

IMPROVEMENT OF RIVERS AND HARBORS IN THE ST. LOUIS, MO.,
DISTRICT.

REPORT OF MAJ. WILDURR WILLING, CORPS OF ENGINEERS.

IMPROVEMENTS.

	Page.		Page.
1. Mississippi River between the Ohio and Missouri Rivers.....	2581	2. Removing snags and wrecks from the Mississippi River below the mouth of the Missouri River, and from Old and Atchafalaya Rivers.....	2598

FOR DESCRIPTION OF IMPROVEMENTS IN THIS DISTRICT SEE PAGES 1084 TO 1090.

1. MISSISSIPPI RIVER, BETWEEN THE OHIO AND MISSOURI RIVERS.

WORKS OF IMPROVEMENT.

The standard forms of construction were used. During the year, works of permanent improvement by hired labor were in progress September 13 to December 28, 1915, as hereinafter described, at Sulphur Springs, Penitentiary Point, Fort Chartres, Turkey Island, Ste. Genevieve, Crain Island, Liberty, Wilkinson, La Cours Island, Union Point, Crawford, Hanging Dog Island, Devils Island, Price Landing, Eliza Towhead, Cairo Protection, and Greenfield Bend, and under contract October 13 to December 27, 1915, and March 10 to 27, 1916, at Kaskaskia Island. Two of the four suction dredges under this office were in commission during the low-water season from September 7, 1915, to December 31, 1915, and were operated on eight channel bars which developed during that time. A hydrographic survey, not continuous, was made, covering in aggregate about 100 miles, including all dredged channels, shoal crossings, and caving banks. River gauges were maintained and read throughout the year and were inspected and repaired as required. The plant was repaired and cared for at the engineer depot, St. Louis, and in the fleet at Graysboro, Mo.

Materials were procured by contract and open-market purchases and by hired labor, as was deemed most advantageous to the department.

CONSTRUCTION WORKS—HIRED LABOR.

NOTE.—Station numbers, wherever shown herein, refer to an origin at the upstream end of the work at that locality. River stages, unless otherwise noted, refer to the St. Louis gauge.

SULPHUR SPRINGS, ILL. (24 MILES BELOW EADS BRIDGE, ST. LOUIS).

[Nov. 19-Dec. 22, 1915.]

Hurdle dikes, repair.—In order to strengthen and hold the outer ends of the hurdles which had been much worn away during recent years at this locality, Nos. 10½, 11, 12, 13, and 14 were repaired with piling and stringers throughout lengths of 50, 160, 200, 150, and 65 feet, respectively. To prevent further bank caving along these hurdles, 1,380 linear feet of shore mattresses were built at their roots as follows: No. 12, 110 feet; No. 13, 320 feet; and No. 14, 950 feet. A spur hurdle 75 feet in length was built near Hurdle No. 14 to prevent the formation of a destructive eddy.

Bank revetment, repair.—Between stations 100 and 124+75 repairs aggregating 71,100 square feet were made to the stone paving along 1,745 linear feet of bank, and new stone paving aggregating 27,600 square feet was placed to the elevation of the 12-foot river stage along 1,270 linear feet of bank between stations 136+30 and 156+20. The bank-protection mattress was repaired along 915 linear feet (96,200 square feet) of bank between stations 115+90 and 127+90.

PENITENTIARY POINT, ILL. (44 MILES BELOW EADS BRIDGE, ST. LOUIS).

[Nov. 5-Dec. 3, 1915.]

Hurdle dike, repair.—The hurdle was repaired throughout 1,050 feet of its length at the outer end and the T head was entirely reconstructed. The drift accumulated along 475 linear feet of the hurdle was overlaid in the usual manner with woven-wire fencing and weighted with stone.

FORT CHARTRES WEST (48 MILES BELOW EADS BRIDGE, ST. LOUIS).

[Oct. 19-30, 1915.]

Hurdle dam, repair.—Hurdle Dam No. ½, located about 100 feet below the head of Establishment Island and across the slough between the island and the main Missouri shore, had been breached at its eastern or island end, and also damaged near the Missouri shore. The gap, 100 feet in width, was closed, and the damaged cribwork of piling and stone at the west end was repaired with brush and stone. A large quantity of drift accumulated above the hurdle along 420 feet of its length was overlaid with a brush mat and weighted with stone.

Bank revetment, repair.—Between stations 0+20 and 15 the stone paving, aggregating 7,000 square feet, was repaired throughout 360 linear feet of bank.

FORT CHARTRES, EAST (50 MILES BELOW EADS BRIDGE, ST. LOUIS).

[Oct. 30-Nov. 11; Dec. 2-5, 1915.]

Bank revetment, repair.—Between stations 24 and 56+50, 38,700 square feet of stone paving were repaired along 2,375 linear feet of bank, and two spur hurdles 50 feet in length were placed in an eddy at stations 34+20 and 35+60.

TURKEY ISLAND, ILL. (51 MILES BELOW EADS BRIDGE, ST. LOUIS).

[Nov. 11-18, 1915.]

Bank revetment, repair.—Between stations 69+70 and 94+10, 21,400 square feet of stone paving were placed in repairs along 760 linear feet of bank.

STE. GENEVIEVE, ILL. (56 MILES BELOW EADS BRIDGE, ST. LOUIS).

[Oct. 25-Nov. 4, 1915.]

Hurdle dike No. 2, repair and restoration.—This hurdle, which was built during 1913, suffered a loss of 200 feet at its outer end during the spring of 1914. The depth of water along the destroyed section being not excessive during the present year, the hurdle was restored for a distance of 250 feet, to its original length, and a T-head 50 feet in length was driven at its outer end. The drift accumulated above 390 linear feet of the hurdle near the shore end was overlaid with woven wire fencing and weighted with stone.

In the aggregate there were placed 48,200 square feet of foundation mattress, 296 piles, and 22 stringers, and 5,800 square feet of drift were sunk.

CRAIN ISLAND, MO. (76 MILES BELOW EADS BRIDGE, ST. LOUIS).

[Sept. 13-Oct. 23, 1915.]

Hurdle dikes, extension and repair.—Hurdle No. 9, which had been constructed to a length of 2,500 feet, was not completed because of insufficient depth of water at the outer end. The usual scouring action of the river having increased the depth, the hurdle was extended 800 feet, to its ultimate length, 3,300 feet, and a 60-foot T-head was constructed at the outer end. The hurdle was strengthened throughout 100 feet of its length, and a drift mattress, 1,390 linear feet, was built and weighted with stone.

Hurdle No. 15, repair.—A gap 300 feet in length in this hurdle was closed, and repairs were made throughout 150 feet of the piling; the drift accumulated above the hurdle along 200 feet of its length was overlaid with a mattress and weighted with stone.

In the work done on hurdles Nos. 9 and 15, 79,800 square feet of foundation mattress, 1,130 piles, and 85 stringers were placed, and 23,900 square feet of drift were sunk.

Bank revetment, extension.—Between stations 63 and 69, the bank paving on Crain Island was raised from the 16-foot to the 22-foot stage, 9,900 square feet being placed.

LIBERTY, MO. (86 MILES BELOW EADS BRIDGE, ST. LOUIS).

[Sept. 16-Oct. 10, 1915.]

Hurdle Dam No. 15, new and repair.—This hurdle was built in 1913 between the main Missouri shore and the west side of Liberty Bar. The continued high stages of the spring and summer washed away the bank at its main shore end for a width of 100 feet, and at the other end, originally on a sand bar, 100 feet of the hurdle was washed out and the bar cut away for 250 feet in addition. To close

these gaps mattresses were constructed at both ends of the hurdle, the piling of which was then extended to the new banks, which were graded and paved. The total extensions are 475 feet, making the present length of the hurdle 1,350 feet. In all 58,400 square feet of foundation mattress, 21,500 square feet of stone bank paving, 426 piles, and 29 stringers were placed.

WILKINSON, ILL. (92 MILES BELOW EADS BRIDGE, ST. LOUIS).

[Oct. 14–Nov. 18, 1915.]

Bank revetment, new.—The bank both above and below the protection placed during the fiscal year 1914 caved rapidly during the high stages of the spring and summer, the maximum erosion being about 450 feet at a point about 2,000 feet below the foot of the protection, where a large eddy working upstream had destroyed about 100 linear feet of the work.

The mattress was extended from station 97+90 to 100+10 and from 131+70 to 141, 1,185 linear feet (151,700 square feet) being placed. The bank was graded and paved to the top throughout the same limits, 62,100 square feet of paving being placed. The original mattress was 3,180 feet in length from station 100 to 131+80.

LA COURS ISLAND, ILL. (94 MILES BELOW EADS BRIDGE, ST. LOUIS).

[Oct. 5–26, 1915.]

Hurdle dike, restoration.—The spring and summer high stages cut away the bank, destroying the shore protection and 190 linear feet of hurdle adjacent thereto. The usual foundation mattress was placed and the gap was closed with piling. Owing to the excessive depth of water (40 feet) on the old hurdle line, the repair line is inclined upstream in much shoaler water, making an angle of about 30° at the junction with the old line. On account of a destructive eddy below the hurdle, the shore protection was extended 440 feet downstream.

In all 270 linear feet of hurdle were restored, in which 59,000 square feet of mattress, 24,600 square feet of stone paving, 204 piles, and 15 stringers were placed.

UNION POINT, ILL. (109 MILES BELOW EADS BRIDGE, ST. LOUIS).

[Oct. 23–Nov. 16, 1915.]

Hurdle Dike No. 6, restoration.—About 280 linear feet of the outer end of this hurdle were broken down by ice during the preceding winter, leaving the foundation mattress intact. This section was restored by driving 340 piles in 3 rows of clumps and placing 22 stringers.

CRAWFORD, MO. (111 MILES BELOW EADS BRIDGE, ST. LOUIS).

[Nov. 17–Dec. 9, 1915.]

Hurdle dike, repair.—Throughout 350 feet at the outer end of this hurdle ice and drift had broken down the piling, leaving the

tops at about the 10-foot stage. This was repaired by driving 86 piles, singly or in clumps, immediately below the old piles, and placing along them 9 stringers.

HANGING DOG ISLAND, ILL. (114 MILES BELOW EADS BRIDGE, ST. LOUIS).

[Nov. 20, 26; Dec. 10, 12, 1915.]

Hurdle Dike No. 9, repair.—The short section of mattress placed at this locality in 1914 has been flanked by the river, and considerable damage has been done to the piling and shore protection of hurdle No. 9. Repairs were made by placing 2,900 square feet of bank paving, 7 piles, and 1 stringer.

DEVILS ISLAND, ILL. (126 MILES BELOW EADS BRIDGE, ST. LOUIS).

[Oct. 14; Nov. 21–Dec. 20, 1915.]

Hurdle Dam No. 1, repair and restoration.—This dam, constructed across the chute between the head of Devils Island and the main Illinois shore during the fall of 1897, was originally 1,200 feet in length, but has been increased by repairs and extensions to its present length of about 2,000 feet. For several years it was fronted and protected by an extensive bar, which has been partially washed away exposing the lower half of the dam, the piling of which is decayed and broken down. As the accretions behind the dam are high, they were graded and paved with stone, but the lost piling was not replaced. There was a gap of 190 feet wide in the dam at its upper or shore end, in which the foundation and shore mattresses were found uninjured, although the bank had receded about 30 feet. A mattress, lightly ballasted with stone, was placed between the old shore mattress and the new bank, and was carried to the top of the latter, as the river fell so rapidly that barges could not be brought over the bar to the bank with sufficient stone for paving of regular thickness. In all, 11,000 square feet of mattress, 6,400 square feet of stone paving, 103 piles, and 5 stringers were placed.

Bank revetment, repair.—Several detached sections of mattress, total 37,800 square feet, were placed in front of hurdle Dam No. 1, between stations 73 and 78+40. The bank between stations 70+80 and 79, was graded and paved to the top, approximately to the 23-foot stage, 48,700 square feet of paving being placed. On Devils Island, several small breaks in the paving between stations 81 and 88, 168 and 173, and at station 200 were repaired, 19,100 square feet of paving being placed. The spur hurdles in the eddies at stations 117 and 138 were repaired.

PRICE LANDING, MO. (163 MILES BELOW EADS BRIDGE, ST. LOUIS).

[Oct. 15–22; Dec. 21–28, 1915.]

Bank revetment, repair.—Several small breaks in the paving, generally due to eddies, were repaired by placing short sections of mattress and regrading and paving the bank. In all, 44,200 square feet of mattress were placed between stations 182+50 and 191+80, and 37,900 square feet of stone paving between stations 150 and 182.

ELIZA TOWHEAD, ILL. (175 MILES BELOW EADS BRIDGE, ST. LOUIS).

[Nov. 25-Dec. 21, 1915.]

Bank revetment, new, and repair.—The bank at this locality had caved rapidly during the preceding summer and threatened to flank the head of the detached section of revetment placed December, 1911, beginning at station 65. During the present season the mattress, which was made unusually wide (160 feet), was extended upstream from station 65+95 to 57+65, 131,600 square feet being placed. The bank was graded and was paved to the 30-foot stage (Cairo gauge) from station 57+65 to 62+65, and below the latter station the paving was raised about 10 feet higher to the top of the bank, 36,500 square feet being placed. In repair, 7,000 square feet of paving were placed between stations 65 and 68.

CAIRO PROTECTION, ILL. (177 MILES BELOW EADS BRIDGE, ST. LOUIS).

[Nov. 20, 30; Dec. 3, 1915.]

Bank revetment, repair.—A small break in the paving, 5,600 square feet, between stations 98+50 and 100 was repaired.

GREENFIELD BEND, MO. (180 MILES BELOW EADS BRIDGE, ST. LOUIS).

[Oct. 22-Nov. 28; Dec. 16-22, 1915.]

Bank revetment, new, and repair.—A section of mattress 175 feet in width (50,400 square feet) was placed between stations 51+50 and 54+95, where the old mattress and paving had sunk, and the bank between these stations was regraded and paved to the 33-foot stage, 20,600 square feet being placed. At the lower end of the work the mattress was extended from station 68+25 to 81+30. It was made 160 feet wide to station 80, at the upper end of an abandoned railroad incline and 60 feet wide for a distance of 130 feet along the outside of the incline, 202,700 square feet in aggregate being placed. The bank was graded between stations 68+25 to 71, and 4,500 square feet of paving were placed in a narrow strip along the shore edge of the mattress.

CONSTRUCTION WORKS—CONTRACT.

KASKASKIA, ILL. (69 MILES BELOW EADS BRIDGE, ST. LOUIS.)

[Oct. 13-Dec. 27, 1915; Mar. 10-27, 1916.]

Bank revetment, new.—Under contract with Rust & Swift, of St. Louis, the construction of subaqueous mattress discontinued in May, 1915, because of high river stages, was resumed and 3,610 linear feet (451,200 square feet) were built between stations 110+20 and 146+30. The outline of the bank being very irregular, a number of detached "pocket" mattresses, totaling 38,900 square feet, were built between the same limits.

During the fall season, the bank, throughout the section protected by the mattress, was graded for stone paving, using the hydraulic method and hand shovels, a drag-line scraper, teams with plows and scrapers, and a sluice box extending from the top of the bank to the water to remove material shoveled by hand.

During the fall and spring seasons the paving was completed to the bankfull stage (26 feet, Chester gage), 263,700 square feet

being placed. Completion of this contract, involving about 1,500 linear feet additional, is contemplated when the river reaches a stage sufficiently low for advantageous work.

DREDGING.

Unusually high stages with more than ample depths for navigation prevailed throughout the greater part of the low-water season of 1915, and less than half the usual amount of dredging was required.

The average daily stage for July, August, and September was nearly 25 feet on the St. Louis gage, or 10 to 15 feet higher than normal for those months.

Several bars of 8½ and 9 feet depths developed early in September, and threatening to become obstructive to 8-foot navigation, the two self-propelling dredges *Fort Gage* and *Fort Chartres*, were accordingly placed in commission, September 7, but considerable rise in stage then occurred and no dredging was required until the middle of October. During the remainder of the season these two dredges did all work required, and as the nonpropelling dredges *Selma* and *Thebes* were not needed, they were not placed in service.

The *Fort Gage* was in commission September 7 to December 31 (116 days), and during 38 working days dredged across 6 channel bars; the *Fort Chartres* was in commission September 5 to December 24 (111 days), and during 14 working days dredged across 2 channel bars; also, while not needed for channel work, the *Fort Chartres* cleared out in 15 days, below Grays Point (137), a new harbor for the floating plant of this engineer district.

The two dredges were operated for a total of 611½ hours, a little more than only one-ninth of their total time in commission, and maintained a good 8-foot channel throughout the district during the low-water season until navigation was stopped by ice (Dec. 28), when they were placed in winter harbors, the *Fort Gage* at United States Engineer depot (3), and the *Fort Chartres* at Graysboro (139). These dredges were also used to assist the one towboat in commission to deliver materials and supplies, and to patrol and sound the steamer channel from St. Louis to Cairo.

Seven main channel bars were dredged, of which one was dredged twice (Brewer Point); and work at two others (Danby and Grand Tower) was discontinued for short periods because of high river stages and the urgent need of the dredges for towing.

Beneficial results were obtained in all cases although the dredging at Grand Tower was not fully completed in width; on account of packed gravel and bowlders accumulated in the bottom of this channel the cut could be dredged to only 1 foot below the zero of the Grand Tower gauge, whereas the original bottom of this channel (dipper dredged, 1909 to 1912) was 2 to 4 feet lower. The accumulation of large and heavy solid materials is probably due to the previous long-continued high stage of river (for almost entire year) bringing such material from the upper reaches of the river.

The gain in depth due to dredging of bars varied from 3½ to 5½ feet; the total length of the seven completed channels having widths of 200 feet or more was 2¾ miles. The total amount of material dredged was 513,600 cubic yards, giving an average dredge rate of 840 cubic yards per hour.

Table of work done by U. S. dredges "Fort Gage" and "Fort Chartres" during the fiscal year ending June 30, 1916.

Dredge.	Bars dredged.	Mileage from St. Louis (Eads Bridge).	Inclusive dates.	Days dredging.	Actual dredging time.	Material removed.	Cuts made.	Total length of cuts.	Dredged channel.			Gain in depth.
									Length.	Depth.	Width.	
Fort Gage.....	Meramec River.....	Miles. 19	Dec. 22-27.....	5	Hours. 46	Cu. yds. 40,100	No. 7	Feet. 7,750	Feet. 1,400	Feet. 10	Feet. 200	Feet. 4
Fort Chartres.....	Danby.....	42	Nov. 10-15; Nov. 23-24.....	8	83½	92,900	9	11,925	2,150	12	225	5½
Do.....	Stanton.....	61	Oct. 17-22.....	6	54	54,600	6	9,675	2,000	13½	225	4½
Fort Gage.....	Grand Tower.....	103	Nov. 23-24; Nov. 27-30; Dec. 6-12.....	13	92	51,600	7	12,600	2,300	14	180	4
Do.....	Schenimann.....	121	Nov. 2-7.....	6	58½	61,900	4	9,075	2,300	10½	200	2
Fort Chartres.....	Grays Point.....	139	Dec. 3-18.....	15	130	120,000	8	10,000	3,200	14	175	5
Fort Gage.....	Sliding Island.....	158	Nov. 16-20.....	5	35	62,600	5	8,025	2,000	12	305	2½
Do.....	Brewer Point.....	166	Oct. 24-25.....	3	50	31,400	3	4,575	725	12	200	4
Do.....	Brewer Point, lower.....	167	Nov. 10-15.....	6	64½	89,000	9	10,275	1,600	9½	280	4½
				67	611½	513,600	63	83,900				

¹Not in main channel; winter harbor for floating plant.

²483,600 cubic yards dredged from main channel.

RIVER STAGE.

During the entire year, with the exception of short periods in November, December, January, and March, the river stage was unusually high, and with the exceptions, total only 28 days, in the months mentioned, the stages were above the mean daily stages.

Five very marked rises within three months, one in July, two in August, one in January-February, and one in May, equaled or slightly exceeded the flood or "bankful" stage (30 feet) at St. Louis, and in the first four instances established new records for extreme high stages on their dates of occurrence. The mean stage for the year was 19.3 feet, or 6.9 feet above the mean stage for 55 years, St. Louis gauge.

St. Louis gauge, 1914-15.

Date.	Highest monthly gauge readings.	Date.	Lowest monthly gauge readings.	Normal range, 55 years continuous records.
1915.		1915.		
July 23.....	Feet. 31.3	July 10.....	Feet. 22.0	Feet. 20.0-14.5
Aug. 22.....	30.4	Aug. 31.....	19.5	14.5- 9.5
Sept. 18.....	24.3	Sept. 10.....	12.5	9.5- 9.0
Oct. 3.....	22.2	Oct. 31.....	11.0	9.0- 8.0
Nov. 30.....	15.5	Nov. 14.....	7.4	8.0- 7.0
Dec. 1.....	14.9	Dec. 29.....	3.2	7.0- 5.5
1916.		1916.		
Jan. 31.....	31.4	Jan. 1.....	4.0	7.0- 8.0
Feb. 1.....	31.4	Feb. 16.....	12.8	8.0-11.5
Mar. 31.....	26.2	Mar. 14.....	11.3	11.5-16.5
Apr. 1, 2.....	26.2	Apr. 30.....	21.9	16.5-19.0
May 31.....	30.0	May 13.....	21.1	19.0-18.0
June 1.....	29.7	June 30.....	22.6	18.0-20.0

CHANNEL CONDITIONS.

Channel conditions were under constant surveillance by the district towboats and dredges while in commission from September 1 to December 31. During July and August, and the following spring season, the steamers were not in commission, with the exception of one towboat employed in towing plant from Graysboro to St. Louis during the early part of May.

During the fall season between the mouth of the Missouri River (-16) and St. Louis (0), the legally required 6-foot depth was maintained by natural action of the river; between St. Louis (0) and the mouth of the Ohio River (183), a channel of required dimensions, 8 feet depth and 200 feet width, was maintained, except for short periods of time at the seven bars hereinafter noted, where the required dimensions were quickly obtained by dredging or by the action (natural scour) of the river itself.

The least depths observed throughout the year were as follows: In July and August, unusually high stages prevailed and channel depths were more than ample for navigation. In September, 8 feet at Moro Island (60) on the 10th; in October, 8 feet at Schenimann (121) on the 28th; in November, 6½ to 7 feet, at Brewer Point (166) 10th to 14th, and at Sliding Towhead (159) on the 16th and 17th; in December, 6 feet at Schenimann (121) on the 25th, and 7½ feet at four other bars, on the 22d and 23d. Ruling depths on other

shoalest bars were not less than 8 feet. Navigation was practically stopped by snow on the 24th and 27th of December. The river stages always being higher during the spring season, the channel depths reported were equal to or greater than project requirements.

Steamer channel reports giving steering directions and least depths on bars, as ascertained by pilots of this office on through trips, were issued during the fall season to vessels and the public through the Lighthouse Service.

SURVEYS, EXAMINATIONS, AND CHANNEL MARKS.

A hydrographic survey was made, covering about 100 miles of river, or one-half of the entire district between the mouths of Ohio and Missouri Rivers.

Fourteen new triangulation stations were established. Fourteen miles of levees in Illinois were located and 14 miles of levels were run between the river gauges at Grays Point and Commerce.

Surveys, general and special, were also made as required, and included all localities where construction works or dredging were in progress or immediately prospective; also where considerable changes, due to caving banks and shifting channels, had taken place.

Also, dredged channels were marked with buoys and steering ranges in addition to the regular beacon lights of the Lighthouse Service.

PHYSICAL DATA.

The river gauges were maintained and read daily throughout the year and their records were checked by plotting on the official hydrograph.

During the year the river at St. Louis oscillated 28.2 feet, between stages 27.4 feet (Jan. 31, Feb. 1) above and 0.8 foot (Dec. 29) below standard low water (4 feet, St. Louis gauge). The normal yearly oscillation is about 24.7 feet, between 22.9 feet above and 1.8 feet below standard low water.

During the extreme high stage in July, three measurements of discharge of the Mississippi River were made at the mouth of River des Peres (8), St. Louis, with results as follows:

Date.	St. Louis gauge.	Area of cross section.	Mean depth.	Width of water-way.	Mean velocity.	Volume of discharge.	Method.	Oscillations.
1915.	<i>Feet.</i>	<i>Sq. ft.</i>	<i>Feet.</i>	<i>Feet.</i>	<i>Ft.-sec.</i>	<i>Sec.-cu.-ft.</i>		
July 1.....	29.25	76,500	43.3	1,767	6.79	519,700	Meter.....	F.
1.....	29.25	74,750	42.3	1,767	7.20	538,500	Rod floats...	F.
3.....	27.90	69,350	39.8	1,740	6.55	454,500	.....do.....	F.

MATERIALS.

For the permanent works of improvement, construction, and repair of hurdle dikes and bank revetments 12,195.08 tons (2,000 pounds) of coal, at a cost of from \$1.38 to \$2.25 per ton, were supplied by contract; 74,392 linear feet (1,493 sticks) of pile timber, at an average cost of 11 cents per linear foot; 40,927 cubic yards of stone and spalls, at from 60 to 69 cents per cubic yard; and 119,630 feet b. m. of mattress lumber at an average cost of \$14.45 per M. feet b. m., were purchased in open market; and 8,042 cords of brush, at \$1.82

per cord, were procured and loaded on Government barges by hired labor.

In construction of bank revetment at Kaskaskia Island, under contract, 495,200 feet b. m. of mattress lumber, at \$34 per M. feet b. m., and 15,212 cubic yards of stone and spalls, at \$1.59 per cubic yard, were furnished and placed by the contractor in completed work.

All other materials, supplies, stores, subsistence, etc., were purchased under competitive bids therefor or in open market and were collected and tested at the engineer depot, St. Louis, Mo., and thence distributed to the various working parties. All coal was tested for payments on the British thermal-unit basis. The following tests of samples of materials were also made for other engineer offices: Coal and rope, secretary's office, Mississippi River Commission; rope, engineer offices, San Francisco, Cal., first and second districts; Cincinnati, Ohio; Nashville, Tenn.; and inspection of castings for Portland, Oreg., engineer office and United States Lighthouse Bureau, San Francisco, Cal.

Numerous inspections were made, as required, of materials and appliances purchased in this vicinity by the Panama Canal.

PLANT.

All plant required for service was maintained in condition by repairs in ordinary upkeep and received extraordinary repairs and rebuilding as necessary to fit it for present and future service. The towboats of this office, *William R. King* and *General J. H. Simpson*, three steel steam tenders, and two smaller wooden tenders were thoroughly repaired. One very old small wooden tender, the *Cahokia*, was sunk November 13 in very deep water while in tow en route to St. Louis, and could not be recovered. Repairs incident to active service were made to the four suction dredges. Repairs were made also to 6 quarter boats, 2 wood-hull derrick boats, 27 wood-hull barges, 4 steel barges, 11 wood-hull pile drivers, 4 steel-hull pile drivers, 2 steel-hull grader and derrick boats, and 1 wood-hull store boat. Repairs were made as required on the steamer *Oleander*, belonging to the Lighthouse Service, for which reimbursement was or will be made by the lighthouse appropriations.

At the Little Rock Quarry, as well as at the engineer depot, St. Louis, the derricks, drills, tracks, cars, and all machinery, tools, and appliances and buildings were kept in good condition.

The total amount appropriated from July 4, 1836, to March 4, 1915, is \$17,956,599.98, as shown on pages 488 and 490, House Document 1491, Sixty-third Congress, third session, under the following headings:

Illinois River to Ohio River-----	\$4, 110, 000. 00
Missouri River to Ohio River-----	13, 746, 599. 98
Missouri River to Meramec River-----	100, 000. 00
Total-----	17, 956, 599. 98
Appropriated by river and harbor act of July 27, 1916-----	350, 000. 00
	<hr/>
	18, 306, 599. 98

Of the above total amount there was appropriated in the years 1836, 1837, and 1844 for pier near St. Louis and obstructions in harbor of St. Louis (not considered in previous project of 1872 nor existing project of 1881) the sum of----- \$75, 000. 00

2592 REPORT OF CHIEF OF ENGINEERS, U. S. ARMY, 1916.

By the acts of 1872, 1874, 1875, 1876, 1878, 1879, 1880, 1882, 1890 there was allotted for work above the mouth of the Missouri River (not in the present district) the sum of.....\$205, 000. 00
 From the appropriation of 1879 there reverted to the Treasury the amount allotted by the act for Wittenberg, Mo..... 10, 000. 00
 \$290, 000. 00

Leaving for work in the present district between the mouths of Missouri and Ohio Rivers under general acts for work in the district and special acts for work at certain localities in the district..... 18, 016, 599. 98
 Receipts from sales..... 88, 255. 07
 Total..... 18, 104, 855. 05

There was expended on the original project under the acts of June 10, 1872, to June 14, 1880, inclusive, \$1,495,000, and under the existing project of 1881 there has been expended to June 30, 1916, \$16,071,901.82. The amount unexpended June 30, 1916, is \$187,953.23. The river and harbor act of July 27, 1916, appropriated \$350,000, making a total of \$537,953.23. The outstanding liabilities June 30, 1916, are \$8,062.26, and amount covered by contract in force \$79,183.54, leaving \$448,770.85 available for the coming year, in addition to \$1,936.58 due from other appropriations.

Amount expended during fiscal year..... \$337, 455. 08
 Reimbursable..... 6, 700. 42
 Total..... 330, 754. 66

APPROPRIATIONS.

[See H. Doc. No. 1491, 63d Cong., 3d sess., pp. 488 and 490.]

Under former projects, from July 4, 1836, to Mar. 3, 1881, inclusive, and under the following heads: Pier near St. Louis and obstructions in harbor of St. Louis, years 1836, 1837, and 1844, \$75,000; Illinois to Missouri Rivers, year 1872, \$25,000; Missouri River to Meramec River, year 1872, \$100,000; Missouri River to Ohio River, year 1873, \$200,000; Ohio River to Illinois River, years 1874, 1878, \$440,000; Illinois River to Ohio River, years 1875, 1876, 1879, 1880, 1881, \$1,450,000; channel opposite St. Louis, Mo., year 1876, \$29,600; ice harbor at St. Louis, Mo., years 1880, 1881, \$60,000; Cape Girardeau and Minton Point, years 1880, 1881, \$30,000, aggregating..... \$2, 409, 600. 00

Present project:

Aug. 2, 1882, Cairo to Illinois River.....	600, 000. 00
July 5, 1884, Illinois River to Ohio River.....	520, 000. 00
Aug. 5, 1886, Illinois River to Ohio River.....	375, 000. 00
Aug. 11, 1888, Illinois River to Ohio River.....	300, 000. 00
Sept. 19, 1890, harbor at St. Louis, Mo.....	182, 000. 00
Sept. 19, 1890, Illinois to Ohio River.....	400, 000. 00
July 13, 1892, Ohio River to Missouri River.....	525, 000. 00
Mar. 3, 1893, Ohio River to Missouri River.....	658, 333. 33
Aug. 18, 1894, Ohio River to Missouri River.....	758, 333. 33
Mar. 2, 1895, Ohio River to Missouri River.....	758, 333. 33
June 3, 1896, Missouri River to Ohio River.....	275, 000. 00
June 4, 1897, Ohio River to Missouri River.....	673, 333. 33
June 4, 1897, preventing break in Mississippi River at Beech-ridge, Ill.....	100, 000. 00
June 19, 1897, Ohio River to Missouri River.....	325, 000. 00
July 1, 1898, Ohio River to Missouri River.....	673, 333. 33
Mar. 3, 1899, Ohio River to Missouri River.....	673, 333. 33
June 6, 1900, Ohio River to Missouri River.....	100, 000. 00

RIVERS AND HARBORS—ST. LOUIS, MO., DISTRICT. 2593

Present project—Continued.	
June 13, 1902, Ohio River to Missouri River.....	\$650,000.00
Mar. 3, 1903, Ohio River to Missouri River.....	650,000.00
Apr. 23, 1904, Ohio River to Missouri River.....	650,000.00
Mar. 3, 1905, Ohio River to Missouri River.....	650,000.00
Mar. 2, 1907, Ohio River to Missouri River.....	250,000.00
May 27, 1908, Ohio River to Missouri River.....	250,000.00
Mar. 4, 1909, Ohio River to Missouri River.....	250,000.00
June 25, 1910, Ohio River to Missouri River.....	250,000.00
June 25, 1910, Ohio River to Missouri River.....	500,000.00
Feb. 27, 1911, Ohio River to Missouri River.....	1,000,000.00
July 25, 1912, Ohio River to Missouri River.....	1,000,000.00
Mar. 4, 1913, Ohio River to Missouri River.....	1,000,000.00
Oct. 2, 1914, Ohio River to Missouri River.....	250,000.00
Mar. 4, 1915, Ohio River to Missouri River.....	300,000.00
July 27, 1916.....	350,000.00
Total of appropriations.....	18,306,599.98
Of the above total amount there was appropriated in the years 1836, 1837, and 1844, for pier near St. Louis and obstructions in harbor of St. Louis (not considered in previous project of 1872, nor existing project of 1881), the sum of.....	\$75,000
By the acts of 1872, 1874, 1875, 1876, 1878, 1879, 1880, 1882, 1890, there was allotted for work above the mouth of the Missouri River (not in the present district) the sum of.....	205,000
From the appropriation of 1879 there reverted to the Treasury the amount allotted by the act for Wittenberg, Mo.....	10,000
	290,000.00
Leaving for work in the present district between the mouth of Missouri and Ohio Rivers, under general acts for work in the district and special acts for work at certain localities in the district.....	18,016,599.98
Receipts from sales.....	88,255.07
Available for work in district.....	18,104,855.05

CONTRACTS IN FORCE.

Name: Rust & Swift.
 Work: Constructing 10,000 linear feet of river-bank protection.
 Price per linear foot: \$12.50, approximately.
 Date of approval: April 29, 1915.
 Date of beginning work: May 10, 1915.
 Date of expiration: December 31, 1915. Extended to December 31, 1916.
 Percentage of completion: 40.

Name: O'Gara Coal Co., trustee.
 Work: Furnishing 1,000 tons coal at St. Louis, Mo.
 Price per ton: \$1.75 on cars.
 Date of approval: February 7, 1916.
 Date of beginning work: January 26, 1916.
 Date of expiration: December 31, 1916.
 Percentage of completion: 50.

Name: Southern Coal, Coke & Mining Co.
 Work: Furnishing 5,000 tons coal aboard or alongside steamers and 15,000 tons coal on barges, at St. Louis, Mo.
 Price per ton: \$1.70 aboard steamers, \$1.45 alongside steamers, and \$1.40 on United States barges.
 Date of approval: February 19, 1916.
 Date of beginning work: January 13, 1916.
 Date of expiration: December 31, 1916.
 Percentage of completion: 5.

Name: The Monongahela River Consolidated Coal & Coke Co. (Succeeded Jan. 10, 1916, by Pittsburgh Coal Co.)

IMPROVEMENT OF RIVERS AND HARBORS IN THE ST. LOUIS, MO.,
DISTRICT.

REPORT OF LIEUT. COL. CLARKE S. SMITH, CORPS OF ENGINEERS.

IMPROVEMENTS.

	Page.		Page.
1. Mississippi River between the Ohio and Missouri Rivers....	2677	2. Removing snags and wrecks from the Mississippi River below the mouth of the Missouri River, and from Old and Atchafalaya Rivers.....	2694

FOR DESCRIPTION OF IMPROVEMENTS IN THIS DISTRICT SEE PAGES 1115 TO 1121.

1. MISSISSIPPI RIVER, BETWEEN THE OHIO AND MISSOURI RIVERS.

WORKS OF IMPROVEMENT.

The standard forms of construction were used.

During the year works of permanent improvement by hired labor were in progress August 16 to December 12, 1916, as hereinafter described, at mouth of Missouri River, Sawyer Bend, Horsetail, Twin Hollows, Sulphur Springs, Michaels Landing, Osborne Field, Fort Chartres, Turkey Island, Liberty, Union Point, Crawford, Hanging Dog Island, Devils Island, Price Landing, Beechridge, Cairo Protection, and Greenfield Bend, and under contract August 14 to December 15, 1916, at Kaskaskia Island. The four suction dredges of this office were in commission during the low-water season, August 1 to December 22, and were operated on 16 obstructive channel bars which developed during that time. A dipper dredge purchased from the Rock Island engineer office was made ready for service, but by reason of the appearance of running ice was not placed in commission. Hydrographic surveys were made covering about 33 miles of river and including all dredged channels, shoal crossings, and caving banks. River gauges were maintained and read throughout the year and were inspected and repaired as required. The plant was repaired and cared for at the St. Louis engineer depot and at fleet in winter harbor, Graysboro, Mo.

Materials were procured by contract and open-market purchases and by hired labor, as was deemed most advantageous to the department.

CONSTRUCTION WORKS—HIRED LABOR.

NOTE.—Station numbers, wherever shown herein, refer to an origin at the upstream end of the work at that locality. River stages, unless otherwise noted, refer to the St. Louis gauge.

2678 REPORT OF CHIEF OF ENGINEERS, U. S. ARMY, 1917.

MOUTH OF MISSOURI RIVER, ILL., 16 MILES ABOVE ST. LOUIS.¹

[Nov. 7-10, 1916.]

Bank revetment, repair.—Between stations 0 and 103, 7,200 square feet of paving were placed.

SAWYER BEND, MO., 7 MILES ABOVE ST. LOUIS.

[Nov. 10-16, 1916.]

Bank revetment, repair.—The head of the work at station -30 was secured by 1,200 square feet of paving; and between stations 48 and 85, 8,700 square feet of paving were placed along 600 linear feet of bank.

HORSETAIL, MO., 9 MILES BELOW ST. LOUIS.

[Nov. 16, 1916.]

Bank revetment, repair.—At station 40, 1,200 square feet of paving were placed.

TWIN HOLLOW, WEST, 14 MILES BELOW ST. LOUIS.

[Nov. 17-20, 1916.]

Bank revetment, repair.—Between stations 20 and 30, 9,400 square feet of paving were placed along 900 linear feet of bank.

SULPHUR SPRINGS, ILL., 24 MILES BELOW ST. LOUIS.

[Nov. 21-23, 1916.]

Bank revetment, repair.—Between stations 116 and 120, and near outer end of hurdle No. 11, 2,800 square feet of paving were placed.

MICHAELS LANDING, MO., 37 MILES BELOW ST. LOUIS.

[Nov. 25, 1916.]

Hurdles, repair.—At the outer ends of hurdles Nos. 1 and 2, on river side of Michaels Towhead, 2,500 square feet of paving were placed.

OSBORNE FIELD, ILL., 39 MILES BELOW ST. LOUIS.

[Nov. 27, 1916.]

Bank revetment, repair.—Between stations 75 and 88, 2,800 square feet of paving were placed along 275 linear feet of bank.

FORT CHARLES, WEST, 48 MILES BELOW ST. LOUIS.

[Nov. 28, 1916.]

Bank revetment, repair.—Between stations 12 and 14, 1,500 square feet of paving were placed along 125 linear feet of bank.

¹ Origin of river distances taken at Eads Bridge.

FORT CHARTRÉS, EAST, 51 MILES BELOW ST. LOUIS.

[Aug. 16—Sept. 12; Nov. 8—Dec. 12, 1916.]

Bank revetment, repair.—A pocket mattress, 436 linear feet (35,100 square feet), was built in an eddy which had destroyed the paving between stations 40 and 45+40, causing the bank to recede from 50 to 80 feet behind the original mattress. Repairs were also made between stations 27 and 60 (the lower end of the work); 3,000 cubic yards of earth were graded from the bank and 38,500 square feet of paving were placed.

TURKEY ISLAND, ILL., 52 MILES BELOW ST. LOUIS.

[Aug. 21—Sept. 18; Dec. 1—8, 1916.]

Bank revetment, repair.—Three pocket mattresses, varying in length from 60 to 500 feet, total length 800 feet (66,900 square feet), were built to check caves or slides at this locality. The bank above the mattresses was graded, 8,000 cubic yards of earth being removed, of which dredge *Fort Gage* removed 6,800 cubic yards during a period when not required for service in the steamer channel. The paving was completely repaired, 81,400 square feet being placed between stations 64+75 and 96+16, the lower end of the work.

LIBERTY ISLAND, MO., 82 MILES BELOW ST. LOUIS.

[Aug. 31—Sept. 30.]

Bank revetment, repair.—The point at Bishop Landing, Mo., was protected by 18,900 square feet of paving.

LIBERTY, MO., 83 MILES BELOW ST. LOUIS.

[Aug. 29—Sept. 28, 1916.]

Hurdles, repair.—The hurdles at this locality, which since construction in 1896 had become decayed and broken down at their outer ends, were repaired throughout lengths projecting beyond the accretions as follows: No. 1, 400 feet; No. 2, 300 feet; No. 3, 150 feet; No. 4, 30 feet; No. 5, 30 feet; No. 7, 15 feet; total, 925 feet. In all, 393 piles were driven and 42 stringers hung.

LIBERTY BEND, ILL., 84 MILES BELOW ST. LOUIS.

[Dec. 11—12, 1916.]

Bank revetment, repair.—Between stations 20 and 30, and 69 and 73, 7,000 square feet of paving were placed along 1,400 linear feet of bank.

UNION POINT, ILL., 100 MILES BELOW ST. LOUIS.

[Oct. 3, 4, and 23—Nov. 9, 1916.]

Hurdle No. 6, repair.—The outer end of this hurdle, last repaired in July, 1913, was strengthened for 50 linear feet with eight additional 3-pile clumps and three stringers.

Hurdle No. 9, new extension.—This hurdle was constructed in 1911 across the chute from the main high bank to the east bank of Craw-

ford Towhead, near its head; since then the towhead has gradually been washed away, exposing the outer root of the hurdle. To prevent further destruction, a shore protection mattress 445 feet in length was placed around the head of the towhead, and the hurdle was repaired and extended to the established channel limit, a distance of 350 feet. In all, 81,900 square feet of mattress, 15,800 square feet of paving, 315 piles, and 26 stringers were placed, and 700 cubic yards of earth were graded from the bank.

CRAWFORD, MO., 111 MILES BELOW ST. LOUIS.

[Sept. 25—Oct. 5, 1916.]

Hurdle, repair.—The hurdle at this locality, built in 1911, had become decayed and badly broken down, though suffering no recent diminution in length. It was strengthened throughout 375 feet at the outer end, or about three-fourths of the present hurdle length, by placing 214 piles and 16 stringers.

HANGING MOUNTAIN ISLAND, ILL., 113 MILES BELOW ST. LOUIS.

[Sept. 19—Nov. 10, 1916.]

Hurdle No. 9, extension.—The bank had receded 300 feet from the root of this hurdle, leaving it detached and likely to become obstructive to navigation. It was again connected to the bank on the continuation of the original line, and the new shore end was graded and paved. In this work 50,200 square feet of mattress, 12,400 square feet of paving, 227 piles, and 19 stringers were placed, and 3,800 cubic yards of earth were graded from the bank.

Hurdle No. 10, repair.—To strengthen the outer end of this hurdle, 40 piles were driven; the accumulated drift was evenly distributed along the upstream side, overlaid with woven wire fencing (2,800 square feet) and ballasted with stone.

Hurdle No. 11, repair.—The T head was repaired by placing two piles and two stringers; six clumps were recabled.

Bank protection.—In order to protect the bank, which had receded 150 feet from the section of mattress placed May, 1914, 1,500 feet above hurdle No. 9, a short connecting hurdle was built between the old mattress and shore, in which were placed 42,000 square feet of mattress, 7,100 square feet of paving, 230 piles and 16 stringers, and 1,500 cubic yards of earth were graded from the bank.

DEVILS ISLAND, ILL., 126 MILES BELOW ST. LOUIS.

[Oct. 2—Nov. 11, 1916.]

Bank protection.—The bank had been caving rapidly in this locality, at the place known as Measels Field, about midway along the island. A mattress was placed along the front in 1897, but the bank continued to cave from the lower end of this mattress (station 151) to the timber above (station 118), and the mattress was detached from the shore, the maximum bank recession being 600 feet. In 1911 a spur hurdle was built at station 139 to connect the detached mattress to the bank, and in 1913 a mattress was begun at station 151 and continued downstream to hurdle No. 11 (station 201+70), near the foot of the island. The spur hurdle had recently caved off, and

the continued caving menaced the head of the protection of 1913. In order to correct this, a short section of mattress, 230 linear feet (26,600 square feet), was placed at the upper end of the caving bank between stations 118 and 120+30, and a larger section, 1,170 linear feet (139,900 square feet), between stations 134+28 and 145+98. The bank along the sections of mattress was graded, 19,900 cubic yards being removed, and was paved to the top—equivalent to the 30-foot, bank-full stage, except near the center of the large cave, which was reached with difficulty because of shoal water; here the paving was completed to the 20-foot stage. There were placed 80,700 square feet of paving, and minor repairs also were made to the old paving near the head of the island (stations 83+70 to 86+80), where small slips had occurred.

PRICE LANDING, MO., 153 MILES BELOW ST. LOUIS.

[Dec. 5-7, 1916.]

Bank revetment, repair.—Along 1,100 linear feet of bank between stations 116 and 192+30, 16,600 square feet of paving were placed; a small pocket mattress (1,900 square feet) was placed in a cave or slide at the extreme lower end of the work, between stations 191+75 and 192+30.

BEECHBRIDGE, ILL., 170 MILES BELOW ST. LOUIS.

[Dec. 1-4, 1916.]

Bank revetment, repair.—Between stations 63 and 105, 20,600 square feet of paving were placed along 2,800 linear feet of bank.

CAIRO PROTECTION, ILL., 177 MILES BELOW ST. LOUIS.

[Nov. 12-28, 1916.]

Bank revetment, repair.—Along 2,100 linear feet of bank between stations 57+55 and 96+25, 30,300 square feet of paving were placed; a pocket mattress, 275 linear feet (25,800 square feet), and a spur hurdle (27 piles, 4 stringers) were placed in a large circular cave between stations 93+50 and 96+25.

GREENFIELD BEND, MO., 181 MILES BELOW ST. LOUIS.

[Nov. 24-29, 1916.]

Bank revetment, repair.—Between stations 5 and 81, 29,700 square feet of paving were placed along 1,200 linear feet of bank, that between stations 68 and 81 being raised to a 25-foot stage, Cairo gauge.

CONSTRUCTION WORKS—CONTRACT.

KASKASKIA ISLAND, ILL., 90 MILES BELOW ST. LOUIS.

[Aug. 14-Dec. 15, 1916.]

Bank revetment, new.—Under contract with Rust & Swift, of St. Louis, the construction of subaqueous mattress, discontinued in March, 1916, because of high river stages, was resumed, and 3,960 linear feet (500,400 square feet) were built between stations 146+15

and 185+75. Four "pocket" mattresses (30,700 square feet) were built in irregular places in the bank between the same limits. The bank was graded for stone paving between stations 146+30 and 180, 182+70 and 183+10; between stations 180 and 182+70 the grading was partially completed, and from station 183+10 to the end of the mattress, station 185+75, no grading was done. Paving was completed between stations 146+30 and 178+25, thence to the end of the mattress it was raised only to the 5-foot stage; in addition, 27,000 square feet of paving were placed over the lower edge of previously placed mattress, which was exposed during the prevailing low stages, making a total of 296,000 square feet.

The original contract was for 10,000 linear feet of revetment, of which 8,590 linear feet has been partially completed. The rate of progress being slow and the amount remaining to be done comparatively small (15 per cent), the contract was terminated on December 15, 1916.

DREDGING.

Good boating stages and ample depths for navigation prevailed until the 1st of August, when the stage having fallen to 12 feet, St. Louis gauge, channel depths were reduced to such an extent that several crossings threatened to become obstructive to 8-foot navigation. The two self-propelling dredges *Fort Gage* and *Fort Chartres* were thereupon placed in commission for the season's work. The *Selma*, nonpropelling, was also placed in service the latter part of August. The fourth dredge (*Thebes*, nonpropelling) was placed in commission September 28, to relieve the *Selma*, owing to the latter's need of engine repairs, and remained in service until October 20, when it in turn was relieved by the *Selma*.

Dredges were in commission and performed service as follows: *Selma*, August 28 to September 28, and October 20 to December 1 (75 days), dredged 1 channel bar, 18 days, and approach to Illinois Southern Railway incline at Little Rock, Mo., 8 days; *Thebes*, September 28 to October 20 (23 days), dredged 1 channel bar, 6 days, and approach to steamboat landing at Grand Tower, Ill., 8 days; *Fort Gage*, August 3 to December 22 (142 days), dredged 8 channel bars, 40 days, winter harbor for floating plant of the district at Graysboro, Mo., 7 days, and graded bank for revetment, 8 days; *Fort Chartres*, August 1 to December 20 (142 days), dredged 12 channel bars, 58 days, and at Chain of Rocks new intake tower, North St. Louis, 9 days. Work performed by the dredges outside the channel was done in the interests of navigation, at times when the navigable depth was ample and dredging in the main channel was not required; the total cost of the work performed at Chain of Rocks was borne by the city of St. Louis.

All other dredging was for the maintenance of the required depth (8 feet) in the steamer channel between St. Louis (0) and the mouth of the Ohio River (183).

The four dredges were operated in the main steamer channel for a total of 1,040 hours, a little more than one-ninth of their total time in commission, and maintained a good 8-foot channel throughout the district during the low-water season until navigation was stopped by ice, December 14. The two self-propelling dredges were also used to

assist the one towboat in commission to deliver materials and supplies and to patrol and sound the steamer channel throughout the district.

Sixteen main channel bars were dredged, of which two were dredged twice and two others a third time. Beneficial results were obtained in all these channels, the gain in depth varying from $2\frac{1}{2}$ to $6\frac{1}{4}$ feet. The total number of channels dredged through the 16 bars was 23, having a combined length of 7 miles and a width of 200 feet; the total amount of material removed from the main channel was 1,051,400 cubic yards in 1,040 hours actual dredging time, giving an average dredge rate of 1,000 cubic yards per hour. Other details are given in the following table:

Table of work done by U. S. dredges "Selma," "Thebes," "Fort Gage," and "Fort Chartres," during the fiscal year ending June 30, 1917.

Dredge.	Bars dredged.	Miles from St. Louis (Fads Bridge).	Inclusive dates.	Days dredging.	Actual dredging time.	Quantity dredged.	Total length cuts.	Dredged channel.			Gain in depth.
								Length.	Width.	Depth.	
1916.											
Fort Chartres	Chain of Rocks ¹	* 10	Nov. 20-Dec. 1	12	77	43,000	7,975	1,300			15
Do	Cliff Cave	13	Sept. 18-21	4	33	41,900	10,800	1,800			10 ¹
Do	do	13	De. 11-13	3	22	24,800	5,400	1,200			10 ¹
Do	Perry Towhead	40	Aug. 5-6	2	2	3,600	425				
Fort Gage	do	40	Aug. 9-11	4	41	62,000	6,800	1,400	200		11
Selma	do	40	Aug. 23-Sept. 8	7	55	41,900	7,900	1,400	200		9
Fort Gage	do	40	Oct. 10-13	4	28	22,400	5,000	900	225		10 ¹
Fort Chartres	Ames Towhead	43	Sept. 22-26	5	36	47,600	10,500	2,000	175		10 ¹
Selma	Litt. a Rock In Line ¹	57	O. L. 20-31	7	44	28,400	5,700	1,600	200		9
Fort Chartres	Sta. Genevieve Bend	62	Aug. 8-11	3	27	32,200	5,400	1,600	200		12
Do	Fort Gage	67	De. 5-8	4	32	42,300	7,100	1,900	250		10 ¹
Fort Gage	Bishop	82	Sept. 18-21	4	28	31,400	5,600	1,200	200		12
Do	Safety Six	85	Aug. 29-Sept. 2	5	46	51,000	7,900	1,400	200		11
Thebes	Grand Tower Landing ¹	103	O. L. 11-19	8	81	68,800	7,800	1,400	150		8
Fort Gage	Grand Tower	104	Sept. 5-11	10	58	31,500	9,200	2,400	180		9 ¹
Selma	do	104	Sept. 14-30	11	69	49,500	12,500	2,400	200		10
Thebes	do	104	O. L. 1-10	8	44	19,600	8,400	1,500	200		10
Fort Chartres	Grand Tower Is. and	104	Nov. 9-17	7	43	14,200	5,600	1,000	200		12
Fort Gage	Hines	105	Oct. 18-19	2	15	5,600	1,700	600			10 ¹
Fort Chartres	Bee Bluff	109	Sept. 21-26	5	61	44,900	8,800	1,500	225		13 ¹
Do	do	118	Aug. 28-Sept. 2	5	42	66,800	10,700	1,900	250		13 ¹
Do	Hamburg Is. and	117	O. L. 6-8	3	33	41,200	13,000	2,100	250		11
Do	Giboney Island	133	Sept. 29-O. L. 3	5	61	53,100	11,900	2,000	250		13 ¹
Fort Gage	Graysboro Harbor ¹	139	Nov. 14-20	5	48	77,400	15,400	2,700	225		10 ¹
Do	Sliding Island	159	Sept. 28-30	3	23	7,400	4,900	2,300			
Fort Chartres	do	159	Oct. 15-17	3	28	31,600	5,700	1,100	225		12
Fort Gage	do	159	Oct. 29-30	2	14	43,500	9,000	1,300	225		11
Fort Chartres	Erewar Point	166	Sept. 5-10	6	55	37,900	11,300	2,300	200		12
Do	Hurricane Field	173	O. L. 11-13	3	23	25,900	6,600	1,300	200		12
<i>Grading of river bank for retirement.</i>				155	1,300	1,199,000	233,900				
Fort Gage	Head Turkey Island	51	Aug. 21-28	8	26	6,800	1,037				

¹ Not in main channel.
² Above St. Louis; all other bars below St. Louis.
³ Not completed, due to ice in river.

⁴ Operations suspended: breakdown of main sand pump.
⁵ Computed by Thebes.
⁶ Dredged to 4 feet below extreme low water.

RIVER STAGE, ST. LOUIS GAGE.

During July the stage of the river followed closely the hydrograph of mean daily stage (a decline from 20 feet to 14.5 feet on the gage) and except for short and moderate rises in August, April, and May, and a flood of short duration in June, the stage for the remainder of the fiscal year was unusually low, being below the mean daily stage a total of 277 days and making new records for extreme low daily stage on 42 calendar days, between December 21 and March 14.

The above-mentioned flood was characterized by its symmetry of rise and fall, rising from 14.7 feet May 27, in almost a straight line, to the crest 32.9 feet June 14, and falling at a slightly less rate to 20.4 feet, slightly above mean daily stage, at the end of the year.

The average of all daily gage readings for the year was 9.8 feet, or 2.6 feet below the mean stage of river, 12.4 feet, derived from daily readings of 56 years' continuous records. The lowest stage, as shown in the following table, was 2.3 feet below gauge zero. Extreme low water (1900) is -2.53 feet and extreme high water (1844) is 41.3 feet. Elevation of gauge zero, 380 feet above mean sea or gulf level.

St. Louis gauge, 1916-17.

Date.	Highest monthly gage readings.	Date.	Lowest monthly gage readings.	Normal range, 56 years' continuous records.
1916.		1916.		
July 1.....	Feet. 21.5	July 31.....	Feet. 14.5	20.0-14.5
Aug. 17.....	17.0	Aug. 31.....	5.7	14.5-9.5
Sept. 1 and 2.....	5.0	Sept. 26 and 27.....	3.7	9.5-9.0
Oct. 30.....	4.0	Oct. 23 and 24.....	2.7	9.0-8.0
Nov. 24.....	4.0	Nov. 3, 4, and 0.....	3.9	8.0-7.0
Dec. 1.....	4.3	Dec. 23.....	2.2	7.0-5.5
1917.		1917.		5.5-7.0
Jan. 25 and 28.....	1.7	Jan. 1 and 2.....	-0.7	7.0-8.0
Feb. 21.....	3.5	Feb. 5.....	-2.3	8.0-11.5
Mar. 31.....	16.4	Mar. 3, 4, and 12.....	1.0	11.5-16.5
Apr. 30.....	23.3	Apr. 10.....	15.5	16.5-19.0
May 4.....	25.8	May 22 and 25.....	14.2	19.0-18.0
June 14.....	32.9	June 30.....	20.4	18.0-20.0

CHANNEL CONDITIONS.

Channel conditions were under the constant surveillance of the district towboats and dredges while in commission during the low-water season, from August 1 to December 24. During July and the following spring season, the steamers were not in commission, with the exception of one towboat employed in towing plant from Graysboro to St. Louis during the latter part of February and early part of March, and again, the latter part of May and early part of June.

During the fall season between the mouth of the Missouri River (-17) and St. Louis (0), the legally required 6-foot depth was maintained by natural action of the river; between St. Louis (0) and the mouth of the Ohio River (183), a channel of required dimensions, 8 feet depth and 200 feet width, was maintained, except for short periods of time at the nine localities hereinafter noted, where the

required dimensions were quickly obtained by dredging or by the action (natural scour) of the river itself.

The least depths observed throughout the year were as follows: In July high stages prevailed and channel depths were ample for navigation. In August, 5 to 6½ feet at Perry Towhead (40) 4th to 8th; 6 feet at Ste. Genevieve Bend (62) 4th to 10th; 7 feet at Seventy-six (93) 29th to 30th. In September, 7 feet at Giboney Island (133) 26th to 29th; 7 feet at Sliding Island (159) 27th to 28th; 7 feet on the 3d and 6 feet on the 4th at Brewer Point (166). In October, 7 and 8 feet at Cliff Cave (13) 23d to 25th. In November, 8 feet at Fort Gage (67) on the 30th. In December, 7 feet at Cliff Cave (13) 6th to 11th; 7 feet at Fort Gage (67) 3d and 5th; 7 feet at Hines (109) on the 14th. Ruling depths on other shoalest bars were not less than 8 feet. Navigation was stopped by ice on the 14th of December, and resumed on the 26th of February.

The U. S. steamer *King*, with tow of barges from Graysboro Harbor (below Grays Point, Mo., 139), arrived at St. Louis, February 27, river stage 1½ feet below standard low water, and reported a least depth of 7½ feet, on only one bar, for full 200 feet width of channel. On return trip, March 1 to 3, at same stage of water, the *King* ran through to Cairo, Ill., sounding all bars and found no depths less than 8 feet.

After the 12th of March the stages were higher and channel depths were equal to or greater than project requirements.

Steamer channel reports giving steering directions and least depths on bars, as ascertained by pilots of this office on through trips, were issued during the fall season to river vessels and the public through the Lighthouse Service.

SURVEYS, EXAMINATIONS, AND CHANNEL MARKS.

Surveys, general and special, covering about 33 miles of river, were made as required, and included all localities where construction works or dredging were in progress or immediately prospective; also where considerable changes due to caving banks and shifting channels had taken place. Dredged channels were marked with buoys and steering ranges in addition to the regular beacon lights of the Lighthouse Service.

PHYSICAL DATA.

The river gauges were maintained and read daily throughout the year and their records checked by being plotted on the official hydrograph.

During the year the river at St. Louis oscillated 41.5 feet, between stages 35.2 feet (June 14) above and 6.3 feet (February 5) below standard low water (4 feet, St. Louis gauge). The normal yearly oscillation is about 25 feet, from 23 feet above to 2 feet below standard low water.

At this particular time when special efforts are being made to revive river traffic, the following table showing available navigable depths throughout this district compiled from published data may prove of value:

Table showing the natural navigable depth of the Mississippi River between St. Louis, Mo., and Cairo, Ill., the average duration of stage and the volume of discharge, at selected stages on the St. Louis gauge.

Stage, St. Louis gauge.	Natural navigable depth.	Average duration of stage, days per year. ¹	Volume of discharge, M cubic feet per second. ²	Remarks.
<i>Feet.</i>	<i>Feet.³</i>			
2½	4	304	35	Extreme low water for open river navigation. ½ foot above mean annual low water, 2.2 feet.
5	5	356	50	
7½	6	317	75	¾ foot above the mean stage, 12.4 feet.
10	7	262	100	
12½	8	210	125	
15	9	162	110	
17½	10	127	195	
20	11	90	230	
22½	12	58	280	¾ foot above mean annual high water, 26.9 feet. Bank full stage (Weather Bureau).
25	13	35	340	
27½	14	18	420	
30	15	8	510	
	16	3	600	

¹ Derived from 48 years complete gauge records; the duration of stage is the average number of days annually that the stage is at or above the stage indicated. (Plate 2 of Atlas, Board on Examination and Survey Report, 1909.)

² From discharge curve at St. Louis 1897 to 1904. (Plate 5, opposite page 1610, Annual Report, Chief of Engineers, 1909.)

³ Bars rise with stage in the ratio of 1 to 2½. Straight line result of 377 least depths, obtained on 377 through trips 1890 to 1908, giving the average natural depth on bars at the stages shown; the data also indicate that the navigable depth may be as little as 5 feet at a 10-foot stage and 8 feet at a 20-foot stage (Plate 2 of Atlas, report, Board on Examination and Survey of Mississippi River, 1909, II. Doc. No. 50, 61st Cong., 1st sess.). By the use of four hydraulic dredges since 1907, the natural navigable depth of 3½ to 4 feet (p. 1116) has been increased about 4 feet, or to 8 feet, when navigation is not stopped by ice, as required by the project.

MATERIALS.

For the operation of steamboats and dredges and the permanent works of improvement—construction and repair of hurdle dikes and bank revetments—12,857 tons (2,000 pounds) of coal, at a cost of from \$1.40 to \$2.20 per ton, were supplied by contract; 52,691 linear feet (1,234 sticks) of pile timber, at a cost of 9½ cents per linear foot; and 27,554 cubic yards of stone and spalls, at from 68 to 75 cents per cubic yard, were purchased by agreement and in open market; 3,600 cords of brush were procured by hired labor at a field cost of \$1.65 per cord and loaded on Government barges.

In construction of bank revetment at Kaskaskia Island, under contract, 548,300 feet board measure of mattress lumber at \$34 per thousand, and 16,300 cubic yards of stone and spalls at \$1.59 per cubic yard were furnished and placed by the contractor in completed work.

All other materials, supplies, stores, subsistence, etc., were purchased under competitive bids therefor or in open market and were collected and tested at the engineer depot, St. Louis, Mo., and thence distributed to the various working parties. All coal was tested for payment on the British thermal-unit basis, also the following tests of samples of materials were made for other engineer offices: Rope, secretary's office, Mississippi River Commission; engineer offices, Cincinnati, Ohio, first district; San Francisco, Cal., third district; wire rope, secretary's office, Mississippi River Commission; glass, United States Lighthouse Bureau; and steel rails, engineer office, Rock Island, Ill.

Numerous inspections were made, as required, of materials and appliances purchased in this vicinity for the Panama Canal.

PLANT.

All plant required for service was maintained in condition by such repairs in ordinary upkeep as were necessary to fit it for present and future service. The towboats of this office, *William R. King* and *General J. H. Simpson*, three steel tenders, and two small wooden tenders were repaired. Repairs incident to active service were made to the four suction dredges and one dipper dredge; 500 feet of new pipe line (32-inch) were built for the two self-propelling suction dredges.

Repairs were made also to 9 quarter boats, 4 office and survey boats, 2 wood-hull derrick boats, 23 wood-hull barges, 14 steel barges, 14 wood-hull pile drivers, 2 steel-hull pile drivers, 2 steel-hull grader and derrick boats, to the steel flats, and steel and wooden skiffs. Repairs were made as required on the steamer *Oleander*, belonging to the Lighthouse Service, reimbursement for expenses incurred being made by that service.

The following plant was sold to other engineer districts: Mississippi River Commission, first and second districts, 4 quarter boats, 12 wood-hull barges, and 1 wood-hull pile driver; Kansas City, Mo., 2 wood-hull pile drivers.

The Little Rock quarry outfit, comprising engines, derricks, steam drills, tracks, trucks, portable buildings, etc., of no use in other branches of the work, were advertised by authority of the Chief of Engineers and sold to the highest bidder, the price realized being \$3,810.20.

Two old and much-worn dipper dredges, *Phoenix* and *Vulcan*, were purchased from the Rock Island engineer district, for use in removing gravel and bowlders from the shoal crossings. These vessels have wooden hulls 80 feet by 30 feet by 8 feet depth, dippers 12 yards capacity and 34 feet booms. These dredges were received late in the fall and repairs necessary to fit the *Phoenix* for service were not completed until the end of the working season. The hull of the *Vulcan* is in bad condition, but was procured mainly to furnish spare parts in future repairs of the *Phoenix*.

Extensive alterations and additions were made to the wheel, rudders, machinery, and boilers of the towboat *Nokomis*, and minor alterations and additions to the tunnel propeller boat *Inspector*, both loaned by the Mississippi River Commission for the use of the board on experimental towboats.

Five quarter boats and three office boats belonging to this office were prepared for service and loaned to the Twelfth Engineer Regiment in camp at Chain of Rocks, North St. Louis, as also were the two quarter boats loaned by the Mississippi River Commission.

The total amount appropriated from July 4, 1836, to March 4, 1915, is \$17,956,599.98, is shown on pages 488 and 490, House Document 1491, Sixty-third Congress, third session, under the following headings:

Illinois River to Ohio River.....	\$4, 110, 000. 00
Missouri River to Ohio River.....	13, 746, 599. 98
Missouri River to Meramec River.....	100, 000. 00
Total	17, 956, 599. 98

RIVERS AND HARBORS—ST. LOUIS, MO., DISTRICT. 2689

Appropriated by river and harbor act of July 27, 1916.....	\$350,000.00
Appropriated by river and harbor act of Aug. 8, 1917.....	350,000.00

18,656,599.98

Of the above total amount there was appropriated in the years 1836, 1837, and 1844 for pier near St. Louis and obstructions in harbor of St. Louis (not considered in previous project of 1872 nor existing project of 1881) the sum of.....

\$75,000.00

By the acts of 1872, 1874, 1875, 1876, 1878, 1879, 1880, 1882, 1890 there was allotted for work above the mouth of the Missouri River (not in the present district) the sum of.....

205,000.00

From the appropriation of 1879 there reverted to the Treasury the amount allotted by the act for Wittenberg, Mo.....

10,000.00

290,000.00

Leaving for work in the present district between the mouths of Missouri and Ohio Rivers under general acts for work in the district and special acts for work at certain localities in the district.....

18,366,599.98

Receipts from sales.....

146,570.32

Total..... 18,513,170.30

There was expended on the original project under the acts of June 10, 1872, to June 14, 1880, inclusive, \$1,495,000, and under the existing project of 1881 there has been expended to June 30, 1917, \$17,828,330.52. The amount unexpended June 30, 1917, is \$259,705.48. The river and harbor act of August 8, 1917, appropriated \$350,000, making a total of \$609,705.48. The outstanding liabilities June 30, 1917, are \$15,516.22, leaving \$594,189.26 available for the coming year, in addition to \$16,819.05 due from other appropriations.

Amount expended during fiscal year.....	\$337,170.18
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Reimbursable.....	75,741.48
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Net expenditures..... 261,428.70

APPROPRIATIONS,

[See II, Doc. No. 1491, 63d Cong., 3d sess., pp. 488 and 490.]

Under former projects, from July 4, 1836, to Mar. 3, 1881, inclusive, and under the following heads: Pier near St. Louis and obstructions in harbor of St. Louis, years 1836, 1837, and 1844, \$75,000; Illinois to Missouri Rivers, year 1872, \$25,000; Missouri River to Meramec River, year 1872, \$100,000; Missouri River to Ohio River, year 1873, \$200,000; Ohio River to Illinois River, years 1874, 1878, \$440,000; Illinois River to Ohio River, years 1875, 1876, 1879, 1880, 1881, \$1,450,000; channel opposite St. Louis, Mo., year 1876, \$29,000; ice harbor at St. Louis, Mo., years 1880, 1881, \$60,000; Cape Girardeau and Minton Point, years 1880, 1881, \$30,000, aggregating.....

\$2,400,000.00

Present project:

Aug. 2, 1882, Cairo to Illinois River.....	600,000.00
July 5, 1884, Illinois River to Ohio River.....	520,000.00
Aug. 5, 1886, Illinois River to Ohio River.....	375,000.00
Aug. 11, 1888, Illinois River to Ohio River.....	300,000.00
Sept. 19, 1890, harbor at St. Louis, Mo.....	182,000.00
Sept. 19, 1890, Illinois to Ohio River.....	400,000.00
July 13, 1892, Ohio River to Missouri River.....	525,000.00
Mar. 3, 1893, Ohio River to Missouri River.....	658,333.33
Aug. 18, 1894, Ohio River to Missouri River.....	758,333.33
Mar. 2, 1895, Ohio River to Missouri River.....	758,333.33
June 3, 1896, Missouri River to Ohio River.....	275,000.00

Present project—Continued.

June 4, 1897, Ohio River to Missouri River	\$478, 833. 83
June 9, 1897, preventing break in Mississippi River at Beech-ridge, Ill.	100, 000. 00
June 19, 1897, Ohio River to Missouri River	325, 000. 00
July 1, 1898, Ohio River to Missouri River	678, 833. 83
Mar. 3, 1899, Ohio River to Missouri River	678, 833. 83
June 6, 1900, Ohio River to Missouri River	100, 000. 00
June 13, 1902, Ohio River to Missouri River	650, 000. 00
Mar. 3, 1903, Ohio River to Missouri River	650, 000. 00
Apr. 28, 1904, Ohio River to Missouri River	650, 000. 00
Mar. 3, 1905, Ohio River to Missouri River	650, 000. 00
Mar. 2, 1907, Ohio River to Missouri River	250, 000. 00
May 27, 1908, Ohio River to Missouri River	250, 000. 00
Mar. 4, 1909, Ohio River to Missouri River	250, 000. 00
June 25, 1910, Ohio River to Missouri River	250, 000. 00
June 25, 1910, Ohio River to Missouri River	500, 000. 00
Feb. 27, 1911, Ohio River to Missouri River	1, 000, 000. 00
July 25, 1912, Ohio River to Missouri River	1, 000, 000. 00
Mar. 4, 1913, Ohio River to Missouri River	1, 000, 000. 00
Oct. 2, 1914, Ohio River to Missouri River	250, 000. 00
Mar. 4, 1915, Ohio River to Missouri River	300, 000. 00
July 27, 1916	350, 000. 00
Aug. 8, 1917	350, 000. 00

Total of appropriations..... 18, 656, 599. 98

Of the above total amount there was appropriated in the years 1830, 1837, and 1844, for pier near St. Louis and obstructions in harbor of St. Louis (not considered in previous project of 1872, nor existing project of 1881), the sum of..... \$75, 000

By the acts of 1872, 1874, 1875, 1876, 1878, 1879, 1880, 1882, 1890, there was allotted for work above the mouth of the Missouri River (not in the present district) the sum of..... 205, 000

From the appropriation of 1879 there reverted to the Treasury the amount allotted by the act for Wittenberg, Mo..... 10, 000

200, 000. 00

Leaving for work in the present district between the mouth of Missouri and Ohio Rivers, under general acts for work in the district and special acts for work at certain localities in the district..... 18, 306, 599. 98

Receipts from sales, \$146,570.32.

COMMERCIAL STATISTICS.

Season of navigation opened March 1, 1916, and closed December 15, 1916.

Arrivals and departures of steamboats and barges at St. Louis, Mo., during the calendar year 1916.

	Number.	Net tonnage.	Times arrived.
Steamboats.....	1	1, 200	8
Do.....	9	500-1, 000	500
Do.....	11	250-499	383
Do.....	9	100-249	324
Do.....	7	50-99	8
	37	.....	1, 221
Barges.....	11	600	16
Do.....	2	100-200	3
Total.....	13	.....	19

Passengers, 505,410.

IMPROVEMENT OF RIVERS AND HARBORS IN THE ST. LOUIS, MO.,
DISTRICT.

REPORT OF MR. WILLIAM S. MITCHELL, DISTRICT ENGINEER.

IMPROVEMENTS.

	Page.		Page.
1 Mississippi River between the Ohio and Missouri Rivers....	2725	2. Removing snags and wrecks from the Mississippi River below the mouth of the Mis- souri River, and from Old and Atchafalaya Rivers.....	2741

FOR DESCRIPTION OF IMPROVEMENTS IN THIS DISTRICT SEE PAGES 1155 TO 1162.

1. MISSISSIPPI RIVER, BETWEEN THE OHIO AND MISSOURI RIVERS.

OPERATIONS DURING THE FISCAL YEAR.

WORKS OF IMPROVEMENT.

New work was not done during the year. Maintenance and repair work only, in which standard forms of construction were used, was done by hired labor, as hereinafter described, from August 24 to December 8, 1917, February 19 and after February 26, 1918, at East Twin Hollows, Osborne Field, West Fort Chartres, East Fort Chartres, Turkey Island, Ste. Genevieve, Mo., Kaskaskia Island, Liberty Bend, Hanging Dog Island, and Devils Island. Three of the four suction dredges of this district were in commission during the low-water season, July 23 to December 9, and were operated on 17 obstructive main channel bars which developed during that time. A dipper dredge, purchased from the Rock Island engineer district in the fall of 1916, was placed in commission August 16 and, despite numerous breakdowns, worked the remainder of the low-water season on the gravel bar in Grand Tower upper crossing. Hydrographic surveys were made covering 68 miles of river, including all dredged channels, shoal crossings, and caving banks. River gauges were maintained and read throughout the year and were inspected and repaired as required. The plant was repaired and cared for at the St. Louis engineer depot and at fleet in winter harbor, Graysboro, Mo.

Materials were procured by contract and open-market purchases and by hired labor, as was deemed most advantageous to the department.

CONSTRUCTION WORKS—HIRED LABOR.

NOTE.—Station numbers, wherever shown herein, refer to an origin at the upstream end of the work at that locality. River stages, unless otherwise noted, refer to the St. Louis gauge. Origin of river distances is Eads Bridge, St. Louis, Mo.; all localities of work are downstream from St. Louis, unless otherwise noted.

TWIN HOLLOWES, EAST, MILES 14 TO 10.

[Oct. 17–Dec. 8, 1917, Feb. 19, and Feb. 26–June 26, 1918.]

Bank revetment, repair.—This work, protecting 11,400 linear feet of the left bank, extends from station 0+00, just below foot of Carroll Island and $13\frac{1}{4}$ miles below St. Louis, downstream to station 114+00. About one-half mile of this protection, destroyed by severe erosion in recent years, was restored and the entire work placed in a thorough state of repair. Three sections of mattress (total 3,050 linear feet, 296,430 square feet) were built and sunk between stations 28 and 62 in restoration of the original work. Several pocket mattresses in short lengths (total 430 linear feet, 50,330 square feet) were built to cover depressions in the paving between stations 24 and 32. The stone paving from stations 17 to 28 was carried to the 20-foot stage, thence to station 63 it was carried to the top of the bank, varying from 25-foot to 30-foot stages. In all, 346,760 square feet of mattress were built and sunk, 15,300 cubic yards of earth were graded from the bank, and 274,900 square feet of stone paving were placed.

OSBORNE FIELD, MILES 38 TO 40.

[June 27–30, 1918.]

Bank revetment, repair.—This work originally protected 11,800 linear feet of the left bank in the vicinity of Kemper Landing, 39 miles below St. Louis; 2,500 feet of the upper end, however, had been destroyed for a number of years (erosion checked by a spur dike at station 15), and recent erosion had severely damaged and threatened to totally destroy the lower 1,000 feet. At the end of the year preparations had been made to repair this lower section with mattress and paving; also, several small slips in the paving of the remainder of the section were to be repaired; 45 cords of brush had been cut and loaded on flats ready for the mat work.

FORT CHARTRES, WEST, MILES 48 AND 49.

[Dec. 5–8, 1917, Apr. 11–May 12, and June 1–27, 1918.]

Bank revetment, repair.—This work, protecting 4,900 linear feet of the right bank, extends from station 0+00 on head of Establishment Island, $47\frac{1}{2}$ miles below St. Louis, downstream to station 49+00, where it joins the Bruce Island revetment, 3,350 feet in length and at present nearly buried by accretions. Several small slips were repaired and the paving was carried to higher stages, 26 feet to 30 feet, between stations 0 and 49; 897 cubic yards of earth were graded from the bank and 120,850 square feet of stone paving were placed.

FORT CHARTRES, EAST, MILES 51 AND 52.

[Nov. 13-30, 1917, Mar. 28-Apr. 3, May 13-31, June 28-30, 1918.]

Bank revetment, repair.—This work, protecting 7,540 linear feet of the left bank in Fort Chartres Bend, extends from station —15+40, 50½ miles below St. Louis, downstream to station 60+00, where it joins the upper section of the Turkey Island revetment. Several slips in the original work between stations 10 and 60 were repaired; 1,890 cubic yards of earth were graded from the bank, and 64,715 square feet of stone paving were placed.

TURKEY ISLAND, MILES 52 AND 53.

[Dec. 1-4, 1917, and Apr. 4-10, 1918.]

Bank revetment, repair.—The upper section of this revetment is in continuation of the East Fort Chartres work and extends from station 60 on the head of Turkey Island, 51½ miles below St. Louis, downstream to station 96+16, thus protecting 3,616 linear feet of the left bank. Several small breaks or slips, between stations 65 and 90, were thoroughly repaired by grading 130 cubic yards of earth from the bank and placing 19,290 square feet of stone paving.

STE. GENEVIEVE, MO., MILES 62 AND 63.

[Oct. 1-16, and Oct. 28-Nov. 13, 1917.]

Bank revetment, repair.—The lower section of this revetment extends from station 0+00, 61½ miles below St. Louis, downstream to station 76+00, thus protecting 7,600 linear feet of the right bank. During recent years the bank was eroded back of the lower end of the work to such an extent as to threaten the total destruction of piling dike No. 25, a short distance below. To prevent further erosion, 92,240 square feet of mattress were built and sunk between stations 62 and 72; 430 cubic yards of earth were graded from the bank, and 47,600 square feet of stone paving were placed to stages varying from 12 feet to 15 feet.

KASKASKIA ISLAND, MILES 66 AND 70.

[Aug. 24-Oct. 27, 1917.]

Bank revetment, repair.—The upper section of this revetment, extending from station 100+00, 68½ miles below St. Louis, downstream to station 185+90, protects 8,590 linear feet of the right bank. Recent erosion having destroyed the greater part of both mattress and paving below station 163, that part of the work was restored and thoroughly repaired, including a second slip of the bank between stations 165 and 167; 178,075 square feet of mattress were built and sunk; 9,500 cubic yards of earth were graded from the bank and 103,425 square feet of stone paving placed.

LIBERTY BEND, MILES 86 TO 89.

[June 10-30, 1918.]

Bank revetment, repair.—This revetment, extending from station —5+00, 85 miles below St. Louis, downstream to station 160+50 (except for 150 feet of bank immediately above station 0+00) protects 16,400 linear feet of the left bank. Stretches of bank swept

bare of paving by the ice in recent years and containing small slips or breaks were repaired. In one of these slips, station 50+50 to station 51+25, a small section of foundation mattress, 3,375 square feet, was built and sunk. Between stations 20 and 50, 3,000 cubic yards of earth were graded from the bank, and 43,000 square feet of stone paving were placed to about the 30-foot stage. Work was in progress at end of year.

HANGING DOG ISLAND, MILES 113 TO 115.

[Oct. 22–Nov. 10, 1917.]

Hurdle dikes, repair.—Ice during the winter of 1916–17 had broken 135 linear feet of hurdle No. 9. This was repaired by driving 110 piles in 41 clumps and placing 9 stringers. Hurdle No. 10 was also repaired by driving 9 piles and placing 3 stringers; total linear feet repaired, 145.

DEVILS ISLAND, MILES 124 TO 127.

[Mar. 29–June 6, 1918.]

Bank revetment, repair.—This long revetment extends from station 0+00, 123½ miles below St. Louis, downstream, past hurdle No. 11, to station 201+70 and, including the hurdle dam (about 2,000 feet in length) at the head of the island, protects 22,170 linear feet of the left bank. In repairs this year four small sections of mattress, 178 feet, 115 feet, 250 feet, and 300 feet in length, were sunk at and below stations 132+50, 145+50, 149+50, and 153+50, respectively; a fifth small section was placed just below hurdle No. 11; total mattress placed, 57,730 square feet; 6,770 cubic yards of earth were graded from the bank and 74,415 square feet of stone paving were placed to medium high stages from stations 86 to 109 and 132 to 157.

DREDGING.

Good boating stages and ample depths for navigation prevailed throughout the district until July 23, when, the river stage having declined to 14½ feet, there appeared one or two bars with channel depths so reduced that dredging became necessary. Thereupon the two pipe-line hydraulic self-propelling dredges *Fort Chartres* and *Fort Gage* were placed in commission for the season's work. The pipe-line hydraulic nonpropelling dredge *Selma* and the dipper dredge *Phoenix* were placed in commission early in September. These four boats accomplished all dredging necessary for maintenance of required depth and width of channel throughout the low-water season. The fourth pipe-line hydraulic nonpropelling dredge *Thebes* was not needed in service.

The dredges, operating in two eight-hour shifts, were in commission and performed service as follows: *Selma*, September 11 to December 9 (90 days), dredged 2 channel bars, 35 days; approach to steamboat landing, Grand Tower, Ill., 6 days; and winter harbor for floating plant of district, Graysboro, Mo., 26 days. *Fort Chartres*, July 23 to December 8 (139 days), dredged 14 channel bars, 67 days;

winter harbor for floating plant of district, U. S. engineer depot, St. Louis, Mo., 7 days; approach to the Aluminum Ore Co.'s dock, East St. Louis, Ill., 4 days; and approach to the Illinois Southern Railway incline, Little Rock, Mo., 3 days. *Fort Gage*, July 27 to December 8 (135 days), dredged 6 channel bars, 21 days; exploration in a proposed dipper dredge channel opposite Grand Tower, Ill., 2 days; approach to steamboat landing, Grand Tower, Ill., 6 days; emergency channel in Ste. Genevieve Bend, in relief of barges of the Aluminum Ore Co., 1 day; approach to Illinois Southern Railway incline, Little Rock, Mo., 31 days; and approach to landing of Independent Stock Yards, St. Louis, Mo., 7 days. The dipper dredge *Phoenix*, September 7 to December 8 (93 days), partially improved the upper steamer channel across the Grand Tower bar (104); removing 4,300 cubic yards of gravel and bowlders therefrom.

The work done by the dredges outside the main steamer channel was in the interests of navigation and was done at times when dredging in the main channel was not required. All other dredging was for the maintenance of the project depth (8 feet) and width (200 feet) of channel between the mouth of Ohio River (183 miles) and St. Louis (0 mile); thence to the mouth of Missouri River (17 miles above St. Louis); no dredging was required to maintain the project depth of 6 feet.

The three suction dredges, operating in the main steamer channel for a total of 829 hours, or one-seventh of their total available time in commission (16-hour days), maintained an excellent 8-foot channel, St. Louis to Cairo, throughout the low-water season until navigation was stopped by ice, December 9. The two self-propelling dredges were also used to patrol, sound, and buoy the channel throughout the district and occasionally to assist the district towboat in delivering materials and supplies. Of the 17 main channel bars dredged, three were dredged twice and another thrice. Good results were obtained in all cases, the gain in depth varying from 3 to 7½ feet. The total number of channels dredged through the 17 bars was 22, having a combined length of 6 miles and an average width of 225 feet. A total of 840,000 cubic yards of material was removed from the main channel in 829 hours actual dredging time, giving an average rate of about 1,000 cubic yards per dredging hour. Other details concerning the dredging service are given in the following table:

Table of work done by U. S. pipe-line hydraulic dredges "Selma," "Fort Gage," and "Fort Chartres" and dipper dredge "Phoenix" during the fiscal year ending June 30, 1918.

Dredged.	Bars dredged.	Miles from St. Louis (Eads Bridge).	Inclusive dates.	Days dredg-ing.	Actual dredg-ing time.	Quantity dredged.	Total length of cuts.	Dredged channel.			Gain in depth.
								Length.	Width.	Depth.	
			1917.		Hours.	Cubic yards.	Feet.	Feet.	Feet.	Feet.	
Fort Gage	Independent stock yards ¹	3	Sept. 13-19	7	46	33,900	6,300	1,250	300	11	6
Fort Chartres	United States engineer depot ¹	4	Nov. 20-Dec. 1	7	35	11,700	2,400	1,550	70	12	4
Do.	Almshaus one dock ¹	4	Oct. 30-Nov. 5	4	22	9,100	1,700	600	600	15	3
Do.	Cliff Cave	14	Aug. 7-12	4	32	45,000	9,500	1,500	225	13½	5
Do.	Pulltight	14	Nov. 6-9	4	37	22,000	8,600	1,900	200	11	3
Fort Gage	Twin Hollows	15	Oct. 18-21	3	31	46,000	8,100	1,960	200	9	3
Fort Chartres	do.	15	Nov. 10-13	4	46	33,600	9,500	2,000	230	10½	4
Do.	Waters Point	23	Aug. 12-14	3	16	19,900	9,700	1,200	175	12	3
Do.	do.	23	Sept. 23-28	6	35	34,700	9,300	1,550	250	10½	4
Fort Gage	St. Nicholas Rock	35	Sept. 19-23	5	28	45,200	6,000	1,150	230	13½	3
Fort Chartres	Perry Towhead, upper	39	July 27-30	4	23	43,900	7,000	900	250	12	3
Do.	Kemper	39	Oct. 3-7	5	34	34,200	8,700	1,500	230	12	3
Do.	Perry Towhead, foot	40	Aug. 17-22	6	76	93,100	12,000	1,450	280	12	3
Do.	Danby Towhead	41	Oct. 8-11	4	18	22,400	6,900	1,000	250	10½	3
Fort Gage	Little Rock Incline ¹	57	Aug. 27-29, Sept. 1-10	8	47	43,400	8,500	1,250	250	10	3
Do.	do.	57	Oct. 26-Nov. 3, Nov. 20-28	23	234	230,400	32,000	1,500	1,300	8	3
Fort Chartres	do.	57	Nov. 15-17	3	35	33,400	6,700	1,800	340	12	3
Fort Gage	St. Genevieve Island	59	Oct. 7-10	4	24	29,800	4,200	900	200	10½	3
Do.	Moro Island	61	Sept. 24-27	4	27	37,500	5,500	1,100	200	13½	3
Fort Chartres	St. Genevieve Bend	62	Aug. 23-27	5	35	56,800	8,400	1,200	260	12	3
Fort Gage	do.	63	Aug. 31-Sept. 1	1	5	5,400	600	400	65	10	3
Fort Chartres	Cherokee Landing	70	Sept. 14-18	5	31	54,600	2,300	450	270	13	3
Do.	Le Cours Island	94	Aug. 29-Sept. 5	7	31	35,400	10,950	2,450	330	9	3
Fort Gage	Grand Tower Landing ¹	104	Aug. 9-14	6	44	62,200	6,000	800	250	12	3
Do.	do.	104	Oct. 8-13	6	38	16,900	3,900	700	240	10	3
Fort Gage	Grand Tower, upper ¹	104	Aug. 8-9	2	10	700	250	250	35	17	3
Phoenix	do.	104	Sept. 7-Dec. 8	52	356	4,800	1,000	500	25	12	3
Fort Chartres	Grand Tower	105	Sept. 6-11	6	30	29,500	5,300	850	270	11	3
Selma	do.	105	Sept. 10-Oct. 7	28	134	23,900	9,700	2,700	250	12	3
Do.	Crawford	110	Oct. 14-20	7	56	35,700	7,000	1,300	200	12	3
Do.	Graysboro Harbor ¹	139	Nov. 11-Dec. 9	28	153	20,600	11,900	3,000	150	8-14	4
Fort Gage	Brewer Point	166	Aug. 20-24	5	43	60,700	7,550	1,700	200	12	3
Do.	do.	166	Sept. 30-Oct. 1	1	6	5,500	1,100	1,100	35	10½	3
Fort Chartres	do.	166	Oct. 15-19	5	31	30,500	9,000	2,100	175	10½	3
Total				268	1,854	1,312,000	244,050				

¹ Outside the main channel. ² Dry bar removed to widen channel and stop caving of revetted bank. ³ Improved in depth but not completed.
⁴ Upstream from origin; all other bars downstream therefrom. ⁴ Trial cut for proposed dipper dredged channel. ⁵ 840,000 cubic yards from main channel.

RIVER STAGE, ST. LOUIS GAUGE.

The stage of the river was unusually low throughout the entire fiscal year, being below the mean daily stage except for 29 days (first 15 days of July, 6 days first part of April, and 3 days first part and 5 days middle part of June) and making new record for extreme low daily stage on 56 days (Sept. 22 to 29, Oct. 7 to Nov. 4, Dec. 10 to 17, Dec. 27 to Jan. 1, Jan. 3, 4, and 7 to 9); also new record was made for extreme low water, as hereinafter stated.

The average of all daily readings for the year was only 8 feet, or about 4½ feet below the mean stage of river, as derived from continuous daily readings for 57 years.

Extreme low water (1917), caused by ice conditions and shown in the following table, is 3.1 feet below gauge zero, and extreme high water (1844) is 41.3 feet on the gauge. Elevation of gauge zero, 380 feet above mean sea or Gulf level.

St. Louis gauge, 1917-18.

Date.	Highest monthly gauge reading.	Date.	Lowest monthly gauge reading.	Normal range 57 years' continuous record.
1917.		1917.		
	<i>Feet.</i>		<i>Feet.</i>	<i>Feet.</i>
July 2.....	22.3	July 31.....	12.5	20-14½
Aug. 1.....	11.9	Aug. 31.....	5.1	14½-10
Sept. 14.....	5.5	Sept. 29.....	2.6	10-9
Oct. 1 and 2.....	3.8	Oct. 15 to 20.....	1.8	9-8
Nov. 14.....	3.0	Nov. 1 and 2.....	2.1	8-7
Dec. 1.....	2.4	Dec. 30.....	-3.1	7-5½
				5½-7
1918.		1918.		
Jan. 25.....	5.4	Jan. 1.....	-2.8	7-8
Feb. 20.....	9.3	Feb. 6 and 14.....	2.8	8-11½
Mar. 31.....	16.5	Mar. 2 and 3.....	7.6	11½-16½
Apr. 6.....	18.9	Apr. 25.....	8.8	16½-19
May 31.....	17.0	May 11.....	8.2	19-18
June 12 and 13.....	20.7	June 24.....	13.9	18-20

CHANNEL CONDITIONS.

Channel conditions were under constant investigation and examination by towboats and dredges of the district during the low-water season, July 23 to December 9. During the greater part of July and the following spring season the district steamers were not in commission, with exception of one towboat employed during March and early April in towing plant from Kellogg and Graysboro winter harbors to the St. Louis engineer depot. A steam tender, however, was engaged during the spring in towing plant, materials, and supplies to the bank-revetment parties in the field.

Throughout the fiscal year the project depth of 6 feet between Missouri River (-17) and St. Louis (0) was maintained by the natural action of the river. Between St. Louis (0) and Ohio River (188) a channel of the required dimensions, 8 feet depth and 200 feet width, was maintained, except for very short periods during the low-water season, on the 13 bars shown in the following table, and across which the required dimensions were quickly obtained by dredging or by the natural scour of the river.

2732 REPORT OF CHIEF OF ENGINEERS, U. S. ARMY, 1918.

Channel depths less than 8 feet between St. Louis and mouth of Ohio River during the fiscal year ending June 30, 1918.

Item.	Crossing or bar.	Miles below St. Louis.	River stage (average).	Dates.	Number of days when depth was—				Remarks.	
					6 feet.	6½ feet.	7 feet.	7½ feet.		
1	Perry Towhead...	39	Feet. 14.3	1917. July 23-25.....				3	Dredged July 27-30, 1917.	
2	.....do.....	39	13.9	July 26-27..... August.....				2	Do. No depth less than 8 feet in August.
3	Cliff Cave.....	14	4.4	Sept. 6-10.....			[5]		10½-foot channel, opposite side of river found on 11th and probably developed before 6th; time is covered, however, by items 4 and 5.	
4	Lacours Island...	94	4.6	Sept. 7-11.....				5	Improved itself to 9 feet depth.	
5	St. Nicholas Rock	35	4.0	Sept. 6 and 17-19.....				4	Dredged Sept. 19-23.	
6	Moro Island.....	61	2.9	Sept. 22-24.....	3				Dredged Sept. 24-27.	
7	Brewer Point.....	166	2.7	Sept. 28.....				1	Dredged Sept. 30-Oct. 1; also improved itself.	
8	Crawford.....	110	1.9	Oct. 14.....				1	Dredged Oct. 14-20.	
9	Brewer Point.....	166	1.9	Oct. 15.....				1	Dredged Oct. 15-19.	
10	Twin Hollows.....	15	1.8	Oct. 17-18.....	2				Dredged Oct. 18-21.	
11	Snell Hollow.....	47	2.1	Oct. 25.....				1	Improved itself to 9 feet depth.	
12	Twin Hollows.....	15	2.8	Nov. 7-9.....				3	Dredged second time Nov. 10-13.	
13	.....do.....	15	2.8	Nov. 10.....				1	Do.
14	Hamilton.....	85	2.4	Dec. 1.....				1	Upper way; 8½ feet in lower way Dec. 3.	
15	Danby.....	41	1.9	Dec. 7.....				1	End of season; running ice eighth and ninth.	
Total shoals....					2	1	7	5	Total. 15	
Total days.....					5	1	15	8	29	

Navigation was stopped by ice December 10 and resumed February 24. The tender *Merameo* made one trip, however, through thick, running ice from Grand Tower (104) to St. Louis engineer depot (8) December 26 to 28, river stage 1 foot below zero of gauge, and found least depths of 5½ feet at Sawmill Hollow (97) and 6 feet at Moro Island (61); least depths on all other bars were 8 feet or greater.

The U. S. steamer *Nokomis*, going south from St. Louis, with a tow of eight heavily loaded barges, February 25 reported no depths, but the U. S. lighthouse tender *Oleander*, making trip from Cairo (185) to St. Louis (0) February 24 to 26, river stage falling from 8.1 feet to 7.1 feet, found a least channel depth of 12 feet, and since then fairly good boating stages have obtained (lowest 8.3 feet) and no channel depth less than 8½ feet has been reported.

Steamer channel reports giving steering directions and least depths on the bars, as ascertained by pilots of this office on through trips, were issued during the fall season to river vessels and the public through the Lighthouse Service.

SURVEYS, EXAMINATIONS, AND CHANNEL MARKS.

Surveys, general and special, covering 68 miles of river, were made as required and included all localities where construction works or

dredging were in progress or immediately prospective; also where considerable changes due to caving banks and shifting channels had taken place. Dredged channels were marked with buoys and steering ranges in addition to the regular beacon lights of the Lighthouse Service.

PHYSICAL DATA.

The river gauges were maintained and read daily throughout the year and the records were checked by being plotted on the official hydrograph.

During the fiscal year the river at St. Louis oscillated 25.4 feet between stages 21.3 feet (July 2) above and 4.1 feet (December 30) below low water 1 foot on St. Louis gauge. The normal yearly oscillation is about 25 feet from 1 foot above to 26 feet above low water.

At the present time when special efforts are being made to revive river traffic the following table, compiled from published data and showing, for selected stages, the average natural depths available for navigation below St. Louis, may prove of value:

Table showing, for selected stages, the natural depths available for the navigation of Mississippi River between St. Louis, Mo., and Cairo, Ill., the average duration of stage and the volume of discharge.

Stage St. Louis gauge.	Natural navigable depth.	Average duration of stage, days per year. ¹	Volume of discharge, M cubic feet per second. ²	Remarks.
<i>Fect.</i> 0	<i>Fect.</i> ³ 4	364	35	Extreme low water for open river navigation. ½ foot above mean annual low water, 2.2 feet.
2½	5	356	50	
5	6	317	78	
7½	7	262	100	
10	8	210	125	
12½	9	162	160	¾ foot above the mean stage, 12.4 feet.
15	10	127	195	
17½	11	90	230	
20	12	58	280	
22½	13	35	340	
25	14	18	420	¾ foot above mean annual high water, 26.9 feet. Bank full stage (Weather Bureau).
27½	15	8	510	
30	16	3	600	

¹ Derived from gauge records for 48 years, duration of stage is the average number of days annually but not continuously that the stages of river are at or above the stage indicated. (Plate 2 of Atlas, Board on Examination and Survey Report, 1909.)

² From discharge curve at St. Louis, 1897 to 1904. (Plate 5, opposite p. 1610, Annual Report Chief of Engineers, 1909.)

³ Bar crests rise with stage in the ratio of 1 to 2½. Obtained from least depths on 377 through trips 1896 to 1908, giving the average natural depth on bars at the stages shown; the data also indicates that the natural navigable depths may vary widely as from 8 feet at a 5-foot stage to only 5 feet at a 10-foot stage, or from 15 feet at a 20-foot stage to only 8 feet at a 26-foot stage. (Plate 2, Atlas, Report, Board on Examination and Survey of Mississippi River, 1909, H. Doc. No. 50, 61st Cong., 1st sess.) By the use of four hydraulic dredges since 1907, the maximum usable low-water depth of 3½ to 4 feet has been increased fully 4 feet, or to the 8 feet required by the project.

MATERIALS.

For the operation of steamboats and dredges and for the permanent works of improvement—construction and repair of hurdle dikes and bank revetment—14,667 tons (2,000 pounds) of coal, at \$2.45 to \$4.75 per ton, were purchased by contracts and in open market; 34,199 cubic yards of stone and spalls, at 70 cents to \$1.15 per cubic yard, were purchased by agreement and in open market;

4,163 cords of brush were procured and loaded on Government barges by hired labor, at a field cost of \$2.85 per cord.

All other materials, supplies, stores, subsistence, etc., were purchased under competitive bids or in open market and were collected and tested at the Engineer depot, St. Louis, Mo., and thence distributed to the various working parties.

Testing and inspection of materials and other work for Engineer offices and other departments of the Government were as follows: Secretary's office, Mississippi River Commission; second district, Cincinnati, Ohio; Rock Island, Ill.; Kansas City, Mo.; Panama Canal; general Engineer depot, Washington, D. C.; United States Weather Bureau; United States Lighthouse Department.

PLANT.

All plant required for service was maintained in working condition by such repairs as were necessary for present and future service.

For the experimental towboat board extensive alterations and repairs were made to the boilers, machinery, propelling wheel, and deck house of the towboat *Wm. R. King*, belonging to this Engineer district, and ordinary repairs to the towboats *Inspector*, *Nokomis*, and *Sachem*, belonging to the Mississippi River Commission.

Extensive repairs were made to the boilers of dredge *Thebes*. Repairs incident to active service were made to the towboat *Gen. J. H. Simpson*, three steel tenders, four suction dredges, and one dipper dredge. Ordinary repairs were made to the snag boats *J. N. Macomb* and *H. G. Wright*, the lighthouse tender *Oleander*, and the two suction dredges *Robert McGregor* and *H. S. Taber* en route from the Arkansas River to service on the Missouri River, expenses incurred by each being paid for by return from the proper appropriation.

Repairs were made also to 5 quarterboats, 3 office and survey boats, 1 storeboat, 11 wooden barges, 25 steel barges, 4 wooden pile drivers, 3 steel pile drivers, 2 steel grader and derrick boats, 1 wooden derrick boat, 35 steel flats, and 22 skiffs.

Two wooden pile drivers, *Nos. 1 and 3*, were sold to the Kansas City Engineer district, and one unserviceable barge, *No. 118*, was sold to the Eagle Packet Co., St. Louis, Mo. The quarterboats and office boats loaned to the Twelfth Engineer Regiment, in camp at Chain of Rocks, North St. Louis, were returned to the St. Louis Engineer depot in July, 1917.

By direction of the Chief of Engineers steel barges were under lease to Edward F. Goltra, St. Louis, Mo., for commercial towing on Mississippi River, as follows: 6 in August, 10 in September, 12 in October and November, 16 December to April, inclusive, and 4 in May and June. The absence of so many barges seriously crippled the

urgent repair of construction works during both fall and spring seasons. To replace the leased barges in district work eight small barges were borrowed from the Kansas City district, but were received in December, too late to be of service, because of sudden closure of navigation by ice. They were returned on demand of that district early in March. A steel derrick boat also was leased to Mr. Goltra in November and December and a steel pile driver was leased to Sikes & Peterman, contractors for the St. Louis water-works, for service on piling dikes at the Chain of Rocks during the fall season.

The towboat *Gen. J. H. Simpson*, retired from service October 31 because of poor condition of the wooden hull, was condemned May 9, as was also the old dipper dredge *Vulcan*.

After being released by the experimental towboat board, the towboat *Sachem* was used instead of the *Gen. J. H. Simpson* during the remainder of the low-water season and in March and early part of April, and was then returned to the Mississippi River Commission, departing for Memphis, Tenn., April 15. Thereafter the tender *Mera-meo* was in commission as already stated.

The buildings of the engineer depot at foot of Arsenal Street, St. Louis, Mo., were repaired and maintained in thoroughly serviceable condition as were all shop machinery, equipment, tools, and appliances, and boarding outfit. A railroad switch track through the yard of the engineer depot, for the sole use of the depot, was constructed in September and October by the Manufacturers Railroad in accordance with their agreement.

COMMERCIAL STATISTICS.

Season of navigation opened February 26, 1917, and closed December 10, 1917.

Arrivals and departures of steamboats and barges at St. Louis, Mo., during the calendar year 1917.

	Number.	Registered tonnage.	Times arrived.
Steamboats.....	1	1,479	4
Do.....	1	1,200	4
Do.....	12	500-1,000	416
Do.....	14	250-499	506
Do.....	13	100-249	323
Do.....	6	46-99	89
	47	.....	1,342
Barges.....	20	1,000	44
Do.....	30	600	48
Do.....	12	100-574	13
Total.....	62	.....	105

Passengers, 275,514.

2736 REPORT OF CHIEF OF ENGINEERS, U. S. ARMY, 1918.

Freight traffic for calendar year 1917.

Articles.	Amount in short tons.	Approximate value.	Average distance freight was carried.	Ton-miles.
			<i>Miles.</i>	
Bauxite ore.....	49,385	\$321,000	185	9,136,225
Coal.....	6,078	17,434	33	198,718
Cooperage.....	450	13,750	15	6,750
Cotton.....	777	310,800	185	143,748
Cotton seed.....	1,154	86,550	185	213,400
Fruit and vegetables.....	3,830	163,296	15	57,450
Garbage.....	49,250	49,250	8	394,000
Grain and products.....	11,495	770,165	45	517,821
Groceries and provisions.....	8,010	734,704	71	790,168
Iron ore.....	3,030	22,119	17	51,519
Iron and steel.....	4,061	243,660	23	92,336
Logs.....	31,541	788,525	149	4,696,054
Lumber.....	10,477	314,310	124	1,297,191
Live stock and products.....	10,181	1,527,150	61	621,607
Oils.....	8,184	489,840	184	1,507,778
Stone.....	32,891	32,891	43	1,404,935
Unclassified and miscellaneous.....	53,474	8,021,100	67	3,580,449
Railroad cars.....	9,000	1,500,000	185	1,665,000
Total.....	293,248	15,401,544		26,848,224

The reports indicate a falling off in shipments of cotton, fruits and vegetables, garbage, grain and products, groceries and provisions, iron and steel, and oils in 1917 as compared with 1916, and increases in bauxite ore, cooperage, cotton seed, iron ore, logs, lumber, live stock and products, railroad cars, and miscellaneous materials, the net gain in tonnage for 1917 over 1916 being 52,595 tons.

Ferry traffic for calendar year 1917.

Articles.	Amount in short tons.	Approximate value.	Average distance freight was carried.	Ton-miles.
			<i>Miles.</i>	
Automobiles.....	5,510	\$5,510,000		4,130
Brick.....	131	1,113		98
Cotton.....	600	240,000		450
Cotton seed.....	9,125	456,250		6,843
Coal and coke.....	2,713,654	6,784,135		2,035,239
Concentrates.....	48,763	3,188,945		36,564
Charts.....	221,142	77,399		165,857
Fruits and vegetables.....	12	600		9
Grain and products.....	229,902	15,403,434		172,427
Groceries and produce.....	113,415	8,606,125		85,062
Iron and steel, manufactured.....	81,855	4,911,800		61,392
Hay.....	461	9,220		346
Live stock and products.....	1,045	156,750		783
Lime and cement.....	34,707	347,070		26,030
Logs.....	8,650	216,250		6,487
Lumber.....	267,472	8,024,160		200,604
Oil.....	55,600	3,330,000		41,625
Stone, sand, and gravel.....	79,495	79,495		59,622
Unclassified and miscellaneous.....	350,148	52,522,200		263,611
Vehicles.....	65,410	13,082,000		49,057
Wines and liquors.....	74	8,880		56
Total.....	4,233,347	122,756,126		3,215,292
Sand barged.....	730,727	164,446	1.6	1,077,623

Passengers, 419,414.

Government materials transported.

Articles.	Amount in short tons.	Approximate value.	Average distance freight was carried.	Ton-miles.
			<i>Miles.</i>	
Brush.....	2,682	\$4,800	28	75,096
Piles.....	100	500	28	2,800
Stone.....	38,929	30,330	45	1,723,530
Coal.....	14,126	42,000	75	1,059,450
Ice.....	513	1,561	87	44,631
Groceries.....	150	23,000	87	13,050
Miscellaneous.....	100	5,874	87	8,700
Total.....	56,600	113,065		2,927,657

RECAPITULATION.

	Amount in short tons.	Approximate value.	Ton-miles.	Passengers.
Freight traffic.....	293,248	\$15,401,544	26,348,224	275,514
Ferry traffic.....	4,238,347	122,756,126	3,215,292	419,414
Sand barged.....	730,727	164,446	1,077,623	.....
Government materials.....	56,600	113,065	2,927,657	.....
Total.....	5,318,922	138,435,181	33,568,796	694,928

Statistics of freight and ferry traffic, sand barged, and Government materials transported, compiled from reports of steamboat and sand companies and official records.

Shipment of oil by river from the Standard Oil Co.'s refinery at Woodriver, Ill., was continued.

The Inland Navigation Co. continued operation during 1917 as far south as New Orleans.

The transportation of bauxite ore from the State of Arkansas to East St. Louis, Ill., for the manufacture of aluminum, which was discontinued in 1916, was resumed in 1917.

The lines of transportation in the district of the Mississippi River between the Ohio and Missouri Rivers during the calendar year 1917 were as follows: Plying north of St. Louis, Mo.: The Kansas City-Missouri River Navigation Co., Streckfuss Line steamers, Eagle Packet Co., steamer *Belle of Cahoun*, Northern Steamboat Co., Edward F. Goltra. Plying south of St. Louis, Mo.: Barrett Line, Huntington & St. Louis Towboat Co., Lee Line steamers, St. Louis & Tennessee River Packet Co., Inland Navigation Co., Eagle Packet Co., Kansas City-Missouri River Navigation Co., Aluminum Ore Co., Peterman-Miller Box Co., Beltz-Peterman Engineering Co., Morrison Ice & Fuel Co., Edward F. Goltra; also the Majestic Excursion Co., Columbia Excursion Co., and the Northern Steamboat Co., handling passengers only.

The published tariff rates per 100 pounds within the river districts, depending on distances the freight was carried, were as follows:

Between St. Louis, Mo., and Cairo, Ill.: First class, 25 to 35 cents; second class, 20 to 30 cents; third class, 15 to 25 cents; fourth class, 12 to 18 cents; fifth class, 10 to 15 cents; and sixth class, 10 to 12 cents.

Between St. Louis, Mo., and Alton, Ill.: First class, 18 cents; second class, 15 cents; third class, 12 cents; fourth class, 10 cents; fifth class, 8 cents; and a "special stock tariff" applying between St. Louis and points on the Illinois River.

The transportation by river of coal and iron ore between St. Louis, Mo., and St. Paul, Minn., and of railroad cars from St. Louis to New Orleans, La., was undertaken during the year by Mr. Edward F. Goltra with towboats and barges leased from the United States.

The permanent dock begun last year by the city of St. Louis at the foot of North Market Street is still under construction.

2738 REPORT OF CHIEF OF ENGINEERS, U. S. ARMY, 1918.

Total cost and work done to June 30, 1918.

HURDLES.

	New.	Restora- tion.	Repairs.	Cost.
Prior to July 1, 1917.....	Linear feet. 402,031	Linear feet. 38,597	Linear feet. 96,684	\$8,320,798.91
During fiscal year ending June 30, 1918—Hanging Dog Island, Ill.....			145	3,000.82
Total.....	402,031	38,597	96,829	8,323,799.73

BANK PROTECTION.

	Mattress.			Paving.			
	New.		Repairs.	Cost.	New.	Repairs.	Cost.
	Linear feet.	Square feet.	Square feet.		Square feet.	Square feet.	
Prior to July 1, 1917.....	356,909	43,371,300	4,984,370	\$2,635,284.82	20,044,579	6,132,665	\$2,696,065.01
During fiscal year ending June 30, 1918:							
Twin Hollows, East.....			346,760	31,717.99		274,900	36,471.31
Osborne Field, Ill.....				898.20			
Fort Chartres, West.....						120,850	17,583.60
Fort Chartres, East.....						64,715	13,362.79
Turkey Island, Ill.....						19,200	2,420.58
Ste. Genevieve, Mo.....			92,240	8,755.46		47,600	8,709.36
Kaskaskia Island, Ill.....			178,075	21,043.80		103,425	18,468.40
Liberty Bond, Ill.....			3,375	1,008.81		43,000	5,877.37
Devils Island, Ill.....			57,730	5,562.32		74,415	14,220.53
Total.....	356,909	43,371,300	5,662,550	2,704,271.00	20,044,579	6,880,860	2,813,199.00

RECAPITULATION.

Hurdles.....	\$8,323,799.73
Bank protection.....	6,517,470.00
Dikes and dams.....	691,893.46
Jetties.....	114,603.53
Dredging.....	2,337,761.44
Surveys.....	382,391.03
Total.....	17,367,919.19

PROPERTY.

	Value July 1, 1917.	Debits.	Credits.	Value June 30, 1918.
Steamers:				
Gen. J. H. Simpson.....	\$6,000.00	\$12,824.00	\$14,824.00	\$4,000.00
Wm. R. King.....	40,000.00	3,665.86	5,665.86	38,000.00
Dredges:				
Selma.....	51,000.00	12,528.93	15,028.93	48,500.00
Thebes.....	48,000.00	10,520.49	10,020.49	48,500.00
Fort Gage.....	113,000.00	33,190.11	39,190.11	107,000.00
Fort Chartres.....	111,500.00	33,057.35	37,557.35	107,000.00
Phoenix.....	1,000.00	9,310.35	9,310.35	1,000.00
Vulcan.....	1,000.00	805.70	1,405.70	400.00
Tenders:				
Isle de Bois.....	750.00		100.00	650.00
Aux Vases.....	750.00		100.00	650.00
Salvati.....	7,000.00	7,247.92	7,947.92	6,300.00
Kaskaskia.....	7,000.00	7,258.17	7,958.17	6,300.00
Meramec.....	7,850.00	9,860.30	10,360.30	7,350.00
Barges:				
Model (10).....	1,000.00	1,258.14	1,358.14	900.00
Steel (25).....	202,000.00	1,641.82	15,041.82	188,600.00
Flat (1).....	100.00	40.28	80.28	60.00
Store boats (2).....	1,500.00	63.32	263.32	1,300.00
Quarter boats (6).....	9,700.00	312.16	1,712.16	8,300.00
Office and survey boats (5).....	7,600.00	267.32	1,367.32	6,600.00

Total cost and work done to June 30, 1918—Continued.

PROPERTY—Continued.

	Value July 1, 1917.	Debits.	Credits.	Value June 30, 1918.
Pile drivers:				
Wood (9).....	\$17,300.00	\$458.91	\$5,858.91	\$11,900.00
Steel (4).....	25,400.00	213.05	1,613.05	24,000.00
Derrick boats, wood (2).....	3,150.00	266.09	716.09	2,700.00
Grader and derrick boats, steel (2).....	21,000.00	1,279.29	2,479.29	19,800.00
Derrick (1).....	500.00		200.00	300.00
Machine boat (1).....	90.00		65.00	25.00
Flats:				
Wood (52).....	1,924.00	8.00	296.00	1,636.00
Steel (63).....	62,750.00	742.45	4,392.45	58,100.00
Small boats:				
Wood (68).....	540.00	484.54	574.54	450.00
Steel (18).....	432.00		32.00	400.00
Portable quarters.....	185.00		20.00	165.00
U. S. Engineer Depot.....	8,000.00	6,274.45	7,274.45	7,000.00
Tools and appliances.....	15,200.00	8,232.48	8,292.48	15,140.00
Boarding outfit.....	5,100.00	1,989.14	2,089.14	5,000.00
Office furniture.....	1,400.00	113.90	243.90	1,270.00
Survey instruments.....	850.00	1.00	151.00	700.00
Total.....	780,571.00	163,815.52	213,490.52	730,896.00

MATERIAL.

Subsistence.....	\$2,599.00	\$46,719.16	\$48,075.16	\$1,243.00
Brush.....		11,873.78	11,784.78	94.00
Piles.....	502.00		502.00	
Stone.....	2,554.00	38,552.43	39,897.56	1,208.87
Rope.....	17,567.62	1,316.16	88.20	18,795.58
Wire.....	1,062.00		902.40	159.60
Iron.....	15,433.00	7,207.35	5,005.35	17,635.00
Nails.....	586.00	102.62	228.82	460.00
Spikes.....	550.00		25.60	524.40
Lumber.....	3,470.00	2,010.30	3,195.30	2,285.00
Oakum.....	200.00		97.50	102.50
Coal.....	3,141.00	47,801.25	48,434.25	2,508.00
Ice.....		2,060.21	2,060.21	
Material, miscellaneous.....	8,499.00	32,621.87	24,797.87	16,323.00
Total.....	56,163.62	190,270.34	185,095.01	61,338.95

EXPENDITURES.

The total amount appropriated from July 4, 1836, to March 4, 1915, is \$17,956,599.98, is shown on pages 488 and 490, House Document 1491, Sixty-third Congress, third session, under the following heading:

Illinois River to Ohio River.....	\$4,110,000.00
Missouri River to Ohio River.....	13,746,599.98
Missouri River to Meramec River.....	100,000.00
Total.....	17,956,599.98
Appropriated by river and harbor act of July 27, 1916.....	350,000.00
Appropriated by river and harbor act of Aug. 8, 1917.....	350,000.00
Appropriated by river and harbor act of July 18, 1918.....	100,000.00
	18,756,599.98

Of the above total amount there was appropriated in the years 1836, 1837, and 1844 for pier near St. Louis and obstructions in harbor of St. Louis (not considered in previous project of 1872 nor existing project of 1881) the sum of \$75,000.00
 By the acts of 1872, 1874, 1875, 1876, 1878, 1879, 1880, 1882, 1890 there was allotted for work above the mouth of the Missouri River (not in the present district) the sum of 205,000.00

2740 REPORT OF CHIEF OF ENGINEERS, U. S. ARMY, 1918.

From the appropriation of 1879 there reverted to the

Treasury the amount allotted by the act for Wittenberg, Mo.....	\$10,000.00	\$200,000.00
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Leaving for work in the present district between the mouths of Missouri and Ohio Rivers under general acts for work in the district and special acts for work at certain localities in the district.....	18,400,509.98
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Receipts from sales, \$180,751.71.

There was expended on the original project under the acts of June 10, 1872, to June 14, 1880, inclusive, \$1,495,000, and under the existing project of 1881 there has been expended to June 30, 1918, \$16,568,308.60. The amount unexpended June 30, 1918, is \$302,291.32. The river and harbor act of July 18, 1918, appropriated \$100,000, making a total of \$402,291.32. The outstanding liabilities June 30, 1918, are \$32,147.84, leaving \$370,143.48 available for the coming year, in addition to \$4,598.61 due from other appropriations.

Amount expended during fiscal year.....	\$344,913.97
Reimbursable.....	24,972.64

Net expenditures.....	319,941.33
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APPROPRIATIONS.

[See H. Doc. 1491, 63d Cong., 3d sess., pp. 488 and 490.]

Under former projects, from July 4, 1836, to Mar. 3, 1831, inclusive, and under the following heads: Pier near St. Louis and obstructions in harbor of St. Louis, years 1836, 1837, and 1844, \$75,000; Illinois to Missouri Rivers, year 1872, \$25,000; Missouri River to Meramee River, year 1872, \$100,000; Missouri River to Ohio River, year 1873, \$200,000; Ohio River to Illinois River, years 1874, 1878, \$440,000; Illinois River to Ohio River, years 1875, 1876, 1879, 1880, 1881, \$1,450,000; channel opposite St. Louis, Mo., year 1876, \$20,000; ice harbor at St. Louis, Mo., years 1880, 1881, \$60,000; Cape Girardeau and Minton Point, years 1880, 1881, \$30,000, aggregating.....

\$2,409,600.00

Present project:

Aug. 2, 1882, Cairo to Illinois River.....	600,000.00
July 5, 1884, Illinois River to Ohio River.....	520,000.00
Aug. 5, 1886, Illinois River to Ohio River.....	375,000.00
Aug. 11, 1888, Illinois River to Ohio River.....	300,000.00
Sept. 19, 1890, harbor at St. Louis, Mo.....	182,000.00
Sept. 19, 1890, Illinois to Ohio River.....	400,000.00
July 13, 1892, Ohio River to Missouri River.....	525,000.00
Mar. 3, 1893, Ohio River to Missouri River.....	658,333.33
Aug. 18, 1894, Ohio River to Missouri River.....	758,333.33
Mar. 2, 1895, Ohio River to Missouri River.....	758,333.33
June 3, 1896, Missouri River to Ohio River.....	275,000.00
June 4, 1897, Ohio River to Missouri River.....	673,333.33
June 4, 1897, preventing break in Mississippi River at Beech-ridge, Ill.....	100,000.00
June 19, 1897, Ohio River to Missouri River.....	325,000.00
July 1, 1898, Ohio River to Missouri River.....	673,333.33
Mar. 3, 1900, Ohio River to Missouri River.....	673,333.33
June 6, 1900, Ohio River to Missouri River.....	100,000.00
June 13, 1902, Ohio River to Missouri River.....	650,000.00
Mar. 3, 1903, Ohio River to Missouri River.....	650,000.00
Apr. 28, 1904, Ohio River to Missouri River.....	650,000.00
Mar. 3, 1905, Ohio River to Missouri River.....	650,000.00
Mar. 2, 1907, Ohio River to Missouri River.....	250,000.00
May 27, 1908, Ohio River to Missouri River.....	250,000.00
Mar. 4, 1909, Ohio River to Missouri River.....	250,000.00
June 25, 1910, Ohio River to Missouri River.....	250,000.00

Present project—Continued.

June 25, 1910, Ohio River to Missouri River.....	\$500,000.00
Feb. 27, 1911, Ohio River to Missouri River.....	1,000,000.00
July 25, 1912, Ohio River to Missouri River.....	1,000,000.00
Mar. 4, 1913, Ohio River to Missouri River.....	1,000,000.00
Oct. 2, 1914, Ohio River to Missouri River.....	250,000.00
Mar. 4, 1915, Ohio River to Missouri River.....	300,000.00
July 27, 1916.....	350,000.00
Aug. 8, 1917.....	350,000.00
July 18, 1918.....	100,000.00
Total of appropriations.....	18,750,500.98
Of the above total amount there was appropriated in the years 1836, 1837, and 1844, for pier near St. Louis and obstructions in harbor of St. Louis (not considered in previous project of 1872, nor existing project of 1881), the sum of.....	\$75,000
By the acts of 1872, 1874, 1875, 1876, 1878, 1879, 1880, 1882, 1890, there was allotted for work above the mouth of the Missouri River (not in the present district) the sum of.....	205,000
From the appropriation of 1879 there reverted to the Treasury the amount allotted by the act for Wittenberg, Mo.....	10,000
	200,000.00

Leaving for work in the present district between the mouth of Missouri and Ohio Rivers, under general acts for work in the district and special acts for work at certain localities in the district..... 18,466,500.98

Receipts from sales, \$180,751.71.

2. REMOVING SNAGS AND WRECKS FROM THE MISSISSIPPI RIVER BELOW THE MOUTH OF THE MISSOURI RIVER AND FROM OLD AND ATCHAFALAYA RIVERS.

OPERATIONS DURING THE FISCAL YEAR.

The work is now being done by the department's two large steel-hull snag boats *J. N. Maccomb*, built in 1874, and *H. G. Wright*, built 1881, fitted with necessary equipment and appliances and operated by Government employeés. These boats patrol the Mississippi River between Head of Passes (13 miles from mouth of South Pass) and mouth of Missouri River 1,265 miles, and 35 miles of Old and Atchafalaya Rivers to Melville, La.; total, 1,300 miles.

Description of the snag boats may be found in Annual Report Chief of Engineers, United States Army, 1895, page 2054 et seq.

At the beginning of the fiscal year both snag boats were laid up in ordinary at St. Louis, Mo., making annual repairs and awaiting a river stage low enough to resume snagging operations.

The *Wright* began active operations July 5, making three round trips from the mouth of Missouri River southward, the first to Natchez, Miss., and the second and third to Cairo, Ill., returning to St. Louis, March 27, where the boat was again laid up in ordinary till the end of the fiscal year, making annual repairs and extensive repairs, as hereinafter noted. The *Wright* was held at Cairo, Ill., from December 9 to March 19, assisting in the care of the steel barges leased to Edward F. Goltra and caught there in the ice, and aiding in the recovery of ballast car parts destined for France but lost from

IMPROVEMENT OF RIVERS AND HARBORS IN THE ST. LOUIS, MO.,
DISTRICT.

REPORT OF COL. WILDURR WILLING, CORPS OF ENGINEERS.

IMPROVEMENTS.

	Page.		Page.
1. Mississippi River between the Ohio and Missouri Rivers--	2803	2. Removing snags and wrecks from the Mississippi River below the mouth of the Missouri River, and from Old and Atchafalaya Rivers--	2823

FOR DESCRIPTION OF IMPROVEMENTS IN THIS DISTRICT SEE PAGES 1222 TO 2823.

1. MISSISSIPPI RIVER BETWEEN THE OHIO AND MISSOURI RIVERS.

OPERATIONS DURING THE FISCAL YEAR 1919.

WORKS OF IMPROVEMENT.

Maintenance of the existing regulation works—hurdle dikes and bank revetments—including such minor extensions as were required for that purpose, and in which the standard forms of construction were used, was continued by hired labor from July 1 to December 2, 1918, and after March 26, as hereinafter described, at Osborne Field, West Fort Chartres, East Fort Chartres, Turkey Island, Ste. Genevieve, Mo., Kaskaskia Island, Chester (Horse Island), Chester (Claryville), Liberty, Mo., Liberty Bend, Wilkinson, Union Point, Devils Island, Minton Point, Price Landing, Beechridge, and Eliza Towhead. Three of the four suction dredges of the district were in commission during the low-water season, July 21 to December 31, and were operated on 13 obstructive main-channel bars which developed during that time. The one dipper dredge belonging to this district was placed in commission September 20 and worked the remainder of the low-water season and from February 1 to March 18 on the gravel bar in Grand Tower upper crossing. Hydrographic surveys were made covering 125 miles of river, including all dredged channels, shoal crossings and caving banks. River gauges were read throughout the year and were inspected and repaired as required. The plant was repaired and cared for at the St. Louis engineer depot and at fleet in winter harbor, Graysboro, Mo. Materials were procured by contract and open-market purchases and by hired labor, as was deemed most advantageous to the department.

CONSTRUCTION WORKS—HIRED LABOR.

Note.—Station numbers (100 feet), wherever shown herein, refer to an origin at the upstream end of the work at that locality. River stages, unless otherwise noted, refer to the St. Louis gauge. Origin of river distances is Eads Bridge, St. Louis, Mo.; all localities of work are downstream from St. Louis, unless otherwise noted.

OSBORNE FIELD, MILES 38 TO 40, LEFT BANK.

[July 1–Oct. 1, 1918.]

Bank revetment, repair.—Work at this locality was in progress at end of fiscal year 1918 (p. 2726, A. R. 1918) and during the summer and fall seasons the following was accomplished: Foundation mattresses of brush, four small sections aggregating 34,530 square feet, were placed in repairs between stations 29 and 30, and 102 and 110; and at the lower end of the work, where an eddy had totally destroyed 600 feet of the protection and the bank had receded in crescent shape a maximum distance of 250 feet, another section of brush mattress, 370 feet in length and containing 29,600 square feet, was placed in the crescent between stations 112 and 114 to prevent further damage by the eddy. The downstream end of the work is now at station 114, 400 linear feet having been destroyed and not yet restored. Between stations 28 and 85, and 102 and 114, 4,200 cubic yards of earth were graded from the bank and 122,595 square feet of stone paving were placed in repairs between the 3-foot and 25-foot stages. Between stations 32 and 85, and 105 and 114, 1,950 cubic yards of earth were graded from the bank and 38,675 square feet of stone paving were placed in new extensions between the 25-foot and 30-foot stages.

FORT CHARTRES, EAST, MILES 51 AND 52, LEFT BANK.

[July 1–10, 1918.]

Hurdle dikes, repair.—A large amount of drift that had collected above hurdle dam No. $\frac{1}{2}$ was distributed and compactly massed together in the deep water above the hurdle. A mattress of brush and woven-wire fencing, 8,200 square feet, was then built over the drift, heavily ballasted with stone and sunk to the bottom, thus solidifying the structure and protecting its foundation.

FORT CHARTRES, EAST, MILES 51 AND 52, LEFT BANK.

[Aug. 17–29 and Oct. 2–9, 1918.]

Bank revetment, repair.—A small mattress, 9,050 square feet, was placed in repairs between stations 40 and 42; 450 cubic yards of earth were graded from the bank and 47,480 square feet of stone paving were placed in repairing several slips between stations 23 and 58, between the 1-foot and 30-foot stages.

FORT CHARTRES, EAST, MILES 51 TO 52, LEFT BANK.

[Oct. 10–11, 1918; Apr. 25–June 14, 1919.]

Bank revetment, repair.—The mattress and lower part of the paving of the lower section of this protection, 5,250 feet in length, was constructed in 1895, and in 1897 the paving was raised to a stage

fairly uniform between 10 and 15 feet; in 1902, the paving of the lower 1,600 feet, now buried in accretions, was raised to the 24-foot stage. Gradual erosion of the high bank behind the upper 2,000 feet has been going on for 12 years or more until the maximum recession between stations 0 and 10 is about 300 feet. To prevent further damage to the work and preserve the present good alignment of the river at this locality, a spur hurdle 250 feet in length was constructed at station 2+50, connecting the existing high bank with the substantial foundation of the old protection, near its upper end; 204 piles were driven, 69 clumps cabled and 5 stringers placed in its construction. While this work was in progress, several breaks which occurred in the upper section (p. 2727, A. R. 1918) were repaired with mattress and paving; some low stage work on this section was also done in the fall. The two sections are separated by 2,600 feet of unprotected bank. Altogether 36,400 square feet of mattress were built and sunk between stations 1 and 5 (lower section), and 105,600 square feet between stations 68 and 70, and 89 and 95 (upper section), a total of 142,000 square feet of brush mattress; 4,100 cubic yards of earth were graded from the bank; 14,700 square feet of paving were placed between stations 1 and 5, at end of spur hurdle, 21,000 square feet, between stations 68 and 70, and 89 and 95, between the 17-foot and 30-foot stages, and 7,460 square feet between stations 60 and 90, between the 1-foot and 5-foot stages—a total of 43,160 square feet of stone paving.

STE. GENEVIEVE, MO., MILES 59 TO 63, RIGHT BANK.

[July 11–Aug. 16, 1918; June 29–30, 1919.]

Hurdle dikes, repair.—Hurdle No. 25, at the lower end of the reach, was originally 1,575 feet in length; only a short spur and the bank root remaining, the repair to this hurdle would tend to preserve the present good bank alignment both above and below. At the shore end 17,000 square feet of brush mattress were placed, 100 cubic yards of earth were graded from the bank, and 14,500 square feet of stone paving were placed between the 6-foot and 30-foot stages. Near the outer end and in an angle where considerable drift had collected, a mattress, 1,800 square feet, was built over the drift and heavily ballasted with stone; considerable stone also was cast among the piling, which are no longer in clump formation but standing separately, due to decay of their tops and fastenings.

Bank revetment, repair.—Between stations 36 and 75, lower section, 1,050 cubic yards of earth were graded from the bank and 42,590 square feet of stone paving were placed in repairing numerous small slips between the 5-foot and 25-foot stages. At the end of the fiscal year a party had again been moved to this locality and preparations made to extend the paving of this section to higher stages.

KASKASKIA ISLAND, MILES 69 TO 72, RIGHT BANK.

[Oct. 26–Nov. 24, 1918.]

Bank revetment, repair and new.—For the last previous work, in 1917, see page 2727, Annual Report 1918. The upper or new section, 8,590 linear feet, and the lower or old section, 5,700 linear feet, are

separated by 3,400 feet of unprotected bank which has been gradually eroded until the adjacent ends of the two sections of revetment have suffered loss by this flanking action of the river. To protect both sections temporarily and prevent further loss until they can be united by a new section, repairs were made at the said adjacent ends as follows: Between stations 184 and 185+90 (lower end of new section), and 0 (upper end of old section) and 1+10, two small sections of brush mattress aggregating 17,325 square feet were placed. Between stations 168 and 185+90 (new) and 0 and 5 (old) 2,900 cubic yards of earth were graded from the bank and 23,875 square feet of stone paving were placed in restoring these sections of revetment and repairing several small slips, all between the 2-foot and 30-foot stages. Between stations 179 and 185+90 (new section) 8,875 square feet of stone paving were placed in new extension between the 20-foot and 25-foot stages, the latter contour being at the foot of the bluff top bank.

CHESTER (HORSE ISLAND), MILES 72 AND 73, RIGHT BANK.

[Nov. 25-29, 1918; June 16-30, 1919.]

Bank revetment, repair.—In the fall season 16,700 square feet of paving were placed in repairing several small breaks between stations 4 and 33, between the 4-foot and 28-foot stages. During the latter part of June and while the mattress was being built at Claryville, Mo. (the locality following), 2,975 cubic yards of earth were graded from the bank, and 7,550 square feet of paving were placed in repairs between stations 28 and 31, between the 20-foot and 32-foot stages; a total of 24,250 square feet of stone paving. Work was in progress at the end of the fiscal year.

CHESTER, MO. (CLARYVILLE), MILE 74, RIGHT BANK.

[June 15-30, 1919.]

Bank revetment, repair, and new extension.—The bank at this locality was protected in 1896 and 1897 with a mattress 3,310 feet in length and stone paving placed above it to the 20-foot stage. Since then no work has been done in the nature of repairs, and in the last five years the river has been gradually wearing away the bank above the top of the paving along its entire length.

The upper 500 feet of the protection had suffered most, being under a flanking action of the river around the foot of Horse Island. To prevent further damage and secure effectively the head of this important work, an upstream extension of the bank protection was begun at a point 1,050 feet above the head of the old work, and at the end of the fiscal year the mattress was nearly completed; 950 linear feet of brush mattress, 97,900 square feet, were built between stations -10 +50 and -1. After the mattress is completed and sunk the bank above it will be graded and paved to the top and the paving of the remainder of the section extended in height as may be required.

LIBERTY, MO., MILES 83 TO 86, RIGHT BANK.

[Mar. 26-May 3, 1919.]

Hurdle dikes, repair.—The hurdles at this locality were built in 1896, and last repaired in 1916; since then the piling has been broken down in several places, by ice and drift, and necessary repairs thereto

were made as follows: Hurdle No. 1, 100 linear feet; No. 2, 30 feet; No. 3, 45 feet; No. 4, 40 feet; No. 5, 115 feet; No. 7, 250 feet; No. 10, 300 feet; No. 15 (hurdle dam), 240 feet; total, 1,120 linear feet. In all, 534 piles were driven, 125 clumps cabled, and 5 stringers placed; also 12,200 square feet of drift were covered with brush mattress and sunk at the shore ends of Nos. 2, 3, and 7.

LIBERTY BEND, MILES 86 TO 89, LEFT BANK.

[July 1—Aug. 5, Nov. 29—Dec. 2, 1918; Apr. 18—May 25, 1919.]

Bank revetment, repair and new.—Work at this locality, in progress at the beginning of the fiscal year (pp. 2727–8, Annual Report, 1918), was continued until August 5; minor low stage repairs were made as required during the latter part of the fall season; between stations 45 and 136, numerous small breaks were repaired by placing 41,120 square feet of stone paving between the 3-foot and 28-foot stages. Along the lower half of this long protection the bank above the old paving was found sloped back by the action of the river and in good shape for extending the paving to higher stages with but little grading. This work begun in the fall was resumed and nearly completed in the spring when it was discontinued because of more urgent work at another locality. Between stations 43 and 159, 1,160 cubic yards of earth were graded from the bank and 146,700 square feet of stone paving were placed in new extensions between the 18-foot and 33-foot stages.

WILKINSON, MILE 93, LEFT BANK.

[Nov. 7–26, 1918.]

Bank revetment, repair.—The upper end of the protection work at this locality had been under a flank attack by channel waters during the last two years until 250 feet had been destroyed and the bank had receded about 150 feet. To prevent further damage the bank revetment was repaired and restored as follows: Between stations 100 (original head of work) and 104, 18,900 square feet of brush mattress were placed.

The bank above the mattress was graded (50 cubic yards) and paved with stone to hold a small neck of high ground, just above the mouth of the narrow slough at the lower end of Wilkinson Island, and the paving was also carried across the slough and connected with the old high bank paving; 18,000 square feet of stone paving were thus placed in repairs between stations 100 and 105, and in minor slips between stations 143 and 145; all between the 3-foot and 25-foot stages.

UNION POINT, MILES 109 AND 110, LEFT BANK.

[May 4–31, 1919.]

Hurdle dikes, repair.—Hurdle No. 9, 1,885 feet in length, built in 1911 and last repaired in 1916, was reinforced the greater part of its length and 3 small gaps were closed; 495 piles were driven and 158 clumps cabled in repairing 1,500 linear feet.

DEVILS ISLAND, MILES 124 TO 127, LEFT BANK.

[Sept. 1-28 and Nov. 8, 1918.]

Bank revetment, repair.—This work was repaired in the last fiscal year, March 29 to June 6, all urgent repairs then being made (p. 2728, A. R., 1918). To insure the safety of the head of the work placed in 1913, additional low-water repairs were required in September and November as follows: Between stations 143 and 148, and 153 and 154, two sections of brush mattress, aggregating 30,375 square feet, were placed; 700 cubic yards of earth were graded from the bank and 54,450 square feet of stone paving placed between the 3-foot and 22-foot stages. Work was discontinued in September because of more urgent work at Beechridge, Ill.

MINTON POINT, MILE 130, LEFT BANK.

[June 1-30, 1919.]

Hurdle dikes, repair.—Hurdle dikes Nos. 1 and 3, 1,000 feet and 1,900 feet in length, respectively, were built in 1904 for the purpose of removing a sand bar in front of Cape Girardeau, Mo. No. 3 was repaired in 1913, for a length of 360 feet at its outer end, but two small gaps near the shore end could not be repaired because of low stage of river, and since then have been increasing in size. The closing of these gaps being urgent and necessary for the preservation of the dikes and their accretions, and the stage of river being suitable therefor, the work was accomplished during the month of June; 651 linear feet of hurdle were repaired, 432 piles were driven, 153 clumps cabled, and 4 stringers placed and cabled. Drift that had accumulated near the shore end was covered with brush mattress aggregating 7,250 square feet, and the entire mass was sunk; also 300 cubic yards of stone were cast among the newly driven piles.

Work was completed the last day of the fiscal year and this party was moved to Hanging Dog Island (113-115), left bank, to repair the hurdles at that locality.

PRICE LANDING, MILES 153 AND 154, RIGHT BANK.

[Oct. 12-25 and Nov. 3-5, 1918.]

Bank revetment, repair.—Several slips in the paving, caused by the bar opposite making in very close, were promptly repaired before damaging erosion took place. Between stations 145 and 185, 25,425 square feet of stone paving were placed in repairs between the zero and 12-foot stages.

BEECHRIDGE, MILES 169 TO 171, LEFT BANK.

[Sept. 29-Oct. 25, 1918.]

Bank revetment, repair.—The protection at this locality had been damaged and in need of repairs for more than a year; the stage of the river being unusually low and an excellent opportunity thus offering, the following repairs were made in the fall season: A depression between stations 27 and 29 was covered with a brush

mattress containing 12,825 square feet; between stations 26 and 102, 650 cubic yards of earth were graded from the bank and 70,945 square feet of stone paving placed between the zero and 20-foot stages.

ELIZA TOWHEAD, MILES 175 AND 176, LEFT BANK.

[Oct. 26—Nov. 2, 1918.]

Bank revetment, repair.—An unusually low stage of river exposed portions of the mattress and paving that had been only lightly covered with stone; these places, between stations 58 and 100, were thoroughly repaired by placing 28,405 square feet of stone paving between the 2-foot and 15-foot stages.

DREDGING.

Although the stage of water was at times considerably below normal during the spring and early summer of 1918, good boating stages and ample depths for navigation prevailed throughout the district until the latter part of July; when, the stage having declined to 7 feet, channel depths were reduced to such an extent that several crossings threatened to become obstructive to 8-foot navigation. Thereupon the two self-propelling suction dredges *Fort Gage* and *Fort Chartres* and the *Thebes*, suction nonpropelling, were placed in commission for the season's work, followed by the dipper dredge *Phoenix* the latter part of September. These four dredges maintained the required depth and width of channel, throughout the low-water season, although river stages were abnormally low and new record for extreme low daily stage was made for 31 continuous days in September and October as hereinafter stated. The fourth suction dredge, the *Selma*, nonpropelling, was made ready for service and held in reserve ready to relieve any one of the three suction dredges in use should occasion demand, but its services were not needed.

The dredges, operated by Government employees in two 8-hour shifts, were in commission and performed service as follows: The *Fort Chartres*, July 21 to December 21 (154 days), dredged 12 channel bars, 47 days; approach to steamboat landing at Grand Tower, Ill. (104), 6 days; obstructive revetment at Salt Lake Towhead (43), 5 days; and harbor at United States Engineer Depot, St. Louis (4), 8 days. The *Fort Gage*, August 8 to December 1 (116 days), dredged 5 channel bars, 21 days; released barges of the Aluminum Ore Co. grounded at Chesley Island (20), and Herculaneum (30), 5 days; and aided snag boat in destroying wreck of sunken ore barge at Allen Towhead (146), 2 days. The *Thebes*, August 1 to October 29 (90 days), dredged 5 channel bars, 40 days. The *Phoenix*, September 20 to December 31, and February 1 to March 18 (149 days), dredged the Grand Tower gravel and boulder bar, upper way (104), 100 days; the work being 38½ per cent completed.

Work performed by the dredges outside the channel was done in the interest of navigation, at times when the navigable depth was ample and dredging in the main channel was not required; the work performed for the Aluminum Ore Co. was paid for by that company; all other dredging was for the maintenance of the project

depth (8 feet) and width (200 feet) in the channel between the mouth of the Ohio River (183) and St. Louis (0); thence to the mouth of Missouri River (17 miles above Eads Bridge) no dredging was required to maintain the project depth of 6 feet.

The three suction dredges operating in the main steamer channel for a total of 870 hours, a little more than one-seventh of their total available time in commission (16-hour days), maintained the required 8-foot channel throughout the low-water season with only slight delays to navigation (see channel conditions, page 17). The two self-propelling dredges were also used during idle intervals to assist the one small towboat in commission to deliver material and supplies and to patrol, sound, and buoy the channel throughout the district. Of the 13 main-channel bars improved by the suction dredges, two were dredged twice, another thrice, and two others, particularly troublesome, Danby Towhead (41) and Snell Hollow (47), were each dredged four times; the latter being finally abandoned by dredging a channel (Sycamore) above and across the river from this particularly bad bar. Good results were obtained in all cases, the gain in depth varying from 2 to 5½ feet. The total number of channels dredged through the 13 obstructive bars was 22, having a combined length of 6½ miles and an average width of 210 feet; the total amount of material removed from the main channel was 969,000 cubic yards in 870 hours actual dredging time, an average rate of fully 1,100 cubic yards per suction-dredge hour. Other details concerning the dredging service are given in the following table:

Table of work done by United States pipe-line hydraulic dredges "Thebes," "Fort Gage," and "Fort Chartres," and dipper dredge "Phoenix" during the fiscal year ending June 30, 1919.

Dredge.	Bars dredged.	Miles from St. Louis (Eads Bridge).	Inclusive dates.	Days dredging.	Actual dredging time.	Quantity dredged.	Total length of cuts.	Dredged channel.			Gain in depth.
								Length.	Width.	Depth.	
1918.											
Fort Chartres.....	United States Engineer depot ¹	4	Aug. 24, Dec. 13-21.....	8	32	19,200	2,900	300	45	12	5
Do.....	Twin Hollows.....	15	Oct. 29-31.....	4	24	33,800	6,700	1,000	300	10 ¹ / ₂	3 ¹ / ₂
Fort Gage.....	Chesley Island ¹	20	Sept. 13-15, 22.....	4	39	42,800	6,200	900	400	8	8
Thebes.....	Waters Point.....	23	Oct. 1-9.....	5	36	34,700	5,800	1,000	300	16	3
Fort Gage.....	Herculeum ¹	30	Sept. 12.....	1	3	4,600	400	100	300	12	3
Fort Chartres.....	Kemper.....	39	Nov. 30-Dec. 3.....	4	35	26,500	8,300	1,500	280	12	3
Do.....	Danby Towhead.....	41	July 21-24.....	4	32	38,300	7,500	1,500	250	12	4
Do.....	do.....	41	Aug. 17.....	1	10	8,800	2,900	1,000	170	11	3
Do.....	do.....	41	Dec. 4-7.....	4	28	26,200	8,300	1,500	250	10 ¹ / ₂	2
Thebes.....	do.....	41	Oct. 10-22.....	9	53	36,400	6,900	1,000	250	9	2
Fort Chartres.....	Salt Lake Towhead.....	42	Aug. 18-20.....	3	31	29,500	7,000	1,200	200	12	2
Do.....	Salt Lake Towhead (submerged revetment). Ames Towhead.....	43	Nov. 23-27.....	5	17	1,000	400	150	40	12	2
Do.....	do.....	43	Aug. 21-23.....	3	27	37,300	7,600	1,500	200	12	3
Do.....	do.....	43	Sept. 30-Oct. 3.....	4	35	49,600	7,000	1,900	200	9	3
Do.....	Sycamore.....	46	Nov. 14-22.....	7	53	89,500	12,200	1,800	250	12	5
Do.....	Small Hollow.....	47	July 26-29.....	4	45	75,700	10,900	2,100	250	12	3
Do.....	do.....	47	Oct. 4-8.....	4	31	42,500	6,000	1,900	180	9	3
Thebes.....	do.....	47	Sept. 18-26.....	8	76	41,700	11,900	1,800	250	9	2
Do.....	do.....	47	Oct. 23-29.....	5	20	12,500	3,200	800	150	10	2
Do.....	do.....	47	Aug. 8-27.....	13	88	61,400	13,700	1,600	250	10 ¹ / ₂	1
Fort Gage.....	Ste. Genevieve Bend.....	62	Oct. 16-18.....	3	26	25,900	6,500	1,200	200	9	4
Do.....	do.....	62	Oct. 21-23.....	3	30	35,900	6,000	1,300	250	10 ¹ / ₂	4
Fort Chartres.....	Crains Island.....	79	Oct. 18-22.....	5	29	48,900	7,900	1,500	230	10 ¹ / ₂	4
Fort Gage.....	Gills Point.....	99	Nov. 20-22.....	3	18	29,900	3,800	1,800	80	10 ¹ / ₂	2
Phoenix.....	Grand Tower, upper ¹	104	Sept. 25-Dec. 31; Feb. 1-Mar. 15.....	100	470	14,200	3,700	900	100	13	4
Fort Chartres.....	Grand Tower Landing ¹	104	Aug. 7-12.....	6	44	55,700	5,400	500	250	12	11
Fort Gage.....	Bee Bluff.....	118	Aug. 12-20.....	8	87	126,200	16,100	4,000	200	13	3
Do.....	Allen Towhead ¹	146	Nov. 30-Dec. 1.....	2	10	10,100	900	200	250	20	6
Do.....	Hurricane Field.....	173	Oct. 2-5.....	4	39	56,900	10,500	1,800	250	9 ¹ / ₂	3
Total.....				234	1,468	1,115,700	199,100	37,750	6,175		

¹ Outside the main channel.

RECAPITULATION.

	Days dredging.	Actual dredging time.	Quantity dredged.	Total length of cuts.	Rate per hour.
Fort Chartres (32-inch).....	66	473	<i>Cu. yards:</i> 582,500	<i>Feet.</i> 101,700	<i>Cu. yards</i> 1,230
Fort Gage (32-inch).....	28	252	332,300	50,800	1,318
Thebes (28-inch).....	40	273	186,700	42,900	684
Phoenix (dipper).....	100	470	14,200	3,700	30
Total.....	234	1,468	1,115,700	199,100	.....

RIVER STAGE, ST. LOUIS GAGE.

The stage of the river continued unusually low throughout the first half of the fiscal year and until the middle of March, being 2 feet to 8 feet below the mean daily stage line during that period, except for six days in September and six days in December, and making new record for extreme low daily stage for 31 continuous days, September 27 to October 27. After the middle of March, the stage advanced and remained above the mean stage line much the greater part of the remainder of the fiscal year.

The average of all daily readings for the fiscal year was 9.9 feet or 2.5 feet below the mean stage of river, 12.4 feet, as derived from all the daily readings (21,183) for the last 58 calendar years.

As shown in the following table, the river oscillated 26.6 feet between stages 25.9 feet (May 11) above, and 0.7 foot (January 5) below low water, 1 foot St. Louis gage. The normal yearly oscillation is about 25 feet from 1 foot above, to 26 feet above low water.

St. Louis gage, 1918-19.

Date.	Highest monthly gage readings.	Date.	Lowest monthly gage readings.	Normal range, 58 years' continuous record.
1918.	<i>Feet.</i>	1918.	<i>Feet.</i>	<i>Feet.</i>
July 3.....	17.4	July 28.....	7.2	20-15
Aug. 4.....	8.5	Aug. 18.....	4.7	15-9½
Sept. 6.....	14.2	Sept. 29 and 30.....	2.0	9½-9
Oct. 29.....	3.1	Oct. 7, 8, and 16-19.....	1.0	9-8
Nov. 13.....	8.2	Nov. 1.....	2.7	8-7
Dec. 25.....	6.0	Dec. 12.....	3.3	7-5
1919.		1919.		5-6
Jan. 30 and 31.....	6.5	Jan. 5.....	.3	6-8
Feb. 28.....	9.0	Feb. 15.....	2.9	8-12
Mar. 24.....	23.1	Mar. 13.....	3.0	12-17
Apr. 16.....	23.1	Apr. 11.....	15.6	17-19
May 11.....	26.9	May 31.....	16.1	19-18
June 7.....	24.4	June 3.....	14.8	18-19
				19-20½
				20½-20

Extreme low water (1917), caused by ice conditions, is 3.1 feet below gage zero; and extreme high water (1844) is 41.3 feet on the gage. Elevation of gage zero, 380 feet above mean sea or Gulf level.

CHANNEL CONDITIONS.

Channel conditions were constantly under investigation and examination by the snag boats, the small towboat *Meramec* and the self-propelling dredges of the district throughout the first half of the fiscal year and after January 20. Between the mouth of Missouri River (—17) and St. Louis (0) the project depth of 6 feet was maintained by the works of regularization aided only by the natural scouring action of the river itself. Between St. Louis (0) and the mouth of Ohio River (183) a channel of the required dimensions, 8 feet depth and 200 feet width, was maintained by the same agencies but aided by dredging, except for certain periods of time when the maximum depths available for navigation were as stated in the following table:

Channel depths less than 8 feet, between St. Louis and mouth of Ohio River, during the fiscal year ending June 30, 1919.

Item.	Crossing or bar.	Miles below St. Louis.	River stage (average).	Dates.	Number of days when depth was—				Remarks.
					6 feet.	6½ feet.	7 feet.	7½ feet.	
			<i>Fect.</i>	1918.					
1				July.....					No depth less than 8 feet.
2				August.....					Do.
3	Waters Point.....	23	2.7	Sept. 26-27.....				2	Dredged to 10 feet, Oct. 1-5.
4	do.....	23	2.3	Sept. 28.....			1		
5	do.....	23	2.0	Sept. 29-30.....			[2]	1	1 day covered by item 7.
6	Ames Towhead.....	43	2.2	Sept. 28-29.....			[2]	1	Dredged to 9 feet, Sept. 30 to Oct. 3; time covered by items 4 and 5.
7	do.....	43	2.0	Sept. 30.....			1		
8	Snell Hollow.....	47	4.3	Sept. 19-22.....				4	Dredged to 9½ feet, Sept. 19-26.
9	Twin Hollows.....	15	1.3	Oct. 18-25.....				[8]	Dredged to 10½ feet, Oct. 28-31; time covered by item 14.
10	Waters Point.....	23	1.7	Oct. 1-3.....			[3]		Dredged to 10 feet, Oct. 1-5; time covered by item 24.
11	Danby Towhead.....	41	1.3	Oct. 5-7 and 12-15.....			[3]	[7]	Dredged to 9 feet, Oct. 10-18; time covered by items 18 and 19.
12	Ames Towhead.....	43	1.8	Oct. 1-2.....				[2]	Dredged to 12 feet, Sept. 30-Oct. 3; time covered by item 24.
13	Snell Hollow.....	47	1.6	Oct. 1-4.....			4		Dredged to 9 feet, Oct. 4-7.
14	do.....	47	1.3	Oct. 5, 6, and 16-26.....			[3]	7	Dredged to 9 feet, Oct. 25-29; 6 days covered by items 17 and 19.
15	Ste. Genevieve Bend.....	62	1.4	Oct. 12-14.....				[4]	Dredged to 9 feet, Oct. 16-18; time covered by items 18 and 19.
16	do.....	62	1.2	Oct. 15-17 and 22.....				[3]	Time covered by items 14 and 19.
17	do.....	62	1.2	Oct. 19-21.....		3			Towboat Sprague grounded 18th and filled 9-foot; dredged channel to 6 feet; redredged to 10½ feet, Oct. 21-23.
18	Craigs Island.....	79	1.2	Oct. 5-13.....				[9]	7 Dredged to 10 feet, Oct. 18-22; 2 days covered by item 14.
19	do.....	79	1.1	Oct. 14-18.....		5			
20	Sawmill Hollow.....	97	1.3	Oct. 10, 11, and 24-26.....				[5]	Good towboat channel, improved itself; time covered by items 14 and 18.
21	do.....	97	1.3	Oct. 12-23.....				[12]	Good towboat channel, improved itself; time covered by items 14, 18, and 19.
22	Crawford Towhead.....	110	1.3	Oct. 13, 14.....				[2]	Good towboat channel, improved itself; time covered by items 18 and 19.
23	Powers Island.....	148	1.2	Oct. 7-15.....				[9]	Do.
24	Hurricane Field.....	173	1.7	Oct. 1-3.....			[3]		Dredged to 10 feet, Oct. 2-5; time covered by item 13.
25	Wilkinson.....	61	2.7	Nov. 1.....				1	Good towboat channel, improved itself.
26	Sawmill Hollow.....	97	2.7	do.....				1	Do.
27				December.....					No depth less than 8 feet.
				1919.					
28				January.....					Navigation closed by ice 3d to 19th; no depth less than 8 feet remainder of month.
29	Ames Towhead.....	43	3.3	Feb. 13-15.....				3	Immediate sharp rise made dredging unnecessary.
30	Snell Hollow.....	47	3.2	Mar. 10-12.....				3	Good towboat channel, improved itself; no depth less than 8 feet, Mar. 13 to June 30.
	Total shoals (26).....				1	5	11	9	
	Total days (43).....				3	11	19	10	

Although channel depths of less than 8 feet prevailed for an unusually long period in the low-water season, the latter part of September and the greater part of October, they were generally ample for the needs of navigation. One boat only—the large towboat *Sprague*—was delayed in this period by the reduced depths, and that after having grounded with two heavily laden barges, through misjudgment, in a dredged channel and destroying it in efforts to get off; being delayed four days until boilers of dredge could be repaired and the channel redredged. Failure in maintaining the required depth during this long period was due to: (a) Difficulty in securing proper working crews for the dredges, owing to disturbed labor conditions and an epidemic of influenza; (b) an unusual amount of boiler trouble on the dredges; and (c) the long continued and extraordinarily low stage of river.

Navigation was stopped by large floes of ice at St. Louis, January 2 and several days thereafter, and owing to backwater from the Ohio River these ice floes jammed and blocked the lower part of the district, below Grays Point (139), January 6 to 19; navigation throughout the district was resumed January 20, when the least channel depth was 10½ feet. Only one crossing in February and one in March had channel depths less than 8 feet, and these, for only three days each, were quickly improved by advancing river stages. Good boating stages prevailed after the middle part of March, and there were no delays whatever to navigation in the last half of the fiscal year because of insufficient channel dimensions.

Steamer channel reports giving steering directions and least depths on the bars, as ascertained by pilots of this office on through trips, were issued during the fall season to river vessels and the public through the Lighthouse Service.

The average natural depths, at selected stages, that are available for navigation between St. Louis, Mo., and Cairo, Ill., are given under Physical Data, page 2733, Annual Report, 1918.

SURVEYS, EXAMINATIONS, AND CHANNEL MARKS.

Surveys, general and special, covering 125 miles of river, were made as required and included all localities where construction works or dredging were in progress or immediately prospective; also where considerable changes, due to caving banks and shifting channels, had taken place. Dredged channels were marked with buoys and steering ranges in addition to the regular beacon lights of the Lighthouse Service.

PHYSICAL DATA.

The river gages were maintained and read daily throughout the year, and the records thereof were checked by being plotted on the official hydrograph.

MATERIALS.

For the operation of towboats and dredges and for use in maintenance of the works of improvement—hurdle dikes and bank revetments—there were procured under proposals and open market agreement 15,645 tons (2,000 pounds) of coal, at an average cost of \$4.53 per ton; 31,678 cubic yards of stone and spalls, at an average cost of \$1.37 per cubic yard; and 70,480 linear feet of pile

timber, at an average cost of 13.6 cents per linear foot; also 4,100 cords of brush were procured and loaded on Government barges by hired labor, at an average cost of \$3.35 per cord. These costs include plant charges.

All other materials, supplies, ship stores, subsistence, etc., were purchased under competitive bids or in the open market and were collected and tested at the Engineer Depot, St. Louis, Mo., and thence distributed to the various working parties.

Testing and inspection of materials and other work for Engineer offices and other departments of the Government were as follows: Secretary's office, Mississippi River Commission; second district, Cincinnati, Ohio; Rock Island, Ill.; Kansas City, Mo.; Wheeling, W. Va.; Panama Canal; General Engineer Depot, Washington, D. C.

PLANT.

All plant required for service was maintained in working condition, such repairs as were necessary for present and probable future service being made at the St. Louis Engineer depot.

Extensive alterations and repairs were made, for the Experimental Towboat Board, to the towboat *Nokomis* of the Mississippi River Commission, and it was transferred in September to the Mississippi River section of the Mississippi-Warrior Waterways of the United States Railroad Administration. Also on account of the said board, extensive alterations and repairs were made to the machinery and boilers of the district towboat *William R. King*; when not disabled by the defective and imperfect machinery that had been installed, this boat was used in towing plant, material, and supplies for the works and dredges of the district. Experimental trips of the *King*, made July 1 to August 7, were unsatisfactory and further alterations and repairs were made at the engineer depot; later trial trips, December 7 to 26, proved satisfactory. Six boilers (two 3-boiler batteries), formerly on this towboat, were sold to the Kansas City district, altered, repaired, and shipped thereto in November. Extensive repairs were also made to the snag boat *H. G. Wright* and steel barges *Nos. 19 and 20*; all three having been badly damaged by ice floes at Cairo Point (183) in January, 1918. Repairs incident to active service were made to three steel tenders, one dipper dredge, and the four suction dredges. Owing to defective boiler sheets the dredges *Fort Gage* and *Fort Chartres* were compelled to abandon operations periodically during the dredging season until temporary repairs could be made; these sheets were renewed in the spring season and all machinery and equipment of both boats placed in a thoroughly serviceable condition.

Ordinary repairs were made to the snag boats *J. N. Macomb* and *H. G. Wright*, the lighthouse tender *Oleander*, and the towboat *Lieut. Lewis*, the latter en route from the Kansas City district to the New Orleans district; extensive repairs were also made to six towboats, the *Choctaw*, *Nokomis*, *A. M. Scott*, *Advance*, *Oscar F. Barrett*, and *Inspector*, in the service of the Mississippi River section of the United States Railroad Administration; all expenses incurred being charged to the proper appropriation. Repairs were made to 5 quarterboats, 3 office and survey boats, 1 storeboat, 6 wooden barges, 25 steel barges, 9 wooden piledrivers, 3 steel piledrivers, 2 steel grader and derrick boats, 2 wooden derrick boats, 11 steel way flats, and 12 skiffs, all of

this district. The self-recording river gage on the Eads Bridge was overhauled and repaired for the United States Weather Bureau.

Two quarter boats, Nos. 4 and 8, and three wooden pile drivers, Nos. 26, 32, and 33, were transferred to the Memphis office September 7; and quarter boat No. 7, on the bank since 1914, was condemned and wrecked; leaving on hand, three quarter boats in good order, and six wooden pile drivers, all in fair condition except that the pumps have been removed from three, for use on towboats. Of the 16 steel barges leased by this office to Edward F. Goltra, St. Louis, Mo., for commercial towing on the Mississippi River, the last four (see A. R., 1918, p. 2734), were returned October 2. Twenty steel barges of this office were leased, 6 in September, 10 in October, and 4 in November, to the Mississippi River section of the United States Railroad Administration and remained in that service at the end of the fiscal year; in partial exchange therefor, 8 wooden barges were received from the said river section in September and remained in the service of the district at the end of the year. Needed repairs to the latter barges when received were made at the engineer depot and charged to the said river section.

Wooden barge No. 209, the steam tenders *Isle De Bois* and *Aun Vases*, and the hull and cabin of the towboat *Gen. J. H. Simpson*, all previously condemned, were sold, and the dipper dredge *Vulcan*, also condemned, was dismantled, the machinery removed, and the hull sunk in deep water. Twenty-six wood flats were condemned and wrecked, leaving 26 on hand, all in poor condition; 8 skiffs and 6 yawls were also condemned and wrecked.

The buildings of the engineer depot at foot of Arsenal Street, St. Louis, Mo., were repaired and maintained in thoroughly serviceable condition as were all shop machinery, equipment, tools, and appliances, and boarding outfit. An open shed 30 feet by 60 feet was built for the use of ironworkers; and a mold loft 40 feet by 105 feet was made from the upper cabin of condemned quarter boat No. 7, with roof trusses of steel angles and a surface floor of hard maple.

COMMERCIAL STATISTICS.

Season of navigation opened February 24, 1918, and remained open remainder of calendar year.

Arrivals and departures of steamboats and barges at St. Louis, Mo., during calendar year 1918.

	Number.	Registered tonnage.	Times arrived.
Steamboats.....	1	1,479	11
Do.....	1	1,160	1
Do.....	1	1,100	3
Do.....	7	510-832	235
Do.....	14	250-495	607
Do.....	16	100-216	212
Do.....	10	30-98	27
	50	.....	1,096
Barges.....		1,000	60
Do.....		600	19
Do.....		100-325	94
Total.....			173

Passengers, 385,133.

2818 REPORT OF CHIEF OF ENGINEERS, U. S. ARMY, 1918.

Freight traffic for calendar year 1918.

Articles.	Amount in short tons.	Approximate value.	Average distance freight was carried.	Ton-miles.
			<i>Miles.</i>	
Bauxite ore.....	64,908	\$366,994	185	12,007,980
Coal.....	10,428	41,712	181	1,884,940
Cooperage.....	2,000	90,000	17	34,357
Cotton.....	550	275,000	185	101,750
Cotton seed.....	1,978	138,460	92	182,474
Fruit and vegetables.....	6,416	320,750	17	109,055
Garbage.....	24,775	34,775	7	243,425
Grain and products.....	33,318	2,498,850	127	4,223,687
Groceries and provisions.....	6,583	653,300	99	646,124
Iron and steel.....	1,960	137,960	54	106,979
Logs.....	27,690	1,107,600	149	4,130,950
Lumber.....	2,244	112,200	50	270,513
Live stock and products.....	10,779	2,155,800	73	784,373
Oils.....	2,027	152,075	180	382,753
Stone, etc.....	9,567	14,350	127	1,219,471
Unclassified and miscellaneous.....	46,979	9,395,800	67	3,194,064
Vehicles.....	1,980	497,250	25	50,613
Total.....	264,149	17,983,776	.....	29,574,408

The reports indicate a falling off in shipments of cotton, lumber, logs, iron ore, iron, groceries, oil, stone, and garbage in 1918, as compared with 1917, and increases in grain, cotton seed, cooperage, live stock, coal, bauxite ore, fruits and vegetables, and miscellaneous merchandise, the net loss in tonnage for 1918 as compared with 1917, being 29,099 tons.

Ferry traffic for calendar year 1918.

Articles.	Amount in short tons.	Approximate value.	Average distance freight was carried.	Ton-miles.
			<i>Miles.</i>	
Automobiles.....	8,771	\$8,771,000		6,578
Cotton.....	200	100,000		150
Cotton seed.....	14,000	980,000		10,500
Coal and coke.....	2,280,976	9,123,904		1,710,732
Concentrates.....	40,750	2,893,250		24,450
Charts.....	110,528	63,553		66,319
Fruits and vegetables.....	16	800		9
Grain and products.....	219,512	16,463,400		164,534
Groceries and produce.....	105,063	10,506,300		78,797
Iron and steel, manufactured.....	71,766	5,023,620		53,824
Hay.....	80	2,400		48
Live stock and products.....	2,182	436,400		1,636
Lime and cement.....	31,944	167,517		19,166
Logs.....	6,559	262,360		4,919
Lumber.....	89,131	4,456,550		66,848
Oil.....	30,455	2,234,125		22,841
Stone, sand, and gravel.....	77,625	116,438		58,169
Unclassified and miscellaneous.....	167,449	33,469,800		125,587
Vehicles.....	84,005	16,801,000		280,821
Wines and liquors.....	14	1,690		8
Total.....	3,341,026	111,944,097	.....	2,096,036
Band barged.....	529,879	158,964	1.46	773,818

Passengers, 303,329.

RIVERS AND HARBORS—ST. LOUIS, MO., DISTRICT. 2819

Government materials transported.

[Calendar year, 1918.]

Articles.	Amount in short tons.	Approximate value.	Average distance freight was carried.	Ton-miles.
Brush.....	1,774	\$5,533	<i>Miles.</i> 40	70,980
Piles.....	429	1,722	100	42,900
Stone.....	51,425	74,607	30	2,116,270
Coal.....	18,821	53,553	40	632,840
Ice.....	729	2,960	40	29,160
Groceries.....	200	42,000	40	8,000
Miscellaneous.....	100	6,000	40	4,000
Total.....	70,478	186,375	.....	2,904,130

RECAPITULATION.

	Amount in short tons.	Approximate value.	Ton-miles.	Passengers.
Freight traffic.....	264,149	\$17,982,776	29,574,408	385,133
Ferry traffic.....	3,341,026	111,944,097	2,696,036	303,829
Sand barged.....	529,879	158,904	773,818	.....
Government materials.....	70,478	186,375	2,904,130	.....
Total.....	4,205,532	130,272,212	35,948,392	688,962

Statistics of freight and ferry traffic, sand barged, and Government materials transported compiled from reports of steamboats, transportation and sand companies, and official records.

The lines of transportation in the district of the Mississippi River between the Ohio and Missouri Rivers during the calendar year 1918 were as follows: Plying north of St. Louis, Mo.: The Kansas City-Missouri River Navigation Co., Streckfus Line steamers, Eagle Packet Co., Calhoun Packet Co., St. Louis & Tennessee River Packet Co., St. Louis-Memphis Transportation Co., and Barrett Line. Plying south of St. Louis, Mo.: Barrett Line, St. Louis-Memphis Transportation Co., St. Louis & Tennessee River Packet Co., Eagle Packet Co., Aluminum Ore Co., Peterson-Miller Box Co., and the Mississippi River section of the Mississippi-Warrior Waterways, United States Railroad Administration.

On September 28, 1918, the transportation of freight between St. Louis, Mo., Memphis, Tenn., and New Orleans, La., was inaugurated by the Mississippi River section of the Mississippi-Warrior Waterways, United States Railroad Administration, and for that purpose 20 steel barges of this district were, by direction of the Chief of Engineers, leased to the administration, and remained in that service during the remainder of the year. From the date of inauguration of the service to the end of the calendar year 1918, the administration transported 22,200 tons of freight, consisting of grain and products, iron, groceries and provisions, and miscellaneous articles. The 22,200 tons, valued at approximately \$2,600,000, are included in the tabulated statement of 264,149 tons of freight traffic in and through the district during the year.

The published tariff rates per 100 pounds within the river district, depending on distances the freight was carried, and which rates prevailed until July 1, 1918, were as follows:

Between St. Louis, Mo., and Cairo, Ill.: First class, 25 to 35 cents; second class, 20 to 30 cents; third class, 15 to 25 cents; fourth class, 12 to 18 cents; fifth class, 10 to 15 cents; and sixth class, 10 to 12 cents.

2820 REPORT OF CHIEF OF ENGINEERS, U. S. ARMY, 1919.

Between St. Louis, Mo., and Alton, Ill.: First class, 18 cents; second class, 15 cents; third class, 12 cents; fourth class, 10 cents; fifth class, 8 cents; and a "special stock tariff" applying between St. Louis and points on the Illinois River.

On July 1, 1918, the above rates were increased 25 per cent by the short line transportation companies plying between St. Louis and Cairo, and between St. Louis and Illinois River points.

The freight rates of the Mississippi section of the Mississippi-Warrior Waterways, United States Railroad Administration, between St. Louis, Mo., Memphis, Tenn., and New Orleans, La., were 80 per cent of the railroad rates, which included free delivery at the places stated to all points reached by competing railroads.

Total cost and work done to June 30, 1919.

HURDLES.

	New.	Restora- tion.	Repairs.	Cost.
Prior to July 1, 1918.....	Linear ft. 402,031	Linear ft. 36,597	Linear ft. 96,829	\$8,323,799.73
During fiscal year ending June 30, 1919:				
Fort Chartres, West.....			(1)	2,542.30
Sta. Genevieve, Mo.....			(2)	4,323.53
Liberty, Mo.....			1,120	19,368.49
Union Point, Ill.....			1,500	11,717.36
Minton Point, Ill.....			651	13,394.99
Total.....	402,031	36,597	100,100	8,375,146.40

¹ 8,200 square feet drift mattress.

² 1,800 square feet drift mattress; 17,000 square feet foundation mattress; 14,500 square feet paving.

BANK PROTECTION.

	Mattress.			Paving.				
	New.		Repairs.	Cost.	New.		Repairs.	Cost.
	Linear feet.	Square feet.	Square feet.		Square feet.	Square feet.		
Prior to July 1, 1918.....	356,909	44,071,300	5,662,550	\$2,704,271.00	20,944,579	26,980,860	\$2,813,199.00	
During fiscal year ending June 30, 1919:								
Osborne Field, Ill.....			64,130	6,915.26	38,675	122,595	23,398.63	
Fort Chartres, East.....			9,050	930.12		47,480	5,569.57	
Turkey Island, Ill.....			142,000	17,693.91		43,160	12,061.11	
Sta. Genevieve, Mo.....						42,590	6,829.46	
Kaskaskia Island, Ill.....			17,325	1,440.61	8,875	23,875	6,690.61	
Chester, Mo.—								
Horse Island.....						24,250	4,088.93	
Claryville.....	950	97,900		9,018.11				
Liberty Bend, Ill.....					146,700	41,120	22,330.91	
Wilkinson, Ill.....			18,900	2,192.47		18,000	3,482.64	
Devils Island, Ill.....			30,375	3,441.95		54,450	8,223.17	
Price Landing, Mo.....						25,425	5,143.84	
Beechridge, Ill.....			12,825	1,168.65		70,945	8,141.19	
Eliza Towhead, Ill.....						28,405	2,040.33	
Total.....	357,859	44,169,200	5,957,155	2,747,072.68	21,138,829	7,523,155	2,922,049.39	

¹ Error in Annual Report, 1913: Price Landing should be 745,000 instead of 45,000 square feet.

² Error in Annual Report, 1918: Prior to July 1, 1917, 6,132,665 should be 6,232,665 square feet.

RECAPITULATION.

Hurdles.....	\$8,375,146.40
Bank protection.....	5,669,121.47
Dikes and dams.....	691,893.46
Jetties.....	114,603.53
Dredging.....	2,609,983.92
Surveys.....	393,209.00
Total.....	17,853,987.78

RIVERS AND HARBORS—ST. LOUIS, MO., DISTRICT. '2821

Total cost and work done to June 30, 1919—Continued.

PROPERTY.

	Value July 1, 1918.	Debits.	Credits.	Value June 30, 1919.
Steamers:				
Gen. J. H. Simpson.....	\$4,000.00	\$280.50	\$4,280.50	.....
Wm. R. King.....	38,000.00	23,324.99	21,324.99	\$40,000.00
Dredges:				
Selma.....	48,500.00	3,796.10	6,796.10	45,500.00
Thebes.....	48,500.00	18,605.45	21,605.45	45,500.00
Fort Gate.....	107,000.00	56,751.94	59,751.94	104,000.00
Fort Chartres.....	107,000.00	61,705.44	65,705.44	103,000.00
Phoenix.....	1,000.00	20,281.06	20,281.06	1,000.00
Vulcan.....	400.00	150.00	550.00	.....
Tenders:				
Isle de Bois.....	650.00	.....	650.00	.....
Aux Vases.....	650.00	.....	650.00	.....
Salvisl.....	6,300.00	10,407.28	11,407.28	5,500.00
Kaskaskia.....	6,300.00	8,008.78	8,808.78	5,500.00
Meramec.....	7,350.00	28,400.10	29,250.10	6,500.00
Barges:				
Model (6).....	900.00	621.96	821.96	700.00
Steel (25).....	188,600.00	6,488.30	17,088.30	178,000.00
Flat (1).....	60.00	15.75	30.75	45.00
Store boats (1).....	1,300.00	21.45	221.45	1,100.00
Quarter boats (4).....	8,300.00	3,319.35	7,619.35	4,000.00
Office and survey boats (5).....	6,500.00	510.27	1,510.27	5,500.00
Pile drivers:				
Wood (9).....	11,900.00	2,004.02	3,904.02	10,000.00
Steel (4).....	24,000.00	282.40	2,282.40	22,000.00
Derrick boats, wood (2).....	2,700.00	1,345.45	1,745.45	2,300.00
Grader and derrick boats, steel (2).....	19,800.00	1,431.36	2,831.36	18,400.00
Derrick (1).....	300.00	.....	300.00	.....
Machine boat (1).....	25.00	26.00	51.00	.....
Flats:				
Wood (52).....	1,636.00	.....	236.00	1,400.00
Steel (63).....	59,100.00	1,570.60	5,070.60	55,600.00
Small boats:				
Wood (68).....	450.00	575.61	655.61	370.00
Steel (18).....	400.00	.....	30.00	370.00
Portable quarters.....	165.00	571.07	571.07	165.00
United States Engineer depot.....	7,000.00	12,183.18	10,063.18	9,100.00
Tools and appliances.....	15,140.00	15,306.46	12,146.46	18,300.00
Boarding outfit.....	5,000.00	2,796.23	4,321.23	3,475.00
Office furniture.....	1,270.00	132.80	302.80	1,100.00
Survey instruments.....	700.00	17.90	117.90	600.00
Total.....	730,890.00	281,092.43	322,963.43	689,025.00

MATERIAL.

Subsistence.....	\$1,243.00	\$48,276.10	\$47,815.10	\$1,704.00
Brush.....	94.00	13,886.55	9,686.55	4,294.00
Piles.....	.....	9,588.05	9,494.05	94.00
Stone.....	1,208.87	47,072.69	46,409.56	1,872.00
Rope.....	18,795.58	19,004.99	15,187.57	22,613.00
Wire.....	159.60	1,517.04	1,156.64	520.00
Iron.....	17,635.00	12,256.44	10,338.44	19,553.00
Nails.....	460.00	166.52	280.52	346.00
Spikes.....	524.40	.....	57.08	467.32
Lumber.....	2,285.00	3,832.07	3,548.07	2,569.00
Oakum.....	102.50	.....	102.50	.....
Coal.....	2,508.00	60,280.92	60,203.92	2,585.00
Ice.....	.....	3,406.06	3,406.06	.....
Material, miscellaneous.....	16,323.00	34,344.62	29,287.83	21,379.79
Total.....	61,338.95	253,632.05	236,973.89	77,997.11

EXPENDITURES.

The total amount appropriated from July 4, 1836, to March 4, 1915, is \$17,956,599.98, is shown on pages 488 and 490, House Document 1491, Sixty-third Congress, third session, under the following headings:

Illinois River to Ohio River.....	\$4,110,000.00
Missouri River to Ohio River.....	13,746,599.98
Missouri River to Meramec River.....	100,000.00
Total.....	17,956,599.98

2822 REPORT OF CHIEF OF ENGINEERS, U. S. ARMY, 1919.

Appropriated by river and harbor act of July 27, 1916	\$350,000.00
Appropriated by river and harbor act of Aug. 8, 1917	350,000.00
Appropriated by river and harbor act of July 18, 1918	100,000.00
Appropriated by river and harbor act of Mar. 2, 1919	700,000.00

19,456,599.98

Of the above total amount there was appropriated in the years 1836, 1837, and 1844 for pier near St. Louis and obstructions in harbor of St. Louis (not considered in previous project of 1872 nor existing project of 1881) the sum of	\$75,000.00
By the acts of 1872, 1874, 1875, 1876, 1878, 1879, 1880, 1882, 1880 there was allotted for work above the mouth of the Missouri River (not in the present district) the sum of	205,000.00
From the appropriation of 1879 there reverted to the Treasury the amount allotted by the act for Wittenberg, Mo	10,000.00
	<u>290,000.00</u>

Leaving for work in the present district between the mouths of Missouri and Ohio Rivers under general acts for work in the district and special acts for work at certain localities in the district	19,166,599.98
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Receipts from sales, \$216,448.23.

There was expended on the original project under the acts of June 10, 1872, to June 14, 1880, inclusive, \$1,495,000, and under the existing project of 1881 there has been expended to June 30, 1919, \$17,008,764.12. The amount unexpended June 30, 1919, is \$662,835.86. The outstanding liabilities June 30, 1919, are \$43,068.15, leaving \$619,767.71 available for the coming year in addition to \$18,310.63 due from other sources.

In addition there is still due from Mr. Edward F. Goltra \$14,780.03 for rental of barges under lease to him from January 1 to April 30, 1918, and for property lost and repair of barges while in his service.

Amount expended during fiscal year	\$518,045.50
Reimbursable	42,893.52

Net expenditures 475,151.98

APPROPRIATIONS.

[See H. Doc. 1491, 63d Cong., 3d sess., pp. 488 and 490.]

Under former projects, from July 4, 1836, to Mar. 3, 1881, inclusive, and under the following heads: Pier near St. Louis and obstructions in harbor of St. Louis, years 1836, 1837, and 1844, \$75,000; Illinois to Missouri Rivers, year 1872, \$25,000; Missouri River to Meramec River, year 1872, \$100,000; Missouri River to Ohio River, year 1873, \$200,000; Ohio River to Illinois River, years 1874, 1878, \$440,000; Illinois River to Ohio River, years 1875, 1876, 1879, 1880, 1881, \$1,450,000; channel opposite St. Louis, Mo., year 1876 \$29,600; ice harbor at St. Louis, Mo., years 1880, 1881, \$60,000; Cape Girardeau and Minton Point, years 1880, 1881, \$30,000, aggregating	\$2,409,600.00
Present project:	
Aug. 2, 1882, Cairo to Illinois River	600,000.00
July 5, 1884, Illinois River to Ohio River	520,000.00
Aug. 5, 1886, Illinois River to Ohio River	375,000.00
Aug. 11, 1888, Illinois River to Ohio River	300,000.00
Sept. 19, 1890, harbor at St. Louis, Mo.	182,000.00
Sept. 19, 1890, Illinois River to Ohio River	400,000.00
July 13, 1892, Ohio River to Missouri River	525,000.00
Mar. 3, 1893, Ohio River to Missouri River	658,333.33
Aug. 18, 1894, Ohio River to Missouri River	758,333.33
Mar. 2, 1895, Ohio River to Missouri River	758,333.33
June 3, 1896, Missouri River to Ohio River	275,000.00

Present project—Continued.

June 4, 1897, Ohio River to Missouri River-----	\$673, 333. 33
June 4, 1897, preventing break in Mississippi River at Beech- ridge, Ill-----	100, 000. 00
June 19, 1897, Ohio River to Missouri River-----	325, 000. 00
July 1, 1898, Ohio River to Missouri River-----	673, 333. 33
Mar. 3, 1899, Ohio River to Missouri River-----	673, 333. 33
June 6, 1900, Ohio River to Missouri River-----	100, 000. 00
June 13, 1902, Ohio River to Missouri River-----	650, 000. 00
Mar. 3, 1903, Ohio River to Missouri River-----	650, 000. 00
Apr. 28, 1904, Ohio River to Missouri River-----	650, 000. 00
Mar. 3, 1905, Ohio River to Missouri River-----	650, 000. 00
Mar. 2, 1907, Ohio River to Missouri River-----	250, 000. 00
May 27, 1908, Ohio River to Missouri River-----	250, 000. 00
Mar. 4, 1909, Ohio River to Missouri River-----	250, 000. 00
June 25, 1910, Ohio River to Missouri River-----	250, 000. 00
June 25, 1910, Ohio River to Missouri River-----	500, 000. 00
Feb. 27, 1911, Ohio River to Missouri River-----	1, 000, 000. 00
July 25, 1912, Ohio River to Missouri River-----	1, 000, 000. 00
Mar. 4, 1913, Ohio River to Missouri River-----	1, 000, 000. 00
Oct. 2, 1914, Ohio River to Missouri River-----	250, 000. 00
Mar. 4, 1915, Ohio River to Missouri River-----	300, 000. 00
July 27, 1916-----	350, 000. 00
Aug. 8, 1917-----	350, 000. 00
July 18, 1918-----	100, 000. 00
Mar. 2, 1919-----	700, 000. 00

Total of appropriations----- 19, 456, 599. 98

Of the above total amount there was appropriated in the years 1836, 1837, and 1844, for pier near St. Louis and obstructions in harbor of St. Louis (not considered in previous project of 1872, nor existing project of 1881), the sum of----- \$75, 000

By the acts of 1872, 1874, 1875, 1876, 1878, 1879, 1880, 1882, 1890, there was allotted for work above the mouth of the Missouri River (not in the present district) the sum of----- 205, 000

From the appropriation of 1879 there reverted to the Treasury the amount allotted by the act for Wittenberg, Mo----- 10, 000

290, 000. 00

Leaving for work in the present district between the mouth of Missouri and Ohio Rivers, under general acts for work in the district and special acts for work at certain localities in the district----- 19, 166, 599. 98

Receipts from sales, \$216,448.23.

2. REMOVING SNAGS AND WRECKS FROM THE MISSISSIPPI RIVER BELOW THE MOUTH OF THE MISSOURI RIVER AND FROM OLD AND ATCHAFALAYA RIVERS.

OPERATIONS DURING THE FISCAL YEAR.

The work is now being done by the department's two large steel-hull snag boats—the *J. N. Macomb*, built in 1874, and the *H. G. Wright*, built in 1881, fitted with the necessary equipment and appliances and operated by Government employees. These boats patrol the Mississippi River between Head of Passes (13 miles from mouth of South Pass) and mouth of Missouri River, 1,265 miles, and 35 miles of Old and Atchafalaya Rivers to Melville, La.; total, 1,300 miles.

Description of the snag boats may be found in Annual Report Chief of Engineers, United States Army, 1895, page 2054 et seq.

IMPROVEMENT OF RIVERS AND HARBORS IN THE ST. LOUIS, MO.,
DISTRICT.

REPORT OF MAJ. DEWITT C. JONES, CORPS OF ENGINEERS.

IMPROVEMENTS.

	Page.		Page.
1. Mississippi River between the Ohio and Missouri Rivers...	2481	2. Removing snags and wrecks from the Mississippi River below the mouth of the Missouri River, and from Old and Atchafalaya Rivers.....	2490

FOR DESCRIPTION OF IMPROVEMENTS IN THIS DISTRICT, SEE PAGES 1197 TO 1205.

1. MISSISSIPPI RIVER BETWEEN THE OHIO AND MISSOURI RIVERS.

OPERATIONS DURING THE FISCAL YEAR 1920.

WORKS OF IMPROVEMENT.

Maintenance of the existing regulation works—hurdle dikes and bank revetments—including such minor extensions as were required for that purpose, and in which the standard forms of construction were used, was continued by hired labor from July 1 to December 1, 1919, January 16 to 20, and after March 11, as hereinafter described, at East Twin Hollows, West Twin Hollows, Pulltight, Meramec River, Foster Island, Lucas, Calico Island, Osborne Field, Danby Landing, Penitentiary Point, West Fort Chartres, East Fort Chartres, Turkey Island, Ste. Genevieve, Mo.; Kaskaskia Island, Chester (Horse Island), Chester (Claryville), Crain Island, Liberty Island, LaCour Island, Union Point, Hanging Dog Island, Price Landing, Beechridge, Eliza Towhead, Cairo, and Greenfield Bend. The four suction dredges of the district were in commission during the low water season, July 1 to December 11, and were operated on 15 obstructive main-channel bars which developed during that time. The one dipper dredge belonging to this district worked September 4 to October 27 and March 3 to 13 on the gravel bar in Grand Tower upper crossing. Hydrographic surveys were made covering 169 miles of river, including all dredged channels, shoal crossings, and caving banks; 19 miles of river were resurveyed for the dredging service. River gages were read throughout the year and were inspected and repaired as required. The plant was repaired and cared for at the St. Louis engineer depot and at fleet in winter harbor, Fayville, Ill.

Materials were procured by contract and open-market purchases and by hired labor, as was deemed most advantageous to the department.

CONSTRUCTION WORKS.

NOTE.—Station numbers (100 feet), wherever shown herein, refer to an origin at the upstream end of the work at that locality. River stages, unless otherwise noted, refer to the St. Louis gage. Origin of river distances is Eads Bridge, St. Louis, Mo.; all localities of work are downstream from St. Louis, unless otherwise noted.

TWIN HOLLOWES, EAST, MILES 14 TO 16, LEFT BANK.

[Oct. 1-14, 1919.]

Bank revetment, repair.—A small section of brush mattress, 4,505 square feet, was built and sunk between stations 55 and 56, connecting the old mattress with the shore; between station 55 and 62 and between the 6-foot and 15-foot stages 150 cubic yards of earth were graded from the bank and 11,377 square feet of stone paving were placed, covering several bare spots in the paving.

TWIN HOLLOWES, WEST, MILES 14 TO 17, RIGHT BANK.

[Sept. 22-Oct. 14, 1919.]

Hurdle dikes, repair.—To prevent further loss, repairs were made to the outer ends of hurdles Nos. 4, 5, and 5½, as follows: No. 4, 45 linear feet; No. 5, 70 linear feet; and No. 5½, 55 linear feet; 138 piles were driven, 55 clumps cabled, and 10 stringers placed. At the outer end of No. 3, drift that had accumulated and become massed together to a depth of about 15 feet in the T-head was covered with a mattress 2,000 square feet, and the entire mass was sunk and ballasted with stone; 125 cubic yards of stone were placed at the base of the piles at the outer ends of Nos. 4 and 5 to protect their foundations.

PULLTIGHT, MILES 16 TO 19, LEFT BANK.

[Sept. 13-19, 1919.]

Hurdle dikes, repair.—The outer ends of hurdles Nos. 4½, 5, and 6 were repaired as follows: No. 4½, 75 linear feet; No. 5, 60 linear feet; No. 6, 25 linear feet; 108 piles were driven, 45 clumps cabled, and 7 stringers placed.

MERAMEC RIVER, MILES 19 AND 20, RIGHT BANK.

[Sept. 5-12, 1919.]

Hurdle dikes, repair.—Since their completion in 1914, the two dikes at this locality, Nos. 2 and 3, have suffered losses of 300 feet and 500 feet, respectively, at their outer ends. To maintain the existing good bank alignment and channel, repairs were made as follows: No. 2, 65 linear feet; No. 3, 105 linear feet; 98 piles were driven, 32 clumps cabled, and 12 stringers placed.

FOSTER ISLAND, MILES 27 AND 28, LEFT BANK.

[Oct. 17-30, 1919.]

Bank revetment, repair.—The paving at this locality was repaired between stations 5 and 12, between the 4-foot and 15-foot stages; 40 cubic yards of earth were graded from the bank, and 17,140 square feet of stone paving were placed.

LUCAS, MILES 28 TO 32, LEFT BANK.

[Oct. 16-31, 1919.]

Hurdle dikes, repair.—These dikes are immediately below the Foster Island revetment, and were last repaired in 1911. During the present year repairs were made to the upper two dikes as follows: No. —4, 210 linear feet; No. —3, 125 linear feet; 183 piles were driven, 57 clumps cabled, and 9 stringers placed. A brush mattress, 4,150 square feet, with stone massed thereon, was built around the exposed piling in the shore end of No. —4, thus forming a short section of solid dike between the piling and the bank.

CALICO ISLAND, MILES 32 AND 33, LEFT BANK.

[June 21-30, 1920.]

Hurdle dikes, repair.—The channel is now attacking the left bank at this locality, the first time since 1911, when the work was last repaired, wearing the accretions away rapidly, exposing the decayed piling. Repairs were made to the short sections remaining at the shore ends, as follows: No. 18, 200 linear feet; No. 19½, 155 linear feet; 206 piles were driven, 67 clumps cabled, 11 stringers placed, 700 square feet of drift mattress were built and sunk, and 5,540 square feet of stone paving were placed at the shore end of No. 18, between the 12-foot and 29-foot stages. At the end of the fiscal year the work was 75 per cent complete.

OSBORNE FIELD, MILES 38 TO 40, LEFT BANK.

[Nov. 26-Dec. 1, 1919.]

Bank revetment, repair.—To repair damage resulting from a severe windstorm in July, 1919, 20 cubic yards of earth were graded from the bank and 8,100 square feet of stone paving were placed between stations 32 and 88, between the 9-foot and 30-foot stages.

DANBY LANDING, MILES 41 TO 43, RIGHT BANK.

[Nov. 19-25, 1919.]

Bank revetment, repair.—The bank was graded, 90 cubic yards of earth being removed, and 17,895 square feet of stone paving were placed between stations 33 and 45, between the 9-foot and 30-foot stages.

2484 REPORT OF CHIEF OF ENGINEERS, U. S. ARMY, 1920.

PENITENTIARY POINT, MILES 44 TO 46, LEFT BANK.

[June 1-11, 1920.]

Hurdle dike, repair.—The one long hurdle at this locality was last repaired in 1916, since which time three small breaks have occurred, two resulting from recent high water stages. Repairs were made along 350 linear feet of hurdle as follows: 189 piles were driven, 63 clumps cabled, 9 stringers placed, and 56 cubic yards of stone were placed around the newly driven piles in one of the breaks.

FORT CHARTRES, WEST, MILES 46 TO 49, RIGHT BANK.

[Nov. 1-18, 1919, June 1-19, 1920.]

Bank revetment and hurdle dikes, repair.—The revetment and dikes at this locality protect 2 miles of bank. A severe windstorm in July, 1919, damaged the paving along the greater part of the revetted bank, while the hurdles have all suffered considerable losses during the past 20 years. To prevent further loss and maintain the present good channel alignment, the following work was done: Hurdles, repaired, No. —3, 112 linear feet; No. —2, 88 linear feet; No. —1, 35 linear feet; No. 0, 77 linear feet; and No. $\frac{1}{2}$, 73 linear feet; 148 piles were driven, 40 clumps cabled, 9 stringers placed, 15,395 square feet of drift mattress and 3,700 square feet of stone paving placed at shore ends. Revetment repaired; 190 cubic yards of earth were graded from the bank and 37,600 square feet of stone paving placed between stations 0 and 48, between the 12-foot and 30-foot stages.

FORT CHARTRES, EAST, MILES 51 AND 52, LEFT BANK.

[Sept. 18-29, 1919, Mar. 12-18, Apr. 6-26, 1920.]

Bank revetment, repair.—The work at this locality was damaged by the severe windstorm in July, 1919, and by the heavy ice floes of the past winter. Repairs were made as follows: Mattress, 19,250 square feet built between stations 35 and 38. Paving, 1,455 cubic yards of earth graded from the bank and 65,330 square feet of stone paving placed between stations 10 and 59, between the 1-foot and 30-foot stages.

TURKEY ISLAND, MILES 52 TO 54, LEFT BANK.

[Aug. 8-17, 21-28, Sept. 18-27, 1919, Apr. 21-22, 1920.]

Bank revetment, repair.—Along the upper section of paving, which was badly damaged by the severe storm of July, 1919, 225 cubic yards of earth were graded from the bank and 67,275 square feet of stone paving were placed between stations 64 and 95, between the 1-foot and 30-foot stages. A large quantity of drift accumulated above the spur hurdle on the lower section was ballasted with stone.

STE. GENEVIEVE, MO., MILES 59 TO 63, RIGHT BANK.

[July 1—Aug. 7, 1919.]

Bank revetment, repair.—Work which was in progress at the end of the last fiscal year was completed; 1,150 cubic yards of earth were graded from the bank and 88,063 square feet of stone paving were placed between stations 14 and 74, between the 8-foot and 32-foot stages.

KASKASKIA ISLAND, MILES 69 TO 72, RIGHT BANK.

[July 15—Sept. 3, 1919.]

Bank revetment, repair.—The lower 1,700 feet of this protection had been destroyed and the river permitted to menace the Horse Island revetment, now a salient point about 1,000 feet below the original end of the Kaskaskia Island work. To prevent further damage, 124,700 square feet of mattress were built between stations 43 and 56, with two short spur dikes (215 linear feet) to deflect the current from the head of Horse Island, 188 piles being driven, 61 clumps cabled, and 17 stringers placed. This section was paved and numerous small slips in the old work were repaired. In all, 10,580 cubic yards of earth were graded from the bank and 78,420 square feet of stone paving were placed, as required, between stations 78 and 83 of the upper section and stations 0 and 56 of the lower section. between the 2-foot and 30-foot stages.

CHESTER (HORSE ISLAND), MILES 72 AND 73, RIGHT BANK.

[July 1—16, Aug. 20—Sept. 7, 1919.]

Bank revetment, repair.—Work at this locality in progress at the end of the last fiscal year was completed as follows: Mattress, 41,810 square feet built between stations 37 and 41, with one spur dike (160 linear feet) at station 40 to deflect the current from the unprotected portion of the island; 143 piles driven, 35 clumps cabled, and 9 stringers placed. Paving, 1,650 cubic yards of earth graded from the bank and 34,325 square feet of stone paving placed between stations 2 and 41, between the 5-foot and 30-foot stages.

CHESTER, MO. (CLARYVILLE), MILE 74, RIGHT BANK.

[July 1—8, Sept. 3—17, 1919.]

Bank revetment, extension and repair.—Work at this locality in progress at the end of the last fiscal year was completed as follows: Mattress, new, 12,800 square feet between stations —1 and 0, connecting with the original work, and mattress, repair, 31,055 square feet between stations 0 and 3+50, connecting the old work with the present shore. Paving, new, 49,775 square feet between stations —6+50 and 0, between the 2-foot and 20-foot stages, and paving, repair, 28,860 square feet between stations 0 and 4, between the 2-foot and 20-foot stages; 1,300 cubic yards of earth were graded from the bank.

CRAIN ISLAND, MILES 75 TO 78, RIGHT BANK.

[Aug. 11-19, 1919; May 24-29, 1920.]

Hurdle dikes and dams, repair.—The outer ends of the dikes were damaged slightly by ice during the past five years, and the dam across the slough between the Missouri shore and Puckett Island was breached. Repairs were made as follows: Hurdles, No. 2, 10 linear feet; No. 3, 10 linear feet; No. 4, 70 linear feet; No. 6, 150 linear feet; No. 9, 40 linear feet; and Dam No. 3, 165 linear feet; 315 piles were driven, 104 clumps cabled, 25 stringers placed, and 160 cubic yards of stone placed around the newly driven piles in the dam.

LIBERTY ISLAND, MILES 81 TO 83, RIGHT BANK.

[Apr. 27-May 29, 1920.]

Bank revetment, extension and repair.—The bank between Anchor Landing and Bishop Landing, a distance of 2 miles, was at one time revetted, except for a section of 900 feet underlaid with gravel, but through bank erosion this revetment became detached from the shore. Eight spur hurdles, built in the spring of 1903 to form a shore connection, were in need of repairs, which were made as follows: Mattress, new, 160 linear feet, 15,200 square feet (new spur hurdle, 120 linear feet), and mattress, repaired, 11,400 square feet (new spur hurdle, 170 linear feet). Paving, new, 5,153 square feet between the 20-foot and 30-foot stages, and paving, repaired, 3,750 square feet; spur hurdles, 550 linear feet of repairs made to the eight old spur hurdles and 3,600 square feet of drift mattress built and sunk at shore ends of spur hurdles Nos. 1 and 11 to solidify the structures. In all, 418 piles were driven, 113 clumps cabled, and 12 stringers placed.

LACOUR ISLAND, MILES 94 AND 95, LEFT BANK.

[Aug. 1-9, 1919.]

Hurdle dike, repair.—The hurdle at this locality being exposed to the current for a distance of 400 feet, with the piling badly deteriorated, was urgently in need of repairs, which were made as follows: 230 piles driven, 77 clumps cabled, and 13 stringers placed.

UNION POINT, MILES 109 AND 110, LEFT BANK.

[July 19-30, 1919.]

Hurdle dikes, repair.—Work on the two hurdles, suspended May 31, 1919, because of high river stage, was completed as follows: No. 6, 110 linear feet; No. 9, 130 linear feet; 221 piles were driven, 73 clumps cabled, and 7 stringers placed.

HANGING DOG ISLAND, MILES 113 TO 115, LEFT BANK.

[July 1-18, 1919.]

Hurdle dikes, extension and repair.—The hurdles, which were last repaired in 1917, were again in need of attention, having been badly damaged by the ice of the last two years. To relieve the pressure

and divert the channel from hurdles Nos. 9 and 10, hurdle No. 0 was extended 400 feet by driving 3 rows of 3-pile clumps, 20-foot centers both ways; no foundation mattress was built, but 576 cubic yards of stone were placed around the base of the piles. Repairs, No. 9, 30 linear feet, No. 10, 50 linear feet, No. 11, 65 linear feet; 297 piles were driven, 100 clumps cabled, and 1 stringer placed.

PRICE LANDING, MILES 153 AND 154, RIGHT BANK.

[Nov. 15–Dec. 1, 1919.]

Bank revetment, repair.—The river bank here is protected by 7,500 linear feet of revetment, and being of a sandy formation requires constant attention to prevent serious losses. Repairs were made as follows: Mattress, 23,760 square feet built between stations 188 and 191. Paving, 36,850 square feet placed between stations 150 and 191, between the 10-foot and 35-foot stages; 650 cubic yards of earth graded from the bank.

BEECHRIDGE, MILES 160 TO 171, LEFT BANK.

[Nov. 2–14, 1919.]

Bank revetment, repair.—The repairs which were left unfinished above the 20-foot stage at the close of the season, 1918, because of more urgent requirements elsewhere, were completed, 31,600 square feet of stone paving being placed between stations 26 and 68, between the 27-foot and 32-foot stages. On account of backwater, resulting from high stages in the Ohio River, work below the 27-foot stage could not be repaired.

ELIZA TOWHEAD, MILES 175 TO 177, LEFT BANK.

[Oct. 28–31, 1919.]

Bank revetment, repair.—Between stations 56 and 57, as the bank has been gradually eroded and threatened to flank and destroy this part of the work, 10,070 square feet of mattress were built. Paving could not be placed as the water was at the top of the bank, due to high river stage.

CAIRO PROTECTION (ELIZA POINT), MILES 177 AND 178, LEFT BANK.

[Oct. 25–31, 1919.]

Bank revetment, repair.—A small slip in the work between stations 101 and 102 was repaired with 5,955 square feet of mattress, and between stations 91 and 102, 12,747 square feet of stone paving were placed between the 18-foot and 25-foot stages (Cairo gage).

GREENFIELD HEND (BIRDS POINT), MILES 181 AND 182, RIGHT BANK.

[Oct. 7–28, 1919; Jan. 16–20, 1920.]

Bank revetment, extension and repair.—This important revetment extends from station 5 to 81+30, about one-half mile below Birds Point, Mo. (p. 2119, Annual Report, 1912; p. 2586, Annual Report, 1916). To prevent further erosion and a threatened flanking of the

head of the work, an extension of 134 feet was made upstream from station 5 to 3+66. The total work done was as follows: Mattress, extension, 13,440 square feet, and mattress, repaired, between stations 68 and 72, 26,700 square feet. Paving, new, between stations 3+66 and 5, and between stations 76 and 81+30, 29,650 square feet, between the 10-foot and 35-foot stages (Cairo gage), and paving, repaired, 30,881 square feet between stations 50 to 52, and 68 to 72, between the 10-foot and 25-foot stages (Cairo gage).

DREDGING.

Good boating stages and ample depths for navigation prevailed until the latter part of July, when, because of the steadily and rapidly declining stage, from 17 feet on the 1st to 8 feet on the 31st, channel depths were reduced to such an extent that several bars threatened to become obstructive to 8-foot navigation. Accordingly the self-propelling suction dredges *Fort Chartres* and *Fort Gage* were prepared for service and began operations the latter part of July. They were closely followed by the nonpropelling suction dredges *Selma* and *Thebes* and the dipper dredge *Phoenix*.

These five dredges, operated by Government employees in two 8-hour shifts, were in commission and performed service as follows: The *Fort Chartres*, July 1 to December 5 (158 days), dredged 6 channel bars 38 days, and approach to the incline of the Illinois Southern Railway at Little Rock, Mo. (57) 8 days. The *Fort Gage*, July 22 to December 11 (143 days), dredged 6 channel bars 41 days; approach to the steamboat landing at Grand Tower, Ill. (104), 3 days; approach to said incline at Little Rock 5 days; and graded bank for revetment work at Greenfield Bend, Mo. (181), 2 days. The *Selma*, August 4 to November 10 (99 days), dredged 4 channel bars 27 days; and approaches to 3 steamboat landings in St. Louis Harbor 31 days. The *Thebes*, September 11 to November 20 (71 days), dredged 1 channel bar 5 days; approach to said incline at Little Rock and approach to incline of Missouri Pacific Railway at East Ivory, Ill. (9), 34 days. The *Phoenix*, August 11 to November 27 and March 3 to 13 (120 days), dredged approaches to 2 steamboat landings in St. Louis Harbor and to stone quarry at Little Rock, Mo. (57), 12 days; and continued work on the gravel and bowlder bar at Grand Tower (104) 62 days.

Work performed by the dredges outside the channel was done in the interest of navigation, at times when the navigable depth was ample and dredging in the main channel was not required; and this work, when performed for private parties, was paid for by the parties benefited; all other dredging was for the maintenance of the project depth (8 feet) and width (200 feet) of channel between the mouth of Ohio River (183) and St. Louis (0); thence to the mouth of Missouri River (17 miles above Eads Bridge) the project depth of 6 feet was maintained without dredging.

The four suction dredges operating in the main steamer channel a total of 967 hours, a little more than one-eighth of their total available time in commission (16-hour days), maintained the required 8-foot channel (St. Louis to Cairo) throughout the low-water season with only slight delays to navigation (see *Channel conditions*).

The two self-propelling dredges were also used during idle intervals to assist the one district towboat in commission to deliver materials and supplies, and to patrol, sound, and buoy the channel throughout the district. Of the 15 main-channel bars improved by the suction dredges, two were dredged twice and one other particularly troublesome bar, Schenimann (122), was dredged four times in four different months. Good results were obtained in all cases, the gain in depth varying from $2\frac{1}{2}$ to $5\frac{1}{2}$ feet. The total number of channels dredged through the 15 obstructive bars was 20, having a combined length of $6\frac{1}{2}$ miles and an average width of 220 feet; the total amount of material removed from the main channel was 1,362,000 cubic yards in 967 hours' actual dredging time, an average rate of fully 1,400 cubic yards per suction-dredge hour. Other details concerning the dredging service are given in the following table:

Table of work done by United States pipe-line hydraulic dredges "Selma," "Thebes," "Fort Gage," and "Fort Chartres," and dipper dredge "Phoenix," during the fiscal year ending June 30, 1920.

Dredge.	Bars dredged.	Miles from St. Louis (Eads Bridge).	Inclusive dates.	Days dredging.	Actual dredging time.	Quantity dredged.	Total length of cuts.	Dredged channel.			Gain in depth.
								Length.	Width.	Depth.	
			1919.		Hours.	Cu. yds.	Feet.	Feet.	Feet.	Feet.	
Selma	St. Louis Harbor:										
Do	Foot of Penross Street ¹	4 above.	Oct. 1-19	19	41	12,100	2,700	600	75	9	5
Phoenix	Foot of Bremen Avenue ¹	3 above.	Oct. 20-28	9	38	3,400	1,000	400	100	12	3
Selma	Dock, East St. Louis ¹	1	Aug. 21-22	2	9	100	25	25	25	10	8
Phoenix	Foot of Chouteau Avenue ¹	2	Aug. 11-13	3	24	1,000	300	300	25	9	2
Do	do.	2	Aug. 16-21	7	34	2,200	300	300	25	13	2
Thebes	East Ivory Incline Missouri Pacific R. R. ¹	9	Sept. 14-18	5	33	12,100	1,800	500	275	11½	1
Selma	CHI Cave	14	Aug. 16-20 and 31	6	58	47,300	7,500	1,500	200	104	16
Do	do.	14	Sept. 6-10, 13-15	8	65	59,300	8,500	1,700	200	9	16
Do	Waters Point	23	Aug. 23-26	4	44	43,000	5,100	1,300	200	8	1
Fort Gage	Riverside	27	July 22-Aug. 1, 6-7	6	44	95,600	9,700	1,300	300	104	4
Selma	do.	28	Sept. 16-20	5	34	19,400	4,700	1,000	200	9	3
Do	Calico Island	31	Sept. 25-28	4	19	11,800	2,800	900	200	104	1
Fort Chartres	Danby	41	Aug. 4-10	7	70	111,800	12,600	2,600	200	12	1
Do	Ames Towhead	43	Aug. 11-16	6	61	95,600	11,800	2,300	225	104	1
Do	Sycamore	46	Aug. 23-24, 29-30	5	46	81,600	10,800	1,800	250	104	1
Phoenix	Little Rock, Mo., Quarry ¹	57	Aug. 28-30	3	23	400	200	200	25	11	1
Thebes	Little Rock, Mo., Incline, Illinois Southern Ry. ¹	57	Sept. 27-Oct. 25	29	158	102,900	13,600	2,000	150	12	1
Fort Chartres	do.	57	Oct. 11-18	8	53	93,400	7,300	1,600	125	134	1
Fort Gage	do.	57	Nov. 28-Dec. 2	5	39	69,500	5,700	2,200	100	16	1
Thebes	Sta. Genevieve Bend	62	Sept. 20-24	5	33	23,900	4,000	1,100	200	104	1
Fort Chartres	Crain Island	78	Aug. 18-21, Sept. 27	5	32	62,500	8,100	1,100	250	12	1
Do	Liberty Island	81	Sept. 5-6, 22-23	7	53	79,600	10,900	1,600	225	104	1
Fort Gage	Gills Point	99	Sept. 25-29	5	52	84,500	13,100	1,500	200	12	1
Do	Grand Tower Landing ¹	104	Sept. 30-Oct. 2	3	24	11,300	1,800	500	150	13	1
Phoenix	Grand Tower, upper ¹	104	Sept. 4-Oct. 27, Mar. 3-13, 1920.	62	325	3,800	2,300	800	175	104	1
Fort Gage	Grand Tower	104	Aug. 23-27, 31, Sept. 4-5	8	63	56,600	12,400	2,000	200	12	3
Do	Hamburg Island	120	Sept. 18-23	6	58	78,000	14,300	3,000	200	104	3
Fort Chartres	Schenmunn	122	July 23-30	8	73	129,300	14,200	2,900	250	104	1
Do	do.	122	Aug. 15-20	6	60	118,900	11,400	2,500	200	12	1
Fort Gage	do.	122	Sept. 13-15	3	37	58,200	7,800	1,900	200	10	3
Do	do.	122	Oct. 24-27	4	33	62,300	7,100	1,100	250	15	4
Do	Brewer Point	166	Sept. 8-10	3	32	62,800	6,600	1,200	200	12	2
Total				266	1,768	1,678,900	220,325	43,725	5,600		

¹ Outside the main channel.

² Straightening channel.

RECAPITULATION.

Dredge.	Days dredging.	Actual dredging time.	Quantity dredged.	Total length of cuts.	Rate per hour.	Advance per hour.
		<i>Hours.</i>	<i>Cu. yds.</i>	<i>Feet.</i>	<i>Cu. yds.</i>	<i>Feet.</i>
Selma (28-inch).....	58	323	197,000	32,600	610	101
Thebes (28-inch).....	39	224	138,800	19,400	620	87
Fort (age) (32-inch).....	49	442	677,900	89,900	1,534	203
Fort Chartres (32-inch).....	46	388	653,600	75,600	1,685	195
Phoenix (dipper).....	74	391	11,500	2,825	29	7
Total.....	266	1,768	1,678,800	220,325		

RIVER STAGE, ST. LOUIS GAGE.

The stage was below normal at the beginning of the year and during the fall season until the middle of October, being 5 to 6 feet below the mean daily stage line during that period and equaling the extreme low readings for August 27 to 29. A rapid rise occurred toward the end of October, and the average stage for November was the highest since 1884. The usual winter decline began early in December, and the stage remained low until the middle of March; then followed the spring rise, the peaks of which slightly exceeded mean annual high water (27 feet) in March, April, and May. In June a decline set in, but the stage did not fall below 14 feet until after the end of the year.

The average of the daily readings for the fiscal year was 11.3 feet, or 1.1 feet below mean stage of river, 12.4 feet, as derived from all daily readings (21,548) for the last 59 calendar years.

As shown in the following table the river oscillated 27.6 feet from 27 feet (in April and May) above the low water to 0.6 foot (Dec. 18) below low water, 1 foot on the gage. The normal yearly oscillation is about 25 feet, from 1 foot above, to 26 feet above low water.

St. Louis gage, 1919-20.

Date.	Highest monthly gage readings.	Date.	Lowest monthly gage readings.	Normal range, 50 years' continuous record.
	<i>Feet.</i>		<i>Feet.</i>	<i>Feet.</i>
1919.		1919.		
July 1.....	17.1	July 31.....	7.9	20 - 15
August 1.....	7.5	August 9 and 30.....	3.8	15 - 9½
September 2.....	7.7	September 17.....	1.1	9½ - 9
October 30.....	20.7	October 25.....	3.8	9 - 8
November 1.....	20.1	November 29.....	8.3	8 - 7
December 1.....	11.6	December 18.....	0.4	7 - 5
				5 - 6
1920.		1920.		
January 1 and 2.....	3.6	January 5 and 6.....	1.9	6 - 8
February 23.....	5.5	February 5.....	3.4	8 - 12
March 31.....	27.6	March 9.....	2.8	12 - 17
April 24.....	28.0	April 4.....	25.1	17 - 19
May 22.....	28.0	May 12.....	20.6	19 - 18
June 4.....	22.2	June 21.....	14.0	18 - 19
				19 - 20½
				20½ - 20

Extreme low water (1917), caused by ice conditions, is 3.1 feet below gage zero; and extreme high water (1844) is 41.3 feet on the gage. Elevation of gage zero, 380 feet above mean sea or Gulf level.

CHANNEL CONDITIONS.

Channel conditions were constantly under investigation by the snag boats, towboats, and self-propelling dredges of the district until the close of navigation, December 9, and thereafter intermittently as permitted by winter conditions until February 12, when the river became free of ice and patrolling was resumed. Between the mouth of Missouri River (-17) and St. Louis (0), the project depth of 6 feet was maintained by the works of regularization aided only by the natural scouring action of the river itself. Between St. Louis (0) and the mouth of Ohio River (183), a channel of the required dimensions, 8 feet depth and 200 feet width, was maintained by the same agencies aided by dredging, except for certain periods when the maximum depths available for navigation were as stated in the following table:

Channel depths less than 8 feet, between St. Louis and mouth of Ohio River, during the fiscal year ending June 30, 1920.

Item.	Crossing or bar.	Miles below St. Louis.	River stage (average).	Dates.	Number of days when depth was—				Remarks.
					6 feet.	6½ feet.	7 feet.	7½ feet.	
			<i>Fect.</i>	1919.					
1	Chiff Cave.....	14	7.2	July 1-25.....					No depth less than 8 feet.
2	.....do.....			July 30-Aug. 7.....			(1)	(8)	Channel improved itself to 8 feet depth or more; time covered by item 7, the same or a lesser depth.
3	.....do.....	14	5.5	Aug. 14-18.....				5	Dredged to 10½ feet depth Aug. 16-20.
4	Waters Point.....	23	5.5	Aug. 17-21.....				(5)3	Dredged to 8 feet depth Aug. 23-26; 2 days covered by item 3.
5	Riverside.....	27	8.1	July 29-31.....				(3)	Dredged to 10½ feet depth July 29-Aug. 1, and Aug. 6-7; time covered by item 7.
6	.....do.....	28	1.5	Sept. 12-18.....	5				Dredged to 9 feet depth Sept. 15-20.
7	Danby.....	41	7.3	July 29-Aug. 7.....				10	Dredged to 12 feet depth Aug. 4-10.
8	Ames Towhead.....	43	1.5	Sept. 13-14.....				(2)	Channel dredged Aug. 11-16, becameshoal and new 9-foot channel developed itself; time covered by item 6.
9	Sts. Genevieve Bend.....	62	1.3	Sept. 12-13 and 16-20.....		(5)		(2)	Dredged to 10½ feet depth Sept. 20-24; time covered by items 6 and 12.
10	Liberty Island.....	81	8.1	Aug. 30-31.....					Channel improved itself to 8 feet depth or more.
11	.....do.....	81	1.5	Sept. 11-21.....				(11)	Dredged to 10½ feet depth Sept. 22-26; time covered by items 6, 12, and 15.
12	Hamburg Island.....	120	1.5	Sept. 14-21.....	(8)5				Dredged to 10½ feet depth Sept. 18-23; 3 days covered by item 6.
13	Schenimann.....	122	9.2	July 26-28.....				2	Dredged to 10½ feet depth July 23-30.
14	.....do.....	122	5.8	Aug. 14.....				1	Dredged to 12 feet depth Aug. 5-20; time covered by item 3.
15	.....do.....	122	1.8	Sept. 11-14.....		(4)1			Dredged to 10 feet depth Sept. 13-15; 3 days covered by item 6.
16	.....do.....			Sept. 22 to close of navigation by ice Dec. 9.					No depth less than 8 feet.
17	.....do.....			1920. From opening of navigation Feb. 12 to Mar. 3.					Do.
18	Chiff Cave.....	14	3.1	Mar. 7-11.....		(2)		(3)	No dredging because of winter conditions and probable increase in stage with warmer weather. Time covered by item 19.
19	Ames Towhead.....	43	3.3	Mar. 5-11.....				7	See item 18.
20	Sts. Genevieve Bend.....	62	3.1	Mar. 4.....				1	Do.
21	.....do.....			Mar. 12 to June 30.....					No depth less than 8 feet.
	Totalshoals (21).....				2	3	12	4	
	Total days (42).....				10	1	28	3	

Although channel depths of less than 8 feet were prevalent during the latter part of July, 17 days in August, and 11 days in September, they were generally ample for the needs of navigation and no serious delays were caused thereby. On a few occasions commercial towboats and barges were subjected to short delays, mainly because they were loaded to more than 8 feet draft or were grounded, through misjudgment, far out of good and sufficient channels; in all cases, however, they were assisted by the district towboat and dredges as required and, as stated, suffered no serious delays. At St. Louis navigation was stopped by large floes of ice December 9, and for several days thereafter, and, owing to backwater from the Ohio River, these ice floes jammed and blocked the lower part of the district below Commerce (144), December 15 to 28; navigation throughout the district was then intermittent until resumed February 12. Three bars which threatened to become obstructive early in March (see foregoing table) were quickly improved by advancing river stages, and in the last half of the fiscal year navigation experienced no delays whatever because of insufficient channel dimensions.

Steamer channel reports giving steering directions and least depths on the bars, as ascertained by pilots of this office on through trips, were issued during the fall season to river vessels and the public through the Lighthouse Service.

The average natural depths, at selected stages, that are available for navigation between St. Louis, Mo., and Cairo, Ill., are given under Physical Data, page 2733, Annual Report, 1918.

SURVEYS, EXAMINATIONS, AND CHANNEL MARKS.

Surveys, general and special, covering 188 miles of river, including 19 miles resurveyed, were made as required and included all localities where construction works or dredging were in progress or immediately prospective; also where considerable changes, due to caving banks and shifting channels, had taken place. Dredged channels were marked with buoys and steering ranges in addition to the regular beacon lights of the Lighthouse Service.

PHYSICAL DATA.

The river gages were maintained and read daily throughout the year, and the records thereof were checked by being plotted on the official hydrograph.

MATERIALS.

For the operation of towboats and dredges and for use in maintenance of the works of improvement—hurdles, dikes, and bank revetments—there were procured under proposals and open-market agreement 14,781 tons (2,000 pounds) of coal, at an average cost of \$4.25 per ton; 30,736 cubic yards of stone and spalls, at an average cost of \$1.26 per cubic yard; and 136,330 linear feet of pile timber, at an average cost of 14.3 cents per linear foot; also, 1,620 cords of brush were procured and loaded on Government barges by hired labor, at an average cost of \$4.95 per cord. These unit costs include plant charges.

All other materials, supplies, ship stores, subsistence, etc., were purchased under competitive bids or in the open market and were collected, inspected, and tested as required at the Engineer Depot, St. Louis, Mo., and thence were distributed to the various working parties.

Testing and inspection of materials and other work for Engineer offices were as follows: First district, Cincinnati, Ohio; third district, San Francisco, Calif.

PLANT.

All plant required for service was maintained in working condition, such repairs as were necessary for present and probable future service being made at the St. Louis Engineer depot.

Extensive repairs.—Oil burners were installed for experimental purposes under the two-boiler battery of dredge *Fort Gage*, but on trial test did not develop the efficiency guaranteed and were discarded. Further tests of the equipment offered by other bidders were not undertaken, as the rise in price of fuel oil had made its present use in competition with coal impracticable. The boiler on tender *Meramec*, being in bad condition and of insufficient capacity, was replaced with a larger and better boiler salvaged from a wrecked steamboat. Four excellent boilers salvaged from a large transfer boat were installed on the snag boat *H. G. Wright*, replacing the old battery which had become unserviceable and was condemned by the United States boiler inspector; this work was interrupted by a strike of the boiler makers for higher wages on June 28. Extensive repairs were also made to the steamer *John Ewens* of the Mississippi River Commission, the lighthouse tender *Oleander*, and to nine towboats, the *Nokomas*, *Choctaw*, *A. M. Scott*, *Advance*, *Oscar F. Barrett*, *Patton*, *Barrett*, *Inspector*, and *F. M. Wallace*, of the Inland Waterways, Mississippi-Warrior Service (Government barge line, St. Louis-New Orleans), all expenses being charged to the proper appropriation.

Ordinary repairs.—The feathering paddle wheel placed on the towboat *William R. King*, for use of the Board on Experimental Towboats, was found very expensive to maintain, and was replaced with a radial fixed paddle wheel of slightly larger diameter. Repairs were made to the four suction dredges of the district, *Selma*, *Thebes*, *Fort Gage*, and *Fort Chartres*, and to the dipper dredge *Phoenix*. The main sand pump of the *Fort Gage* was fitted with new lining plates, and the *Fort Chartres*' pipe line, sunk in deep water during a severe wind storm in July, was salvaged and repaired. Both of these dredges were provided with larger steam cylinders for the steering engines.

Repairs were made to the snag boats *J. N. Macomb* and *H. G. Wright*, and to 3 quarter boats, 4 office and survey boats, 1 store boat, 2 wooden barges, 5 steel barges, 5 wooden pile drivers, 4 steel pile drivers, 2 steel grader and derrick boats, 2 wooden derrick boats, 7 steel flats, and 17 skiffs, all of this district. Twenty-five wooden flats were condemned and destroyed, leaving one on hand in poor condition. Twelve wooden barges furnished by the St. Louis-New Orleans barge line, to replace temporarily and in part the 20 steel barges of the district held by that line, were calked and repaired and returned to their owners. Six of the district barges were returned during the year, leaving 14 steel barges (lease expired June 30, 1919) still held by the Government barge line.

Seven large steel barges built for service on the Upper Mississippi were delivered at the Engineer depot and received equipment and repairs to slight injuries received en route. Six large steel barges of the Government barge line (St. Louis-New Orleans) received

minor equipment and were cared for in harbor for idle plant as were the Upper Mississippi barges.

The buildings of the Engineer depot at foot of Arsenal Street, St. Louis, Mo., were repaired and maintained in thoroughly serviceable condition, as were all shop machinery, equipment, tools, and appliances, and boarding outfit. The blacksmith shop was enlarged to accommodate a larger steam hammer and two cranes for handling heavy forgings.

Total cost and work done to June 30, 1920.
HURDLES.

	New.	Restoration.	Repair.	Cost.
	Linear feet.	Linear feet.	Linear feet.	
Prior to July 1, 1919.....	402,031	36,597	100,100	\$8,375,146.40
During fiscal year ending June 30, 1920:				
Twin Hollows, west ¹			170	5,722.02
Pullticht, Ill.....			160	2,958.81
Meramec River, Mo.....			170	4,271.76
Lucas Works ²			335	5,428.84
Calico Island ³			355	8,349.40
Penitentiary Point, Ill.....			350	8,093.07
Fort Chartres, west ⁴			385	9,809.77
Crain Island, Mo.....			445	10,593.33
Lucour Island, Ill.....			400	5,082.24
Union Point, Ill.....			240	5,353.44
Hanging Dog Island, Ill.....	400		145	8,683.81
Total.....	402,431	36,597	103,255	8,447,494.09

¹ Cost includes 2,000 square feet of drift mattress.

² Cost includes 4,150 square feet of brush dike.

³ Cost includes 700 square feet of drift mattress and 5,540 square feet of stone paving.

⁴ Cost includes 15,395 square feet of drift mattress and 3,700 square feet of stone paving.

BANK PROTECTION.

	Mattress.			Paving.			
	New.	Repair.	Cost.	New.	Repair.	Cost.	
	Lin. ft.	Sq. ft.	Sq. ft.	Sq. ft.	Sq. ft.		
Prior to July 1, 1919.....	357,859	44,169,200	5,957,155	\$2,747,070.08	21,138,829	7,523,155	\$2,922,051.39
During fiscal year ending June 30, 1920:							
Twin Hollows, east.....			4,505	1,217.67		11,377	2,412.05
Foster Island, Ill.....						17,140	2,735.54
Osborne Field, Ill.....						8,100	1,813.05
Danby Landing, Mo.....						17,895	3,093.32
Fort Chartres, west.....						37,600	7,339.32
Fort Chartres, east.....			19,250	4,053.70		65,330	13,491.96
Turkey Island, Ill.....						67,275	11,905.15
Ste. Genevieve, Mo.....						88,063	14,110.56
Kaskaskia Island, Ill.....			124,700	17,267.73		78,420	15,808.72
Chester, Mo. (Horse Island) ²			41,810	8,269.71		34,325	4,045.52
Chester, Mo. (Claryville).....	100	12,800	31,055	4,805.98	49,775	28,860	7,712.25
Liberty Island ³	160	15,200	11,400	8,807.43	5,153	3,750	15,025.24
Price Landing, Mo.....			23,760	2,621.39		36,850	6,760.77
Beechridge, Ill.....						31,000	4,869.88
Eliza Towhead, Ill.....			10,070	2,325.08			
Cairo Protection.....			5,955	923.69		12,747	2,014.97
Greenfield Bend.....	134	13,440	26,700	4,555.73	29,650	30,881	8,603.97
Total.....	358,253	44,210,640	6,256,360	2,802,018.19	21,223,407	8,093,368	3,044,396.66

¹ Cost includes 215 linear feet of piling spur dikes.

² Cost includes 160 linear feet of piling spur dikes.

³ Cost includes 290 linear feet of piling spur dikes, new, and 550 linear feet of piling spur dikes, repair, and 3,800 square feet of drift mattress.

RECAPITULATION.

Hurdles.....	\$8,447,494.09
Bank protection.....	5,846,414.85
Dikes and dams.....	691,893.46
Jetties.....	114,603.53
Surveys.....	409,548.73
Dredging.....	2,869,413.05
Total.....	18,379,367.71

Total cost and work done to June 30, 1920—Continued.

PROPERTY.

	Value July 1, 1919.	Debits.	Credits.	Value June 30, 1920.
Steamer Wm. R. King.....	\$40,000.00	\$36,041.93	\$36,041.93	\$40,000.00
Dredges:				
Solma.....	45,500.00	19,154.10	22,154.10	42,500.00
Thebes.....	45,500.00	12,614.03	15,614.03	42,500.00
Port Gage.....	104,000.00	53,749.25	59,749.25	98,000.00
Port Chartres.....	103,000.00	59,508.60	65,508.60	97,000.00
Phoenix.....	1,000.00	14,033.79	14,033.79	1,000.00
Tenders:				
Salvisti.....	5,500.00	11,378.50	11,018.50	5,800.00
Kaskaskia.....	5,500.00	7,715.45	8,015.45	5,200.00
Meramec.....	6,500.00	16,073.93	12,993.93	9,580.00
Barges:				
Model.....	700.00	3,704.38	1,104.38	3,300.00
Steel.....	178,000.00	425.27	10,425.27	168,000.00
Flat.....	45.00	155.27	155.27	45.00
Store boat.....	1,100.00	135.80	310.80	925.00
Quarrier boats.....	4,000.00	697.76	1,297.76	3,400.00
Office and survey boats.....	5,500.00	3,933.05	4,808.05	4,625.00
Pile drivers:				
Wood.....	10,000.00	2,129.04	4,829.04	7,300.00
Steel.....	22,000.00	284.75	1,864.75	20,400.00
Derrick boats, wood.....	2,300.00	1,111.28	1,561.28	1,850.00
Grader and derrick boats, steel.....	18,400.00	925.35	1,925.35	17,400.00
Flats:				
Wood.....	1,400.00	224.26	1,574.26	50.00
Steel.....	55,000.00	475.25	3,675.25	52,400.00
Small boats:				
Wood.....	370.00	979.49	1,034.49	315.00
Steel.....	370.00		35.00	335.00
Portable quarters.....	165.00			165.00
United States Engineer depot.....	9,100.00	15,981.89	14,081.89	11,000.00
Tools and appliances.....	18,300.00	14,208.16	14,903.16	17,005.00
Boarding outfit.....	3,475.00	2,770.53	3,474.53	2,780.00
Office furniture.....	1,100.00	64.45	214.45	950.00
Survey instruments.....	600.00	236.50	236.50	600.00
Automobile (touring car).....		1,253.35	403.35	850.00
Total.....	689,025.00	280,045.11	313,105.11	655,965.00

MATERIAL.

Substance.....	\$1,704.00	\$52,323.84	\$51,319.84	\$2,713.00
Brush.....	4,294.00	1,031.79	12,325.79	
Piles.....	94.00	2,475.82	18,170.82	1,399.00
Stone.....	1,872.00	38,659.73	39,781.73	750.00
Rope.....	22,613.00	8,037.75	18,106.75	12,544.00
Wire.....	520.00	336.91	740.91	116.00
Iron.....	19,553.00	15,778.97	9,605.97	25,606.00
Nails.....	340.00	139.45	134.45	351.00
Spikes.....	467.32	31.70	84.08	415.00
Lumber.....	2,569.00	5,733.61	4,457.61	3,845.00
Okum.....		109.92	109.92	
Coal.....	2,585.00	62,759.03	62,033.03	3,311.00
Ice.....		4,171.72	4,171.72	
Fuel oil.....		3,517.17	3,012.17	505.00
Material, miscellaneous.....	21,379.79	33,701.30	31,255.09	23,826.00
Total.....	77,997.11	252,813.77	255,369.88	75,441.00

EXPENDITURES.

The total amount appropriated from July 4, 1836, to March 4, 1915, is \$17,956,599.98, as shown on pages 488 and 490, House Document 1491, Sixty-third Congress, third session, under the following headings:

Illinois River to Ohio River.....	\$4,110,000.00
Missouri River to Ohio River.....	13,746,599.98
Missouri River to Meramec River.....	100,000.00
Total.....	17,956,599.98
Appropriated by river and harbor act of July 27, 1916.....	350,000.00
Appropriated by river and harbor act of Aug. 8, 1917.....	350,000.00
Appropriated by river and harbor act of July 18, 1918.....	100,000.00
Appropriated by river and harbor act of Mar 2, 1919.....	700,000.00
Appropriated by river and harbor act of June 5, 1920.....	400,000.00

19,856,599.98

2408 REPORT OF CHIEF OF ENGINEERS, U. S. ARMY, 1920.

Of the above total amount there was appropriated in the years 1836, 1837, and 1844 for pier near St. Louis and obstructions in harbor of St. Louis (not considered in previous project of 1872 nor existing project of 1881) the sum of.....	\$75,000.00
By the acts of 1872, 1874, 1875, 1876, 1878, 1879, 1880, 1882, 1890 there was allotted for work above the mouth of the Missouri River (not in the present district) the sum of.....	205,000.00
From the appropriation of 1879 there reverted to the Treasury the amount allotted by the act of Wittenberg, Mo.....	10,000.00
	\$290,000.00

Leaving for work in the present district between the mouths of Missouri and Ohio Rivers under general acts for work in the district and special acts for work at certain localities in the district..... 19,566,599.98

Receipts from sales, \$271,931.50.

There was expended on the original project under the acts of June 10, 1872, to June 14, 1880, inclusive, \$1,495,000, and under the existing project of 1881 there has been expended to June 30, 1920, \$17,450,961. The amount unexpended June 30, 1920, is \$601,678.50. The outstanding liabilities June 30, 1920, are \$40,504.48, leaving \$561,174.02 available for the coming year in addition to \$23,961.34 due from other sources.

In addition there is still due from Mr. Edward F. Goltra \$14,599.59 for rental of barges under lease to him from January 1 to April 30, 1919, and for property lost and repair of barges while in his service.

Amount expended during fiscal year.....	\$570,649.28
Reimbursable.....	54,012.78
Net expenditures.....	516,636.50

APPROPRIATIONS.

[See H. Doc. 1491, 63d Cong., 3d sess., pp. 488 and 490.]

Under former projects, from July 4, 1836, to Mar. 3, 1881, inclusive, and under the following heads: Pier near St. Louis and obstructions in harbor of St. Louis, years 1836, 1837, and 1844, \$75,000; Illinois to Missouri Rivers, year 1872, \$25,000; Missouri River to Meramec River, year 1872, \$100,000; Missouri River to Ohio River, year 1873, \$200,000; Ohio River to Illinois River, years 1874, 1878, \$440,000; Illinois River to Ohio River, years 1875, 1876, 1879, 1880, 1881, \$1,450,000; channel opposite St. Louis, Mo., year 1876, \$29,600; ice harbor at St. Louis, Mo., years 1880, 1881, \$60,000; Cape Girardeau and Minton Point, years 1880, 1881, \$30,000, aggregating..... \$2,409,600.00

Present project:

Aug. 2, 1882, Cairo to Illinois River.....	600,000.00
July 5, 1884, Illinois River to Ohio River.....	520,000.00
Aug. 5, 1886, Illinois River to Ohio River.....	375,000.00
Aug. 11, 1888, Illinois River to Ohio River.....	300,000.00
Sept. 19, 1890, harbor at St. Louis, Mo.....	182,000.00
Sept. 19, 1890, Illinois River to Ohio River.....	400,000.00
July 13, 1892, Ohio River to Missouri River.....	525,000.00
Mar. 3, 1893, Ohio River to Missouri River.....	658,333.33
Aug. 18, 1894, Ohio River to Missouri River.....	758,333.33
Mar. 2, 1895, Ohio River to Missouri River.....	758,333.33
June 3, 1896, Missouri River to Ohio River.....	275,000.00
June 4, 1897, Ohio River to Missouri River.....	673,333.33
June 4, 1897, preventing break in Mississippi River at Becch-ridge, Ill.....	100,000.00
June 19, 1897, Ohio River to Missouri River.....	325,000.00
July 1, 1898, Ohio River to Missouri River.....	673,333.33

Present project—Continued.

Mar. 8, 1899, Ohio River to Missouri River	\$673,333.83
June 6, 1900, Ohio River to Missouri River	100,000.00
June 13, 1902, Ohio River to Missouri River	650,000.00
Mar. 3, 1903, Ohio River to Missouri River	650,000.00
Apr. 28, 1904, Ohio River to Missouri River	650,000.00
Mar. 3, 1905, Ohio River to Missouri River	650,000.00
Mar. 2, 1907, Ohio River to Missouri River	250,000.00
May 27, 1908, Ohio River to Missouri River	250,000.00
Mar. 4, 1909, Ohio River to Missouri River	250,000.00
June 25, 1910, Ohio River to Missouri River	250,000.00
June 25, 1910, Ohio River to Missouri River	500,000.00
Feb. 27, 1911, Ohio River to Missouri River	1,000,000.00
July 25, 1912, Ohio River to Missouri River	1,000,000.00
Mar. 4, 1913, Ohio River to Missouri River	1,000,000.00
Oct. 2, 1914, Ohio River to Missouri River	250,000.00
Mar. 4, 1915, Ohio River to Missouri River	300,000.00
July 27, 1916	350,000.00
Aug. 8, 1917	350,000.00
July 18, 1918	100,000.00
Mar. 2, 1919	700,000.00
June 5, 1920	400,000.00

Total of appropriations..... 19,856,599.98

Of the above total amount there was appropriated in the years 1830, 1837, and 1844, for pier near St. Louis and obstructions in harbor of St. Louis (not considered in previous project of 1872, nor existing project of 1881), the sum of..... \$75,000

By the acts of 1872, 1874, 1875, 1876, 1878, 1879, 1880, 1882, 1890 there was allotted for work above the mouth of the Missouri River (not in the present district) the sum of..... 205,000

From the appropriation of 1879 there reverted to the Treasury the amount allotted by the act for Wittenberg, Mo..... 10,000

290,000.00

Leaving for work in the present district between the mouth of Missouri and Ohio Rivers, under general acts for work in the district and special acts for work at certain localities in the district..... 19,566,599.98

Receipts from sales, \$271,931.50.

2. REMOVING SNAGS AND WRECKS FROM THE MISSISSIPPI RIVER BELOW THE MOUTH OF THE MISSOURI RIVER, AND FROM OLD AND ATCHAFALAYA RIVERS.

OPERATIONS DURING THE FISCAL YEAR.

The work is now being done by the department's two large steel-hull snag boats—the *J. N. Macomb*, built in 1874, and the *H. G. Wright*, built in 1881—fitted with the necessary equipment and appliances and operated by Government employees. These boats patrol the Mississippi River between Head of Passes (13 miles from the mouth of South Pass) and mouth of Missouri River, 1,265 miles, and 35 miles of Old and Atchafalaya Rivers to Melville, La.; total, 1,300 miles.

Description of the snag boats may be found in Annual Report, Chief of Engineers, United States Army, 1895, page 2054 et seq.

At the beginning of the fiscal year both snag boats were laid up in ordinary at St. Louis, Mo., making annual repairs and awaiting a river stage low enough to resume snagging operations.

1. *Preliminary examination and survey of Arkansas River, from Little Rock to its mouth, with a view to determining if a minimum depth at all seasons of 4½ feet can be maintained.*—Reports dated September 14, 1916, and April 24, 1920, with maps, were submitted to Congress December 21, 1920. The improvement of this locality by the United States is not deemed advisable at the present time.

2. *Preliminary examination of Arkansas River, Ark. and Okla., from Little Rock to the mouth of the Grand River.*—Report dated January 25, 1921, was submitted to Congress June 21, 1921. The improvement of this locality by the United States is not deemed advisable to a greater extent than occasional snagging on reaches actually used for navigation.

The local engineer was also charged with the duty of making other preliminary examinations and surveys provided for by the river and harbor acts of July 27, 1916, and August 8, 1917, as follows, and reports thereon will be duly submitted when received:

1. *St. Francis River, Ark. and Mo., commencing at the head of what is known as the Sunk Lands, at or near the town of St. Francis, Clay County, Ark., and extending to the foot of said Sunk Lands, or near the town of Marked Tree, Poinsett County, Ark.;* and in making such examination and survey, which shall be thorough and complete, the engineer or engineers having the same in charge shall also prepare plans, specifications, and make estimates of the cost of said improvement, and define the channel or the course of said canal, and shall take into account and make report upon any proposition by local interests for participation in the expense of said project in connection with the reclamation of contiguous lands or other land subject to overflow by said stream.

2. *Black River, Ark. and Mo.*

3. *Black River, Ark. and Mo., above Black Rock, Ark., etc.*

IMPROVEMENT OF RIVERS AND HARBORS IN THE ST. LOUIS, MO., DISTRICT.

This district includes the Mississippi River between the Ohio and Missouri Rivers, and removing snags and wrecks from the Mississippi River below the mouth of the Missouri River and from Old and Atchafalaya Rivers.

District engineer: Maj. DeWitt C. Jones, Corps of Engineers.

Division engineer: Col. Charles L. Potter, Corps of Engineers.

IMPROVEMENTS.

	Page.		Page.
1. Mississippi River between the Ohio and Missouri Rivers.	1196	2. Removing snags and wrecks from the Mississippi River below the mouth of the Missouri River, and from Old and Atchafalaya Rivers.	1203

1. MISSISSIPPI RIVER BETWEEN THE OHIO AND MISSOURI RIVERS.

Location and description.—The Mississippi River rises in Lake Itasca, Minn., flows south 2,477 miles, and empties into the Gulf of Mexico. The St. Louis engineer district embraces the 200-mile section, known as the middle Mississippi, between the tributary Ohio

and Missouri Rivers, and 1,078 to 1,278 miles from the Gulf. The drainage area of the valley down to the Ohio and discharging through the district is about 707,000 square miles. The discharge per second at low water,¹ 1 foot on St. Louis gage, is 40,000 cubic feet; at mean stage, 12½ feet gage, 160,000 cubic feet; and at bank-full stage, 30 feet gage, 600,000 cubic feet. These stages obtain for, or exceed in duration, annual averages of 360, 162, and 4 days, respectively, and the average natural depths available for navigation at the same stages are about 4½, 9, and 16 feet; i. e., the crests of the bars rise and fall with the stage in the ratio of 1 to 2½. The oscillation between annual low and high waters averages 40 feet at Cairo, mouth of Ohio River, and 25 feet at St. Louis, 17 miles below mouth of Missouri River; the extreme range is 55.7 feet at Cairo and 44.4 feet at St. Louis. Low water at the mouth of Ohio River is 275 feet above mean sea level, and at the mouth of Missouri River it is 395 feet, the average slope being 0.6 foot per mile. The current at mean stage is about 2½ miles per hour, and the average width between banks is 4,300 feet.

Original condition.—The waterway of the middle Mississippi was divided by numerous islands and bars which distributed large portions of the flow through chutes, sloughs, and secondary channels to the detriment of navigation; at many of these localities the natural width of river was 1 to 1½ miles and the maximum usable channel depth at low water was only 3½ to 4 feet.

Previous projects.—The original project for the general improvement of this river section was recommended by a board of engineers in a report dated April 13, 1872, concurred in by the Chief of Engineers. The amount expended thereunder was \$1,495,000 for new work. For further details of previous projects see page 1879 of Annual Report for 1915.

Existing project.—This provides for obtaining and maintaining a minimum channel depth of 8 feet at low water² from the mouth of Ohio River (1,078 miles from the Gulf) to St. Louis, 183 miles, and 6 feet thence to the mouth of Missouri River, 17 miles, with a minimum width of channel of 200 feet, to be obtained by regulating works and dredging, as follows:

First. By regulating works, for closing sloughs and secondary channels, narrowing the river to a uniform width of about 2,500 feet at bank-full stage, building new banks where the natural width is excessive, and by protecting new and old banks from erosion where necessary to secure permanency.

Second. By dredging or other temporary expedients, pending the completion of the permanent improvement, so as to maintain each season the required low-water depth of channel.

The project for regulating works was adopted in 1881 (Annual Report, Chief of Engineers, 1881, p. 1536). Dredging was introduced as a part of the project by the river and harbor acts of 1896 and 1902. The part of the project which proposed regulating works was practically abrogated by the acts of March 3, 1905, March 2, 1907, and joint resolution of June 29, 1906. The river and harbor act of June 25, 1910, restored the regulating works to the project

¹ "Standard low water," adopted in 1881, was 4 feet on the St. Louis gage, the discharge being approximately 40,000 cubic feet per second; due to lowering of the low-water plane in St. Louis Harbor, that volume now passes at the 1-foot stage.

² One foot, St. Louis gage, and 4 feet, Cairo gage.

and began appropriations, "with a view to the completion of the improvement within twelve years," at an estimated cost of \$21,000,000, exclusive of amounts previously expended, and \$400,000 annually thereafter for maintenance (H. Doc. No. 50, with accompanying atlas, 61st Cong., 1st sess., 1909; also H. Doc. No. 168, 58th Cong., 2d sess., 1903).

Operations and results during fiscal year.—Maintenance of the existing regulation works was continued by hired labor July 1 to December 9, 1920, and after March 23, 1921. At 12 localities 26 permeable dikes of piling were repaired, 3,720 linear feet, costing \$91,801.63; bank revetments were repaired at 15 localities, 180 squares of mattress, and 3,737 squares of stone paving, costing \$63,414.96. The total thus expended for maintenance of regulation works was \$155,216.59. Three pipe-line hydraulic dredges, operated by hired labor, August to December, and two, in June, maintained the required or project depths and width of channel; 1,419,000 cubic yards of sand and gravel were dredged from 20 main channel areas having a combined length of 8 miles and an average width of 240 feet. The average gain in depth due to all dredging was 4 feet, and the total cost of dredging was \$258,622.10. Surveys were made covering 186 miles of river, including all dredged channels; 90 miles were resurveyed, making a total of 276 river miles of hydrographic surveys, at a cost of \$11,683.46. The total expenditures for maintenance of river works and channel conditions, including dredging and surveys, were \$425,522.15; in addition, \$62,400.54 was expended on account of liabilities due at the end of the previous year, making the total expenditures \$487,922.69. A hydrograph, shown opposite this page, was constructed from the daily readings of 60 years' continuous gage records at St. Louis, 1861 to 1920.

Condition at end of fiscal year.—The existing project is 34 per cent completed. Physical extent of work accomplished and status and requirements of the project are as follows:

Project of 1881 (restored 1910).	Permeable piling dikes (hur-dles), linear feet.			Revetments (bank proteo-tion), linear feet.		
	Con-structed.	Lost.	Existing and projected.	Con-structed.	Lost.	Existing and projected.
Total June 30, 1910 As published ¹	372,528		225,806	304,043		236,158
As revised 1921.....	373,323	147,522	225,806	302,232	66,074	236,158
Estimate for completion ¹			300,000			900,000
Total.....			525,806			1,136,158
1911-1921.....	29,783	40,609		57,171	18,033	
Total June 30, 1921.....	403,116	188,131	525,806	359,403	84,107	1,136,158
Requirements.....			310,321			866,912

¹ H. Doc. No. 50, 61st Cong., 1st sess., 1909, pp. 53-55.

² 40.9 per cent.

³ 24.2 per cent.

⁴ 59.1 per cent.

⁵ 75.8 per cent.

Because of the small and insufficient appropriations for this district in recent years, the regulation works have deteriorated rapidly and many sections thereof have been entirely destroyed; existing

structures are being maintained in as good condition as the very limited funds available therefor will permit. Between the mouth of Ohio River and St. Louis dredging¹ is always required during the fall or low-water season from July or August to the close of navigation by ice or winter conditions, usually in December, and is occasionally required in the spring season; project dimensions of channel in that section of river have been maintained throughout navigation seasons for the last 14 years, except for short periods of time when river stage was very low and dredges were attacking the obstructive bars. Between St. Louis and the mouth of Missouri River the project dimensions of channel have been maintained with but very infrequent aid from dredging when river stage was unusually low. From the opening of the navigation season, usually in February, to July inclusive, or when river stage is above 10 feet on the St. Louis gage, a minimum channel depth of 8 feet generally prevails throughout the entire district without dredging or other artificial aid. (For the natural depths available to navigation, see p. 2733, A. R. 1918.) The least channel depths last observed were: From mouth of Ohio River to St. Louis, 8 feet, December 2-9, 1920, St. Louis gage 2.9 to 3.2 feet; from St. Louis to mouth of Missouri River, 8½ feet, November 20, 1920, St. Louis gage 4.1 feet. The total expenditures under the existing project from 1881 to date are \$9,930,463.70 for new work and \$7,984,564.75 for maintenance, including dredging and surveys, a total sum of \$17,915,028.45. The amount expended on the existing project since the estimate was revised in 1910 is \$1,970,046 for new work.

Local cooperation.—There has been no local cooperation in recent years (Annual Report for 1902, p. 2607, and H. Doc. No. 1067, 61st Cong., 3d sess., p. 30). Since 1838 private and corporate interests at their own expense have constructed 56,000 linear feet of dikes and railroad inclines costing \$1,664,000, and 83,000 linear feet of revetments and paved wharves costing \$6,769,000; all of which are more or less essential or contribute to the completion of the project of improvement.

Terminal facilities.—Besides numerous steamboat landings of more or less importance as river service stations, there are within the district only two cities, St. Louis and East St. Louis, provided with terminal facilities worthy of the name; although, there are simple facilities, such as paved wharves and small derricks and warehouses, at Ste. Genevieve, Chester, Grand Tower, Cape Girardeau, Thebes, and Commerce. Cairo, between the two rivers but with its main wharf on the Ohio River (1 to 4 miles above mouth) and therefore not strictly within this engineer district, may be mentioned herein, this office having recently made a survey there of the two inclines of the Illinois Central Railroad preliminary to the contemplated alteration of one of them for use by the War Department, Inland and Coastwise Waterways, Mississippi-Warrior Service.

St. Louis Harbor contains 21 terminal facilities, most of them modern and all privately owned except the paved wharves and the new concrete Municipal Dock which are owned and operated by the

¹ Annual quantity indefinite; in last 10 years, one-half million to 3 million cubic yards; average, 1½ million cubic yards.

city. The dock, now completed, is 900 feet long, with concrete foundations already built for an additional 400 feet, has modern equipment—cranes, gantries, and temporary warehouses—all provided by the city at a cost of \$625,000. Further additions to the dock, though advocated and proposed by the city, are not likely in the near future. As the dock stands it is one of the finest terminal facilities of its kind on the inland waterways. A number of the privately owned terminals are available for public use, the most noteworthy being the Burlington and Central B grain elevators equipped for rail-to-river traffic only and the ore dock of the Mississippi Valley Iron Co.

In East St. Louis harbor are nine terminals, all privately owned except the dock originally built at a cost of \$23,000 and used by the Kansas City-Missouri River Navigation Co., but now owned and operated by the said Waterways Service. Of the other eight terminals, one, an incline, owned by the Terminal Railroad Association and leased to the said Waterways Service, was rebuilt by this office this year at a cost of \$16,500 for use in connection with a concrete track barge improvised for a terminal of that service, which also has built recently, at Dubuque, Iowa, for a similar purpose, a thoroughly equipped, modern, covered, steel terminal barge 75 feet wide and 320 feet long. The only other adequate terminal available for public use in East St. Louis harbor is the excellent permanent dock built by the Alton & Southern Railway, at a cost of \$200,000, and used by the Aluminum Ore Co. for the transfer of bauxite and coal.

St. Louis and a number of the smaller cities in the district have built and for many years maintained paved landings or wharves, the aggregate cost of which approximates \$4,000,000. Various inclines for transferring cars across the river on boats and barges are maintained by the railroads at St. Louis, Ivory Station, Ste. Genevieve, and Chester. The facilities described are considered adequate for the existing commerce of the district, although additional and modern terminals established at St. Louis, East St. Louis, Chester, Cape Girardeau, and Birds Point (opposite Cairo) would undoubtedly stimulate and increase river traffic. (For a full description of terminal facilities see H. Doc. No. 652, 66th Cong., 2d sess.)

Effect of improvement.—The effect of the improvement has been to make transportation easier and safer and to facilitate commerce by permitting the use of larger boats and barges.

Proposed operations.—Dredging, as needed to maintain the requirements of the project, and the most urgent and necessary repairs to existing dikes and revetments, including such minor extensions as may be required for that purpose, will be carried on throughout the coming fiscal year except in the winter when navigation is stopped by ice. The balance of \$550,870.79 available July 1, 1921, will be applied in the ensuing fiscal year as follows:

(a) Operation of 4 pipe-line dredges.....	\$300,000.00
(b) Maintenance of existing regulation works.....	124,620.79
(c) Repair and care of plant.....	95,000.00
(d) Office, engineering, surveying, and gages.....	26,250.00
(e) Contingencies.....	5,000.00
Total.....	550,870.79

Item (b) for regulation works, \$124,620.79, will be increased by unexpended balances, if any, from the other items.

During the low-water season, July to December, inclusive, when both maintenance of regulation works and dredging are actively prosecuted, funds will be expended at the rate of \$50,000 to \$80,000 per month, depending upon the amount of dredging that may be required; a total of \$50,000 will be expended in January and February on repairs and care of floating plant in winter harbors; for the period March to June, inclusive, expenditures for maintenance of regulation works and repairs of plant should normally be about \$150,000; that sum, however, must be reduced if a greater than average amount of dredging shall have been required in the fall.

Prices having become somewhat stabilized, it is believed that with the funds now available the project dimensions of channel can be maintained throughout the year, together with a nominal but not the needed amount of repairs to the regulation works; all funds will be exhausted by June 30, 1922.

Attention is invited to the fact heretofore stated and often reiterated, that the existing regulation works can not be maintained with the meager allotments made therefor in recent years. The losses shown, 1911 to 1921, under *Condition at end of fiscal year*, are serious and amount in value of replacement at present prices to nearly \$2,000,000; as a result the river, at several localities, is again becoming excessively wide, a mile or more, and unless necessary sums for needed restorations and channel corrections are made available, radical increase in the purely temporary dredging work with attendant increase in plant and operating expenses must be expected and provided for. Also many insistent complaints are being received from riparian owners, who, at one time, felt fairly secure behind the regulation works confining the river within certain limits and in such reliance have made valuable improvements on their properties; these owners naturally feel that the Government, having undertaken to secure the river banks, should maintain and extend the works begun and placed for that purpose in behalf of navigation and incidentally to their own great benefit.

At the present rapid rate of loss all dikes constructed, which to date have cost about \$8,500,000, will be destroyed in 50 years; add to this sum \$50,000 for annual repairs to dikes and at the end of 50 years \$11,000,000 will have been expended without advanced improvement; revetments also (total cost \$6,000,000) are deteriorating, but not at such rapid rate as the dikes.

If it be the intent of Congress that the present deterioration of these works and the river banks shall continue, then it is recommended that the work of river channel improvement in this district be confined to dredging alone, at an annual cost of about \$350,000. But, if the improvement works existing in 1922 are to be preserved and maintained in good condition, a minimum sum of \$1,000,000 should be made available for the fiscal year 1923 and the same sum annually for at least 5 years thereafter, in prosecution of the plan first outlined above. A reexamination of the project—a revision of that made in 1910 and again in 1915—appears desirable and necessary and therefore is recommended.

Recommended modifications of project.—None.

References to published articles not previously reported.—None.

1202 REPORT OF CHIEF OF ENGINEERS, U. S. ARMY, 1921.

Commercial statistics.—The commerce of the calendar year 1920, which is fairly typical of preceding years, consisted mainly of apples, animals and animal products, bauxite ore, cement, coal, grain and its products, groceries and provisions, hardware, iron, steel and metals, logs, lumber, machinery and vehicles, molasses, oil, sisal, and unclassified items. The entire project dimensions of channel are used and the improvement has greatly facilitated traffic, which shows a general increase in the last 5 years as indicated by the following:

Comparative statement.

Calendar year.	Short tons.	Approximate value.	Passengers.	Calendar year.	Short tons.	Approximate value.	Passengers.
1916.....	240,653	\$13,209,000	505,410	1919.....	288,286	\$22,694,001	442,603
1917.....	293,248	15,401,544	275,514	1920.....	363,082	30,870,399	447,704
1918.....	264,149	17,982,776	385,133				

¹ Includes 70,958 tons of Government materials used in improvement works; not included in previous years.

Financial summary.

Amount expended on all projects to June 30, 1921, after deducting receipts from sales, etc., amounting to \$314,747.22:

New work.....	\$11,425,463.70
Maintenance.....	7,984,564.75
Net total expended.....	19,410,028.45

Total appropriations to date of this report..... 19,966,599.98

Fiscal year ending June 30.	1917	1918	1919	1920	1921
Expended for new work ¹	\$24,722.56		\$34,800.58	\$25,761.85	
Expended for maintenance ¹	295,021.19	\$341,595.55	440,791.40	490,874.65	\$487,922.69
Total expended ¹	319,743.75	341,595.55	475,592.98	516,636.50	487,922.69
Appropriated or allotted.....	350,000.00	350,000.00	800,000.00	400,000.00	400,000.00

July 1, 1920, balance unexpended.....	\$601,678.50
Amount allotted from river and harbor act approved Mar. 1, 1921.....	400,000.00
Receipts from sales, etc., during fiscal year 1921.....	42,815.72
June 30, 1921, amount expended during fiscal year, for maintenance.....	1,044,494.22
July 1, 1921, balance unexpended.....	487,922.69
July 1, 1921, outstanding liabilities.....	556,571.58
July 1, 1921, balance available.....	5,700.74
July 1, 1921, balance available.....	550,870.79
Amount (estimated) required to be appropriated for completion of existing project.....	18,480,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1923, for new work and for maintenance.....	\$1,000,000.00

¹ Not deducting receipts from sales, etc.

² Exclusive of available funds.

IMPROVEMENTS.

	Page.		Page.
1. Mississippi River between the Ohio and Missouri Rivers.	1220	2. Removing snags and wrecks from the Mississippi River below the mouth of the Missouri River, and from Old and Atchafalaya Rivers.	1225

1. MISSISSIPPI RIVER BETWEEN THE OHIO AND MISSOURI RIVERS.

Location and description.—The Mississippi River rises in Lake Itasca, Minn., flows south 2,477 miles, and empties into the Gulf of Mexico. The St. Louis engineer district embraces the 200-mile section, known as the middle Mississippi, between the tributary Ohio and Missouri Rivers, and 1,078 to 1,278 miles from the Gulf. The drainage area of the valley down to the Ohio and discharging through the district is about 707,000 square miles. At St. Louis the discharge in cubic feet per second for the low-water plane,¹ 1-foot gauge, is 40,000; at mean stage, 12.4-foot gauge, 150,000; at bank-full stage, 30-foot gauge, 600,000; and for the maximum flood plane about 1,250,000. The average natural depths available for navigation at the same stages are about 4½, 9, and 16 feet; i. e., the crests of the bars rise and fall with the stage in the ratio of 1 to 2½. The oscillation between annual low and high waters averages 40 feet at Cairo, mouth of Ohio River, and 25½ feet at St. Louis, 17 miles below mouth of Missouri River; the extreme range is 55.7 feet at Cairo and 44.4 feet at St. Louis. Considering annual averages, river stage at St. Louis oscillates between low water (1.6 feet) and mean stage for 200 days and between mean stage and high water (27.1 feet) for 152 days. The low-water plane at the mouth of Ohio River is 274 feet above mean sea level and at the mouth of Missouri River it is 395 feet, the average slope being six-tenths foot per mile. The current at mean stage is about 2½ miles per hour and the average width between banks is 4,300 feet.

Original condition.—The waterway of the middle Mississippi was divided by numerous islands and bars, which distributed large portions of the flow through chutes, sloughs, and secondary channels to the detriment of navigation; at many of these localities the natural width of river was 1 to 1½ miles and the maximum usable channel depth at low water was only 3½ to 4 feet.

Previous projects.—The original project for the general improvement of this river section was recommended by a board of engineers in a report dated April 13, 1872, concurred in by the Chief of Engineers. The amount expended thereunder was \$1,495,000 for new work. For further details of previous projects see page 1879 of Annual Report for 1915.

Existing project.—This provides for obtaining and maintaining a minimum channel depth of 8 feet at low water from the mouth of Ohio River (1,078 miles from the Gulf) to St. Louis, 183 miles, and 6 feet thence to the mouth of Missouri River, 17 miles, with a mini-

¹ One foot on St. Louis gauge, 3 feet on Commerce gauge, and 4 feet on Cairo gauge, the plane of reference, adopted in 1915, for district operations. "Standard low water," adopted in 1881, was 4 feet on the St. Louis gauge, the discharge being approximately 40,000 cubic feet per second; because of locally contracted waterway and consequent lowering of low-water plane that volume now passes at the 1-foot stage.

mum width of channel of 200 feet, to be obtained by regulating works and dredging, as follows:

First. By regulating works, for closing sloughs and secondary channels, narrowing the river to a uniform width of about 2,500 feet at bank-full stage, building new banks where the natural width is excessive, and by protecting new and old banks from erosion where necessary to secure permanency.

Second. By dredging or other temporary expedients, pending the completion of the permanent improvement, so as to maintain each season the required low-water depth of channel.

The project for regulating works was adopted in 1881 (Annual Report, 1881, p. 1636). Dredging was introduced as a part of the project by the river and harbor acts of 1896 and 1902. The part of the project which proposed regulating works was practically abrogated by the acts of March 3, 1905, March 2, 1907, and joint resolution of June 29, 1906. The river and harbor act of June 25, 1910, restored the regulating works to the project and began appropriations "with a view to the completion of the improvement within twelve years," at an estimated cost of \$21,000,000, exclusive of amounts previously expended, and \$400,000 annually thereafter for maintenance. (H. Doc. No. 50, with accompanying atlas, 61st Cong., 1st sess., 1909; also H. Doc. No. 168, 58th Cong., 2d sess., 1903).

Operations and results during fiscal year.—Maintenance of the existing regulating works was continued by hired labor July 12 to December 24, 1921, January 14 to March 26, and after May 26, 1922. At 15 localities 31 permeable dikes of piling were repaired, 4,050 linear feet, costing \$78,588.80; bank revetments were repaired at 17 localities, 1,808 squares of mattress, and 3,812 squares of stone paving, costing \$112,366.70. The total thus expended for maintenance of regulating works was \$190,955.50. In one of these revetments, Liberty Island, 310 linear feet of mattress, 248 squares, costing \$6,188.99, and 98 squares of paving costing \$1,542.10, were placed in necessary new extension. The district pipe line hydraulic dredges, operated by hired labor, July to December and in June, maintained the required or project depths and width of channel; 1,485,000 cubic yards of sand and gravel were dredged from 15 main channel areas having a combined length of 8.4 miles and an average width of 230 feet; the average gain in depth due to all dredging was 4 feet, and the total cost thereof \$269,060.85. Surveys were made covering 173 miles of river, including all dredged channels; 52 miles were resurveyed, making a total of 225 river miles of hydrographic surveys, at a cost of \$25,967.21. The total expended for new work and for maintenance of river works and channel conditions, including dredging and surveys, was \$493,714.65; in addition, \$5,700.74 was expended on account of liabilities due at the end of the previous year, making the total expenditures \$499,415.39.

Condition at end of fiscal year.—The existing project is 34 per cent completed. For physical extent of work accomplished and status and requirements of the project, see Annual Report for 1921, page 1198.

Because of the small and insufficient appropriations for this district in recent years the regulating works have deteriorated rapidly and many sections thereof have been entirely destroyed; existing structures have been maintained in as good condition as the limited

funds available therefor would permit. Between the mouth of Ohio River and St. Louis dredging¹ is always required during the fall or low-water season from July or August to the close of navigation by ice or winter conditions, usually in December, and is occasionally required in the spring season; project dimensions of channel in that section of river have been maintained throughout navigation seasons for the last 15 years, except for short periods of time when river stage was very low and dredges were attacking the obstructive bars. Between St. Louis and the mouth of Missouri River the project dimensions of channel have been maintained by action of the river with but very infrequent aid from dredging when river stage was unusually low. From the opening of the navigation season, usually in February, to July inclusive, or when river stage is above 10 feet on the St. Louis gauge, a minimum channel depth of 8 feet generally prevails throughout the entire district without dredging or other artificial aid. (For the natural depths available to navigation, see Annual Report for 1918, p. 2733.) The least channel depths last observed were: From mouth of Ohio River to St. Louis, 9½ feet, June 6-8, 1922, St. Louis gauge 13.7 to 14.6 feet; from St. Louis to mouth of Missouri River, 18 feet, May 20, 1922, St. Louis gauge 15.4 feet. The total expenditures under the existing project from 1881 to date are \$9,888,396.61 for new work and \$8,476,249.05 for maintenance, including dredging and surveys, a total sum of \$18,364,645.66. The amount expended on the existing project since the estimate was revised in 1910 is \$1,927,978.91 for new work.

Local cooperation.—Although no local cooperation has ever been required by law, the United States participated with local interests in some of the first confining or regulating works of the district. For historical sketch see Annual Report, 1902, page 2607, and House Document No. 1067, Sixty-first Congress, third session, page 30. Since 1838 private and corporate interests at their own expense have constructed 45,700 linear feet of solid and permeable dikes or wing dams costing \$1,100,000, and 85,000 linear feet of bank protection, including various revetments, paved wharves, railroad inclines, terminal docks, and improved landings, costing \$8,600,000. All of these structures contribute to the confinement and general improvement of the river and to the completion of the existing project.

Terminal facilities.—In addition to the water terminal and transfer facilities of the district fully described, as of December 31, 1918, in House Document No. 652, Sixty-sixth Congress, second session, pages 1211-1239, and in Annual Report, 1921, pages 1199-1200, two interchange terminals of the Inland and Coastwise Waterways, Mississippi-Warrior Service, were constructed during the year (both completed in January) under the supervision of the district engineer acting for that service, as follows:

The South St. Louis River Terminal, at foot of Rutger Street, St. Louis, was built under contract with Frazier-Davis Construction Co., St. Louis, Mo., for \$209,050; total cost, \$213,500. The structure consists of a timber dock, 480 feet in length, carrying two railroad tracks, a steel freight house 240 feet by 60 feet, and two 100-foot steel lift bridges, or ramps, equipped with electrically driven chain

¹ Annual quantity of sand dredged, indefinite; in last 10 years, one-half million to three million cubic yards; average, 1½ million cubic yards.

conveyors for operating 2-ton trucks between a landing barge along the dock front and the freight house; and there are also two 15-ton locomotive cranes for transferring freight between railroad cars and cargo barges. The equipment is modern in every respect, and space along the downstream river front has been provided for a duplicate unit, or extension, of this dock whenever it may be required.

The East St. Louis Railroad-River Terminal, about three-fourths mile below Eads Bridge, consists of a new double-track railroad incline to be operated in connection with two concrete landing barges equipped with double tracks and placed tandem below the incline so that freight may be transferred, at all ordinary river stages, directly between cargo barges and railroad cars on the track barges along a frontage of 560 feet. This incline, $3\frac{1}{2}$ per cent grade, is 1,214 feet in length and at its lower end is about 50 feet inshore from incline No. 5, of the local Terminal Railroad Association, from which the site is leased. The new incline has supplanted the old structure and was built under contract with Myers Construction Co., St. Louis, Mo., for \$45,000; parts of the work—approaches, clumps of landing piles, and scrapping of the old incline—costing \$8,000 were furnished in materials and labor by the district. The total cost of the new incline, exclusive of the track barges, was \$53,000.

Effect of improvement.—Some of the resultant benefits to commerce from the improvement are: (a) Larger and deeper draft boats and barges are now being used; (b) the difficulties and hazards of navigation have been reduced, 8-foot navigation throughout the lowest of low-water seasons being an accomplished fact; (c) freight rates by rail to points on Mississippi River and tributaries are much lower than to points only a few miles back from the rivers; freight rates by water are generally 80 per cent of the rail rates.

Proposed operations.—Dredging, as needed to maintain the requirements of the project, and the most urgent and necessary repair and maintenance of existing dikes and revetments, including such minor extensions and new works as may be required for that purpose, will be carried on throughout the coming fiscal year, except in winter, when navigation is stopped by ice. The balance, \$987,248.52, available July 1, 1922, will be applied in the ensuing fiscal year, as follows:

(a) Maintenance of channel, dredging by United States plant, upkeep and operation of four pipe-line dredges and auxiliary plant, including installation of oil-burning furnaces, by hired labor, six months at \$40,000 and six months at \$15,000.....	\$330,000.00
(b) Maintenance of existing regulating works and necessary new works by United States plant and hired labor (including rentals of barges, \$8,100).....	277,248.52
(c) Care and upkeep of district plant other than dredges by hired labor, including installation of oil-burning furnaces on steamer <i>King</i>	85,000.00
(d) Conversion of one nonpropelling dredge to self-propelling.....	75,000.00
(e) New plant, six steel barges (district type No. 16 and No. 25), at \$20,000; two derrick boats (steel hulls on hand), at \$7,500.....	135,000.00
(f) Purchase and repair wooden plant from Kansas City district, 18 barges and 1 quarter boat.....	35,000.00
(g) Office, engineering, surveys, and gauges.....	40,000.00
(h) Contingencies.....	10,000.00
Total.....	987,248.52

1224 REPORT OF CHIEF OF ENGINEERS, U. S. ARMY, 1922.

Item (b) to be increased by any savings made upon the other items.
 Item (e) plans to be submitted in accordance with Orders and Regulations 303 and 1046.

During the low-water season, July to December, inclusive, when both maintenance of regulating works and dredging are actively prosecuted, funds will be expended at the rate of \$90,000 to \$110,000 per month, depending upon the amount of dredging that may be required; a total of \$50,000 will be expended in January and February on repairs and care of floating plant in winter harbors; for the period March to June, inclusive, expenditures for regulating works, new plant, and repairs of plant should be about \$300,000; that sum, however, will be reduced if a greater than average amount of dredging shall have been required in the fall.

With the funds now available the project dimensions of channel will be maintained throughout the year, together with the needed repairs to the regulating works and such new works as may be necessary. All funds will be exhausted by June 30, 1923.

While the present project is continued in force an annual appropriation of \$1,000,000 for new work and for maintenance of works and channel conditions is recommended.

Recommended modifications of project.—None.

Commercial statistics.—River traffic for the calendar year 1921 was 33 per cent greater in total tonnage and 50 per cent higher in value than in 1920; also the number of passengers was nearly doubled. The upbound tonnage, although 17,500 tons less than in 1920, was practically double in value, due to the discontinuance of the barge service of the Aluminum Ore Co., which formerly transported large quantities of bauxite, a low-grade ore, from Bauxippi, Ark., to East St. Louis, and to the higher grades and increased tonnage of upbound freight carried by the Federal barge line. Large consignments of several new commodities, principally bagging, cotton, sugar, and textiles, were handled; otherwise the river traffic was fairly typical of preceding years, consisting mainly of animals and animal products, cement, coal, grain and its products, groceries and provisions, hardware, iron, steel, and metals, logs, lumber, machinery, sisal, vehicles, and many unclassified items. The full project dimensions of channel were utilized, the draft of loaded barges being generally 7 to 8 feet and occasionally 9 feet. The improvement has greatly facilitated traffic, which shows a general increase in the last five years, as indicated by the following:

Comparative statement.

Calendar year.	Short tons.	Approximate value.	Passengers.	Calendar year.	Short tons.	Approximate value.	Passengers.
1917.....	203,248	\$15,401,544	275,514	1920.....	1 363,082	\$30,870,399	447,704
1918.....	264,149	17,982,776	385,133	1921.....	1 481,151	47,481,764	832,963
1919.....	288,286	22,684,001	442,603				

¹ Includes Government materials for river improvement work not included in previous years, 70,058 tons in 1920, and 80,799 tons in 1921.

Financial summary.

Amount expended on all projects to June 30, 1922, after deducting receipts from sales, etc., amounting to \$364,545.40:

New work.....	\$11,388,390.61
Maintenance.....	8,476,249.05
Net total expended.....	19,859,645.66
Total appropriations to date of this report.....	20,881,599.98

Fiscal year ending June 30.	1918	1919	1920	1921	1922
Expended for new work ¹		\$34,360.58	\$25,701.85		\$7,731.09
Expended for maintenance ¹	\$341,595.55	440,701.40	490,874.05	487,922.00	401,084.30
Total expended ¹	341,595.55	475,151.98	516,636.60	487,922.00	409,415.39
Appropriated or allotted.....	350,000.00	800,000.00	400,000.00	400,000.00	915,000.00

July 1, 1921, balance unexpended.....	\$556,571.53
Amount allotted from War Department appropriation act approved June 30, 1922.....	915,000.00
Receipts from sales, etc., during fiscal year 1922.....	49,708.18
	1,521,369.71

June 30, 1922, amount expended during fiscal year: ¹	
For new work.....	\$7,731.09
For maintenance.....	401,084.30
	409,415.39

July 1, 1922, balance unexpended.....	1,021,954.32
July 1, 1922, outstanding liabilities.....	34,705.80
July 1, 1922, balance available.....	987,248.52
Amount (estimated) required to be appropriated for completion of existing project.....	² 18,480,000.00

Amount that can be profitably expended in fiscal year ending June 30, 1924:	
For new work.....	² 500,000.00
For maintenance.....	² 500,000.00
Total.....	² 1,000,000.00

2. REMOVING SNAGS AND WRECKS FROM THE MISSISSIPPI RIVER BELOW THE MOUTH OF THE MISSOURI RIVER, AND FROM OLD AND ATCHAFALAYA RIVERS.

Location and description.—The Mississippi River rises in Lake Itasca, Minn., flows south 2,477 miles, and empties into the Gulf of Mexico. The St. Louis snagging district embraces that portion of the river between Head of Passes, and the mouth of Missouri River, 1,265 miles, 8 miles of Old River (present mouth of Red River), and 27 miles of Atchafalaya River from Red River to Melville, La.; total, 1,300 miles.

Original condition.—Navigation of the river was seriously obstructed by numerous snags, drift-heaps, etc., which had lodged in

¹ Not deducting receipts from sales, etc.
² Exclusive of available funds.

District engineer: Maj. DeWitt C. Jones, Corps of Engineers, to August 23, 1922, and Maj. Lunsford E. Oliver, Corps of Engineers, since that date.

Division engineer: Col. Charles L. Potter, Corps of Engineers.

IMPROVEMENTS.

	Page.		Page.
1. Mississippi River between the Ohio and Missouri Rivers.....	1079	2. Removing snags and wrecks from the Mississippi River below the mouth of the Missouri River, and from Old and Atchafalaya Rivers.....	1085

1. MISSISSIPPI RIVER BETWEEN THE OHIO AND MISSOURI RIVERS.

Location and description.—The Mississippi River rises in Lake Itasca, Minn., flows south 2,477 miles, and empties into the Gulf of Mexico. The St. Louis engineer district embraces the 200-mile section, known as the middle Mississippi, between the tributary Ohio and Missouri Rivers, and 1,078 to 1,278 miles from the Gulf. The drainage area of the valley down to the Ohio and discharging through the district is about 707,000 square miles. At St. Louis the discharge in cubic feet per second for the low water plane, 1-foot gauge, is 40,000; at mean stage, 12.4-foot gauge, 150,000; at bank-full stage, 30-foot gauge, 600,000; and for the maximum flood plane about 1,250,000. The average natural depths available for navigation at the same stages are about 4½, 9, and 16 feet; i. e., the crests of the bars rise and fall with the stage in the ratio of 1 to 2½. The oscillation between annual low and high waters averages 40 feet at Cairo, mouth of Ohio River, and 25½ feet at St. Louis, 17 miles below mouth of Missouri River; the extreme range is 55.7 feet at Cairo and 44.4 feet at St. Louis. Considering annual averages, river stage at St. Louis oscillates between low water (1.6 feet) and mean stage for 200 days and between mean stage and high water (27.1 feet) for 152 days. The low-water plane at the mouth of Ohio River is 274 feet above mean sea level and at the mouth of Missouri River it is 395 feet, the average slope being six-tenths foot per mile. The current at mean stage is about 2½ miles per hour and the average width between banks is 4,300 feet.

Original condition.—The waterway of the middle Mississippi was divided by numerous islands and bars, which distributed large portions of the flow through chutes, sloughs, and secondary channels to the detriment of navigation; at many of these localities the natural width of river was 1 to 1½ miles and the maximum usable channel depth at low water was only 3½ to 4 feet.

Previous projects.—The original project for the general improvement of this river section was recommended by a board of engineers in a report dated April 13, 1872, concurred in by the Chief of Engineers. The amount expended thereunder was \$1,405,000 for new work. For further details of previous projects see page 1879 of Annual Report for 1915.

One foot on St. Louis gauge, 3 feet on Commerce gauge, and 4 feet on Cairo gauge the plane of reference, adopted in 1918, for district operations. "Standard low water," adopted in 1881, was 4 feet on the St. Louis gauge, the discharge being approximately 40,000 cubic feet per second; because of locally contracted waterway and consequent lowering of low-water plane that volume now passes at the 1-foot stage.

Existing project.—This provides for obtaining and maintaining a minimum channel depth of 8 feet at low water from the mouth of Ohio River (1,078 miles from the Gulf) to St. Louis, 183 miles, and 6 feet thence to the mouth of Missouri River, 17 miles, with a minimum width of channel of 200 feet, to be obtained by regulating works and dredging, as follows:

First. By regulating works, for closing sloughs and secondary channels, narrowing the river to a uniform width of about 2,500 feet at bank-full stage, building new banks where the natural width is excessive, and by protecting new and old banks from erosion where necessary to secure permanency.

Second. By dredging or other temporary expedients, pending the completion of the permanent improvement, so as to maintain each season the required low-water depth of channel.

The project for regulating works was adopted in 1881 (Annual Report, 1881, p. 1536). Dredging was introduced as a part of the project by the river and harbor acts of 1896 and 1902. The part of the project which proposed regulating works was practically abrogated by the acts of March 3, 1905, March 2, 1907, and joint resolution of June 29, 1906. The river and harbor act of June 25, 1910, restored the regulating works to the project and began appropriations "with a view to the completion of the improvement within twelve years," at an estimated cost of \$21,000,000, exclusive of amounts previously expended, and \$400,000 annually thereafter for maintenance. (H. Doc. No. 50, with accompanying atlas, 61st Cong., 1st sess., 1909; also H. Doc. No. 168, 58th Cong., 2d sess., 1903.)

Recommended modifications of project.—None.

Local cooperation.—Although no local cooperation has ever been required by law, the United States participated with local interests in some of the first confining or regulating works of the district. For historical sketch see Annual Report, 1902, page 2607, and House Document No. 1067, Sixty-first Congress, third session, page 30. Since 1838 private and corporate interests at their own expense have constructed 45,700 linear feet of solid and permeable dikes or wing dams costing \$1,100,000, and 85,000 linear feet of bank protection, including various revetments, paved wharves, railroad inclines, terminal docks, and improved landings, costing \$8,600,000.

All of these structures contribute to the confinement and general improvement of the river and to the completion of the existing project.

The Missouri-Illinois Railroad Co., Bonne Terre, Mo., contributed \$10,000, May 3, 1923, toward the construction of new and the restoration of old regulating works in the vicinity of Little Rock Landing, Mo., for the purpose of removing a sand bar obstructing the railroad incline at that point, thus incidentally improving the alignment of the banks and channel and protecting from erosion the alluvial bank opposite in Illinois.

Terminal facilities.—The water terminal and transfer facilities of the district are fully described, as of December 31, 1918, in House Document No. 652, Sixty-sixth Congress, second session, pages 1211-1239; in addition thereto, reference is made to Annual Reports, 1921, pages 1190-1200, and 1922, pages 1222-1223.

A traveling coal and ore handling bridge, electrically operated river-rail terminal, capacity 500 tons per hour, bucket travel 450 feet

and storage height 50 feet, was erected at the foot of Malt Street, St. Louis, Mo., at a cost of \$210,000 paid from the Emergency Shipping Fund.

Effect of improvement.—Some of the resultant benefits to commerce from the improvement are: (a) Larger and deeper draft boats and barges are now being used; (b) the difficulties and hazards of navigation have been reduced, 8-foot navigation throughout the lowest of low-water seasons being an accomplished fact; (c) freight rates by rail to points on Mississippi River and tributaries are much lower than to points only a few miles back from the rivers; freight rates by water are generally 80 per cent of the rail rates.

Operations and results during fiscal year.—Maintenance of existing regulating works, including such minor extensions and new works as were required for that purpose, was continued by hired labor, July 1 to December 13, 1922, and after January 6, 1923. At 10 localities, 18 permeable dikes of piling, 4,665 linear feet, were repaired at a cost of \$91,686.93; and at 3 localities, 2 new dikes and 2 extensions, 2,025 linear feet, were built costing \$47,300.13. Bank revetments were repaired at 18 localities, 1,275 squares of mattress and 4,569 squares of stone paving, costing \$131,222.98; necessary new extensions to bank revetments were made at 6 localities, 3,810 linear feet, 3,381 squares of mattress and 1,939 squares of stone paving, costing \$156,506.87. The total thus expended for maintenance of regulating works was \$426,716.91, and for new work \$75,004.83. The district pipe-line hydraulic dredges, and the dipper dredge *Davenport* leased from the Rock Island district, all operated by hired labor, July to April, maintained the required or project depths and width of channel; 1,706,200 cubic yards of sand and gravel were dredged from 22 main channel areas having a combined length of more than nine miles and an average width of 240 feet; the average gain in depth due to all dredging was 3½ feet, and the total cost thereof \$166,014.24. Surveys were made covering 196 miles of river, including all dredged channels; 28 miles were resurveyed, making a total of 224 river miles of hydrographic surveys, at a cost of \$26,159.96. The total expended was \$693,895.94; in addition \$34,705.80 was expended on account of liabilities due at the end of the previous year, making the total expenditures \$728,601.74, of which \$75,004.83 was for new work and \$653,596.91 was for maintenance.

Condition at end of fiscal year.—The existing project is 34 per cent completed. For physical extent of work accomplished and status and requirements of the project, see Annual Report, 1921, p. 1198.

Because of the small and insufficient appropriations for this district in recent years, the regulating works have deteriorated rapidly and many sections thereof have been entirely destroyed; existing structures have been maintained in as good condition as the limited funds available therefor would permit. Between the mouth of Ohio River and St. Louis dredging¹ is always required during the fall or low-water season, from July or August to the close of navigation by ice or winter conditions, usually in December, and is occasionally required in the spring season; project dimensions of channel in that section of river have been maintained throughout navigation seasons for the last 15 years, except for short periods of

¹ Annual quantity of sand dredged, indefinite; in last 10 years, 500,000 to 3,000,000 cubic yards; average, 1,250,000 cubic yards.

time when river stage was very low and dredges were attacking the obstructive bars. Between St. Louis and the mouth of Missouri River the project dimensions of channel have been maintained by action of the river with but very infrequent aid from dredging when river stage was unusually low. From the opening of the navigation season, usually in February, to July, inclusive, or, when river stage is above 10 feet on the St. Louis gauge, a minimum channel depth of 8 feet generally prevails throughout the entire district without dredging or other artificial aid. For the natural depths available to navigation, see Annual Report for 1918, page 2723. The least channel depths last observed were: From mouth of Ohio River to St. Louis, 10½ feet, June 2, 1923, St. Louis gauge, 10.9 feet; from St. Louis to mouth of Missouri River, 12 feet, May 12, 1923, St. Louis gauge, 12.2 feet. The total expenditures under the existing project from 1881 to date are \$9,955,271.62 for new work, and \$9,129,845.96 for maintenance, including dredging and surveys, a total sum of \$19,085,117.58. The amount expended on the existing project since the estimate was revised in 1910 is \$1,194,853.92 for new work.

Proposed operations.—Dredging, as needed to maintain the requirements of the project, and the repair and maintenance of existing dikes and revetments, including such minor extensions and new works as may be required for that purpose, will be carried on throughout the coming fiscal year, except in winter when navigation is stopped by ice. The balance unexpended (\$1,111,482.40) including \$10,000 contributed under *Local cooperation* July 1, 1923, will be applied in the ensuing fiscal year, as follows:

(a) Maintenance of channel, dredging by United States plant, operation, upkeep and care when idle of 4 pipe-line dredges and auxiliary plant, 24 dredge months, at \$10,000, and 24 dredge months, at \$2,000, by hired labor, and installations of oil burning equipment on 2 dredges, by contract and hired labor \$17,000	\$306,000.00
(b) Maintenance of existing regulating works and construction of necessary new work, by United States plant and hired labor	163,455.00
(c) Upkeep and care when idle of plant other than dredges, by hired labor, including installation of oil burning equipment on towboat <i>King</i> , by contract and hired labor	75,000.00
(d) New plant: 10 steel barges, at \$20,000; 10 steel barges (flats), at \$3,000; 5 steel pile drivers, at \$15,000; steel pontoons and pipe-line (replacement) of dredge <i>Selma</i> \$30,000, by contracts, and 1 towboat at \$100,000, by contract for hull and cabin and hired labor	485,000.00
(e) Office, engineering, surveys and gauges	45,000.00
(f) Contingencies	10,000.12
Payment of liabilities and contract obligations, July 1, 1923	78,027.28
	1,111,482.40

During the low-water season, July to December, inclusive, when maintenance of regulating works and dredging are actively prosecuted, funds will be expended at the rate of \$90,000 to \$110,000 per month, depending upon the amount of dredging that may be required; a total of \$50,000 will be expended in January and February on repairs and care of floating plant in winter harbors; for the period March to June, inclusive, expenditures for regulating works, new plant, and repair of plant should be about \$400,000; that sum, however, will be reduced if a greater than average amount of dredging shall have been required in the fall.

With the funds unexpended the project dimensions of channel will be maintained throughout the year, together with the needed repairs to the regulating works and a limited amount of new work tending toward the rectification of the channel and its easier maintenance will be done. All funds will be exhausted by June 30, 1924.

The sum of \$1,000,000 can be profitably expended during the fiscal year ending June 30, 1925, as follows:

(a) Maintenance of channel, dredging by United States plant, operation, upkeep and care when idle of 4 pipe-line dredges and auxiliary plant, 24 dredge months, at \$10,000, and 24 dredge months, at \$2,000, by hired labor, and installation of oil burning equipment on 2 nonpropelling dredges, by contract and hired labor, \$17,000.....	\$305,000
(b) Maintenance of existing regulating works and construction of necessary new works, by United States plant and hired labor.....	305,000
(c) Upkeep and care when idle of plant other than dredges, by hired labor.....	75,000
(d) New plant: 4 steel barges, at \$20,000; 10 steel barges (flats), at \$3,000; 1 small steam towboat, at \$45,000; 5 pile drivers, at \$15,000; and steel pontoons and pipe-line (replacement) for dredge <i>Thebes</i> , \$80,000, by contracts.....	260,000
(e) Office, engineering, surveys and gauges.....	45,000
(f) Contingencies.....	10,000
	1,000,000

Commercial statistics.—River traffic in the calendar year 1922, was 66,063 tons greater in total tonnage than in 1921, of which 59,075 tons of the increase was garbage, downbound. The total downbound tonnage was 26,867 tons greater in 1922 than 1921. The upbound tonnage in 1922 was 40,096 tons greater in 1922 than 1921. The principal items were animals and animal products, vegetable products, textile, wood, and paper, nonmetallic minerals, ores, metals and manufactures, machinery and vehicles, chemicals, garbage, and unclassified materials. The full project dimensions of channel were utilized, the draft of loaded barges being generally 7 to 8 feet, and occasionally 9 feet. The improvement has greatly facilitated traffic, which shows a general increase in the last 5 years as indicated by the following:

Comparative statement.

Calendar year.	Short tons.	Approximate value.	Passengers.	Calendar year.	Short tons.	Approximate value.	Passengers.
1918.....	264,149	\$17,982,776	385,133	1921.....	1,481,151	47,481,764	832,993
1919.....	288,286	22,684,001	442,603	1922.....	1,548,114	43,193,133	1,945,642
1920.....	363,082	30,870,399	447,704				

¹ Includes Government materials for river improvement work not included in previous years, 70,058 tons in 1920, 80,799 tons in 1921, and 95,274 tons in 1922.

Financial summary.

UNITED STATES FUNDS.

Amount expended on all projects to June 30, 1923, after deducting receipts from sales, etc., amounting to \$372,825.22:

New work.....	\$11,450,271.62
Maintenance.....	9,129,845.96
Net total expended.....	20,580,117.58
Total appropriations to date of this report.....	21,681,599.98

1084 REPORT OF CHIEF OF ENGINEERS, U. S. ARMY, 1923.

Fiscal year ending June 30.	1919	1920	1921	1922	1923
Expended for new work ¹	\$34,860.58	\$28,791.85	\$457,922.09	\$7,731.05	\$71,004.53
Expended for maintenance ¹	440,791.40	490,574.65		491,004.30	653,596.91
Total expended ¹	475,651.98	519,366.50	457,922.09	498,735.35	724,601.44
Appropriated or allotted.....	800,000.00	400,000.00	400,000.00	915,000.00	800,000.00

July 1, 1922, balance unexpended.....	\$1,021,804.32
Amount allotted from War Department appropriation act approved Mar. 2, 1923.....	800,000.00
Receipts from sales, etc., during fiscal year 1923.....	8,279.82
June 30, 1923, amount expended during fiscal year: ¹	1,830,084.14
For new work.....	\$76,004.83
For maintenance.....	653,596.91
July 1, 1923, balance unexpended.....	1,101,482.40
July 1, 1923, outstanding liabilities.....	\$82,612.28
July 1, 1923, amount covered by uncompleted contracts.....	5,415.00
July 1, 1923, balance available.....	1,033,455.12
Amount (estimated) required to be appropriated for completion of existing project.....	\$17,680,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1925:	
For new work.....	\$500,000.00
For maintenance.....	\$500,000.00
Total.....	\$1,000,000.00

CONTRIBUTED FUNDS.

Amount expended on all projects to June 30, 1923:	
New work.....	
Maintenance.....	
Total contributions to date of this report.....	10,000.00

Fiscal year ending June 30.	1919	1920	1921	1922	1923
Expended for new work.....					
Expended for maintenance.....					
Appropriated or allotted.....					\$10,000.00

Amount contributed by local interests for work at Little Rock Landing, Mo.:	\$10,000.00
July 1, 1923, balance unexpended.....	10,000.00
July 1, 1923, outstanding liabilities.....	10,000.00

¹ Not deducting receipts from sales, etc.
² Changed from amount stated in 1922 report, which was in error.
³ Exclusive of available funds.

RIVERS AND HARBORS—ST. LOUIS, MO., DISTRICT 1085

CONSOLIDATED FINANCIAL SUMMARY FOR MISSISSIPPI RIVER BETWEEN THE OHIO AND MISSOURI RIVERS.

Amount expended on all projects to June 30, 1923, after deducting receipts from sales, etc., amounting to \$372,825.22:

New work.....	\$11,450,271.02
Maintenance.....	9,129,845.96
Net total expended.....	20,580,117.58
Total appropriations and contributions to date of this report.....	21,691,599.98

Fiscal year ending June 30.	1919	1920	1921	1922	1923
Expended for new work.....	\$34,360.03	\$25,761.85		\$7,731.09	\$75,004.83
Expended for maintenance.....	440,791.40	490,874.65	\$487,922.09	491,684.30	653,596.91
Total expended.....	475,151.43	516,636.50	487,922.09	499,415.39	728,601.74
Appropriated and contributed...	800,000.00	400,000.00	400,000.00	915,000.00	810,000.00

July 1, 1922, balance unexpended.....	\$1,021,804.32
Amount allotted from War Department act approved Mar. 2, 1923.....	800,000.00
Funds contributed for improving Mississippi River near Little Rock Landing, Mo.....	10,000.00
Receipts from sales, etc., during fiscal year 1923.....	8,279.82

June 30, 1923, amount expended during fiscal year: ¹	1,840,084.14
For new work.....	\$75,004.83
For maintenance.....	653,596.91
	728,601.74

July 1, 1923, balance unexpended.....	1,111,482.40
July 1, 1923, outstanding liabilities.....	72,612.28
July 1, 1923, amount covered by uncompleted contracts.....	5,415.00
	78,027.28

July 1, 1923, balance available.....	1,033,455.12
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Amount (estimated) required to be appropriated for completion of existing project.....	\$17,680,000.00
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Amount that can be profitably expended in fiscal year ending June 30, 1925:	
For new work.....	\$500,000.00
For maintenance.....	\$500,000.00
Total.....	\$1,000,000.00

2. REMOVING SNAGS AND WRECKS FROM THE MISSISSIPPI RIVER BELOW THE MOUTH OF THE MISSOURI RIVER, AND FROM OLD AND ATCHAFALAYA RIVERS.

Location and description.—The Mississippi River rises in Lake Itasca, Minn., flows south 2,477 miles, and empties into the Gulf of Mexico. The St. Louis snagging district embraces that portion of the river between Head of Passes, and the mouth of Missouri River, 1,265 miles, 8 miles of Old River (present mouth of Red River), and

¹ Not deducting receipts from sales, etc..

² Exclusive of available funds.