

1895

288 REPORT OF THE CHIEF OF ENGINEERS, U. S. ARMY.

Amount drawn under section 7, act of August 11, 1888.....	\$100,000.00
June 30, 1895, amount expended during fiscal year.....	\$78,270.52
June 30, 1895, outstanding liabilities.....	4,054.45
June 30, 1895, amount covered by uncompleted contracts.....	*17,675.03
	100,000.00

July 1, 1895, amount available for fiscal year 1895-96..... 100,000.00
 (See Appendix W 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 good 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 lines desired, from the solid matter brought down by the river and which is collected by means of hurdlework. The banks, both new and old, are revetted where necessary.

The object of the improvement is to eventually obtain 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, inclusive, 1894, was \$5,190,490.18. It resulted in extending the improvement to Fort Chartres Landing, about 40 miles below St. Louis, and in giving a least depth of 6 feet in the channel at low water.

Amount expended during the past fiscal year, \$382,204.74, which resulted in extending the work to Stanton's Landing at Ste. Genevieve, 48 miles below St. Louis, with a least depth over the entire distance of 6 feet.

The depths here given are with reference to the plane of standard low water, which is 4 feet above the zero of the gauge at St. Louis.

The work projected for the distance above given is not entirely completed. There are gaps to be filled as soon as the stage of water permits of resuming work at unfinished points.

The total of construction work done during the year is as follows:

	Linear feet.
Hurdles built.....	19,530
Hurdles added to and repaired.....	550
Bank protection (revetment), including extensions and repairs.....	10,566

Of the works constructed to date it must be said that they have been of great benefit to navigation.

* The contract for replating the U. S. snag boat *H. G. Wright*, amounting to \$22,900, will be paid partly from this year's appropriation and partly from the appropriation for fiscal year 1895-96.

The sum asked for the fiscal year ending June 30, 1897, is to be applied to continuance of work under the present project.

July 1, 1894, balance unexpended.....	\$197, 843. 15
Amount appropriated by sundry civil act approved August 18, 1894.....	758, 333. 33
Amount appropriated by sundry civil act approved March 2, 1895.....	758, 333. 33
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June 30, 1895, amount expended during fiscal year.....	1, 714, 509. 81
	382, 204. 74
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July 1, 1895, balance unexpended.....	1, 332, 305. 07
July 1, 1895, outstanding liabilities.....	\$126, 505. 79
July 1, 1895, amount covered by uncompleted contracts.....	155, 780. 55
	<hr/>
	282, 286. 34
	<hr/>
July 1, 1895, balance available.....	* 1, 050, 018. 73
	<hr/>
{ Amount (estimated) required for completion of existing project.....	9, 492, 500. 01
{ Amount that can be profitably expended in fiscal year ending June 30, 1897.....	433, 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 March 3, 1893.	
(See Appendix W 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 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 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 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, 1894, \$150,762.03.

Soundings made in December, 1893, when the river stood at zero of the gauge, showed a navigable depth of 11 feet in the improved channel.

There was no expenditure during the past fiscal year.

Soundings taken April 20, 1895, ranged from 12 to 24 feet in depth with the river at a 7-foot stage.

The deposit from action of the hurdles is still increasing and is described in the full report of the officer in charge.

* Of this amount, \$1,018,918.73 is at present available for works in progress, \$31,100 being allotted for special work at Cape Girardeau and Cairo. The \$8,746.74 remaining from the allotment of \$50,000 for work at Ste. Genevieve, made in the act of September 19, 1890, was expended during the past fiscal year in repairs to and extension of the work opposite Ste. Genevieve Landing at Little Rock, and which was begun in 1891.

W 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 $3\frac{1}{2}$ to 4 feet. The channel is divided at a number of points by islands forming sloughs and secondary channels behind them, through which a good deal of the volume of 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.

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 $1\frac{1}{2}$ 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 where 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 hurdle consists, 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 the 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 round 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 hurdle 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 distance below as to make the angle of the braces about 45 degrees.

The heel of the brace 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 the 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 are 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.

The foregoing is a general description of the work of construction during the past year.

At the beginning of the fiscal year the work for improvement had extended to Fort Chartres Crossing, or Bruce Island, but the construction at several points had been left incomplete, especially as to number and extent of works, partly in order to observe the effect of the hurdle as built. A number of new banks, the result of deposits induced by the hurdles, will require revetment to secure their permanency as soon as they become high enough, notably so at Horsetail, Twin Hollows, and Jim Smith's.

The localities upon which work was done during the year extended from St. Louis down to and including the head of Moro Island, opposite Ste. Genevieve, Mo. The work done during the year is as follows:

HORSETAIL BAR, IMMEDIATELY BELOW ST. LOUIS.

The work at this locality consisted in extension of the bank protection on the west side of the river. Two hundred and ninety linear feet of stone and mattress revetment were placed, the mattress work extend-

ing below the water surface and the stonework to a line 12 feet above low water.

PULLTIGHT, $7\frac{1}{2}$ MILES BELOW ST. LOUIS.

The work at this locality consisted in continuing the additions and extensions begun to the series of hurdles at this point in the spring of 1893. Two buttresses of brush and stone at the river ends of hurdles 0 and 1 were raised, and buttresses of the same materials were built to the same height at the river ends of hurdles $0\frac{1}{2}$ and 2. These buttresses were placed for the purpose of protecting the river ends of these hurdles, which are situated along a slightly concave line, from the action of the ice as it breaks up in February or March.

The depth at this crossing is now not less than 8 feet where in the early part of 1893 it was but $4\frac{1}{2}$ feet.

SULPHUR SPRINGS, 15 MILES BELOW ST. LOUIS.

Considerable trouble was experienced at this locality on account of shoal water before improvements were begun, and also during the low-water season of 1893. The channel, in crossing from bank to bank of the river, made two abrupt changes of direction nearly at right angles to the axis of the stream. The improvement was begun in 1887, but the work of the past year has added to the number of hurdles, and some of those previously built were extended and repaired during the year.

The low stage of water during the past spring interfered with the completion of the work, but that already accomplished has much improved the navigation at this point. Number of linear feet of hurdles built during the year, 7,595.

FOSTERS ISLAND, $17\frac{1}{2}$ MILES BELOW ST. LOUIS.

A section of mattress, 100 feet in length, was placed in extension of the old revetment.

LUCAS, 20 MILES BELOW ST. LOUIS.

Some additions, extensions, and repairs were made to the hurdles built at this place in 1888-1890. Total linear feet of hurdle built during the year, 150. The work at this point is still in progress.

CORNICE ISLAND, 23 MILES BELOW ST. LOUIS.

Construction work commenced at this locality on the 1st of June on hurdles 1, 2, 3, 4, and 5, and the work was in progress at the close of the year. Total linear feet of hurdles built, 2,510.

MICHAELS, 27 MILES BELOW ST. LOUIS.

The work here consisted in construction of hurdle No. 1 and in the repair, so far as practicable, at the existing low stages of water, of No. 3 of the series which was built in 1892. Eight buttresses of brush and stone were placed about 300 feet apart on a line 80 feet from the hurdle, on its upstream side, to serve as protection against moving ice, to which this hurdle will be the most exposed. Four piers of stone connect the inshore end of this hurdle with the shore, the shelving rock near shore preventing pile driving for about 200 feet. Total number of linear feet of hurdles built, 3,250.

FORT CHARTRES, 40 MILES BELOW ST. LOUIS.

Navigation at this locality has always been more or less difficult. Work for its improvement was begun in 1875 by the partial construction of a dam to close the chute west of Bruce Island, then called Fort Chartres towhead. No further work was done here until 1892, when the building of a series of hurdles was commenced for the purpose of closing the chute. Two hurdles were built during the year named, but considerable damage was done to them when the ice in the river broke up in February, 1893.

During the spring of 1893 and the fiscal year, 1894, 10,250 linear feet of hurdles were completed for closing the chute, and the bank opposite was protected in part to a distance of 5,500 feet below Sycamore Landing.

The work of the past fiscal year consisted mainly in protection of the east bank of Bruce Island by means of revetment carried up the shore to the foot of the abrupt bank.

At the beginning of the extreme low-water season of last year, a shoal with about 5 feet of water upon it developed in the channel crossing nearly opposite the landing at Fort Chartres, the river at the same time showing a tendency to split up into several channels, none of which would have sufficient depth.

With a view to deepening the water over this bar along the line that was being used by the steamers and tows, and in order to afford some temporary relief, at least to navigation, two portable jetties of a total length of 900 feet, and improvised from barges and grub plank, were experimented with at this locality. These jetties were placed so as to form a funnel-shaped chute concentrating the flow between them upon the bar. As the only practicable channel for navigation at this time lay between the jetties, and as towboats with tows were obliged to make the crossing between the jetties by "flanking," which required a good deal of space, the jetties could not be placed as near each other, and especially so at their lower ends, as was necessary or desirable, and this fact, taken in connection with the short length of the jetties, was unfavorable to full demonstration of the experiment.

As it was, however, a narrow channel, 9 feet deep, was soon excavated parallel and near to the upper face of the lower jetty, and which could have been enlarged by the operation of a powerful sand pump had one been available then. An accumulation of sand formed, though below and in juxtaposition to the lower jetty and between this bar and one but a short distance below it, one of the narrow channels already mentioned into which the river appeared to be splitting up was deepened to 7 feet, which depth was increased to 9 feet, with ample width, by the aid of pile-driver jets directed against the crest of the bar, which was a short one, axially. This experiment began September 5 and terminated September 20, the desired depth having been obtained.

It would have been interesting to have made further experiments with these jetties, but as the necessary depth for navigation had been obtained and as there began to be need for the barges elsewhere they had to be withdrawn.

It is not expected that such jetties can be relied upon alone to produce very marked results. But there may be occasionally times during seasons of low water when their use as auxiliaries to permanent works of contraction, and especially in connection with a suitable dredge, also regarded as auxiliary, may be of assistance to navigation, and even if such assistance takes only the shape of a small and temporary increase

in depth at one or more of the worst bars, it appears worth the while to employ such auxiliaries—to a limited extent, at least—for what they may be worth, particularly when the cost is but a few dollars per foot.

This subject will be touched upon again and farther on in this report.

TURKEY ISLAND, 42 MILES BELOW ST. LOUIS.

The work at this island consisted in placing a mattress below the water surface and carrying the stone revetment up the bank for 15 feet above low water for the protection of 1,200 linear feet of the west face of the island. This work was in progress at the close of the year

STE. GENEVIEVE, 48 MILES BELOW ST. LOUIS.

The improvement of this reach of river, extending from Turkey Island to Kaskaskia Island, comprises several series of projected hurdles and revetments.

The work of the fiscal year for this reach consisted in repairing and in adding to the hurdles built in 1891 and 1892 for the improvement of the channel and landing at Little Rock, as provided for in the river and harbor act of 1890, and in the extension of this work down to Moro Island, protection of the west face of the island, and commencement of construction of a series of hurdles on the west side of the river at Stantons Landing at Ste. Genevieve.

Total length of hurdle constructed during the year, 6,575 linear feet; total length of revetment, 5,700 linear feet.

The work was still in progress at the close of the year.

DEVILS ISLAND, 114½ MILES BELOW ST. LOUIS.

The only work done at this locality consisted in the placing of a short portable jetty composed of several of the barges which had been used for the Fort Chartres experiment, the object being to secure some small increase in depth on the narrow bar, the ruling depth upon which was but 4 feet and that depth only existing in a channel which crossed the bar in a direction nearly at a right angle to the axis of the river.

The river at this locality is about 4,000 feet wide; last fall it had a low-water depth of 2½ to 4 feet throughout the entire width, and small velocity of current. It was the shoalest crossing between St. Louis and Cairo, and not only obstructed general navigation, but interfered with the movement of our own boats and barges engaged in procuring brush for the works at points 75 miles and more above.

A small gain in depth was effected by this jetty, aided by pile-driver jets, but a steamer of one of the navigation lines having a tow grounded in this channel, caused the bottom to flatten out, so that the increase was lost. But the increase in depth that had been effected was about as much as had been expected from the short length of jetty available.

Early in September last (1894) I had a conference at this office with one of the members of the committee on dredging of the Mississippi River Commission, which has charge of improvement work on the Mississippi River below the mouth of the Ohio, in regard to some proposed experimental operations of their dredge *Experimenter* above the mouth of the Ohio. It was understood as a result of the conference that the dredge, which was then working below the mouth of the Ohio, would probably soon move up to Devils Island, where the set of the current was reported as favoring operations by a dredge across a particular portion of the bar, and commence operations upon a line to be first sub-

mitted to this office. As the dredge, however, did not move up as soon as I had expected, it being still engaged below the Ohio, I addressed a personal note on the 9th of October to the secretary of the Commission to the effect that I had been expecting for several weeks past that the dredge would come up to this side of the Ohio River, and that there was a very good chance for trying it at Devils Island. Answer was returned to the effect that the dredge would probably move up shortly to Devils Island. It arrived on the ground about the 17th of October, and commenced work some days later. Some of the discharge pipes for the dredge were towed from St. Louis to Devils Island by the steamer *Dolphin No. 2*, at that time in the employ of this office, in order to assist those operating the dredge. The result of the dredging was a good channel for the rest of the season. The channel has also been in use this season, which has been one of unusually low water for this part of the year.

The total of construction work done during the year is as follows:

Hurdle built.....	linear feet..	19,530
Hurdle repaired.....	do.....	550
Bank protection (revetment) built, including extensions and repairs..	do.....	10,566

All of the work for placing material was done by hired labor.

MATERIAL USED.

The following quantities of piles, brush (for mattresses), and rock were used in the works during the year:

Piles.....	linear feet..	764,929
Brush in place.....	cords..	33,794.3
Rock in place.....	cubic yards..	61,965.5

UTILIZATION OF DRIFTWOOD.

At high stages of the river immense quantities of driftwood are carried downstream by the flood. A great deal of this drift lodges against the hurdles, and sometimes in quantities sufficient to menace their stability either through static pressure or by producing scour about the piling. If the fields of drift thus formed can be sunk in place just above the hurdles they form excellent permeable dams, often of considerable height, and also serve as protection to the hurdles against which they have rested; but in general the drift must be sunk quickly, otherwise, especially at very high stages of water, it may become dangerous to the hurdles, as noted above.

The fields of drift are sunk by laying on top of them, rapidly and as evenly as possible, a sort of mattress of brush, and then weighting the whole with stone.

A good deal of such drift was utilized in this way during the year.

LABOR AND MATERIALS.

Of the brush used 14,496.2 cords were procured by hired labor and 19,298.1 cords by contract. Of the stone used 34,792.6 cubic yards were procured by hired labor at the United States quarry at Little Rock, Mo., a short distance above Ste. Genevieve, and 27,172.9 cubic yards by contract, and 133,327 linear feet of piling by purchase in open market and 631,602 linear feet by contract. Other materials, including rope, bolts, wire, spikes, nails, and miscellaneous supplies, were procured in open market. The work of placing the materials was all done by hired labor.

PLANT.

The plant that was on hand at the beginning of the fiscal year was insufficient for the proper expenditure of the appropriation of August 18 last, and of the subsequent (expected) appropriation of \$758,333.33, and which was made March 3 last, and an increase of the plant by 1 tow and dredge boat, 12 model barges, and 15 skiffs was therefore authorized by the Department. The tow and dredge boat is building under contract, to be delivered on or before August 1 next, and the barges, also building under contract, are to be delivered by August 30, 1895. The skiffs were purchased under informal contract.

A full list of the plant is given in the table forming part of this report, giving the value of property.

In my project of August 28 for the expenditure of the appropriation by the act of August 16, 1894, appears the following:

It is also submitted that a dredge would be useful as auxiliary to the work, not only where contraction works have been and are being constructed, but it would also afford more or less relief at crossings generally between the Missouri and the Ohio.

The operation of the dredge would be to some extent experimental, but it could be expected to lessen difficulties to navigation at low stages of water by increasing the depths sooner than the contraction works would, though such dredged depths might be only temporary and might have to be renewed several times each season. A single dredge might not, however, suffice, and experience then would indicate the number required.

This is the boat already reported as authorized to serve as a tow and dredge boat.

PLATES.

Six plates accompany this report. Plate No. 1, on a scale of 1-100,000, is a map of the river from the mouth of the Missouri River to Big Eddy, a distance of 102 miles. This is a general map, showing localities, and location of completed and projected works. The other plates show the localities and works more in detail. The plates all aid materially to a full explanation of the work projected and completed.

GAUGES.

Daily gauge observations were continued under direction of this office at 12 localities, covering the river from the Chain of Rocks, above the northerly boundary of St. Louis, to Gray's Point, a distance of about 158 miles. The gauge readings show decided changes in stages of water and in slopes on the portion of the river under improvement immediately below St. Louis, but the full extent of such changes can only be given after the gauge readings shall have been further continued for several seasons.

The fiscal year just ended has been the longest period of low water ever recorded at the St. Louis gauge. The year opened with a falling river, the stage of water on the 1st of July being 17 feet on the gauge. It passed below the 10-foot stage July 22, to the 3-foot stage during November and December, and to the zero stage in January. In the spring months of April and May it nearly reached the 10-foot stage, but did not pass it until June 13. There was, then, a period of nearly eleven months in which the river fluctuated between the zero and the 10-foot stage.

CONDITION OF THE RIVER.

The plan for improvement has contemplated, since 1881, carrying the works downstream from St. Louis, making the improvement complete and thorough as it progressed—that is, so far as practicable to do so. It is not always practicable, however, to advance and maintain hurdle and revetment construction work in proportion to the extent of accretions, and hence while the aim and effort may be to thoroughly complete the work at one locality before proceeding to another, it generally becomes necessary to start new lines of hurdles or new revetments at other points in order to keep the work going. The accretions depend, as to dimensions, almost entirely upon frequency, height, and duration of floods from the Missouri River. When these floods are small, comparatively, and of short duration, smaller accretions may be looked for. It may take years before accretions at certain localities become broad enough or high enough to admit of their being revetted, and again there are sometimes periods when the stage of water in the river is so low that barges with material for the works, and occasionally even pile drivers, can not move about outside of the navigable channel for the time being so as to complete a work at some one point, and it then becomes necessary to utilize the time, men, and plant by working at some other point equally in need of improvement. During the fall of 1893 and 1894, and even during part of the past spring, the low water retarded construction considerably.

The navigable channel has been improved and ruling depths at low water have been considerably greater than prevailed throughout the reach under improvement (from St. Louis to Ste. Genevieve here referred to) before work for improvement began, and considerable improvement has been effected during the past fiscal year in spite of the difficulties mentioned under which work progressed. The least depth found during the year within this reach of river, and which formerly contained some of the shoalest bars between St. Louis and the mouth of the Ohio, was at Fort Chartres, where, as has already been stated, there was a depth of but 5 feet in the early part of September, at a $3\frac{1}{2}$ foot stage on the St. Louis gauge, but which depth was soon increased to 9 feet. In general, it must be said, although the improvement is far from being completed, in fact being not much more than fairly begun, that the river between the mouths of the Ohio and Missouri is much better for navigation than it was before the work of improvement began, and that the difficulties and dangers to navigation are much less than they were twenty years ago. In giving credit for the improvement, the operations of the snag boats, in freeing the channels of snags and other obstructions, must not be overlooked.

Total amount of dams, dikes, hurdles, and revetments built by the United States since improvement was begun in 1872, and also total of accretions due to hurdles:

Dams.....	linear feet..	8,326
Dikes.....	do.....	11,620
Hurdles.....	do.....	309,801
Bank protection (revetment).....	do.....	136,625
Accretions due to hurdlework.....	acres..	7,045

The details of the work done during the fiscal year are given in the reports herewith of Mr. D. M. Currie, principal assistant engineer, Mr. William S. Mitchell, assistant engineer, and Mr. Gerald Bagnall, assistant engineer.

The procuring of brush and quarrying of stone by hired labor was done by parties in charge of Mr. E. D. Libby, assistant engineer.

ENGINEER DEPOT, FOOT OF ARSENAL STREET, ST. LOUIS.

At this depot were made most of the repairs to tools and appliances and minor repairs to the floating plant. An account, in detail, of this work is given in the accompanying report of Mr. C. D. Lamb, superintendent.

STATISTICS.

For amount of commerce and navigation benefited by the improvement, attention is respectfully invited to the tables herewith of statistics of the commerce of the river. These statistics were compiled by Mr. Elliott Jones, chief clerk.

VALUE OF PROPERTY.

The present value of property belonging to this work is shown in the following table:

Class of property.	Value July 1, 1894.	Purchases, additions, and repairs.	Expenses and deterioration charged to works of improvement.	Value June 30, 1895.
Steamer Gen. Gillmore (1).....	\$13,711.89	\$20,755.08	\$18,925.67	\$15,541.30
Steamer Gen. T. L. Casey (1).....	24,925.70	18,015.47	18,351.57	24,589.60
Steamer Dolphin No. 2 (hired).....		3,087.75	3,087.75	
Tow and dredge boat.....		1,437.16		1,437.16
Steam tenders (7).....	20,326.91	12,784.79	6,901.78	26,209.92
Barges, model (46).....	138,697.81	13,166.09	25,503.59	126,360.31
Barges, quarter (8).....	16,176.63	4,039.49	4,104.70	16,111.42
Quarter boats (10).....	51,104.59	2,268.09	3,488.36	49,884.32
Office and survey boats (4).....	12,326.00	4,602.32	1,460.35	15,467.97
Pile drivers (35).....	118,578.75	30,336.10	18,736.85	130,178.00
Derrick boats (2).....	4,873.65	170.89	870.89	4,173.65
Derrick.....	1,011.50	1,048.71	300.44	1,759.77
Machine shop.....	1,590.07	496.06	798.16	1,287.97
Small boats (429).....	61,575.97	12,033.61	29,297.83	44,311.75
Portable quarters.....	5,902.21	354.72	1,358.72	4,898.21
Portable jetties.....		2,714.02		2,714.02
Ways (supply depot).....	3,584.98	311.23	992.38	2,903.83
Supply depot.....	4,280.25	2,807.46	2,550.11	4,537.60
Tools and appliances.....	13,343.92	7,929.61	8,231.82	13,041.71
Boarding outfit.....	25,374.03	7,716.03	6,634.57	26,455.49
Office furniture.....	533.48		53.35	480.13
Survey instruments.....	1,910.26	11.50		1,921.76
Photographic apparatus.....	257.14			257.14
Total.....	520,085.74	140,086.18	151,048.80	514,523.03

ESTIMATE.

The original estimate of cost of this improvement of the 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 from appropriations that has been available for this work to June 30, 1895, is \$6,904,999.99, leaving the sum of \$9,492,500.01 for further appropriation or consideration.

LIST OF APPROPRIATIONS.

By act of—	Amount	By act of—	Amount
June 10, 1872.....	\$100,000.00	July 5, 1884.....	\$520,000.00
March 3, 1873.....	200,000.00	August 5, 1886.....	375,000.00
June 23, 1874.....	200,000.00	August 11, 1888.....	300,000.00
March 3, 1875.....	200,000.00	September 19, 1890.....	400,000.00
August 14, 1876.....	200,000.00	July 13, 1892.....	525,000.00
June 18, 1878.....	240,000.00	March 3, 1893.....	658,333.33
March 3, 1879.....	200,000.00	August 18, 1894.....	758,333.33
June 14, 1880.....	250,000.00	March 2, 1895.....	758,333.33
March 3, 1881.....	600,000.00		
August 2, 1882.....	600,000.00		
		Total.....	7,084,999.99

Of these amounts \$180,000 was allotted by acts and projects for improvement between the Illinois and Missouri rivers, including Alton Harbor, leaving as amount applicable for general improvement between the mouth of the Ohio River and the mouth of the Missouri River \$6,904,999.99, as just given above.

Amount expended to include June 30, 1894, \$5,190,490.18.

Amount expended during the fiscal year ending June 30, 1895, \$382,204.74.

The balance available June 30, 1895, will be expended in continuing the improvement according to the approved project, and unless some unforeseen contingency interferes (none is apprehended, however) the balance will be practically expended by the close of the fiscal year ending June 30, 1896.

In addition to the actual work of construction there is a large and expensive plant to be maintained and cared for, and which will be increased by the number of boats (1 tow and dredge boat and 12 barges) now under construction by contract.

The safe harborage of the floating property during winters is always a matter of solicitude with this office.

The river and harbor act of July 13, 1892, contained the following:

Improving the Mississippi River from the mouth of the Ohio River to the landing on the west bank below the Washington Avenue Bridge, Minneapolis, Minnesota; continuing improvement, one million one hundred and twenty-five thousand dollars: *Provided*, That on and after the passage of this act additional contracts may be entered into by the Secretary of War for such materials and work as may be necessary to carry on continuously the systematic improvement of the Mississippi River between the points mentioned, or said materials may be purchased and work may be done otherwise than by contract, to be paid for as appropriations may from time to time be made by law, not exceeding in the aggregate one million six hundred and twenty-five thousand dollars per annum for three years, commencing July first, eighteen hundred and ninety-three: *And provided further*, That of the amount herein appropriated five hundred and twenty-five thousand dollars shall be expended from the mouth of the Ohio River to the mouth of the Missouri River and six hundred thousand dollars from the mouth of the Missouri to Minneapolis; and the amounts for which additional contracts are authorized to be entered into shall be expended in like proportion.

The amount contemplated to be expended annually on the Mississippi River between the mouths of the Ohio and Missouri rivers for three years, in addition to the appropriation of \$525,000 of 1892, appeared to be, therefore, \$758,333.33. The three appropriations, however, following that of 1892, were:

By act of—	
March 3, 1893	\$658, 333. 33
August 18, 1894	758, 333. 33
March 2, 1895	758, 333. 33

These three appropriations are included in the amount given above as appropriated to date.

It is presumed that the appropriation of \$758,333.33 is the last to be made under the provisions of the act of 1892.

The plant accumulated since 1892 in order to carry on the improvement at the rate that the act of 1892 provided for is in condition, with ordinary annual repairs to some of it, to last for a number of years to come.

The sum of \$760,000 can be profitably expended during the fiscal year ending June 30, 1897, in continuing the work under the present approved project.

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 ended June 30, 1895, amounted to \$1,197,346.70.

The amount of internal revenue collected was \$7,388,503.13.

Money statement.

July 1, 1894, balance unexpended.....	\$197, 843. 15
Amount appropriated by sundry civil act approved August 18, 1894....	758, 333. 33
Amount appropriated by sundry civil act approved March 2, 1895.....	758, 333. 33
	1, 714, 509. 81
June 30, 1895, amount expended during fiscal year.....	382, 204. 74
	1, 332, 305. 07
July 1, 1895, balance unexpended.....	1, 332, 305. 07
July 1, 1895, outstanding liabilities.....	\$126, 505. 79
July 1, 1895, amount covered by uncompleted contracts....	155, 780. 55
	982, 286. 34
July 1, 1895, balance available.....	*1, 050, 018. 73
Amount (estimated) required for completion of existing project.....	\$9, 492, 500. 01
Amount that can be profitably expended in fiscal year ending June 30, 1897.....	760, 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 March 3, 1893.	

Abstract of proposals for 12 model barges received in response to advertisement dated September 24, 1894, and opened October 24, 1894, by Maj. Charles J. Allen, Corps of Engineers, at St. Louis, Mo.

No.	Name and address of bidder.	Barges.	Price.	Amount.
		<i>Number.</i>		
1	George T. Nelles & Co., Leavenworth, Kans.....	12	\$3, 540	\$42, 480
2	Interstate Lumber Co., Chattanooga, Tenn.....	12	3, 385	40, 620
3	The Cincinnati Marine Rwy. Co., Cincinnati, Ohio.....	12	3, 584	43, 008
4	Louis H. Skinner, Wilmington, N. C.....	12	4, 041	48, 492
5	Ed. J. Howard, Jeffersonville, Ind.....	4 or 6	3, 600	14, 400
6	David S. Barmore, Madison, Ind.....	8	3, 590	28, 720

Available, \$758,333.33; from appropriation of August 18, 1894.
No. 2 lowest; acceptance recommended.

Abstract of proposals for tow and dredge boat received in response to advertisement dated December 24, 1894, and opened January 23, 1895, by Maj. Charles J. Allen, Corps of Engineers, at St. Louis, Mo.

No.	Name and address of bidder.	Amount.
1	Iowa Iron Works, Dubuque, Iowa.....	\$35, 000
2	M. A. Sweeney Co., Jeffersonville, Ind.....	31, 300
3	Jas. Rees & Sons, Pittsburg, Pa.....	45, 500
4	The Cincinnati Marine Rwy. Co., Cincinnati, Ohio.....	31, 987
5	Ed. J. Howard, Jeffersonville, Ind.....	27, 375

Available, \$600,349; from appropriation of August 18, 1894.
Bid No. 5 the lowest; acceptance recommended.

* Of this amount \$1,018,918.73 are at present available for works in progress, \$31,100 being allotted for special work at Cape Girardeau and Cairo. The \$8,746.74 remaining from the allotment of \$50,000 for work at Ste. Genevieve made in the act of September 19, 1890, was expended during the past fiscal year in repairs to and extension of the work opposite Ste. Genevieve Landing at Little Rock, which was begun in 1891.

2070 REPORT OF THE CHIEF OF ENGINEERS, U. S. ARMY.

Abstract of proposals for piles received in response to advertisement dated December 31, 1894, and opened January 30, 1895, by Maj. Charles J. Allen, Corps of Engineers, at St. Louis, Mo.

No.	Name and address of bidder.	First class.							
		36 to 40 feet.		41 to 45 feet.		46 to 50 feet.		51 to 35 feet.	
		No.	Price per foot.	No.	Price per foot.	No.	Price per foot.	No.	Price per foot.
1	C. C. Mengel, jr., & Bro. Co., Louisville, Ky.	2,000	Cents. 20	1,500	Cents. 22	1,000	Cents. 25	500	Cents. 30
2	Fredk. Hartweg, Cincinnati, Ohio.	2,000	9.50	1,500	9.50	1,000	9.50	500	9.50
3	St. Louis Refrigerator and Wooden Gutter Co., St. Louis, Mo.	2,000	10.66	1,500	10.66	1,000	10.66	500	10.66
4	Berthold & Jennings, St. Louis, Mo.	2,000	12.72	1,500	12.72	1,000	12.72	500	12.72

No.	Name and address of bidder.	Second class.					
		25 to 30 feet.		31 to 35 feet.		36 to 40 feet.	
		No.	Price per foot.	No.	Price per foot.	No.	Price per foot.
1	C. C. Mengel, jr., & Bro. Co., Louisville, Ky.		Cents.		Cents.		Cents.
2	Fredk. Hartweg, Cincinnati, Ohio.	1,000	6.75	4,000	6.75	5,000	6.75
3	St. Louis Refrigerator and Wooden Gutter Co., St. Louis, Mo.	1,000	7.15	4,000	7.15	5,000	7.15
4	Berthold & Jennings, St. Louis, Mo.						

No.	Name and address of bidder.	Second class.						Amount.
		41 to 45 feet.		46 to 50 feet.		51 to 65 feet.		
		No.	Price per foot.	No.	Price per foot.	No.	Price per foot.	
1	C. C. Mengel, jr., & Bro. Co., Louisville, Ky.		Cents.		Cents.		Cents.	\$50,090.00
2	Fredk. Hartweg, Cincinnati, Ohio.	5,000	6.75	3,000	6.75	2,000	6.75	76,316.25
3	St. Louis Refrigerator and Wooden Gutter Co., St. Louis, Mo.	5,000	7.15	3,000	7.15	2,000	7.15	82,137.25
4	Berthold & Jennings, St. Louis, Mo.							27,666.00

No. 2 lowest; acceptance recommended.
Amount available, \$381,666; appropriated by act of August 18, 1894.

Abstract of proposals for brush received in response to advertisement dated December 31, 1894, and opened January 30, 1895, by Maj. Charles J. Allen, Corps of Engineers, at St. Louis, Mo.

No.	Name and address of bidder.	Brush.	Price per cord.	Amount.
1	Fredk. Hartweg, Cincinnati, Ohio.	Cords. 30,000	\$2.44	\$73,200
2	James Short, St. Charles, Mo.	30,000	2.78	83,400

All bids considered too high. Rejection recommended.
Amount available, \$581,666; appropriated by act of August 18, 1894.

Abstract of proposals for stone received in response to advertisement dated December 31, 1894, and opened January 30, 1895, by Maj. Charles J. Allen, Corps of Engineers, at St. Louis, Mo.

No.	Name and address of bidder.	Quantity offered.	Price.	Amount.	Mode of delivery.
		<i>Cubic yds.</i>	<i>Cents.</i>		
1	John Cleary, Chester, Ill.	10,000	58	\$5,800	Delivered on Government barges at Chester, Ill.
2	Edward Hely, West Plains, Mo.	50,000	64	32,000	Delivered on Government barges at Government works, the United States to do the towing and charge contractor towage eight-tenths of a cent per yard per mile for upstream towage and four-tenths of a cent per yard per mile for downstream towage.
3	Bussen Bros., Oakville, Mo.	10,000	50	5,000	Delivered on Government barges at Quarantine, Mo.
4	John Burns, St. Louis, Mo.	30,000	45	13,500	Delivered on Government barges near Riverside, Mo.
5	James Short, St. Charles, Mo.	20,000	47	9,400	Delivered on Government barges 1 mile above Crystal City Landing, Mo.
6	Martin Lorenz, St. Louis, Mo.	30,000	54	16,200	Delivered on Government barges at foot of Cahokia street, St. Louis, Mo.

Acceptance recommended of bids Nos. 1, 3, and 4.
Amount available, \$581,666; appropriated by act of August 18, 1894.

Abstract of proposals for steam pumps for tow and dredge boat received in response to advertisement dated January 30, 1895, and opened February 20, 1895, by Maj. Charles J. Allen, Corps of Engineers, at St. Louis, Mo.

No.	Name and address of bidder.	Amount.
1	S. C. Forsaith Machine Co., Manchester, N. H.	\$2,275
2	Hooker Colville Steam Pump Co., St. Louis, Mo.	*4,275
3	M. M. Buck Manufacturing Co., St. Louis, Mo.	2,575
		4,725
4	Chas. W. Melcher Machine Co., St. Louis, Mo.	†3,720
		3,460
5	Daniel Kelly, Philadelphia, Pa.	†2,956
6	Barr Pumping Engine Co., Philadelphia, Pa.	3,884
		3,600

*Increased by telegram.

†By letter accompanying bid.

Award recommended to bid No. 2.
Amount available, \$424,800; from appropriation of August 18, 1894.

Abstract of proposals for coal received in response to advertisement dated February 6, 1895, and opened February 26, 1895, by Maj. Charles J. Allen, Corps of Engineers, at St. Louis, Mo.

No.	Name and address of bidder.	30,000 bushels coal delivered on U. S. boats at U. S. engineer depot or elsewhere in St. Louis Harbor (per bushel)	50,000 bushels coal delivered on U. S. barges, the barges to be towed as specified (per bushel).	Amount.
1	Consolidated Coal Company of St. Louis, St. Louis, Mo.	<i>Cents.</i> 7½	<i>Cents.</i> 6½	\$5,500

Only one bid received. Rejection recommended.
Amount available, \$422,000; from appropriation of August 18, 1894.

2072 REPORT OF THE CHIEF OF ENGINEERS, U. S. ARMY.

Abstract of proposals for steam capstans with engines for tow and dredge boat received in response to advertisement dated February 6, 1895, and opened February 26, 1895, by Maj. Charles J. Allen, Corps of Engineers, at St. Louis, Mo.

No.	Name and address of bidder.	Price (each).	Amount.
1	South St. Louis Foundry, St. Louis, Mo.....	\$540	\$2, 160
2	Shoellhorn-Albrecht Machine Co., St. Louis, Mo.....	600	2, 400
3	Fulton Iron Works, St. Louis, Mo.....	900	3, 000
4	Geo. J. Fritz, St. Louis, Mo.....	682	2, 728

No. 1 lowest; acceptance recommended.
Amount available, \$422,000; from appropriation of August 18, 1894.

Abstract of proposals for rope received in response to advertisement dated February 6, 1895, and opened February 21, 1895, by Maj. Charles J. Allen, Corps of Engineers, at St. Louis, Mo.

No.	Name and address of bidder.	5,000 pounds pure manila rope, $\frac{3}{4}$ inch diameter.	15,000 pounds pure manila rope, $\frac{3}{4}$ inch diameter.	15,000 pounds pure manila bolt rope, 1 inch diameter.
		<i>Cents.</i>	<i>Cents.</i>	<i>Cents.</i>
1	Simmons Hardware Co., St. Louis, Mo.....	8	7 $\frac{1}{2}$	9
2	Eagle Boat Store Co., St. Louis, Mo.....	7.46	6.96	8.21
3	M. M. Buck Manufacturing Co., St. Louis, Mo.....	7.49	6.97	8.49
4	Jas. J. Hawk, St. Louis, Mo.....	6.865	6.865	7.97
5	Harry E. Coffin, Memphis, Tenn.....	6 $\frac{1}{2}$	6 $\frac{1}{2}$	7 $\frac{1}{2}$
6	H. L. Fox & Co., St. Louis, Mo.....	6 $\frac{1}{2}$	6 $\frac{1}{2}$	7 $\frac{1}{2}$
7	Thos. S. Maxwell, St. Louis, Mo.....	7 $\frac{1}{2}$	7	8 $\frac{1}{2}$

No.	Name and address of bidder.	15,000 pounds pure manila bolt rope, 1 $\frac{1}{2}$ inches diameter.	10,000 pounds pure manila bolt rope, 1 $\frac{1}{4}$ inches diameter.	10,000 pounds pure manila bolt rope, 1 $\frac{1}{2}$ inches diameter.	Total.
		<i>Cents.</i>	<i>Cents.</i>	<i>Cents.</i>	
1	Simmons Hardware Co., St. Louis, Mo.....	9	9	9	\$6.025
2	Eagle Boat Store Co., St. Louis, Mo.....	8.21	8.21	8.21	5.522
3	M. M. Buck Manufacturing Co., St. Louis, Mo.....	8.49	8.49	8.49	5.665
4	Jas. J. Hawk, St. Louis, Mo.....	7.97	7.97	7.97	5.358
5	Harry E. Coffin, Memphis, Tenn.....	7.72	7.72	7.72	5.233
6	H. L. Fox & Co., St. Louis, Mo.....	7 $\frac{1}{2}$	7 $\frac{1}{2}$	7 $\frac{1}{2}$	5.225
7	Thos. S. Maxwell, St. Louis, Mo.....	7 $\frac{1}{2}$	7 $\frac{1}{2}$	7 $\frac{1}{2}$	5.225
		8 $\frac{1}{2}$	8 $\frac{1}{2}$	8 $\frac{1}{2}$	5.525

* Supplemental bid by letter accompanying bid.

Nos. 5 and 6 lowest; acceptance recommended of No. 5.
Amount available, \$420,000, from appropriation of August 18, 1894.

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

UNITED STATES ENGINEER OFFICE,
St. Louis, Mo., June 30, 1895.

MAJOR: I have the honor to submit the following report for the fiscal year ending June 30, 1895, upon the improvement of the Mississippi River between the Ohio and Missouri rivers, of which I have had supervision under your direction, including as part of it the reports of assistants in local charge.

A summary of the work that had been done by the United States at the several localities at the beginning of the fiscal year was given in the report of last year. See Annual Report of the Chief of Engineers, 1894, page 1577 et seq. Tables herewith submitted give the quantities of work in bank protection, dikes, dams, and hurdles, with areas reclaimed by the hurdles. Table No. 3 shows 59 miles of hurdles built and 22 miles of bank protected in carrying the improvement continuously down-

stream to Ste. Genevieve works, Missouri, a distance of 56 miles below Eads Bridge, St. Louis. Many of the works within this reach are incomplete and have been designedly left so to await results.

The protection of new banks, which has of necessity to follow their formation, can only be completed after the desired results shall have been obtained. By this sequence of work time becomes an important element in the improvement, and when considered in connection with a single locality where work has been in progress for several years the process may have a prima facie appearance of slowness. Fortunately, however, increased channel depths result from the works built during the earlier stages of the improvement.

During this year new work was prosecuted and additions, extensions, and repairs were made to old works at several localities in carrying the improvement continuously down stream, viz: Horsetail Bar, west side; Pulltight, Sulphur Springs, Fosters Island, Lucas, Cornice Island, Michaels, in Rush Tower reach; Fort Chartres, both sides; Turkey Island, Ste. Genevieve, both sides, and portable jetties were placed to hasten results at Fort Chartres, and for temporary relief to navigation at Devils Island.

Horsetail Bar.—The work at this locality was the continuation of the extension of the protection of the new bank formed on the west side of the river by hurdles which were built in 1881 and following years. It comprised fabricating and placing 290 linear feet of mattress below water surface at the stage prevailing during October, and stone revetment to the stage of 12 feet above standard low water upon the same frontage; this extended the bank protection up to Dike No. 1, where it connected with that previously placed, thus making the protection continuous from the head of the bank at the mouth of the river Des Peres to a distance of about 2,800 feet below Dike No. 1.

Pulltight.—At this locality the work for the year was in continuation of additions, extensions, and repairs begun in 1893 on the series of hurdles projected for its improvement. The buttresses on the river ends of Hurdles Nos. 0 and 1 were raised to the stage of 14 feet above standard low water by alternate layers of brush and stone, and buttresses of stone were built to the same elevation on the river ends of 0½ and 2. This work places the series of hurdles as far as built in good condition to be efficient for the removal of the bars which formerly obstructed navigation. The results have been very satisfactory. Not less than 7½ feet was found in the Pulltight crossing during this year where there was only 4½ feet during the year 1893.

Sulphur Springs.—This is one of the localities notable for shoal water before improvements were begun, and especially throughout the low-water season of 1894. The channel was difficult to navigate with tows on account of abrupt changes of direction and crossings from one side of the river to the other nearly at right angles to the axis of the stream.

The improvement was begun here during the fiscal year 1887, when a number of hurdles in the series were built. The work of this year was building additional hurdles; also extending and repairing those formerly built. On account of the low stage of water during this year all of the hurdles of this projected series could not be completed, but the work so favorably affected the channel, both in depth and direction, that its navigation is much less difficult. The hurdles built this year aggregate 7,595 feet in length, distributed on Nos. 3 to 18, inclusive.

Fosters Island.—The only work at this locality during the year was placing a section of mattress 100 feet in length, which had broken away from the hurdles at Sulphur Springs and revetting the bank above it. As placed, it forms part of an extension of the bank protection of 1882 to 1884, and which will be required for the completion of the island protection.

Lucas.—At this locality the work was in making additions, extensions, and repairs to the series built there from 1888 to 1890. The length of completed hurdle built during this year aggregated 150 feet, distributed on Hurdles Nos. 4½, 9, and 11, on which work was in progress at the close of the year.

Cornice Island.—At this locality work was begun June 1 on the construction of Hurdles Nos. 1, 2, 3, 4, and 5 proposed for its improvement and continued to the close of this year. The total length of hurdles built aggregated 2,510 feet.

Rush Tower Reach.—This reach formerly comprised several detached works between the head of Calico Island and Brickey's Mill, which were grouped together for purposes of administration, but during this year the division between the administrative reaches was made at Michaels, the head of the locality formerly designated, in distinction from other works within Rush Tower Reach, as "Hurdles on west side below Kennett's Castle," and the designation Michaels has been given it.

Michaels.—The work at this locality comprised the construction of Hurdle No. 1 and repairing, as far as practicable at the prevailing low stages of water, No. 3 of the projected series.

The location of No. 1 was changed by swinging its shore end about 1,500 feet upstream, leaving the other end unchanged, thus giving the line a direction inclined

downstream to Osborne Towhead, which was protected by mattress and revetment. On account of the exposed position of the hurdle 8 buttresses, spaced about 300 feet apart, were built 80 feet above the hurdle. In making the shore connection 4 piers of stone were built to the elevation of 16 feet above low water. Another pier will be required, and all of them should be raised to the height of the hurdle, to prevent a stream of water pouring around the shore end at high stages of river.

On Hurdle No. 3 the work was the completion of the repair of the piling in the west gap, which was in progress at the beginning of the fiscal year (see Annual Report of the Chief of Engineers for 1894, page 1605) and in building 9 stone piers to secure a connection with the rocky shore at the west end. The aggregate length of hurdle built was 3,250 feet.

Fort Chartres.—This is one of the localities notable for difficult navigation. Work for its improvement was begun in 1875, when a dam was partly built to close the chute west of Bruce Island, then known as Fort Chartres Towhead, after which no further work was done until the fiscal year 1893, when a series of hurdles was constructed during that and the following year, and the bank opposite was protected in part to a distance of 5,500 feet below Sycamore Landing.

The work of this year was the trimming of the piers on the rocky shore at the west end of the hurdles, the protection of the east bank of Bruce Island, and placing portable jetties to concentrate the current upon the narrow bar which still obstructed the navigable channel. The stone piers connecting the hurdles of the series west of Bruce Island with the rocky shore, which were built during high stages of water, were repaired by placing part of the stone to better advantage. The protection of the east bank of Bruce Island consisted in placing mattress 125 feet wide below water surface for a distance of 3,300 feet above the foot of the island and covering the space between the shore edge of the mattress and the foot of the abrupt bank with revetment.

Upon the approach of the low-water season, about September 1, a shoal with about 5 feet depth developed in the crossing of the bar nearly opposite Fort Chartres Landing. The channel above held close to the Illinois side of the river with a large body of water continuing down that shore until Crook's Landing below was reached, when it dispersed into several small channels, none of which were suitable for navigation, while the main or larger body spilled over the reef in a broad sheet to Bruce Island. In order to hasten the cutting of a channel through the reef, two portable jetties were placed so that they formed a funnel-shaped chute, which concentrated the flow upon the bar. The only channel practicable for navigation passed between the jetties, and as towboats could only make the crossing by flanking, the space between the jetties at the lower orifice could not be sufficiently reduced to obtain the full results desired. A narrow channel 9 feet deep was soon opened along the face of the lower jetty, but a bar which formed immediately below it concentrated the water which passed east of the jetties into a narrow stream along the upper face of the dry bar below, opening a channel 7 feet in depth, which was increased to 9 feet with ample width by the use of pile-driver jets.

These jetties were comparatively inexpensive, as they were improvised from plank and material used in carrying on the improvement; a small amount of grub plank was the only material purchased directly for the purpose. The work on the jetties was begun September 5, and they were removed on the 20th of the same month after the desired results had been obtained.

Turkey Island.—The work at this locality consisted in placing a mattress below water surface for the protection of 1,200 feet of the west face of the island, with stone revetment to the stage of 11 feet above standard low water. The work was in progress at the close of the fiscal year.

Ste. Genevieve.—This locality, extending from the foot of Turkey Island to Kaskaskia, comprises several series of hurdles and bank protection on both sides of the river projected for its improvement. The work of this year included the repair, as far as practicable, of the hurdles below the foot of Turkey Island, built in 1891 and 1892 in accordance with the project to prevent the channel leaving Little Rock, the landing for Ste. Genevieve, required by river and harbor act of 1890; the extension of this series, which has been included in the general project for the improvement of the river, down to the head of Moro Island; the protection of the west face of Moro Island on the Illinois side of the river; and the construction of a series of hurdles on the Missouri side at Stanton's Landing.

The work was still in progress at the close of the year, when the hurdles constructed aggregated 6,575 feet, distributed on Nos. 4, 6, 8, 10, 12 and 15 on the Illinois, and Nos. 2 and 3 on the Missouri side of the river, and the bank of Moro Island was protected a distance of 5,700 feet by a mattress of the usual form placed below the water surface, with revetment above it to the foot of the abrupt bank.

Devils Island.—The only work at this locality was the placing of a portable jetty similar to those used at Fort Chartres in an attempt to increase the depth on the narrow bar, over which only 4 feet of water could be carried by steamers, and that

depth was found only in a channel which crossed the bar nearly at right angles to the axis of the river. The water was spread in a thin sheet from bank to bank of the river, with a depth of 2½ to 4 feet throughout its entire width of about 4,000 feet, without dry bars and with only small differences of depth or velocities of current, and without any well-defined indications that the channel would improve from the unaided efforts of the river.

The channel used by the steamers after crossing the Devils Island bar followed the Illinois side some distance below and crossed to Cape Girardeau from Wahoo, where there was another shoal, with little if any more depth than was found at Devils Island. There was, however, a tendency to form a channel crossing to Flora Creek on the Missouri side, leaving Devils Island above the bar, sufficient to induce several steamers to attempt a crossing, but up to the date on which work was begun no better channel had been found than that via Devils Island and Wahoo bars.

The crossing at Devils Island Bar was about 600 feet out from the island shore at the lower hurdle of the series built there in 1883. The portable jetty, 600 feet in length, was placed above this hurdle, and was inclined downstream from the shore to the best water, while pile-driver jets were used on the bar to aid in deepening the channel. A small gain in depth was made, but a steamer with its tow grounding in the channel flattened it out so that gain was lost. No appreciable benefit was obtained from the use of this jetty on account of the broad expanse of water, feeble current, and want of available plant to concentrate the flow. The barges being needed for other work, the jetty was transferred to piles driven for a support, and as the Mississippi River Commission had begun surveys and taken steps preparatory to operating the dredge *Experimenter* on the bar, the force used in connection with this work was withdrawn.

Plates.—For further information this report makes reference to plates numbered 1, 2, 3, 4, 5, and 6. Plate No. 1, on a scale of 1:100000, is a map of the river from the Missouri River to Big Eddy, 85 miles below Eads Bridge, showing the location of works in the reach under process of continuous improvement, with bars as they appeared upon the dates of the latest surveys and examinations available; for the part above the Merchants Bridge, St. Louis, from the Mississippi River Commission charts of 1879-1889, with sketches made last year above Sawyer Bend; between the Merchants Bridge and the southern limits of St. Louis, from the low-water survey by this office in 1894, with examinations recently made between the Merchants and Eads bridges; for the part between the southern limits of St. Louis and Kaskaskia River, from the low-water surveys of 1895, and for the part below the latter point, from the low-water survey of 1894.

Plates 2 to 6, inclusive, on a scale of 1:25000, shows the location and condition of the works June 30, 1895. The localities where the work has been prosecuted during this fiscal year are shown on the plates as follows:

No. 2. Horsetail Bar and Pulltight.

No. 3. Sulphur Springs and Fosters Island.

No. 4. Lucas and Cornice Island.

No. 5. Michaels and Fort Chartres.

No. 6. Turkey Island and Ste. Genevieve.

These plates also show works which have been projected and those previously built, together with bars, as they appeared upon certain dates and stages as noted thereon.

Procuring materials.—The brush required during the first half of the fiscal year, 10,749.1 cords, and 3,131.9 of the 25,754 cords required during the last half, was procured by hired labor. The remainder, 22,622.1 cords, was procured by contract from James Short.

The stone required was procured as follows: By hired labor, 34,792.6 cubic yards; purchased in open market upon bids, after legal notice, 9,187.1 cubic yards, and by contract with John Burns, 17,173.97 cubic yards.

Of the piles required, 7,497 were procured from the St. Louis Refrigerator and Wooden Gutter Company, 8,515 from Frederick Haftweg—both under formal contract—and 3,395 from John Cleary, in open market upon bids, after legal notice.

Other materials, including bolts, clevises, nails, rope, wire, spikes, and miscellaneous supplies, were purchased as required, usually in open market upon bids after legal notice, but were procured by contract whenever that method was most economical and advantageous to the Government.

Plant.—The plant at the beginning of this fiscal year, even with the additions provided for, was still insufficient for the proper expenditure of this and future appropriations, besides a number of the vessels had become unserviceable from age; therefore it was determined to increase the plant by 1 tow and dredge boat, 12 model barges, and 15 skiffs. The skiffs have been purchased under an informal contract, and the boat and barges are now in process of construction by contract—the boat with E. J. Howard, of Jeffersonville, Ind., and the barges with the Interstate Lumber Company, of Chattanooga, Tenn. The plant now available for service comprises

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the following: 2 towboats, 7 steam tenders, 54 model barges, 35 pile drivers, 1 small machine-shop boat, 2 derrick boats, 1 steam derrick, 10 quarter boats, besides portable buildings for quarters and storerooms; 4 office and survey boats, 265 flats, and the necessary yawls, skiffs, tools, and appliances.

The towboat *Gen. Gillmore* was sunk by striking a hidden obstruction at Fort Chartres, and was thoroughly repaired on the marine ways of this city. Two pile drivers were sunk in front of the engineer depot by ice upon the breaking up of the gorges in February, and they were hauled out on the ways at the depot for repairs. Most of the vessels comprised in the plant are comparatively new and in good condition, except the hull of the towboat *Gen. Gillmore*, which was built twelve years ago, with the machinery much older; 16 model barges, which have been in service more than ten years, 3 of them fourteen years, and the machinery of 7 pile drivers, which has been in use fourteen years.

Engineer depot.—An important adjunct to the plant is the engineer depot, which comprises warehouses for the storage of subsistence supplies and the various materials used in connection with the improvement, blacksmith and carpenter shops, and a building yard with ways for use in construction and repair of barges and smaller vessels appertaining to the plant. It has a water frontage of about 900 feet available for care of vessels harbored there for repairs or other purposes.

During this year in the work of constructing, completing, outfitting, and repairing the plant, the towboats *Gen. Gillmore* and *Gen. T. L. Casey*, steam tenders, pile drivers, derrick boats, barges, quarter boats, office and survey boats, flats, skiffs, and yawls were overhauled and restored to serviceable condition as required.

Gauges.—Gauges were read under the direction of this office daily at Chain of Rocks, Bissells Point, Engineer Depot, Jefferson Barracks, Waters Point, Cornice Rock, Brickeys Mill, Little Rock, East Kaskaskia, Chester, Bishops, and Grays Point. The readings of these gauges and also the readings of the St. Louis gauge obtained from the Weather Bureau have been filed for use in determining the changes in stages and surface slopes resulting from the improvement of the river after their readings shall have been continued through a sufficient period.

The gauges show decided changes in stages and slopes on the portion of the river immediately below St. Louis now under process of improvement, but the extent of such changes resulting from the works can only be given after a long period of gauge observations.

Stages of water.—This year is remarkable for the low stages of water which prevailed. Beginning with 13 feet above standard low water July 1, the river fell to that stage by the last of August; a rise of 2 feet kept it above standard low water until the end of September, when it fell below and remained there until the opening of navigation, February 26. During the entire spring season the river remained unusually low, not exceeding the 6-foot stage above standard low water until June 13, when it rose to a 9-foot stage, which is 5 feet less than the minimum spring, generally called the June, rise recorded at St. Louis since 1861.

Condition of the river.—Prior to the beginning of this year the works for the improvement of the river continuously downstream from St. Louis had been well advanced to Fort Chartres, a distance of 47 miles below, and by the operations of this year this distance has been extended 9 miles farther downstream. Further work, however, will be required at most of the localities within this reach.

The navigable channel has been improved and the minimum depths have been considerably greater than prevailed within the same reach before the improvements began or than prevailed in the unimproved portion as far down as the Ohio River. The least depth found during this year in this reach, which formerly contained some of the shoalest bars between St. Louis and the Ohio River, was at Fort Chartres, where there was only 5 feet in the early part of September, but it was soon increased to 9 feet as the result of the improvement and the application of portable jetties. The depths below the portion of the river under process of improvement were no more than 4 feet at a number of points during the unusually low stage which prevailed from August to the close of the season's navigation in December.

Form of construction.—Hurdles in various modifications of form have been built in experimenting to determine which would secure the desired result at the least cost. A résumé of the forms of construction used at different times in connection with the improvement prior to the beginning of this year is given in the report for the fiscal year 1894. (See Annual Report of the Chief of Engineers for 1894, Appendix X 2, page 1577 et seq.)

The forms of hurdle used this year do not differ materially from those used last year, the essential features of a broad foundation mattress with piling driven centrally through it in form and height to resist the impact of ice and drift and to check the velocity of flow at all stages below that of flood are common to all of them, though details may be varied to suit particular cases. They may still be considered in the experimental stage, for although they have stood remarkably well, the absence of

floods or high stages when ice gorges were breaking prevented a severe test of their strength to withstand the forces which have tested other forms most severely.

The form of bank protection was the same as that used during the preceding year and described with an account of its development in the annual report above mentioned. It consists, essentially, of a mattress with its shore edge placed at the intersection of the water surface with the bank and extending into the stream 120 feet beyond the curve of standard low water, with a revetment of stone from the mattress to the top of the bank.

Accompanying reports.—Reference is made to the reports of assistants in local charge submitted herewith for further details. They are as follows: Report of Mr. Gerald Bagnall, assistant engineer, upon works at Horsetail Bar, Pulltight, Sulphur Springs, Fosters Island, Lucas, and Cornice Island; report of Mr. William S. Mitchell, assistant engineer, upon works at Michaels, in Rush Tower reach, Fort Chartres, Turkey Island, Ste. Genevieve, and Devils Island; reports of Mr. E. D. Libby, assistant engineer, upon brush and stone procured by hired labor; reports of Mr. John O. Holman, assistant engineer, upon gauges and works constructed; report of Mr. C. D. Lamb, superintendent, upon constructing, repairing, and outfitting the plant at the engineer depot.

Very respectfully, your obedient servant,

D. M. CURRIE,
Assistant Engineer.

Maj. CHAS. J. ALLEN,
Corps of Engineers.

REPORT OF MR. WILLIAM S. MITCHELL, ASSISTANT ENGINEER, ON WORKS AT MICHAELS LANDING, FORT CHARTRES, TURKEY ISLAND, STE. GENEVIEVE, AND DEVILS ISLAND.

STE. GENEVIEVE, MO., *June 30, 1895.*

MAJOR: I have the honor to submit the following report of operations for the improvement of the Mississippi River within the reach below Michaels Landing during the fiscal year ending June 30, 1895:

For the first three months in the year work of construction, owing to lack of funds, was suspended and the plant was in harbor at Rush Tower and Cornice Bluff.

During this time, however, considerable work of a minor and temporary character was done; 1,341 sticks of pile timber were received on an unexpired contract and were transferred to Government barges to be held for use on the resumption of active operations; a low-water survey was made from Foster Island to Kaskaskia to note changes in channel depths and in bar and shore lines; the Missouri shore opposite Chester was also surveyed to determine the amount of erosion (it was found to be very slight) during the preceding spring high water and an examination was made of Kaskaskia Chute. This chute was formerly the bed of the Kaskaskia River and at its head, near the town of that name, was crossed by a bridge long since destroyed. The piers of this bridge had been toppled over by the river or removed with the exception of that on the west bank, which at the beginning of the low-water season, in the latter part of July, became, by reason of the rapid erosion of the bank, dangerous to navigation. It was destroyed by dynamite and the main channel of the river now passes over its site.

The low water also developed two very shoal bars which became serious obstructions to navigation in September. These were at Fort Chartres and Devils Island.

At Fort Chartres the crossing over the reef next Bruce Island shoaled to 5 feet. An attempt to increase this was made by the construction of temporary dams so located as to concentrate into the crossing the flow over the bar. The first dam placed (September 5 to 8) was 600 feet in length, located 200 yards below the Island Light, with its ends in deep water, 8 feet and 12 feet, respectively, on the east and west sides of the bar. The dam consisted of five barges moored in line above clumps of piles, and over the upstream sides of the barges were hung close aprons or gates of 2-inch grub plank 16 feet long, each overlapping the next about 1 foot and wide enough to reach from the bottom to the water surface and heavily weighted with stone. A scour to 9 feet in depth by 30 feet in width was caused along the front of the jetty. There was a corresponding shoaling below the barges which protected a large area of the bar from the current, the latter being driven east of the dam to the lower dry sand bar. A second and similar jetty of four barges was placed above the crossing on the reef, parallel with the island shore, the two dams forming the sides of a wide funnel to concentrate the flow over the crossing. The scour along the second jetty was not as great as that near the lower line, and although the depth on the crossing remained at about 6 feet it did not increase beyond that. The space between the funnel sides was too great, being about 1,000 feet. This, however, could not be lessened without danger of collision from steamers and tows which in passing, owing to the obliquity of the current, were compelled to flank across the bar and to pass between the jetties.

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East of the lower dam the channel increased rapidly in depth and crossed the reef near the shoulder of the dry bar below the end of the island. When 7 feet depth was obtained 4 pile drivers were placed at work jetting on the reef with their pumps and soon had a well-defined channel 9 feet in depth across it. The dams were then (September 20 to 24) removed, the pile drivers and barges being taken for similar work to Devils Island. The east channel was soon after marked and lighted by the Light-House Department, and continues in general use and is the best channel in the vicinity, being about 2 feet deeper than the upper crossing, and, although it has flattened out somewhat, it has ever since given greater depths than are found at other points.

The locations of the dams, directions, and depths of currents and channels are shown on the accompanying tracing.

At Devils Island the steamer crossing was about 600 feet out from the hurdle near the lower end of the island and had shoaled to $4\frac{1}{2}$ and 5 feet. It was very short and almost at right angles with the axis of the main river, which is here very wide and shallow, spreading at low stages with feeble current over an enormous flat bar submerged from $2\frac{1}{2}$ to 4 feet, there being no dry sand or ridge anywhere in the vicinity to concentrate the water into a channel.

A jetty or wing dam of barges and plank aprons was placed (September 24 to 27) in a line 700 feet long, sloping slightly downstream from the island shore above the hurdle to deep water. It was located on a shoal on which only $3\frac{1}{2}$ to 4 feet of water was found. The pile drivers were also used to jet on the reef as at Fort Chartres, but owing to the feeble current no great gain in depth was made on the crossing, although a scour was effected along the line of the dam. The barges were afterwards removed (October 5 to 9), and in their stead piles were driven as supports for the plank aprons and the dam was permitted to remain during the rest of the season.

A number of steamers and barges were aground on the crossing in September and October, the bar proving a serious obstruction to navigation.

On October 11 the small force engaged on this dam was withdrawn, a survey of the bar and vicinity having been begun by the Mississippi River Commission by which the dredge *Experimenter* was to be placed at work.

Construction work was resumed October 1 at Rush Tower and Fort Chartres.

RUSH TOWER WORKS.

Hurdle No 1.—At the stage of river then prevailing (4 feet on St. Louis gauge) the line originally projected for this hurdle was partly across a dry bar and partly in such shoal water that pile drivers could not be floated. For this reason the west end of the hurdle was moved upstream 1,500 feet, making a diagonal line 3,000 feet long from the foot of the bluff at Michaels Landing to its original east end at Osborne Towhead. A minimum depth of 3 feet on this line was thus secured, which was thought sufficient, as the river was then very low and the usual October rise was expected. But the river continued to fall steadily until 2 feet on the gauge was reached and remained all season at an extraordinarily low stage (about 3 feet), so that the line was in great part in very shoal water and much difficulty and delay were occasioned. As the pile drivers could not get to the rear line to drive brace piles, for 1,250 feet of the line the piling was driven in two rows of staggered four-pile clumps. In this 1,250 feet about 700 feet had to be driven before the mattress was fabricated, as the depth was insufficient to float the drivers over a mattress. The remainder of the line was driven in four-pile clumps, spaced 9-foot centers, and doubly braced from three-pile clumps 25 feet back of them. The hurdle was built with an allowance of one pile per running foot of line. For a connection with the rocky shore four piers of stone, spaced 25-foot centers, were raised to the level of the 16-foot stage. One more pier and an increased height of all to the 22-foot level will be required at high water to complete the hurdle to the main bank.

To protect the line from ice there were built eight large buttresses of pile clumps and stone, spaced 300 feet between centers and 80 feet above the hurdle. These buttresses were founded on brush mattresses 110 feet wide by 130 feet long, lapping 10 feet on the hurdle foundation. The original plan was to fill in the buttresses with brush and stone, but, on account of scarcity of materials and the shortness of the season, only the front wedge of each was filled with stone to the 12-foot stage, and the remainder was filled to the water surface around each clump of piles. The details of a buttress are shown in the accompanying drawing.

To fix the outer end of the hurdle, Osborne Towhead was protected with a mattress and stone revetment to the 12-foot level from a point 200 feet below the hurdle, around the upper end of the towhead and along the entire length of its east side.

Hurdle No. 3.—The repairs to the piling, which were begun in June and were incomplete on the suspension of work in the summer, were finished, and for a shore connection nine stone piers, 25-foot centers and to the 22-foot level, were built.

The location of the works at Rush Tower with depths of channels and bar lines are shown on the chart.

FORT CHARTRES WORKS.

The stone piers forming the shore connections of the hurdles in this system were redressed and walled up in rough bond to prevent slipping under pressure from high water.

A low-water mattress was placed (October 2 to 31) to protect the rapidly caving east bank of Bruce Island. It was of the ordinary type, 125 feet in width, and extends 3,300 feet upstream from the lower end of the island. Between the shore edge of the mattress and the foot of the abrupt bank at the level of the 6-foot stage of river (St. Louis gauge) a space of an average width of 14 feet was revetted with stone. The bank above was not graded, but will be revetted after the action of the first high water.

The location of the mattress is shown in the accompanying chart.

All work for the fall season was completed November 27 and the plant was at once removed for the winter to the harbor in St. Marys Bend and to the engineer depot.

About 729 sticks of pile timber, delivered November 26 on the contractor's barges at the harbor, were transferred to Government barges.

The ice formed during the winter was unusually heavy, but fortunately on breaking up it passed out at a low stage of river (about 10 feet, St. Louis gauge) without the slightest damage to the works. The river remained at such a low stage during the spring that when operations were resumed the project for the reach near Ste. Genevieve was found to be the only one which could be advantageously begun. Accordingly work was begun (April 15) with the repair of Hurdle No. 4 above Mudds Landing and the construction of other hurdles in this series. As the new lines were to lie between the Illinois bank and a sand bar (dry at a 12-foot stage) protecting their outer ends, it was thought that the construction of the alternate lines, Nos. 6, 8, 10, 12 (spaced 2,000 feet apart), and No. 15, crossing Moro Slough, would secure such results as would render the remaining lines, in whole or in part, unnecessary. Hurdle No. 14 was omitted, as it was found to cross very deep water, necessitating the use of very long piles, and its site seemed protected by Nos. 12 and 15, but as it was at the upper end of the deep water along Moro Island shore the protection mattress for the island was moved up to that point.

Of the series of hurdles on the west side of the river it was decided to build all the lines (omitting only No. 1 as too short to be effective) abutting on the towheads in front of Ste. Genevieve.

EAST SERIES.

Hurdles Nos. 2 and 3.—These lines have collected large deposits about them which now form a continuous bar, dry at mean stages, with the lower end of Turkey Island. Both hurdles have been badly broken by ice, but on account of shoal water repair was not possible.

Hurdle No. 4.—This line was originally 950 feet in length, but the piling in its outer half has also been demolished by ice. The remainder of the hurdle was repaired and the piling restored for 300 feet with curtains to the 15-foot level. On account of shoal water nothing further could be done.

Hurdles Nos. 6 and 8.—These hurdles are 725 and 850 feet in length, respectively, and are completed.

Hurdle No. 10.—This line is 1,100 feet in length, and is complete, with the exception of the piling, for 300 feet across what has been throughout the season a dry bar. This portion will be driven at a higher stage of river.

Hurdles Nos. 12 and 15.—These lines are 1,550 and 1,150 feet in length and are also completed. The latter line is without ice buttresses, as its ends abut on the Illinois shore and Moro Island.

These hurdles are all of the same type. They are founded on woven brush mattresses 100 feet wide, extending from revetments of stone on the main bank to T-head mattresses at their outer ends. As the Illinois bank is here very firm, the stone revetments were not carried along the bank beyond the foundation mattresses and were raised from the mattresses to the foot of the abrupt bank only, or on those portions of the bank which had already assumed a suitable slope, no grading being done. In consequence the tops of the end revetments are at the levels of the following contours: No. 6, 17 feet; No. 8, 15 feet; No. 10, 18 feet; No. 12, 20 feet; No. 15, both ends 17 feet.

As the outer ends of Nos. 6 and 8 were so protected and in comparatively shoal water the T-head mattresses were made only 200 feet in length. The T-heads for Nos. 10 and 12 were made the usual 300 feet in length, and as the bank of Moro Island was sandy it was protected with a 300-foot shore mattress at the root of hurdle No. 15. This is, of course, the length of the revetment at this point.

The average allowance of piling for all these hurdles is one pile per linear foot of line. This proportion varies from one-half stick per foot in very shoal water to one

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and a half sticks in deep, strong currents. The piles were driven in three or four pile clumps staggered in double rows, the top of each clump being bound with four turns of an 18-strand wire (No. 14) cable. In deep water, as at the outer ends of lines Nos. 10 and 12, the rows of clumps were strengthened by braces from a row of three pile clumps driven 25 feet below the main hurdle, each of the latter clumps supporting two braces. The outer ends of Hurdles Nos. 6 to 12, inclusive, are protected from above by ice buttresses similar to those built at Rush Tower and filled with brush and stone to the 15-foot level. The buttresses are immediately above the hurdle lines and are founded on the hurdle mattresses.

All the hurdles are screened with brush curtains to the 15-foot level.

WEST SERIES.

Hurdle No. 2.—The foundation and T-head mattresses have been placed as has also the shore-protection mattress, which was increased in length to 400 feet on account of the very soft character of the bank against which the hurdle abuts. This length of bank was graded by a water jet from a pile driver to a slope of 2 to 1 and was revetted with stone to the top.

Only a portion of the piling for this hurdle has been driven.

Hurdle No. 3.—The foundation T-head and bank-protection mattresses have been placed, and about 500 feet of piling has been driven.

Hurdle No. 4.—The bank-protection mattress has been begun.

BANK PROTECTION.

Moro Island.—A protection mattress of the usual type has been placed (May 11 to June 25) along the west shore of this island from hurdle No. 14 to the bar below the steamer crossing. It is 5,700 feet in length by 127 feet in width, and was built in thirty-eight working days. Between the inner edge of the mattress and the foot of the abrupt bank at about the level of the 10-foot contour, a space averaging 20 feet in width with very flat slope, a layer of spalls 12 inches thick has been placed for the full length of the mattress. This will prevent cutting at high water along the foot of the bank behind the mattress and will afford a good footing for the riprap which is to be placed after the bank has been graded by the action of the river.

Turkey Island.—On June 14 the construction was begun of a protection mattress for the west bank of this island. The head of the mattress was placed about opposite White Sand Depot, at the upper end of the deep water along the shore.

As the delivery of brush has been slow, only a small force has been engaged, and but 1,200 feet of the 5,000 feet contemplated have been completed.

The locations of all the works are shown on the accompanying charts, and the following tables give the amounts of the work done, the expenditures of materials, and the service of equipment at each locality.

Considerable delay has been occasioned this spring by the slow delivery of pile timber and brush by the contractors.

Throughout the entire year the river has been almost unprecedentedly low. This, during the fall, made navigation extremely difficult and hazardous, but the prolonged low water during the winter cut out a well-defined channel in which the entire flow has been concentrated since the opening of navigation in the spring, and the depths obtained have been remarkably good for the stages of river prevailing. Especially has this been the case throughout those portions of the river under process of improvement.

TABLE NO. 1.—*Portable jetties located at Fort Chartres and Devils Island.*

	Fort Chartres.	Devils Island.	Total.
Length	900	700	1,600
Piles:			
Driven	30	25	55
Penetration	550	440	990

TABLE NO. 2.—Work done at Rush Tower Works.

	Hurdles.		Total.
	No. 1.	Repairs of No. 3.	
Hurdles.....linear feet..	3,000	250	3,250
Piles:			
Driven.....number..	3,776	306	4,082
Penetration.....feet..	59,201	4,337	63,538
Braces.....number..	429	3	432
Foundation mattress, including T-heads.....	3,951		3,951
{ linear feet..			
{ square feet..	422,090		422,090
Protection mattress, east side Osborne Towhead.....	1,025		1,025
{ linear feet..			
{ square feet..	126,407		126,407
Stone revetment, east side Osborne Towhead.....	1,037		1,037
{ linear feet..			
{ square feet..	23,164		23,164
Ice buttresses.....number..	8		8
Piers, shore connection.....do....	4	9	13

TABLE NO. 3.—Work done at Bruce Island, bank protection.

	Linear feet.	Square feet.
Protection mattress.....	3,276	404,817
Revetment above mattress.....	3,276	46,200

TABLE NO. 4.—Work done at Turkey Island, bank protection.

	Linear feet.	Square feet.
Protection mattress.....	1,200	152,400
Revetment above mattress.....	600	12,000

TABLE NO. 5.—Ste. Genevieve works, hurdles, cast series.

	Repair and restoration No. 4.	No. 6.	No. 8.	No. 10.	No. 12.	No. 15.	Total.
Hurdles, equivalent.....linear feet..	300	725	850	900	1,550	1,150	5,475
Piles:							
Driven.....number..	250	856	996	790	1,595	1,007	5,503
Penetration.....feet..	4,215	14,546	15,344	12,704	26,109	16,559	89,477
Braces placed.....number..				48			48
Foundation mattress, including T-heads.....		836	1,056	1,308	1,855	1,315	6,460
{ linear feet..							
{ square feet..		83,600	105,600	136,910	185,500	131,500	643,110
Curtains.....linear feet..	773	705	850	800	1,550	1,150	5,828
Revetment, shore ends.....do....		100	100	100	100	300	700
{ linear feet..							
{ square feet..		1,800	1,500	2,300	3,500	10,500	19,600

TABLE NO. 6.—Ste. Genevieve works, Moro Island bank protection.

	Linear feet.	Square feet.
Protection mattress.....	5,700	723,900
Revetment above mattress.....	5,700	114,000

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TABLE NO. 7.—*Sto. Genevieve works, hurdles, west series.*

	No. 2.	No. 3.	No. 4.	Total.
Hurdles, equivalent.....linear feet..	350	750		1,100
Piles:				
Driven.....number..	50	443		493
Penetration.....feet..	816	8,329		9,145
Foundation mattress, including T-heads.....	1,560	1,497	(*)	3,057
{ square feet..	170,000	164,000		334,000
{ linear feet..	400			400
Bank graded.....	14,000			14,000
{ square feet..	4,500			4,500
{ cubic yards..	400			400
Revetment, shore ends.....	16,000			16,000
{ linear feet..				
{ square feet..				

* Begun.

TABLE NO. 8.—*Summary of work done during fiscal year ending June 30, 1895.*

	Fort Char- tres and Devils Island.	Rush tower.	Bruce Island bank protec- tion.	Turkey Island bank protec- tion.	Sto. Genevieve works.			Total.
					Hur- dles, east series.	Moro Island bank protec- tion.	Hur- dles, west series.	
Wing dams.....linear feet..	1,600							1,600
Hurdles, equivalent.....do..		3,250			5,475		1,100	9,825
Piles:								
Driven.....number..	55	4,082			5,503		493	10,133
Penetration.....feet..	990	63,538			89,477		9,145	163,150
Braces.....number..		432			48			480
Foundation mattress, including T-heads. { linear ft.		3,951			6,460		3,057	13,468
{ square ft.		422,090			643,110		334,000	1,399,200
Curtains.....linear feet..					5,828			5,828
Protection mattress { do.		1,025	3,276	1,200		5,700		11,201
{ square ft.		126,407	404,817	152,400		723,900		1,407,524
{ linear feet..							400	400
Bank graded.....							14,000	14,000
{ square ft.							4,500	4,500
{ cubic yds.							400	400
Stone revetment placed { lin. ft.		1,037	3,276	600	700	5,700	400	11,713
{ sq. ft..		23,164	46,200	12,000	19,000	114,000	16,000	230,964

Very respectfully, your obedient servant,

WM. S. MITCHELL, *Assistant Engineer.*

Maj. CHAS. J. ALLEN,
Corps of Engineers.

REPORT OF MR. GERALD BARNALL, ASSISTANT ENGINEER, ON WORKS AT HORSETAIL BAR, PULLTIGHT, SULPHUR SPRINGS, FOSTERS ISLAND, LUCAS AND CORNICE ISLAND.

CORNICE ISLAND, MISSOURI, *June 30, 1895.*

MAJOR: I have the honor to make the following report of operations at Horsetail Bar, west, Pulltight, Sulphur Springs, Fosters Island, Lucas and Cornice Island for the fiscal year ending June 30, 1895.

The plant which had been employed at Horsetail Bar, east, in the spring of 1894 remained in harbor at Kimmswick, Mo., from July 1 to September 30, 1894. During that time the force employed on the fleet, besides their regular duties of watching and caring for the plant, were occupied in transferring piles from the contractor's barges to Government barges and in assisting to calk such boats as needed it. The office force was employed during that period in making and plotting surveys and in making detail drawings of the different methods employed in the construction of hurdles.

On October 1, 1894, work was commenced at Sulphur Springs and continued until the close of the season. Work was carried on at Horsetail Bar, west, from November 10 to the close of the season, and at Pulltight from October 10 to November 10, 1894. On April 15, 1895, operations were resumed at Sulphur Springs and continued until June 30, 1895. On May 18 a small piece of mat was placed on Fosters Island as bank protection. On May 17 a shore mat was placed on Hurdle 4½ at Lucas. On May 25 work was commenced at Cornice Island and continued to the end of the fiscal year.

WORK DONE.

Horsetail Bar, west.—Two hundred and ninety linear feet of bank protection was completed immediately below Dike No. 1. This was carried up the bank to about a 16-foot stage. (See Plate II.)

Pulltight.—The buttresses on lines Nos. 0 and 1 were raised to an 18-foot stage by alternate layers of brush and stone. Buttresses were constructed on the outer ends of lines 0½ and 2 and carried to an 18-foot stage. (See Plate II.)

Sulphur Springs.—Hurdles 5½, 6½, 8, 8½, 10, 10½, 12, and 17 were finished and all curtained except Hurdle 17, where the depth of water made it advisable not to curtail. Hurdles 3½ and 13 were nearly completed. Hurdles 14, 15, and 15½ were commenced, but could not be completed without encroaching upon the steamboat channel. At Hurdle 18 the shore mat was built and sunk. (See Plate III.)

Fosters Island.—One hundred feet of bank protection was placed on the upper end of the island and carried to about a 16-foot stage. (See Plate III.)

Lucas.—Hurdles 4½, 9, and 11, were commenced. On Hurdle 4½, 170 feet of mattress, which had broken loose at Sulphur Springs, was floated into position and sunk as a shore mat. (See Plate IV.)

Cornice Island.—Hurdles 2, 3, 4, and 5 were nearly completed and Hurdle No. 1 commenced. (See Plate IV.)

Class of hurdles constructed at Sulphur Springs.—Hurdles 3½, 6½, 8½, 10½, and 15 were braced diagonally with two braces to each clump. The outer ends of Hurdles 8, 10, 12, 15½, and 17, and the inshore end of Hurdle 13, were also braced diagonally. The outer half of Hurdles 12 and 17 were strengthened by a second row of clumps driven close behind the upper row, on account of their exposed position and the strength of current prevailing there. Where diagonal braces were placed behind a strengthened hurdle, as on the extreme outer ends of 12 and 17, the braces were bolted to the lower row of clumps. The outer ends of Hurdles 6½ and 12 were protected by buttresses built to a 20-foot stage and on the outer end of Hurdle 8½ a buttress was commenced but only completed to an 18-foot stage. The shore at the ends of all the hurdles was protected from cutting by a shore mat 300 feet long above which revetment was placed to such heights as the stage of river would admit without excessive cost.

METHODS OF CONSTRUCTION.

The methods of construction employed were the same as those described on pages 1596 to 1598, Report of Chief of Engineers for 1894.

RESULTS AND OBSERVATIONS.

There was a good navigable channel between St. Louis and Michaels Landing during the low-water season of 1894. While there has been considerable deposit at the different localities, the excessively low stage of river since the opening of the spring season has prevented results which might have been expected had the river reached its usual height. The chief deposits during the fiscal year have been at Horsetail Bar, east, Carrolls Island, and Twin Hollows.

During the seasons of the fall of 1894 and of the spring of 1895 work was retarded by the low stage of river, which interfered seriously with the procuring of material.

PLANT.

The new pile drivers have continued to do very effective work both as regards the number of piles driven and the penetration obtained. A third steam tender was added to the plant employed during the year and has greatly helped to expedite the work. The old quarter barges with portable shanties which remained in service at the end of the fiscal year ending June, 1894, have been replaced by large quarter boats, tending to increased comfort and better health of the men.

TABLE NO. 1.—Showing work done at Horsetail Bar, west, and at Pulltight, during the fiscal year.

HORSETAIL BAR, WEST.		Square feet.
Bank protection:		
Mattress constructed and sunk, 40 by 100 feet; 250 by 115 feet.....		32,750
Revetment placed		31,707
PULLTIGHT.		
Buttress constructed at Hurdle—		Cubic yards.
No. 0		1,352
No. 0½		2,318
No. 1		773
No. 2		2,318
Total.....		6,761

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TABLE NO. 2.—Showing work done at Sulphur Springs, Ill., during fiscal year.

	At Hurdle No.—							
	3½.	5½.	6½.	8.	8½.	10.	10½.	12.
Hurdles constructed...linear feet..	400	420	440	570	640	675	930	1,000
Hurdles braced.....do.....	400		440	80	550	160	730	230
Hurdles strengthened.....do.....								450
Hurdles rebuilt.....do.....								
Foundation mattress con- structed and sunk.....}sq. ft.	985	880	1,041	790	805	940	1,455	1,578
Shore mattress constructed and ballasted.....}sq. ft.	100,880	90,720	101,633	88,480	90,160	105,280	101,040	161,376
Buttress constructed and bal- lasted.....cubic yards.			3,663		3,543			4,193
Revetment at end of hurdle.sq. ft.	30,178	10,458	23,476	16,480	16,008	25,638	16,660	9,290
Curtain constructed...linear feet.	380	380	345	555	575	630	870	885
Earth excavation...cubic yards.		370		800				
Piles driven.....number..	325	292	463	439	716	573	847	852
Braces placed.....do.....	98		104	14	158	46	175	54
Stringers placed.....do.....								

	At Hurdle No.—							Total.
	13.	14.	15.	15½.	16.	17.	18.	
Hurdles constructed...linear feet..	870	150	260	435		700		7,490
Hurdles braced.....do.....	300		150	175		200		3,415
Hurdles strengthened.....do.....						200		650
Hurdles rebuilt.....do.....		60	45					105
Foundation mattress con- structed and sunk.....}sq. ft.	1,260	415	554	945	300	1,320	355	13,623
Shore mattress constructed and ballasted.....}sq. ft.	131,520	36,880	52,448	88,720	29,280	143,040	39,760	1,421,217
Buttress constructed and bal- lasted.....cubic yards.								5,508
Revetment at end of hurdle.sq. ft.	13,118	11,968	17,198	25,848		2,688	14,660	11,399
Curtain constructed...linear feet.								234,028
Earth excavation...cubic yards.	1,200	150					880	4,620
Piles driven.....number..	585	117	224	315	24	534	9	3,400
Braces placed.....do.....	75		40	44		35		6,315
Stringers placed.....do.....						9		843
								9

TABLE NO. 3.—Showing work done at Fosters Island and Lucas during the fiscal year.

FOSTERS ISLAND.

Bank protection:

Matress constructed and sunk.....	{ linear feet... 100
Revetment placed.....do.....	{ square feet.. 11,200
	4,851

LUCAS.

	At hurdle No.—			
	4½.	9.	11.	Total.
Hurdles constructed.....linear feet..			150	150
Foundation mattress constructed and sunk.....		170	865	1,035
Piles driven.....number..	19,040		85,300	104,340
		31	95	126

TABLE NO. 4.—Showing work done at Cornice Island, Missouri, during fiscal year.

	At Hurdle No.—					Total.
	1.	2.	3.	4.	5.	
Hurdles constructed.....linear feet..	180	540	635	515	640	2,510
Foundation mattress constructed and sunk.....}square feet..	995	1,020	910	1,085	1,090	5,100
Buttress constructed and ballasted...cubic yds.	104,880	114,240	97,920	116,720	116,200	549,960
Revetment at end of hurdle.....square feet..				1,733		1,733
Curtain constructed.....}linear feet..	1,500	19,600			7,650	28,750
Piles driven.....number..					400	400
					7,200	7,200
	100	391	417	311	401	1,620

Very respectfully, your obedient servant,

GERALD BAGNALL, Assistant Engineer.

Maj. CHAS. J. ALLEN,
Corps of Engineers.

REPORT OF MR. C. D. LAMB, SUPERINTENDENT, ON OPERATIONS AT U. S. ENGINEER DEPOT.

UNITED STATES ENGINEER DEPOT,
St. Louis, Mo., June 30, 1895.

MAJOR: I have the honor to submit the following report of operations at the engineer depot during the fiscal year ending June 30, 1895:

The force employed during July and August was small, being only that required to care for the property on hand and handle the stores and material received, but early in September the repairing of plant for use during the fall season was begun with a force consisting of 60 carpenters and calkers and 35 laborers. This force was reduced as repairs were completed; but a few were retained, with the 5 machinists and 2 blacksmiths, through the winter, employed in constructing and repairing the plant for use in the spring. The force was again increased in the spring, and all floating equipment calked as required for use. The employees retained at the close of the year included only those required for needed construction and those employed in handling the supplies received and shipped.

The work done upon plant during the year, as in former reports, is divided into three classes—construction, extraordinary repairs, and ordinary repairs.

There was also considerable work done on material besides the labor employed in handling supplies shipped to the construction works below.

CONSTRUCTION.

Tenders.—Steam tenders Nos. 5, 6, and 7 were received on July 4. They were provided with reels, racks, coal bunkers, etc., and sent out for service when needed for construction work in September.

Pile drivers.—The old pile drivers Nos. 1 to 6, retired during 1893, were replaced with new drivers bearing the same numbers.

These were built on six of the Cincinnati hulls with extra heavy hoisting engines, having 7 by 10 inch cylinders, and 14-foot boilers, 42 inches diameter, with four 10 $\frac{1}{2}$ -inch flues. Nos. 4, 5, and 6 were built with steel leads of the pattern described in previous reports, but Nos. 1, 2, and 3 with yellow pine leads, 8 by 12 inches by 42 feet high. No. 2, however, was damaged by the ice in February, and the hull was replaced by another having steel leads of the usual pattern.

The machinery for use in replacing that retired from pile drivers Nos. 16, 17, and 18 was received and placed aboard the hulls on which it will be used, and the leads and sills were set up on Nos. 16 and 17.

Barges.—Another hatch was cut in each end of barges Nos. 101 to 138, and hoods placed over both hatches at each end to turn fresh air into their holds.

Quarter boats.—Quarter boats Nos. 7, 8, 9, and 10 were supplied with cross bulkheads in the dining room, swinging fenders, pumps, lockers, bunk ladders, galvanized ventilating pipes running into the holds, and hatch hoods, and sent out for service as required.

Office and survey boats.—Boat No. 4 was provided with iron pumps and hatch hoods, and made ready for service.

Small boats.—Twenty-four decked flats were equipped with ways, and twelve of them with capstans. Ten open flats were decked. Fifteen new skiffs were painted.

Tools and appliances.—Fire tools, spanners, etc., were made for 12 pile drivers. Other tools were made as required, including 20 sets of mattress chains, 268 capstan bars, 4 calking flats, 50 life floats, 50 pikes, 100 pump boxes, 12 jackscrews, and 150 stage planks.

Boarding outfit.—Tables, benches, and clothes boxes were constructed for use on quarter boats Nos. 7 to 10, comprising 77 tables, 200 benches, and 24 boxes.

Portable jetties.—Two hundred gates for portable jetties were made during the spring for use during low water, each 10 by 10 feet, of No. 16 corrugated iron riveted to three unequal leg angle irons, each 3 by 5 by 5-16 inch and 16 feet long.

EXTRAORDINARY REPAIRS.

Towboat Gen. T. L. Casey.—The steam capstan purchased during the last fiscal year was fitted to its place on the boat. The bulkheads were changed to allow space for a kitchen upstairs and to give more room for coal on deck.

Towboat Gen. Gillmore.—The steamer *Gen. Gillmore* was docked at Carondelet after being sunk during October, and repairs upon her hull completed at this place during November. The work done here consisted in renewing the deck, nosing, and plank-sheer forward, calking the deck, topsides, and outriggers, and relaying the brick in the furnace.

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Steam tenders.—A new steam capstan was purchased and set up on tender No. 3.

Pile drivers.—Extensive repairs were made to pile drivers Nos. 7, 10 and 15 during the fall, the cabins being rebuilt and new leads set up complete. These leads were of yellow pine, like those of No. 1, but the sills, braces, and chocks were of iron.

Barges.—The barges built in 1885, Nos. 1, 2, 3, 5 to 9, and 30, were pulled out upon the ways and extensively repaired. The work done was about the same on each barge, and consisted in renewing the rotten plank in the bottom and lower sides, calking the butts and new work, sheathing the decks with inch boards, and renewing the bits, kevels, timber heads, nosing, and plank-sheer.

Quarter barges.—Quarter barge No. 27, which was on the ways at the beginning of the year, was calked and launched.

The quarter barges built in 1885, Nos. 4, 11, 28, and 29, were docked and repaired to the same extent as the barges built at the same time. The portable buildings were removed from No. 9, and it was sent out for service as a barge.

Small boats.—Eighteen skiffs were repaired with new sides of California redwood.

ORDINARY REPAIRS.

When work was resumed for the fall season the entire floating plant was calked and prepared for service, except a few small boats on the bank at this place. A part of this work was performed at the yard and apart at the works below by a force sent down for that purpose.

The same repairs were repeated in the spring, partly at the depot and partly at the winter harbor.

In addition to the above, small repairs were made at the depot, as follows:

Towboat Gen. T. L. Casey.—Small repairs were made to the escape pipe and furnace of the boat, and nine of the swinging fenders were renewed.

Towboat Gen. Gillmore.—The escape pipe and five fenders were renewed.

Steam tenders.—Small repairs were made as required upon the hulls and machinery of all the tenders, No. 3 being pulled out upon the ways, the knuckle seams calked, and the rudders repaired during the fall and again in the spring, when the rudder posts were entirely renewed and the furnace repaired.

The Providence capstan was taken out of No. 4 and replaced by that from the steamer *Gen. Casey*.

Tenders Nos. 1, 2, 6, and 7 were pulled out upon the ways late in the fall and kept there until work was resumed in the spring, when they were thoroughly repaired and made ready for service.

Pile drivers.—Small repairs were made during the fall season upon the leads of Nos. 11 and 20 and the engines of Nos. 14 and 25.

Three of the pile drivers at the depot were damaged by the ice during the break-up of the latter part of February; the gunwales of Nos. 2 and 6 were broken, and No. 15 was crowded out on the bank and the hull twisted. No. 15 was docked and calked. The machinery of Nos. 2 and 6 was set up on other hulls, and the damaged hulls were pulled out and repaired. They will be used in rebuilding Nos. 17 and 18.

Repairs were made upon the ironwork of drivers Nos. 25 to 35, consisting of new chocks, side braces, winch heads, sheave boxes, etc., and a new lead was set up on driver No. 29.

Derrick boats.—Small repairs were made upon the braces of both Nos. 1 and 2.

Barges.—Besides the calking at the beginning of the fall and spring season, small repairs were made as required upon Nos. 101 to 113.

The temporary quarters were removed from Nos. 1, 3, and 5 and the portable buildings from No. 9, and they were put back into service as barges.

Quarter boats.—The roofs of Nos. 1 to 7 were painted, the stovepipes riveted together, and small repairs made to the cabins and fenders.

Machine shop.—The machine shop was provided with a new roof in the fall. It was pulled out upon the ways during the winter, and is now blocked up on the bank.

Small boats.—All of the flats used during 1894, except 79, and all of the yawls and skiffs except 3, were pulled out upon the bank and piled up for the winter.

One hundred and forty-one flats, 54 skiffs, and 12 yawls were calked and sent out for service in the spring.

Tools and appliances.—Tools of all kinds were repaired as required during the year, the largest items of this kind being wheelbarrows, blocks, trucks, etc.

Boarding outfit.—All the ice boxes in use were rebottomed during the spring and the discharge pipes repaired. The large ice boxes on pile-driver hulls were removed and set up on quarter barges Nos. 11 and 28.

Boarding outfit of all kinds was repaired as required.

Engineer depot.—The shipping platform was extended 60 feet to the city wharf line during the low-water season and clumps of piles were driven along the front for moorings.

All the permanent buildings at the depot were roofed with sheet iron and the underpinning raised and sills renewed.

Ways.—The ways were kept in repair during the year and the mud washed away from the outer end. They were used almost continuously during the fall and spring, and have probably saved more than their cost since being built.

The plant docked during the year consisted of 6 tenders, 1 pile driver, 6 driver hulls, 9 barges, 4 quarter barges, the machine shop, and 79 flats, which were pulled out for calking.

The power was supplied by pile drivers, of which two were required to pull out a barge. As at present arranged, a barge can be pulled out and blocked up on the tilting table in about six hours at an expense of about \$30.

Owing to the extension of the shipping platform above and consequent fill underneath, it will probably be necessary to extend the ways farther out after the next high water.

Material and supplies.—The brush procured by contract during the spring was received and measured at the depot. All the other materials and supplies used in construction, except piles and stone, were also received here and shipped out as required.

Very respectfully, your obedient servant,

C. D. LAMB,
Superintendent.

Maj. CHAS. J. ALLEN,
Corps of Engineers.

Table showing details of cost of labor and material, deterioration of plant, engineering and office expenses, towing, etc., apportioned among the following-named works carried on during the fiscal year ending June 30, 1895: Horsetail, Pulllight, Sulphur Springs, Foster Island, Lucas, Cornice Island, Michaels, Fort Chartres, Turkey Island, Ste. Genevieve (Illinois and Missouri), and Devils Island.

Labor, plant, and material.	Hurdles.	Protec- tion.	Dredg- ing and portable jetties.	Total.
Labor, superintendence, etc.....	\$96,520.86	\$10,080.23	\$2,388.21	\$108,999.36
U. S. engineer office.....	12,020.40	1,190.27	352.75	13,563.42
General expense.....	10,836.69	1,072.40	270.73	12,179.82
Care of plant.....	20,006.55	2,562.41	608.79	20,177.75
Care of material.....	4,605.33	457.05	151.04	5,213.42
Steamer Gen. Gillmore.....	1,861.55	253.26	145.06	2,259.87
Steamer Gen. T. L. Casey.....	986.30	1,151.88	429.09	2,567.27
Steamer Dolphin No. 2.....		7.44	215.91	223.35
Steam tenders.....	6,323.54	253.12	202.86	6,839.52
Quarter barges.....	3,172.65	112.43	65.36	3,310.44
Quarter boats.....	2,202.71	284.54	50.69	2,603.94
Office and survey boats.....	1,368.90	31.38	60.07	1,460.35
Pile drivers.....	16,044.00		942.65	17,887.25
Derrick boats.....	34.07			34.67
Small boats.....	24,724.63	2,522.22	279.46	27,526.31
Portable quarters.....	482.77	5.12	5.18	493.07
Supply depot.....	2,274.72	224.96	50.43	2,550.11
Tools and appliances.....	4,434.30	615.88	84.53	5,134.71
Boarding outfit.....	4,952.19	677.20	64.06	5,693.45
Office furniture.....	45.00	4.50	3.85	53.35
Subsistence.....	23,798.92	3,211.84	466.47	27,387.23
Brush.....	51,772.80	16,530.66		68,303.55
Piles.....	54,352.60		285.19	54,637.79
Stone.....	46,483.98	14,091.67	68.48	60,644.11
Rope.....	440.93	14.61		455.54
Wire.....	2,624.42	467.06	46.00	3,137.48
Iron.....	17.24			17.24
Nails.....	300.45	76.98	20.16	397.59
Spikes.....	953.00	159.00	8.00	1,120.00
Bolts.....	104.86			104.86
Clevises.....	835.88			835.88
Lumber.....	161.70	16.07	764.01	941.78
Oakum.....	8.47	19		8.66
Coal.....	6,181.76	437.41	220.00	6,839.17
Coal, blacksmith's.....	2.30			2.30
Ice.....	1,823.80	181.72	89.45	2,094.97
Miscellaneous material.....	1,963.11	118.59	78.00	2,159.70
Total.....	411,554.65	56,822.09	8,482.54	476,859.28

Division Engineer. It is the opinion of the local engineer that the Upper White River is worthy of improvement, and that the proper method of improving all of it, except the alluvial portion, is by means of locks and fixed dams. The Division Engineer, Colonel Robert, concurs in the opinion that this portion of the river is worthy of improvement by the United States from Batesville, Ark., to Buffalo Shoals, a distance of about 89 miles, and that the proper method of improvement is by locks and dams; but that the remainder of the upper White River is not worthy of improvement just now. In submitting these reports the opinion was expressed by this office that the stream was not worthy of improvement. The reports were transmitted to Congress and printed in House Doc. No. 98, Fifty-fourth Congress, first session. (See also Appendix U 9.)

EXAMINATION OF WOLF RIVER, TENNESSEE, AND REPORT UPON CAVING OF WEST BANK OF MISSISSIPPI RIVER IN FRONT OF HELENA, ARK.

The preliminary examination of *Wolf River, Tennessee*, from its mouth to a point 5 miles above, required by the act of August 17, 1894, was made by Capt. Graham D. Fitch, Corps of Engineers, and report thereon submitted under date of January 24, 1896. It is the opinion of Captain Fitch, concurred in by this office, that Wolf River is worthy of improvement by the General Government from the mouth to the lower railroad bridge, a distance of about 2 miles. No survey was needed to enable a project and estimate of cost of improvement to be prepared. The report was transmitted to Congress and printed in House Doc. No. 218, Fifty-fourth Congress, first session. (See also Appendix V 1.)

Under date of March 14, 1896, Col. G. L. Gillespie, Corps of Engineers, president of the Mississippi River Commission, submitted to this office a report in regard to the *caving in of the west bank of the Mississippi River in front of Helena, Ark.*, together with a report by the district office, Capt. Graham D. Fitch, Corps of Engineers, dated March 7, 1896, giving details and an estimate of the cost of the necessary protection work. Owing to the urgent necessity for this work the matter was presented to the Secretary of War with recommendation that it be submitted to Congress for its consideration. The reports were transmitted to Congress and printed in House Doc. No. 316, Fifty-fourth Congress, first session. (See also Appendix V 2.)

REMOVING SNAGS AND WRECKS FROM MISSISSIPPI RIVER; IMPROVEMENT OF MISSISSIPPI RIVER BETWEEN THE OHIO AND MISSOURI RIVERS, OF HARBOR AT ST. LOUIS, MO., AND OF KASKASKIA RIVER, ILLINOIS.

This district was in the charge of Maj. Chas. J. Allen, Corps of Engineers, to January 10, 1896; in the temporary charge of Lieut. Chester Harding from January 10 to 13, 1896; and in the charge of Maj. Thomas H. Handbury, Corps of Engineers, since January 13, 1896. The officers in charge had serving under their immediate orders Lieutenant Harding from July 1, 1895, to January 10, 1896, and January 13 to April 18, 1896, and Lieut. Charles S. Bromwell, Corps of Engineers, from May 12 to June 28, 1896. Division Engineers, Col. Henry M. Robert, Corps of Engineers, to December 14, 1895, and Col. J. W. Barlow, Corps of Engineers, since February 5, 1896.

1. *Removing snags and wrecks from Mississippi River.*—Before this work was inaugurated the navigation of the river was very much interfered with by numerous snags, logs, etc., which had lodged in the channel, and to which a new accession was brought down on each rise of the river, thus constantly adding new and unknown obstructions to

those already there. A large number of wrecks, dangerous to navigation, also occupied the channel.

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

The total amount expended for this purpose can not be definitely given, as previous to the appropriation made by act of March 3, 1879, a general amount was appropriated to be applied to several streams as their needs required. From March 3, 1879, when the first specific appropriation was made, up to June 30, 1895, \$1,097,280.98 had been expended for this purpose. This expenditure materially improved the navigation of the river and lessened the danger to boats. During the fiscal year ending June 30, 1896, the sum of \$102,225.74, including outstanding liabilities (\$100.32), was expended upon the improvement. Two snag boats were employed in removing the obstructions to navigation between St. Louis and Natchez, and the work resulted in removing 2,979 snags, cutting down 19,648 trees, removing 11 drift piles and 1 wreck; total distance traveled, 14,264 miles.

The work accomplished during the year has been of great benefit to navigation and commerce. Formerly the wrecking of steamboats from running against snags was of frequent occurrence, but since the snag boats have been regularly at work it is unusual to hear of a boat being sunk by a snag.

The replating and other repairs to the hull of the snag boat *H. G. Wright*, that were in progress at the end of the last fiscal year, under contract to be completed August 1, 1895, were not finished until December 26, 1895.

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 wherever necessary.

Amount to be drawn under section 7, act of August 11, 1888	\$80,496.26
June 30, 1896, amount expended during the fiscal year	80,395.94
June 30, 1896, outstanding liabilities	100.32
July 1, 1896, amount available for fiscal year 1896-97	100,000.00

(See Appendix W 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 good 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 lines desired,

from 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 eventually obtain 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, 1895, was \$5,572,694.92. It resulted in extending the improvement in a partially completed condition to Ste. Genevieve, 48 miles below St. Louis, and in giving a channel 6 feet in depth at low water throughout this distance.

The amount expended during the past fiscal year resulted in extending the work to the foot of Liberty Reach, 80 miles below St. Louis, an extension of 32 miles to that under improvement last year. The greater portion of this extension has been made since the low water season of last year. During that season a channel depth of 6 feet was maintained throughout the reach of river under improvement, except for a very short time in two localities. This was owing to a slight rise in the river followed by a sudden fall. The low-water season of last year was exceptionally long and the water exceptionally low. At one time during the season of navigation it was 5 feet below the plane of standard low water, which is 4 feet above the zero of the gauge at St. Louis.

In the unimproved portion of the river 3½ and 4 feet were the ruling depths during this time. It is confidently expected that a channel depth of 6 feet can be maintained during the next low-water season throughout the additional length of river undergoing improvement.

The total of the construction work done during the year is as follows:

	Linear feet.
Hurdles built.....	52,460
Bank protection, revetment.....	20,810

The river and harbor act of June 3, 1896, provides for the construction and maintenance of dredges, portable jetties, and works of like character, which will give temporary relief to navigation during low water.

The funds now available, and those which may be made available, for carrying on this work during the fiscal year ending June 30, 1897, 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, 1898, will be applied to a continuance of the same work.

July 1, 1895, balance unexpended.....	\$1,332,305.07
Amount appropriated by act of June 3, 1896.....	275,000.00
	<u>1,607,305.07</u>
June 30, 1896, amount expended during fiscal year.....	998,793.99
July 1, 1896, balance unexpended.....	608,511.08
July 1, 1896, outstanding liabilities.....	\$9,846.75
July 1, 1896, amount covered by uncompleted contracts.....	37,884.40
	<u>47,731.15</u>
July 1, 1896, balance available.....	* 560,779.93

* Of this balance, amounts have been allotted by mandatory acts of Congress as follows:

Bank protection at Cairo, Ill., act July 5, 1884 (balance).....	\$8,600
Continuing improvement at Cape Girardeau, Mo., act August 5, 1886 (balance). 22,500	22,500
Removing bar in front of Chester, Ill., and protecting west bank of river opposite Chester, act of June 3, 1896.....	30,000

Total..... 61,100

{	Amount (estimated) required for completion of existing project	\$9, 217, 500. 01
	Amount that can be profitably expended in fiscal year ending June 30, 1898	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 March 3, 1893.	

(See Appendix W 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 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 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, 1895, \$150,762.03. There was no expenditure during the past fiscal year.

The full amount of the estimate for improvement of this part of the harbor has been appropriated. With the balance remaining it is proposed to repair damage that may occur to the hurdles from ice and drift and to extend them wherever found necessary to do so.

July 1, 1895, balance unexpended	\$31, 237. 97
July 1, 1896, balance unexpended	31, 237. 97
July 1, 1896, outstanding liabilities	153. 34
July 1, 1896, balance available	31, 084. 63

(See Appendix W 3.)

4. *Kaskaskia River, Illinois.*—The amount, \$10,500, originally estimated for this improvement having been appropriated and the work completed prior to July 1, 1895, no work was done during the past fiscal year and no further appropriation is asked for.

July 1, 1895, balance unexpended	\$39. 20
December 16, 1895, deposited to the credit of the Treasurer of the United States	39. 20

(See Appendix W 4.)

IMPROVEMENT OF MISSISSIPPI RIVER BETWEEN MOUTH OF MISSOURI RIVER AND MINNEAPOLIS, AND OF GALENA RIVER, ILLINOIS.

This district was in the charge of Lieut. Col. W. R. King, Corps of Engineers, since July 6, 1895, having under his immediate orders Lieut. Charles Keller, Corps of Engineers, and in the temporary charge of Lieutenant Keller to July 6, 1895.

TABLE No. 2.—Summary of expenses for operating U. S. snag boats H. G. Wright and J. N. Macomb, etc.—Continued.

Application.	1896.						Total.
	January.	February.	March.	April.	May.	June.	
Office expenses.....	\$571.07	\$304.00	\$308.28	\$350.43	\$503.03	\$500.00	\$4,700.26
Supervision.....							247.30
Expenses of snag boat H. G. Wright:							
Crew.....	1,528.38	4,332.00	2,170.33	1,509.00	1,434.00	1,458.00	16,610.88
Outfit.....	120.88	23.05	17.51	868.00	26.00	110.04	1,174.94
Fuel.....	655.70	775.25	720.03	313.00		8.20	2,685.90
Subsistence.....	615.06	494.17	317.00	322.95	60.70	604.04	3,350.25
Supplies.....	199.13	127.69	172.05	64.92	120.25	180.08	910.88
Repairs.....	241.57	9.77	1.00	432.48	977.95	584.94	8,103.22
Miscellaneous.....	39.80					24.40	67.90
Expenses of snag boat J. N. Macomb:							
Crew.....	4,320.00	2,170.00	2,074.00	1,801.67	1,285.00	1,240.00	23,428.67
Outfit.....	11.58	315.27			8.20	378.89	1,108.00
Fuel.....	1,300.00	1,209.10	2,122.75	205.50	169.00		9,605.75
Subsistence.....	713.25	776.74	581.03	340.47	65.73	674.94	5,750.30
Supplies.....	16.21	184.10			100.05	312.19	1,348.38
Repairs.....	11.48	6.00	20.07	244.15	155.23	252.57	1,189.57
Miscellaneous.....	4.25				4.40		101.72
Total.....	10,659.24	10,728.13	8,561.44	6,460.37	5,031.70	6,244.79	*80,496.26

* Includes \$100.32 outstanding liabilities.

W 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 good deal 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 where 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 hurdle consists, 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 the 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 hurdle 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°.

The heel of the brace 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 the 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 Clute, 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, Minton Point, and Cape Girardeau and vicinity of Cairo.

At the beginning of the fiscal year work was in active progress in the field in the following localities: Twin Hollows, Sulphur Springs, Lucas, Cornice Island, Michaels Landing, Turkey Island, Ste. Genevieve, and Liberty Island. The work was being done by day labor, and the material procured partly by day labor and partly by contract. The towing was done by towboats belonging to the Government.

The following is a brief summary of the work done during the year in the various localities in their order from St. Louis down. The distances are measured from the south limit of St. Louis, which is 8 miles below the bridge.

For a clear understanding of the situation reference is invited to the accompanying map of the reach of the river covered by the work.

Horsetail Bar.—This reach comprises that portion of the river lying between the River Des Peres and the foot of Carroll Island. It is about 3 miles in length.

Work in this locality was commenced October 21 and discontinued November 14. In this time the bank upon the west side was revetted for a distance of 1,500 feet from the standard low-water line to about 14 feet above.

Before the improvement of the river was commenced this was probably the worst locality during low water to be found below St. Louis. At these stages $3\frac{1}{2}$ and 4 feet were frequently the best water that could be found. It is now so far improved that it is omitted from the localities at which soundings are taken by steamboat men.

Twin Hollows (6 miles below St. Louis).—At this locality two sections of mattress for protection of the bank below standard low water, aggregating 2,120 feet, were put in place and the bank above them partly revetted. This work was commenced July 5 and suspended for the season August 2.

Sulphur Springs.—This locality commences about 13 miles below St. Louis and extends down 4 miles.

The work done here during the season consisted in extending and strengthening hurdle lines and protecting their inshore ends with bank revetment.

Work has been necessarily slow at this point on account of having to gradually crowd the steamboat channel to the westward and at the same time not interfere with navigation.

The work of the season was commenced July 15, suspended July 28, resumed October 4, and suspended November 19.

There were 2,350 feet of hurdle work done and 10,580 square feet of revetment at ends of hurdles put in place; 2,230 piles were driven.

Foster Island (17½ miles below St. Louis).—In this locality the work consisted in carrying the protection of the west side of Foster Island up to about 11 feet above standard low water for a distance of 800 feet.

The work was commenced October 22 and suspended November 2.

Lucas.—This locality extends from the foot of Foster Island, 20 miles below St. Louis, downstream about 3 miles to Cornice Island.

The work consisted in building a number of short hurdles to reestablish in efficiency the series formerly built here and new lines of hurdles to extend the work downstream. Considerable work was done in strengthening the upper hurdles of the series where the water was deep and the trend of the channel decidedly toward shore.

Work was continued in this locality until October 19, resumed November 14, and continued until November 24, the close of the season. It was again resumed March 11, 1896, and suspended for a more favorable stage of water April 11, when the working party was transferred down the river to Liberty Reach.

The work done here during the season is represented by 9,420 feet of hurdle constructed, 312,981 square feet revetment at ends of hurdles, and a large amount of other work pertaining to them; 7,825 piles were driven.

Cornice Island (23 miles below St. Louis).—The work in this locality was the completion of the series of five hurdles begun during the preceding year. The work was in progress at the beginning of the year and closed August 6. During the season 495 feet of hurdle was constructed and 1,965 feet strengthened; 1,910 linear feet of curtain was made; 7,170 square yards of bank revetment was placed at the ends of the hurdles, and other work done. This work was finished August 6 as far as the stage of the river would admit.

Michaels Landing (27 miles below St. Louis).—At this point commences a series of work extending down the river about 9 miles, covering what is known as the Rush Tower Reach. The principal work done during the year consisted in repairs, extensions, and completion to hurdles previously commenced, and in bank protection. In the extension of one of the principal upper hurdles it was deflected downstream and connected with the upper end of a towhead, which was substantially revetted. A considerable current was thrown against this hurdle, to resist which the hurdle was made proportionately strong. The foundation mattress was increased in width to 130 feet. The length of hurdle built was 1,750 feet. Piles were placed in clumps of 3 and 4 each, 8 feet apart, and curtained to a height of 20 feet. The shore connections of the hurdles were strengthened, and the ice buttresses were raised and strengthened with stone. Heavy mattresses were made and sunk over the drift that had collected along the upper side of this hurdle. The following are items of principal work done in this locality: Piles driven, 1,025; foundation mat made and placed, 2,650 linear feet; curtains made, 2,500 linear feet; drift mat made, 3,502 linear feet.

At Danby Landing, in this locality, the project contemplated the revetment of the Missouri shore wherever the bank was eroded to the proposed shore line. The position of the bank having reached that line, the revetment of the shore between this point and the head of the Chute between Ames and Lee islands was begun September 18. A section 4,750 feet long was revetted by placing a mattress below low water and carrying the revetment about 15 feet above that line. The work was discontinued November 15.

Fort Chartres.—This is a reach of the river commencing near Brick-eyes Mill, 38 miles below St. Louis, and extending downstream 8 miles to the foot of Turkey Island.

At Bruce Island, in this locality, some bank-revetment work was done during the first two weeks in November. The revetment was raised from the 6-foot contour, at which it had been left in the fall of 1894, to the 12-foot contour, to which the bank had been graded by the action of the high water of July, 1895. This bank for the entire length, 3,350 feet, that had received its low-water protection in 1894, was completed.

At Crooks Landing the work of the year consisted in the construction of hurdles, which had been delayed on account of changes in the channel in the vicinity. On account of the abnormally low water during the fall of 1895, parts of the hurdles of this series could not be built. The river ends of some rested during this working season upon bars inaccessible to the pile drivers and other plant used in their construction. The head of the series was reinforced by building two strong lines furnished with buttresses and heavy revetments. The hurdles of this series were built with foundation mattresses 100 feet in width, through which the piles were driven in double tiers of 4-pile clumps, curtailed to the 15-foot stage of water, but different from the usual form in that the tops of the piles sloped from the 25 to the 15-foot stage of water upon the outer 500 feet of the ends of the hurdles, with the view to facilitating the passage of drift and ice over them.

The work was discontinued October 19. It is represented by 2,964 piles driven; 3,910 linear feet foundation mattress sunk; 2,760 linear feet curtain work; 688 linear feet drift-mat made; 8,300 square feet stone revetment in place, and 2 ice buttresses constructed.

Turkey Island.—Work was in progress at this point at the beginning of the year, continued through July, suspended and resumed again about the middle of October, and discontinued November 21. It consisted in revetting the west face of the island. A low-water protection was given to this for a distance of 5,250; and the revetment extended up the bank to a 15-foot stage on the upper 2,500, and to the 8-foot stage for the next 750 feet, and to the 5-foot stage on the lower 2,000 feet.

Ste. Genevieve.—The reach of the river under improvement in this locality extends from Little Rock, Mo., 47 miles below St. Louis, to near the mouth of the Kaskaskia River, 7 miles below.

This has always been a reach of wide river over which low-water navigation was difficult on account of the variable and uncontrolled position of the channel. The improvement in progress consists in the construction of a series of hurdles extending out from the Illinois and Missouri shores. The work was commenced in 1891, when three hurdles were built upon the Illinois side.

During the last year these were repaired and ten additional ones constructed on the same side of the river. On the Missouri side six hurdles were completed and five partially so, making a total of about 23,500 feet. There were about 23,000 piles, 26,000 cords of brush, and 42,300 cubic yards of stone used.

The space over which the river can wander during low water is now limited in width to 2,500 feet, and there is every prospect that navigation in this locality will hereafter be materially improved.

Liberty.—This reach of the river commences at Waters Landing, 71 miles below St. Louis, and extends about 6 miles downstream. The work done here during the year consisted in the protection of the right bank of the river between Anchor Landing and Bishops Landing, and in the construction of a series of hurdles between this latter place and Jones Point. The revetment work was done in three sections and has

a total length of 7,250 feet. The upper section, 1,800 feet, is just above Anchor Landing, and is separated from the remainder by a space of 900 feet, which is occupied by a very shoal gravel bar, over which it seemed unnecessary to lay a mattress.

The remaining 5,450 feet is continuous, although placed in two sections, advantage being taken of two favorable stages of water. The stonework was carried above the mattress for its entire length to the 16-foot contour, no grading being attempted. As soon as high water has effected this the bank will be revetted to its top.

In the construction of this revetment there was used 7,000 cords of brush and 10,600 cubic yards of stone.

In the locality mentioned seven hurdles were constructed and their river ends strengthened and protected. The total length of these is 11,050 feet. In their construction there were used 9,000 piles, 13,400 cords of brush, and 20,400 cubic yards of stone.

Temporary expedients.—Some experience in temporary expedients for deepening channels across bars was had during last low-water season. The steamer *Gen. H. L. Abbot*, which is furnished with two jet pumps capable of throwing 5,000 gallons per minute each, was used with marked success at the crossing at the foot of Ste. Genevieve Bend and also at other points in that reach.

A very troublesome bar appeared during the low water of last season in the vicinity of Danby Landing. This was successfully improved in a few days by the expedient of a temporary movable jetty. This was made by first driving a row of piles 20 feet apart to mark the direction of the jetty and form a support for a number of small flats 40 feet in length, 16 feet wide, belonging to our plant and used for other purposes about the works. Extending down into the water from the upper side of these were a number of corrugated sheet steel panels, each 10 by 10 feet, made by riveting the steel to three angle bars 3 inches by 3 inches in section and 16 feet long. These projected above and below the sheets. Suitable arrangements were made for holding them against the flats.

A jetty 1,200 feet in length was built here in four days with a force of 22 men. The circumstances were such that it was necessary to build this across a shallow bar, leaving the water to pass around both ends. The effect was almost immediately shown. The channels commenced to deepen, and in a short time a depth of 6 feet was available for tows and 7 feet for single boats where 4 feet had been the best water. The river in the meantime had fallen 1 foot.

At the close of the season all of the material of which the jetty was made was removed.

The location of the work, briefly mentioned above, together with its character and extent, is shown definitely upon the plates herewith.

For more detailed information concerning it reference is invited to the reports, herewith forwarded, of the assistants in local charge of the work, with their accompanying tables, showing work done, localities, material used, etc.

Results of work done and condition of the river.—The main idea kept in view while carrying out the work projected for the improvement of the Mississippi River between the mouths of the Missouri and Ohio rivers has been to get control of it in the upper portion and then proceed downward, taking each reach where there has been excessive width and bad navigation at low water in succession. It has not been intended to complete the improvement in one locality before going to another, nor would this be desirable. The aim is to first improve the low-water navigation in the upper reach by confining the river within

the prescribed limits of 2,500 feet and giving it a proper direction of approach for passing through the next difficult reach below.

As this work progresses downward sufficient additions are made to the upper work to keep the river within the desired lines. By the time this process is carried to Cairo the newly made banks in the vicinity of St. Louis will have become sufficiently high by the deposition of sediment to receive their permanent revetment.

The river as far down as the foot of Liberty Reach, 80 miles below St. Louis, has now undergone the first step in its improvement. This is an addition of 32 miles during this fiscal year. During the last low-water season there was a channel depth of 6 feet maintained throughout the portion of the river then under improvement, with the exception of a very short time in two localities, and these were owing to a slight rise in the river followed by a sudden fall. The low-water season of last year was exceptionally long and the water exceptionally low. At one time during the season of navigation it was more than 5 feet below our standard plane of low water. In the unimproved portion of the river $3\frac{1}{2}$ and 4 feet were the ruling depths during this time.

The next reach in which difficult navigation was experienced last season is in the vicinity of Devils Island, 116 miles below St. Louis and 65 miles above Cairo. This reach, and another extending from Commerce downstream about 7 miles, are the principal localities not yet improved, at which much difficulty is experienced during low water.

When the improvement of the river is completed in accordance with the project it is expected that a low-water channel 8 feet in depth will have been obtained. That it will be able to maintain itself at that depth at all times without the aid of dredging and other temporary expedients can not be asserted with positive certainty on account of the large quantities of sand and other sedimentary matter spasmodically emptied into the Mississippi River by the Missouri.

It is a matter of official record, derived from a series of sediment and discharge observations taken in 1879 at St. Charles on the Missouri River, that the amount of material brought down in suspension by that river, together with the sand rolled along the bottom, was sufficient during that year to have covered a space 1 mile square to a depth of 400 feet, or in other words, sufficient to fill a space 2,500 feet wide and 105 miles long to a depth of 8 feet; or would fill a street 100 feet wide, 53 miles long, to a height of nearly 400 feet.

Allusion is made in this manner to this record with the view to emphasizing the fact that there is a large quantity of material brought into the head of this reach of the Mississippi River every year which must be taken care of in some way, either used in building up the banks or passed through to Cairo and into the lower river. If the Missouri River, during a high stage, throws out more than an average quantity of this and then suddenly falls, the result is an engorgement of the improved channel of the Mississippi in certain localities which it must have time to push on down or work its way through. At such times movable dikes, dredges, and other temporary expedients will be necessary.

Plant.—The most important additions to the plant during the year were the towboat *Gen. H. L. Abbot*, fitted with pumps for jet dredging, and 12 model barges. These were constructed under contract, the former at a cost of \$27,375, and the latter at a cost of \$3,385 each.

The *Abbot* has a length of hull of 170 feet, width of 32 feet, and depth of hold of 5 feet, with suitable cabin and other parts; engines 20-inch diameter, 8-foot stroke; 4 boilers, each 42-inch diameter, 28 feet long, with 2 flues of 9½-inch diameter and 2 of 11-inch diameter; 2 duplex jet pumps 20 by 24 inch steam cylinder and 12 by 24 inch water cylinder, each

capable of delivering 5,000 gallons of water per minute. The boat is also supplied with an electric-light plant. The cost of the pumps and electric-light plant is not included in the contract price for the boat.

This boat was received from the contractor in August, 1895, since which time it has been in almost continuous use, and opportunity has been had for testing its various parts.

The barges are the usual style and model adopted for these works, 135 feet long, 28 feet beam, and 5 feet depth of hold. They are estimated to carry about 300 tons.

Other minor additions have been made to the plant during the year; also the current repairs, which, for so large an outfit as is required for these works, has aggregated a considerable amount.

Jet dredge boat.—On one of the model barges it is intended to mount two 15-inch centrifugal pumps of the Edwards Cataract pattern. These are each supplied with a direct-connection Ideal engine, 15 by 14 inches, for motive power. Two boilers, 42-inch shell, 28 feet long, with 4 flues, will furnish the steam. The suction pipes of these pumps will be over the sides and discharge over the bow of the barge. They are designed to throw about 20,000 gallons of water per minute through flattened nozzles upon sand bars, and thus wash the obstructing material into the deeper water below, making thereby a channel through the bars. The parts of this dredge are now in the process of being assembled and will be ready for operations early during the next low-water season.

For further details touching the plant reference is invited to the reports of Assistant D. M. Currie and C. D. Lamb, superintendent of the supply depot.

Physical investigations.—Water gauges have been read during the year under directions from this office at the following-named places, with the view to collecting data to be used in future investigations of the physical phenomena of the river and their bearing upon the work in progress, viz: Chain of Rocks, Bissells Point, St. Louis, United States Engineer Depot, Jefferson Barracks, Waters Point, Cornice Rock, Brick-eyes Mill, Little Rock, Kaskaskia, Chester, Bishop, and Greys Point.

The low-water season of the past year is notable for its duration and the extreme low stage which prevailed in the winter when navigation would have otherwise been free.

The stage was below the standard low water from September 27 to December 19. At this time there began a sudden rise which reached 23 feet on the St. Louis gauge. It fell again nearly to standard low water by the middle of January. Low stages prevailed until April 10, followed by medium and high stages, reaching 27.7 feet at St. Louis May 27.

It is evident that some change is taking place in the slope of the low-water surface of the river throughout those portions affected by the improvements in progress. With the view to ascertaining, if possible, the character and extent of this change, an investigation of the data at hand bearing upon the river between the Chain of Rocks and Cornice Rock was instituted. The results of this are set forth in the report of Assistant J. O. Holman, transmitted herewith. The data at hand and available for this investigation are entirely inadequate to anything like a proper scientific discussion of the subject or to a just conclusion as to what change is taking place in the regimen of the river as its improvement progresses.

The investigation indicates the direction in which additional data should be sought that may lead to useful results.

This work was in charge of Maj. C. J. Allen, Corps of Engineers, United States Army, until January 10, 1896. From that date to Jan-

uary 13 temporarily in charge of Lieut. Chester Harding, Corps of Engineers, United States Army, and since that date in charge of Maj. Thos. H. Handbury, Corps of Engineers, United States Army.

Mr. D. M. Currie has continued to discharge the duties of principal assistant engineer upon the work and Mr. Wm. S. Mitchell and Mr. Gerald Bagnall those of assistants in charge of the large field parties. 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 is assembled and distributed and repairs to tools and minor repairs to the floating plant are made, has continued in charge of Superintendent C. D. Lamb. All these gentlemen have satisfactorily discharged their several duties.

ESTIMATE.

The original estimate of 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 the funds appropriated and made available for this work to June 30, 1896, is \$7,180,000.

LIST OF APPROPRIATIONS.

By act of—		By act of—	
June 10, 1872	\$100,000.00	August 5, 1886	\$375,000.00
March 3, 1873	200,000.00	August 11, 1888	300,000.00
June 23, 1874	200,000.00	September 19, 1890	400,000.00
March 3, 1875	200,000.00	July 13, 1892	525,000.00
August 14, 1876	200,000.00	March 3, 1893	658,333.33
June 18, 1878	240,000.00	August 18, 1894	758,333.33
March 3, 1879	200,000.00	March 2, 1895	758,333.33
June 14, 1880	250,000.00	June 3, 1896	275,000.00
March 3, 1881	600,000.00		
August 2, 1882	600,000.00	Total	7,359,999.99
July 5, 1884	520,000.00		

Of these amounts \$180,000 was allotted by acts and projects for improvement between the Illinois and the Missouri rivers, including Alton Harbor, leaving a balance of \$7,180,000, 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, 1896, an available balance of \$560,779.93, exclusive of outstanding liabilities. The amount that has been expended on the project to this date is, therefore, \$6,619,220.07.

The amount expended during the fiscal year ending June 30, 1896, is \$998,793.99.

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

For bank protection at Cairo, Ill., act of July 5, 1884	\$8,600
For continuing improvement at Cape Girardeau, Mo., act of August 5, 1886	22,500
For bank protection on east side of Mississippi River opposite to mouth of Missouri River, act of June 3, 1896	50,000
For removing bar in front of Chester, Ill., and protecting west bank of river opposite Chester, act of June 3, 1896	30,000
Total	111,100

The river and harbor act of June 3, 1896, appropriates the sum of \$275,000 for carrying on continuously the systematic improvement of this portion of the river, and it also authorizes an additional \$325,000 to be expended during the fiscal year ending June 30, 1897, and during each of the three succeeding years \$673,333.33.

In addition to the special allotments for revetting the east bank of

the river opposite the mouth of the Missouri, and removing a bar at Chester and revetting the bank opposite, the act also 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 the maintenance of the same, with the view to 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 of the river is closed by ice.

The expense of carrying out this provision, which contemplates a resort to temporary expedients for the relief of navigation until the more permanent work contemplated by the original project has been done and produced its results, can not at this time be estimated. It should not be charged to the estimate for the original work.

The balance of the estimate for the original project not yet appropriated amounts to \$9,217,500.

The balance available June 30, 1896, \$560,779.93, together with the additional \$325,000 authorized by the act of June 3, 1896, to be expended during the fiscal year ending June 30, 1897, if appropriated, will be expended in carrying out the original project as modified by the provisions of that act. It is proposed during the coming low-water season to provide dredges, portable jetties, and devices of a similar character sufficient to insure at least 6 feet depth of channel from St. Louis to Cairo.

It is estimated that the sum of \$800,000 can be profitably expended during the fiscal year ending June 30, 1898, 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 ended June 30, 1896, amounted to \$1,129,966.56.

The amount of internal revenue collected was \$6,469,443.88.

Money statement.

July 1, 1895, balance unexpended.....	\$1,332,305.07						
Amount appropriated by act of June 3, 1896	275,000.00						
	1,607,305.07						
June 30, 1896, amount expended during fiscal year	998,793.99						
July 1, 1896, balance unexpended.....	608,511.08						
July 1, 1896, outstanding liabilities.....	\$9,846.75						
July 1, 1896, amount covered by uncompleted contracts....	37,884.40						
	47,731.15						
July 1, 1896, balance available.....	* 560,779.93						
<table border="0" style="margin-left: 20px;"> <tr> <td>{ Amount (estimated) required for completion of existing project.....</td> <td>9,217,500.01</td> </tr> <tr> <td>{ Amount that can be profitably expended in fiscal year ending June 30, 1898.....</td> <td>800,000.00</td> </tr> <tr> <td>{ Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of March 3, 1893.</td> <td></td> </tr> </table>		{ Amount (estimated) required for completion of existing project.....	9,217,500.01	{ Amount that can be profitably expended in fiscal year ending June 30, 1898.....	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 March 3, 1893.	
{ Amount (estimated) required for completion of existing project.....	9,217,500.01						
{ Amount that can be profitably expended in fiscal year ending June 30, 1898.....	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 March 3, 1893.							
* Of this balance amounts have been allotted by mandatory acts of Congress as follows:							
Bank protection at Cairo, Ill., act July 5, 1884 (balance).....	\$8,600.00						
Continuing improvement at Cape Girardeau, Mo., act August 5, 1886 (balance).....	22,500.00						
Removing bar in front of Chester, Ill., and protecting west bank of river opposite Chester, act of June 3, 1896	30,000.00						
Total.....	61,100.00						
Mississippi River opposite mouth of Missouri River (not mandatory. To be expended at discretion of Secretary of War)	50,000.00						
Total	111,100.00						

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navigation of the river and lessened the danger to boats. During the fiscal year ending June 30, 1897, the sum of \$83,421.64 was expended upon the improvement. Two snag boats were employed in removing the obstructions to navigation between St. Louis and New Orleans, and the work resulted in removing 3,072 snags, cutting down 31,014 trees, removing 24 drift piles and 2 wrecks; total distance traveled, 15,978 miles.

The work accomplished during the year has been of great benefit to navigation and commerce. Formerly the wrecking of steamboats from running against snags was of frequent occurrence, but since the snag boats have been regularly at work it is unusual to hear of a boat being sunk by a snag.

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 wherever necessary.

Amount drawn under section 7, act of August 11, 1888..... \$83,421.64
June 30, 1897, amount expended during the fiscal year..... 83,421.64

July 1, 1897, amount available for fiscal year 1897-98..... 100,000.00
(See Appendix W 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 good 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 from 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 eventually obtain 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, 1896, was \$6,571,488.91, exclusive of \$180,000 allotted by acts and projects for improvement between the Illinois and the Missouri rivers, including Alton Harbor. It resulted in extending the improvement in a partially completed condition to Red Rock, Mo., 87 miles below St. Louis.

The work done during the last year in the line of the permanent improvement has consisted in repairs to existing contraction works and

revetment and a further extension of the same in localities where work had already been commenced.

New work was commenced a few miles below Commerce, where there is a very bad stretch of low-water navigation. This consisted of a hurdle dam placed across Doolans Slough, separating Powers Island from the Missouri shore, which took off about one-half the low-water discharge of the river.

This resulted in a marked improvement in low-water navigation through this reach.

The river and harbor act of June 3, 1896, provided for the expenditure of \$30,000 in the vicinity of Chester, Ill. A low-water revetment was placed against the bank opposite this place for a distance of 3,310 feet, and rock revetment carried up the slope to the 10-foot contour. There is still remaining unexpended of this amount sufficient to carry this revetment to the 20-foot contour above low water.

In this same act it was provided that "there may be expended, under the direction of the Secretary of War, not exceeding \$50,000, or so much thereof as may be necessary, in order to improve the channel of the river, and to protect the east bank of the Mississippi River from caving in and being washed away at or near a point opposite the mouth of the Missouri River and extending south along said east bank." Pending a consideration of the necessity for this work in the interest of navigation the allotment remains unexpended.

Work in the nature of portable jetties and dredging for the temporary improvement of the channel was done in the vicinity of Chain of Rocks, Harrisonville, Calico Island, Turkey Island, Ste. Genevieve, Seventy-Six Landing, Grand Tower Bend, Schenimans, Goose Island, and Hackers Bend. In all of these localities the channel depths were increased from 1 to 3 feet.

For this temporary improvement of the channels through shoal reaches there is now in store 9,000 feet of portable jetty, or sufficient for nine jetties each 1,000 feet in length. A party and outfit on the ground can put this in place at the rate of 400 feet per day. The cost of these jetties, including material, putting in place, removing and storing, and all other expenses, does not exceed \$4.50 per linear foot.

Two towboats have been arranged so that they can stir up the sand on shoal bars with their wheels and wash it into deep pools below. One of these is supplied with large jet pumps. One jet-dredge was designed especially for throwing a broad sheet of water with considerable velocity upon these bars, thus washing them downstream and increasing the depth of water over them. These are the temporary expedients resorted to with good results during the last low-water season.

For the coming season there is provided in addition to these a hydraulic dredge capable of removing 500 cubic yards of sand per hour and depositing it at a distance of 500 feet on either side of the channel. This dredge was completed about the close of last low-water season.

There is also under contract and in process of construction two steel-hulled hydraulic dredges, designed in accordance with the results of the latest developments in this line of machinery. These are to be completed about the middle of October, and will each have a capacity of 1,000 cubic yards per hour.

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 the coming low-water season 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, 1898, 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, 1897, to be paid for as appropriations are made by law, at the rate of \$673,333.33 annually.

July 1, 1896, balance unexpended.....	\$608,511.08
Amount appropriated by sundry civil act approved June 4, 1897.....	673,333.33
	<hr/>
June 30, 1897, amount expended during fiscal year.....	1,281,844.41
	499,325.48
	<hr/>
July 1, 1897, balance unexpended.....	782,518.93
July 1, 1897, outstanding liabilities.....	1,952.11
	<hr/>
July 1, 1897, balance available.....	1,780,566.82
	<hr/>
{ Amount (estimated) required for completion of existing project.....	8,544,166.68
{ Amount that can be profitably expended in fiscal year ending June 30, 1899, as authorized by river and harbor act of June 3, 1896.....	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 W 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 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 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

¹Of this balance special allotments have been made by Congress as follows:	
Bank protection at Cairo, Ill., act of July 5, 1884 (balance).....	\$8,600.00
Continuing improvement at Cape Girardeau, Mo., act of August 5, 1886 (balance).....	22,500.00
Removing bar in front of Chester, Ill., and protecting west bank of river opposite Chester, act of June 3, 1896 (balance).....	6,155.82
Bank protection on east side of Mississippi River opposite mouth of Missouri River, act of June 3, 1896.....	50,000.00
	<hr/>
Total	87,255.82

W 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 $3\frac{1}{2}$ 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, Port Charles, 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 $1\frac{1}{2}$ 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 where 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 hurdle consists, 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 the 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 hurdle 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°.

The heel of the brace 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 the 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, Minton Point, Cape Girardeau, Powers Island, and vicinity of Cairo.

Since last annual report works looking to the permanent improvement of the river have been carried on in the following localities, viz: Sulphur Springs, Michaels Landing, Rush Tower, Ste. Genevieve,

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Chester, Liberty and Powers Island. Work in the nature of portable jetties and dredging for the temporary improvement of the channel was done in the following localities: Chain of Rocks, Harrisonville, Calico Island, Turkey Island, Ste. Genevieve, Seventy-Six Landing, Grand Tower Bend, Schenimans, Goose Island, and Hackers Bend.

Sulphur Springs.—This locality commences about 13 miles below St. Louis and extends down 4 miles.

The work done here was confined to the east side of the river and consisted of repairs, extensions, and additions to the hurdles already in place, equivalent in the aggregate to 990 feet of new hurdle. The location and extent of this work is shown upon Pl. I herewith.

Michaels Landing (27 miles below St. Louis).—This point is the commencement of a series of works extending down the river about 9 miles, covering what is known as the Rush Tower Reach.

No. 1 hurdle of this series was broken last season by a loaded coal barge going through it after the tornado of May 27, 1896. The breach was enlarged to 750 feet during the high stages of last winter and this spring. The construction of a new hurdle, No. 2, in rear of this opening and the repairs to No. 1 were commenced on the 8th of June, this fiscal year, and are now in progress. No. 2 hurdle is 2,800 feet in length, of the ordinary type, and is nearly completed. The location and extent of this work are shown upon Pl. II, and material used and work done on this and other works mentioned are given in the tables devoted to these subjects to be found in the report of Assistant D. M. Currie, herewith.

Rush Tower.—The bank protection placed in the years 1893 and 1894 between Osborne Field and Durfees Landing, 38 miles below St. Louis, had never been completed to high water. The bank above the revetment had been eroded back until there was danger of the work being destroyed. Wherever this danger was most imminent additional rock was used to repair breaks and carry the revetment farther up the banks.

Ste. Genevieve.—The reach of the river under improvement in this locality extends from Little Rock, Mo., 47 miles below St. Louis, to near the mouth of the Kaskaskia River, 7 miles below.

One hurdle on the Illinois side of the river was repaired, and four on the Missouri side extended to their projected lengths. Some work was done on the head of Stanton's tow-head for the purpose of protecting it from erosion. The location of this work is shown upon Pl. III herewith.

Chester, Ill. (73 miles below St. Louis).—The river and harbor act of June 3, 1896, contained a mandatory clause requiring 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." The work done in compliance with this law consisted in revetting the bank opposite Chester as far as the funds available would permit. The work was commenced September 8 and completed for the season October 27, 1896. The mattress used for the protection of the foot of the bank below low water was of the usual type, 125 feet wide. The protection was commenced at the old railroad incline in Clearyville and extended downstream 3,310 feet. The rock revetment was carried up the slope of the bank a distance of about 10 feet above low water. The last high water has graded the upper bank to a proper slope for continuing this revetment. The funds remaining will be sufficient to carry this up to about the 20-foot contour. The location and extent of this work is shown upon Pl. IV herewith.

Liberty.—This reach of the river commences at Waters Landing, 79 miles below St. Louis, and extends about 6 miles downstream.

The work done here consisted in extending to completion four hurdles

under construction at the commencement of the year and building an additional one. The east bank of the river, known as Liberty Bend, has been for some time subjected to very rapid erosion. The bank is high, consisting of sand and loam under which lies a stratum of quicksand, all of which makes it very difficult to protect from the erosive action of the water. At a point near the upper end of the bend a strong hurdle dike about 700 feet in length was built out from the bank to prevent the flanking of the revetment. Under the protection of this the revetment was commenced and extended downstream for a distance of 6,850 feet. The average width of the subaqueous mattress was about 130 feet. The above low-water revetment was carried up to the 20-foot stage along the upper 4,450 feet, then gradually down to the 14-foot stage on the next 800 feet, and continued at that height from thence to the end. In order to hold this bank it will be necessary to extend the revetment farther downstream and carry it up to a higher stage all along its entire length.

Powers Island.—This reach extends from Commerce, Mo., 143 miles below St. Louis, downstream about 7 miles. Within this reach are located what is known as "Jacket Pattern" and "Goose Island" shoals, localities that have given great trouble to navigation. The river here is excessively wide, and much of the water passes down sloughs behind islands or is spread out over sand bars.

Doolans Slough, which separates Powers Island from the main Missouri shore, is estimated to carry off about one-half of the low-water discharge of the river and cause much of the trouble experienced on the Goose Island and Jacket Pattern shoals.

The work of closing this with a permeable hurdle dam was commenced July 9 and finished September 9, 1896. The dam was located nearly 2 miles below the head of Powers Island and 4 miles below Commerce, across a narrow part of the chute where there is a width of only 1,600 feet and where the banks are firm and the cross section regular.

The type of construction was that of the ordinary pile hurdle, but with material for three hurdles massed in one. The foundation for the dam was the ordinary continuous mattress 150 feet wide, two-thirds of the width lying below the piling. On the top of this was another mat 50 feet wide, and in deep water third and fourth tier mattresses 25 feet wide, laid just below the main row of piling to reenforce them and build up the bottom to something like an even cross section and receive the overfall of the dam.

The bank at each end of the dam was protected by mattresses 600 feet long by 125 feet and 150 feet wide on the east and west sides, respectively, and extending 250 feet above and 350 feet below the structure.

The banks were graded from the edges of these mattresses at low water to their tops to a slope of 1 on 2. Over this was laid a revetment of stone. Some settling took place in this revetment during the fall and winter, which was easily repaired.

The effect of closing this slough was very manifest during the low water of last fall, when but little or no trouble was experienced in these shoal places in the main channel, which had heretofore always given trouble at that season.

TEMPORARY EXPEDIENTS.

In my last annual report a brief description was given of a jet dredge boat then in process of construction. This boat was completed and commenced operations about September 1, on the approach of low

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water. From this date until the end of October, when the river commenced to rise, it was in commission. Work was done by it at Harrisonville Crossing, Calico Island, Stantons Towhead, Grand Tower Bend, and Schenimans. At all of these localities the channel was materially improved by its operations, the depths being increased from 1 to 3 feet. This outfit consisted of the dredge boat, a quarter boat, a pile driver, a barge with supply of coal and piles, and one of the steam tenders. The dredge was furnished with a double crew during a part of the time that it was in service, in order that it might be operated night and day. The cost of the dredge alone, not including the original cost of the barge and two pile driver hoisting engines obtained from our plant, was \$18,001.54.

The average cost per month of this dredge with its attendant outfit was approximately \$2,650. A tracing showing the arrangement of the machinery upon this dredge and its method of operation is forwarded herewith.

The discharge pipes from the jet pumps on the towboat *Gen. H. L. Abbot* were changed so as to deliver at the stern of the boat instead of the bow as originally arranged, and two spuds were added near the bow. By this arrangement the boat could go on a bar, head upsteam, drop the spuds, work her wheel and the jet pumps, and soon make a material increase in the depth of water. Working in this manner this boat was able to give valuable assistance at short shoals.

Portable jetties.—During the past two low-water seasons experiments have been made with cheap devices designed to concentrate the water at shoal places and by increasing its velocity induce a scour that will give a depth of channel sufficient for the pressing needs of navigation, these devices to be removed as soon as they have effected their object or the river has risen.

The results obtained last season were very gratifying and have led to the adoption of a system which may be briefly described as follows: Having determined upon the direction that should be given to the jetty in order to produce the best results and admit of the easiest possible construction, piles are driven firmly into the bed of the river along this line at distances apart varying from 10 to 20 feet, depending upon the depth of water and the strength of current. In extreme cases, instead of single piles clumps of two or three may be driven. Along these piles at a proper distance above the water surface other piles are made fast longitudinally either by wire or rope. These are to support the upper ends of corrugated sheet-steel panels, the lower end of which is to rest upon the bottom of the river. Each panel is 10 feet in width, measured in the direction of the jetty, and from 10 to 20 feet long, depending upon the depth of water in which it is to be used. It is made of No. 14 United States standard gauge corrugated sheet steel, riveted to three 5-inch I-beams, 12.50 pounds per foot. Suitable links or clevises are provided for handling the panels. To prevent scour taking place along the lower edge of the panels, and thus permitting them to swing through between the piles, a mattress from 8 to 10 feet wide is made by placing small fascines side by side. This is tied to the lower edge of the panels and sunk with rocks. The method of constructing these jetties is shown upon the tracing forwarded herewith.

At the end of the low-water season the jetties are removed. The panels are taken up, cleaned, painted, and stored. The piles are also removed to be used in future work.

During the low-water season portable jetties were constructed and removed in the following localities: Turkey Island, 1,150 feet; Ste.

Genevieve, 1,460 feet; Seventy-six Landing, 750 feet; Schenimans, 1,000 feet; Goose Island, 850 feet, and Hackers Bend 1,350 feet, making in all 6,560 feet. The field expenditures for this work were as follows:

Labor, \$8,865.14; subsistence, \$1,865.16; piles (not recovered), \$1,139.35; stone, \$110.40; rope, \$900; wire, \$148.20; spikes, \$12; lumber, \$27.66; coal, \$1,072.86; miscellaneous, \$300.56; panels (not recovered), \$1,359.92; total, \$15,801.25, equal to \$2.41 per linear foot. Add to this the proportionable expenses for plant, repairs, deterioration, towage, office, engineer depot, etc., which amounts to \$13,049.06, or \$1.99 per linear foot, the total cost was \$28,850.31, or \$4.40 per linear foot.

The cost of the piles and panels not recovered was \$2,499.27, an average of 38 cents per foot. Had these been recovered the total cost per linear foot would have been \$4.02.

If the jetties had been abandoned and no attempt made to recover any of the material the cost would have been: Labor, \$5,789.29; subsistence, \$1,225; piles, \$3,632; stone, \$110.40; rope, \$900; wire, \$148.20; spikes, \$12; lumber, \$27.66; coal, \$704; miscellaneous, \$268.56; panels, \$18,378.10; total, \$31,250.21. Add to this \$8,500, the proportionate other expenses chargeable to this work, the total cost will be \$39,750.41, or \$6.06 per linear foot.

During the season about 11 per cent of the recoverable material was lost.

In each of the localities where jetties were constructed, except Seventy-six Landing, their effect was hastened by the aid of No. 1 jet dredge or the steamer *Gen. Abbot*. The channel depth was increased from 1 to 3 feet, as follows: At Turkey Island, 2½ feet; Ste. Genevieve, 1 foot; Seventy-six Landing, 2 feet; Schenimans, 3 feet; Goose Island, 1½ feet, and Hackers Bend, 1 foot. These increases are after allowance has been made for differences in the stage of water. The least channel depth at any of these localities when the jetties were removed was 8 feet.

The foregoing facts and figures fully demonstrate that it is practicable, within reasonable limits of expense, to maintain a navigable channel 6 feet in depth at all stages of water between St. Louis and the mouth of the Ohio River by means of portable jetties, aided by dredges, provided that the permanent contraction works now in process of construction be maintained and proceeded with; and there is every reason to believe that a channel depth of 8 feet can be maintained by these means when the whole reach of the river has been permanently contracted within the limits contemplated in the project for its general improvement.

There is now in store and ready for use sufficient corrugated steel panels to construct 9,000 feet of portable jetty or sufficient for nine jetties, each 1,000 feet in length. A party and outfit on the ground with the material should put this in place at the rate of 400 feet per day.

Hydraulic dredge No. 2.—With the view to giving the greatest relief possible to navigation during the approaching low-water season by temporary expedients, authority was obtained from the Chief of Engineers, June 12, 1896, to construct a second hydraulic dredge, making use of such parts of the plant belonging to the work as could be made available.

One of the most recently constructed model barges used for transporting stone was selected and given such additional strength by bulkhead timbers as was necessary to enable it to sustain the heavy

machinery to be placed upon it without vibration when in motion. This barge is 135 feet long, with 28-foot beam, and has a 6-foot depth of hold. On it was placed a 20-inch centrifugal pump, actuated by a horizontal compound condensing engine, connected directly with the pump shaft. Diameter of high-pressure engine, 11 inches; diameter of low-pressure engine, 25 inches, with 18-inch stroke. The pump and engine are upon the same cast-iron base. This machinery was purchased from Edwards & Co., New York. Steam is furnished by three boilers, Mississippi River type, 48 inches diameter and 28 feet long, each having five flues 11 inches in diameter. The ordinary working steam pressure of the boilers is 140 pounds. The engines make 200 revolutions per minute and the pump discharges about 2,000 cubic feet of material. On the basis that 10 per cent of this is sand, which is a very reasonable estimate, the dredge will excavate about 450 cubic yards per hour. The suction pipe is 20 inches in diameter from the pump out to the bow of the boat. At this point the pipe branches to the right and left, with a quarter turn 15 inches in diameter. At the ends of these is a stuffing box and another quarter turn, which permits the pipe to extend down over the bow of the boat and into the water. These stuffing boxes allow each branch of the pipe to move in a vertical plane. At their lower ends these pipes separate by Ys into two branches, each 12 inches in diameter, and terminate in nozzle pieces with opening 30 inches by 6 inches. The two 15-inch pipes are tied together by suitable bracing and raised and lowered by means of a derrick with boom extending out beyond the boat. The hoisting power is obtained from a pile-driver engine taken from the plant. The same engine is used to haul the dredge ahead and keep it up to its work.

Immediately at the pump the discharge pipe makes a quarter turn and is enlarged to 24 inches in diameter. It passes back through the boat and over the stern on to flatboats, which support it for a distance of 500 feet. At the stern of the boat there is an S-shaped piece in the pipe having a horizontal swivel joint, which permits the discharge to be made in any horizontal direction. Where the pipe passes from one flat to another there is a short piece of para rubber hose which permits a flexible motion. The flatboats on which this pipe is supported are a part of the outfit of the plant used for low-water revetment. In the discharge pipe near the pump there is a priming valve used when starting the pump.

To operate the dredge piles are driven on each side of the channel to be opened and at some little distance from it lines are made fast to these and the dredge and discharge pipe maneuvered by means of them.

This dredge was not completed until the end of November, about the time the river commenced to rise. There was no opportunity to give it a practical test upon a channel bar, but it was operated experimentally for several days and all its parts thoroughly tested. It bids fair to be a very satisfactory machine. Its cost was \$21,705.76.

Hydraulic dredges Nos. 3 and 4.—The dredges Nos. 1 and 2 above described are what may be termed temporary expedients, constructed hastily to meet the urgent requirements of low-water navigation during last season. With the object of obtaining a more permanent plant of this kind and to comply with the provisions of the river and harbor act of June 3, 1896, a thorough study of the subject of dredging as applied to river bars was made. This has resulted in a type of dredge of large capacity and light draft, which is easily handled, has ample accommodations for its crew, and at the same time can readily dispose of its own dredged material beyond the lateral limits of the channel to be improved.

The main features of the dredge may be briefly described as follows:

The hull to be made of steel throughout and to be 160 feet long, 40 feet beam, and 6 feet 6 inches depth of hold. There is an opening or well at the bow, in which the suction pipes are placed, 24 feet wide at forward end, 18 feet at after end, by 34 feet long. The two projecting ends thus formed are tied together by a box girder.

There are two centrifugal pumps with suction and discharge openings 20 inches in diameter. The discharge pipe is immediately enlarged to 24 inches in diameter. The pumps are single suction, with interior lining capable of being conveniently removed when worn.

Each pump is driven by a horizontal noncondensing compound direct-connected engine, 15-inch high pressure, 26-inch low pressure, with 18-inch stroke, capable of developing 300 actual horsepower, with approximately 200 revolutions per minute, under a boiler pressure of 140 pounds per square inch, and maintaining, through the suction and discharge pipes, the velocity necessary to carry at least 20 per cent of sand with 80 per cent of water through 500 feet of discharge pipe.

The steam is to be supplied by 6 boilers of the Mississippi River steamboat type, each 48 inches in diameter and 28 feet long, and containing 5 flues each 11 inches in diameter. The boilers are arranged in two batteries of three each, capable of being worked separately or together.

With each main pump there is a jet pump for applying water under pressure through nozzles to the sand at the entrance to the suction pipes. The jet pumps are of the Worthington type, with compound engines capable of delivering 1,200 gallons per minute against a pressure of 65 pounds.

The suction pipe of each main pump has a diameter of 20 inches. It leaves the pump by a reverse curve, passes out through the hull and by a radial joint down through the suction well and terminates with a nozzle or suction head 10 feet wide and 20 inches high, and provided with screen bars or lobes. In order to present the opening in the most favorable manner to the sand the suction head is slightly curved.

There is one discharge pipe for each main pump. At the stern of the dredge there is in each pipe a reverse-curve swivel joint, by means of which the pipe beyond the dredge is slightly raised and can be changed in direction through an angle of 180 degrees. On the outside of the dredge the discharge pipes are in lengths of 24 feet connected by flanges; each two of such lengths are connected by a coupling and piece of flexible rubber hose. The pipes are supported every 25 feet upon steel pontoons so arranged that they may swing under the pipe and present their narrowest dimensions to the current. Each discharge pipe is 500 feet in length and terminates with a baffle plate, for the purpose of steadying the pipe line while the material is going through it.

Cabin accommodations are provided for a double crew consisting of 50 officers and men.

The electric-light plant consists of two 2,000-candlepower arc lights, one 4,000-candlepower focussing headlight with reflector, seventy-five 16-candlepower incandescent lamps, with the necessary engine, dynamo, switch board, and other appurtenances and appliances for a complete first-class outfit. All other outfit and appliances necessary to a complete dredge are provided.

When occasion requires it is intended that the dredge shall be in operation night and day. The output per hour will be 600 yards or 1,200 yards for the dredge.

Four sheets of drawings showing the main features of the dredge are forwarded herewith.

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After the plans and specifications for this dredge had been prepared proposals for constructing two were advertised for February 6, 1897. The bids received were opened March 8, 1897. The lowest of these being The Bucyrus Company, South Milwaukee, Wis., in \$204,800 for both, a contract was entered into with them March 17, 1897. The dredges are to be completed on or before October 10, 1897. Satisfactory progress is being made with their construction.

Plant.—The plant pertaining to this work was kept in good state of repairs during the year and rendered efficient service. There are 16 of the barges used for transporting stone, brush, and other material that have been in constant service for fourteen years. They are practically beyond repair and will have to be replaced by new ones after one more season's work. One or two new towboats will also be needed for carrying on the dredging operations.

Surveys and investigations.—During the year a resurvey of the river has been made at the low-water stage from Red Rock, Mo., 87 miles below St. Louis, to the mouth of the Ohio. This has been plotted to a scale of 1:100,000. A tracing from the map is forwarded herewith. The details connected with this survey, together with the physical data relating to the Mississippi River between the mouth of the Missouri and the mouth of the Ohio rivers, collected since last annual report, may be found in the report of Assistant John O. Holman, which is also forwarded.

Mr. D. M. Currie has continued to discharge the duties of principal assistant engineer upon the work and Mr. William S. Mitchell and Mr. Gerald Bagnall those of assistants in charge of the large field parties. 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 is assembled and distributed and repairs to tools and minor repairs to the floating plant are made, has continued in charge of Superintendent O. D. Lamb. All these gentlemen have satisfactorily discharged their several duties.

For further details concerning the operations of the year reference is invited to their reports, which are herewith transmitted.

ESTIMATE.

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 the funds appropriated and made available for this work to June 30, 1897, is \$7,853,333.32.

The total appropriations for this work to date amount to \$8,033,333.32. 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 \$7,853,333.32, 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, 1897, an available balance of \$780,566.82, exclusive of outstanding liabilities. The amount that has been expended on the project to this date is therefore \$7,072,766.50.

The amount expended during the fiscal year ending June 30, 1897, is \$499,325.48.

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

For bank protection at Cairo, Ill., act of July 5, 1884.....	\$8,600.00
For continuing improvement at Cape Girardeau, Mo., act of August 5, 1886.....	22,500.00
For bank protection on east side of Mississippi River opposite to mouth of Missouri River, act of June 3, 1896.....	50,000.00
For removing bar in front of Chester, Ill., and protecting west bank of river opposite Chester, act of June 3, 1896, \$30,000; balance unexpended.....	6,155.82
Total.....	87,255.82

The river and harbor act of June 3, 1896, provides that contracts may be entered into and material purchased and work done otherwise than by contract for the section of the Mississippi River between the mouth of the Ohio and the mouth of the Missouri River for the fiscal year ending June 30, 1897, not to exceed in amount \$325,000.

From this amount, when it becomes available, it is expected to pay for the two steel-hulled hydraulic dredges, now contracted for and in process of construction, and for stone and piles to be used in contraction works and revetting the banks also contracted for. The full amount of this \$325,000 may be used in discharging the obligations of these contracts.

The balance of the estimate for the original project not appropriated June 30, 1897, is \$8,544,166.68.

It is estimated that the sum of \$800,000 can be profitably expended during the fiscal year ending June 30, 1899, 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 ended June 30, 1897, amounted to \$1,139,723.86. The amount of internal revenue collected was \$6,825,959.28.

Money statement.

July 1, 1896, balance unexpended.....	\$608,511.08
Amount appropriated by sundry civil act approved June 4, 1897.....	673,333.33
	<hr/>
June 30, 1897, amount expended during fiscal year.....	1,281,844.41
	499,325.48
	<hr/>
July 1, 1897, balance unexpended.....	782,518.93
July 1, 1897, outstanding liabilities.....	\$1,952.11
July 1, 1897, amount covered by uncompleted contracts.....	(*)
	<hr/>
	1,952.11
	<hr/>
July 1, 1897, balance available.....	† 780,566.82
	<hr/>
{ Amount (estimated) required for completion of existing project.....	8,544,166.68
{ Amount that can be profitably expended in fiscal year ending June 30, 1899.....	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.	

* The river and harbor act of June 3, 1896, authorized contracts to be entered into and work to be done to the amount of \$325,000. Under this authority contracts have been entered into as per table herewith, which will consume this entire amount. At the end of the fiscal year the amount had not been appropriated.

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

Bank protection at Cairo, Ill., act July 5, 1884 (balance).....	\$8,600.00
Continuing improvement at Cape Girardeau, Mo., act of August 5, 1886 (balance).....	22,500.00
Removing bar in front of Chester, Ill., and protecting west bank of river opposite Chester, act of June 3, 1896 (balance).....	6,155.82
Bank protection on east side Mississippi River opposite mouth of Missouri River, act of June 3, 1896.....	50,000.00
Total.....	87,255.82

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List of appropriations.

By act of—		By act of—	
June 10, 1872	\$100,000.00	August 5, 1886	\$375,000.00
March 3, 1873	200,000.00	August 11, 1888	300,000.00
June 23, 1874	200,000.00	September 19, 1890	400,000.00
March 3, 1875	200,000.00	July 13, 1892	525,000.00
August 14, 1876	200,000.00	March 3, 1893	658,333.33
June 18, 1878	240,000.00	August 18, 1894	758,333.33
March 3, 1879	200,000.00	March 2, 1895	758,333.33
June 14, 1880	250,000.00	June 3, 1896	275,000.00
March 3, 1881	600,000.00	June 4, 1897	673,333.33
August 2, 1882	600,000.00		
July 5, 1884	520,000.00	Total	8,033,333.32

Abstract of proposals for piles received in response to advertisement of March 2, 1897, and opened March 22, 1897, by Maj. Thos. H. Handbury, Corp of Engineers, at St. Louis, Mo.

No.	Name and address of bidder.	First-class piles (price per foot).				Amount.
		3,200, 36 to 40 feet.	2,400, 41 to 45 feet.	1,600, 46 to 50 feet.	800, 51 to 65 feet.	
		Cents.	Cents.	Cents.	Cents.	
1	George Wolf, Grand Tower, Ill.....					
2	John H. Crowder, Commerce, Mo....	10½	10½	10½	10½	\$36,540.00
3	P. S. McCann, Grand Tower, Ill.....	12½	12½	12½	12½	43,500.00
4	Fred. Hartweg, Cincinnati, Ohio....	10½	10½	10½	10½	
5	H. A. Russell, St. Louis, Mo.....					37,410.00

No.	Name and address of bidder.	Second-class piles (price per foot).						Amount.
		400, 25 to 30 feet.	1,600, 31 to 35 feet.	2,000, 36 to 40 feet.	2,000, 41 to 45 feet.	1,200, 46 to 50 feet.	800, 51 to 65 feet.	
		Cents.	Cents.	Cents.	Cents.	Cents.	Cents.	
1	George Wolf, Grand Tower, Ill.....	7½	7½	7½	7½	7½	7½	\$25,147.25
2	John H. Crowder, Commerce, Mo....	6	6	6	6	6	6	19,788.00
3	P. S. McCann, Grand Tower, Ill.....	7½	7½	7½	7½	7½	7½	24,735.00
4	Fred. Hartweg, Cincinnati, Ohio....	6½	6½	6½	6½	6½	6½	21,437.00
5	H. A. Russell, St. Louis, Mo.....	6	6	6	6	6	6	19,788.00

Acceptance recommended of bid No. 2 for first-class piles, and bid Nos. 2 and 5 for second-class piles.

Abstract of proposals for stone, received in response to advertisement dated March 2, 1897, and opened March 22, 1897, at 12 o'clock noon, by Maj. Thos. H. Handbury, Corps of Engineers, at St. Louis, Mo., for work of improving Mississippi River between mouths of Ohio and Missouri rivers.

No.	Name and address of bidder.	Quantity offered.	Price.	Amount.	Remarks.
		Cu. yards.	Cents.		
1	Wm. G. Allison and Sab. Oliver, Chester, Ill.	40,000	39	\$15,000	1 bid only received. Landing 1 mile above Cheater.
2	Bussen Broe., St. Louis, Mo....	10,000	50	5,000	Landing Quarantine, Mo.
3	Earl E. Burke, Neeleys Landing, Mo.	20,000	48	9,600	Landing near Neeleys, Cape Girardeau, Mo.
4	Nelson Sisson, Grand Tower, Ill.	10,000	51	5,100	Landing opposite Grand Tower, Ill.
5	Wm. C. Swanwick, Chester, Ill..	30,000	39½	11,970	Landing Menard, Randolph County, Ill.
6	Bennett James, Mitchie, Ill.....	40,000	37½	14,950	Landing Penitentiary, Chester, Ill.
7	St. Louis Quarry and Construction Co., St. Louis, Mo.	40,000	58	23,200	Landing St. Louis Workhouse Quarry and Chester Penitentiary Quarry.
8	John W. Reno, Chester, Ill.....	40,000	35	14,000	Southern Illinois Penitentiary Landing, Chester, Ill.
9	James Short, St. Charles, Mo....	10,000	51	5,100	½ mile above Sand Depot, Mo.
	.....do	10,000	47	4,700	Chester, Ill.
	.....do	10,000	53	5,300	Apple Creek, Mo.
	.....do	10,000	60	6,000	Grays Point, Mo.
10	Martin Lorenz, St. Louis, Mo....	20,000	49	9,800	Landing foot Cahokia street, St. Louis, Mo.
11	John A. Lohrum, St. Louis, Mo.	20,000	50	10,000	Landing foot Osage street, St. Louis, Mo.

Acceptance recommended of bid No. 3.

APPENDIX W—REPORT OF MAJOR HANDBURY. 2023

Abstract of proposals for two hydraulic dredges received in response to advertisement dated February 6, 1897, and opened March 8, 1897, at 12 o'clock, noon, by Maj. Thos. H. Handbury, Corps of Engineers, at St. Louis, Mo.

No.	Name and address of bidder.	Price for two dredges.	Price for one dredge.
1	John O'Brien Boiler Works Co., St. Louis, Mo	\$224,900.18	\$118,000.11
2	The Bucyrus Co., South Milwaukee, Wis.....	204,800.00	102,400.00

Acceptance recommended of bid No. 2.

List of contracts in force.

Articles.	Name of contractor.	Date of approval.	Date of beginning work.	Date of expiration.
2 hydraulic dredges.....	The Bucyrus Co.....	Apr. 6, 1897	April 16, 1897	Oct. 10, 1897.
4,000 piles, more or less.....	H. A. Russell.....	Apr. 14, 1897	15 days after notice.	When delivery is completed.
20,000 cubic yards stone, more or less.	Earl E. Burke.....	May 5, 1897	.....do.....	Do.
12,000 piles, more or less.....	John H. Crowder...	May 6, 1897	.....do.....	Do.

COMMERCIAL STATISTICS.

Receipts and shipments at St. Louis, Mo., during the years 1893, 1894, 1895, and 1896.

Articles.	1893.	1894.	1895.	1896.
RECEIPTS.				
	<i>Tons.</i>	<i>Tons.</i>	<i>Tons.</i>	<i>Tons.</i>
Barbed wire, ores, and metals (pig and manufactured).....	11,357	23,942	24,759	30,395
Cement.....	13,429	7,718	11,026	9,342
Coal and coke.....	23,180	26,625	18,785	50,820
Cotton and cotton products.....	903	2,249	1,593	2,822
Groceries and dairy products.....	22,888	20,407	16,481	14,440
Hay, seed, grain, flour, meal, etc.....	77,709	77,489	67,586	55,148.
Live stock and products.....	13,392	14,820	20,623	27,474
Lumber.....	120,510	228,087	189,721	173,891
Merchandise and sundries.....	304,099	175,633	138,317	300,741
Vegetables and fruits.....	5,440	6,133	19,321	6,883
White lead, oils, etc.....	68	48	63	44
Wines and liquors.....	181	79	75	50
Wool.....	269	280	490	206
Total.....	599,405	583,510	508,830	671,765
SHIPMENTS.				
Barbed wire, ores, and metals (pig and manufactured).....	7,912	2,066	2,378	2,277
Cement.....	.....	.....	.....	.....
Coal and coke.....	28,874	76,055	47,402	99,558
Cotton and cotton products.....	19	16	11	10
Groceries and dairy products.....	11,789	9,479	11,645	9,919
Hay, seed, grain, flour, meal, etc.....	274,201	148,477	123,734	350,180
Live stock and products.....	7,631	9,955	10,305	10,233
Lumber.....	6	3,135	4,452	5,457
Merchandise and sundries.....	95,699	105,261	94,459	85,213
Vegetables and fruits.....	3,210	1,878	3,273	2,076
White lead, oils, etc.....	1,513	1,356	1,828	2,575
Wines and liquors.....	6,038	5,383	3,852	4,911
Wool.....	8	19	21	1
Total.....	436,900	363,080	303,355	572,410

Transferred by ferries across the river at St. Louis.

	Tons.		Tons.
1893.....	2,829,053.	1895.....	2,809,791
1894.....	2,826,859	1896.....	2,529,786

2024 REPORT OF THE CHIEF OF ENGINEERS, U. S. ARMY.

Shipments down the river from landings between St. Louis and Cairo during the years 1893, 1894, 1895, and 1896.

Grain, including flour, meal, etc., and coal:	Tons.
1893	21, 294
1894	57, 120
1895	26, 715
1896	75, 513

RECAPITULATION.

	1893.	1894.	1895.	1896.
	<i>Tons.</i>	<i>Tons.</i>	<i>Tons.</i>	<i>Tons.</i>
Receipts and shipments at St. Louis.....	1, 036, 305	946, 590	812, 185	1, 244, 175
Transferred by ferries at St. Louis.....	2, 829, 053	2, 826, 859	2, 809, 791	2, 529, 789
Shipped from landings between St. Louis and Cairo..	21, 294	57, 120	26, 715	75, 513
Total	3, 886, 652	3, 830, 569	3, 648, 691	3, 849, 474

List of steam-power boats that arrived at St. Louis during the year 1896.

Size of boats.	Draft.	Boats.	Times arrived.
	<i>Feet.</i>		
Under 500 gross tons	2.5 to 6	86	1, 251
Between 500 and 1,000 gross tons.....	4 to 7.6	21	711
Over 1,000 gross tons	6 to 9.5	12	382
Total.....		119	2, 344

List of barges and scows that arrived at St. Louis during the year 1896.

Size of boats.	Draft.	Barges and scows.	Times arrived.
	<i>Feet.</i>		
Under 500 gross tons	2.5 to 7.5	275	976
Between 500 and 1,000 gross tons.....	5.2 to 8	21	95
Over 1,000 gross tons	5.3 to 9	60	236
Total.....		356	1, 307

List of steamers and barges permanently enrolled and licensed at the port of St. Louis on the 31st day of December, 1896.

	Number of vessels.	Gross tonnage.	Net tonnage.
Permanently enrolled:			
Steamers (wood)	87	30, 682.46	30, 175.76
Barges	87	82, 027.02	81, 936.18
Steamers (iron).....	4	1, 690.29	1, 639.82
Permanently licensed:			
Steamers under 20 tons (wood)	6	68.95	56.95
Steamers under 20 tons (iron)	3	86.50	44.90
Barges under 20 tons.....	2	27.79	27.79
Yachts under 20 tons.....	3	30.28	25.77
Total.....	192	114, 613.24	113, 907.17

CONSTRUCTION.

Cost of works during fiscal year ending June 30, 1897.

Labor, plant, and material.	Sulphur Springs, hurdles.	Rush Tower, protection.	Michaels, hurdles.	Ste. Genevieve, Ill., hurdles.	Ste. Genevieve, Mo., hurdles.	Ste. Genevieve, Mo., protection.	Chester, Mo., protection.
Labor, superintendence, etc.	\$3,610.98	\$784.21	\$7,740.41	\$875.17	\$3,854.69	\$435.32	\$4,736.98
United States Engineer Office.	619.12	160.42	758.06	150.24	1,677.40	84.20	375.06
General expense.	508.00	133.73	665.55	122.78	1,382.26	69.86	281.53
Plant.	1,643.48	417.26	1,834.54	400.92	4,428.56	220.30	1,102.62
Material.	644.91	140.84	245.63	162.93	1,673.31	78.06	718.16
Steamer Gen. Gillmore.	67.32	24.48		42.84			
Steamer Gen. T. L. Casey.	521.54	140.64	1,045.90		246.12	87.90	234.40
Steamer Gen. H. L. Abbot.		125.63	555.03		310.86		
Steam tenders.	290.64		238.65	24.22	317.98		
Quarter barges.			101.92	16.63	105.64		177.92
Quarter boats.	68.95	21.67	230.09	17.73	206.85		106.38
Office and survey boats.	29.26	14.63	378.05	3.99	45.22		38.57
Pile drivers.	452.76		863.98	96.04	1,042.72		
Machine shop.	23.30						
Small boats.	319.66	20.55	844.49	72.67	1,236.42		361.13
Portable quarters.			8.13	1.65	10.45		17.60
Tools and appliances.	122.94	30.66	405.86	51.10	511.00		286.16
Boarding outfit.	63.24	15.81		26.35	263.50		147.56
Office furniture.	4.55	.91		1.17	11.57	.52	6.11
Subsistence.	899.13	176.59	1,186.21	147.77	2,242.72	163.23	1,362.92
Brush.	750.00		3,449.07	229.50	3,901.19	408.20	3,861.29
Piles.	2,752.59		6,993.09	403.08	5,120.39		
Stone.	878.86	1,921.69	4,109.88	407.28	6,525.56	500.11	6,335.30
Rope.	27.00		121.25	63.00	283.32		220.50
Wire.	235.60		89.41	18.72	233.52	10.45	184.30
Iron.	1.78		1.46		4.90		2.67
Nails.			34.80				
Spikes.	48.00		90.20	11.10	81.00	3.40	91.00
Screw bolts.	20.49				5.61		
Clevises.	54.27				29.48		
Lumber.	19.44		7.29		8.17		12.15
Coal.	284.66	4.59	494.22	22.98	512.84	2.30	103.87
Coal, blacksmiths.	.38		.38		.05		
Material, miscellaneous.	135.38	1.60	38.46	5.00	145.17		80.00
Total	15,097.92	4,135.91	31,997.01	3,875.49	41,319.99	2,063.91	23,844.18

Labor, plant, and material.	Liberty, protection.	Liberty, hurdles.	Power Island, Missouri, hurdles.	Portable jetties.	Dredging.	Total.
Labor, superintendence, etc.	\$13,580.31	\$3,920.44	\$20,918.71			\$70,457.17
United States Engineer Office.	2,571.68	1,645.48	3,916.21		\$766.08	12,723.95
General expense.	2,126.76	1,358.30	3,226.65		575.04	10,450.44
Plant.	7,758.68	4,334.72	9,343.85		2,248.26	33,733.25
Material.	2,470.86	1,612.19	3,923.16		1,466.21	13,136.25
Steamer Gen. Gillmore.	250.92				12.24	397.80
Steamer Gen. T. L. Casey.	375.04	105.48	568.42		462.48	3,787.92
Steamer Gen. H. L. Abbot.		325.16	273.43		6,115.73	7,705.36
Dredge No. 1.					7,956.95	7,956.95
Dredge No. 2.					2,126.94	2,126.94
Steam tenders.	145.32	726.15				1,697.96
Quarter barges.			266.88			669.04
Quarter boats.	226.55	186.18				1,063.40
Office and survey boats.	189.65	31.92	129.01			710.80
Pile drivers.	41.16	833.20	3,299.66			6,619.52
Machine shop.	27.96	70.20				121.46
Small boats.	928.14	872.73	1,797.47			5,953.26
Portable quarters.			26.40			64.23
Portable jetties.				\$28,850.31		28,850.31
Tools and appliances.	785.84	367.92	1,032.22			3,543.40
Boarding outfit.	379.44	189.73	532.27			1,617.89
Office furniture.	16.77	11.05	27.17		12.48	92.30
Subsistence.	3,563.99	2,082.98	5,182.10			17,007.09
Brush.	12,597.46	5,929.50	9,329.22			43,455.43
Piles.	156.60	5,980.34	14,363.82			35,779.51
Stone.	18,281.14	4,829.63	14,277.76			58,067.21
Rope.	270.00	457.29	558.00			2,010.36
Wire.	308.10	234.59	522.60			2,089.09
Iron.		1.78	6.78			19.37
Nails.	23.51		1.70			65.01
Spikes.	131.00	65.00	227.04			747.74
Screw bolts.		34.54	79.29			139.93
Clevises.		186.96	238.52			509.20

2026 REPORT OF THE CHIEF OF ENGINEERS, U. S. ARMY.

Cost of works during fiscal year ended June 30, 1897—Continued.

Labor, plant, and material.	Liberty, protection.	Liberty, hurdles.	Power Island Mis- souri, hur- dles.	Portable jetties.	Dredging.	Total.
Lumber		\$9.72	\$29.16			\$85.93
Oakum		1.54				1.54
Coal	\$134.36	329.76	1,150.23			3,039.86
Coal, blacksmiths' .....		.38	1.00			2.28
Material, miscellaneous	39.64	132.11	384.30			961.66
Total	67,545.87	41,854.13	95,633.12	\$28,850.31	\$21,742.41	\$377,460.25

Total cost of works to June 30, 1897.

Name of work.	Expended—		Total.
	Prior to July 1, 1896.	During year 1896-97.	
Sawyer Bend, protection	\$96,803.63		\$96,803.63
Venice dikes	36,341.85		36,341.85
St. Louis Harbor	144,048.94		144,048.94
Arsenal Island, protection	42,599.06		42,599.06
Closing Cahokia Chute	119,958.21		119,958.21
Channel opposite St. Louis	58,455.54		58,455.54
Horsetail Bar, dikes 1 to 5, inclusive	225,066.81		225,066.81
Horsetail Bar, training wall	81,253.28		81,253.28
Horsetail Bar, hurdles	618,447.68		618,447.68
Horsetail Bar, bank protection	68,632.42		68,632.42
Carrolle Island, hurdles	40,343.98		40,343.98
Twin Hollows, west side, hurdles	315,611.64		315,611.64
Twin Hollows, west side, bank protection	56,567.66		56,567.66
Twin Hollows, east side, bank protection	129,435.57		129,435.57
Pulltight, hurdles	519,185.10		519,185.10
Pulltight, bank protection	7,818.23		7,818.23
Beards Island, primary hurdle	7,166.24		7,166.24
Beards Island, bank protection	84,258.76		84,258.76
Chesley Island, hurdles	27,808.61		27,808.61
Chesley Island, bank protection	73,916.55		73,916.55
Jim Smiths, hurdles	365,803.33		365,803.33
Jim Smiths, bank protection	7,569.58		7,569.58
Sulphur Springs, hurdles	356,252.39	\$15,097.92	371,350.31
Foster Island, protection	46,637.49		46,637.49
Lucas, hurdles	272,802.82		272,802.82
Cornice Island, hurdles	63,545.27		63,545.27
Rush Tower, hurdles	218,267.90		218,267.90
Michaels, hurdles	129,169.19	31,997.01	161,166.20
Rush Tower, bank protection	82,312.88	4,135.91	86,448.74
Danbys, bank protection	25,190.80		25,190.80
Fort Chartres, dam	36,812.86		36,812.86
Fort Chartres, west side, hurdles	225,883.99		225,883.99
Fort Chartres, west side, bank protection	19,458.12		19,458.12
Bruce Island, bank protection	3,971.99		3,971.99
Fort Chartres, east side, bank protection	39,846.88		39,846.88
Crooks	39,829.94		39,829.94
Turkey Island, dam	24,463.85		24,463.85
Turkey Island, bank protection	28,829.33		28,829.33
Ste. Genevieve, Ill., hurdles	287,246.44	3,375.40	270,621.93
Ste. Genevieve, Ill., bank protection	26,189.85		26,189.85
Ste. Genevieve, Mo., hurdles	215,735.96	41,319.09	257,055.95
Ste. Genevieve, Mo., bank protection	1,045.26	2,063.91	2,063.91
Moro Island, bank protection	66,465.62		66,465.62
Kaaskafia, bank protection		23,844.18	23,844.18
Chester, Mo., bank protection	5,053.91		5,053.91
Liberty Island, dam	83,699.54	87,545.87	151,245.41
Liberty Island, bank protection	140,510.75	41,854.13	182,364.88
Liberty Island, hurdles	65,871.17		65,871.17
Devils Island, dike No. 1	66,526.88		66,526.88
Devils Island, dams 1 and 2	33,436.37		33,436.37
Minton Point, hurdles	31,930.18		31,930.18
Cape Girardeau, primary hurdles		95,633.12	95,633.12
Power Island, Mo., hurdles	160,439.82		160,439.82
Cairo, bank protection	15,852.38	28,850.31	44,202.69
Portable jetties, operating	2,810.61	21,742.41	24,553.02
Dredging			
Total	5,916,682.06	377,460.25	6,294,142.31

APPENDIX W—REPORT OF MAJOR HANDBURY.

2027

Total cost of work to June 30, 1897—Continued.

PROPERTY ACCOUNT.

Class of property.	Value July 1, 1896.	Debits.	Credits.	Value June 30, 1897.
Steamer Gen. Gillmore.....	\$15,369.92	\$16,178.39	\$14,251.48	\$17,296.83
Steamer Gen. T. L. Casey.....	22,909.59	17,790.92	17,946.20	22,754.31
Steamer Gen. H. L. Abbot.....	39,166.22	19,212.59	19,700.00	38,678.81
Dredge No. 1.....	1,516.07	27,297.60	7,956.95	20,856.72
Dredge No. 2.....		28,093.13	2,126.94	25,966.19
Dredge No. 3.....				
Dredge No. 4.....		1,202.98		1,202.98
Steam tenders.....	26,207.66	3,467.59	3,950.42	25,724.83
Barges, model.....	151,232.40	22,465.35	20,802.59	152,895.16
Barges, quarter.....	12,666.55	371.18	2,171.18	10,866.55
Quarter boats.....	47,026.45	5,858.97	2,029.31	50,856.11
Office and survey boats.....	14,259.53	651.72	981.97	13,929.28
Pile drivers.....	126,867.51	7,582.97	11,303.75	123,146.73
Derrick boats.....	3,473.65	976.98	529.06	3,921.57
Derricks.....	1,824.35		263.39	1,560.96
Machine shop.....	1,043.26	1,418.78	482.61	1,979.43
Small boats.....	31,743.39	8,259.57	7,598.99	32,405.97
Portable quarters.....	4,169.60	370.04	570.33	3,969.31
Portable jetties.....	8,848.99	51,362.78	28,850.31	26,361.46
Ways (supply depot).....	2,352.11	638.02	475.72	2,514.41
Supply depot.....	4,095.19	6,001.76	1,667.88	8,429.07
Tools and appliances.....	16,476.14	11,226.65	6,478.92	21,223.87
Boarding outfit.....	27,751.26	1,621.86	3,123.39	26,249.23
Office furniture.....	572.12	18.50	114.42	476.20
Survey instruments.....	1,900.58	133.82	190.05	1,844.35
Photographic apparatus.....	257.14			257.14
Total	556,729.68	232,201.65	153,563.86	635,867.47

MATERIAL ACCOUNT.

Class of material.	Value July 1, 1896.	Debits.	Credits.	Value on hand June 30, 1897.
Subsistence.....	\$2,029.05	\$34,353.86	\$33,273.24	\$3,109.67
Brush.....	3,534.11	41,894.50	43,455.43	1,973.19
Piles.....	998.63	44,425.87	37,810.67	7,613.83
Stone.....	2,688.89	56,681.71	58,177.61	1,192.99
Rope.....	27,573.85	3,878.83	3,109.98	28,342.70
Wire.....	2,491.79	1,465.48	2,251.73	1,705.54
Iron.....	3,540.32	18,594.22	19,559.44	2,575.10
Nails.....	1,474.25	93.03	271.44	1,295.84
Spikes.....	1,719.33	1,141.10	1,024.40	1,836.03
Bolts, screw.....	972.11		230.28	741.83
Bolts, assorted.....	46.86		17.17	29.69
Clevises.....	446.66	258.56	509.20	196.02
Lumber.....	5,588.35	12,474.31	10,334.24	7,728.42
Lumber (linear feet).....	1.74			1.74
Oakum.....	467.68	573.00	895.70	144.98
Coal.....	2,126.75	22,178.15	23,223.48	1,081.42
Coal, blacksmiths'.....	35.18	153.58	185.41	3.35
Ice.....		3,834.07	3,834.07	
Material, miscellaneous.....	11,083.70	39,959.13	44,456.27	6,586.56
Total	66,819.25	281,959.40	282,619.76	66,158.89

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

St. Louis, Mo., June 30, 1897.

MAJOR: I have the honor to submit the following report upon the improvement of the Mississippi River between the Ohio and Missouri rivers for the fiscal year ending June 30, 1897.

The operations for the year comprised the construction of works for the improvement of the river at Sulphur Springs, Michaels, Rush Tower, Ste. Genevieve, Chester, Liberty, and Powers Island, and for temporary relief to navigation; portable jetties at Turkey Island, Ste. Genevieve, Seventy-six Landing, Schenimans, Goose Island, and Hackers Bend, and, with the exception of Seventy-six Landing, all sup-

plemented by dredging. Dredging was also done at Chain of Rocks, Harrisonville, Calico Island, and foot of Grand Tower Bend.

At Sulphur Springs, east side, repairs, extensions, and additions were made to hurdles as far as practicable at the stages of water prevailing during the fall season, equivalent in the aggregate to 990 feet of new hurdle, distributed as follows: On 1½, 600 feet; on 3¼, 220 feet; and on 5¼, 170 feet, in which 837 piles were driven, 89 braces placed, 540 linear or 54,000 square feet of foundation mattress fabricated and sunk, 115 linear or 11,500 square feet of mattress fabricated and placed to protect shore ends, 555 linear or 6,710 square feet of foundation mattress, and 2,775 square feet of drift mattress fabricated and sunk, 2,300 linear or 33,815 square feet of curtains fabricated and placed, and 500 linear or 13,500 square feet of revetment placed. In the protection of the head of Stantons Towhead 295 linear or 24,970 square feet of mattress was fabricated and sunk.

The bank opposite Chester, Ill., was protected by a mattress placed below water surface and revetment above to the stage of 10 feet above low water of 1863, St. Louis gauge, to a distance of 3,310 feet below the railway incline at Clearyville, Mo., in which the quantities of work are 3,310 linear or 413,750 square feet of mattress fabricated and sunk and 3,310 linear or 75,560 square feet of revetment placed.

At Liberty hurdles Nos. 1, 4, 7, and 10 were extended to completion, and No. 11 was begun and extended 1,140 feet from shore as far as practicable at the low stages which prevailed during the first half of the year when the work was done. The east bank was protected to a distance of 6,850 feet from its initial point near the head of Liberty Bend by a subaqueous mattress about 130 feet average width, but varying between 128 and 144 feet, and by revetment 41 feet in average width, extending to the plane of 20-foot stage on the upper 4,450 feet, then gradually down to 14-foot stage on the next 800 feet, which continued to the end. The quantities of work are: In hurdles, 1,429 piles driven; 285 braces placed; 1,455 linear or 162,900 square feet of foundation mattress fabricated and sunk; 720 linear or 43,200 square feet of drift mattress fabricated and sunk; 36,630 square feet of revetment placed, and 2,317 linear or 43,072 square feet of curtains fabricated and placed. In protecting Liberty Bend the quantities of work are, 6,850 linear or 886,400 square feet of mattress fabricated and sunk; 6,850 linear or 280,463 square feet of revetment placed; 12,418 cubic yards of earth excavated, and 34 piles driven.

At Powers Island a hurdle dam 1,600 feet long was built across Doolan Slough, about 2¼ miles below Beaver Dam Rock, the point at which the volume passing through the slough at low water separated from the main branch of the river. The distance from the dam to the junction of the slough with the main branch at the foot of Powers Island is about the same as that above the dam to the point of separation, making the possible head at the dam about 3¼ feet, due to the fall in 5 miles at the rate of 0.7 of a foot per mile, as determined by recent survey. The location was the most favorable for stability in the slough, but on account of the possible pressures, unstable bed, and banks extra precautions were taken to secure permanency of the dam. The number of piles was increased to more than double that ordinarily used in hurdles, the foundation mattress was doubled over the space between upper and lower rows of piles, the bottom was brought to uniform level by making layers of drift and brush cribs, and the tops of the piles extended to a height which would prevent drift passing over them while the river remained within its banks. Drift was sunk above the dam on half of its length from the island and cribbed mattresses above the other half. Clumps of piles were driven through these mattresses in the deep water to a distance of 600 feet from the Missouri shore. The bank at each end was protected to a distance of 250 feet above and 350 feet below the dam by a subaqueous mattress and stone revetment above to the top of the bank, which was graded to a slope of 2 to 1 to receive it. A spur dike extending from the top of the dam at a point 100 feet from the end of the piling was built at each end to make shore connections.

During the high water of January the revetment at each end settled about 5 feet and was repaired with stone removed from the top of the bank.

The quantities of work are as follows: Piles driven, 3,525; braces placed, 413; foundation mattress fabricated and sunk, 2,510 linear or 371,175 square feet; drift mattress fabricated and sunk, 4,421 linear or 117,525 square feet; curtains fabricated and placed, 450 linear or 7,180 square feet; revetment placed for protection of ends of dam, 1,160 linear or 49,850 square feet, and 4,870 cubic yards of earth excavated in grading 1,383 linear feet of bank.

The quantities of work done in hurdles and bank protection are shown in the accompanying tables.

Table of work done on hurdles during the fiscal year ending June 30, 1897.

Locality.	Foundation mattress fabricated and sunk.		Drift mattress fabricated and sunk.		Shore mattress fabricated and ballasted.		Curtain constructed.	
	Lin. ft.	Sq. ft.	Lin. ft.	Sq. ft.	Lin. ft.	Sq. ft.	Lin. ft.	Sq. ft.
Sulphur Springs:								
Hurdle No. 14.....	540	54,000			115	11,500	380	3,560
Hurdle No. 24.....							175	3,150
Hurdle No. 34.....								
Hurdle No. 54.....								
Total	540	54,000			115	11,500	555	6,710
Michaels Landing:								
Hurdle No. 1.....								
Hurdle No. 2.....	2,416	306,863						
Total	2,416	306,863						
Ste. Genevieve, Ill.:								
Hurdle No. 15.....							230	2,625
Ste. Genevieve, Mo.:								
Hurdle No. 8.....								
Hurdle No. 12.....			650	19,200			270	4,590
Hurdle No. 14.....	705	81,600	1,265	47,050				
Hurdle No. 15.....			880	24,250			1,800	28,600
Total	705	81,600	2,775	90,500			2,070	33,190
Liberty:								
Hurdle No. 1.....			720	43,200				
Hurdle No. 4.....							545	12,300
Hurdle No. 7.....							747	13,297
Hurdle No. 10.....	300	33,000					665	13,235
Hurdle No. 11.....	1,155	129,300					360	4,280
Total	1,455	162,900	720	43,200			2,317	43,172
Powers Island, Mo.:								
Hurdle dam.....	2,510	371,175	4,421	117,525			1,450	7,180
Grand total	7,626	976,598	7,916	251,225	115	11,500	6,622	92,877

Locality.	Revetment placed.		Earth excavated.	Buttresses built.	Piles driven.	Penetration of piles.	Braces placed.
	Lin. ft.	Sq. ft.					
Sulphur Springs:							
Hurdle No. 14.....		3,085			564	10,267	81
Hurdle No. 24.....					8	147	
Hurdle No. 34.....		3,000			191	3,414	8
Hurdle No. 54.....					74	1,274	
Total		6,085			837	15,102	89
Michaels Landing:							
Hurdle No. 1.....	506	26,020			195	3,383	3
Hurdle No. 2.....					1,670	33,428	
Total	506	26,020			1,865	36,811	3
Ste. Genevieve, Ill.:							
Hurdle No. 15.....					151	2,398	
Ste. Genevieve, Mo.:							
Hurdle No. 8.....	175	5,250					
Hurdle No. 12.....	275	8,250					
Hurdle No. 14.....				1	1,028	17,458	45
Hurdle No. 15.....				1	419	7,045	
Total	450	13,500		3	1,447	24,503	45
Liberty:							
Hurdle No. 1.....							
Hurdle No. 4.....							
Hurdle No. 7.....							2
Hurdle No. 10.....		21,250			709	11,941	162
Hurdle No. 11.....		15,360	800		720	12,980	121
Total		36,630	800		1,429	24,921	285
Powers Island, Mo.:							
Hurdle dam.....	1,160	49,850	4,870		3,525	65,353	413
Grand total	2,116	132,085	5,670	3	9,254	169,688	836

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Table of work done on bank protection during the fiscal year ending June 30, 1897.

Locality.	Bank protection mattress fabricated and sunk.		Revetment placed.		Earth excavated. Cub. yds.	Piles driven. No.	Penetration. Feet.
	Lin. ft.	Sq. ft.	Lin. ft.	Sq. ft.			
Rush Tower.....				54,900			
Ste. Genevieve, Mo.....	295	24,970	250	7,500			
Chester, Ill.....	3,310	413,750	3,310	75,560			
Liberty, Ill.....	6,850	886,400	6,850	280,483	12,418	34	566
Total.....	10,455	1,325,120	10,410	418,443	12,418	34	566

PROCURING MATERIALS.

Of the brush required, 26,899 cords was procured by hired labor.

Of the stone required, 23,188.8 cubic yards was procured by hired labor; 11,808.7 cubic yards from Martin Lorenz, and 11,887.8 cubic yards from Bussen Bros. by contract, and 8,508.8 cubic yards was purchased in open market. Of the piles required, 11,729 were procured by contract and 268 by purchase in open market.

TEMPORARY EXPEDIENTS.

Upon the approach of the low-water season, about the 1st of September, shoal bars appeared at the Chain of Rocks above and at several points below St. Louis, threatening to seriously obstruct navigation. This was prevented by the use of portable jetties and dredging, both separately and combined.

The plant available at the beginning of the season comprised the stern-wheel steamer *Gen. H. L. Abbot* with jet pumps arranged to discharge in front of the wheel, the boat being held in position by spuds while the wheel moved ahead slowly, half or full head as required; dredge No. 1, described in report of Chief of Engineers for 1896, and a stock of panels for the construction of portable jetties.

During the season further additions were made to the plant by completion of dredge No. 2, placing spuds on the steamer *Gen. T. L. Casey*, and by the construction of additional panels for jetties to a number sufficient for 10,000 feet.

The work was inaugurated September 4 to 12, on the former date by dredge No. 1, at Harrisonville, where the river had divided into three distinct channels, each with a minimum depth of 4½ feet; on the latter date by the *Abbot*, at the Chain of Rocks, where 4 feet was the depth, and by a portable jetty at Turkey Island, where the depth was 5 feet.

The work was continued to the close of the season, about the 1st of December, by dredging and placing portable jetties as required to maintain a minimum channel depth of 6 feet.

Dredge No. 1, upon leaving Harrisonville, worked successively at Ste. Genevieve, foot Grand Tower Bend, Schenimans, then returned to Harrisonville and thence to Calico Island, where it closed the season's operations. The *Abbot* patrolled the river to Cairo, found and buoyed the best channel bars, dredging where necessary to secure 6-foot depth; moved plant engaged in this work, in addition to towing in connection with both temporary and permanent works.

The aggregate length of portable jetties was 6,560 feet, in seven lines, varying between 1,350 and 460 feet, placed and removed as follows: Turkey Island, 1,150 feet, placed September 12-15, removed November 16-20; Ste. Genevieve, east side, 1,000 feet, placed October 23-30, removed December 2-5, and 460 feet, west side, placed November 4-9 and removed November 28-December 3; Seventy-Six Landing, 750 feet, placed October 14-20 and removed November 27-30; Schenimans, 1,000 feet, placed October 4-20 and removed November 27-30; Goose Island, 850 feet, placed October 17-22 and November 9-11 and removed November 23-25; and at Hackers Bend, 1,350 feet, placed October 28-November 6 and removed November 17-21.

The depth increased at all the localities between dates of placing and removing the jetties from 3½ feet at Turkey Island to 1½ feet at Seventy-Six Landing, from one-fourth to 1 foot of which, however, may have been due to the higher stages of water when removed, except at Seventy-Six, where the stage was half a foot less at the time of removal than at the time of placing the jetty. The channel depths at the dates of placing and removal, respectively, were: At Turkey Island, 6½ and 10 feet; at Ste. Genevieve, 5½ and 7½ feet; at Seventy-Six Landing, 8 and 9½ feet; at Schenimans, 5 and 8 feet; at Goose Island, 6 and 8 feet, and at Hackers Bend, 6½ and 8½ feet. This shows an increase, on account of temporary expedients, of about 2 feet in depth upon the average.

Dredging alone also gave satisfactory results. At the Chain of Rocks the *Abbot*, in nine working hours, dredged a new channel with 5-foot depth, crossing the bar with easy curves instead of the tortuous one, with less than 4 feet depth found there.

At Harrisonville there were three channels, each with depths varying between 4½ and 5½ feet. The lower of these was selected to be dredged because it was improving, while the others were deteriorating. Dredge No. 1 worked there from September 4-11 and increased the minimum depth from 4½ feet to 7½ feet.

On October 5 the *Abbot* removed a lump from this channel, and November 2-14 dredge No. 1 cut off a point of the upper reef that projected into the channel.

At Calico Island two low-water channels developed, each with 4 feet depth, one passing by Cornice Island hurdles, the other by Calico Island. The latter was 180 feet wide and reasonably straight, while the other was narrow and tortuous, and therefore was selected to be dredged. The depth was increased to 7½ feet and the width to 300 feet by dredge No. 1, working from October 18-31.

At Turkey Island the *Abbot* worked eight hours October 7 in the channel undergoing process of improvement by the portable jetties then in position, with the result of an increase of 2½ feet to a least depth of 10 feet with ample width.

The Ste. Genevieve reach had been greatly improved by the hurdles under process of construction, but a shoal developed near the lower end of the series, where the hurdles were either incomplete or had not been built long enough to have secured their full effect upon the channel. This shoal consisted of a hard ridge of gravel over blue clay, and could be crossed by either of three channels with nearly the same depth, known as the lower, middle, and upper ways. The last named had the least depth, but on account of its easy curves was the best for permanency and for use by descending steamers; therefore an effort was made to improve it by dredging. Dredge No. 1 began work on the morning of September 15, and the *Abbot* began during the forenoon of the same day, and both worked continuously until noon of the following day, when the *Abbot* was withdrawn for other work. The dredge continued the work night and day until the 18th without securing material improvement, as the sand moved into it from above about as fast as it was removed. The excavated material was carried by the currents across the lower reef, however, of this channel to the upper end of the lower channel and caused an increase in depth of that channel. The dredge was changed from the upper to the lower channel on the 18th, and by the 20th had increased its depth to 8 feet.

The shoal re-formed and was dredged October 4, 7, and 28-29 by the *Abbot*, and the channel was afterwards kept open by the portable jetties placed October 23-30 and November 4-9.

Work was begun by dredge No. 1 on a shoal at the foot of Grand Tower Bend September 21, and continued to October 1 with interruptions on account of a rise in the river. A channel depth of 8 feet was secured. This channel shoaled to 6 feet, and was again dredged by the *Abbot* October 9, after which it remained open.

One of the most persistent shoals encountered during the entire season was that at Schenimans. This consisted of a reef of coarse sand which moved out readily under the action of dredge No. 1 and the *Abbot* separately and combined, but sand of the same character moved down from the bar above and rapidly re-formed the shoal, so that the improvement of dredging was indeed temporary. Dredge No. 1 worked alone from October 2-10, and in connection with the *Abbot* from the latter date to the 15th, when dredging was suspended and a portable jetty was placed. After this, twelve hours' dredging by the *Abbot* November 2-3 secured the desired channel depth, which continued until the jetty was removed at the end of November. The channel shoaled again and was dredged out by the steamer *Casey* December 12-14.

Goose Island has long been noted as one of the worst shoals between St. Louis and the Ohio River. It presented only a single short shoal this year, across which the *Abbot* dredged a channel October 3, and a jetty 500 feet long placed there October 17-21 and extended to 650 feet in length November 9-11 maintained ample depth and width of channel throughout the season.

Hackers Bend shoaled late in the season, and after placing a temporary jetty there the *Abbot* worked nine hours October 31, and secured the desired depth and width of channel.

This completes the account of actual field work prosecuted during the year for the improvement of this section of the river for temporary relief to navigation.

FORMS OF CONSTRUCTION.

Forms of construction for hurdles and bank protection remain of the same type as has been in use several years, with such changes in detail at each locality as may be required to suit existing conditions. In portable jetties some of the changes were important. The panels rested on stringers attached to the upstream side of piles instead of, as heretofore, on flats supported by the piles. The weight of steel and depth of new panels were increased. The panels of 1895 were 10 by 10 feet corrugated steel, No. 16, riveted to 3 angle bars 16 feet long. The new panels were made of the same width, 10 by 14 feet and 18 feet deep, of No. 14 corrugated steel, riveted to 3 steel I-bars 12.25 and 14.75 pounds per foot. These changes increased the weight from 650 pounds to 1,100 pounds and 1,600 pounds per panel for depths 14 and 18 feet, respectively. A mattress built of fascines was attached to the lower edge of

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each panel before it was sunk in all of the portable jetties except at Turkey Island and at Seventy-Six Landing, where the panels were placed without protection against scour. These were built during the early part of the season and the scour was such as to weaken the jetties and show that protection was necessary.

The cost of the portable jetties was \$4.40 per linear foot, including towage, service of plant, supervision, and all contingent expenses. If the jetties had not been removed their cost would have been \$6.06 per linear foot.

PLANT.

The plant was constructed, repaired, and outfitted as required.

Dredges Nos. 1 and 2 and 800 panels for portable jetties comprise the principal items of construction.

Barges Nos. 102, 103, 105, 108, and 113 were pulled out at the engineer depot and thoroughly repaired.

The steamers *Gen. H. L. Abbot*, *Gen. T. L. Casey*, and *Gen. Gillmore*, steam tenders, barges, quarter boats, pile drivers, derrick boats, small boats, engineer depot, and portable buildings were repaired as required.

RESULTS.

All shoals have been either removed or greatly improved from St. Louis to the foot of Liberty, a distance of about 90 miles, as far as the works have been carried downstream on a project which embraces continuous improvement, and at detached points at which work has been prosecuted in advance of the general project.

SURVEYS, GAUGES AND STAGES OF RIVER.

The survey from Red Rock, Missouri, was prosecuted and was completed with triangulation from the Ohio River to the Grand Chain, thence sketched to Cape Rock, plane table survey from Cape Rock to Moccasin Springs, partly finished survey from Red Rock to Grand Tower, and borings in the west chute at Grand Tower.

Additional gauges were established at Red Rock, Commerce, Thompsons, and Grand Tower.

The stages of water were neither extremely high nor very low. On St. Louis gauge the highest 30.9 feet, and the lowest 3.8 feet.

ACCOMPANYING REPORTS.

I am indebted to the reports of assistants in local charge for much of the information contained in this report, especially statements of quantities of work and other details as follows: Upon works at Sulphur Springs, Rush Tower, and Liberty, to the report of Mr. Gerald Bagnall, assistant engineer; upon works at Ste. Genevieve, Chester, Powers Island, and portable jetties to the report of Mr. William S. Mitchell, assistant engineer; upon procuring brush and stone by hired labor, to the report of Mr. E. D. Libby, assistant engineer; upon surveys and gauges, to the report of Mr. John O. Holman, assistant engineer; and upon construction and repairs of plant by hired labor, and other operations at the engineer depot, to the report of Mr. C. D. Lamb, superintendent.

PLATES.

For further information, this report refers to plates numbered I, II, III, IV, and V, showing location and extent of works for the improvement; No. VI showing portable jetty or dike used in improving low-water navigation, and No. XII showing surveys from Red Rock, Missouri, to the Ohio River.

Very respectfully, your obedient servant,

D. M. CURRIE, *Assistant Engineer.*

Maj. THOS. H. HANDBURY,
Corps of Engineers, U. S. A.

REPORT OF MR. W. S. MITCHELL, ASSISTANT ENGINEER, ON WORKS AT MICHAEL, STE. GENEVIEVE REACH, CHESTER, ILL., POWER ISLAND, AND ON PORTABLE JETTIES.

ST. LOUIS, MO., June 30, 1897.

MAJOR: I have the honor to submit the following report of operations for the permanent improvement of the Mississippi River near Ste. Genevieve, Chester, and Commerce and for the temporary correction of the low-water channel by means of portable jetties for the fiscal year ending June 30, 1897.

For the amounts of work done and expenditures in materials and labor reference is made to the accompanying tables.

The locations of the various works are shown on the charts on file, and their description will be given in their order downstream.

MICHAEL LANDING.

Hurdle No. 1.—In May, 1896, this hurdle was broken through by two coal barges which had been set adrift at St. Louis by the tornado of that month, and although the break was small, yet, owing to unfavorable stages of river during the remainder of the year, it could not be reached for repairs. The high water of the winter and the flood of the spring poured through the gap, widening and deepening it greatly. On the resumption of work in June on account of the depths found it was decided not to attempt to restore the piling in the gap at present, but to strengthen the remainder of the line and to build hurdle No. 2 in the deposit which had been gained below No. 1. The piling was strengthened by additional timber, by recabbling, by resetting and bolting braces, and the revetment at the outer end of the line on Osborne Towhead was repaired and raised to the top of the bank.

Hurdle No. 2.—This line was begun June 11 and at the close of the year was nearly completed. It is 2,800 feet in length and will be finished in July. It is of the ordinary type, with a foundation mattress widened to 125 feet on account of the soft deposit in which it is built. The piling is in two rows of three pile clumps spaced 6 feet apart, a third row being added in the deeper water through which the line passes.

STE. GENEVIEVE, ILL.

Hurdle No. 15.—The extension of this line to the Illinois bank was in progress at the beginning of the fiscal year and was completed July 9.

STE. GENEVIEVE, MO.

Hurdles Nos. 6, 8, and 10.—In July slight additions were made to the stone revetments of Nos. 6 and 10, raising that of the former to the 16-foot contour and that of the latter to the 20-foot contour. The entire stone revetment at the shore end of No. 8 was laid.

Hurdle No. 12.—This line was almost finished at the beginning of the year. It was completed July 22, the work done consisting of sinking drift along the outer end of the piling, finishing the curtaining and placing the shore revetment. An ice buttress was built at the junction of the line with the channel limit, and the piling was extended 100 feet beyond that point across the T-head mattress.

Hurdle No. 14.—Work on this hurdle was continued until August 26, when it was completed, with the exception of curtains, which could not be placed because of the accumulation of drift above the entire length of the piling. A portion of this drift was sunk along the outer half of the line. In the deepest water a second sinking was made and the piling there was also braced from the lower side. An ice buttress similar to that on No. 12, and similarly placed, was built, and the piling was also extended across the T-head mattress as in the former line.

Hurdle No. 16.—This hurdle was also in process of construction at the beginning of the year, and at the end of August was completed. It was curtained for its full length, the drift along its outer portion was sunk, and a buttress was built at its river end.

Stanton towhead.—A protection mattress was begun in the latter part of July at the upper end of the towhead, but only 300 linear feet were fabricated and sunk when the part was moved to Power Island for work of greater urgency.

CHESTER, ILL.

Bank protection.—The protection of the Missouri bank opposite Chester was begun September 8, and work was completed for the season October 27. The mattress was of the ordinary type, 125 feet wide, and extends downstream 3,310 feet from the end of the old railroad incline, past the water front of the town of Clearyville to the fields below. Above the mattress no grading was attempted, the stone revetment being carried on the natural slope of the bank to the following heights:

For 900 feet below the incline to the 9-foot contour.

For 1,300 feet below the incline to the 13-foot contour.

For 1,100 feet below the incline to the 8-foot contour.

The mean elevation is about 10 feet, all referred to the St. Louis gauge.

About 2,500 cubic yards of stone will be required to complete the revetment to the 20-foot contour. This will be done during the coming season, as the spring high water has graded the upper part of the bank to the desired slope. The completion of this work will exhaust the appropriation under which it was begun.

POWER ISLAND.

A permeable dam to close Doolan Slough, the chute between Power Island and the Missouri shore below Commerce, was built, July 9 to September 9, with the force from Ste. Genevieve, which was transferred to the dam as rapidly as it was released from the former work.

For many years, at low-water stages, this chute has diverted a very considerable portion of the river volume which otherwise would have gone to the improvement

of the shoals at "Jacket Pattern" and "Goose Island," both of which have been serious obstacles to navigation.

The dam was located nearly 2 miles below the head of Power Island and 4 miles below Commerce, Mo., across a narrow part of the chute, which was there about 1,600 feet in width, and where the banks were firm and the cross section regular. At a stage of 13 feet, St. Louis gauge, the mean depth was 20 feet and the maximum depth 27 feet near the Missouri shore. The type of construction was that of the ordinary pile hurdle, with the material for three hurdles massed in one.

The piling was driven in three rows, 4 feet apart, of clumps, spaced 6 feet centers of 3 and 4 sticks each, according to depth of water. The clumps in each row were staggered with those in the adjacent rows. The rear row was braced in the usual manner, and although no stringers were bolted on, yet between the adjacent rows short cotton wood stringers were laid so that strain in the upper row would be quickly distributed through all. The tops of the piles were left at the level of the tops of the adjacent banks, an elevation corresponding to a 30-foot stage. After the first two rows of clumps were driven the piling was so crowded that it was found necessary to discontinue the use of the water-jet as it loosened piles already driven and induced scour. The remaining piles were driven with the hammer alone. The average penetration for all piles was 18½ feet.

The foundation for the dam was an ordinary continuous woven mattress widened to 150 feet, two-thirds of the width lying below the piling. On top of this mattress another 50 feet wide, and in the deep water third and fourth tier mattresses 25 feet wide, were laid just below the main rows of piling to reinforce them to build up the bottom to an even cross section and to receive the overfall from the dam. The brace pile clumps were driven through these auxiliary mats.

Unfortunately the brush obtained was very large, necessitating the use of unusual quantities both of it and of stone wherewith to sink it. As such still brush does not quickly conform to irregularities of bottom nor follow down in case of scour until the latter has assumed dangerous proportions, a very large excess of stone was used as ballast.

During construction a large body of drift accumulated above half the length of the hurdle next the island. This was sunk, and along the other half of the line, to bring all to a common crest, cribbed brush mattresses were built and sunk. A fourth row (600 feet long) of four-pile clumps were driven through these cribbed mattresses in the deep water next the Missouri shore, and the entire front of the dam was curtailed to the level of a 10-foot stage.

The bank at each end of the dam was protected by a mattress 600 feet long by 125 feet and 150 feet wide on the east and west sides, respectively, and extending 250 feet above and 350 feet below the structure. From their tops to the edges of these mattresses the banks were graded by water jets to a slope 2:1, and on this slope a stone revetment was laid in two courses, the first, 9 inches thick, of spalls extending from the lower ends of the mats to 50 feet above the piling, and over this dressing a heavy course of stone was laid, covering the entire graded bank.

A small spur dike of stone was built on each bank, with crest sloping from the top of the revetment to the piling at the 20-foot level, and on that slope 100 feet into the line forming shore connections for the dam.

The greatest head of water observed on the dam during construction was 22 inches, September 8 (St. Louis gauge, 6.4 feet).

At the close of the season water still poured through the structure, although its beneficial effect was manifest during the low-water season in increased navigable depths over the neighboring shoals at Jacket Pattern and Goose Island.

On September 30 a slight settling was reported in the west spur dike and revetment back of the mattress. They were restored and strengthened by the addition of three bargeloads of stone in the early part of October.

During the winter the river rose to an extraordinary height for that season, 24.8 feet (January 7), and after its subsidence both revetments sank about 5 feet just above the spur dikes, the west revetment January 15 and the east revetment January 29. Both were repaired, January 18 and 19 and February 4-6, respectively, with a force hired at Commerce and with stone taken from the tops of the revetments, narrowing them about 8 feet.

In April the spring rise reached 28½ feet and overflowed Power Island and the Missouri bank, flowing around the ends of the dam in streams about 200 feet in width and with considerable velocity, but no serious damage was done.

Large fields of drift were caught above the piling, which will be sunk at the first opportunity.

PORTABLE JETTIES.

In the early part of September the river reached a 6-foot stage, St. Louis gauge, and a number of bars threatened to become serious obstructions to navigation.

To correct the channel temporarily at Turkey Island, Stanton's, Seventy-six Landing, Schenimans, Goose Island, and Hacker Island, jetties were built similar to that used at Danby Landing in 1895. Only one jetty was required at each of

these places, with the exception of Stanton's, where there were two, one on either side of the channel.

Work was begun at Turkey Island September 12, and, although interrupted by a sharp rise of 5 feet September 15 to 29, was completed at Goose Island November 11. The aggregate length of the jetties was 6,560 feet for seven lines, varying from 1,350 feet to 460 feet, and they remained in place from two months, as at Turkey Island, to fifteen days, as at Hacker's, their average duration being thirty-four days.

On the approach of winter the jetties were removed November 16 to December 5, the recovered panels and piling being stored for future use.

By the action of the jetties the channel was deepened at each of the bars named from 1 to 3 feet. At Stanton's, where the bar has been persistent for the past two years, 1 foot was gained, and the same was had at Hacker's, where the jetty was in place but a short time and where the river has very great width. At Schenimans 3 feet additional depth was obtained, slowly at first, but rapidly after a cut had once been established through the crest of the sand wave which seemed to have lodged at that place. The erosion at the other points lay between these limits, and the average was about 2 feet; nor at the close of the season was there left less than 7½ feet navigable water on any of these bars.

The corrugated steel panels used in 1895 were so successful that 8,000 linear feet more, slightly altered in design, were made and used last fall in the jetties named. The new panels are of the same length as the old, 10 feet, but are increased in width to 14 and 18 feet, and are made on I-beams instead of angle bars, which have proved weak. The corrugated metal was extended to within 1 foot of the ends of the beams and washers were used over the sheets with all rivets, greatly increasing the strength of the structure. These changes increased the weights of the panels from 1,000 to 1,200 and 1,600 pounds, in the two new sizes made, but they are still light enough to be easily handled.

The old panels were also used during the season, the angle bars having been reinforced by 3 by 6 inch oak beams.

To support the panels the use of flats, as in 1895, was discontinued as adding needless incumbrance to the plant. Instead, piles were driven in line at 5 to 20 foot intervals, according to depth of water and strength of current, and were connected by stringers lashed to them with light wire cables. Where deep scour occurred, and in repairs to lines where broken, the piles were driven in clumps of 2 or 3 sticks, as needed, but in general single sticks were used, driven as deep as possible, the penetration averaging 20 feet. At first the stringers were placed just above the water, but slight rises in the river so interfered with work that they were afterwards allowed to clear the surface by 12 to 18 inches.

The panels were attached directly to the stringers with lashings of three-fourths-inch rope, the tops of the beams resting on the stringers and their lower ends on the river bottom above the line of the piling, the slope of the panel depending on the depth of water in which placed. In shoal water the old small panels were used and the new larger sizes in greater depths, the selection of the proper panels from the barges occasioning slight delay, which in future may be avoided by having all panels of the maximum size required. In shoal water this will give them a very flat slope, but it is not a disadvantage.

The first jetties placed this year at Turkey Island and Seventy-six Landing were built without protection to the river bottom, and such scour occurred in the deep water as to break the lines in several places. Some scour had been anticipated, and to prevent the panels as they worked back from swinging through under the stringers, a lower stringer of very heavy poles was placed against the upper side of the piling, about 3 feet from the bottom. This arrested the panels in a vertical position and immediately directed such a stream of water against the bottom at the base of the piling that it was quickly scoured so deeply as to weaken the latter, and the line gave way. After this experience the use of the secondary stringer was abandoned, the panels were allowed to swing through, and, being partly lifted by the current, did much less damage and were afterwards reset. On all the other jetties the bottom was protected by mattresses 3 to 6 by 10 feet, made of brush fascines, one mattress loaded with stone being attached to each panel before it was placed. They were very efficient and in the three lower jetties, Schenimans, Goose Island, and Hacker's, no break occurred. At Stanton's, however, both lines were broken and the west jetty was repaired by placing a mattress 140 by 16 feet of fascines across the break in 18 feet of water and resting the ends of the panels upon it. The fascines were made of young willows bound with hide rope in 6-inch bundles, the brush being cut on the bars near each work.

Some delay in the rate of construction is made in attaching the mattresses to the panels, but immunity from scour is so essential as to overbalance it. To sink light woven mats in long lengths previous to placing the panels, somewhat as in the repairs to the Stanton west jetty referred to, is probably quicker, but will involve a slightly increased plant (way flats, etc.) and force, both of which are undesirable. The plant used with each party (there were two parties in the field, one working from Turkey Island to Schenimans, the other to Goose Island and Hacker's) was a

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full tow for any of the towboats, and as it was constantly moving from place to place it was essential to keep it below this limit. Plant for one party consisted of 3 pile drivers, 1 derrick boat, 6 decked flats, 1 steam tender, 1 barge of pile timber, 1 barge of panels, 1 fuel barge, 1 large quarter boat, and a crew of about 55 men. The rate of construction for each party was about 150 feet of jetty per day. At the close of the season the rate of removal was 50 per cent greater.

Three lines—Turkey Island, Stanton east jetty, and Seventy-six Landing (the first and last without mattresses)—were all started from the east bank of the river and projected across channels deeper than 10 feet leading into side chutes part of whose waters they were intended to divert into the steamer channel. In each instance the jetty was broken for 100 to 200 feet in the deep water, and although clumps of piles at short intervals succeeded in holding a repaired line in 18 feet depth at Stanton west jetty, yet this seemed to indicate that the limiting pressure for the light structure used was reached in about 10 feet of water and that to sustain the pressures due to greater depths the structure must become much heavier and more expensive. The lower jetties (Schenimans, Goose Island, and Hacker's), were all unbroken. They were protected at bottom by facine mats and were located on bars in mid-river, in depths from 3½ to 10 feet, and served to bring the crests of these bars to the water surface. Their effect was quite as marked as that of the jetties connected with the shore.

The head of water observed in the jetties did not exceed 6 inches, but the currents along their lengths and around their lower ends, next the shoals, were very strong. In each instance the line was given an inclination to direct this flow toward the shoal, but the pour was so close around the end of the jetty that its effect was to give width to the channel rather than to deepen it at a distance from the piling, the latter being accomplished by the damming action of the structure.

In removing the jetties 75 per cent of the piling and 93 per cent of the panels were re-covered, and 10 per cent of the latter will require repairs.

But few changes are suggested for the plant. The derricks should be set on the newer pattern drivers, as their hoists are quicker and stronger and have one more winch head than those on the old drivers. The derrick booms should be 45 feet in length, which is 5 to 10 feet longer than those in service last season. The running gear should consist of two whip lines, instead of one whip, and a double boom fall, all to be of 1½ inch manila rope, which will insure quick and safe working.

For drawing out piling at the close of the season the blocks used were much too light. Strains were noted as high as 15 tons on one driver, and 22 tons on two drivers, with water jets going in each case before the pile could be started. In order to do quickly such heavy, rough work, extra strong double and treble blocks for 5-inch lines should be provided.

Table of work done during the fiscal year ending June 30, 1897.

	Michael landing.		Ste. Gene-	Ste. Genevieve, Mo.			
	Hurdle No. 1.	Hurdle No. 2.	vieve, Ill. Hurdle No. 15.	Hurdle No. 8.	Hurdle No. 12.	Hurdle No. 14.	Hurdle No. 15.
Lengths of work projected.....feet..	2,900	2,800	1,300	1,200	2,450	3,000	3,000
Equivalent lengths built.....do....	(a)	2,000	150	(a)	(a)	1,000	600
Piles driven.....number..	198	1,670	151			1,028	419
Piles driven, penetration.....feet..	3,383	33,423	2,398			17,458	7,045
Piles re-covered.....number..							
Braces placed.....do.....	3					45	
Stringers placed.....do.....							
Foundation mattress fabricated and sunk.....linear feet.....		2,414				705	
Foundation mattress fabricated and sunk.....square feet.....		306,863				81,600	
Drift mattress fabricated and sunk, linear feet.....					650	1,265	860
Drift mattress fabricated and sunk, square feet.....					10,200	47,050	24,250
Bank-protection mattress fabricated and sunk.....linear feet.....							
Bank-protection mattress fabricated and sunk.....square feet.....							
Curtains placed.....linear feet..			230		270		1,800
Do.....square feet.....			2,625		4,590		28,600
Stone revetment placed.....linear feet..	506			175	275		
Do.....square feet.....	26,020			5,250	8,250		
Grading.....linear feet.....							
Do.....cubic yards.....							
Buttresses built.....number.....					1	1	1
Panel placed.....do.....							
Panel re-covered.....do.....							

a Repairs.

APPENDIX W—REPORT OF MAJOR HANDBURY. 2037

Table of work done during the fiscal year ending June 30, 1897—Continued.

	Sta. Genevieve, Mo., bank protection.	Chester, Ill., bank protection.	Powers Island, Mo., hurdle.	Portable jetties.	Total.
Lengths of work projected.....feet.....		6,000	1,600	6,600	
Equivalent lengths built.....do.....	295	8,310	1,600	6,560	
Piles driven.....number.....			3,525	835	7,823
Piles driven, penetration.....feet.....			65,353	16,800	145,865
Piles re-covered.....number.....				592	592
Braces placed.....do.....			413		461
Stringers placed.....do.....				209	209
Foundation mattress fabricated and sunk.....linear feet.....			2,510		5,631
Foundation mattress fabricated and sunk.....square feet.....			371,175		750,638
Drift mattress fabricated and sunk, linear feet.....			4,421		7,196
Drift mattress fabricated and sunk, square feet.....			117,525		208,025
Bank-protection mattress fabricated and sunk.....linear feet.....	295	3,310			3,605
Bank-protection mattress fabricated and sunk.....square feet.....	24,970	413,750			438,720
Curtains placed.....linear feet.....			1,450		3,750
Do.....square feet.....			7,180		42,995
Stone revetment placed.....linear feet.....	250	3,310	1,160		5,676
Do.....square feet.....	7,500	75,560	49,850		172,430
Grading.....linear feet.....			1,383		1,383
Do.....cubic yards.....			4,870		4,870
Buttresses built.....number.....					8
Panels placed.....do.....				670	670
Panels re-covered.....do.....				621	621

Table of jetties, fiscal year ending June 30, 1897.

Location.	Lengths.	Dates of—		Channel depths when—		Gain in channel depth.		
		Placing.	Removal.	Placed.	Re-moved.	Total induration of jetty.	Due to oscillation on local gauge.	Due to jetty.
Turkey Island.....	<i>Feet.</i> 1,150	Sept. 12-15	Nov. 16-20	<i>Feet.</i> 6½	<i>Feet.</i> 10	<i>Feet.</i> 3½	<i>Feet.</i> ½	<i>Feet.</i> 2½
Stanton's East.....	1,000	Oct. 23-30	Dec. 2-5	5½	7½	2	1	1
Stanton's West.....	460	Nov. 4-9	{Nov. 28} {Dec. 3}	5½	7½	2	1	1
Seventy-six Land- ing.....	750	Oct. 1-8	Nov. 23-25	8	9½	1½	½	2
Shenimans.....	1,000	Oct. 14-20	Nov. 27-30	5	8	3	¾	3
Goose Island.....	850	{Oct. 17-21} {Nov. 9-11}	Nov. 23-25	6	8	2	½	1½
Hacker Island.....	1,350	{Oct. 26-31} {Nov. 2-6}	Nov. 17-21	6	8½	2½	1½	1
Total.....	6,500							

Location.	Local gauge at time of—		St. Louis gauge at time of—		Depths in which jetty was placed.
	Placing.	Removal.	Placing.	Removal.	
Turkey Island.....	b142.75	b143.50	171.70	172.00	<i>Feet.</i> 4-15
Stanton's East.....	b141.80	b142.85	171.01	171.70	3-12
Stanton's West.....	b141.80	b142.85	171.01	171.70	2-8
Seventy-six Landing.....	c115.35	c114.75	172.85	172.55	4-12
Shenimans.....	d7.5	d7.7	172.25	172.10	3-6½
Goose Island.....	e94.00	e94.30	172.10	172.55	6-9
Hacker Island.....	e93.15	e94.50	170.80	172.90	4½-9½

a Channel depths taken from steamer leadline soundings.
 b Little Rock.
 c Grand Tower.
 d Cape Girardeau.
 e Commerce.

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Table of material expended, fiscal year 1896-97.

	Michael Land- ing, Mo., hurdle.	Ste. Gene- vieve, Ill., hurdle.	Ste. Genevieve, Mo.		Chester, Mo., bank protection.	Powers Island, Mo., hurdles.	Port- able jetties.	Total.
			Hurdle.	Bank protection.				
Subsistence, rations.....number..	5,277	564	8,560	623	5,202	19,779	6,877	46,882
Brush.....cords..	1,815.3	150	2,549.8	296.8	4,484.5	6,093.2	.....	15,359.6
Piles.....number..	1,868	104	1,350	.....	.....	3,875	243	7,440
Do.....feet..	77,701	4,640	58,855	.....	.....	165,011	13,096	319,303
Stone.....cubic yards..	3,424.9	442.7	7,093.1	543.6	6,886.2	15,519.3	120	34,029.7
Rope.....pounds..	1,500	700	3,148	.....	2,450	6,200	10,000	23,998
Wire.....do..	4,706	985	12,396	550	9,700	27,505	7,800	63,642
Iron and steel.....do..	81	.....	275	.....	.....	381	30	767
Nails.....do..	1,740	.....	.....	.....	.....	86	.....	1,826
Spikes.....do..	4,510	555	4,050	170	4,550	11,352	600	25,787
Screw bolts.....number..	.....	.....	55	.....	.....	720	.....	775
Do.....pounds..	.....	.....	330	.....	.....	4,664	.....	4,994
Clevises.....number..	.....	.....	44	.....	.....	356	.....	400
Lumber.....feet..	300	.....	336	.....	500	1,200	1,106	3,442
Coal.....bushels..	5,431	300	6,695	80	1,356	15,018	13,566	42,394
Coal, blacksmith's.....pounds..	200	.....	25	.....	.....	575	.....	800
Ice.....do..	84,000	10,000	155,000	10,000	56,000	290,050	65,620	670,670
Miscellaneous material.....	\$38.46	\$5.00	\$145.17	.....	\$30.00	\$384.30	\$300.56	\$953.49

Very respectfully, your obedient servant,

WM. S. MITCHELL,
Assistant Engineer.

Maj. THOS. H. HANDBURY,
Corps of Engineers, U. S. A.

REPORT OF MR. JOHN O. HOLMAN, ASSISTANT ENGINEER, ON SURVEY AND GAUGES.

ST. LOUIS, Mo., June 30, 1897.

MAJOR: I have the honor to submit the following report of the survey between Red Rock and Cairo, and in connection therewith a report on gauges, test borings at Grand Tower, and low-water discharge measurements at St. Louis.

The survey consisted of triangulation, topography, and hydrography. The triangulation was carried only from Thebes to Cairo. Most of the stations were situated on the main banks of the river, and where likely to remain permanent for several years were marked by a gas-pipe hub 1½ inches in diameter, covered by a cast-iron cap lettered U. S. The permanent stations on the rock shore between Commerce and Thebes were marked by a triangle cut in the stone with hole drilled in center. The main chain of the triangulation between Thebes and Cairo is composed of 90 stations connected by 10 single triangles and 44 quadrilaterals. Thirty-three of these stations are permanent. Eight more permanent stations back from the river bank are located by auxiliary triangles, and 8 objects, such as spires, chimneys, and flagstaves, are located by intersections.

The instrument used was a Buff & Berger transit theodolite, 7-inch horizontal limb, with verniers reading to ten seconds. Angles were measured in order around the station, right to left direct and left to right reversed. Two sets on different parts of the limb were taken at each station, which gave 4 pointings and 8 readings on each target. In nearly all the sights the pole of the target could be bisected at its foot, doing away largely with errors in phase and plumbing of the target. The desired limit of the closure of the triangle was ten seconds, but extra sets had to be taken at several stations to obtain this result, as the work was carried on under nearly all conditions of weather.

The work depends on the secondary triangulation of the Mississippi River Commission. (Report Chief of Engineers, 1884.) The length and azimuth of the Dickey-Rouse line, in their fifth triangle above Cairo, and the geodetic coordinates of its extremities were used in the office reduction of the triangulation from Cairo to the connection with the Commerce-Hafner line in their sixteenth triangle above Cairo. The latter line was used as the base in computing the Commerce-Thebes stretch. Single triangles were adjusted to closure by giving equal weight to each angle, and the quadrilaterals were adjusted by the method given in Johnson's Surveying, pages

494-500. The discrepancies on the Commerce-Hafner line, as computed from the Dickey-Rouse base, are as follows:

Distance, plus.....	meters..	0 .04
Azimuth, plus.....		14'' .15
Latitude, plus.....		0'' .00
Longitude, minus.....		0'' .05

The topography was delineated by the plane table. The field work began at Commerce, and the field reduction of the triangulation between that point and Cairo and also between Commerce and Thebes was used in the projection of the plane table charts. The topography included the bar and shore lines and the general features within 200 to 500 feet of the bank on the main shore and large islands. The bluff contours and general topography not included by the survey was copied from the maps published by the Mississippi River Commission. Owing to the near approach of the winter season, the survey above Thebes was not as complete as below that point, except in the reaches between Cape Rock and Moccasin Springs and between Red Rock and Seventy-Six Landing. The survey above Thebes was based on the coordinates of precise bench marks, stone line benches, and flag stations published by the Mississippi River Commission.

The soundings on each map or plane-table chart were reduced to the average of the stages on the nearest gauge for the days on which the sounding was done. The soundings were taken in the low-water channel and in cross-section lines spaced about 1,000 feet apart; they were located by two transits set up at triangulation stations or at flag stations used in the plane-table work.

GAUGES.

There are 20 gauges now in service on the Mississippi River between the Ohio and Missouri rivers, of which 13 were maintained during the entire fiscal year. They are given below in their order downstream:

Location of gauge.	Miles from Eads Bridge.		Maintained by—
	High stage.	Low stage.	
Chain of Rocks, Missouri.....	9.7	10.2	St. Louis Water Department.
Bissells Point, Missouri.....	3.3	3.3	Do.
Eads Bridge.			
St. Louis, Mo.....	0.4	0.4	Engineer Department, Vicksburg.
Supply Depot, Missouri.....	3.1	3.1	Engineer Department, St. Louis.
Jefferson Barracks, Mo.....	10.7	10.8	Do.
Waters Point, Missouri.....	21.3	21.8	Do.
Cornice Rock, Missouri.....	31.2	32.1	Do.
Brickeys Mill, Missouri.....	43.8	45.4	Do.
Little Rock, Mo.....	53.8	56.2	Do.
East Kaskaskia, Ill.....	62.7	66.1	Do.
Chester, Ill.....	69.5	73.0	Weather Bureau.
Bishops, Mo.....	78.1	82.1	Engineer Department, St. Louis.
Devils Backbone, Missouri.....	84.7	89.4	Do.
Grand Tower, Ill.....	98.6	103.4	Do.
Moccasin Springs, Mo.....	112.0	117.2	Do.
Cape Girardeau, Mo.....	125.3	131.1	Mississippi River Commission.
Grays Point, Mo. (Engineer).....	130.6	136.6	Engineer Department, St. Louis.
Grays Point, Mo. (Commission).....	131.8	137.8	Mississippi River Commission.
Commerce, Mo.....	138.6	144.6	Engineer Department, St. Louis.
Thompsons, Mo.....	156.7	163.8	Do.

The gauges at Thompsons, Commerce, Moccasin Springs, and Grand Tower were established during the present fiscal year. The latter gauge has been maintained several years by the employees of the Grand Tower Coal Company, but without level connection. The gauge at Devils Backbone was not fully established and is not included in the table of slopes given later. The Engineer gauge at Grays Point was abandoned in favor of the Mississippi River Commission gauge at the same locality, which had previously been abandoned by the Commission shortly after the establishment of the gauge at Cape Girardeau.

The survey of 1889 above Eads Bridge, the low-water plane-table survey of 1895 between that point and Bishops and the surveys of 1896 below the latter point were used in obtaining the gauge distances. The low-water distance was measured on the line of the low-water channel except at Grand Tower Island where the channel in the main river was used instead of the steamboat channel which passes back of

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the island during low stages. The high-water distance was measured on a line midway between the main banks in which the limit line of the contraction works, either constructed or projected, was used as the main bank of the river. The midway bank distance is 4.4 miles less between Eads Bridge and Cairo Point than given in previous tables, the difference arising partly from changes at Fish Bend and the head of Kaskaskia Cut-off and partly from the straightening of the channel due to the works of improvement.

Table of slopes between gauges at low and high stages during the fiscal year 1897.

	Slope in feet per mile. Stage on the St. Louis gauge.				Gauge oscillation from Nov. 1 to May 2.
	4.4.	24.8.	23.8.	30.9.	
	Nov. 1.	Jan. 7.	Mar. 28.	May 2.	
From Chain of Rocks					23.05
To Bissells Point.....	1.22	0.58	0.64	0.45	28.55
Thence to St. Louis.....	.18	.87	.45	.73	26.50
Supply Depot.....	.15	.24	.31	.65	25.15
Jefferson Barracks.....	.88	.46	.54	.66	23
Waters Point.....	.48	.53	.52	.56	22.80
Cornice Rock.....	.76	.58	.60	.57	24.50
Brickeys Mill.....	.52	.69	.60	.60	23.80
Little Rock.....	.54	.74	.70	.80	21.65
East Kaskaskia.....	.99	.63	.66	.53	26.65
Chester.....	.34	.78	.73	.75	23.90
Bishops.....	.46	.45	.45	.48	23.95
Grand Tower.....	.57	.60	.58	.64	23.10
Moccasin Springs.....	.58	.61	.56	.64	22.55
Cape Girardeau.....	.59	.54	.42	.51	23.80
Grays Point (Com).....	.37	.67	.47	.60	22.50
Commerce.....	.22	.71	.34	.66	19.50
Thompsons.....	.77	.67	.18	.59	23.60
Cairo Point.....	.73	.64	.12	.45	.....

The slope between the gauges at Cairo and Belmont on the dates given in the above table was accepted as the slope in the Ohio River below Cairo. The elevation of the water surface at Cairo Point found by this method was used in obtaining the slope below the gauge at Thompsons.

The second column is the slope at the crest of a quick rise when the slope below Commerce was not influenced by a high stage in the Ohio River. The third column is the slope at the crest of a wave which reached the mouth of the Ohio two days after the crest of the flood in that river, and shows the extent of the back water in the Mississippi. The fourth column is the slope at the highest stage on the St. Louis gauge in 1897 and after the subsidence of the flood in the Ohio. The last column is the oscillation at each gauge between the low reading of November 1 and the high of May 2.

The first column is the low-water slope at the stationary period which prevailed November 1, the lowest stage on the St. Louis gauge during the fall season. The large slope above Bissells Point and the small slope below remains about the same as in previous years. The greatest change is between Little Rock and East Kaskaskia, where the slope has been increased by the shortening of the low-water channel, the fall of 10 feet between these gauges remaining the same during the years 1893 to 1896. The low-water slope between Thompsons and Cairo Point varied from 0.91 when both rivers were low to 0.11 when the Ohio was high.

The low-water plane of the river immediately below St. Louis, which has been changing since the establishment of the gauges in 1891, continues this year with a decided change. The readings of 4.4, 3.4, 5.4, and 1.9 on the gauges at St. Louis, Jefferson Barracks, Waters Point, and Cornice Rock on November 1 of this fiscal year have been reduced by 1.4 feet in the following table:

Low-water gauge readings 1891 to 1896.

	1891.	1892.	1893.	1894.	1895.	1896.
St. Louis.....	4	3.72	3.13	2.50	2.30	3
Jefferson Barracks.....	4.03	3.65	2.73	1.50	1.05	2
Waters Point.....	4	4	4	4	4	4
Cornice Rock.....	4.15	3.77	2.43	1.90	1.05	.50

TEST BORINGS AT GRAND TOWER.

The borings at the head of Grand Tower Island were taken to ascertain the character of the river bed and the low-water channel depth which could be secured over the rock bottom by dredging the main channel of the river.

The borings were made with the jet pipe of a pile driver. The weight of the pipe, aided by the jet of water passing through it, easily penetrated most of the material encountered down to large bowlders or to solid rock. The depths at which the different strata of sand, gravel, gravel mixed with bowlders, and solid rock were encountered were noted by the "feel" of the jet pipe, i. e., the resistance and the sounds noticed by those handling the pipe.

The borings, 300 in number, were scattered irregularly over the rock ledge which extends across the river from the "bullheads," opposite Grand Tower, diagonally downstream to the head of the island. The borings developed a channel over the low part of this ledge not quite 300 feet in width and 10 feet in depth below the zero of the Grand Tower gauge, which could be secured by dredging material composed mostly of sand and gravel, with occasional beds of bowlders and hardpan, to an average depth of 9 feet. At low stages of the river the Grand Tower gauge registers 0.5 feet more than the St. Louis gauge.

DISCHARGE MEASUREMENTS.

The discharge measurements were taken near Sydney street, St. Louis, December 16 and 17, 1896. Previous measurements by this office give the following comparisons:

Discharge measurements in the vicinity of St. Louis.

Date.	Method.	Stage.	Width.	Area.	Velocity per second.	Discharged.
		<i>Feet.</i>	<i>Feet.</i>	<i>Sq. ft.</i>	<i>Feet.</i>	<i>Cu. ft.</i>
Dec. 14, 1896	Double floats.....	5.4	1,920	29,940	1.71	51,240
Oct. 25, 1895	.....do	2.7	1,855	22,040	2.20	48,000
Dec. 16, 1896	Rod floats	5.5	2,069	27,680	2.41	66,600
Dec. 17, 1896	.....do	6	2,063	29,810	2.40	71,500

Field operations covered a period of three months from September 1. The office force consisted of the assistant engineer in charge, 3 transitmen, and 3 rodmen, with a total of 31 in the party. This number was increased to 42 while taking the borings at Grand Tower during the month of November.

Very respectfully, your obedient servant,

JOHN O. HOLMAN, *Assistant Engineer.*

Maj. THOS. H. HANDBURY,
Corps of Engineers, U. S. A.

REPORT OF MR. E. D. LIBBY, ASSISTANT ENGINEER, ON PROCURING BRUSH AND STONE FOR WORKS OF IMPROVEMENT.

STE. GENEVIEVE, MO., *June 30, 1897.*

MAJOR: I have the honor to submit the following report of operations at procuring brush and stone during the fiscal year ending June 30, 1897:

PROCURING BRUSH.

At the beginning of the fiscal year two brush forces were in the field. Of these, brush force No. 1 was working at Eliza Towhead, and remained in that locality until September 14, when, in order to bring the party nearer the works of construction, it was moved to Liberty Island, where operations were carried on until instructions to disband the party were received. Active field work closed on October 16, and on October 21 the outfit, with the exception of derrick boat No. 1, was towed to winter harbor.

Derrick boat No. 1 was taken to the engineer depot for repairs.

Operations at procuring brush for the spring season were not commenced until June. Brush force No. 1 was reorganized on June 1, and on June 3 was taken to Turkey Island, where the procuring of brush was carried on until June 15. The ground being too soft for further work at this locality, the party was moved to the

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head of Fish Bend on June 15, where operations were carried on during the remainder of the fiscal year. Brush force No. 1 procured during the year 17,352.9 cords of brush. That which was obtained at Eliza Towhead was larger than has been used heretofore, and while no difficulty was experienced in handling it at the derrick boat, the work in the woods was very heavy, and this, in combination with the hot weather, caused no little trouble in maintaining a good working force of laborers.

The brush procured at Liberty Island was mostly of good size and quality for mattress building.

Brush force No. 2, at the opening of the fiscal year, was procuring brush at Fairy Island. From this locality it was moved, on July 14, to Moro Island, and on July 18 to Wilkinsons Island, where work was carried on until August 10. On August 11 the party was moved to Jones Point, where it remained until September 10, when the force was disbanded and the outfit was taken to Liberty Island, and from that place was taken to winter harbor with the outfit of brush force No. 1. This party procured 9,546.1 cords of brush.

With the exception of hot weather, the fall season and also the stage of the river that prevailed during the fall season were very favorable for obtaining brush at those localities where work was carried on. Heavy rains or any considerable rise of the river would have interfered seriously with the operations of brush force No. 1 at Eliza Towhead and Liberty Island, and of No. 2 at Jones Point.

On account of the high stage of the river during the early spring most of the land on which suitable brush is to be found was overflowed, and the ground was still very soft when operations began in June, but localities were found at which brush could be obtained in sufficient quantity to supply the works of construction.

During the fiscal year 26,899 cords of brush were procured.

PROCURING STONE.

During the months of July and August and until September 8 work at Little Rock Quarry was carried on with a force of about 140 men of all grades.

On September 8 instructions were received to disband the force. This was done as soon as the plant and tools had been properly taken care of.

The only work done during the winter and until June was to watch and care for the engineer property at the quarry.

On June 1 a small force was organized, and work was resumed and carried on during the remainder of the fiscal year.

Operations were confined throughout the year entirely to the lower quarry, the demand for stone not being sufficient to require an extension of the work to the upper quarry.

In the operations of quarrying during the fall season three steam drills were employed and were in constant service, steam for running them being supplied from the stationary boiler, from a pile-driver boiler, or from a portable boiler, as circumstances made most convenient.

Hand drilling was employed for block holing, and in locations not easily accessible with a steam drill.

During the fall season a very large part of the excavating was done by a water jet from a pile-driver pump. This method of removing the earth from the top of the ledge was found to be much more economical than by the use of shovel and pick.

With the small force employed in June only one steam drill was in service, and the pump used for excavating was not employed.

The loading of stone on barges was done entirely by steam derrick.

During the fiscal year there were procured 28,188.8 cubic yards of stone.

Very respectfully, your obedient servant,

E. D. LIBBY, *Assistant Engineer.*

Maj. THOS. H. HANDBURY,
Corps. of Engineers, U. S. A.

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

ST. LOUIS, MO., *June 30, 1897.*

MAJOR: I have the honor to submit the following report of operations at the supply depot during the fiscal year ending June 30, 1897.

The employees on the work July 1 included 81 carpenters, 8 machinists, and 32 laborers. This force was increased temporarily as the work required, but after the plant had been prepared for service in the spring it was reduced to 4 machinists, 20 carpenters, and about 25 laborers, besides the office force, watchmen, etc., and work was continued until the close of the year.

The work done upon the plant during the year is divided into four classes: Construction, equipping for service, extraordinary repairs, and ordinary repairs, which includes watching and care of property. Labor was also employed in handling materials and supplies of various kinds.

CONSTRUCTION.

Portable jetties.—The construction of jetties was begun in July and completed early in November.

Eight thousand linear feet was made in gates or panels each 10 feet long, 200 of these gates being 18 feet wide, and the remaining 600 each 14 feet wide, all of No. 14 corrugated iron riveted to steel I-beams 6 inches deep.

The beams for the smaller gates were 16 feet long and weighed 12½ pounds per linear foot, and they projected 12 inches beyond the corrugated iron on each side with clevises of one-half-inch iron in each end for convenience in handling.

The larger gates were made in the same way, but the beams were 20 feet long and weighed about 15 pounds per foot.

All of the iron used was painted with one coat of red oxide of iron, and another coat was applied to the finished gates.

The cost of these jetties on board a barge ready for use was about \$19 per square, or \$26.60 for each of the 14-foot and \$34.20 each for the 18-foot gates.

About 750 of these gates were sent out for service and returned at the close of the season. Many of them were found so buckled and twisted by the strains to which they were exposed that they must be taken apart and straightened, and it seems advisable to stiffen them by channels or plates across the ends of the beams. This work could be done at a cost of about \$5 per gate and would greatly increase their strength.

The gates made in 1895 of No. 16 iron were badly torn, and many of the sheets can not be made suitable for use, and should be replaced with new ones of No. 14 iron or even heavier if it can be procured.

Tools and appliances.—Three derricks were made and set up on pile drivers Nos. 7, 15, and 19 for handling portable jetties. They were made of different sizes, the most satisfactory for the purpose having a 35-foot mast and 45-foot boom.

Tools of all kinds were made for use on the plant as required, including blocks, fire tools, chains, cant hooks, jackscrews, etc.

EQUIPPING FOR SERVICE.

Dredge No. 1.—This was designed for use as a jet dredge, and was equipped on barge No. 142, the cabin being built here, and most of the machinery purchased. It was pulled out on the ways during the last fiscal year and strengthened by the additional fore and aft bulkheads and heavy oak boiler beams.

The cabin was 90 feet long, 20 feet wide, and 12 feet high, with skylights and canvas roof.

The jets are furnished by two centrifugal pumps, 36 inches diameter, with suction 15 inches in diameter located on the side of the barge amidships.

The discharge pipes are each 15 inches in diameter and run parallel to each other back to the stern, where they are divided into two 12-inch streams and pass through flat nozzles with openings 3¼ by 18 inches.

Each pump is driven by an "Ideal" engine with a 14 by 15 inch cylinder coupled to the shaft and taking steam from a battery of two boilers of ordinary marine type, each 42-inch diameter by 28 feet long.

The dredge is lighted by a "Brush" focusing headlight, and 3 "Adams Bagnet" arc lights, all of 2,000 candlepower, with 24 incandescent lamps in the cabin.

The current for these lights is furnished by a 9 kilo-watt quadripolar "Western" dynamo, driven by a 7 by 10 inch "Ideal" engine.

Two hoisting engines with 7 by 10 inch cylinders, taken from pile-drivers Nos. 18 and 21, are set up on the stern for use with the derricks in handling the discharge pipes, and a "Providence" capstan with 5 by 7 inch cylinders on the bow for use in pulling the dredge into any desired position.

Dredge No. 2.—This dredge is equipped on barge No. 143 which is of the same size, and strengthened in the same manner as No. 142, but the cabin is built 2 feet wider than that of dredge No. 1. It is designed for use as a suction dredge; the material removed being drawn through the pump and carried away in the discharge pipe.

It is furnished with one centrifugal pump 48 inches in diameter, with a 20-inch supply pipe, receiving over the bow through 4 flattened cast-iron intakes, each about 5¼ by 30 inches wide.

The discharge 20-inch diameter at the pump was enlarged to 24 inches and run back through a swivel pipe at the stern into iron pipe carried on flats. Five hun-

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dred feet of this pipe is used, coupled together and connected to the dredge by short pieces of 24-inch hose.

A hoisting engine with 7 by 10 inch cylinders taken from pile driver No. 16 is set up on the bow. The drum shaft was taken out and replaced with a plain shaft carrying a winch at each end, for use in handling suction pipes. A "Providence" capstan with 5 by 7 inch cylinders is set up on the stern.

The pump is driven by a direct connected, compound, condensing engine with a 12-inch high and 25-inch low pressure cylinder and 18-inch stroke.

Steam is furnished by 3 boilers, which, with the electric light plant, are similar to those on dredge No. 1.

EXTRAORDINARY REPAIRS.

Barges.—Extensive repairs were made during the year upon barges Nos. 102, 103, 106, 108, and 113. They were pulled out upon the ways and the rotten side plank, top timbers, decking, deck beams, stems, kevels, bits, chocks, and timberheads removed and replaced with new.

The bottom, sides, and decks were calked, the sides painted, and the barges launched for service.

No. 101 was pulled out during the fall and remained on the ways at the close of the year, and with Nos. 104, 110, and 111 will need the above-mentioned repairs to render it fit for service.

ORDINARY REPAIRS.

Steamer Gen. H. L. Abbot.—A pair of spuds were made during the fall season and set up alongside the derricks, by which the boat can be held while dredging in shoal water. They were made of white oak, 16 inches in diameter, and could be raised by blocks fastened to the top of the derrick mast. They work well in practice, though it may be found necessary to replace them with larger sticks.

A discharge pipe, 6 inches in diameter, was carried from each of the large pumps back to the stern and passed down through the ports between the rudders so as to strike the bed of the river at about the same point as the current from the wheel.

The rudders were repaired at intervals during the fall season. The starboard rudder was entirely rebuilt, while the stocks of the other two were renewed. The stocks were made of oak 14 by 16 inches, but as they seem unable to withstand the strains to which they are subjected, iron stocks were made during the winter of 13-inch pipe five-eighths inch thick, with stiffening plates of 1 by 12 inch steel.

A suction pipe 60 feet long and 12 inches diameter, of sheet iron, was made for the large pumps, put together in short pieces, with two flexible joints, of the bellows pattern, suitable for pumping out barges or other sunken plant.

The cylinder of the steam steering gear was cracked during the fall; it was taken out in the spring, and replaced with another of the same size, but made of flange steel five-eighths inch thick which will probably withstand any strain to which it will be subjected. This cylinder and its steam pipe was protected with sectional covering.

Steamer Gen. T. L. Casey.—A pair of iron spuds were set up alongside the derricks to hold the boat while washing with the wheel. They are of 10-inch steel pipe five-eighths inch thick, and pass down through heavy cast-iron shoes in the guards.

A set of bronze packing rings was fitted to the main engines. A blistered sheet in one of the main boilers was replaced with a new one and a broken stay bolt repaired.

A new plumber block was put under the starboard end of the shaft. The furnace was repaired during the fall. The breeching was repaired in the spring, new fire liners put in, and the furnace walls relaid.

The port rudders were renewed during the fall. Small repairs were made upon the nosing, chocks, etc., and the outriggers were calked as required.

The canvas on the roof was renewed and painted two coats during the spring, and the cabin was painted throughout, with the exception of the small staterooms.

Steamer Gen. Gillmore.—The old "Brush" dynamo, wound only for arc lights, was taken out during the fall and replaced with a 9 kilo watts "Western" machine capable of running the old arc lights as well as the 85 incandescent lamps put in with the dynamo. The engine is small, but seems able to do the work required.

The old canvas on the roof was removed at the winter harbor, the ceiling patched and new canvas put on. The boat was brought to the depot in April and all necessary repairs made. The work done included the renewal of the entire head, fantails, pitmans, both guards, with exception of some of the outriggers, one main hog chain brace, the beds of the pumps' doctor, and dynamo, parts of the boiler deck, the port pillow block, the exhaust pipe from the engines to the heater, the cam yokes with brackets, and the doctor valves.

The old felt covering on the pipes and drums was found crumbled to a powder, and it was replaced with a carbonate of magnesia covering.

The top sides and outriggers were calked and painted. The entire cabin was scraped and painted three coats.

Dredges.—The top sides of Nos. 1 and 2 were calked.

Tenders.—Small repairs were made upon all the tenders as required.

The Providence capstan on No. 4 became unserviceable and was replaced with a stronger and more durable one.

Tenders Nos. 3 and 4 were pulled out on the ways and breaks in the hulls repaired.

Nos. 1, 2, 6, and 7 were pulled out in the fall and repaired during the winter.

Nos. 6 and 7 were calked and launched in the spring, ready for service.

Barges.—The top sides of all the 66 barges, except those on the ways, were calked and repaired during the fall and again in the spring. The broken floor timbers in No. 137 were repaired with 28 crotch floors.

Quarter boats.—The top sides of Nos. 1 to 10 were calked twice during the year.

The canvas on the roofs of Nos. 1 to 6 was replaced with new, and painted. These boats were also painted two coats on the outside and one coat in the cabin.

The old wooden bunks in Nos. 4 to 7 were torn out and replaced with iron beds holding single mattresses of woven wire.

Office and survey boats.—The top sides of all were calked in fall and spring.

The canvas roofs of Nos. 1 and 2 were renewed and their hulls and cabins painted.

Pile drivers.—The iron leads on Nos. 2, 4, 5, 6, 9, 12, and 24 were found unsafe during the fall and replaced with wooden leads.

The hulls of Nos. 1, 5, 6, and 8 leaked badly during the fall, and they were pulled out on the ways, the rakes and parts of the gunwales were renewed, and the machinery repaired.

The hoisting engines were removed from Nos. 16, 18, and 21 during the fall for use on the dredges, but the remaining 25 drivers with hoists are in a serviceable condition.

Two of the old crab-frame drivers, Nos. 10 and 20, are now in use on the bank at the depot; the others, Nos. 8, 11, 7, 15, and 19, are available for use, though the last three have been equipped with derricks for handling portable jetties.

Derrick boats.—The sides of Nos. 1 and 2 were calked in the fall and spring.

No. 1 was pulled out in the fall, a break in the hull repaired, the engine overhauled, the roof re-covered with canvas, and the derrick repaired.

Machine shop.—A small engine lathe was purchased and set up during the winter. This was 6½ feet long, 14-inch swing, with all the necessary attachments.

The shop was raised about 4 feet, bringing the floor up to a 33-foot stage, and the inside was painted.

Small boats.—All the serviceable flats, yawls, and skiffs were repaired and sent out for service during the summer. A few were towed to the winter harbor, but 210 flats, 124 skiffs, and 11 yawls were brought back to the depot and pulled out on the bank.

Seventy-five flats were repaired, calked and launched, ready for service in the spring.

The repairing of skiffs was continued during the year. New sides of California redwood were put in 35 as required, and about 100 made ready for service in the spring.

Portable buildings.—The roof of 6½ sections on barge No. 29 was covered with new canvas, and repairs were made upon the roofs of those at the depot.

Portable jetties.—The jetties sent out for service were returned and piled up on the bank. The damaged sheets were removed during the winter and preparations made for replacing them with heavier iron.

Ways.—The ways were in constant use throughout the season, but will need extensive repairs in about a year. The outer ends are covered with mud by each rise in the river, and it seems advisable to rebuild them with a different incline extending out to the wharf line.

The following plant was pulled out for repairs during the year: Six tenders, 6 barges, 4 pile drivers, 1 driver hull, and 1 derrick boat.

Supply depot.—An iron shed 54 by 120 feet was built at the lower end of the yard to cover the lumber kept in stock. The frame was made of old Z-bars from unserviceable steel leads, and the roof of the bent and twisted sheets taken from portable jetties.

New sheets of light iron were purchased to cover the sides and ends, and the whole painted with red oxide.

The old shipping platform was found unsafe, and was replaced with a new one. This was made of cypress piling decked with yellow pine. It is 37 feet above low water at the west end, and 9 feet lower at its outer end, 190 feet from the wall, about on the City wharf line.

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The two portable buildings near the office were taken down and set up in one building below the wall just north of the platform. Its floor was placed at a 36-foot stage, which gives about 6 feet of headroom underneath, sufficient space in which to store the castings kept in stock.

The blacksmith and sheet iron shops alongside the platform were raised to a 33-foot stage.

The iron roofs of all permanent buildings were painted.

Seven clumps of mooring piles were driven along the river front for fastenings.

A steam hammer was set up in the blacksmith shop, taking steam from the machine boat. It has a 400-pound ram with an 8 by 18 inch steam cylinder.

The bins and pigeonholes in the warehouse were increased to about 400, which hold the stock of pipe fittings, etc., required.

Tools and appliances.—All the tools necessary for use here and on construction works were repaired, stored, or issued as required.

Boarding outfit.—The laundry boxes, tables, benches, bunks, stovepipe, and other boarding outfit were repaired and handled as needed upon the works.

Materials and miscellaneous stores.—The subsistence stores, lumber, and all other material used on the works, except brush, stone, piles, and coal, were received, stored, and issued from the depot as required.

Very respectfully, your obedient servant,

C. D. LAMB, *Superintendent.*

Maj. THOS. H. HANDBURY,
Corps of Engineers, U. S. A

W 3.

IMPROVEMENT OF HARBOR AT ST. LOUIS, MISSOURI.

St. Louis Harbor has a length of about 18 miles, being divided into two nearly equal parts by the Eads Bridge. The upper portion of the harbor between this bridge and the northern limits of the city is about 10 miles in length. About 3 miles above the Eads Bridge is the Merchants' Bridge. The lower portion of the harbor, included between the Eads Bridge and the River Des Peres, is about 8 miles long. A good depth of water and accessible landings exist in this lower part of the harbor, and a sufficient depth is found above the Merchants' Bridge.

Between the Merchants' and Eads bridges there had existed for a considerable number of years middle bars, and also shoals near the Illinois shore, which interfered with navigation and which will be mentioned again further on.

Appropriations for improvement of St. Louis Harbor had been made as early as 1836, and a longitudinal stone dike was built at that time near the head of the present works by Capt. R. B. Lee, Corps of Engineers. Other work done in later years by the United States consisted in the building of stone and brush dikes generally normal to the direction of the current, in the closing of Cahokia Chute, and the protection of the bank in Sawyer Bend.

The river and harbor act of Congress approved September 10, 1890, contained an appropriation of \$182,000 for improving harbor at St. Louis, Mo., and the officer in charge, in submitting a project for its expenditure, recommended that the money be applied to the portion of the harbor between the Eads and Merchants' bridges. The approved project consisted in contracting this portion of the river to a width of about 2,000 feet by means of a system of hurdles built along the Illinois shore for a distance of about 13,000 feet, with a view to removing the bars which then existed and which interfered with navigation at low stages of the river, and also to improve the ferry landings on the Illinois shore. The object of the hurdles was to cause deposits of

MISSISSIPPI RIVER.

MAP SHOWING CONDITION OF WORKS OF IMPROVEMENT
IN VICINITY OF

SULPHUR SPRINGS

June 30, 1897.

SCALE, 1/4" = 1/2 MILE.

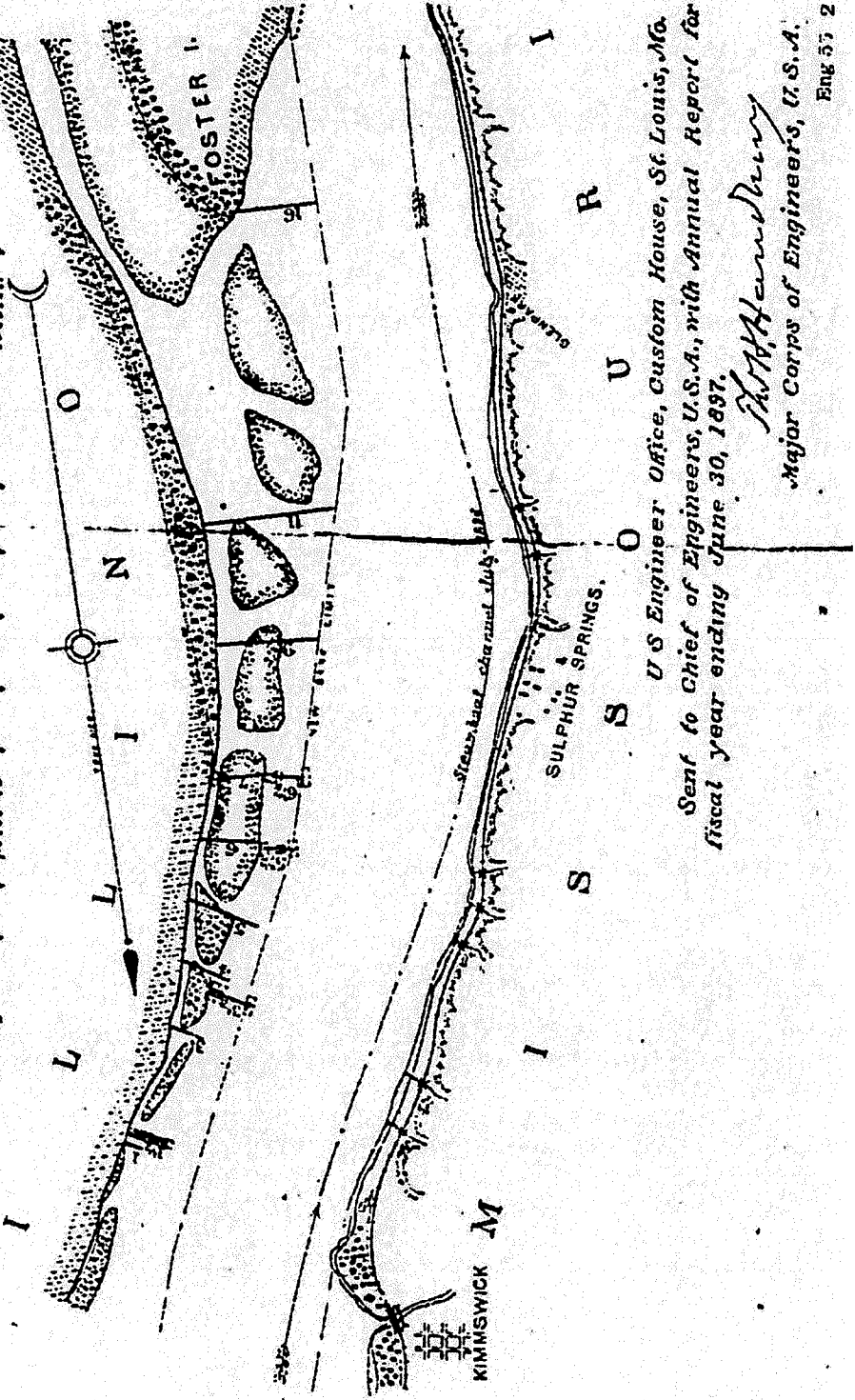
Rats are shown as they appeared July 24, 1896, at stage 176 ft. above standard low water.

••••• prior to

— built during this fiscal year, shown thus

Hardly Protection

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U.S. Engineer Office, Custom House, St. Louis, Mo.
Sent to Chief of Engineers, U.S.A., with Annual Report for
fiscal year ending June 30, 1897.

W. H. Hendry

Major Corps of Engineers, U.S.A.