth at all periods of the year, except when navigation is closed by ice.

In the $9,485,219.34 above mentioned is included what has been expended for dredge plant, portable jetties, and appliances for temporary improvement of the channel and for operating the same. This amounts to about $576,208.05. Of this, $42,718.52 was expended during this fiscal year. The present value of the plant pertaining to this temporary work is now estimated at approximately $225,526.27.

The available balance includes the unexpended balances from special allotments made by Congress, as follows:

For bank protection at Cairo, Ill., act of July 5, 1884	$2,571.70
For revetting bank opposite mouth of Missouri River, act of March 3, 1899	30,872.84
For protection of bank on Missouri side and to deepen and straighten channel at Wittenberg, Mo., act of March 3, 1899	10,000.00
Total	43,444.54

The balance of the estimate for the original project not appropriated June 30, 1901, is $6,592,500.02.

It is estimated that the sum of $1,000,000 can be profitably and economically expended during the fiscal year ending June 30, 1903, in the permanent improvement of the river, in accordance with the original project and in the work of temporary improvement, with a view to obtaining a navigable channel from St. Louis to Cairo not less than 250 feet wide and 9 feet deep at all periods of the year, in accordance with the requrements of the river and harbor act of June 3, 1896. Of this amount it is estimated that $150,000 will be expended upon the operation and maintenance of dredges, portable jetties, and other appliances for the temporary improvement of the river.

It is believed that the importance of this improvement is conceded,

and that therefore no argument as to its desirability or necessity is required. Such being the case, the only question at issue is its successful and economical prosecution to a proximate completion. The work is of great magnitude and cost, and is of such a character that, unless pressed with such appropriations as its magnitude warrants, satisfactory results either as to progress or economy can not be expected. Successful results from the partial execution of the projected improvement will be of no great value to through traffic, the most important class of navigation, until extended throughout the full length of this reach. Uncompleted works suffer damage and depreciation by inability to protect and complete them on account of partial or complete failure of appropriations, and the large plant required for their prosecution entails a considerable loss by its care and depreciation during each suspension of operations, as was the case during the greater part of the past fiscal year.

In order that the work can be intelligently and economically carried forward, ample appropriations for a term of years should be provided, as is now done in the case of important contract works, and an appropriation of $1,000,000 per annum for five years is earnestly recommended for this purpose.

This work is in the collection district of New Orleans. The nearest port of entry is St. Louis, Mo., at which place the customs collected during the fiscal year ending June 30, 1901, amounted to $1,700,780.72. The amount of internal revenue collected was $15,673,447.02.

Money statement.

July 1, 1900, balance unexpended		[1]$401,875.11
June 30, 1901, amount expended during fiscal year		335,760.90
July 1, 1901, balance unexpended		156,114.21
July 1, 1901, outstanding liabilities		4,083.97
July 1, 1901, balance available		[2]152,030.24
July 1, 1901, amount covered by uncompleted contracts		12,249.60
Amount (estimated) required for completion of existing project		$6,772,500.02
Amount that can be profitably expended in fiscal year ending June 30, 1903, in addition to the balance available July 1, 1901:		
For works of improvement	$850,000.00	
For maintenance of improvement	150,000.00	
		1,000,000.00
Submitted in compliance with requirements of sundry civil act of June 4, 1897, and of section 7 of the river and harbor act of 1899.		

[1] $3.13 less than amount stated in previous annual report.

[2] Distributed under subheadings as follows:

For bank protection at Cairo, Ill., act of July 5, 1884	$2,571.70
For revetting bank opposite mouth of Missouri River, act of March 3, 1899	30,872.84
For from mouth of Ohio River to mouth of Missouri River, act of June 6, 1900	96,336.10
For protection of bank on Missouri side and to deepen and straighten channel at Wittenberg, Mo., act of March 3, 1899	10,000.00
Amount covered by uncompleted contracts	12,249.60
	152,030.24

LIST OF APPROPRIATIONS.

By act of—		By act of—	
June 10, 1872	$100,000.00	September 19, 1890	$400,000.00
March 3, 1873	200,000.00	July 13, 1892	525,000.00
June 23, 1874	200,000.00	March 3, 1893	658,333.33
March 3, 1875	200,000.00	August 18, 1894	758,333.33
August 14, 1876	200,000.00	March 2, 1895	758,333.33
June 18, 1878	240,000.00	June 3, 1896	275,000.00
March 3, 1879	200,000.00	June 4, 1897	673,333.33
June 14, 1880	250,000.00	July 19, 1897	325,000.00
March 3, 1881	600,000.00	July 1, 1898	673,333.33
August 2, 1882	600,000.00	March 3, 1899	673,333.33
July 5, 1884	520,000.00	June 6, 1900	100,000.00
August 5, 1886	375,000.00		
August 11, 1888	300,000.00	Total	9,804,999.98

Contract in force.

Articles.	Name of contractor.	Date of approval.	Date of beginning work.	Date of expiration.
60 flatboats	Ruell C. Arnold	July 27, 1899	10 days after notice.	Sept. 29, 1900

COMMERCIAL STATISTICS.

Receipts and shipments at St. Louis, Mo., during the years 1897, 1898, 1899, and 1900.

Articles.	Receipts.				Shipments.			
	1897.	1898.	1899.	1900.	1897.	1898.	1899.	1900.
Barbed wire, ores, and metals (pig and manufactured)	*Tons.* 25,449	*Tons.* 15,424	*Tons.* 2,001	*Tons.* 1,900	*Tons.* 2,513	*Tons.* 2,240	*Tons.* 2,049	*Tons.* 1,887
Cement	4,747	1,915	1,131	827				
Coal and coke	22,490	24,850	36,350		117,280	69,555		5,720
Cotton and cotton products	1,803	2,221	2,628	1,227	1,776	1,445	1,825	2,524
Groceries and dairy products	18,311	23,582	19,395	27,298	9,492	11,886	10,353	10,372
Hay, seed, grain, four, meal, etc	34,694	54,934	44,335	60,953	230,221	218,889	90,889	128,392
Live stock and products	24,153	21,579	22,122	22,850	9,190	5,790	6,846	7,229
Lumber	103,165	129,376	86,572	85,808	4,480	3,945	724	4,158
Merchandise and sundries	327,993	228,321	291,793	305,619	84,895	78,199	82,505	76,485
Vegetables and fruits	13,513	4,191	9,848	5,333	2,810	1,856	3,169	2,501
White lead, oils, etc	90	25	152	18	1,975	2,077	1,128	1,481
Wines and liquors	30	24	9	6	4,721	3,677	4,217	4,881
Wool	232	143	279	171	12	24		
Total	576,670	506,585	466,610	512,010	469,365	399,583	203,205	245,580

Transferred by ferries across the river at St. Louis.

	Tons.		Tons.
1897	3,042,674	1899	5,036,730
1898	4,033,871	1900	5,218,967

Shipments down the river from landings between St. Louis and Cairo, during the years 1897, 1898, 1899, and 1900.

Grain, including flour, meal, etc., and coal—

	Tons.
1897	69,815
1898	53,785
1899	30,716
1900	52,640

	To special appropriations for—		
Aug. 14, 1876.	Channel of Mississippi River, opposite St. Louis	$29,600.00	
June 14, 1880.	Cape Girardeau and Minton Point	20,000.00	
	Ice harbor at St. Louis	50,000.00	
Mar. 3, 1881.	Do	10,000.00	
	Cape Girardeau and Minton Point	10,000.00	
Sept. 19, 1890.	Harbor at St. Louis	182,000.00	
June 4, 1897.	Preventing break at Beechridge, Ill	100,000.00	
			$401,600.00
	To miscellaneous receipts (deposited):		
June 30, 1879.	Error not found	27.51	
1879 to 1887.	Fuel sold to officers	214.73	
June 30, 1878.	Error voucher 45, first quarter, 1877	.67	
Mar. 31, 1879.	Sale of powder and fuse	33.60	
Nov. 15, 1882.	Repayment of mileage	86.64	
Jan. 20, 1887.	Error voucher 60, November, 1886	.10	
Sept. 1, 1887.	Barge sunk by Anchor Line	1,708.53	
Jan. 17, 1900.	Repayment error voucher 3, September, 1898	5.84	
July 28, 1900.	Canceled vouchers 97 and 141, June, 1900.	21.71	
Aug. 10, 1900.	Disallowed on voucher 125, August, 1899	.84	
Dec. 20, 1900.	Overpayment on voucher 149, November, 1900	13.00	
			2,113.17
	To appropriations for—		
June 10, 1872.	Mississippi River, between Illinois and Missouri	25,000.00	
	Mississippi River, between Missouri and Meramec	100,000.00	
Mar. 3, 1873.	Mississippi River, between Missouri and Ohio	200,000.00	
June 23, 1874.	Mississippi River, between Ohio and Illinois	200,000.00	
Mar. 3, 1875.	Mississippi River, between Illinois and Ohio	200,000.00	
Aug. 14, 1876.	Do	200,000.00	
June 18, 1878.	Do	240,000.00	
Mar. 3, 1879.	Do	200,000.00	
June 14, 1880.	Do	250,000.00	
Mar. 3, 1881.	Do	600,000.00	
Aug. 2, 1882.	Mississippi River, Cairo to Illinois	600,000.00	
July 5, 1884.	Mississippi River, between Illinois and Ohio	520,000.00	
Aug. 5, 1886.	Do	375,000.00	
Aug. 11, 1888.	Do	300,000.00	
Sept. 19, 1890.	Do	400,000.00	
July 13, 1892.	Mississippi River, between Ohio and Missouri	525,000.00	
Mar. 3, 1893.	Do	658,333.33	
Aug. 18, 1894.	Do	758,333.33	
Mar. 2, 1895.	Do	758,333.33	
June 3, 1896.	Do	275,000.00	
June 4, 1897.	Do	673,333.33	
July 19, 1897.	Do	325,000.00	
July 1, 1898.	Do	673,333.33	
Mar. 3, 1899.	Do	673,333.33	
June 6, 1900.	Do	100,000.00	
			9,829,999.98
	To nonpayments—		
June 30, 1901.	Unpaid percentage on annulled contract	900.17	
	Unpaid percentage on contracts in force	765.60	
	Unpaid labor	3,725.54	
	Unpaid miscellaneous	3,406.61	
			8,797.92
	Total		10,293,719.84

June 30, 1901.	By construction between Illinois and Missouri rivers—		
	Piasa Island dam	$37,910.41	
	Piasa Island dam, cutting channel	3,116.86	
	Alton dam	33,740.05	
	Alton dike	126,652.74	
			$201,420.06
	By construction between Missouri and Ohio rivers		8,467,461.04
	By jetties		114,603.53
	By dredging		246,367.13
	By surveys and gauges		212,448.28
	By amounts withdrawn for office of Chief of Engineers		2,120.50
	By loss account		146,066.93
	By property on hand		650,506.20
	By material on hand		58,943.43
	By appropriations unexpended:		
	Mississippi River, Missouri to Ohio	$156,114.21	
	St. Louis Harbor	31,237.97	
	Beechridge, Ill	6,430.56	
			193,782.74
	Total		10,293,719.84

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

ST. LOUIS, MO., *June 30, 1901.*

CAPTAIN: I have the honor to submit the following report of operations for the improvement of the Mississippi River from the Ohio to the Missouri River during the fiscal year ending June 30, 1901:

This work was begun in 1872 and carried on as funds have been available. For the object of the improvement, projects, classes of works, forms of construction, and localities at which work had been done prior to the beginning of this fiscal year, reference should be made to the Annual Report of the Chief of Engineers for 1900, Appendix Z 2, pages 2631 et seq., with references therein named.

The operations this year comprised constructing, extending, and repairing hurdles and bank protection for the permanent improvement; dredging and buoying the channel for temporary relief to navigation; constructing, repairing, and caring for plant; making surveys, procuring materials, and other work incidental to the improvement.

Work for permanent improvement was carried on at the following localities: Mouth of the Missouri River, Osborne Field, Danby landing, Rush Towhead, Penitentiary Point, Ste. Genevieve, Illinois; Ste. Genevieve, Mo.; opposite Chester, Liberty, Mo.; Liberty, Ill.; Devils Island, Illinois; Buffalo Island, Mo.; Cairo protection; surveys.

Dredging was done at the following localities: Sulphur Springs, Stantons Towhead, entrance to harbor in Old River, Manskers, and Bainbridge. The channel across shoals was kept buoyed during the low-water season.

MOUTH OF THE MISSOURI.

The protection of the bank opposite the mouth of the Missouri River was extended to the medium stage ranging between the planes of 17 and 20 feet above low water of 1863, St. Louis gauge, and the subaqueous protection was extended 1,000 feet downstream to Station 110+25, with revetment to the foot of the bluff bank at about the stage of 13 feet, St. Louis gauge.

OSBORNE FIELD, ILLINOIS (RUSH TOWER REACH).

This protection was extended 3,030 feet downstream by a subaqueous mattress and revetment to the stage of 16 feet above low water of 1863, St. Louis gauge. The old work was repaired as required.

DANBY LANDING.

The work at Danby landing was the repair of several small breaks in the bank protection caused by a middle bar which for two years had been moving gradually downstream, throwing the volume of the river at low stages in a narrow channel against the revetment and scouring to depths much greater than existed when the mattress was placed.

In the early part of July two breaks were made, followed by a third in the middle of the month, a fourth on the 27th, and a fifth in the latter part of October. They were all small and were embraced within about 1,200 feet, beginning 500 feet from the upper end of the stonework. They were between 50 feet and 150 feet in length and extended back through the revetment and in one instance 20 feet farther.

These breaks were all repaired with new lumber mattress, laid on the old bank lines, with smaller mats in the pockets thus formed.

Above the mattresses the bank was regraded and faced anew with stone to the 20-foot level.

About 1,250 linear feet of mattresses were made and 2,000 feet of bank was revetted.

RUSH TOWHEAD, ILLINOIS.

The protection of Rush Towhead was begun and 2,435 feet of subaqueous mattress were placed with revetment above to the stage of 13 feet above low water of 1863, St. Louis gauge.

PENITENTIARY POINT.

The work at this locality was the protection of the bank to the stage of 14 feet above low water of 1863, St. Louis gauge.

A subaqueous mattress 6,350 feet long was placed, September 25 to October 13, from the foot of the wooded point—Penitentiary Point—below Salt Lake Slough, along the bank and extending around the point below Farmer landing.

The wooded bank referred to, about 1,200 feet in length, was not revetted, as it was thought to be sufficiently protected for the present by fallen trees and brush.

The stone revetment was partly placed at the same time with the mattress shortly afterwards (November 3 to 9), was completed along the entire length of the latter to the foot of the bank at about the 14-fool level.

STE. GENEVIEVE, ILLINOIS.

The work at this locality was the construction of hurdle No. —2, which was 850 feet in length.

The hurdle was located 4,100 feet upstream from hurdle No. 2 of the same series, and was built with three rows of three-pile clumps, with the shore end protected by revetment and the river end supported by a T-head and buttress.

The mattress was built of lumber in the usual manner. The foundation mattress for the main line, 107 feet in width, was carried continuously from the shore to the river end. Submerged anchors, first used on construction works in the repair of hurdle No. 10, at Liberty, were used instead of the anchor row of piles to hold the mattress in position during its construction and sinking.

The anchors, cast-iron disks 16 inches in diameter, were jetted by the pile drivers to a uniform depth of 17 feet on a range 100 feet above the upstream edge of the mattress at intervals varying from 25 feet in the strong current at the river end to 35 feet in the weaker current near the shore. Two cables of ¾-inch wire attached to each anchor provided separate fastenings for the plant and the mattress, the shorter cables of 55 feet in length holding the mooring flats in position just above the mattress, and the longer cables of 120 feet in length, leading under the mooring flats, holding the mattress until released by means of a tripper at the end of each cable.

Three anchors with single cables of 50 feet in length were placed 300 feet apart on a range 500 feet above the line of the mattress anchors solely for mooring plant during the construction of the hurdle. They were used by the driver crews in placing and recovering mattress anchors and while driving the first row of piles in the main line, by the mattress crew in holding the lumber barge and way flats while building and the stone barge while sinking the mattress; and after the main line was driven were again used in floating stone barges across the face of the hurdle while reballasting the mattress at the base of the clumps. The use of the submerged anchor in hurdle construction has been very satisfactory, and especially in sinking the foundation mattress.

The first and second rows of clumps in the main line and 250 feet of the third row at the shore end were driven in the usual manner with the piles in the first row, or at least one in each clump projecting to the 25-foot stage above low water. Cables were placed from the upper to the lower row whenever necessary to bring the clumps into contact with the longitudinal stringers placed between the different rows. The remainder of the third row consisted of three-pile clumps driven directly under every third clump of the upper row, with short stringers between the single clump and the adjacent clumps of the second row. The stringers between the first and second rows were placed so as to break joints on the same third clump of the upper row, thus utilizing to the best advantage the supporting strength of the third row. The mattress, where broken by the driving from 30 to 40 feet below its upstream edge, was reballasted with two barge loads of riprap and one of spalls as a protection against scour at the base of the clumps.

The shore end of the hurdle was protected by 95 feet of mattress placed above and 115 feet below the foundation mattress, and with it formed a protection 300 feet in length by 100 in width, of which 125 feet was above and 175 feet below the main line. These mattresses were heavily ballasted in sinking and then revetted from the low-water stage to the water's edge. The revetment was continued to the top of the graded bank, but was gradually decreased in length from 300 feet at the base to 228 feet at the top of the bank. The piles jetted in the bank for the shore connection of the main line were placed in a clump of three at the water's edge and continued in a single row to the 20-foot stage. The shore end of the longitudinal stringer, carried on the downstream side of the single row, was buried in the bank at about the 22-foot stage and covered with revetment. The shore dike of riprap, raised 2 feet above the revetment, was placed around the piles, jetted in the bank, and continued 40 feet into the clumps of the main line.

The T-head mattress, 300 feet in length by 100 in width, was placed equally above and below the main line. The T-head piles were driven on the limit line and were placed in a double row of three-pile clumps for a length of 40 feet above the main line and in a single row of three-pile clumps for a length of 80 feet below the main line. The tops of all the piles above and one of each clump in 40 of the 80 feet below the main line reached the 25-foot stage, the height to which the piles in the first row of the main line were carried. Three barge loads of riprap were used in the buttress, of which one was placed at the base of the clumps and on the T-head mattress and two in the angle formed by the main line and the downstream portion of the T-head clumps. The crest of the stone, which was just below the main line, was brought to the 10-foot stage.

STE. GENEVIEVE, MO.

The work at Ste. Genevieve, Mo., was the protection against further erosion of the accretions accumulated by the hurdle system and to prevent further destruction of the hurdles. The mattress was placed from 500 feet above hurdle No. 12 to within 400 feet of hurdle No. 18, a total length of 6,900 feet. Revetment was placed to the stage of 10 feet above low water of 1863 upon 6,500 feet of this distance—being omitted at a few points where the bank was below the prevailing stage of water, 8 feet St. Louis gauge. The projecting ends of hurdles 12, 14, 15, and 18 were filled in with stone, forming them into buttresses or spur dikes.

The mattress was carried around the ends of Nos. 12 and 15, but was stopped at No. 14, across which a T-head mattress was sunk.

The channel through this reach shifted several times during the low-water season from the crossing between hurdles Nos. 20 and 22 on the east side and Nos. 10 and 12 on the west, but finally was buoyed over the middle bar, and ran from the Moro Light to the foot of Stanton Towhead.

OPPOSITE CHESTER.

At this locality the work was in repair and extension of the protection of the river front of Horse Island. This protection was placed during high stages of the river. A small cave which had occurred under the mattress was repaired, and the revetment was extended 1,300 feet downstream to the lower end of the mattress previously placed. See Annual Report Chief of Engineers, 1900, Appendix Z 2, pages 2631 et seq.

LIBERTY, MO.

The work at Liberty, Mo., included bank protection and hurdles.

BANK PROTECTION.

The bank protection at this locality was repaired and extended as follows:

The erosion of the bank at the upstream end of the protection, which had undermined 100 linear feet of the revetment and destroyed the head of the mattress, was checked for the remainder of the season by spreading a barge load of riprap and one of spalls for a length of 100 feet at the base of the caving bank, and further damage to the mattress was prevented by spreading a barge load of riprap and two of spalls across its head in a shore distance of 150 feet.

The revetment above the mattress, reduced by the erosion of the bank to 1,700 feet in length, was raised to an average stage of 21 feet above low water. The space of 900 feet between the upper and lower mattress, where the shore bar of gravel rendered mattress protection unnecessary, was revetted to the 18-foot stage above low water for a length of 400 feet at the upper end and 100 feet at the lower portions of the gravel formation. The revetment at the head of the lower mattress was raised to the 18-foot stage for a length of 300 feet.

Stations and stages to which the revetment was raised during the working period:

Stations of 100 feet.	Stage above low water.
1 to 6	20
7 to 8	21
9	20
10 to 14	21
15 to 16	22
17 to 18	21
18 to 22	18
26 to 27	18
27 to 30	18

NOTES.—Destroyed by the erosion of the bank between stations 0 and 1.
Station 18, foot of upper mattress.
Above gravel formation. Not revetted between stations 22 and 26.
Station 27, head of lower mattress.

HURDLES.

The work of repairing hurdles was in progress at the beginning of the fiscal year, and was continued until completed by closing the gap in hurdle No. 10.

The work of this year, equivalent to 175 feet of main line, finished the second and third rows of three-pile clumps across the gap and a single row of three-pile clumps under the shore end of the old hurdle, which, for a length of 225 feet, remained in fair condition. At the shore, where a bar prevented the use of the drivers, the clumps were strengthened by braces jetted to a depth of 8 feet, with the top of the brace butted against and wired to the second or lower row of clumps in the old hurdle. The new work connected with the old hurdle at the shore end, but in order to avoid the deep water through the gap at the bar end, the hurdle was deflected 80 feet upstream, joining the old hurdle from above. This detour of the main line increased the length of driving required from 290 to 420 feet, and with the equivalent length of 75 feet under the shore end, made a total of 495 feet required for the repair of the hurdle. The small amount of drift in front of the hurdle where the bar connection was made allowed the close approach of the drivers and obviated the construction of a buttress between the new and old work.

LIBERTY, ILL.

The work at Liberty, Ill., was the extension and repair of the bank protection.

The bank protection at this locality, 6,850 feet of which was placed in 1896, was continued downstream to a total length of 13,425 feet. The work done includes 6,575 feet of mattress, with revetment, to an average stage of 14 feet above low water, and the repair and raising 5,500 feet of the former revetment to the 19-foot stage.

The mattress was built of lumber to the regulation width of 120 feet. Two parties were engaged simultaneously in its construction, one building and sinking 3,615 feet in 13 working days, an average of 283 feet per day, and the other 2,975 feet in 13¼ days, an average of 224 feet per day. These lengths of 3,615 and 2,975 feet were built and placed in continuous sections, with the inshore edge of the mattress following the stage of the river, which changed from the 7 to the 13-foot stage during the period of construction from September 19 to October 6.

The revetment above the new work was placed between the low-water stage and the foot of the bluff bank, in which 3,092 yards of spalls were used in covering the mattress and 3,835 yards of riprap in the medium-stage revetment.

Stations and stages to which the revetment was raised during the working period:

Stations of 100 feet.	Stage above low water.	Stations of 100 feet.	Stage above low water.	Stations of 100 feet.	Stage above low water.
14 to 23	20	37	18	61 to 65	18
24	21	38	20	66 to 67	19
25 to 27	22	39 to 40	19	68	20
28 to 29	20	41 to 44	18	69 to 71	18
30	19	45	19	72	16
31 to 32	17	46 to 47	20	73 to 111	14
33 to 35	19	48 to 50	18	112 to 134	13
36	21	51 to 60	17		

NOTES.—The revetment between stations 0 and 13½ is in good condition and partially covered with deposit.

1,931 yards of riprap used in recovering bare places between stations 13½ and 68½ and in extending that portion of the revetment to the stages as tabulated.

Station 68½, junction of old and new work.

Revetment above new work carried to foot of the bluff bank.

DEVILS ISLAND, ILLINOIS.

The work at Devils Island was the extension of the bank protection at Swift Sure 5,350 feet upstream to the foot of Hamburg Towhead, with subaqueous mattress and revetment above to the foot of the bluff bank at the stage of about 9 feet above low water of 1863.

The mattress of 120 feet in width was built of lumber. The two parties engaged in the simultaneous construction built continuous sections of 2,600 and 2,750 feet in 14 and 12 working days, respectively, a combined average of 206 feet per day for each party. The stage of river during its construction gradually dropped from the 10 to the 6 foot stage, and marks the contours covered by the inshore edge of the mattress.

Riprap and spalls were used in the subaqueous revetment, which covered the inshore edge of the mattress to about the low-water stage and a narrow strip along the base of the bluff bank to an average stage of 9 feet above low water.

BUFFALO ISLAND, MISSOURI.

The work at Buffalo Island was the placing of 5,000 feet of subaqueous protection, with revetment above, to the foot of the bluff bank at about the stage of 8 feet above low water of 1863. This protection extends from a point about 250 feet above the foot of Anita Towhead to about 1,100 feet below Philadelphia Point.

"Two parties were engaged in the construction of the mattress, one building and sinking 2,900 feet in fifteen and a half working days, an average of 187 feet per day, and the other 2,100 feet in fourteen days, an average of 151 feet per day. These lengths were built of lumber in continuous sections 120 feet in width, and were placed with their inshore edge at about the 8-foot contour, the average stage of the river during the period of construction."

"Spalls and stones to the amount of 1,500 yards were used in the revetment which covered the mattress above the low-water stage and a narrow strip along the base of the bluff bank to the 7 and 8 foot contour.

CAIRO PROTECTION, ILLINOIS.

The work at Cairo protection was in repair of that work.

"A lumber mattress 466 feet in length by 120 in width was placed at the upstream end of the Cairo protection to check the erosion which threatened the partial destruction of that work. Of this length, 400 feet was placed above and 66 feet feet below the small point of exposed revetment, which in all probability marked the upstream end of the former protection. The mattress was built with both the Mississippi and Ohio at the 13-foot stage, but the current along the bank was much less than expected and not as strong as during the inspections of the locality during lower stages. The water was 40 feet deep at the outer edge of the mattress.

"Eight barge loads of riprap, 2,113 cubic yards, were used, of which 1½ were used in sinking the mattress; 2 were unloaded in a shore distance of 110 feet, covering 55 feet of the mattress and 55 feet of the river bed just above, and 4½ were used in revet-

ting the remaining length of mattress for a width of 40 feet along the shore and the bank above to the 14-foot stage. The total length of the revetment was 690 feet, of which 55 was upstream and 169 downstream from the limit of the mattress."

DREDGING.

At Sulphur Springs two cuts were made across a reef which threatened to become an obstruction to navigation. After working three days there was an increase of 5½ feet in depth, from 6½ to 12 feet, but in the meantime the river had risen 3½ feet, showing a gain of 2 feet due to dredging. The dredge returned to this locality and did further work.

At Crystal City a channel 1,500 feet long from Cornice Island Hurdle to the railroad incline was dredged three cuts wide (about 120 feet), and a cut of single width (40 feet) was made from the incline to the deep water passing Platin Rock. The depth in the channel approaching the incline was increased 8 feet, from 5 feet to 13 feet, and ontinued in good condition to the close of the season.

At Stantons Towhead there were three distinct crossings, of which the lower two were marked by lights, when dredging was begun upon the lowest one. A channel two cuts wide was dredged and the ridge between partly cleared up when a rise in river made further work unnecessary.

At entrance to Harbor in Old River dredging began early in the season while awaiting developments in the needs of work for the relief of navigation and again at the close of the season.

At Manskers a shoal developed and dredging was begun, but a rise in the river gave sufficient channel depth, and work was discontinued after working one day.

At Bainbridge the channel divided and made two crossings, both shoal, which was improved only after considerable dredging.

BUOYING CHANNEL.

A party was organized early in August to patrol the river, sound and mark the best channel on all shoal crossings throughout the reach between the Ohio and Missouri rivers, which gave great relief to navigation.

PROCURING MATERIALS.

The quarry force procured the stone required, 46,880 cubic yards, in addition to that procured under contract and in open market.

PLANT.

The plant was constructed, repaired, and cared for as required.

Sixty flats were under process of construction by contract with Mr. R. C. Arnold, of Leavenworth, Ind., of which 51 have been delivered.

The other plant, including steamers *Wm. R. King*, *Gen. H. L. Abbot*, and *Gen. T. L. Casey*, and dredges Nos. 3 and 4, received such ordinary repairs as were required. The steamer *Gen. Gillmore* was condemned as a towboat and was broken up, the parts being either sold or used for other purposes, as was most advantageous to the Government.

SURVEYS.

Surveys were made as required in connection with the construction of permanent improvement works, the application of temporary expedients and for the study of local channel conditions from Fines Bluff to Cornice Island, from Danby to Brickey Mill, from Moro Island to Kaskaskia, and from Clearyville to the foot of Liberty Bend.

A special survey was made of the harbor approach to the landing at Harrisonville, Ill., and the bank between the Chain of Rocks and Sawyer Bend was located.

The slopes between Turkey Island and Bishop Landing were determined and plotted.

Discharge measurements begun during the preceding fiscal year were continued until March of this year at the engineer depot, this city. The table herewith shows this year's results. See table, Annual Report of the Chief of Engineers for 1900, pages 2659 and 2660, showing results of last year.

The gauges established along this reach of the river were repaired as required, read, and the readings recorded for future reference.

RESULTS.

Six feet was the least channel depth, except during short periods of transition from higher to lower stages and changes in sailing directions.

FORMS OF CONSTRUCTION.

The forms of construction have remained essentially unchanged, unless the substitution of the disk anchor for anchor piles be considered a change of form. It has been used wherever anchorage was required and has many advantages over ordinary anchorages for use in connection with this improvement, works having similar conditions, and for many other purposes.

REPORTS OF ASSISTANTS.

This report is indebted to the reports of assistants in local charge for quoted text and quantities of work shown in the annexed tables, as follows: To report of Mr. William S. Mitchell for quantities of work at mouth of the Missouri; Osborne Field; Danbys; Rush Towhead; Penitentiary Point; Ste. Genevieve, Mo., and opposite Chester (Horse Island), Ill. To the report of Mr. John O. Holman for quantities of work and other details at Ste. Genevieve, Ill.; Liberty, Mo., bank protection and hurdles; Liberty, Ill.; Devils Island; Buffalo Island, and Cairo protection. To the report of Mr. E. D. Libby for procuring stone by hired labor. To reports of Mr. W. M. Penniman and Mr. E. C. Wiley, respectively, masters of dredges Nos. 3 and 4, for dredging operations. To Mr. C. D. Lamb's report for care and repair of plant.

PLATES.

For location of works reference should be made to plates Nos. 1 and 2.

TABLES.

The quantities of work done are shown in the accompanying tables.

Very respectfully, your obedient servant,

D. M. CURRIE, *Assistant Engineer.*

Capt. EDW. BURR,
Corps of Engineers, U. S. A.

BANK PROTECTION.

Table of work for the year ending June 30, 1901.

	Mattress.		Revetment.	
	Linear feet.	Square feet.	Linear feet.	Square feet.
Illinois bank opposite mouth of Missouri River:				
Subaqueous, new	1,000	125,000		
Medium stage, new			9,425	320,500
Osborne Field, Ill.:				
Subaqueous, new	3,080	408,900		
Medium stage, new			3,000	109,000
Medium stage, repair			5,000	12,000
Danby Landing, Mo.:				
Subaqueous, repair	1,250	205,175		
Medium stage, repair			2,000	68,950
Rush Towhead, Ill.:				
Subaqueous, new	2,435	304,375		
Medium stage, new			2,435	43,400
Penitentiary Point, Ill.:				
Subaqueous, new	6,350	793,750		
Medium stage, new			6,300	118,300
Ste. Genevieve, Mo.:				
Subaqueous, new	6,900	957,500		
Medium stage, new			6,500	123,000
Bank opposite Chester (Horse Island), Ill.:				
Medium stage, new			1,325	31,675
Liberty, Mo.:				
Subaqueous, repair			250	23,500
Medium stage, new			2,500	51,575
Liberty, Ill.:				
Subaqueous, new	6,575	789,000		
Medium stage, new			12,075	283,600
Devils Island, Ill.:				
Subaqueous, new	5,350	642,000		
Medium stage, new			5,350	32,000

Table of work for the year ending June 30, 1901—Continued.

	Mattress.		Revetment.	
	Linear feet.	Square feet.	Linear feet.	Square feet.
Buffalo Island, Mo.:				
Subaqueous, new	5,000	600,000		
Medium stage, new			5,000	35,000
Cairo protection:				
Subaqueous, repair	466	55,920		
Medium stage, repair			690	30,000
Total	38,356	4,876,620	61,850	1,232,500

RECAPITULATION.

Subaqueous:				
New	36,640	4,615,525		
Repair	1,716	261,095		
Medium stage:				
New			53,910	1,098,050
Repair			7,940	134,450
Total	38,356	4,876,620	61,850	1,232,500

HURDLES.

Table of work done for the year ending June 30, 1901.

STE. GENEVIEVE, ILL.

Hurdles.	Hurdle number.	Amount.	Piles.	Stringers.	Cables.	Mattress.		Revetment.		Grading.	
						Linear feet.	Square feet.	Linear feet.	Square feet.	Linear feet.	Cubic yards.
Shore protection, new	—2	*Sq. ft.* 32,240	27	3	10	210	21,200	276	11,040	300	450
Main line, new		*Lin. ft.* 850	726	57	464	852	90,334				
Tee-heads and buttresses, new		1 of each.	54		30	300	30,000				
Total			807	60	504	1,362	141,534	276	11,040	300	450

Total length of hurdles built, 850 feet.

LIBERTY, MO.

Hurdles.	Hurdle number.	Amount.	Piles.	Stringers.	Cables.
Main line, repair	10	*Linear ft.* 175	172	34	287

Total length of hurdles built, 175 feet.

RECAPITULATION.

Locality.	Length built.	Length repaired.	Tee-heads and buttresses.	Piles.	Stringers.	Cables.	Mattress.		Revetment.		Grading.	
							Linear feet.	Square feet.	Linear feet.	Square feet.	Linear feet.	Cubic yards.
Ste. Genevieve, Ill	850		2	807	60	504	1,362	141,534	276	11,040	300	450
Liberty, Mo		175		172	34	287						
Total	850	175	2	979	94	791	1,362	141,534	276	11,040	300	450

Table of discharge measurements taken during the year ending June 30, 1901.

[William S. Mitchell, observer.]

Date.	Locality.	St. Louis gauge reading.	Discharges, cubic feet per second.		
			Rod floats.	Current meters.	
				No. 29.	No. 34.
1900.		*Feet.*			
July 2	St. Louis, engineer depot	11.4	136,702	.....	.....
5	.....do	11.4	134,782	.....	.....
9	.....do	10.7	126,694	.....	.....
11	.....do	10.2	124,501	.....	.....
13	.....do	10.5	126,426	.....	.....
16	.....do	9.8	118,644	.....	.....
18	.....do	9.5	120,968	.....	.....
20	.....do	9.2	110,038	.....	.....
23	.....do	11.8	150,645	.....	.....
25	.....do	12.9	161,723	.....	.....
30	.....do	12.0	144,744	.....	.....
Aug. 1	.....do	11.4	137,690	.....	.....
3	.....do	10.5	124,448	.....	.....
7	.....do	8.4	101,519	.....	.....
10	.....do	7.1	89,791	.....	.....
21	.....do	8.9	112,098	.....	.....
24	.....do	9.2	110,854	.....	.....
28	.....do	8.9	111,838	.....	.....
31	.....do	9.6	117,343	.....	.....
Sept. 4	.....do	10.1	123,091	.....	.....
7	.....do	9.9	118,084	.....	.....
12	.....do	7.3	94,308	.....	.....
14	.....do	6.7	84,897	.....	.....
18	.....do	6.0	81,744	.....	.....
21	.....do	6.3	82,227	.....	.....
25	.....do	7.6	94,047	.....	.....
28	.....do	8.3	101,363	.....	.....
Oct. 2	.....do	11.0	132,457	.....	.....
5	.....do	13.4	161,279	.....	.....
9	.....do	13.2	164,749	.....	.....
12	.....do	11.5	136,931	.....	.....
16	.....do	10.2	123,556	.....	.....
19	.....do	10.1	122,875	.....	.....
23	.....do	11.7	142,578	.....	.....
26	.....do	12.5	152,813	.....	.....
30	.....do	12.6	154,635	.....	.....
Nov. 7	.....do	13.5	163,749	.....	.....
13	.....do	12.6	155,033	.....	.....
20	.....do	11.9	149,608	.....	.....
27	.....do	11.8	145,471	.....	152,936
28	.....do	11.6	141,971	144,383	142,005
Dec. 1	.....do	10.0	120,886	126,425	123,527
4*a*	.....do	8.6	103,357	109,683	109,300
4*b*	.....do	8.6	103,744	111,594	109,748
8*a*	.....do	7.4	89,787	100,114	102,094
8*b*	.....do	7.4	92,756	98,960	97,886
11	.....do	6.9	88,110	92,313	92,080
14*a*	.....do	6.2	81,841	84,910	83,505
14*b*	.....do	6.2	80,378	81,645	82,291
19	.....do	4.8	66,532	71,674	71,554
21	.....do	4.4	62,243	69,769	68,880
27	.....do	3.8	60,144	62,099	62,072
1901.					
Jan. 7	.....do	0.6	39,891	41,706	40,399
10	.....do	2.2	49,771	53,553	52,330
12	.....do	4.5	70,244	72,556	71,476
28	.....do	4.8	70,014	72,788	72,594
Feb. 16	.....do	2.6	52,721	55,746	59,601
Mar. 2	.....do	4.1	65,911	66,492	65,888

a A. M. *b* P. M.

1902

1. Removing snags and wrecks from the Mississippi River below the mouth of the Missouri River.—Before this work was begun, and for many years thereafter, the navigation of the river was seriously incommoded by numerous snags, logs, etc., which had lodged in the channel, and to which additions were made with each rise in the river. A large number of wrecked flatboats, barges, steamboats, and other river craft are found in the navigable channels and form a continual menace to life and property.

For the removal of these obstructions appropriations were made as early as 1824. The project adopted consisted of building boats suitable for removing the snags, logs, rack heaps, etc., and operating them whenever the stage of water was favorable and funds were available.

The amount expended upon this work on the reach of the river below the mouth of the Missouri prior to 1879 can not now be definitely ascertained, for the reason that during much of the time appropriations were made at irregular intervals in lump sums, to be applied to several streams as their needs or the terms of the law might require. From March 3, 1879, when the first specific appropriation was made, up to June 30, 1901, there had been expended $1,633,834.59. This expenditure made great improvement in the navigation of the river and lessened the danger to boats.

Two steel snag boats were employed in removing the obstructions to navigation between the mouth of the Missouri River and New Orleans, and during the year removed 3,907 snags, 27 drift piles, and 7 wrecks; 28,870 trees were felled and 17,857 miles in all was traversed.

An annual appropriation, not to exceed $100,000, for carrying on this work was made by the act of August 11, 1888. Under this appropriation the two snag boats will patrol the river and remove obstructions where necessary.

For recapitulation of commercial statistics reference should be made to report upon improving Mississippi River between Ohio and Missouri rivers.

Amount drawn under section 7, act of August 11, 1888	$92,039.67
June 30, 1902, amount expended during fiscal year	92,039.67
July 1, 1902, amount available for fiscal year 1902-3	100,000.00

(See Appendix X 1.)

2. Mississippi River between Ohio and Missouri rivers.—In its original condition the navigable channel of this section of the Mississippi River had a natural depth in many places of only 3½ to 4 feet at low water. The channels were divided by islands, which formed sloughs and secondary channels or chutes, through which a great deal of the volume of the flow was diverted, to the detriment of navigation.

The first effort to improve this condition began in 1872 and was continued for a number of years as appropriations were made, the works consisting of dikes and dams of brush and stone, erected with a view to confining the low-water volume to a single channel, and of revetments to hold and preserve the banks where necessary or advisable to do so.

The present project is a continuation of the plan adopted in 1881. It contemplates confining the flow of the river to a single channel having an approximate width below St. Louis of 2,500 feet, the natural width in many places being a mile or more at mean high water. This result is to be attempted by closing sloughs and secondary channels and by building out new banks where the natural width is excessive,

using for this purpose permeable dikes or hurdles of piling that collect and hold the solid matter that is carried in suspension or rolled on the bottom by the river. The banks, both old and new, are to be revetted or otherwise protected where necessary to secure permanency. Pending the completion of the permanent improvement, the low-water channel is to be improved each season by the use of dredges and other temporary expedients.

The object of the improvement is to obtain eventually a minimum depth, at standard low water, of 6 feet from the mouth of the Missouri to St. Louis, and of 8 feet from St. Louis to the mouth of the Ohio.

The original estimate of the cost of the improvement, as revised in 1883, is $16,397,500.

The total amount expended to June 30, 1902, was $9,541,368.73, exclusive of $180,000 allotted by acts to projects for improvement between the Illinois and the Missouri rivers, including Alton Harbor.

The amount expended during the fiscal year ending June 30, 1902, includes $556.50 expended for repairs to dredge plant. The total amount thus far expended for what is termed temporary channel improvements is $587,053.43, much of which has been for plant that is now on hand and available for future work. The approximate value of this plant is $209,425.81.

The result of the expenditure of this amount has been the partial improvement of the entire reach of the river from St. Louis to Cairo. During the past year there was at all times during open navigation a channel depth of 5 feet or more throughout this reach. The river attained a low-water stage of 5.9 feet below standard low water.

No funds were available for this improvement further than to care for the plant appertaining thereto, and no work was done during the past fiscal year.

With the present appliances and such others as may be developed for the temporary improvement of low-water channels, it is expected that a navigable depth of at least 6 feet will be maintained between St. Louis and Cairo during all stages, while the river is open to navigation, until the projected depth can be obtained throughout by the extension and completion of the permanent works.

It seems now certain that the procuring of satisfactory channels at all seasons of open navigation is merely a matter of providing funds in sufficient amounts to do the work economically. The local officer states that $250,000 is required annually for temporary low-water operations alone.

The river and harbor act approved June 13, 1902, appropriated $650,000 for continuing the improvement of the reach of the Mississippi River from the mouth of the Ohio to and including the mouth of the Missouri River.

Recapitulation of commercial statistics.

	1898.	1899.	1900.	1901.
	Tons.	*Tons.*	*Tons.*	*Tons.*
Receipts and shipments at St. Louis	906,168	669,815	757,590	672,076
Transferred by ferries at St. Louis	4,033,871	5,036,730	5,218,967	5,860,592
Shipped from landings between St. Louis and Cairo	53,785	30,716	52,640	30,978
Total	4,993,824	5,737,261	6,029,197	6,563,646

July 1, 1901, balance unexpended		$156,114.21
Received for expenses of rented pile drivers		97.81
Amount appropriated by river and harbor act approved June 13, 1902		650,000.00
		806,212.02
June 30, 1902, amount expended during fiscal year:		
By vouchers	$72,332.96	
By amount paid by Auditor for War Department	50.00	
By amount reserved by Office Chief of Engineers	100.00	
		72,482.96
July 1, 1902, balance unexpended		733,729.06
July 1, 1902, outstanding liabilities		377.72
July 1, 1902, balance available		[a]733,351.34
Amount that can be profitably expended in fiscal year ending June 30, 1904, in addition to the balance unexpended July 1, 1902. Submitted in compliance with requirements of sundry civil act of June 4, 1897.		650,000.00

(See Appendix X 2.)

3. Harbor at St. Louis, Mo.—St. Louis Harbor is about 18 miles long and divided into two nearly equal parts by the Eads Bridge. The upper part, included between the bridge and the northern limits of the city, is about 10 miles in length.

Congress, by act approved September 19, 1890, appropriated $182,000 for improvement of this harbor.

The navigable reach between the Eads Bridge and Merchants Bridge was at that time obstructed by a number of middle bars. The project adopted for improvement of the harbor under the appropriation of 1890 provided for a contraction of the waterway between those bridges to a width of about 2,000 feet, in order to concentrate the flow upon the bars and thus cause scour to the depth desired. The contraction works consisted of a series of hurdles extending out from the Illinois shore, the object of the hurdles being to collect deposits of material brought down during floods, and thus build up a new bank out to the line desired.

This work, which was accomplished by the close of the fiscal year ending June 30, 1892, caused extensive deposits of sediment along the line of hurdles and has resulted in considerable increase in channel depth, with corresponding benefit to navigation.

Amount expended to July 1, 1902, $150,762.03.

The only work at this locality during the past year had in view the raising and strengthening of the river ends of Bischoff and Long dikes and the repairing and extending of Hurdle No. 10. A survey of the harbor was also made.

All the funds appropriated for this work have been expended.

For recapitulation of commercial statistics reference should be made to report upon improvement of Mississippi River between Ohio and Missouri rivers.

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[a] Distributed under subheadings as follows:

For bank protection at Cairo, Ill., act of July 5, 1884	$2,571.70
For revetting bank opposite mouth of Missouri River, act of March 3, 1899	30,772.84
For from mouth of Ohio River to mouth of Missouri River, acts of June 6, 1900, and June 13, 1902	690,006.80
For protection of bank on Missouri side and to deepen and straighten channel at Wittenberg, Mo., act of March 3, 1899	10,000.00
	733,351.34

TABLE No. 2.—*Summary of expenses for operating U. S. snag boats H. G. Wright and J. N. Macomb in connection with the work of removing obstructions in Mississippi River during the fiscal year ending June 30, 1902*—Continued.

Application	1902.						
	January.	February.	March.	April.	May.	June.	Total.
Office expenses	$1,005.60	$4.20	$1,079.74	$198.98	$996.50	$12.80	$5,428.34
Expenses of snag boat H. G. Wright:							
Crew	2,101.00	2,131.60	1,862.83	1,392.50	1,456.05	1,424.00	22,510.72
Outfit	.....	85.00	.....	159.05	1,350.33	4,323.50	5,907.88
Fuel	543.80	1,073.80	186.00	367.25	80.00	.....	5,967.33
Subsistence	333.62	482.92	208.84	118.22	139.81	419.11	4,874.26
Supplies	.....	.....	.....	243.30	237.32	.....	750.26
Repairs	.....	.....	.....	406.05	880.53	111.09	1,592.86
Miscellaneous	.....	.....	.....	.....	.....	.....	.....
Expenses of snag boat J. N. Macomb:							
Crew	2,114.00	2,156.00	2,159.00	1,370.67	1,360.00	1,357.00	23,092.84
Outfit	.....	.....	.....	242.84	912.04	4,385.48	5,540.36
Fuel	830.25	780.00	1,492.00	206.25	107.61	.....	9,783.69
Subsistence	412.93	296.82	485.32	110.66	139.81	419.09	4,805.19
Supplies	.....	.....	.....	410.11	214.72	.....	645.83
Repairs	.....	.....	.....	905.16	805.53	5.75	1,716.44
Miscellaneous	.....	.....	.....	.....	.....	.....	24.15
Total	7,341.20	6,959.74	7,473.73	6,131.04	8,680.25	12,467.32	[a]92,689.67

[a] Includes $7,302 liabilities incurred during fiscal year, but remaining unpaid on June 30, 1902.

X 2.

IMPROVEMENT OF MISSISSIPPI RIVER BETWEEN OHIO AND MISSOURI RIVERS.

A concise statement of the project for and history of this work will be found in the Annual Report of the Chief of Engineers, U. S. Army, to which this report is an appendix, as well as on page 2631 of the Report of the Chief of Engineers, U. S. Army, for 1900.

Reference should be made to the Report of the Chief of Engineers, U. S. Army, for 1894, pages 1577 et seq., for information relating to the development of the various forms of construction and for a résumé of the various types employed between 1872 and 1894 and to the Reports of the Chief of Engineers, U. S. Army, for 1895 (p. 2059), 1896 (p. 1717), 1897 (p. 2012), 1898 (p. 1698), 1900 (p. 2632), and 1901 (p. 2169) for minor details as to forms of construction.

Since the adoption of this project work has been done substantially according to the methods referred to above at the following localities: Piasa Island, Alton Harbor, mouth Missouri River, St. Louis Harbor, Cahokia chute, Arsenal Island, Horsetail Bar, Carroll Island, Twin Hollows, Pulltight and Beards Island, Chesley Island, Jim Smiths, Sulphur Springs, Foster Island, Lucas, Cornice Island, Calico Island, Michaels Landing, Osborne Field, Rush Tower, Danby Landing, Fort Chartres, Crooks Landing, Turkey Island, Ste. Genevieve, Kaskaskia Island, Horse Island (Chester), Clearyville, Liberty Island, Seventy-six Landing, Hamburg, Devils Island, Minton Point, Cape Girardeau, Commerce Island, Burnham Island, Powers Island, Goose Island, Buffalo Island, and vicinity of Cairo.

PERMANENT IMPROVEMENT.

On account of lack of available funds work was confined to the care and repair of plant, and collection of physical data by reading gauges and measuring volumes of discharge at low stages in continuation of the same class of work begun in 1900, as reported in Annual Report of Chief of Engineers, 1901, pages 2173–2197. Two discharge measurements during the fiscal year 1902 were made, with results as follows:

Measurements of discharge of Mississippi River, 1901–2.

Dates.	Locality.	Gauge readings.			Oscillation.	Width of waterway.	Area of entire cross section.
		St. Louis gauge, 0=166.26 feet above St. Louis datum.	Elevations of water surface above St. Louis datum.				
			St. Louis gauge.	Local gauge.			
						Feet.	*Sq. ft.*
Nov. 8, 1901	Foot of Arsenal street, St. Louis, Mo.	3.40	169.66	168.98	S.	2,284	23,754
Jan. 16, 1902	.....do.....	1.26	167.52	167.01	S.	2,319	20,616

Dates.	Locality.	Area of cross section below standard low water.a	Mean depth.	Elevation of mean bottom above St. Louis datum.	Total volume of discharge.	Mean velocity.	Number of stations.	Method.
		Sq. ft.	*Feet.*	*Feet.*	*C. ft. per sec.*	*Ft. per sec.*		
Nov. 8, 1901	Foot of Arsenal street, St. Louis, Mo.	25,100	10.4	158.6	57,446	2.42	20	Full depth. Rod floats.
Jan. 16, 1902	.....do.....	27,161	8.9	158.2	42,631	2.13	12	Do.

Running ice.

aStandard low water reads 4 feet on the St. Louis gauge and 3.8 feet on the engineer depot gauge.

PLANT AND MATERIAL.

The plant belonging to this improvement has been maintained in condition to be safe and to reduce its deterioration while idle to a minimum. Worn-out items have not been replaced on account of lack of funds and for reasons stated in the Annual Report of the Chief of Engineers, 1901, page 2173.

Mr. D. M. Currie has continued in charge of the duties of principal assistant engineer, with Assistant Engineers William S. Mitchell, John O. Holman, E. D. Libby, and C. D. Lamb.

The district suffered a serious loss in the sudden death of Mr. John O. Holman, on November 19, 1901, while on duty on the river. Mr. Holman was a thoroughly competent engineer, and his services for some twenty years have been faithful and efficient. In November Assistant E. D. Libby was obliged, on account of failing health, to take an extended leave of absence without pay, which terminated on May 28, 1902, when he finally relinquished his position and severed his connection with this district. Assistant William S. Mitchell has remained on duty in local charge of such work as has been done in

this district, as has Assistant C. D. Lamb, in charge of the engineer depot. The assistant engineers and office force have performed their duties with customary efficiency and zeal.

ESTIMATES.

The original estimate of the cost of the improvement of the Mississippi River between the mouths of the Ohio and Missouri rivers, as revised in 1883, is $16,397,500.

The total appropriations to date amount to $10,454,999.98. Of this amount $180,000 was allotted by acts and projects for improvement between the Illinois and Missouri rivers, including Alton Harbor, leaving a balance of $10,274,999.98 to be applied to the project for the general improvement between the mouths of the Ohio and Missouri rivers. The balance of the estimate for the original project for the general improvement between the Ohio and Missouri rivers not appropriated June 30, 1902, is therefore $6,122,500.02.

The amount that has been expended upon the project to this date is $9,541,368.78.

The balance available June 30, 1902, of the amount appropriated is $733,631.25, to which must be added $97.81 received on account of rental of pile drivers under authority of the Secretary of War, a total of $733,729.06, exclusive of outstanding liabilities.

The amount expended during the fiscal year was $72,482.96, of which $72,332.96 was by voucher, $50 by Auditor for the War Department, and $100 reserved by the office of the Chief of Engineers.

The river and harbor act approved June 3, 1896, provides—

That any balance of former appropriations now available and the money hereby appropriated and authorized to be expended for the said section of said river between the mouth of the Missouri River and the mouth of the Ohio River, or so much thereof as may be necessary, shall be expended in the construction of suitable dredge boats, portable jetties, and other suitable appliances, and in the maintenance and operation of the same, with the view of ultimately obtaining and maintaining a navigable channel from St. Louis to Cairo, not less than two hundred and fifty feet in width and nine feet in depth at all periods of the year, except when navigation is closed by ice.

In the $9,541,368.78 above mentioned is included what has been expended for dredge plant, portable jetties, and appliances for temporary improvement of the channel and for operating the same. This amounts to about $587,053.43. Of this $556.50 was expended during the fiscal year for necessary repairs to dredges. The approximate value of this plant at the beginning of the fiscal year was $225,526.27. Since then the depreciation in value, with $556.50 added for repairs, is estimated to be $16,656.96, which has been charged to the loss account, due to suspension of work on account of the failure of appropriations. The approximate value of this plant at this time is therefore $209,425.81.

The available balance includes the unexpended balances from special allotments made by Congress, as follows:

For bank protection at Cairo, Ill., act of July 5, 1884	$2,571.70
For revetting bank opposite mouth of Missouri River, act of March 3, 1899	30,772.84
For protection of bank on Missouri side and to deepen and straighten channel at Wittenberg, Mo., act of March 3, 1899	10,000.00
Total	43,344.54

Money statement.

July 1, 1901, balance unexpended		$156,114.21
Received for expenses of rented pile drivers		97.81
Amount appropriated by river and harbor act approved June 13, 1902		650,000.00
		806,212.02
June 30, 1902, amount expended during fiscal year:		
By vouchers	$72,332.96	
By amount paid by Auditor for War Department	50.00	
By amount reserved by Office Chief of Engineers	100.00	
		72,482.96
July 1, 1902, balance unexpended		733,729.06
July 1, 1902, outstanding liabilities		377.72
July 1, 1902, balance available		[a]733,351.34
Amount (estimated) required for completion of existing project		6,122,500.02
Amount that can be profitably expended in fiscal year ending June 30, 1904, in addition to the balance available July 1, 1902:		
For works of improvement	$850,000.00	
For maintenance of improvement	150,000.00	
		1,000,000.00
Submitted in compliance with requirements of sundry civil act of June 4, 1897, and of section 7 of the river and harbor act of 1899.		

LIST OF APPROPRIATIONS.

By act of—		By act of—	
June 10, 1872	$100,000.00	March 3, 1893	$658,333.33
March 3, 1873	200,000.00	August 18, 1894	758,333.33
June 23, 1874	200,000.00	March 2, 1895	758,333.33
March 3, 1875	200,000.00	June 3, 1896	275,000.00
August 14, 1876	200,000.00	June 4, 1897	673,333.33
June 18, 1878	240,000.00	July 19, 1897	325,000.00
March 3, 1879	200,000.00	July 1, 1898	673,333.33
June 14, 1880	250,000.00	March 3, 1899	673,333.33
March 3, 1881	600,000.00	June 6, 1900	100,000.00
August 2, 1882	600,000.00	June 13, 1902	650,000.00
July 5, 1884	520,000.00	Other receipts	97.81
August 5, 1886	375,000.00		
August 11, 1888	300,000.00		
September 19, 1890	400,000.00	Total	10,455,097.70
July 13, 1892	525,000.00		

[a] Distributed under subheadings as follows:

For bank protection at Cairo, Ill., act of July 5, 1884	$2,571.70
For revetting bank opposite mouth of Missouri River, act of March 3, 1899	30,772.84
For from mouth of Ohio River to mouth of Missouri River, acts of June 6, 1900, and June 13, 1902	690,006.80
For protection of bank on Missouri side and to deepen and straighten channel at Wittenberg, Mo., act of March 3, 1899	10,000.00
	733,351.34

1903

logs, etc., which had lodged in the channel, and to which additions were made with each rise of the river. A large number of wrecked flatboats, barges, steamboats, and other river craft was found in the navigable channels and formed a continual menace to life and property.

For the removal of these obstructions appropriations were made as early as 1824. The project adopted consisted of building boats suitable for removing snags, logs, drift heaps, etc., and operating them whenever the stage of water was favorable and funds were available.

The amount expended upon this work on the reach of the river below the mouth of the Missouri prior to 1879 can not now be definitely ascertained, for the reason that during much of the time appropriations were made at irregular intervals in lump sums, to be applied to several streams as their needs or the terms of the law might require. From March 3, 1879, when the first specific appropriation was made, up to June 30, 1902, there had been expended $1,726,889.86. This expenditure made great improvement in the navigation of the river and lessened the danger to boats.

Two steel snag boats were employed in removing the obstructions to navigation between the mouth of the Missouri River and Natchez, and during the year 1,552 snags were pulled, 2 drift piles removed, 6,895 trees cut, and 10,325 miles patrolled.

An annual appropriation, not to exceed $100,000, for carrying on this work was made by the act of August 11, 1888. Under this appropriation the two snag boats will continue to patrol the river and remove obstructions where necessary.

For recapitulation of commercial statistics reference should be made to the report upon improving the Mississippi River between the Ohio and Missouri rivers.

Amount drawn under section 7, act of August 11, 1888	$72,587.48
June 30, 1903, amount expended during fiscal year	72,587.48
July 1, 1903, amount available for fiscal year 1903–4	100,000.00

(See Appendix Z 1.)

2. Mississippi River between Ohio and Missouri rivers.—In its original condition the navigable channel of this section of the Mississippi River had a natural depth in many places of only 3½ to 4 feet at low water. The channels were divided by islands, which formed sloughs and secondary channels or chutes, through which a great deal of the volume of the flow was diverted, to the detriment of navigation.

The first effort to improve this condition began in 1872 and was continued for a number of years as appropriations were made, the works consisting of dikes and dams of brush and stone, erected with a view to confining the low-water volume to a single channel, and of revetments to hold and preserve the banks where necessary or advisable to do so.

The present project is a continuation of the plan adopted in 1881. It contemplates confining the flow of the river to a single channel having an approximate width below St. Louis of 2,500 feet at bank-full stage, the natural width in many places being a mile or more at mean high water. This result is to be attempted by closing sloughs and secondary channels and by building out new banks where the natural width is excessive, using for this purpose permeable dikes or

bundles of piling that collect and hold the solid matter that is carried in suspension or rolled on the bottom by the river. The banks, both old and new, are to be revetted or otherwise protected where necessary to secure permanency. Pending the completion of the permanent improvement, the low-water channel is to be improved each season by the use of dredges and other temporary expedients.

The object of the improvement is to obtain eventually a minimum depth at standard low water of 6 feet from the mouth of the Missouri to St. Louis and of 8 feet from St. Louis to the mouth of the Ohio.

The original estimate of the cost of the improvement, as revised in 1883, is $16,397,500.

The total amount expended to June 30, 1903, was $10,037,957.77, exclusive of $180,000 allotted by acts to projects for improvement between the Illinois and Missouri rivers, including Alton Harbor.

The amount expended during the fiscal year ending June 30, 1903, includes $48,151.76 expended for temporary expedients. The total amount thus far expended for temporary channel improvements is $627,425.85, much of which has been for plant that is now on hand and available for future work. The approximate value of this plant is $194,677.10.

The result of the expenditure of this amount has been the partial improvement of the entire reach of the river from St. Louis to Cairo. During the past year there was at all times during open navigation a channel depth of 6 feet or more throughout this reach. The river attained a low-water stage of 3.5 feet above standard low water.

With the present appliances and such others as may be developed for the temporary improvement of low-water channels, it is expected that a navigable depth of at least 6 feet will be maintained between St. Louis and Cairo during all stages, while the river is open to navigation, until the projected depth can be obtained throughout by the extension and completion of the permanent works.

It seems now certain that the procuring of satisfactory channels at all seasons of open navigation is merely a matter of providing funds in sufficient amounts to do the work economically. The local officer states that $150,000 is required annually for temporary low-water operations alone.

The act for sundry civil expenses of the Government approved March 3, 1903, appropriated $650,000 for continuing the improvement of the reach of the Mississippi River from the mouth of the Ohio to and including the mouth of the Missouri River.

Recapitulation of commercial statistics.

	1899.	1900.	1901.	1902.
	Tons.	*Tons.*	*Tons.*	*Tons.*
Receipts and shipments at St. Louis	669,815	757,590	672,076	641,182
Transferred by ferries at St. Louis	5,036,730	5,218,967	5,860,592	5,731,635
Shipped from landings between St. Louis and Cairo	80,716	52,640	30,978	17,179
Total	5,787,261	6,029,197	6,563,646	6,389,996

July 1, 1902, balance unexpended	$733,729.06
November 25, 1902, received from sale of condemned property	2,386.09
Amount appropriated by sundry civil act approved March 3, 1903	650,000.00
	1,386,115.15
June 30, 1903, amount expended during fiscal year	496,589.04
July 1, 1903, balance unexpended	889,526.11
July 1, 1903, outstanding liabilities	8,749.90
July 1, 1903, balance available	[a]880,776.21
July 1, 1903, amount covered by uncompleted contracts	107,228.71
Amount that can be profitably expended in fiscal year ending June 30, 1905, in addition to the balance available July 1, 1903	650,000.00
Submitted in compliance with requirements of sundry civil act of June 4, 1897.	

(See Appendix Z 2.)

3. To prevent the Mississippi River from breaking through into the Cache River at or near a point known as Beechridge, a few miles above Cairo, Ill.—The sundry civil act approved June 4, 1897, contained an item providing for this work, which reads as follows:

For the purpose of preventing the Mississippi River from breaking through into the Cache River at or near a point known as Beach Ridge [Beechridge], a few miles north of Cairo, whereby the national cemetery at Mound City, at the mouth of the Cache River, and the marine hospital at Cairo would be in imminent danger of destruction, the sum of one hundred thousand dollars, or so much thereof as may be necessary, is hereby appropriated, to be immediately available.

The project for this work not having been based upon a survey under the Engineer Department, and the extent of the work contemplated being unknown, an estimate of its total cost could not then be given. From a study of the conditions involved, it seemed that the object of the appropriation could best be carried out by revetting as great a length of the bank of the Mississippi River in the vicinity of Beechridge railroad station as the funds would cover.

The project for the expenditure of the amount appropriated contemplated commencing at a suitable point on the bank of the river a short distance above the nearest point to Beechridge station, building a short hurdle out into the stream to protect the head of the revetment, and then revetting the banks in the usual manner down as far as the funds would suffice.

Under this project and during the previous fiscal years a hurdle 275 feet long was constructed and 9,435 linear feet of subaqueous mattress was placed. This mattress was about 180 feet wide, and followed the form of construction used in this section of the Mississippi River, the upper 440 feet having been built of brush and the remainder of lumber. The bank above the mattress was revetted with stone to the

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[a] Distributed under subheadings as follows:

For revetting bank opposite mouth of Missouri River, act of March 3, 1899	$30,772.84
For from mouth of Ohio River to mouth of Missouri River, acts of June 13, 1902, and March 3, 1903	818,293.41
For protection of bank on Missouri side and to deepen and straighten channel at Wittenberg, Mo., act of March 3, 1899	10,000.00
For allotment for Sawyers Bend, act of June 13, 1902	21,709.96
	880,776.21

Z 2.

IMPROVEMENT OF MISSISSIPPI RIVER BETWEEN OHIO AND MISSOURI RIVERS.

A concise statement of the project for and history of this work will be found in the Annual Report of the Chief of Engineers for 1903, page 390, as well as on page 2631 of the Report of the Chief of Engineers, United States Army, for 1900.

Reference should be made to the Report of the Chief of Engineers, United States Army, for 1894, pages 1577 et seq., for information relating to the development of the various forms of construction and for a résumé of the various types employed between 1872 and 1894, and to the Reports of the Chief of Engineers, United States Army, for 1895 (p. 2059), 1896 (p. 1717), 1897 (p. 2012), 1898 (p. 1698), 1900 (p. 2632), and 1901 (p. 2169) for minor details as to forms of construction.

Since the adoption of this project work has been done substantially according to the methods referred to above at the following localities: Mouth Missouri River, St. Louis Harbor, Cahokia Chute, Arsenal Island, Horsetail bar, Carroll Island, Twin Hollows, Pulltight, Beards Island, Chesley Island, Jim Smiths, Sulphur Springs, Foster Island, Lucas, Cornice Island, Rush Tower, Michaels Landing, Danby Landing, Rush Towhead, Penitentiary Point, Turkey Island, Ste. Genevieve, Kaskaskia Island, Chester, Liberty Island, Seventy-six Landing, Hamburg, Devils Island, Minton Point, Cape Girardeau, Commerce Island, Burnham Island, Powers Island, Goose Island, Buffalo Island, Greenleaf Bend, and vicinity of Cairo.

During the fiscal year ending June 30, 1903, work for the permanent improvement of the river has been carried on, as hereinafter described, at the following localities: Lucas, Rush Tower, Danby Landing, Rush Towhead, Turkey Island, Ste. Genevieve, Mo., Chester, Liberty Island, Greenleaf Bend, and Cairo Protection.

PERMANENT IMPROVEMENT.

Lucas Hurdles (29 miles below St. Louis).—A summary of the operations at this point will be found on page 2633 of the Report of the Chief of Engineers for 1900.

For the further improvement of this reach four additional hurdles were built during the year: No. 1, on the Missouri side in front of Herculaneum, Mo., about 300 feet above the mouth of Joachim Creek; Nos. 16½, 18, and 19½ on the Illinois side. For location, reference should be made to Plate I. The total construction amounted to 4,500 linear feet of hurdles.

A good depth was maintained in the channel during the year.

Rush Tower, Illinois (37 miles below St. Louis).—The Illinois shore between Osborne Field and Kempers Landing was protected for 8,770 feet during 1892, 1893, and 1894. The protection was extended 3,030 feet further downstream in 1901, with subaqueous mattress and revetment up to the foot of the bluff bank, to an average stage of 16 feet above the low water of 1863.

The bank above the protection having been graded by the river, the revetment was repaired and was carried up to an average stage of 25 feet above the low water of 1863.

The total amount of revetment placed was 3,730 linear, or 116,700 square feet.

Danby Landing, Missouri (40 miles below St. Louis).—The protection at this locality was begun in 1895. The mattress had been placed for 5,450 linear feet, and all except 700 feet at the upper end was revetted to stages of from 16 to 20 feet.

During the fiscal year 1903 the old work was repaired and all the revetment raised to a height of 26 feet above the low water of 1863; as high as the bank had been graded.

The total amount of bank covered was 5,400 linear, or 118,100 square feet.

Rush Towhead, Illinois (42 miles below St. Louis).—The protection, 2,435 feet long, built in 1901, was carried up to a 13-foot stage. It was extended 100 feet farther upstream, and all, except 700 feet, made inaccessible to barges by a bar which formed in its front, was carried to the top of the graded bank at a 27-foot stage during 1903. The total amount of revetment placed was 1,835 linear, or 61,200 square feet.

Turkey Island, Illinois (52 miles below St. Louis).—The protection of the west shore of the island was begun in 1895, when a mattress was built for 5,250 feet and revetment begun. The stonework was repaired in 1898 and carried to stages of from 10 to 15 feet.

Work for the extension of this protection to higher planes was begun at this place November 30, 1902, and 1,600 feet of revetment near the lower end was raised to a 24-foot stage, in which a total of 59,600 square feet of revetment was placed.

Ste. Genevieve, Mo. (60 miles below St. Louis).—A summary of the operations at this point will be found on page 2170 of the Report of the Chief of Engineers for 1901.

The revetment was raised from a 20-foot stage to a 28-foot stage for 450 linear feet below hurdle No. 18, in which 5,400 square feet of revetment was placed. Work was suspended on account of the high water of June.

Chester, Mo. (Horse Island and Claryville, 74 miles below St. Louis).—The bank of Horse Island was protected for a distance of 4,058 feet during 1899. The revetment was repaired and extended up to an average stage of 20 feet during 1900 and 1901. The work of 1903 was in repair and extension downstream and to higher planes.

The upper portion of the bank inside the protection had been cut away by high water, allowing a large body of water to run down inside the mattress. The bank was eroded for about 1,400 feet, with a maximum recession of 75 feet, beginning 2,600 feet below the head of the old protection.

A mattress varying in width from 60 feet to 130 feet was built to protect the bank inside the old mattress from station 26 to a point 288 feet below the foot of the old work. At two places where the erosion had been greatest a single line of piles was driven to a distance of 60 feet from shore. The old revetment was repaired, and portions raised to a stage of 30 feet above the low water of 1863.

Work was suspended about the end of May on account of high water. Considerable erosion occurred during June between stations 17 and 26.

A total of 1,746 linear, or 166,230 square feet of mattress was built and sunk and 1,950 linear, or 23,735 square feet of revetment placed.

Liberty, Mo. (82 miles below St. Louis).—The protection between Anchor Landing and Bishops Landing was built in 1877. It was partly rebuilt in 1895 and was then completed up to a 12-foot stage.

It was repaired in 1900 and a part of the bank revetted up to 21 feet above the zero of the St. Louis gauge.

No work could be done the following year on account of the failure of appropriations, and the bank was cut away inside the protection, the maximum recession being about 400 feet.

To prevent further damage, and to restore the shore line to the old protection, eight short hurdles were begun between the foot of Cranes Island and the foot of the old mattress during the spring of 1903. These hurdles are numbered 1½, 6½, 8, 9, 10, 11, 12, and 13, the number showing their distance in thousands of feet below Cranes Island. They will have an aggregate length of about 2,000 feet, and were built to a stage of about 30 feet at the shore end. The outer ends will be about 15 feet lower when completed, but their construction was suspended on account of the high water of June.

The equivalent of about 1,500 linear feet of completed hurdle was built during the year.

Liberty, Ill. (85 miles below St. Louis).—A summary of the operations at this point will be found on page 2171 of the Report of the Chief of the Engineers for 1901.

The revetment was repaired and raised to an average stage of 25 feet from station 31 to station 80, and to 22 feet from station 80 to station 108, during the fall season of 1903.

A total of 6,610 linear, or 176,400 square feet of revetment was placed.

Greenleaf Bend, Illinois (167 miles below St. Louis).—The protection of the soft and rapidly caving bank in this bend was begun during the first half of the fiscal year 1903.

The mattress was built and the bank revetted up as far as graded, or to an average stage of 18 feet, for a distance of 6,075 feet, in which 891,725 square feet of mattress was woven and sunk and 138,840 square feet of revetment placed.

Cairo protection, Illinois (178 miles below St. Louis).—For description of this work, see Reports of the Chief of Engineers from 1877 to 1881, and for 1885, 1887, 1891, and 1899.

A break made in the revetment between the two upper spur dikes by the high water of 1902 was repaired this year by 290 linear, or 11,310 square feet of revetment and a short spur dike. This work exhausted the balance of the appropriation of 1884, amounting to $2,571.70.

TEMPORARY EXPEDIENTS.

Dredging.—The past year has been remarkable for the high stages prevailing during the season of navigation. The minimum gauge reading was 7.5 feet on September 24, after which it rose and varied from 9 feet to 21 feet during the remainder of the fall season. These high stages rendered but little dredging necessary. The dredges were kept in commission, however, from the beginning of the low-water season until the end of November, and worked for short periods at Crystal City, Ste. Genevieve Bend, and Philadelphia Point in each case until their use was made unnecessary by high water.

PLANT.

The plant belonging to this improvement deteriorated while idle on account of the exhaustion of available funds during the preceding year.

Repairs begun in August and prosecuted vigorously throughout the fiscal year restored to a serviceable condition sufficient of the plant to supply urgent needs.

The steamer *Gen. T. L. Casey* was docked and extensively repaired at the Carondelet ways of the Wiggins Ferry Company in the fall and the steamer *Gen. H. L. Abbot* in the spring.

Six barges, one quarter boat, one office and survey boat, and seven pile drivers were extensively repaired on the ways at the engineer depot during the year, a store boat was equipped for carrying ice and provisions to working parties in the field, and the construction of eight steel flats, each 16 feet by 55 feet, for which material was bought in 1901, was nearly completed.

The current repairs needed to maintain the plant in an efficient working condition were made as required.

MATERIAL.

The piles, lumber, and part of the stone required for the construction works were procured by contract; the remainder of the stone was procured by hired labor and payment of royalty at Little Rock quarries, near Ste. Genevieve, Mo. No bids having been received in the autumn, all the stone used during that season was procured at those quarries, but contracts were made in the spring and 2,407 cubic yards were purchased under them.

ORGANIZATION.

The organization remained substantially the same as last year (see pages 1598 and 1599 of Report of Chief of Engineers for 1902), with the exception of the loss incurred by the death of Assistant Engineer E. D. Libby, which occurred at Concord, N. H., April 24, 1903.

Mr. Libby was born in Maine in 1852, graduated from Dartmouth College in 1879 and from Thayer School with degree of civil engineer in 1882, and was appointed assistant resident engineer and served as such until 1887, when he severed his connection at his own request to accept a position with an iron works at Wilmington, Del., whence he went to Providence, R. I., with the Boston and Providence Railroad, returning to this office as assistant engineer, where he was actively engaged until the winter of 1901–2, when, on account of failing health, he was given a furlough without pay.

Mr. Libby filled every position which he held under this office with entire satisfaction to the officer in charge and with credit to himself. His ability as a civil engineer, which he brought to bear upon all his work with untiring industry, was of high order.

ESTIMATES.

The original estimate of the cost of the improvement of the Mississippi River between the mouths of the Ohio and Missouri rivers, as revised in 1883, is $16,397,500.

The total appropriations to date amount to $11,104,999.98. Of this amount $180,000 was allotted by acts and projects for improvement between the Illinois and Missouri rivers, including Alton Harbor, leaving a balance of $10,924,999.98 to be applied to the project for the

general improvement between the mouths of the Ohio and Missouri rivers. The balance of the estimate for the original project for the general improvement between the Ohio and Missouri rivers not appropriated June 30, 1903, is, therefore, $5,472,500.02.

The amount that has been expended upon the project to this date is $10,037,957.77.

The balance available June 30, 1903, of the amount appropriated is $887,042.21, to which must be added $97.81 received on account of rental of pile drivers under authority of the Secretary of War, and $2,386.09 received from sale of condemned property, a total of $889,526.11, exclusive of outstanding liabilities.

The amount expended during the fiscal year was $496,589.04, of which $496,524.12 was by voucher and $64.92 by Auditor for the War Department.

The river and harbor act approved June 3, 1896, provides—

> That any balance of former appropriations now available, and the money hereby appropriated and authorized to be expended for the said section of said river between the mouth of the Missouri River and the mouth of the Ohio River, or so much thereof as may be necessary, shall be expended in the construction of suitable dredge boats, portable jetties, and other suitable appliances, and in the maintenance and operation of the same, with the view of ultimately obtaining and maintaining a navigable channel from St. Louis to Cairo not less than two hundred and fifty feet in width and nine feet in depth at all periods of the year, except when navigation is closed by ice.

In the $10,037,957.77 above mentioned is included what has been expended for dredge plants, portable jetties, and appliances for temporary improvement of the channel and for operating the same. This amounts to about $627,425.85. Of this, $48,151.76 was expended during the fiscal year for operating dredges and minor repairs of same. The approximate value of this plant at the beginning of the fiscal year was $209,425.81. Its present approximate value is $194,677.10.

The available balance includes the unexpended balances from special allotments made by Congress, as follows:

For revetting bank opposite mouth of Missouri River, act of March 3, 1899	$30,772.84
For protection of bank on Missouri side and to deepen and straighten channel at Wittenberg, Mo., act of March 3, 1899	10,000.00
Total	40,772.84

PHYSICAL DATA.

Gauges.—The gauges on this part of the river have been read and repaired as required.

Discharge measurements.—Measurements for the discharge of the river were made with full-depth rod floats at the engineer depot. Measurements with two Haskell meters were made by the Mississippi River Commission, on July 18 and 19, in the same cross section as that used by the floats and at the same stations. One meter was in bad order, but the other gave velocities and discharge that agreed very closely with the results from the floats. The curves of velocity and discharge have been determined between a 5-foot and a 15-foot stage, but more observations are needed for higher and lower stages.

Measurements were also made at Chester, Ill., to determine the discharge of the flood of June, in which a maximum of 900,000 cubic feet per second was obtained, with surface velocities in midstream of 8 miles per hour.

1904

quired by the river and harbor act approved June 13, 1902, were submitted by Captain Fitch, through the division engineer, Col. Amos Stickney, and Lieut. Col. H. M. Adams, Corps of Engineers, respectively, and these reports were reviewed by the Board of Engineers for Rivers and Harbors, pursuant to law. A plan for improvement at an estimated cost of $3,000 is submitted. The report was transmitted to Congress and printed in House Document No. 205, Fifty-eighth Congress, second session. (See also Appendix W 10.)

REMOVING SNAGS AND WRECKS FROM MISSISSIPPI RIVER; IMPROVEMENT OF MISSISSIPPI RIVER BETWEEN OHIO AND MISSOURI RIVERS.

This district was in the charge of Maj. Thos. L. Casey, Corps of Engineers. Division engineer, Col. O. H. Ernst, Corps of Engineers.

1. Removing snags and wrecks from the Mississippi River below the mouth of the Missouri River.—Before this work was begun the navigation of the river was seriously interfered with by numerous snags, logs, etc., which had lodged in the channel, and to which additions were made with each rise of the river. A large number of wrecked flatboats, barges, steamboats, and other river craft were found in the navigable channels and formed a continual menace to life and property.

For the removal of these obstructions appropriations were made as early as 1824. The project adopted consisted of building boats suitable for removing snags, logs, drift heaps, etc., and operating them whenever the stage of water was favorable and funds were available.

The amount expended upon this work on the reach of the river below the mouth of the Missouri prior to 1879 can not now be definitely ascertained, for the reason that during much of the time appropriations were made at irregular intervals in lump sums, to be applied to several streams as their needs or the terms of the law might require. From March 3, 1879, when the first specific appropriation was made, up to June 30, 1904, there had been expended $1,377,722.59. This expenditure made great improvement in the navigation of the river and lessened the danger to boats.

Two steel snag boats were employed in removing the obstructions to navigation between the mouth of the Missouri River and Natchez, and during the year 4,654 snags were pulled, 18 drift piles removed, 17,034 trees cut, and 17,319 miles patrolled.

An annual appropriation, not to exceed $100,000, for carrying on this work was made by the act of August 11, 1888. Under this appropriation the two snag boats will continue to patrol the river and remove obstructions where necessary.

For recapitulation of commercial statistics, reference should be made to the report upon improving the Mississippi River between the Ohio and Missouri rivers.

Amount drawn under section 7, act of August 11, 1888	$88,245.25
June 30, 1904, amount expended during fiscal year	88,245.25
July 1, 1904, amount available for fiscal year 1904-5	100,000.00

(See Appendix X 1.)

2. Mississippi River between Ohio and Missouri rivers.—In its original condition the navigable channel of this section of the Mississippi River had a natural depth in many places of only 3½ to 4 feet at low water. The channels were divided by islands which formed sloughs

and secondary channels or chutes, through which a great deal of the volume of the flow was diverted to the detriment of navigation.

The first effort to improve this condition was begun in 1872 and was continued for a number of years as appropriations were made, the works consisting of dikes and dams of brush and stone erected with a view to confining the low-water volume to a single channel, and of revetments to hold and preserve the banks where necessary or advisable to do so.

The present project is a continuation of the plan adopted in 1881, approved by letter of the Chief of Engineers, dated March 31, 1881.

It contemplates confining the flow of the river to a single channel having an approximate width below St. Louis of 2,500 feet at bank-full stage, the natural width in many cases being a mile or more at mean high water. This result is to be attempted by closing sloughs and secondary channels and by building out new banks where the natural width is excessive, using for this purpose permeable dikes or hurdles of piling that collect and hold the solid matter that is carried in suspension or rolled on the bottom of the river. The banks, both new and old, are to be revetted or otherwise protected where necessary to secure permanency. Pending the completion of the permanent improvement, the low-water channel is to be improved each season by the use of dredges and other temporary expedients.

The object of the improvement is to obtain eventually a minimum depth, at standard low water, of 6 feet from the mouth of the Missouri to St. Louis, and of 8 feet from St. Louis to the mouth of the Ohio.

The original estimate of the cost of the improvement, as revised in 1883, is $16,397,500.

The total amount expended to June 30, 1904, was $10,629,390.66, exclusive of $180,000 allotted by acts to projects for improvement between the Illinois and Missouri rivers, including Alton Harbor.

The amount expended during the fiscal year ending June 30, 1904, includes $906.30 expended for temporary expedients. The total amount thus far expended for temporary channel improvements is $630,836.34, much of which has been for plant that is now on hand and available for future work. The approximate value of this plant is $181,136.33.

The result of the expenditure of this amount has been the partial improvement of the entire extent of the river from St. Louis to Cairo. During the past year there was at all times during open navigation a channel depth of eight feet or more throughout this section. The river reached a low-water stage of sixth-tenths of a foot below standard low water.

With the present appliances and such others as may be developed for the temporary improvement of low-water channels, it is expected that a navigable depth of about 8 feet can be maintained between St. Louis and Cairo during all stages, while the river is open to navigation, until the projected depth can be obtained throughout by the extension and completion of the permanent works.

It seems now certain that the procuring of satisfactory channels at all seasons of open navigation is merely a matter of providing funds in sufficient amounts to do the work economically. The local officer states that $150,000 should be provided annually for temporary low-water operations alone.

The Board of Engineers for Rivers and Harbors constituted under the provisions of section 3 of the river and harbor act of June 13, 1902,

has, pursuant to a request from the Committee on Rivers and Harbors of the House of Representatives, submitted a report dated November 12, 1903, as to whether, by dredging or otherwise, a suitable channel in the Mississippi River between the mouth of the Missouri River and the mouth of the Ohio River can not be established and maintained at less expense than in accordance with the existing project. A plan for improvement at an estimated cost of $20,000,000 and $400,000 annually for maintenance is presented. The report is printed in House Document No. 168, Fifty-eighth Congress, second session, and is herewith in Appendix X 2.

The sundry civil act approved April 28, 1904, appropriated $650,000 for continuing the improvement of the Mississippi River from the mouth of the Ohio to and including the mouth of the Missouri River.

Report on preliminary examination of Missouri Chute authorized by the river and harbor act of June 13, 1902, is printed in House Document No. 76, Fifty-eighth Congress, second session, and is herewith in Appendix X 3.

Recapitulation of commercial statistics.

	1900.	1901.	1902.	1903.
	Tons.	*Tons.*	*Tons.*	*Tons.*
Receipts and shipments at St. Louis	757,590	672,076	641,182	552,617
Transferred by ferries at St. Louis	5,218,967	5,860,592	5,731,635	6,328,154
Shipped from landings between St. Louis and Cairo	52,640	30,978	17,179	43,867
Total	6,029,197	6,563,646	6,389,996	6,924,638

July 1, 1903, balance unexpended		$889,526.11
Amount appropriated by sundry civil act approved April 28, 1904		650,000.00
July 1, 1904, miscellaneous receipts		1,220.71
		1,540,746.82
June 30, 1904, amount expended during fiscal year:		
For works of improvement	$399,740.43	
For maintenance of improvement	191,692.46	
		591,432.89
July 1, 1904, balance unexpended		949,313.93
July 1, 1904, outstanding liabilities		33,721.26
July 1, 1904, balance available		[a] 915,592.67
July 1, 1904, amount covered by uncompleted contracts		50,699.46
Amount that can be profitably expended in fiscal year ending June 30, 1906, in addition to the balance unexpended July 1, 1904. Submitted in compliance with requirements of sundry civil act of June 4, 1897, and of section 7 of the river and harbor act of 1899. (See Appendix X 2.)		650,000.00

[a] Distributed under subheadings as follows:

For from mouth of Ohio River to mouth of Missouri River, acts of March 3, 1903, and April 28, 1904	$884,845.35
For protection of bank on Missouri side and to deepen and straighten channel at Wittenberg, Mo., act of March 3, 1899	10,000.00
For allotment for Sawyers Bend, act of June 13, 1902	20,747.32
	915,592.67

X a.

IMPROVEMENT OF MISSISSIPPI RIVER BETWEEN OHIO AND MISSOURI RIVERS.

A concise statement of the project for and history of this work will be found in the Annual Report of the Chief of Engineers for 1904, page 412, as well as on page 2631 of the Report of the Chief of Engineers, United States Army, for 1900.

Reference should be made to the Report of the Chief of Engineers, United States Army, for 1894, pages 1577 et seq., for information relating to the development of the various forms of construction and for a résumé of the various types employed between 1872 and 1894, and to the Reports of the Chief of Engineers, United States Army, for 1895 (p. 2059), 1896 (p. 1717), 1897 (p. 2012), 1898 (p. 1698), 1900 (p. 2632), and 1901 (p. 2169) for minor details as to forms of construction.

Since the adoption of this project work has been done substantially according to the methods referred to above at the following localities: Mouth Missouri River, St. Louis Harbor, Cahokia Chute, Arsenal Island, Horsetail Bar, Carroll Island, Twin Hollows, Pulltight, Beards Island, Chesley Island, Jim Smiths, Sulphur Springs, Foster Island, Lucas, Cornice Island, Rush Tower, Michaels Landing, Danby Landing, Rush Towhead, Penitentiary Point, Turkey Island, Ste. Genevieve, Kaskaskia Island, Chester, Crain Island, Liberty Island, Seventy-six Landing, Willard, Hamburg, Devils Island, Minton Point, Cape Girardeau, Commerce Island, Burnham Island, Powers Island, Goose Island, Buffalo Island, Greenleaf Bend, Hurricane Field, Greenfield Bend, and vicinity of Cairo.

During the fiscal year ending June 30, 1904, work for the permanent improvement of the river has been carried on, as hereinafter described, at the following localities: Opposite Missouri River, Pulltight, Chesley Island, Danby Landing, Penitentiary Point, Ste. Genevieve, Chester, Crain Island, Liberty, Liberty Bend, Willard, Goose Island, Buffalo Island, Greenleaf Bend, Hurricane Field, and Greenfield Bend. (See Pls. 1 and 2.)

PERMANENT IMPROVEMENT.

Opposite mouth of Missouri River (15 miles above St. Louis).—In 1899 and 1900 the Illinois bank opposite the mouth of the Missouri River was protected below the plane of low water with a lumber mattress for 11,025 feet. Above the shore edge of the mattress the bank slope was revetted with stone to the levels of river stages varying from 5 feet to 20 feet on the St. Louis gauge, the latter height being about the top of the bank for 10,000 feet of the protection.

The old revetment, which was found in fair condition, was thoroughly repaired and raised to the top of the bank for its full length. The mattress was extended 2,745 feet. The bank along the new mattress is much higher than along the old work, and for 1,500 feet at its upper end was graded by the action of the river to a suitable slope for the reception of stone as high as the 21-foot level. This portion of the

bank was also fully revetted, so that the completed protection is now 12,500 feet in length, the mattress alone extending 1,270 feet farther, with a nearly vertical bank above it.

Pulltight, Illinois (15 miles below St. Louis).—The accretions gained by the hurdles, built 1882, 1883, 1884, 1889, 1893, 1894, and 1895 at this locality have so suffered from erosion during the last three years that the new bank of the river has receded a maximum distance of about 700 feet, the cutting beginning at the main shore above the hurdle system and extending in varying amounts to the outer end of hurdle No. 7 near the foot of Beard Island, and destroying the outer ends of the upper hurdles so that a channel of the river ran across them, leaving to the west the buttresses of Nos. 1 and 2, which, when built, were at the east channel limit. In order to restore the former bank and channel conditions, it was decided to rebuild the hurdles gradually, either directly upon the old lines or by spurs located between the latter and extending from the present bank to the channel limit line. One such hurdle was built lying between Nos. $\frac{1}{4}$ and $\frac{1}{2}$, thus being serially No. $\frac{3}{8}$. It is 860 feet in length and is fully completed with buttress and T-head at its outer end. Another hurdle, No. 1, about 2,000 feet farther downstream, was begun June 6, and was nearly completed at the end of the year. Other lines of the same character will be built as local conditions indicate their necessity.

Chesley Island, Missouri (19 miles below St. Louis).—The original hurdles (1883, 1884, and 1885) closing the chute between this island and the Missouri shore having been almost destroyed by fire, ice, and drift, allowing a considerable volume of water with strong current (13 feet depth—St. Louis gauge, 20 feet) to pass through, it was decided to close the chute again with a new hurdle dam 250 feet in length, located 1,250 feet below the former hurdles, or about one-third mile below the head of the island. On account of the soft character of the bottom the foundation for this dam was laid with a double thickness of mattress along the piling line. After the completion of the hurdle a rise in the river lodged above it a large mass of drift, which was promptly sunk, adding greatly to the strength and effectiveness of the dam.

The revetment at the head and on the east face of the island has suffered seriously from erosion during the last two years. It was repaired during the first half of this fiscal year, but the spring flood caused an erosion which will require new protection on a considerable length of bank. This has not yet been begun.

Danby Landing, Missouri (40 miles below St. Louis).—Several small breaks and slides in this revetment, which were developed this season by the falling river, were repaired. Their aggregate length was about 600 feet, but they were scattered along 3,000 feet of the protection.

Penitentiary Point, Illinois (42 miles below St. Louis).—About 6,350 feet of this bank, beginning a quarter of a mile below the mouth of Salt Bend Slough, was protected in 1901 with a mattress and partially with stone, the bank above being then too steep for the completion of the latter part of the revetment.

During the last two high waters the work was badly damaged and its efficiency destroyed in its lower half by deep erosion of the bank, which left the new shore line from 400 feet to 600 feet behind its

former location. The mattress was extended upstream 1,250 feet to the slough and downstream 4,225 feet along the newly eroded bank, making the entire length of partially protected bank now 7,600 feet. The stonework was carried to the top of the bank, fully completing the revetment for about 4,500 feet at its upper end, and for the remaining distance to the top of the natural bank slope, at about the level of a 15-foot stage.

Ste. Genevieve, Mo. (60 miles below St. Louis).—This protection was placed 1897–1901. The original length was 7,350 feet downstream from hurdle No. 18, but by wear at the lower end and cutting into the bank behind the mattress it has been shortened in recent years to about 6,000 feet of complete protection, the lower levels of the revetment beyond this running gradually out into the river, at stages above mean low water, until the end of the mattress is 250 feet from the bank.

During the last few seasons the channel has been close to the revetted bank, crowded against it by a middle bar, causing numerous slips in the stonework and several circular caves in the bank. The stonework was thoroughly repaired and raised nearly to the top of the bank, and short sections of mattress were placed in the caves. In one of the largest of these a spur hurdle was built to break the eddy there encountered. With these repairs and additions the protection is now fully completed for 6,000 feet from hurdle No. 18. For the remaining distance (1,350 feet) the mattress is in place and the stonework is exposed at low stages, both, however, detached from the bank, as has been said. To prevent further erosion and damage to this section a short hurdle, No. 24, about 175 feet in length, was built at a point 6,900 feet below No. 18, connecting the new bank with the old revetment; it is thought that this will restore the bank line eventually to its former location.

The lower end of this revetment was damaged during the spring flood and was repaired.

On the approach of low water, early in August, the crossing between the Missouri shore at the foot of the revetment and the mouth of Kaskaskia River threatened to become shoal and an obstruction to navigation. To correct this tendency a hurdle, No. 25, was built from the Missouri shore at a point about 600 feet below the revetment just referred to, projecting 1,575 feet into the river and forcing the channel to the Illinois shore near the mouth of the Kaskaskia, where it maintained a good depth throughout the year.

The hurdle was very strongly built with T-head and buttress at the outer end, and, for 900 feet of its length from shore, heavy drift which had accumulated above it was sunk, adding much to its strength.

The April flood, however, passed over the soft bank at the root of this hurdle and cut it away without damaging the structure, until the latter was entirely detached and about 400 feet distant from the new bank. As the depths found on the original line of the hurdle across the newly scoured channel were excessive, the hurdle was connected anew to the bank by an addition built diagonally upstream from its inner end, 450 feet, to the wooded shore, which was there revetted with a lumber mattress and stone.

Chester, Mo. (Horse Island, 69 miles below St. Louis).—This protection was placed in 1897–98. It is 4,346 feet long, but only the

upstream third of its length was in good condition at the beginning of the present season, the remainder of the bank above the mattress having suffered much from erosion. At the upper end of the latter stretch about 1,650 feet of the subaqueous protection was replaced and several pocket mattresses were sunk in the caves where the erosion had been most irregular.

Crain Island, Missouri (72 miles below St. Louis).—The main chute (known as Missouri Chute) between the Missouri shore and Puckett Island, and the small chute between the latter and Crain Island, were closed in the spring by the construction of two hurdle dams, 1,400 feet and 375 feet in length, respectively.

These hurdles were in moderate depths of water and in consequence were more lightly built than usual, the piling being in two rows of 3-pile clumps spaced 8 feet apart and driven through double-tier foundation mattresses of lumber. The hurdles were curtained to the level of a 25-foot stage.

During the high water in May the erosion of the head of Crain Island became a menace to the smaller dam. To stop the erosion the protection of the head of Crain Island was begun, but, on account of the high stage of river, was not carried further than to effect the object in view. The bank was protected with a mattress and stone revetment for 1,519 feet. As the depths were not very great, although the current was swift and destructive to the bank, the mattress used was narrow, 75 feet to 90 feet in width, and its shore edge was sunk at about the contour of the 15-foot stage. Between this level and the water edge the bank was loosely coated with spalls and stone, to be rearranged when exposed at lower stages; thence to the 30-foot contour the bank was graded and paved with stone in the usual manner.

Liberty, Mo., below Anchor Landing (77 miles below St. Louis).—The shore hurdles between Crain Island and Bishop Point, work upon which had been interrupted by the high water of June, 1903, were completed. The aggregate length added to them during the year is 650 linear feet, and their separate completed lengths are now as follows: No. 1½, 275 feet; No. 6½, 200 feet; No. 8, 450 feet; No. 9, 350 feet; No. 10, 400 feet; No. 11, 200 feet; No. 12, 225 feet, and No. 13, 225 feet, making a total length of 2,325 feet. The ends of these lines slope from a 25-foot stage to a 15-foot stage, the outer piles in hurdles Nos. 8 to 13, inclusive, resting in the stonework of the old revetment.

Liberty, Mo., below Bishop Landing (80 miles below St. Louis).—Hurdles Nos. 7 and 10 of this system were broken several years ago, but the chutes leading to them have been too shoal, except at extreme high water, to permit their repair until this season. Hurdle No. 7, which was broken next the shore, was repaired by the construction of a shore revetment and 525 feet of new hurdle line on a line inclining upstream from the original location and following the shoalest water in the vicinity. Hurdle No. 10 was broken about 1,000 feet from shore, and the repair consisted of 725 feet of new hurdle running somewhat upstream and around the gap in the line, again following the shoalest water. The old piling, in both hurdles, was reenforced and strengthened with new piles where necessary and accessible.

Liberty Bend, Illinois (81 miles below St. Louis).—The entire length of subaqueous protection laid along this bank is 13,425 feet. Upon the upper 11,000 feet the stonework had been laid as high as the

20-foot to 25-foot levels. For the remaining distance, 2,325 feet, stone had not been placed above the 14-foot stage, but by the action of the river was at the beginning of the year about 2 feet lower, although the bank above it showed very little wear. The stonework was repaired and raised to the high bank at levels from 28 feet to 30 feet along the first section, which, therefore, may be considered completed. The second section should be completed at the earliest opportunity.

Willard, Ill. (111 miles below St. Louis).—A hurdle was begun at this locality during June and was in process of construction at the close of the fiscal year, a part only of the foundation having been laid. The hurdle will probably be completed early in the ensuing season.

Goose Island, Illinois (145 miles below St. Louis).—The channel in the vicinity of Anita Towhead having been shoal and difficult for two seasons, requiring dredging, it was decided to extend the Goose Island system of hurdles by the construction of line No. 14, projecting from the bank at Commercial Point, to concentrate the flow. The hurdle was completed with T-head and buttress early in the year, and is 1,520 feet in length.

Buffalo Island, Missouri (148 miles below St. Louis).—When the first work in this locality, 5,000 feet of mattress and partially completed stonework above it, was placed, in 1900, along the foot of Anita Towhead, Griffith Island and Philadelphia Point, about 4 miles of protection in all were contemplated. Since that time the erosion has been greatest from Price Landing to 1 mile below the head of Buffalo Island, with maximum recession of the bank of 1,000 feet (since survey, 1899), near Elkin Landing. The bight of the bend thus has been moved downstream about half a mile, which will necessitate an extension of the contemplated protection to a length of 5½ miles.

Two sections of mattress, 2,285 feet and 1,880 feet long, respectively, spaced 2,885 feet apart, were placed, beginning, respectively, 400 feet above Price Landing and 600 feet below the head of Buffalo Island. The shore edges of these mattresses were secured with stone and spalls, and the bank above the first section was revetted to the top of the natural slope at the levels of 12-foot to 15-foot stages, and about 180 feet in the second section had been revetted to the 13-foot stage, when work was stopped by cold weather.

Greenleaf Bend, Illinois (161 miles below St. Louis).—The works previously placed in this vicinity at Greenleaf Bend and Beach Ridge are both included in the above caption. The original lengths of these sections were 6,075 feet and 9,435 feet, respectively. Both had suffered slight losses at their lower ends, but this year these losses were restored and the mattresses were extended in lengths to 7,575 feet and 10,430 feet, lying 3,200 feet apart.

To prevent the usual formation of eddies against the unprotected bank immediately below the ends of these works, short spur hurdles of piling were built across the mattresses, 175 feet and 300 feet from their lower ends, the eddies formed under the spurs thus falling upon the mattresses, which are able to resist them. The stonework was thoroughly repaired and raised to the high-water line wherever necessary, and was extended along the new mattresses to the top of the natural bank slope. At the close of the year the upper section of the

work was completed to the high-water line at the levels of 30-foot stage for 4,600 feet, and was 3 to 9 feet lower for the remainder of its length. The lower section was completed to the 30-foot stage for 9,000 feet, and was 2 to 12 feet lower for the remaining distance.

Hurricane Field, Missouri (165 miles below St. Louis).—A protection of this rapidly caving bend was begun. The mattress was laid with considerable difficulty along 5,060 feet of the bank. Its shore edge, at the level of a 12-foot stage, was secured with stone and spalls, and along 3,000 feet of the bank at the upstream end of the work the revetment was carried from 6 to 16 feet higher, to the top of the naturally graded bank slope.

Greenfield Bend, Missouri (172 miles below St. Louis).—For the protection of the bank at this locality considerable expenditures have been already made at and above Bird Point by the railroads terminating there. A part of this work has been destroyed by the river cutting behind it, leaving portions of the stonework detached from the bank to menace navigation should the bank be allowed to recede farther. A protection for the bank and short-spur hurdles to connect these stone piles with it were designed, but by reason of the high stages of river and consequent great depths found, the construction of the hurdles was not attempted. The bank, however, was protected by a mattress for 1,925 feet immediately above the fascine work of the railroads and along it the stonework was carried to the top of the natural bank slope at the levels of stages varying from 12 to 18 feet. To secure the head of the work a short-spur hurdle was built across the mattress 100 feet below its upstream end.

TEMPORARY EXPEDIENTS.

The only dredging or other temporary expedients carried on during the year was at Okaw crossing, from the foot of Ste. Genevieve Bend to mouth of the Okaw River, where the wheels of the towboats *Gen. H. L. Abbot* and *T. L. Casey* were used. The unusually high stage of the river rendered other dredging unnecessary.

Buoys were placed on all crossings which threatened to become shoal.

PLANT.

The plant belonging to this improvement was repaired and necessary additions were made to maintain its efficiency. New hulls were built for tenders *Nos. 6* and *7*, and each was equipped with a fire pump and steam capstan. Six barges, 1 office and survey boat, 5 pile drivers, and 1 derrick boat were extensively repaired on the ways at the engineer depot, and 8 steel flats, begun the preceding year, were completed. A new machine shop was built and equipped with boilers taken from the condemned steamer *Gen. Gillmore*, the engines from condemned pile drivers, and the material used was taken largely from that on hand which had become unserviceable for the purposes for which it was purchased.

MATERIAL.

The piles, lumber, and part of the stone required for the construction works were procured by contract; the remainder of the stone

was procured by hired labor and payment of royalty at Little Rock quarries, near Ste. Genevieve, Mo.

PHYSICAL DATA.

The gauges established along this reach of the river were read and repaired as required.

Measurements of the discharge of the river were made with full-depth rod floats at stages 25 feet and under at the engineer depot, and at higher stages at Chester, Ill. The results of these measurements are shown in the following table, which is in continuance of the table published in the Annual Report of the Chief of Engineers for 1901, pages 2206 et seq.

ORGANIZATION.

During the year death has made serious inroads upon the working force of this district, depriving it of the services of two of its principal employees.

On September 20, 1903, Mr. William C. Stevens, who had been connected with the Engineer Department, in various districts, since 1880, as clerk and chief clerk, and whose conscientious services were of great value to the officer in charge, died at St. Louis, Mo., after some months' illness.

On June 28, 1904, Mr. D. M. Currie, who had been connected with the Mobile, Ala., district from 1871–72, and with the St. Louis district since 1873 as assistant engineer and principal assistant engineer, died suddenly at St. Louis, Mo. The loss of this faithful, genial, and efficient assistant is deeply felt by all who were associated with him, and his long experience in the work of the district rendered his services especially valuable to the Government.

Mr. S. G. Clark was promoted to be chief clerk on October 12, 1903, and Mr. William S. Mitchell to be principal assistant engineer on June 29, 1904.

On October 1, 1904, Junior Engineers W. M. Penniman and F. Y. Parker were promoted to be assistant engineers.

ESTIMATES.

The original estimate of the cost of the improvement of the Mississippi River between the mouths of the Ohio and Missouri rivers, as revised in 1883, is $16,397,500.

The total appropriations to date amount to $11,754,999.98. Of this amount $180,000 was alloted by acts and projects for improvement between the Illinois and Missouri rivers, including Alton Harbor, leaving a balance of $11,574,999.98 to be applied to the project for the general improvement between the mouths of the Ohio and Missouri rivers. The balance of the estimate for the original project for the general improvement between the Ohio and Missouri rivers not appropriated June 30, 1904, is therefore $4,822,500.02.

The amount that has been expended upon the project to this date is $10,629,390.66.

The balance available June 30, 1904, of the amount appropriated is $945,609.32, to which must be added $3,704.61 received from miscellaneous receipts, a total of $949,313.93, exclusive of outstanding liabilities.

The amount expended during the fiscal year was $591,432.89, of which $590,632.89 was by voucher and $800 was reserved for the Board of Engineers on Rivers and Harbors.

The river and harbor act approved June 30, 1896, provides:

That any balance of former appropriations now available, and the money hereby appropriated and authorized to be expended for the said section of the river between the mouth of the Missouri River and the mouth of the Ohio River, or so much thereof as may be necessary, shall be expended in the construction of suitable dredge boats, portable jetties, and other suitable appliances, and in the maintenance and operation of the same, with the view to ultimately obtaining and maintaining a navigable channel from St. Louis to Cairo not less than two hundred and fifty feet in width and nine feet in depth at all periods of the year, except when navigation of the river is closed by ice.

In the $10,629,390.66 above mentioned is included all amounts expended for dredge plants, portable jetties, and appliances for temporary improvement of the channel and for operating the same, altogether $630,836.34. Of this, $906.30 was expended during the fiscal year for dredging. The approximate value of this plant at the beginning of the fiscal year was $194,677.10. Its present approximate value is $181,136.33.

The available balance includes the unexpended balance from special allotment made by Congress, as follows:

For protection of bank on Missouri side and to deepen and straighten channel at Wittenberg, Mo., act of March 3, 1899	$10,000

Money statement.

July 1, 1903, balance unexpended		$889,526.11
Amount appropriated by sundry civil act approved April 28, 1904		650,000.00
July 1, 1904, miscellaneous receipts		1,220.71
		1,540,746.82
June 30, 1904, amount expended during fiscal year:		
For works of improvement	$399,740.43	
For maintenance of improvement	191,692.46	
		591,432.89
July 1, 1904, balance unexpended		949,313.93
July 1, 1904, outstanding liabilities		33,721.26
July 1, 1904, balance available		[a]915,592.67
July 1, 1904, amount covered by uncompleted contracts		50,699.46
Amount (estimated) required for completion of existing project		4,822,500.02
Amount that can be profitably expended in fiscal year ending June 30, 1906, in addition to the balance unexpended July 1, 1904:		
For works of improvement	$850,000.00	
For maintenance of improvement	150,000.00	
		1,000,000.00
Submitted in compliance with requirements of sundry civil act of June 4, 1897, and of section 7 of the river and harbor act of 1899.		

LIST OF APPROPRIATIONS.

By act of—		By act of—	
June 10, 1872	$100,000.00	August 18, 1894	$758,333.33
March 3, 1873	200,000.00	March 2, 1895	758,333.33
June 23, 1874	200,000.00	June 3, 1896	275,000.00
March 3, 1875	200,000.00	June 4, 1897	673,333.33
August 14, 1876	200,000.00	July 19, 1897	325,000.00
June 18, 1878	240,000.00	July 1, 1898	673,333.33
March 3, 1879	200,000.00	March 3, 1899	673,333.33
June 14, 1880	250,000.00	June 6, 1900	100,000.00
March 3, 1881	600,000.00	June 13, 1902	650,000.00
August 2, 1882	600,000.00	March 3, 1903	650,000.00
July 5, 1884	520,000.00	April 28, 1904	650,000.00
August 5, 1886	375,000.00	Other receipts	3,704.61
August 11, 1888	300,000.00		
September 19, 1890	400,000.00		
July 13, 1892	525,000.00	Total	11,758,704.59
March 3, 1893	658,333.33		

[a] Distributed under subheadings as follows:

For from mouth of Ohio River to mouth of Missouri River (acts of March 3, 1903, and April 28, 1904)	$884,845.35
For protection of bank on Missouri side and to deepen and straighten channel at Wittenberg, Mo. (act of March 3, 1899)	10,000.00
For allotment for Sawyers Bend (act of June 13, 1902)	20,747.32
Total	915,592.67