

[PUBLIC LAW 14—79TH CONGRESS]

[CHAPTER 19—1ST SESSION]

[S. 35]

AN ACT

Authorizing the construction, repair, and preservation of certain public works on rivers and harbors, and for other purposes.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That in connection with the exercise of jurisdiction over the rivers of the Nation through the construction of works of improvement, for navigation or flood control, as herein authorized, it is hereby declared to be the policy of the Congress to recognize the interests and rights of the States in determining the development of the watersheds within their borders and likewise their interests and rights in water utilization and control, as herein authorized to preserve and protect to the fullest possible extent established and potential uses, for all purposes, of the waters of the Nation's rivers; to facilitate the consideration of projects on a basis of comprehensive and coordinated development; and to limit the authorization and construction of navigation works to those in which a substantial benefit to navigation will be realized therefrom and which can be operated consistently with appropriate and economic use of the waters of such rivers by other users.

In conformity with this policy—

(a) Plans, proposals, or reports of the Chief of Engineers, War Department, for any works of improvement for navigation or flood control not heretofore or herein authorized, shall be submitted to the Congress only upon compliance with the provisions of this paragraph (a). Investigations which form the basis of any such plans, proposals, or reports shall be conducted in such a manner as to give to the affected State or States, during the course of the investigations, information developed by the investigations and also opportunity for consultation regarding plans and proposals, and, to the extent deemed practicable by the Chief of Engineers, opportunity to cooperate in the investigations. If such investigations in whole or part are concerned with the use or control of waters arising west of the ninety-seventh meridian, the Chief of Engineers shall give to the Secretary of the Interior, during the course of the investigations, information developed by the investigations and also opportunity for consultation regarding plans and proposals, and to the extent deemed practicable by the Chief of Engineers, opportunity to cooperate in the investigations. The relations of the Chief of Engineers with any State under this paragraph (a) shall be with the Governor of the State or such official or agency of the State as the Governor may designate. The term "affected State or States" shall include those in which the works or any part thereof are proposed to be located; those which in whole or part are both within the drainage basin involved and situated in a State lying wholly or in part west of the ninety-eighth meridian; and such of those which are east of

the ninety-eighth meridian as, in the judgment of the Chief of Engineers, will be substantially affected. Such plans, proposals, or reports and related investigations shall be made to the end, among other things, of facilitating the coordination of plans for the construction and operation of the proposed works with other plans involving the waters which would be used or controlled by such proposed works. Each report submitting any such plans or proposals to the Congress shall set out therein, among other things, the relationship between the plans for construction and operation of the proposed works and the plans, if any, submitted by the affected States and by the Secretary of the Interior. The Chief of Engineers shall transmit a copy of his proposed report to each affected State, and, in case the plans or proposals covered by the report are concerned with the use or control of waters which rise in whole or in part west of the ninety-seventh meridian, to the Secretary of the Interior. Within ninety days from the date of receipt of said proposed report, the written views and recommendations of each affected State and of the Secretary of the Interior may be submitted to the Chief of Engineers. The Secretary of War shall transmit to the Congress, with such comments and recommendations as he deems appropriate, the proposed report together with the submitted views and recommendations of affected States and of the Secretary of the Interior. The Secretary of War may prepare and make said transmittal any time following said ninety-day period. The letter of transmittal and its attachment shall be printed as a House or Senate document.

(b) The use for navigation, in connection with the operation and maintenance of such works herein authorized for construction, of waters arising in States lying wholly or partly west of the ninety-eighth meridian shall be only such use as does not conflict with any beneficial consumptive use, present or future, in States lying wholly or partly west of the ninety-eighth meridian, of such waters for domestic, municipal, stock water, irrigation, mining, or industrial purposes.

(c) The Secretary of the Interior, in making investigations of and reports on works for irrigation and purposes incidental thereto shall, in relation to an affected State or States (as defined in paragraph (a) of this section), and to the Secretary of War, be subject to the same provisions regarding investigations, plans, proposals, and reports as prescribed in paragraph (a) of this section for the Chief of Engineers and the Secretary of War. In the event a submission of views and recommendations, made by an affected State or by the Secretary of War pursuant to said provisions, sets forth objections to the plans or proposals covered by the report of the Secretary of the Interior, the proposed works shall not be deemed authorized except upon approval by an Act of Congress; and subsection 9 (a) of the Reclamation Project Act of 1939 (53 Stat. 1187) and subsection 3 (a) of the Act of August 11, 1939 (53 Stat. 1418), as amended, are hereby amended accordingly.

SEC. 2. The following works of improvement of rivers, harbors, and other waterways are hereby adopted and authorized in the interest of national security and the stabilization of employment, and shall be prosecuted as speedily as may be consistent with budgetary requirements, under the direction of the Secretary of War and supervision of the Chief of Engineers, in accordance with the plans in the respec-

tive reports hereinafter designated and subject to the conditions set forth therein: *Provided*, That no project herein authorized shall be appropriated for or constructed until six months after the termination of the present wars in which the United States is engaged unless the construction of such project has been recommended by an authorized defense agency and approved by the President as being necessary or desirable in the interest of the national defense and security, and the President has notified the Congress to that effect: *Provided further*, That penstocks or other similar facilities adapted to possible future use in the development of hydroelectric power shall be installed in any dam herein authorized when approved by the Secretary of War upon the recommendation of the Chief of Engineers and of the Federal Power Commission, and such recommendations shall be based upon consideration of the proper utilization and conservation in the public interest of the resources of the region:

Northeast Harbor, Maine; House Document Numbered 132, Seventy-sixth Congress;

Isle au Haut Thoroughfare, Maine; Senate Document Numbered 15, Seventy-seventh Congress;

Hendricks Harbor, Maine; Senate Document Numbered 40, Seventy-sixth Congress;

Portland Harbor, Maine; House Document Numbered 560, Seventy-sixth Congress; and the maintenance of Soldier Ledge Channel in Hussey Sound, Casco Bay, at a depth of forty feet, in accordance with the report of the Chief of Engineers dated October 26, 1942;

Josias River, Maine; House Document Numbered 227, Seventy-sixth Congress; except that the useful work done on the project by local interests shall be accepted toward the fulfillment of the requirements of local cooperation;

Newburyport Harbor, Massachusetts; House Document Numbered 703, Seventy-sixth Congress;

Gloucester Harbor and Annisquam River, Massachusetts; House Document Numbered 329, Seventy-seventh Congress;

Manchester Harbor, Massachusetts; House Document Numbered 447, Seventy-seventh Congress;

Salem Harbor, Massachusetts; House Document Numbered 701, Seventy-sixth Congress;

Marblehead Harbor, Massachusetts; House Document Numbered 85, Seventy-seventh Congress;

Boston Harbor, Massachusetts; in accordance with the report of the Chief of Engineers dated April 28, 1943;

Dorchester Bay and Neponset River, Massachusetts; House Document Numbered 394, Seventy-seventh Congress;

Weymouth Fore River, Massachusetts; House Document Numbered 291, Seventy-seventh Congress;

Cohasset Harbor, Massachusetts; House Document Numbered 425, Seventy-sixth Congress;

Duxbury Harbor, Massachusetts; Senate Document Numbered 115, Seventy-seventh Congress;

Chatham (Stage) Harbor, Massachusetts; House Document Numbered 456, Seventy-seventh Congress;

Wellfleet Harbor, Massachusetts; House Document Numbered 557, Seventy-sixth Congress;

Neches and Angelina Rivers, Texas; Senate Document Numbered 98, Seventy-sixth Congress;

The improvement of the Trinity River and tributaries, Texas, for navigation, flood control, and allied purposes is hereby approved and authorized in accordance with the reports contained in House Document Numbered 403, Seventy-seventh Congress;

Lavon Reservoir on East Fork of Trinity River, Texas; House Document Numbered 533, Seventy-eighth Congress;

Houston Ship Channel, Texas; House Documents Numbered 226 and 256, Seventy-sixth Congress; and in accordance with the report of the Chief of Engineers dated August 21, 1943;

Clear Creek and Clear Lake, Texas; House Document Numbered 319, Seventy-seventh Congress;

Chocolate and Bastrop Bayous, Texas; House Document Numbered 337, Seventy-sixth Congress: *Provided*, That the authorization is not to be construed as final approval for the improvement of Bastrop Bayou;

Channel from Pass Cavallo to Port Lavaca and Lavaca-Navidad Rivers, Texas, in accordance with the report of the Chief of Engineers dated December 10, 1943, House Documents Numbered 314, Seventy-sixth Congress, and 659, Seventy-seventh Congress;

Guadalupe River, Texas; House Document Numbered 247, Seventy-sixth Congress: *Provided*, That whenever any power project, not under Federal license, is benefited by the Canyon Reservoir project, the Federal Power Commission after notice to the owner or owners of such unlicensed project and after opportunity for hearing, shall determine and fix a reasonable and equitable annual charge to be paid to the United States on account of such benefits by said owner or owners or other recipients of such benefits;

Aransas Pass-Corpus Christi Channel, Texas; House Document Numbered 544, Seventy-eighth Congress;

Brazos Island Harbor, Texas; House Document Numbered 335, Seventy-sixth Congress, and House Document Numbered 347, Seventy-seventh Congress;

Ouachita and Black Rivers, Arkansas and Louisiana; House Document Numbered 104, Seventy-sixth Congress;

Mississippi River between the Ohio and Missouri Rivers; House Document Numbered 231, Seventy-sixth Congress;

Mississippi River between Missouri River and Minneapolis: The existing project for lock and dam numbered 2 is hereby modified in accordance with the recommendation in House Document Numbered 432, Seventy-seventh Congress;

Mississippi River between Missouri River and Minneapolis: The construction of lock and dam numbered 26 at Alton, Illinois, is hereby declared to be in accord with the project authorized by the River and Harbor Act approved August 30, 1935;

Mississippi River between Missouri River and Minneapolis; House Documents Numbered 103 and 547, Seventy-sixth Congress; 263, Seventy-seventh Congress; and 449, Seventy-eighth Congress;

Mississippi River between Missouri River and Minneapolis: The existing project is hereby modified to provide for remedial works in accordance with the recommendations of the district engineer in the report submitted in House Document Numbered 137, Seventy-sixth Congress, and for such remedial works or land acquisitions in any levee

MISSISSIPPI RIVER BETWEEN OHIO RIVER AND MOUTH
OF MISSOURI RIVER

LETTER

FROM

THE SECRETARY OF WAR

TRANSMITTING

LETTER FROM THE CHIEF OF ENGINEERS, UNITED STATES ARMY, DATED MARCH 15, 1939, SUBMITTING A REPORT, TOGETHER WITH ACCOMPANYING PAPERS AND AN ILLUSTRATION, ON REEXAMINATION OF MISSISSIPPI RIVER BETWEEN THE OHIO RIVER AND MOUTH OF THE MISSOURI RIVER, WITH A VIEW TO DETERMINING WHETHER ANY MODIFICATION IN THE EXISTING PROJECT FOR IMPROVEMENT OF MISSISSIPPI RIVER BETWEEN MOUTH OF THE MISSOURI RIVER AND EAST ST. LOUIS, ILL., IS ADVISABLE AT THE PRESENT TIME, REQUESTED BY RESOLUTION OF THE COMMITTEE ON RIVERS AND HARBORS, HOUSE OF REPRESENTATIVES, ADOPTED OCTOBER 31, 1938

MARCH 23, 1939.—Referred to the Committee on Rivers and Harbors and ordered to be printed with an illustration

WAR DEPARTMENT,
Washington, March 21, 1939.

THE SPEAKER OF THE HOUSE OF REPRESENTATIVES.

DEAR MR. SPEAKER: I am transmitting herewith a report dated March 15, 1939, from the Chief of Engineers, United States Army, on reexamination of Mississippi River between the Ohio River and the mouth of the Missouri River, requested by resolution of the Committee on Rivers and Harbors, House of Representatives, adopted October 31, 1938, together with accompanying papers and illustration.

Sincerely yours,

HARRY H. WOODRING,
Secretary of War.

WAR DEPARTMENT,
OFFICE OF THE CHIEF OF ENGINEERS,
Washington, March 15, 1939.

The CHAIRMAN, COMMITTEE ON RIVERS AND HARBORS,
House of Representatives, United States, Washington, D. C.

MY DEAR MR. CHAIRMAN: 1. The Committee on Rivers and Harbors of the House of Representatives, by resolution adopted October 31, 1938, requested the Board of Engineers for Rivers and Harbors to review the reports on Mississippi River between the Ohio River and the mouth of the Missouri River, submitted in House Document No. 50, Sixty-first Congress, first session, and subsequent reports, with a view to determining whether any modification in the existing project for improvement of the Mississippi River between the mouth of the Missouri River and East St. Louis, Ill., is advisable at the present time; and to formulate for the stretch of the river in question a comprehensive plan, with estimates of cost, for all advantageous improvements to whomsoever the benefits therefrom may accrue. I enclose the report of the Board in response thereto.

2. After full consideration of the reports secured from the district and division engineers, the Board recommends modification of the existing project for Mississippi River between the Ohio and Missouri Rivers to approve a comprehensive plan for development of the Mississippi River at Chain of Rocks, generally in accordance with the plan herein; to provide for construction of a lateral canal at an estimated first cost to the United States of approximately \$10,290,000, with annual maintenance and operation costs of \$70,000, subject to such modification as the Chief of Engineers may find necessary when the project is undertaken; and to authorize the relocation of the river channel and reclamation of the area in Sawyer Bend for airport, park, recreational, and similar purposes at a cost to local interests of approximately \$17,555,000; provided that any modification of the present river channel required by the civic development be deferred until completion of the lateral canal herein recommended in the interest of navigation and that the river diversion work connected with such civic development be under the supervision of the Chief of Engineers in order to insure that the interests of interstate and foreign commerce be properly protected, and further provided that local interests hold and save the United States free from any claims for damages that might be incurred due to the construction, maintenance, or operation of such civic development or any part thereof.

3. After due consideration of these reports, I concur in the views and recommendations of the Board.

Very truly yours,

J. L. SCHLEY,
Major General,
Chief of Engineers.

REPORT OF THE BOARD OF ENGINEERS FOR RIVERS AND HARBORS

WAR DEPARTMENT,
BOARD OF ENGINEERS FOR RIVERS AND HARBORS,
Washington, D. C., March 6, 1939.

Subject: Mississippi River at Chain of Rocks.
To: The Chief of Engineers, United States Army.

1. This report is in response to the following resolution, adopted October 31, 1938:

Resolved, by the Committee on Rivers and Harbors of the House of Representatives, United States, That the Board of Engineers for Rivers and Harbors created under section 3 of the River and Harbor Act, approved June 13, 1902, be, and is hereby, requested to review the reports on Mississippi River between the Ohio River and the mouth of the Missouri River, submitted in House Document Numbered 50, Sixty-first Congress, first session, and subsequent reports, with a view to determining whether any modification in the existing project for improvement of the Mississippi River between the mouth of the Missouri River and East St. Louis, Illinois, is advisable at the present time; and to formulate for the stretch of the river in question a comprehensive plan with estimates of cost, for all advantageous improvements to whomsoever the benefits therefrom may accrue.

2. The waterway under consideration is the upper end of the Middle Mississippi River, which is formed by the junction of the Missouri with the Upper Mississippi at a point 195 miles above the mouth of the Ohio River and 658 miles below Minneapolis. Improvement of the Middle Mississippi authorized by Congress provides for obtaining and maintaining, by regulating works and dredging, a channel not less than 9 feet deep with a minimum width of 300 feet from the mouth of Ohio River to the northern limit of the city of St. Louis, mile 191; thence 200 feet wide to the mouth of Missouri River. Below the Merchants Bridge, at mile 183.2, the project has been substantially completed and dependable depths are generally maintained for all-year barge navigation to New Orleans.

3. In the Upper Mississippi, a project to provide a minimum depth of 9 feet with width adequate for barge navigation is in process of attainment by construction of a series of dams with navigation locks at 26 sites between Minneapolis and Alton, Ill., 8 miles above the mouth of Missouri River. This project was 81 percent complete on June 30, 1938, and all locks and dams will be in operation by the beginning of the 1940 navigation season. Improvement of the Illinois River has provided a 9-foot channel between Chicago and the Mississippi River and further improvement of connecting channels to facilitate barge navigation between Lake Michigan and the Illinois River has been recommended to Congress. Improvement of the Missouri River has been authorized by Congress to provide a channel 200 feet wide and 6 feet deep to Sioux City, Iowa, 795 miles above the mouth. On June 30, 1938, this project was 85 percent complete to Kansas City, 386 miles above the mouth, and 66 percent complete in the section thence to Sioux City. Operation of the Fort Peck Dam is expected to augment low flows sufficiently to provide 8-foot minimum depth in the Missouri River below Sioux City.

4. In the Mississippi River, rock ledges across the river bed at miles 185.6 and 187.8 occur in an area known as Chain of Rocks, over which low-water depths are frequently as little as 5½ feet and velocities at low and at high water are such as seriously to hamper navigation. Erosion of the river bed below Chain of Rocks during the past 100

years has caused a lowering of the low-water plane by about 10 feet, of which 8 feet occurred during the past 50 years. Continued lowering is to be expected. Below Chain of Rocks, adequate depths may usually be readily maintained by dredging, and velocities are not restrictive to navigation but continued lowering will still further increase the slopes and reduce depths over Chain of Rocks. Lowering of depths over Chain of Rocks has been accompanied by lowered water surface in the river above and by reduced depth over the lower sill in the lock at Alton, the lowermost in the series of Upper Mississippi navigation dams. Not only has the minimum elevation of low water been reduced but the duration of low stages has been materially prolonged. This reduction of stages has resulted from a succession of low-water years but will be contributed to by the reduced flows to be expected in the Illinois River following the permanent reduction in diversion from Lake Michigan through the Chicago Sanitary Canal. To provide an adequate channel for barge navigation in the upper reaches of the Middle Mississippi so as to permit full utilization of the improved channels of the Upper Mississippi, the Illinois, and the Missouri, improvement of the channel at Chain of Rocks and in the river above to the mouth of the Missouri and to Alton Dam is requested by navigation interests. Officials of Granite City, Ill., desire that the improvement be so planned as to provide a harbor for that industrial area. Other civic and regional planning interests urge consideration of the possibilities of a comprehensive development of the waterway in combination with utilization of the waterfront for airport, recreational, boating, park, and similar purposes.

5. The city of St. Louis on the west and the cities of East St. Louis and Granite City, with many smaller communities, on the east occupy practically the entire river front in the Chain of Rocks reach. With a combined population of approximately 1,000,000 they form a very important industrial and distributing center. St. Louis is the focus of trunk-line railroads, improved highways, airways, and of water transportation on the principal branches of the Mississippi system. Water-borne commerce, almost equally balanced as to upstream and downstream, and the major portion of it from and to points beyond the local area, increased from 891,750 tons in 1929 to 2,250,000 tons in 1937. Approximately one-half of the 1937 tonnage was nonmetallic minerals and one-quarter vegetable food products. Usual river movement is in tows of 1,000-ton barges propelled by steam or motor towboats. In view of the volume of traffic that has used the river despite the difficulties of navigation at Chain of Rocks and the incompleteness of through channels in the Missouri, Upper Mississippi and Illinois, it is expected that commerce will increase steadily to 10,000,000 tons annually within 4 or 5 years following completion of present projects.

6. The district engineer presents two plans, either of which would assure adequate depths over or around Chain of Rocks. Plan I would provide a lateral canal between levees through the flood plain east of the existing channel, which would be left unchanged to carry flood flows and for open-river navigation during high stages. The canal would provide 8 miles of slack-water channel of slight curvature and well defined for easy navigation in fogs and smoke, replacing 10 miles of open river that is now hazardous because of curvature and poor visibility as well as inadequate depth and dangerous currents.

Locks would be provided near the lower end of the canal to overcome the difference in elevation between the slack-water canal pool and the regulated river channel downstream. Levees to protect the canal against floods would serve also as the river-front levee of the drainage districts occupying the eastern flood plain and widening of the canal to obtain necessary material for levee embankment would provide a needed commercial harbor at Granite City. The canal project would provide adequate depth for safe navigation around Chain of Rocks and if minimum flows are not further reduced would with the aid of maintenance dredging assure adequate depths to the Alton Dam. Should reduced flows occur with such frequency as to constitute a hindrance to navigation at the lower approach to the Alton Dam it may become necessary to supplement the canal by construction of a low dam across the main channel just below Chain of Rocks Bridge, plan I (b).

7. Under plan II, a low movable dam would be constructed in the river as in plan I (b), with navigation locks in the river and straightened low-water navigation channel dredged eastward of the present main channel. Further study of this plan has indicated certain advantages to be obtained from a comprehensive development of the area in the combined interest of river navigation, aerial navigation, recreational and civic improvement, and certain economies to be realized from conducting the urgently needed navigation improvement in such a way that contemporary or eventual undertaking of the comprehensive plan may be benefited thereby. Placing of the spoil dredged from the proposed navigation channel where it will form fill for the future development rather than merely wasting it will afford a saving estimated at \$3,000,000. To permit the improvement required for the comprehensive plan, however, the channel must be located still farther eastward than would be required for navigation alone, and enlargement of the navigation channel to provide also for the relocation of the flood channel would still further increase costs over what is required for navigation alone. Estimated costs of the two basic plans and of modifications of each are as follows:

Plans	Initial construction	Maintenance and operation	Annual charge
I (a) Canal and lock.....	\$9,000,000	\$70,000	\$506,000
I (b) Navigable dam.....	1,703,000	15,000	95,000
Total.....	11,303,000	85,000	601,000
II (a) Dam, locks, navigable channel.....	9,522,000	50,000	476,000
II (b) Additional for shifting channel.....	1,236,000		277,000
Additional for enlarging channel.....	5,240,000		
Total.....	16,000,000	50,000	753,000

In addition, for full comprehensive development for airport, park, and recreational use, and to provide a harbor for Granite City, further construction estimated to cost \$16,000,000 would be required.

8. The district engineer points out that navigation conditions at Chain of Rocks must be corrected to permit full utilization of connecting channels. He believes that the improvement proposed under either plan I (a) or plan II (a) will accomplish the desired result and notes that the estimated costs are about equal. He prefers the canal

method, plan I (a), because it would give somewhat better navigation conditions, would provide a needed harbor for Granite City, and would interfere little with the regimen of the river. He recommends that improvement be undertaken at the earliest practicable date in accordance with plan I (a) with authorization of construction of the low dam, plan I (b), if and when it may be necessary.

9. The division engineer points out that if the low dam, plan I (b), is subsequently found necessary, the total initial cost of plan I will substantially exceed the cost of plan II (a) and the annual charge for plan I will be 25 percent higher than for plan II (a). Plan I would have no important effect upon the realization of the comprehensive development, but plan II (a) might contribute spoil for fill estimated as worth \$3,000,000 to the ultimate development. The division engineer further considers the fact that plans II (a) and II (b) afford greater flood capacity than plan I (a), under which the flood plain would be somewhat constricted and flood heights perceptibly increased. The division engineer recommends improvement for navigation in accordance with plan II (a) with the further recommendation that the improvement be as proposed in plan II (b) if the additional funds required become available. He concurs with the district engineer in the recommendation that any work done by local interests under the comprehensive plan be in accordance with plans approved by and constructed under the supervision of the Chief of Engineers.

VIEWS AND RECOMMENDATIONS OF THE BOARD OF ENGINEERS FOR RIVERS AND HARBORS

10. In the opinion of the Board, existing authority is adequate to cover any work necessary to maintain project depths in the Mississippi River above the mouth of the Missouri River. The project for the Middle Mississippi authorizes only contraction works and bank protection, together with such dredging as may be necessary. Under this type of improvement, a generally adequate channel has been obtained below St. Louis, but lowering of the river bed below Chain of Rocks has increased velocities and decreased depths over the section between Merchants Bridge and the mouth of Missouri River. Improvement of the present unsatisfactory conditions at Chain of Rocks should be undertaken promptly to provide for the needs of commerce. This improvement should be coordinated with the comprehensive development of the water front of the city of St. Louis.

11. The reporting officers have considered two possible solutions of the problem. One contemplates the construction of a canal to bypass the section. The other would require a dam with locks in the river and construction of an approach channel on a new alignment. The lateral canal will assure adequate depths and safe velocities regardless of possible further lowering of the river bed below the Chain of Rocks, and it will afford needed harbor facilities for industrial areas on the east side of the river. The canal will involve no disturbance of the regimen of the river at and immediately below the mouth of the Missouri and therefore will avoid the grave possibility of serious silting which might attend the operation of a dam in the river. Operation of the canal during the ice season will be less hazardous than operation of a wicket dam. Improvement under either plan would require several years, during which time navigation would continue

to be subjected to the uncertainties of the present unsatisfactory conditions at Chain of Rocks. The canal improvement, however, can be carried out without the further interference with navigation which would attend the major engineering task of shifting the Mississippi River into a new channel. The Board concludes that the most practicable means of providing for navigation is by construction of a lateral canal.

12. Shifting of the river into a suitable channel generally eastward of Mosenhien Island would be necessary to permit reclaiming of the river bed in Sawyer Bend and its development for airport, park, and similar purposes. The Board has selected what it considers to be the best features from each of the two plans of the reporting officers and presents a comprehensive plan, shown on the accompanying map, for advantageous improvements estimated to cost as follows:

	Lateral canal, Federal cost	Civic develop- ment, local cost
(a) Lands and rights-of-way.....	\$530,000	\$1,550,000
(b) Removal of Hamer dike.....		20,000
(c) Remedial works.....	250,000	210,000
(d) Highway relocation.....	700,000	
(e) Interceptor creek and appurtenances.....		3,850,000
(f) Channel excavation.....	2,700,000	10,050,000
(g) Lock in canal.....	5,680,000	
(h) Revetment of channel banks.....	430,000	1,500,000
(i) Control works for lagoons.....		375,000
Total.....	10,290,000	17,555,000

Installation of facilities necessary to permit use of the reclaimed area for airport, park, recreational, and similar purposes would involve additional local costs estimated at \$10,000,000.

13. The Board recommends modification of the existing project for Mississippi River between Ohio and Missouri Rivers to approve a comprehensive plan for development of the Mississippi River at Chain of Rocks, generally in accordance with the plan herein, to provide for construction of a lateral canal at an estimated first cost to the United States of approximately \$10,290,000, with annual maintenance and operation costs of \$70,000, subject to such modification as the Chief of Engineers may find necessary when the project is undertaken; and to authorize the relocation of the river channel and reclamation of the area in Sawyer Bend for airport, park, recreational, and similar purposes at a cost to local interests of approximately \$17,555,000; provided that any modification of the present river channel required by the civic development be deferred until completion of the lateral canal herein recommended in the interest of navigation and that the river diversion work connected with such civic development be under the supervision of the Chief of Engineers in order to insure that the interests of interstate and foreign commerce be properly protected, and further provided that local interests hold and save the United States free from any claims for damages that might be incurred due to the construction, maintenance, or operation of such civic development or any part thereof.

For the Board:

M. C. TYLER,
Brigadier General, Corps of Engineers,
Senior Member.

REVIEW OF REPORTS ON MISSISSIPPI RIVER BETWEEN OHIO
RIVER AND THE MOUTH OF MISSOURI RIVER

SYLLABUS

Two alternate plans of improvement have been developed for the river section considered in the report. Either plan is capable of providing an adequate and dependable navigation channel between the mouth of the Missouri River and East St. Louis, and, with the exception of differences in channel velocities, possesses practically equal merit insofar as navigation in that section is concerned. An 8-mile canal with navigation lock, plan I (a), located to the eastward of the present bed of the Mississippi River appears to offer the greatest number of advantages to navigation and shipping interests. Eventually it may become necessary to construct a movable low-head dam near Chain of Rocks Bridge (mile 190.5), if the low-water flows, which are apprehended as the result of other operations outside the district, become sufficiently small to limit the draft of vessels using Alton locks. This deferred construction, designated as plan I (b), would create sufficient elevation of water surface by slack water to provide project clearance over the lower miter sills at Alton locks for all anticipated conditions of low-water flow. This plan provides a harbor for Granite City, Ill. Plan I (a) is estimated to cost \$9,600,000 and the conditional development in plan I (b) \$1,700,000 additional. The alternate, plan II (a), contemplates the construction of a movable dam with locks about 400 feet downstream of Chain of Rocks Bridge, a straightened and dredged channel between Mosenthien and Cabaret Islands and a widened section on the upstream side of the dam to facilitate approach to the locks. This plan insures that sufficient water will always be available for navigation over the lower sills of Alton locks. The cost of the plan is estimated at \$9,250,000. No provision is made for any industrial harbor for Granite City, Ill.; such a development would cost \$400,000 additional. It is possible to provide a comprehensive civic development containing recreation and park area, bathing beaches, and an airport in the area now covered by the existing river channel and part of Mosenthien Island, provided a new river channel be cut between Mosenthien and Cabaret Islands, as contemplated in plan II (a) above. Such a development would be possible with either of the two general plans for improvement of navigation, but plan II (a) would reduce the cost of the civic development by about \$3,000,000, or the cost of depositing the dredge spoil from the new river channel in the area to be made into a recreational center. The cost of this civic development, plan II (b), is estimated as \$22,000,000, which is \$3,000,000 less than the cost of a civic development if the canal plan were approved in connection therewith. The district engineer recommends that the immediate construction of a canal with lock be authorized at a cost of \$9,600,000, and that the construction of a dam at Chain of Rocks be authorized at a cost of \$1,700,000, to be constructed if and when the Chief of Engineers finds that such additional construction is necessary in order to adjust for navigation future low-water deficiencies at Alton locks, and he further recommends that the Chief of Engineers be authorized to approve application and plans for the construction of the comprehensive civic development, when submitted by a legally constituted public agency authorized to assume all necessary obligations involved therein.

WAR DEPARTMENT.

UNITED STATES ENGINEER OFFICE.

St. Louis, Mo., December 15, 1938.

Subject: Review of House Document No. 50, Sixty-first Congress, first session, Mississippi River between mouth of Missouri River and East St. Louis, Ill.

To: The Chief of Engineers, U. S. Army (through the Division Engineer).

1. *Authority.*—This review of reports on the Mississippi River contained in House Document No. 50, Sixty-first Congress, first session, and subsequent reports, is submitted in compliance with a resolution by the Committee on Rivers and Harbors of the House of Representatives adopted October 31, 1938, which is as follows:

Resolved by the Committee on Rivers and Harbors of the House of Representatives, United States, That the Board of Engineers for Rivers and Harbors created under

section 3 of the River and Harbor Act approved June 18, 1902, be, and is hereby, requested to review the reports on Mississippi River between the Ohio River and the mouth of the Missouri River, submitted in House Document Numbered 50, Sixty-first Congress, first session, and subsequent reports, with a view to determining whether any modification in the existing project for improvement of the Mississippi River between the mouth of the Missouri River and East St. Louis, Illinois, is advisable at the present time; and to formulate for the stretch of the river in question a comprehensive plan with estimates of cost, for all advantageous improvements to whomsoever the benefits therefrom may accrue.

2. *Reports under review.*—The principal reports in review, contained in House Document No. 50, are reports on examination and survey of Mississippi River from St. Louis, Mo., to its mouth with a view to obtaining a navigable channel 14 feet deep and of suitable width, including consideration of a proposed waterway from Chicago, Ill. to St. Louis, Mo., as described in House Document No. 263, Fifty-ninth Congress, first session, and a report with reference to water power and to land drainage along the routes mentioned. The following alternate plans, with estimated costs, were considered and discussed: Dredging, regularization, canalization with movable dams, canalization with fixed dams, lateral canals, reservoirs, and several combinations of these plans.

3. The Special Board created by act of Congress approved March 2, 1907, which board prepared the basic report, concluded that, while all the plans considered, except reservoirs, were feasible from an engineering standpoint, the most practicable means of obtaining and maintaining a navigable channel of 14 feet depth from St. Louis to the mouth of the Mississippi River was by the combined method of dredging and regularization works in the open river. The Board of Engineers for Rivers and Harbors concurred in the conclusions of the Special Board as to methods of securing the desired depth, but did not believe that a 14-foot channel from Chicago to the Gulf was warranted by the then existent or prospective commerce, but that a 9-foot through channel was warranted. The Chief of Engineers also concurred in these views and submitted the report to the Committee on Rivers and Harbors on June 7, 1909. Most of the data in the above report relevant to this report are contained in its appendices.

4. Early projects had provided for improvement by dredging and regulating works between St. Louis and Cairo. Construction of regulating works was practically suspended under the acts of March 3, 1905, and March 2, 1907, and the joint resolution of June 29, 1906. The River and Harbor Act of June 25, 1910, restored regulating works to the project in accordance with the recommendations contained in House Document No. 50, Sixty-first Congress, first session, and a prior report but did not alter the previously approved project depth of 8 feet and width of 200 feet.

5. House Document No. 1374, Sixty-first Congress, third session, dated February 9, 1911, contains the report of a Special Board of Engineers, appointed in compliance with the River and Harbor Act approved June 25, 1910, to consider and report upon a waterway from Lockport, Ill., by way of the Des Plaines and Illinois Rivers, to the mouth of the Illinois River, and certain related subjects. The board, among other things, recommended that a cut 500 feet wide be made through the Chain of Rocks. The Chief of Engineers concurred in this recommendation.

6. River and Harbor Committee Document No. 9, Sixty-ninth Congress, second session, contained a recommendation by the district

engineer that a 9-foot channel with a width of 300 feet be provided from the Ohio River to the northern boundary of the city of St. Louis. This was also recommended by the Chief of Engineers and authorized by the River and Harbor Act of January 21, 1927.

7. In report of May 11, 1928, contained in River and Harbor Committee Document No. 12, Seventieth Congress, first session, the Chief of Engineers recommended that a 9-foot channel with a width of 200 feet and additional width around bends be provided in the Mississippi River between Grafton and St. Louis at an estimated first cost of \$1,500,000. It is stated in the report that with very small diversions a lock and dam may be required and that the estimate did not provide for alleviating unsatisfactory navigation conditions at Chain of Rocks. The report definitely pointed out that eventually additional works might be needed in that section but it was concluded from the information then available that the regulating works and dredging covered by the estimate would provide reasonably adequate facilities for a number of years. The work recommended was authorized by the River and Harbor Act of July 3, 1930.

8. In a report of October 19, 1933, printed in House Document No. 184, Seventy-third Congress, second session, the division engineer noted that a satisfactory channel had not been provided in the Chain of Rocks section by open channel methods to that date, and expressed the belief that it could not be provided by such methods. He pointed out that the uncertainties involved are objectionable in view of the Lakes-to-Gulf Waterway as a whole being no more dependable than its least reliable section and recommended the construction of a dam and lock at St. Louis, the exact location of the structures to be left to decision of the Chief of Engineers. However, the Chief of Engineers in his report stated that since Fort Peck Dam, under construction at the headwaters of the Missouri River, was expected to ameliorate low-water conditions on the Missouri River and in the Mississippi River below the mouth of the Missouri; no modification of the project for improvement of the Mississippi below the mouth of the Missouri to improve low-water conditions should be undertaken at that time.

9. *Description.*—The Mississippi River rises above Lake Itasca, Minn., flows in a southerly direction about 2,434 miles and empties into the Gulf of Mexico. Its basin extends from the Appalachian Mountains on the east to the Rocky Mountains on the west and from Canada on the north to the Gulf of Mexico on the south. The basin embraces about 9,715 square miles of Canada and all or part of 31 States of the Union, comprising a total area of 1,240,000 square miles.

10. The drainage basin of the Mississippi River is divided into six main watersheds: Upper Mississippi, Missouri, Ohio, Arkansas, Red, and central valley. The river above the mouth of the Missouri River is commonly called the upper Mississippi, and below the mouth of Ohio River the lower Mississippi, the 195-mile section between the two being known as the middle Mississippi, and the combination of the middle and lower sections, as the central valley.

11. That part of the Mississippi River being considered herein extends from East St. Louis, Ill. (Eads Bridge) to the mouth of Missouri River, a distance of 15 miles, between river miles 180 and 195 above the mouth of Ohio River. Necessarily, consideration is also given the 7.9-mile section between the Missouri River mouth and dam

No. 26 at Alton, Ill., insofar as any improvements proposed in this report may affect that section. The general locality is shown on sheet 1.¹

12. The upper Mississippi has its origin in a series of lakes just above Lake Itasca in Minnesota and flows 1,170 miles to its confluence with the Missouri River. The watershed area, which comprises 171,560 square miles, extends from as far eastward as the Illinois-Indiana line to the Minnesota-South Dakota line on the west, and from a point opposite the middle of Lake Superior at approximately 47° north latitude to the mouth of Missouri River. In general the terrain is alternately rolling and flat with a considerable portion swampy.

13. The Missouri River is formed by the junction of the Jefferson, Madison, and Gallatin Rivers at Three Forks, Mont., whence it flows in a general southeasterly direction for 2,473 miles to empty into the Mississippi. The drainage basin extends westward from a low divide, separating Missouri and upper Mississippi drainage, to the Rocky Mountains. It is bounded on the north by a less conspicuous divide, separating the Missouri and Hudson Bay drainage and on the south by the Ozark uplift and an east-west ridge across central Kansas. The terrain of the watershed, while extremely rough in its western portion, is comparatively smooth and flat in its easterly portions. The drainage area of the Missouri River is 529,350 square miles, or about 75 percent of the total drainage area of 701,000 square miles above the lower end of the reach being discussed.

14. Although the area of the Missouri River watershed is more than three times that of the upper Mississippi, the mean flow at St. Charles is about 75,000 cubic feet per second as compared to 90,000 cubic feet per second for the upper Mississippi River at Grafton. This difference is due to the lesser rainfall and the higher rate of evaporation in the Missouri Basin. The middle Mississippi at St. Louis has a mean discharge of 165,000 cubic feet per second. The maximum and minimum discharges of the upper Mississippi at Grafton have been 460,000 and 14,000 cubic feet per second respectively; of the middle Mississippi at St. Louis 1,300,000 and 24,000 cubic feet per second; and of the Missouri River at St. Charles 840,000 and 8,000 cubic feet per second. In the reach under consideration, maximum range in stage is 46.9 feet at St. Louis; high-water widths vary from 2,000 to 9,000 feet and low-water widths from 1,000 to 3,000 feet; slopes vary from 0.3 foot per mile at the lower end to about 2 feet per mile in the Sawyer Bend reach, miles 184 to 188.

15. The average navigation season in the reach under consideration is from February 15 to December 15, but the last few years there has been a growing tendency for navigation to use the river the entire year, except at times when it is actually blocked by very heavy ice or ice gorges. As a consequence, aids to navigation are now maintained throughout the year.

16. The record, as a whole, of low-water stages at St. Louis should not be taken as an indication of present conditions or of conditions to be expected in the future. Low-water flows have been augmented in the past by diversions from Lake Michigan through the Illinois Waterway. In the future these will be lessened and other artificial modifying effects will exist as discussed later in this report under the heading "Difficulties attending navigation." Furthermore, low-

¹ This drawing and others to which reference is made are contained in appendix D. (Not printed.)

water flows of given amount resulted in higher stages in the past than they do under present conditions. During the past 100 years the low-water plane at St. Louis has been lowered about 10 feet by erosion of the channel below the Chain of Rocks section. The mean of the lowest annual stages of a 77-year record is 0.92 feet, St. Louis gage. On an average during this period the river has been below this stage only about 7 days per year. However, during the last 10 years the river has been below this stage an average of 69 days per year. This is due partially to less than normal flows and partially to continued lowering of the channel bed. The lowest stage of record occurred in December 1937, and was -5.5 feet, St. Louis gage. During that year the stage was below the mean of lowest annual stages for 123 consecutive days. The lowest stage during the navigation season, -4.1 feet, St. Louis gage, occurred in August 1936. Even at these extremely low stages, depths are ample in the harbor below Merchants Bridge and current velocities are only about 1½ to 2 miles per hour, but in the Chain of Rocks reach, miles 183 to 191, depths at extreme low water have been less than project requirements and even as little as 5½ feet over rock, with velocities of about 5½ miles per hour. In the section between the northern boundary of St. Louis and Alton Dam, miles 191 to 202.9, depths less than project have been encountered, at times as little as 5 feet, with current velocities of about 3 miles per hour. Completion of Alton Dam and addition of several dikes above the Missouri River has apparently improved conditions.

17. Mean stage of the river is 11.66 feet, St. Louis gage, and the river has been generally at or above that stage about 195 days a year. At such stages there is ample depth for navigation, and current velocities average about 3 to 6 miles per hour throughout the reach under consideration.

18. The Weather Bureau flood stage is 30 feet, St. Louis gage, and stages have equaled or exceeded that value an average of 5 days per year, during which time there were ample depths for navigation but currents were swift, especially in the vicinity of Chain of Rocks Bridge, mile 195, where at times they approached 8 miles per hour.

19. The Missouri River, which enters the Mississippi just above Chain of Rocks, has been under improvement to provide a navigable channel 200 feet wide and 6 feet deep between the mouth and Sioux City, Iowa, but 8-foot depths are anticipated when Fort Peck Reservoir is in operation. This project was, on June 30, 1938, approximately 85 percent complete from the mouth to Kansas City, Mo., and 66 percent complete between Kansas City, Mo., and Sioux City, Iowa. Since June 6, 1935, regular transportation has been carried on between the mouth and Kansas City by the Federal Barge Line.

20. The upper Mississippi River is under improvement to provide a 9-foot channel of adequate width by means of a series of locks and dams at 26 sites between Alton, Ill., and Minneapolis, Minn. The project was about 81 percent completed as of June 30, 1938, and it is estimated that all of the locks and dams will be in operation by March 1940.

21. *Tributary area.*—The areas contiguous to the section of the Mississippi River considered herein are highly industrialized sections on both sides of the river with large numbers of important industries, high population densities, and well-developed networks of railroads and highways.

22. The average width of flood plain of the upper and middle Mississippi varies from 3 to 5 miles. However, in Sawyer Bend, which lies about halfway between Merchants and Chain of Rocks Bridges, the plain widens to a distance of 12 miles. The eastern or Illinois side of the area from Alton to and including East St. Louis, Ill., is subject to flooding, but practically this entire area from the mouth of Missouri River downstream to a point 5 miles below Eads Bridge now lies within the limits of the East Side Levee and Sanitary District, and is afforded a considerable degree of protection against floods by 32 miles of levees. This protection is soon to be increased by the reconstruction of levees to Mississippi River Commission standards. At present the flank levees are about 70 percent completed. Work has not been started on the river-front levees, as funds have not yet been made available therefor.

23. The larger portion of the western or Missouri side of the specific area under consideration is, with few exceptions, naturally well above high-water stages and practically no flood protection works are existent or proposed, except in the Columbia Bottoms. The city of St. Louis, located on this bank, extends from a point just above Chain of Rocks Bridge to the mouth of River Des Peres, 19 miles downstream.

24. The region immediately surrounding both the foregoing areas is a principal east-west gateway for practically all of the transcontinental rail systems of the United States and many of the commodities manufactured in the vicinity are distributed in world trade. It is a notable market for hogs, horses, mules, furniture, feeds, drugs, automobiles, and a leading producer of shoes, furs, and tobacco. The "heavy" industries are well represented in production of iron, steel, coal, coke, oil, lead, zinc, brick, cement, glass, and sand. The great diversity of products in the region makes it a valuable trade center and offers a well-balanced market to the shipping industries.

25. The population density is estimated at an average of 200 persons per square mile and the maximum probably exceeds 25,000. In the following table are listed the latest available census data for the urban area:

TABLE 1.—Population (1930 census)

City or town:		City or town:	
Alton.....	30, 151	Madison.....	7, 661
East Alton.....	4, 502	Granite City.....	25, 130
Wood River.....	8, 136	National City.....	1, 209
Roxana.....	1, 139	East St. Louis.....	74, 347
Hartford.....	1, 566	Cahokia.....	286
Venice.....	5, 362	Caseyville.....	743
Brooklyn.....	2, 063	St. Louis ¹	821, 960

¹ In Missouri; all others in Illinois.

26. The region is a rail center of the Middle West, with 18 trunk-line railroads entering the area, 14 on tracks of the Terminal Railroad Association and the others on rails of their own. The States of Illinois and Missouri have both developed excellent highway systems and both States have their road programs well advanced. Numerous paved roads cross the region in all directions. In recent years many miles of all-weather farm-to-market roads have also been constructed. The metropolitan area possesses a good system of traffic relief routes

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in and around the congested district, but many additional miles of these roads are needed and are gradually being constructed. Air lines are also sharing in the development and are becoming an important part of the transportation system. The inland waterways system furnishes much needed service for the shipment of bulk commodities and cheap transportation for the distribution of farm and manufactured products. The upper Mississippi connecting with the trade territory of the North, the Illinois River and Waterway extending to Chicago and the Great Lakes region, the Missouri River tapping the agricultural Northwest, and the lower Mississippi offering access to Ohio River ports and to world ports through the Gulf of Mexico, make this area an ideal shipping center.

27. The climatic conditions are shown in the following table of mean precipitation and temperature at St. Louis, Mo., taken from the Annual Meteorological Summary of the Weather Bureau, St. Louis, January 1938:

TABLE 2

Month	Mean precipitation	Mean temperature	Month	Mean precipitation	Mean temperature
January.....	2.34	31.1	July.....	2.98	78.8
February.....	2.56	34.8	August.....	2.99	77.5
March.....	3.38	44.1	September.....	3.46	70.5
April.....	3.81	56.1	October.....	2.72	58.4
May.....	4.34	67.0	November.....	2.83	45.4
June.....	3.82	75.0	December.....	2.21	34.9

NOTE.—Length of record, mean precipitation, 90 years; mean temperature, 58 years.

28. *Bridges.*—Four bridges cross the Mississippi River within the reach under consideration, two more have been authorized by Congress and plans approved by the War Department, but their construction has not been started. The two bridges just below lock and dam No. 26 are also considered herein. All of these bridges are of the fixed span type except the Alton Railroad bridge which has a swing span over the navigable channel. Tolls are charged for vehicles using the existing highway bridges and will be charged on the authorized bridges. No alterations in any of the existing bridges are proposed at the present time. Data for these eight bridges are itemized in table 3.

TABLE 3.—Bridges from Eads Bridge to Alton, Ill.

Name and miles above Ohio River	Owner	Purpose	Number of spans ¹	Horizontal clearance	Vertical clearance			Elevation of low steel, mean sea level	Construction authorized by Congress	Plans approved by War Department	Construction completed
					Above low water of 1904	Above high water of 1844					
Eads (180.0)	Terminal R. R. Association	Combined railroad and highway.	3	Feet 2 517 4 498	Feet 2 88.2	Feet 2 47.0	2 408.5	July 25, 1866 July 20, 1868		July 2, 1874.	
Franklin Ave. (190.2)	City of East St. Louis, Ill.	Highway	3	2 940 4 450	96.2	55.0	476.3	May 3, 1934	July 18, 1934	Not begun.	
Cass Ave. (190.7)	St. Clair County, Ill.	do.	5	2 675 4 435	96.6	55.0	476.8	Aug. 30, 1935	Sept. 17, 1935	Do.	
McKinley (182.5)	Illinois Terminal R. R. Co.	Combined electric railway and highway.	3	2 500	89.0	47.7	470.1	Feb. 15, 1907 Feb. 16, 1910	July 5, 1907	Nov. 9, 1910.	
Merchants (183.2)	Terminal Railroad Association.	Railroad	3	2 505 4 503	88.2	44.9	467.6	Feb. 3, 1897 Sept. 10, 1898	Nov. 15, 1898	June 21, 1899.	
Chain of Rocks (190.5)	Kingshighway Bridge Co.	Highway	8	2 680	92.6	55.7	482.3	Feb. 23, 1927	Aug. 30, 1927 Oct. 20, 1927	Oct. 31, 1929.	
Clark (202.7)	St. Charles County, Mo.	do.	8	2 437 10 276	87.6	52.5	484.8	May 22, 1926 Mar. 2, 1927	Mar. 5, 1927	Aug. 31, 1928.	
Alton Railroad (202.7)	Missouri & Illinois Bridge & Belt Railroad Co.	Railroad	9	11 200			434.1	Aug. 28, 1890	Aug. 1, 1891	In 1894.	

¹ River spans.
² Center span.
³ At center of channel span.
⁴ 2 side spans.
⁵ West channel span.
⁶ For width of 625 feet of west channel span and 385 feet of 2 other spans.

⁷ 2 other spans.
⁸ 3 main spans.
⁹ 2 main spans.
¹⁰ Left span.
¹¹ Each side pivot pier.

29. *Prior reports.*—Numerous reports have been made, prior to the reports in review, covering the Mississippi River between the Ohio and Illinois and between the Ohio and Missouri Rivers. Two of these presented plans somewhat similar to the proposals considered in the present report. The first, Senate Document No. 50, Forty-first Congress, third session, proposed the opening of Cabaret Slough (between Mosenthien and Cabaret Islands) to reduce scour (bank erosion) in Sawyer Bend and remove bars at the lower end of Cabaret Island. This was to be accomplished by building a dike from the head of Cabaret Island to deflect the current into the chute and by dredging the chute to start the flow of the river into it. It was believed that the river would scour a larger channel which could then be improved and regulated by dikes and revetments, all at an estimated cost of \$408,841, at that time.

30. The second report, House Document No. 263, Fifty-ninth Congress, first session, was a survey report on a proposed 14-foot waterway between Lockport, Ill., and St. Louis, Mo. The portion pertinent to the report under review was prepared by the Mississippi River Commission for the stretch of Mississippi River between Illinois River and St. Louis, and considered a wicket dam just below the railroad bridge at Alton, which, with dredging, was to provide a 14-foot channel to Grafton. From Alton to St. Louis a canal was proposed with entrance, provided with guard walls and gates, just above the dam at Alton, and running approximately parallel to the river through Illinois bottom lands to St. Louis Harbor, entering about three-fourths of a mile above Merchants Bridge. The canal was to be provided with a lock at its lower end having a 30-foot lift, and was to be protected throughout its length by levees on both sides. The estimated cost of this work was at that time \$6,533,880.

31. *Existing project.*—The original project for the improvement of the Mississippi River between the Ohio and Missouri Rivers was recommended by a board of engineers in a report dated April 13, 1872. The Chief of Engineers concurred in this recommendation. The cost and expenditures for the Middle Mississippi prior to the adoption of the present project in 1881 were \$1,610,000 for new work. (For further details see p. 1879 of the Annual Report for 1915.)

32. The present project provides for obtaining and maintaining a minimum channel depth of not less than 9 feet, a minimum width of not less than 300 feet at low water, with additional width in bends, from the mouth of the Ohio River, mile 0, to the northern boundary of the city of St. Louis, mile 191; thence 200 feet wide, with additional width in bends to the mouth of the Missouri River, mile 195, all to be obtained by regulating works and dredging: First, by regulating works for closing sloughs and secondary channels and narrowing the river, building new banks where the natural width is excessive and protecting new and old banks from erosion where necessary to secure permanency; second, by dredging to maintain channels of project dimensions.

33. 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 June 3, 1896, June 13, 1902, and March 2, 1907. That part of the project for the middle Mississippi which proposed regulating works was practically abrogated by the acts of March 3, 1905, and March 2, 1907, and the joint resolution of

June 29, 1906. The River and Harbor Act of June 25, 1910, restored regulating works to the project and began appropriations with a view to the completion of the improvement between the Ohio and Missouri Rivers within 12 years, at an estimated cost of \$21,000,000, exclusive of amounts previously expended. The River and Harbor Act of January 21, 1927, provided for a depth of 9 feet and width of 300 feet from the Ohio River to the northern boundary of St. Louis and increased the estimate for maintenance to \$900,000 annually (River and Harbor Committee Doc. No. 9, 69th Cong., 2d sess.). The River and Harbor Act of July 3, 1930, modified the project between the northern boundary of the city of St. Louis and Grafton (mouth of Illinois River) to provide for a channel 9 feet deep and generally 200 feet wide with additional width around bends, at an estimated cost of \$1,500,000, with \$125,000 annually for maintenance (River and Harbor Committee Doc. No. 12, 70th Cong., 1st sess.). The River and Harbor Act of September 22, 1922, provided for dredging channels to landing places on the main river and subsidiary sloughs above the mouth of the Missouri River.

34. The existing project for the Upper Mississippi River provides for a channel of 9-foot depth and of adequate width between the mouth of Missouri River and Minneapolis, Minn., by the construction of a system of locks and dams supplemented by dredging. The project between the Illinois River and Minneapolis was adopted by the River and Harbor Act of July 3, 1930, in accordance with the plan submitted in House Document No. 290, Seventy-first Congress, second session. Under Public Resolution No. 10, Seventy-second Congress, first session, approved February 24, 1932, the Chief of Engineers was granted discretionary authority to make such modification in the plan as may be advisable. The River and Harbor Act of August 30, 1935, among other things, extended the lower limits of the project to the mouth of Missouri River, and authorized improvement by a system of locks and dams supplemented by dredging in accordance with plans recommended in House Document No. 137, Seventy-second Congress, first session. Several other modifications of the project, that are not pertinent to the present review, have been made.

35. In the first section between East St. Louis (Eads Bridge), mile 180, and the northern boundary of St. Louis, mile 191, the total cost of improvements, consisting of solid dikes and bank protection, was about \$245,000, all for new work, prior to adoption of the existing project (1881). The total cost under the existing project has been about \$312,300 for new work and \$274,400 for maintenance. The project is about 77 percent completed as of June 30, 1938.

36. In the short section of river between the northern boundary of St. Louis, mile 191, and mouth of Missouri River, mile 195, no work was done prior to 1881. The cost under the existing project has been about \$334,600 for new work and \$252,900 for maintenance. This project is also about 77 percent completed.

37. In the third section, Missouri River, mile 195, to Alton Dam, mile 202.9, which, although actually beyond the geographical limits of this review, is none the less indivisibly related thereto, the total cost of prior projects was about \$200,000 for new work and \$18,000 for maintenance; and the costs under the existing project are about \$1,089,600 for new work and \$673,800 for maintenance. This project is about 75 percent completed as of June 30, 1938.

38. *Local cooperation.*—Under the existing and previous projects no local cooperation has been required by law.

39. *Other improvements.*—From time to time, between 1836 and 1916, considerable work, which has contributed to the improvement of navigation, has been done throughout this reach by local agencies. This work consisted in building dikes of brush and stone, piling dikes, bank protection, and paved sloping wharves. A résumé of these improvements, giving the type of work, quantity, locality, cost, and local agency responsible for construction, is given in table 4.

TABLE 4

By whom built	Locality and miles above Ohio River	When built	Type of work	Length (feet)	Cost
City of St. Louis.....	St. Louis wharf, 180-185.	1853-76	Sloping wharf, paved with granite blocks.	6,000	\$833,340
Do.....	East St. Louis to Chain of Rocks, 180-190.5.	1840-69	Solid dikes of brush and stone.	-----	918,955
Do.....	Sawyer Bend, 187.5-190.	1897-1913	Bank protection.....	14,500	213,600
Do.....	Chouteau Island, 190-192.	1916	Piling dikes.....	2,850	108,350
Do.....	Chouteau Island, 191.5-193.3.	1913	Bank protection.....	11,300	173,390
Total of work done by city of St. Louis.					2,253,185
East Side levee and sanitary district.	Eads Bridge to Venice Landing, 180-181.5.	1913-15	Bank protection on sand fill and piling toe wall.	7,775	1,214,750
Riparian owners.....	Eads Bridge to mouth of Missouri River, 180-195.	1840-1913	Brush and stone and piling dikes.	11,500	207,000

NOTE.—Total of work done by local agencies, \$3,674,915.

40. *Terminal and transfer facilities.*—There are seven important river terminals in the reach under consideration in this report. These are listed and described in Table 5. Both East St. Louis and St. Louis have considerable water-front areas which are not now in use, but which, although privately owned, are available as potential sites for additional river terminals.

TABLE 5. Terminal facilities, Mississippi River between Missouri River and East St. Louis

Location and miles above Ohio River	Owner or operator	Purpose for which used	Mechanical appliances	Railroad connection	Remarks
East St. Louis, Ill., 180.1	Cargill, Inc.	Loading grain from elevator to barges.	Conveyor from elevator to river house, then spouts to barge.	Terminal Railroad Association.	Private "belt elevator."
East St. Louis, Ill., 181.2	Missouri-Illinois Material Co.	Unloading sand from barges to trucks and railroad cars.	Floating derrick with clamshell bucket, and conveyor.	do.	Private.
St. Louis, Mo., 181.3	do.	do.	Gantry crane with clamshell bucket, and conveyor.	do.	Do.
St. Louis, Mo., 181.7	City of St. Louis, owner; Federal Barge Line, operator.	Handling all kinds of commodities	2 steel gantry cranes, 1 stationary crane, and 3 locomotive cranes.	do.	Public "municipal dock."
St. Louis, Mo., 182.5	St. Louis Material & Supply Co.	Unloading sand and gravel from barges.	Gantry crane with clamshell bucket.	do.	Private.
St. Louis, Mo., 183.0	St. Louis Basket & Box Co.	Unloading logs from barges.	Steel derrick.	do.	Do.
St. Louis, Mo., 184.0	Norris Grain Corporation.	Transferring grain from elevator to barges.	6 power shovels, 6 loading spouts, and 2 belt conveyors.	Chicago, Burlington & Quincy R. R.	Public "Burlington elevator."

41. *Survey.*—Various surveys have been made of this section of the Mississippi River. In preparation of this report, recourse has been made to all available data but especially to several unpublished sectional surveys. The main references are a topographic survey of Chain of Rocks and vicinity made in 1934-35, two local surveys made since that date, and a special probing survey to determine rock elevations at the site of the dam considered in this report. Prints of maps and drawings, used and developed in connection with this report, are bound in a separate atlas designated as appendix D.²

42. Model studies of the Mississippi River in the vicinity of Chain of Rocks have been and are being conducted in the laboratories of the Waterways Experiment Station at Vicksburg, Miss. One method considered followed in general the present channel alinement through Sawyer Bend but moved the channel eastward 1,500 feet, hard against Mosenthien Island and away from ledge rock in the bend. It was indicated that after tests simulating 30 years in the prototype the low-water plane would be lowered approximately 4 feet at mile 192 and 1 foot at the Alton Dam, mile 202.9. The effect of closing Sawyer Bend by a dike from the head of Mosenthien Island to the Missouri shore and putting the channel between Mosenthien and Cabaret Islands was also investigated. This type of improvement also showed a marked tendency to lower the low-water plane throughout the reach under consideration. The conclusions drawn from the tests seem to indicate that while both methods of improvement would offer prompt relief to navigation temporarily, their ultimate effect of lowering the low-water plane would endanger the usefulness of Alton locks during extreme low water, which would require additional and costly corrective work. One of the plans of improvement proposed in this report contemplates moving the channel into the chute between Mosenthien and Cabaret Islands as outlined in the second method just described, but adds a movable dam near Chain of Rocks Bridge to overcome the deleterious effects caused by lowering of the low-water plane.

43. *Difficulties attending navigation.*—Between Alton and Cairo project dimensions are now available at practically all times, or can readily be restored by dredging, except at two locations—one at Hancock Rocks near Commerce, Mo. (mile 41), and the other at Chain of Rocks (miles 183.3 to 190.5). The reach at Hancock Rocks is now under improvement and, it is believed, will be satisfactory to navigation interests before next low water. There remains, then, only the Chain of Rocks reach to be improved before reasonably dependable 9-foot navigation can be assured between Minneapolis and Chicago to Cairo or, for that matter, to New Orleans.

44. In any channel some shoaling will always be encountered, but in the upper and middle Mississippi this shoaling is now expected to be much less than formerly and to be readily and quickly removable by dredging, except through the Chain of Rocks reach, miles 183.3 to 190.5, where excessive velocities impede navigation at the upper end during high water and where, during low water, excessive velocities and shallow depth prevent "project depth" navigation and obstruct lighter-draft traffic. Moreover, due to considerable smoke and fog frequently found in this reach, navigation of the long Sawyer Bend in the river below Chain of Rocks Bridge is hazardous in spite of the

² Not printed.

numerous buoys and lights maintained. Fortunately, the worst river conditions usually occur during the winter period, December 15 to March 1, when river traffic has been slight, but of recent years winter traffic has been increasing. During the record low-water year of 1937, depths as low as 5½ feet were measured, even though for only 1 day, but less than 9-foot depths were available for a total of more than 2 months (not consecutive).

45 From Chain of Rocks Bridge to the mouth of the Missouri (mile 195), project dimensions have been generally maintained, but some dredging of shoals between pools is required during unusually low water, as during the record low year of 1937, when less than 9 feet was reported for a total of about 1½ months (not consecutive), and for 1 day a depth of 5 feet on one bar was reported. But as no rock underlies this section of river, these shoals are readily and quickly removable and do not long hold up navigation, if at all.

46. From the mouth of Missouri River to dam No. 26, mile 202.9, a navigable channel of project depth is generally available, but here again during the navigation season of the very low water year of 1937, depths of less than 9 feet have been reported frequently, and occasionally depths as little as 5½ feet have been reported. Some of this shoaling was due to construction of solid "contracting" dikes and the movement of sand occasioned thereby. With the completion of these remedial works, this section of the river should be much improved. In this section, channel-maintenance dredging has increased during the late dry years (but not so rapidly as in the Chain of Rocks reach), averaging about \$7,500 per annum from 1930 to 1935, inclusive, and about \$14,300 per annum since 1935.

47. As mentioned in paragraph 44, difficult navigation is experienced in the 7-mile Chain of Rocks-section at both extremes of river stage. In recent years, notably the past 7, from 1931 to 1937, inclusive, as the seasons became generally drier and the river tows increasingly heavier, navigation has become increasingly more difficult. There are two localities in the section at which natural rock sills encroach on the existing channel where the river flows over bedrock. The rock sills are located at miles 185.6 and 187.8, and at low-water stages they act as weirs and "spill" into the well-regulated channel below, producing velocities in the rock sections which are difficult to negotiate with large tows, especially for towboats of small horsepower. The "weir" action of the sills has gradually developed with the lowering of the low-water plane in that part of St. Louis Harbor below Bissell Point.

48. The low-water plane in St. Louis Harbor has lowered approximately 10 feet during the past century in the soft alluvial material of which the river bed is composed. Approximately 8 feet of this lowering, however, has occurred in the last half century. Ordinarily this lowering of the low-water plane would continue upstream until a condition of equilibrium was reached, but just above Bissell Point the bedrock outcrop is encountered and the erosion halted. Thus this stream which has an average fall of 0.6 foot per mile between the Ohio and Missouri Rivers, has, in the Chain of Rocks section, a measured fall which exceeds 2 feet per mile; while in the highly contracted section, in St. Louis Harbor, it has an average fall of only 0.3 foot per mile. Any future additional lowering of the low-

water plane will, of course, increase the differential between the rock sills and the easily eroded section.

49. During high-water periods, current velocities as great as 12 feet per second are encountered in the vicinity of Chain of Rocks Bridge, where the channel is constricted by an outcrop of rock extending from the Missouri shore to a point well out into the river, and by the bridge piers, intake towers, and Homer dike. The high velocities, coupled with these obstructions which cause a strong "draw" of current obliquely toward the Missouri shore, all make navigation difficult and hazardous at this point.

50. The navigation conditions just described are based upon stream flows experienced in the past, but it is believed that anticipated flow conditions, discussed in the succeeding paragraphs, will aggravate the difficulties at certain times of the year.

51. The discharge of the Mississippi River below the mouth of the Illinois River has been augmented, since 1848, by diversion from Lake Michigan. During the period from 1900 to 1928, this diversion increased from an annual average of 2,990 to 10,000 cubic feet per second, including direct diversion plus that pumped as water supply for the Chicago area. A Supreme Court decree of April 21, 1930, ordered a gradual reduction in the direct diversion so that after December 31, 1938, it may not exceed an annual average of 1,500 cubic feet per second. It is estimated that for some years to come the average annual diversion by pumpage will amount to an additional 1,700 cubic feet per second, making a total diversion of 3,200 cubic feet per second. The low-water discharge hydrographs contained in the accompanying folio of drawings (appendix E)² show the actual flows at St. Louis and the computed flows, assuming the total diversion had been limited to an annual average of 3,200 cubic feet per second during the period 1928 to 1937, inclusive. Where the hydrographs appear blank, the flows exceed 120,000 cubic feet per second.

52. Future flows will be affected by operation of the reservoir now under construction on the Missouri River at Fort Peck, Mont. This reservoir will be operated so as to increase low flows on the Missouri River when needed in the interests of navigation on that stream. The modified hydrographs referred to above have been further altered as illustrated for the 10 years to take into account the computed effect of Fort Peck Reservoir on flows at St. Louis, assuming the reservoir to have been full in 1928 and operated according to the present proposed plan. It will be noted that in general the reservoir would not have increased flows at St. Louis prior to August 1 of each year. During some periods the reservoir operation would have more than offset the effects of reduced diversion from Lake Michigan; but at other times, particularly in the winter period during the nonnavigation season on the Missouri River, the reservoir would have been storing water, and flows at St. Louis would have been correspondingly decreased. It must be borne in mind that when Fort Peck Reservoir is placed in operation the ultimate operation may differ from the present preliminary plan when the effects of distance and the uncertainties of flow coordination have been experienced. The net effect may be a further lowering of the low-water plane at the miter sill at Alton Lock or, on the other hand, may be less than that indicated by the present proposed method of operation. As previously stated,

² Not printed.

navigation is often possible between St. Louis and Cairo during the entire winter, and as aids to navigation are maintained throughout the year, it is proposed to maintain the navigation pool at Alton until both the Mississippi and Illinois Rivers are frozen over.

53. The probable effect on downstream flows of the navigation pools, established, or soon to be established, above Chain of Rocks, have also been considered. The computed effects at St. Louis during the low-water periods of the navigation seasons of 1933 and 1934, had the pools been in operation, are indicated on hydrographs for those years. Computations have not been made for other years. The reductions in flows indicated are partially due to evaporation from the increased surface areas of the navigation pools. Also, during low-water periods when flows are decreasing, discharges will be diminished by retention in the pools of water which, under natural conditions, would appear as flow released from channel storage as stages recede.

54. In the drawings (appendix E)² are also shown intermittent actual and computed stage hydrographs for tail-water elevation at lock and dam No. 26 covering the periods of lowest water of record and modified to take into account the prescribed reduction in diversion, and operation of Fort Peck Reservoir which, through backwater effects above the mouth of Missouri River, would have affected Alton stages and, for the year of 1934, the operation of the navigation pools. These graphs, when compared with the elevations of the lower miter sills of the Alton locks, 385.0 mean sea level, indicate the need for an improvement which will increase the elevation of the tail water at Alton if vessels of the draft expected to use the project are to be assured adequate depths to enter the locks safely at all times. Other locks of the project, and of the Illinois Waterway in general, provide depths of 11 feet or more over the miter sills above the designed elevation of flat pool downstream. The Alton locks were designed to afford such depth below the minimum elevation of low water during the navigation season of 1930. But the increasingly lower flows experienced in the drought years 1931 to 1937, inclusive, and the increased interest in navigation, during part of the winter season heretofore considered "closed," has indicated quite clearly the desirability, if not necessity, of works which would increase the tail-water elevation at Alton locks, especially if such works can be designed so as also to afford relief from the unsatisfactory navigation conditions in the Chain of Rocks reach.

55. *Improvements desired.*—At the public hearing held in St. Louis on November 17, 1938, about 100 persons were in attendance, representing Federal, State, and municipal governments and regional planning bodies. Representatives of civic organizations from the Missouri and Illinois sides of the area, drainage and levee district commissioners, navigation interests, local businessmen, and a railroad official expressed their views.

56. With the exception of the officials from the Chouteau Island drainage and levee district and the Chouteau, Nameeki, and Venice drainage and levee district, no objections were raised to the plans suggested by local interests. But a railroad official pointed out that his company owned considerable very valuable industrial land along the present shore of the river, for which they would expect proper compensation due to its great value for shipment, both by water and

²Not printed.

by rail, in the event that the river was turned out of its present course alongside the railroad property. A representative of a cement company also pointed out that the plan to change the present course of the river would put his company's plant off the river, and although no river shipments had been made from the cement plant at that location, still plans for use of the river for both receipts and shipments were under serious consideration. The city of St. Louis stated it had no objection to the plan, provided the city was not called upon to incur any expense connected therewith, and provided that a canal be provided for in any plan, which canal would divert sewage and surface run-off and the effluent from the city's filtration plant at the Chain of Rocks, all of which now flow into the river, to some point in the river below the proposed change in river alinement.

57. Essentially, only two plans were proposed by local interests. One group advocated training the river through Mosenthien Island chute and closing the existing channel by making an earth fill between Mosenthien Island and the Missouri shore. This fill was then to be developed into an airport, park, and recreation center.

58. Another group proposed the construction of a canal to the eastward of Chain of Rocks, so alined that it would approach the western limits of Granite City and provide that city with a harbor to give easier access to the river. They proposed no change in the river alinement.

59. Navigation interests expressed themselves as greatly in need of some type of improvement through this troublesome reach, with its shallow depths and swift currents, but expressed no preference for, nor objection to, either of the plans proposed. One navigator did state that he believed the canal route had a definite advantage in that navigation would be possible through it during periods of smoke and fog, which are frequently encountered in the Chain of Rocks, especially during the winter, while the present open river passage, because of its width, is very difficult, if not hazardous, to use because of poor visibility of landmarks at such times. Minutes of the hearing, objections to plans proposed by local interests and a printed copy of one type of development are contained in appendixes² A, B, and C.

60. *Commerce.*—The movement of commerce on the middle Mississippi is fairly well balanced in that almost equal tonnages are transported upstream and down. The major portion of the total tonnage is from and to points beyond the St. Louis-East St. Louis area, although records for the port of St. Louis show shipments of 508,493 tons and receipts of 417,027 tons during the calendar year 1937. Of the total moved in the middle Mississippi, 52 percent or 1,168,717 tons went through Chain of Rocks area.

61. Table 6, which lists the commerce moved on the middle Mississippi River during the past 10 years, shows that there has been a growth of traffic during the period even while pertinent contributing channels were under construction. Although a dependable 9-foot channel will soon be available to Minneapolis, it has not yet been completed. A 9-foot channel has recently been made available to Chicago, but the connection between lake and river channels, and to industrial areas in Chicago, is still considered inadequate. The Missouri River improvement now provides a useable waterway but of less depth than the Mississippi. Fort Peck Reservoir, when completed, is expected to provide considerable increase in low-water depths

² Not printed.

on the Missouri River. Although the channel below the mouth of the Missouri has been substantially improved during the period for which traffic is listed, as noted in paragraphs 43 and 44, the Chain of Rocks section is restrictive and at certain other points downstream a 9-foot channel is not yet always available. In view of the above, and the general condition of business during a portion of the years for which traffic is shown in table 6, the amount of traffic listed is considered of historical interest rather than as evidence of future traffic which may be expected.

TABLE 6

Calendar year	Amount, tons ¹	Value, dollars	Calendar year	Amount, tons ¹	Value, dollars
1928.....	1,430,183	68,660,861	1933.....	1,098,063	96,635,902
1929.....	891,750	61,302,890	1934.....	1,858,011	89,401,839
1930.....	926,957	63,008,513	1935.....	1,729,093	109,895,172
1931.....	1,303,034	53,977,976	1936.....	1,094,536	122,405,185
1932.....	1,577,390	63,207,618	1937.....	2,251,497	137,503,058

¹ Tons, as used herein, are of 2,000 pounds.

62. Although the facilities used for transportation on the Mississippi River are especially suitable for bulk cargoes, approximately 40 percent of the tonnage reported for the middle Mississippi River consists of package freight. The following table shows the tonnage and valuation by classification of traffic on the middle Mississippi River during 1937.

TABLE 7

Classes of commodities	Tonnage	Value	Classes of commodities	Tonnage	Value
Animals and animal products.....	25,657	\$3,361,006	Ores, metals and manufactures of.....	144,391	\$11,811,921
Vegetable food products.....	595,811	51,669,308	Machinery and vehicles.....	40,452	19,993,882
Vegetable products, inedible.....	17,469	3,993,501	Chemicals.....	52,334	5,382,629
Textiles.....	103,103	13,390,012	Unclassified.....	38,411	7,390,401
Wood and paper.....	76,205	2,935,994			
Nonmetallic minerals.....	1,157,671	10,704,164	Total.....	2,251,497	137,503,058

63. It is expected that upon completion of the canalization of the upper Mississippi River and further improvements on the Illinois Waterway and Missouri River, traffic in the middle Mississippi River will increase more rapidly during the following 4 or 5 years, reaching a total of about 10 millions of tons by the end of that period. It is believed that about 80 percent of this traffic will move through the section under consideration in this report, and unless decided improvement of the navigation channel is made, a serious detriment to through transportation and a curtailment of normal traffic development will result for the reasons previously given under the heading "Difficulties attending navigation."

64. The commercial craft using the river include towboats with cargo barges, several excursion boats, and one packetboat, with maximum drafts of 10 feet and horsepower up to 2,700. Barges range from small sizes up to those having a capacity of 3,000 tons. Although as much as 12,000 tons of cargo have been handled up-bound in a single tow, the usual tow consists of six barges containing about 1,000 tons of cargo each. There are shown in table 8 the

drafts of the various craft using the middle Mississippi in 1937 and the number of trips made by each type.

TABLE 8

Draft (feet)	Up-bound				Down-bound			
	Steamers	Motor vessels	Barges	Total	Steamers	Motor vessels	Barges	Total
10.....							12	12
9.....			581	581			448	448
8.....			49	49			128	128
7.....	4	1	71	76	3	2	263	268
6.....	425	158	374	957	423	178	726	1,326
5.....	324	91	166	581	323	102	253	678
4.....	64	92	152	308	65	122	207	394
3.....	8	441	45	494	8	410	110	528
2.....		69	1,202	1,331	1	71	599	671
Total.....	825	852	2,700	4,377	823	685	2,715	4,453
Total net registered tonnage.....	427, 821	110, 345	2, 759, 812	3, 297, 078	428, 917	110, 134	2, 719, 395	3, 258, 446
Passengers:								
Excursion.....				494, 804				494, 804
Regular.....	2, 070			2, 070	2, 088			2, 088
Ferry.....	120, 535			120, 535				

1 Across river.

65. Because of the difficulties of navigation described in paragraph 43 et seq., it is now frequently necessary, especially at times of low or high water, for towboats to "double trip" through the Chain of Rocks reach. This is usually true at all times for towboats of small horsepower. Although such a condition is found in other rivers (such as on the Rhine where it is necessary to break tows into smaller units in order to pass through the swift currents of rocky section between Saint Goar and Bingen), yet such a condition is always a very serious inconvenience and expense to navigation. Improvement of this "bottle-neck" section of the river, which will afford satisfactory, safe, and uninterrupted navigation, will not only aid local traffic but, because of its greater volume, will be proportionately more beneficial to through traffic, the value of which, though very real and tangible, is difficult to express in dollars and cents.

66. *Water power.*—Under the plans of improvement considered and for which details are given later in this report, little, if any, opportunity is afforded to permit the economical production of electrical energy.

67. In the plan designated as No. I (a) which consists of a bypass canal with locks to the eastward of Cabaret Island, the best place for a generating station would be at the lock site which is about 6,000 feet above the lower terminus of the canal. The elevation of the bottom of the canal would be 378 feet, mean sea level, and the range in head would vary from about 4.5 to 11.5 feet, with a flat water surface in the canal. The flow of water required to generate power would necessitate slope in the water surface and the head loss would then vary from about ½ to 1½ feet. Although power plants have been constructed which operate at heads as low as those mentioned herein, they are not usually successful as commercial ventures and in the majority of instances have been built for military purposes. In this case the amount of power which could be generated is so small and

the cost of installing facilities so large that it probably would not be attractive to private enterprises and any possible profit from power production would be small at best and negligible in considering which, if any, of the plans of improvement discussed herein should be adopted.

68. Plan No. II consists of a low-head movable dam with lock at mile 190.4 (about 400 feet below Chain of Rocks Bridge) and certain channel improvements. Power could not be economically generated since the pool would be raised less than half the time.

69. *Plans of improvement.*—Two types of improvement have been investigated for the river section under consideration; these are hereinafter designated as plans I and II.

70. Plan I is presented in two phases. The initial phase, I (a), contemplates the construction of a landward canal about 8 miles long with the downstream terminus opposite river mile 184, about seven-tenths of a mile above Merchants Bridge, and the upstream terminus opposite mile 194, about 1.0 mile below the mouth of Missouri River. A standard lock, 110 by 600 feet, is to be located about 6,000 feet above the lower canal entrance, and levees are to parallel the canal on both banks above the lock site. The levee on the east side of the canal would increase local flood protection. Plan I (b), the second phase of the improvement, consists of the addition of a low-head movable dam without locks at mile 190.4, about 400 feet below Chain of Rocks Bridge, for the purpose of creating slack water in the section of river above the dam. The necessity for the construction of the dam is dependent upon the future development of regimen of the river and consequently is a contingent feature of plan I (a). These plans are shown on sheets² 1 to 8, inclusive.

71. Plan II is presented in alternative form in that first a method of securing the required navigation improvement is given and then a modification of the plan is presented to provide also for improvements for local flood protection, recreation, and civic development in addition to navigation. The basic plan consists of a movable dam with a standard lock, 110 by 600 feet, at mile 190.4, about 400 feet downstream of Chain of Rocks Bridge, with a dredged and straightened navigation channel between Mosenthien and Cabaret Islands and an enlargement of the upstream approach to the proposed lock by cutting away a portion of the Illinois shore above and below Chain of Rocks Bridge.

72. Both plans I and II are discussed in greater detail in the following paragraphs. Incidental construction, remedial works, benefits to interests other than navigation, cost estimates, and other pertinent data are also subsequently considered. The modification for civic and recreational development can also be fitted into the canal plan (plan I (a)) without interference therewith.

73. Plan I (a) involves the following works: (a) A canal about 8 miles long with lower terminus at mile 184 and upper terminus at mile 194; a single lock 110 feet wide and 600 feet long to be located about 6,000 feet above the lower terminus, with provision for an auxiliary lock when its need becomes apparent. Elevation of lower miter sill is to be 362 feet, mean sea level³ (this low elevation allows for further lowering of low water plane in St. Louis harbor); upper miter sill 376 feet; and top of lock walls 432 feet, except for the upper gate bay section which is to be built to elevation 436 and provided

² Not printed.

³ All elevations referred to mean sea level, Fifth General Adjustment (1929).

with high gates in order to prevent overtopping at maximum probable stages. On such infrequent occasions navigation could use the open river. Foundations tentatively are assumed to be on large concrete and timber piling driven to bedrock, which is estimated to be about elevation 330. Details of the proposed lock are shown on sheet 6.²

(b) Bottom of canal is to be at elevation 378 mean sea level; width of bottom, 300 feet; side slopes are to be 3 horizontal to 1 vertical; average depth of cut 32 feet, minimum 10 feet and maximum about 45 feet. It is proposed to revet the west bank of the canal about 500 feet below the upper entrance to protect from possible scour by currents along the entrance. Revetment of the remainder of the canal, however, is considered unnecessary. There will be no through current in the canal; its banks are to have a gradual slope, and the 200 foot berms to be provided between the canal and the toe of the levees are regarded as adequate to withstand without serious consequence any possible erosion of banks that might be caused by waves from passing craft. Minimum depth in the canal will exceed that on the lower miter sill at Alton Lock by at least 3 feet. Typical sections of canal are shown on sheet 4.² The alinement and profile are shown on sheet 5.² It is estimated that about 24,000,000 cubic yards of excavation will be required for the canal. It is assumed that the excavation of the canal and construction of the levees would be accomplished by using hydraulic dredges and draglines. From data available it is believed that the materials to be handled are sandy loam or sand, and the estimates are made accordingly.

(c) Levees are to be provided on each side of the canal, extending from the lower end of the lock walls to the upper canal entrance. They are to be built with materials excavated from the canal and the canal side toe of each levee is to be placed 200 feet from the edge of the cut to prevent heaving of the canal bottom because of surcharge. The elevation of the levee crown is to be 436 feet, or 2.5 feet above the computed maximum probable elevation of highest water of record at the upper canal terminus, since such a stage would prevail for all that portion of the canal upstream of the locks. A crown width of 10 to 20 feet (dependent upon amount of spoil) and 1 on 5 side slopes are used, except where flatter slopes on the landward levee would be necessary to cover a seepage line of 1 on 7. In the event that it should be found desirable to provide a roadway for two-way traffic on top of either or both levees, the top width of 20 feet could be increased and continued throughout for a relatively small additional cost. Between approximate stations 85 and 115, where insufficient excavated materials are available to develop the required levee section, the canal would be widened to a bottom width of about 550 feet, thereby securing without additional cost a harbor for Granite City about 3,000 feet in length. Typical cross-sections are shown on sheet 4.²

(d) The upstream entrance to the canal is located a sufficient distance below the mouth of the Missouri River to permit easy passage of navigation from the one to the other in either direction. The entrance was based also on model tests at the United States Waterways Experiment Station at Vicksburg, which indicated that practically throughout the range of ratios of flows of the Missouri and Upper Mississippi Rivers the flow of the Upper Mississippi would, in general, be strong enough to prevent the heavily silt-laden Missouri River water from

² Not printed.

entering the canal. Because of the fact that there will be no current through the canal, it is anticipated that the major portion of the silt would be deposited near the upper entrance, where it can be readily removed by dredging.

74. Certain remedial construction required along the route of the canal is briefly described below. In some instances local benefits will result, as in the cases of the levees of the East Side levee and sanitary district and the Chouteau, Nameoki, and Venice drainage and levee district, where the higher and stronger levees located along the canal will be joined to the existing line of protecting levees.

(a) The Granite City Waterworks has two plants which would be affected. One is an obsolete plant located on the Mississippi River at the head of Cabaret Island. Its intakes have been abandoned, but there have been retained two shallow reservoir basins in which treated water is stored for emergency use. Its main supply lines, consisting of an 18-inch and a 20-inch pipe, would cross the line of the proposed canal. Either comparable basins could be provided eastward of the canal or the existing site retained and the conduit sunk to a suitable elevation below the bottom of the cut. Of the two methods the latter would be the more economical. The main pumping unit of the Granite City Waterworks is located on the Mississippi River at mile 192.2, and the canal would also cross its conduit, which consists of a 54-inch diameter lock-joint concrete pipe. Similar remedial measures are also available in this case, but it would again be more economical to lay the conduit under the canal than to move the entire pumping plant to the landward or eastern side of the canal. The proposed remedial construction is indicated on sheet 4.²

(b) One gas and two oil lines would also be crossed by the canal and provision would have to be made for relocating these below the bottom of the cut. See sheet 4.²

(c) All affected electric service and telephone lines, including long-distance trunk lines now carried on Chain of Rocks Bridge, could be carried on the proposed highway bridge over the canal. Relocation of certain minor service and telephone lines would be necessary.

(d) The highway to Chain of Rocks Bridge would be crossed by the canal, and provision must be made for continuation of uninterrupted access to the bridge. It has been found quite feasible to provide a through span bridge over the canal, having a clear horizontal opening of 350 feet and a vertical clearance of at least 45 feet above maximum computed high water. The approaches are to be made on an earth fill and four 120-foot deck trusses are used on each side of the center span. This structure is shown on sheet 7.²

(e) No drainage structures would be blocked by the proposed canal as far as is known. The main sewer outlet of Granite City has its outlet downstream of the proposed lock and would not be affected. The pumping plant of the Chouteau, Nameoki, and Venice drainage and levee district, opposite river mile 194.2, could be made to discharge into the canal since the effluent contains no sewage. The heads at which the pump would discharge would be increased by a small amount. This, and any additional seepage that might result, would be more than offset by the benefits of increased protection that would be afforded by the levee on the eastern side of the canal.

² Not printed.

(f) There are several levee districts which would be affected by the canal proposed in plan I (a). Under authority of the Flood Control Act of June 22, 1936, the East Side sanitary and levee district levees (in Illinois), are to be raised and strengthened to provide a freeboard of 2 feet above the computed elevation of maximum high water of record. Funds have been allotted for work on the upper and lower flank levees; the upper flank levee is completed and the lower flank is about 90 percent finished. Funds have not yet been appropriated for the levee reconstruction in the vicinity of the canal. The proposed eastern embankment along the canal opposite river miles 184.5 to 193.8 (see sheet 1)² would provide the same degree of protection as is contemplated by the existing approved levee project. If the levee of the Chouteau, Nameoki, and Venice district (raising and strengthening also approved by Congress but no funds yet appropriated) near mile 194, shown on sheet 1 be strengthened, and the new levee also shown thereon be built, a total of 14.8 miles of levee construction in the East Side levee and sanitary and Chouteau, Nameoki, and Venice districts would be eliminated and this would effect a saving of \$185,000, including lands and damages, all of which could be credited to plan I (a). The levees of the Chouteau Island district are practically only low earth embankments, below standards in grade and section, and afford only a slight degree of protection to the enclosed area. There is no authorized project for this district, and the grade of the existing levee is only sufficiently high to withstand flood heights of 3½ years' frequency. At higher flood stages these levees would be overtopped even if built to approved grade and section and the eastern limit of the flood plain would become the western embankment of the canal. The short section of levee marked "American Bottom" levee on sheet 1,² lying between Chouteau and Cabaret Sloughs, protects an area which is part of the Chouteau, Nameoki, and Venice district. Reconstructing this section of levee to the western canal embankment would afford this small area the same degree of protection contemplated in the approved levee project at a cost no greater than originally estimated for that portion of the project. The proposed St. Louis County levee in Missouri was also authorized by the Flood Control Act of 1936. The grade which is approved would afford protection only to a flood of 15-year frequency, and at higher flows the levees would be overtopped and the area flooded. As a consequence the flood plane for computed elevation of maximum high water of record would not be materially affected by this proposed levee construction.

(g) Certain roads which serve the various farms and residences would be crossed by the canal and new access would be required in order to restore to local residents the same facilities which now exist. It has been determined that these roads may be connected with Highway No. 66 between Chain of Rocks Bridge and the proposed bridge over the canal. About 3 miles of dirt roads would have to be improved and surfaced with gravel to permit the same access to the segregated areas as now exists. Any fill required could be supplied from the canal excavation.

(h) It is estimated that this plan would result in raising the level of the maximum flood by an amount less than half a foot in the vicinity of the mouth of the Missouri River. This amount is less than the computed swell head for comparable conditions at the dams on the

² Not printed.

upper Mississippi, and the top grade for levees in the vicinity designed to resist such a flood have an allowance of 2 feet for freeboard.

75. The canal, as proposed, with a 300-foot base width and the bottom at elevation 378, would provide a channel around Chain of Rocks which is equal to the project requirements for the middle Mississippi River. In addition, it would have many other advantages which will be given later under the discussion of the plans described in this report. Approximately 1,800 acres of land would be required for right-of-way of which about 200 acres are in sloughs, 275 acres are not cleared, and the remainder of about 1,325 acres have been cleared and for the most part are under cultivation. No costly improvements exist on this land, which is subject to overflow. It is estimated that between 2 and 3 years would be required for completion of the canal and lock.

Estimated costs of plan I (a)

1. Lock in canal.....	\$4, 543, 600
2. Excavation of canal and building levees.....	1, 920, 000
3. Right-of-way for canal and levees.....	425, 000
4. Remedial works:	
(a) Bridge over canal for Chain of Rocks Bridge	
Highway (U. S. No. 66).....	\$560, 000
(b) Remainder of remedial works listed in par. 74.....	203, 000
	763, 000
Subtotal.....	7, 651, 600
Overhead, engineering, and contingencies, 25 percent of \$7,651,600.....	1, 912, 900
Subtotal.....	9, 564, 500
Interest during construction, \$9,564,500 for 1 year at 3 percent.....	286, 935
Total.....	9, 851, 435
Less levee construction eliminated, see par. 74 (f).....	-185, 000
Total initial cost.....	9, 666, 435

ANNUAL COST

Operation of lock.....	\$35, 000
Dredging in canal.....	30, 000
Levee and bridge maintenance and patrol.....	5, 000
Total annual operation and maintenance.....	70, 000
Interest on initial investment, \$9,666,435, at 3½ percent.....	338, 325
Amortization in 40 years—1.18 percent of \$5,849,885 (cost of lock, plus 25 percent, plus 1 year interest).....	69, 028
Amortization in 50 years—0.76 percent of \$3,816,550 (remainder of initial cost).....	29, 006
Total annual cost.....	506, 359

76. Plan I (b) is an extension of I (a) in the event that the reduced upper diversion from Lake Michigan, losses occasioned by the Mississippi slack water system, and the operation of Fort Peck Reservoir are found to produce effects as serious as those outlined in paragraphs 51 to 54, inclusive. The viewpoint assumed therein is that of unusually severe conditions, and experience may prove that the combination of circumstances, producing those low-water flows, will be very infrequent. In the event that it does become evident that the aforementioned adverse effects are likely to occur with sufficient frequency to constitute a hindrance to navigation, and cannot be overcome more economically by other means, the dam hereinafter

described could be built to correct such conditions. In any event it would be necessary to construct the canal and lock prior to construction of the dam in order not to obstruct navigation during construction.

77. The site selected for the dam is in the Mississippi River at mile 190.4, about 400 feet below Chain of Rocks Bridge. The structure would consist of chanoine wickets which could be raised during periods of low water to provide a water surface elevation of 396.0 feet, at the dam and 396.5 feet at Alton, Ill. Thus a clearance of 11.5 feet over the lower miter sill at Alton would be assured at extreme low stages. The dam would be founded on bedrock, except that the bedrock itself on the western or Missouri side of the river would be used as a natural spillway for a distance of 800 feet. No locks at the dam would be required since navigation could use the canal. When open-river stages at the dam exceed approximately elevation 391 the wickets may be lowered to the river bed and navigation may use the open river if desired. The composition and pertinent features of the dam are shown on sheet 8.² The water surface profiles for certain open-river conditions, and the backwater effects of the dam, are shown on sheet 2.² It is estimated that this dam could be built in 18 months to 2 years.

Estimated costs of plan I (b)

1. Low-head movable dam in river at mile 190.4.....	\$1,308,000
2. Removal of Homer dike.....	15,000
Subtotal.....	1,323,000
Overhead, engineering and construction, 25 percent of \$1,323,000....	330,750
Subtotal.....	1,653,750
Interest during construction, \$1,653,750 for 1 year at 3 percent.....	49,613
Total initial cost.....	1,703,363
ANNUAL COST	
Operation of dam.....	¹ \$15,000
Interest on initial investment, \$1,703,363 at 3½ percent.....	59,618
Amortization in 40 years of \$1,703,363 (cost of dam, including 25 percent).....	20,100
Total annual cost.....	94,718

78. Upon completion of the second phase of plan I, namely construction of the dam, the total cost of the improvement would be as follows:

Initial cost, plan I (a).....	\$9,666,000
Initial cost, plan I (b).....	1,703,000
Total initial cost.....	11,369,000
Annual cost, plan I (a).....	506,000
Annual cost, plan I (b).....	95,000
Total annual cost.....	601,000

79. Plan II (a) involves locks and a movable type dam in the Mississippi River located at mile 190.4, immediately downstream of Chain of Rocks Highway Bridge, together with the widening of the upper approach channel along the Illinois shore, the construction of

¹ Because of infrequent operation of dam it is assumed that lock force would assist in operation of dam.
² Not printed.

a low closing dike across the present main channel below the dam from the Missouri shore to the head of Mosenthien Island, and dredging a new lower approach channel in the river bed between the proposed dam and Merchants Bridge, following approximately the slough lying between Mosenthien and Cabaret Islands, involving removal of about 30,000,000 cubic yards of material. In this scheme, low-water flows would follow the new channel while flood flows would utilize both the new and present channels.

80. The locks and dam would be located on a rock foundation. A navigable type dam is proposed, consisting of a natural rock spillway extending approximately 800-feet out from the Missouri shore, with 2,160 feet of additional spillway provided by chanoine wickets, including a navigable pass 1,100 feet wide adjacent to the lock structure and in direct line with the navigation span of Chain of Rocks Bridge. The lock structure proposed would consist of a standard lock 110 feet by 600 feet, together with the upstream gate-bay section of a 110 by 360-foot auxiliary lock, which could be completed when the needs of navigation so require. Pier No. 10 of Chain of Rocks Bridge would be enveloped by the riverward lock wall, pier No. 11 falling within the lock esplanade. The building housing the control machinery would be located on the land wall. Access to the control house would be from the highway bridge at time of high water, when the locks are submerged, and by roadway on the Illinois shore when the locks are in operation. The general location and plan of the proposed locks and dam are indicated on sheets 9 and 10.²

81. The general location and cross-sectional areas for the channel excavation below the dam have been based on the results of model tests made at the United States Waterways Experiment Station at Vicksburg and on the existing cross-sectional area of the low-water channel below Merchants Bridge. The alinement of this channel, as well as the channel enlargement for the upper approach, is shown on sheets 1 and 3.² A gas main, crossing the river about mile 185 and shown on sheets 1 and 11,² would need relocation because of the channel change. It is estimated that this plan could be completed in about 3 to 4 years.

Estimated costs of plan II (a)

1. Navigable dam.....	\$1, 400, 000
2. Lock structure, control house, and appurtenances.....	2, 420, 000
3. Removing Homer dike.....	15, 000
4. Channel excavation, lower approach.....	2, 400, 000
5. Channel excavation, upper approach.....	160, 000
6. Revetment, upper approach.....	210, 000
7. Revetment, lower approach.....	396, 000
8. Land acquisition.....	65, 000
9. Stone protection at end of closing dike.....	40, 000
10. Closing dike.....	190, 000
11. Remedial work.....	100, 000
Subtotal.....	7, 396, 000
Overhead, engineering, and contingencies, 25 percent of \$7,396,000..	1, 849, 000
Subtotal.....	9, 245, 000
Interest during construction, \$9,245,000 for 1 year at 3 percent.....	277, 350
Total initial cost.....	9, 522, 350

² Not printed.

Estimated costs of plan II (a)—Continued

	ANNUAL COST	
Operation of lock and dam.....		\$50, 000
Interest on initial investment, \$9,522,350 at 3½ percent.....		333, 282
Amortization in 40 years; 1.18 percent of \$4,918,250 (cost of lock and dam plus 25 percent plus 1 year interest).....		58, 035
Amortization in 50 years; 0.76 percent of \$4,604,100 (remainder of initial cost).....		34, 912
Total annual cost.....		476, 229

82. The above plan would make possible dependable adequate navigable depths and channel widths from Merchants Bridge; mile 183.2, to the proposed Chain of Rocks Dam, mile 190.4, via open river for all flows, and thence to and over the lower sills of the Alton locks, mile 202.9, and for a distance up the Missouri River of approximately 8 miles, by slack-water pool during periods of low flow (about 45 percent of the time), otherwise by open river; would provide for movement of silt under open river conditions from and through the upper pool during 55-percent of the time, during times of flows exceeding about 100,000 cubic feet per second; would offer a greatly improved alignment for navigation, both for open-river and slack-water movements above and below Chain of Rocks Bridge; would lessen velocities between Chain of Rocks and the lower end of Mosenthien Island from about 5.5 miles per hour to about 3.5 miles per hour for low to mean flows, and in the reach below the dam would not increase velocities for higher flows. High-water stages would not be increased. The elevation of lower miter sills at the proposed locks would be such as to allow a further lowering of the low-water plane in St. Louis Harbor, without impeding entrance to the locks. For water surface profiles and typical cross-sections of plans II (a) and II (b) see sheet 11.²

83. Plan II (b) is an alternative to the purely navigation improvement described in plan II (a). Further study indicates that the proposed channel improvement below the Chain of Rocks Dam may be so located as to make it practicable to afford room for certain civic improvements for the city of St. Louis, such as an airport, park, and recreation center, on Mosenthien Island and in Sawyer Bend, all protected from floods by means of a high levee the full length of the improvement, sufficient in width for a river-front boulevard on its top. The joint accomplishment of the navigation improvement and the civic development would make possible a substantial contribution to the necessary embankment for the latter development by judicious placement of the spoil from the navigation channel excavation, and thus effect a reduction in the cost of the civic development without increasing the cost of the navigation project.

84. In addition to the navigation improvements, described in paragraphs 79 to 82, the more comprehensive development of the Chain of Rocks reach involves, for the Missouri side: A recreation and transportation development; a levee embankment paralleling the proposed channel of such height and cross-section as to provide flood protection to the enclosed area, with a river-front boulevard and parking space thereon; additional channel excavation for flood flows, indicated on sheets 11 and 12,² to compensate for the built-up area; an embankment for an airport site; viaduct connections between existing city

² Not printed.

streets and the river-front boulevard; an intercepting channel to carry the run-off and drainage from the adjacent area to a point of discharge near Merchants Bridge; and various facilities for bathing, boating, and other forms of recreation. The general plan is indicated on sheet 12,² and an illustration of such a possible development in completed form is shown on sheet 16.² Cross-sections indicative of the levee and airport embankments and details of the possible recreation and transportation development are shown on sheet 11.² General plans and profiles of the viaducts and intercepting channel appear on sheets 12, 13, 14, and 15.² Work on the Illinois side would involve enlargement of the East Side levee and sanitary district front levee between Merchants Bridge and Granite City waterworks road, a distance of 2.9 miles, to adequate height and cross-section for protection from computed maximum elevation of a flood with discharge equal to that of record; provision thereon of a river-front highway which would serve as a portion of the beltline connection between the newly completed highway at the northern end of Granite Heights and McKinley Bridge; and provision for the enlargement of Cabaret slough to improve access for river transportation to the Granite City industrial area.

85. The levee embankments on each side of the river would provide protection against the computed high water of the maximum flow of record. The levee enlargement on the Illinois side would be sufficient in width for a two-lane highway. On the Missouri side the levee embankment would form the right bank of the new river channel and would extend from high ground immediately below Homer dike at the St. Louis waterworks to a junction with the natural river bank a short distance upstream of Merchants Bridge. To provide against high water at the lower end of the area, the protective works would need to be extended across existing railroad tracks and yards by means of removable bulkheads and embankment to high ground some 3,000 feet west of the river bank. A top width of 100 feet is proposed for the river-front levee, on which would be located two two-lane roadways so separated as to provide parking areas for automobiles. At the upstream end the roadway would connect with the present Riverview Drive and at the lower end with Adelaide Avenue by means of a viaduct. Two additional intermediate entrances to the park and airport would be provided; the first located along the northern side of the airport and connecting with Riverview Drive, the second located along the southern side of the airport and connected to Calvary Avenue by means of a viaduct.

86. The relocation of the low-water channel toward the Illinois shore so as to provide sufficient room for the airport would require an increase of 8,000,000 cubic yards of excavation over that of plan II (a). The flood-water channel required to compensate for the area in the present flood channel to be occupied by the development would require an additional 27,000,000 cubic yards. The extent of channel work, relocated navigation channel and the floodway, amounting to approximately 65,000,000 cubic yards below the proposed dam and approximately 2,000,000 cubic yards in the upper approach, is shown on the general plan, sheet 12,² and by the representative cross-sections on sheet 11.² It is proposed to place the total excavation from the

² Not printed.

navigation channel and the flood channel below the dam in the levee and roadway embankments to the proposed grade, and the airport fill to a top elevation of 425. The remainder of the excavation below the dam would be spoiled in the park areas.

87. The viaduct connections would consist of embankments insofar as practicable, actual viaduct structures being limited to locations where found to be economically or physically necessary. In each case the structures would be of steel girder design with concrete piers and abutments, a four-lane roadway being provided.

88. The proposed interceptor would provide for carrying the discharge from Maline and Harlem Creeks and various storm and sanitary sewers to the river below the protected area. Facilities for pumping local drainage from the protected area at extreme high-water periods are a part of the plan.

89. A controlled intake is proposed in the levee embankment at the upper end of the bathing pool to permit inflow of water in event river water is found satisfactory for this purpose, although it is anticipated that the normal supply for the bathing pool would be purified water which would be available at approximately 6 cents per 100 cubic feet from the adjacent waterworks or a supplemental plant. At the lower end of the boating pool a large culvert is proposed. This would be sufficient in size to permit ingress and egress of small boats at ordinary river stages and would be controlled against flood waters by means of a vertical-lift gate.

90. The provision of channel facilities for Granite City would consist of enlargement of part of Cabaret Slough by means of dredging. A channel 200 feet wide, extending from the mouth of the slough up about 2 miles to the area adjacent to Granite City would be provided, together with a turning basin at the latter location. The involved excavation, approximately 4,600,000 cubic yards, would be available for the East Side levee and roadway improvement which involves about 1,173,000 cubic yards of fill.

91. Except for possible remedial works for St. Louis and Granite City waterworks, only those portions of the suggested development dependent upon disposal of excavated material need be accomplished jointly with the through navigation improvements. Other features, such as roadway and viaduct connections, could be constructed as funds become available. The development of the airport could follow and the creek diversion project could await action on the development of recreation features, as until that time the drainage could be passed through the lower outlet in the levee embankment, following the present river channel. In this manner a reasonable distribution of needed funds might be arranged to provide for an orderly progress of construction. The additional estimated cost of improvements involved in the more comprehensive plan which need be accomplished jointly with the through navigation improvement, i. e., the costs over and above the costs for the navigation improvement alone (which are indicated in par. 81) are:

1. Additional excavation for navigation channel due to movement toward Illinois side to permit space for airport.....	\$960, 000
2. Excavation for compensating flood channel.....	3, 240, 000
3. Additional revetment.....	594, 000
4. Remedial work.....	65, 000
5. Controlled inlet.....	10, 000
6. Controlled outlet.....	178, 000

7. Additional land acquisition.....	\$136,000
8. Additional clearing.....	37,000
Subtotal.....	5,220,000
Less estimated cost of closing dike not required in this plan.....	-190,000
Subtotal.....	5,030,000
Overhead, engineering, contingencies, etc., 25 percent of \$5,030,000..	1,257,500
Subtotal.....	6,287,500
Interest during construction, \$6,287,500 for 1 year at 3 percent....	188,625
Total initial cost.....	6,476,125
Additional annual cost:	
Interest on initial investment, \$6,476,125 at 3½ percent.....	226,665
Amortization in 50 years—0.76 percent of \$6,476,125.....	49,219
Total additional annual cost.....	276,884

92. The estimated cost of additional improvements involved in the more comprehensive plan which may be accomplished subsequent to the navigation improvement:

1. Adelaide Avenue Viaduct.....	\$791,000
2. Calvary Avenue Viaduct.....	805,000
3. Bulkheads for railroad closure.....	13,000
4. Interceptor creek and appurtenances.....	3,080,000
5. Excavation, Granite City channel.....	322,000
6. Levee highway, Illinois side.....	577,000
7. Roadway paving, Missouri side.....	360,000
8. Culverts between boating basins.....	108,000
9. Additional land acquisition.....	1,000,000
10. Airport development.....	2,500,000
11. Park and recreation development.....	3,000,000
Subtotal.....	12,556,000
Overhead, engineering, contingencies, etc., 25 percent of \$12,556,000	3,139,000
Total.....	15,695,000

¹ Because of many uncertainties, including source of funds, annual charges on the items listed in paragraph 92 have not been estimated.

93. The total estimated initial cost of plan II (b), exclusive of interest during construction, is:

From par. 81.....	\$9,245,000
From par. 91.....	6,288,000
From par. 92.....	15,695,000
Grand total.....	31,228,000

94. *Discussion.*—Except for differences in channel velocity, the plans which have been described in the foregoing paragraphs possess practically equal merit insofar as satisfying the requirements of navigation through the Chain of Rocks reach is concerned, and they are believed to be sufficiently comprehensive to provide necessary project dimensions for present and future traffic needs, in that section. The costs of the canal, plan I (a), and the Chain of Rocks lock and dam, plan II (a), are so nearly the same that the selection of either must depend upon other advantages which they offer.

95. *Plan I (a)—Canal with locks, around Chain of Rocks.*—The canal, with bottom at elevation 378 upstream from the locks, would be sufficiently deep to permit 9-foot navigation for all flow conditions previously experienced and would have for any anticipated low-

water flow at least 3 feet more depth than would occur under those conditions on the lower miter sill of the Alton locks. Any further increase in low water depths over that sill by provision of additional flow from whatever source or by construction of a dam below the canal entrance would be accompanied by a corresponding increase in depth in the canal. With the levee embankments paralleling the cut from the locks almost to the upper entrance, the canal would offer a passageway for river craft that could be readily navigated at all times except when ice conditions in the river make navigation unsafe, and except for short periods, occurring perhaps once or twice in a century, when the locks would be made inoperative by a flood equal to the maximum of record. On such occasions navigation could use the open river. The canal embankments would somewhat constrict the overbank floodway at certain localities, but the effect of this constriction has been computed to be less than half a foot for the maximum recorded flood. A rise or "swell head" of about 1 foot has been deemed permissible for the navigation dams in the upper Mississippi.

96. The principal advantages of the canal route are:

(a) It would permit upstream traffic to move in slack water rather than against the swift currents now encountered in the present river channel through the Chain of Rocks section.

(b) Downstream traffic would have the option of passing through the canal or, when depths are adequate, of using the open river channel without interference of a dam.

(c) Riparian interests on the Missouri side of the river in Sawyer Bend would retain undisturbed their present access to the river.

(d) On the Illinois side, because of the fact that the quantity of material required for the levees paralleling the canal would, for a short section above the lock, exceed that available from a canal of 300 feet bottom width, the canal would be widened on the bottom an additional 250 feet, thereby providing a harbor about 3,000 feet long for Granite City and the surrounding industrial areas without additional cost. This harbor could readily be further extended if the need therefor should arise in the future.

(e) It would afford additional local flood protection to a substantial acreage.

(f) It would permit the postponement of construction of a movable dam in the river until need therefor is more definitely established.

(g) It would shorten the distance between Merchants Bridge and mouth of Missouri River by about 2 miles.

(h) It would allow safe and easy passage of craft during periods of smoke and fog, which now exist in this vicinity, when open-channel navigation might have to be suspended.

(i) The existing channel could still be used by lighter and relatively more powerful craft and pleasure boats if delays occasioned by lockage were not desired.

(j) Except for its limited encroachment on the flood plain, plan I (a) would not interfere with the construction of the park and recreational area of plan II (b) with its accompanying change in river alignment, and the two plans could be readily combined.

97. The four outstanding disadvantages of this plan are:

(a) It would not raise water surface elevations upstream of the upper canal entrance. If the anticipated low-water flow losses above Chain of Rocks discussed in paragraphs 50 to 54, actually occur and

become sufficiently frequent to constitute at Alton a hindrance to through transportation, the canal would not in itself offer any means of correcting the situation. This condition would require correction by means of additional storage and release of water at low-flow periods or by the construction of a low dam at Chain of Rocks, plan I (b). This is further discussed below.

(b) Areas within the leveed canal right-of-way downstream of the upper canal entrance would be subjected to water surface elevations equal to those at the upper canal entrance and thus have greater heights of water against the canal levee embankments during flood periods. This higher water might cause some additional seepage into the levee-protected lands outside of the canal prism, but the additional protection afforded by higher and stronger levees would probably more than counteract this.

(c) While it would permit the present river channel to remain open for passage of high-water flows, nevertheless, as stated above, it is estimated that the encroachment of the canal on the flood plain would increase the elevation of the maximum flood of record by slightly less than five-tenths of a foot. It is estimated that to provide equal protection to affected areas now protected, or to be protected, by proposed levees in the vicinity, an additional cost of less than \$60,000 would be entailed.

(d) The canal would tend to silt up and would require maintenance dredging. The silting is not believed to be a very serious problem, since the upper canal terminus opening in the Mississippi below the mouth of the Missouri receives the relatively clear water of the Upper Mississippi as shown by tests of the United States Waterways Experiment Station at Vicksburg, Miss. Also, it is believed that most of the silting would be concentrated within a half mile of the canal entrance because of the absence of flow in the canal. From that section it would be readily removable by dredging.

98. Investigation of the probable flows based upon the past 10 years of record (including 7 very dry years), indicates that to assure a depth of 10 feet over the miter sills at Alton, either a dam will be required downstream or additions to the low-water flow at Alton will be required. It is estimated that to provide depths of 10 feet or 11 feet over the lock sills during the worst year would require volumes of about 1,150,000 or 1,950,000 acre feet, respectively, of water during the months of March to November, and 420,000 or 835,000 acre feet, respectively, for the months of December, January, and February. A number of navigation pools above Alton are drawn down during the winter. By delaying the lowering of these pools until water is needed at Alton, it is believed that a 10-foot depth over the Alton Lock sills may be maintained at all times during the months of December, January, and February, without any other source of additional water, although at a slight additional cost. The headwater reservoirs below Lake Itasca in Minnesota, now owned and operated by the United States, could be operated under existing authority to supply flow increments to offset in part the deficiencies during the remaining months of the year. Congress has recently authorized the construction of a system of flood control reservoirs in the Upper Mississippi River basin. Selection of the reservoirs to be constructed has not been made, but it is possible that a number may be constructed above Alton within the next several years. While the primary purpose of

these reservoirs would be flood control, certain of them may be operated so as to result in further increase in low-water flows. While it is true that the latter source of additional water is by no means certain, nevertheless it appears reasonable to delay decision as to the actual necessity for a dam until the effects of the various projects on the extreme low flow become more certain.

99. If, after the construction and operation of the canal and the locks and dams in the Upper Mississippi, it is found that the apprehended low flows occur and additional water surface elevation is required at Alton, the dam near Chain of Rocks Bridge described under plan I (b) could be added to this proposed project. Designed for use only during periods of low water, it would not detract from the advantages cited for the canal and would supplement the use of the canal by providing slack-water stages up to Alton Dam and perhaps reduce the frequency of dredging in the canal by maintaining higher water surfaces. At low water, with dam operating, a depth of 18 feet would be available in the canal. Because of the short periods when the dam would be raised, the open river would still be available for a major portion of the time to those navigation interests, if any, desiring to use it. Downstream tows might at certain river stages find it advantageous in order to avoid locking through the canal. Revetment of the banks of the canal to protect them from possible erosion from waves created by passing craft has been considered, but for the reasons given in paragraph 73 (b) it is not deemed necessary.

100. The main advantage of plan I in both its phases lies in the fact that the construction of the dam under plan I (b) can be postponed without serious consequence until its necessity is clearly established, and it is ascertained that it is not required merely to correct a condition of infrequent occurrence. In such case this expenditure could be eliminated. If civic interests desire to use the existing river channel to develop other previously discussed improvements for recreation, the needs of navigation would not be affected and there would remain only the necessity of providing in the immediate vicinity the same area of floodway to compensate for that diverted to other uses.

101. *Plan II (a)—Lock and dam at Chain of Rocks.*—The lock-and-dam plan, II (a), which contemplates (a) the construction of a movable dam about 400 feet below Chain of Rocks Bridge with one lock 110 feet by 600 feet and provision for future construction of an auxiliary lock, and (b) the dredging of necessary channels above and below the dam, assures for its basic premise that low-water flows in the river will become sufficiently small to make the clearance over the lower miter sill in the lock at Alton a predominant factor in local navigation problems.

102. The plan would make available to navigation an adequate and dependable channel between Merchants Bridge and Alton Dam. The proposed method of pool operation, the provision of passageways for silt movement, the construction of a dredged channel in alluvium, and the availability of both the new and old channels for flood flows are considered adequate to secure a solution of the navigation difficulties in this vicinity. The lower miter sills of the proposed locks would be set to such elevation that even further upstream progress of the lowered low-water plane of St. Louis Harbor would not impede their use in the future. In its basic scope this plan offers a number of advantages similar to those pertaining to the canal plan, I (a), namely,

some river shortening; slack-water navigation during certain seasons; some improvement of fog and smoke difficulties; and an open river during medium and higher flows. In addition, it would provide assurance of adequate clearance over the lower miter sills at Alton Locks at all times.

103. The chief disadvantages of this plan lie in the behavior of three unknown factors: (a) the Missouri River silt, which may not move through the dam as readily as anticipated; (b) the stability of the proposed dredged channel between the dam and Merchants Bridge; and (c) the velocity of the current in the navigable channel in the vicinity of the proposed dam. The backwater created by the proposed dam may cause some silting in the Mississippi and Missouri River channels, which it is expected would be washed out when the dam is lowered, if such silting were not prevented by the method of dam operation. However, there probably will be some silting in the backwater fringes on the Missouri River. Navigation of the open river channel under this plan would be more difficult than in the canal during periods of bad visibility, although conditions would be greatly improved over those now existing in the river by the elimination of the long curved section in Sawyer Bend. During periods of high water, undesirable cross currents might be set up near the head of Mosenthien Island, where the old and new channels separate, and again below the island where the channels rejoin, although such conditions were not observed in model studies and are not anticipated to be serious.

104. Ice conditions in the river might seriously affect the operation of the dam, and this condition would have a similar effect on the proposed dam at Chain of Rocks of the canal-and-dam plan, I (b), as would also the other disadvantages mentioned in the paragraphs above. With reference to ice difficulties, the following quotation is made from a report of Lt. Col. C. L. Hall, Corps of Engineers, United States Army, then district engineer at Cincinnati, Ohio to the Sixteenth International Congress of Navigation at Brussels in 1935, page 13 of paper 12, regarding operation of similar type dams on the Ohio River.

If a heavy flow of ice occurs while dams are down, nothing can be done with them to assist navigation. If this flow occurs when the dams are up, very serious operating complications are caused. As previously explained, a sufficient amount of pack ice will make it very difficult to lower the dams. If heavy needle ice has formed, the difficulties will be even greater. If dams remain up, the pack ice, propelled by the current, may also injure structures. Far more serious, a rise in the river may occur while the dams are frozen with the wickets up. This will cause increased flood heights. With a dam up and the river flowing over it, navigation will be blocked until the river falls. Since navigation in heavy flowing ice is almost impossible, it would appear at first glance that dams should normally be lowered when ice conditions become serious, but before lowering becomes hazardous. Unfortunately, however, perfect weather forecasts are never obtainable. It is not possible to determine in advance, with assurance, whether or not the ice pack will grow more menacing. If the responsible authorities are too timid, and lower the dams unnecessarily, the stage of water in the pools will, of course, fall below project depth. Then engineers may be properly charged with causing an unnecessary interruption to commerce, and, in some cases, of seriously affecting the operation of industrial plants located along the banks, due to lowering the water surface below the mouths of their water supply intakes. If they are too bold and keep the dams up, they may cause serious financial loss to the Government, and prolonged interruptions to commerce while repairs are being made.

105. The Chain of Rocks lock-and-dam plan, II (a), does not provide, in itself, for an industrial harbor for Granite City, as does the

canal plan, I (a). However, such a harbor could be provided by dredging a separate channel. This construction would increase the cost of the lock-and-dam plan, II (a), by the amount estimated for that item under the civic-developments plan, II (b). Granite City officials desire an industrial and boat harbor and have stated their preference for the canal plan, I (a). (See letters of Mayor Fitzpatrick and Mr. P. M. Davidson, appendix B.)² In plan II (a) the proposed dike at the head of Sawyer Bend would have the effect of cutting off the flow at low stages and closing navigation access to the upper end of the old channel between Chain of Rocks and Bissell Point and would cause an increase in silting therein. At such stages the depths in the old channel would be controlled by the water surface elevations at the lower end of Mosenthien Island. The riparian owners would probably suffer some damage, and consequently would offer considerable objection to this plan, but as long as they are not entirely cut off from the river it is not believed under present court rulings in similar cases that any damages could be collected from the Federal Government.

106. *Plan II (b)—Civic development.*—The civic-development plan, II (b), which broadens the scope of the lock-and-dam plan, II (a), to provide for a more comprehensive development in this area, would improve and protect the interests of navigation by practically the same methods described in the lock-and-dam plan, II (a). It is more comprehensive than the latter, however, in that it would make possible the construction of an extensive recreation center and airport in the present (Sawyer Bend) channel on a fill which could be constructed with dredge spoil from the cut made to provide the flood channel. The provision for an adequate floodway in high stages, protecting embankments, and other phases of the plan have previously been described. Insofar as engineering design is concerned, the project is feasible.

107. The cost of the civic-development plan, II (b), would be considerably in excess of the basic-navigation plan, II (a), but many features are incorporated which would provide other benefits. The more comprehensive plan, II (b), would, of course, tend to constrict the present flood discharge area and to raise flood heights.

108. While hydraulic computations can show that no increase in flood stages would result, yet it is questionable whether additional excavation between the new overbank limits to provide additional cross-section would compensate for this constriction. A study of the history of the narrowing and deepening of the river, and consequent raising of the high-water plane and lowering of the low-water plane in St. Louis Harbor below Merchants Bridge (mile 183.3) since 1880 indicates it is possible that even the excavation of the river channel to greater dimensions might not entirely compensate for this contraction of the floodway width. In unusually high flood stages the river scours over 100 feet below low water to bedrock, and still the high-water levels are raised. In addition to the improvements described in paragraph 82, the civic-development plan, II (b), provides also for a roadway on the East Side levee as a unit of a proposed riverside drive along the Illinois bank (which roadway can also be built on the protective levee along the canal in the canal plan, I (a)), and for an airport development on the Missouri side. The advisability of establishing an airport in this location has been questioned

² Not printed.

on account of the number of days that fog and smoke are encountered, a frequent complaint of navigation interests; but there is no difference of opinion as to the saving in time that an airport so close to the city would have over that now available. The postmaster of St. Louis stated that for air mail 35 minutes each way, between airport and postoffice, would be saved. The river terminal development for Granite City provided in the civic-development plan, II (b), can also be included in the lock-and-dam plan, II (a), at the same cost. The Granite City harbor included in the canal plan, I (a), is automatically included at no increased cost.

109. The nearest existing large recreation center to this area under consideration is Forest Park in St. Louis, 7 miles away. Chain of Rocks Park just adjacent is quite a small area, and has no bathing or boating facilities. Alton Pool, where the Government now owns land that might be developed into a recreation center, is over 12 miles away by land. The bathing facilities provided in the comprehensive plan could be serviced with filtered water from the adjacent city waterworks as long as the growth of St. Louis did not overtax its capacity. The present rate for supplying industrial plants is reported as only 6 cents per 100 cubic feet and probably for such a meritorious purpose, could be obtained at less cost. The necessity for recreation facilities is unquestioned and their economic value is very real, but difficult to express in monetary terms.

110. The filling of Sawyer Bend to provide the site for the proposed park and airport would encounter the following difficulties:

(a) Riparian owners, who would be deprived of their present access to the river, would demand high compensation for the depreciation of property values. Certain large potential industrial sites now held for possible future river-rail transportation facilities would be adversely affected. One industry now located near the river, which reports planning to use the waterway, would be denied this right or would be put to considerable expense to obtain river terminals beyond the development.

(b) Certain city and county sewers now empty into the Mississippi River in the area selected for improvement. These would have to be intercepted and emptied downstream from the proposed area. In this same category are the outlets from Chain of Rocks waterworks, which would have to be extended to the new river bank. Plans indicate the method proposed for such diversion and these methods are reported as generally satisfactory to the city of St. Louis, but full approval has not been obtained. The city would not expect to maintain the diversion canal or operate the pumps.

(c) The city of St. Louis has not indicated a willingness to maintain the viaduct approaches to, and embankments on, this development, even presuming that the Federal Government or some other agency would provide funds for the initial development. In fact, the city's statement was definite that it did not expect to participate in any expense connected with this plan.

(d) Part of the proposed development now lies in the State of Illinois and part in the State of Missouri. The joint ownership and operation of the development would undoubtedly entail complications which might be serious unless undertaken by a Federal or interstate agency, in which case the matters of expense raised in (b) and (c), above, might also be settled.

(e) The construction of the lock-and-dam plan, II (a), would effect a saving in total expense of the civic development plan, II (b), of about \$3,000,000, the cost of the material spoiled from the dredged channel, but would also result in numerous, though not insuperable, difficulties in coordinating various parts of the work in order not to obstruct or unreasonably hamper navigation.

(f) It should also be noted that where the excavation required in the lock-and-dam plan, II (a), would assist in building up fill for the civic-development plan, II (b), none of the work under the canal plan, I (a), or the canal-and-dam plan, I (b), would be of any assistance in decreasing the cost of the civic development. On the other hand, the civic development could be carried on without any effect on the canal plan, I (a), or the canal-and-dam plan, I (b).

111. *Conclusions.*—Navigation conditions at Chain of Rocks are such as to require correction at the earliest practicable date in order that full use may be made of the almost completed canalization improvement of the upper Mississippi and Illinois Rivers. The swift currents over the steep slopes of this section at high and low flows and the shallow depth over the rocky ridges at the low flows make this the controlling point of the entire upper Mississippi River system.

112. Two different schemes of improvement were studied, and either one would satisfactorily overcome the navigation difficulties in this reach. They are approximately equal in cost, but each has major advantages absent in the other.

113. The lock-and-dam plan, II (a), would automatically provide for overcoming any deficiency in low-water flows that might occur and would, without further expense, insure that vessels could pass through Alton locks with over 9-foot draft at all times. But in order to provide a harbor development for Granite City, an additional expenditure of over \$400,000 would be required.

114. The canal plan, I (a), would provide a harbor for Granite City without additional expense, but in order to insure adequate low-water depths over the sills of Alton locks equal to that in the lock-and-dam plan, II (a), it would be necessary to adopt plan I (b) at an additional cost of over 1½ million dollars, to cover the construction of the dam at Chain of Rocks. However, this latter expenditure need not be made until it is certain that the apprehended reduction in flow actually will occur, and in the interim navigation would not be stopped, but would, at extreme low flows, be required to carry on with lighter loads and a reduced draft.

115. The canal plan, I (a), would interfere less with the regimen of the river, would provide easier navigation during fog or smoke, would not be subject to swift currents, and would not cause silting in the river. Some silting above the dam is bound to occur both in the Mississippi and Missouri Rivers; the amount and seriousness thereof is questionable. There would be some silting encountered in the canal, but probably all at the upper end thereof.

116. The desirable comprehensive civic development, plan II (b), can be readily combined with either of these developments, but if constructed at the same time as the lock-and-dam plan, II (a), a considerable saving would be made. Neither the canal plan, I (a), nor the canal-and-dam plan, I (b), would be of any assistance in the construction of the civic development.

117. *Recommendation.*—After careful consideration of all of the above, I recommend, subject to such modification as the Chief of Engineers might find necessary when the project is undertaken, that the canal project, substantially as described herein as plan I (a), be authorized for construction at the earliest practicable date, at a cost of approximately \$9,600,000; and further, that the dam substantially as described herein as plan I (b) be authorized, at a cost of approximately \$1,700,000, but with construction to be undertaken only when and if the Chief of Engineers finds such construction is necessary in the interests of interstate and foreign commerce.

118. I further recommend that the Chief of Engineers be authorized to approve application and plans for construction of the civic development or any integral part thereof substantially as described in plan II (b), provided such application is submitted by a public agency legally authorized to assume all the necessary obligations to construct, maintain, and operate such development, or integral part thereof, including compensation for property or other damages incurred, and also provided that the construction work connected with such plan be under the supervision of the Chief of Engineers in order to insure that the interests of interstate and foreign commerce be properly protected, and with the further proviso that the said public agency save and hold the United States free from any damages that might be incurred due to the construction, maintenance, or operation of such civic development, or any part thereof.

P. S. REINECKE,
Lieutenant Colonel, Corps of Engineers,
District Engineer.

[First endorsement]

OFFICE OF THE DIVISION ENGINEER,
UPPER MISSISSIPPI VALLEY DIVISION,
St. Louis, Mo., December 17, 1938.

The CHIEF OF ENGINEERS, UNITED STATES ARMY:

1. I concur in the finding of the district engineer that the benefits of further improvement to facilitate navigation past the important Chain of Rocks section of the Mississippi River would be sufficient to justify the expenditure of funds required. The plans presented by the district engineer for such improvement have been carefully considered. A brief discussion of the costs and benefits pertinent to each plan appears necessary to make possible further comparable consideration.

2. The initial costs indicated in the report for plans I (a) and II (a) are about equal. However, it is the view of this office that the estimates for plan II (a) are somewhat more conservative. It is considered that the estimated cost of embankment and fill for plan I (a) should be increased (about 10 percent) and that provision should be made in the estimate for the possible need of revetment along the canal-cut slopes in event wave wash should indicate such need. It is considered that expenditures for revetment work for either plan should await the actual need. However, to make the plans comparable, contingencies of a similar nature should be included in each plan.

3. The canal plan (plan I (a)) would provide for passing navigation by Chain of Rocks, a distance of 8 miles, in slack water practically all the time. Without the dam proposed in plan I (b) the reach of river from mile 194 to Alton locks (mile ± 203) will remain subject to open-river velocities, flows, and resulting depths. Compared thereto, plan II (a) would make possible dependable adequate depths over the lower sills of the Alton locks; would provide slack water on the Mississippi River from mile 190.4 to Alton locks, mile 203, and for about 8 miles above the mouth of the Missouri River for periods when flows are about 100,000 cubic feet per second or lower, i. e., about 45 percent of the time. The balance of the time open-river conditions would prevail. Addition of the dam proposed in plan I (b) to the canal plan would provide slack-water facilities in the Mississippi to Alton locks and on the Missouri equal to those indicated for plan II (a), and overcome practically all velocity difficulties inherent to plan II (a) for flows greater than 100,000 cubic feet per second in the Chain of Rocks reach.

4. Plan I (a) is less positive than plan II (a) in that it does not assure adequate depths above the mouth of the Missouri River, and investigations indicate that the possibility of securing such depths by increased flows is very remote. The opportunity which the flood-plain canal would afford to delay decision as to the need for a dam should be taken advantage of if plan I (a) is selected for use. This would prove to be an advantage if future flows should prove adequate. However, delay in construction of the dam would be a disadvantage if future conditions should show that a dam is needed, for under that circumstance lack of a dam during the trial period would be a hindrance to commerce. In my opinion, the opportunity to delay decision as to the dam should not materially affect the choice of plan.

5. Insofar as navigation facilities for Granite City are concerned, it is believed that these can be incorporated into plan II (a) without increasing the annual cost of this plan to above that for plan I (a). The economic justification for such facilities has not been investigated in connection with this report, and no additional funds should be spent on such improvements except as the result of a subsequent investigation.

6. It is noted that if in the future a dam as included in plan I (b) should be necessary in connection with plan I (a), the annual cost of plan I (a) and (b) combined would exceed that of plan II (a) by \$125,000, or over 25 percent. I believe that at some time in the reasonably near future a second lock would be needed in connection with either plan considered. The second comparable lock in connection with plan I (a) would be much more expensive than a second for plan II (a). Though the best navigation conditions are to be expected by a combination of plans I (a) and I (b), I do not believe that the more costly plan offers advantages to navigation which justify the risk of possible substantially increased costs. Comparing costs and benefits of the two plans, it appears that the requirements of dependable 9-foot navigation can be adequately met at the least ultimate cost by adoption of plan II (a).

7. As pointed out by the district engineer, plan I (a) would increase the stage for the maximum discharge of record by a small amount. Computations indicate that it would increase the stage of certain lesser floods by greater amounts. Not all the land in this area sub-

ject to overflow is protected by levees from the maximum flow of record. On the other hand, plan II (a) would apparently decrease the stage of all flood flows of record by a small amount due to improved channel characteristics, and computations made in this office indicate that plan II (b) would not increase the stage for the maximum flow of record and would slightly decrease the stage of all lesser flood flows. Plans II (a) and (b) are thus considered definitely superior from the flood standpoint.

8. Plan II (b) is designed to be a part of the comprehensive plan for the area so as to accomplish the maximum improvement at the minimum cost. It would not be physically impossible to construct the airport, recreation park, and auxiliary features if plan I (a) were undertaken. However, this plan would accomplish none of the work embodied in the comprehensive development and would occupy a portion of the flood plain and thus increase the amount of excavation required for the accommodation of flood flows in connection with the airport development in Sawyer Bend. It would not preclude the comprehensive development except that additional cost, estimated as upward of \$3,000,000, may become an important consideration in that respect. I believe that in the selection of a plan of improvement for navigation, consideration should be given to its relation to the other potentialities of the region.

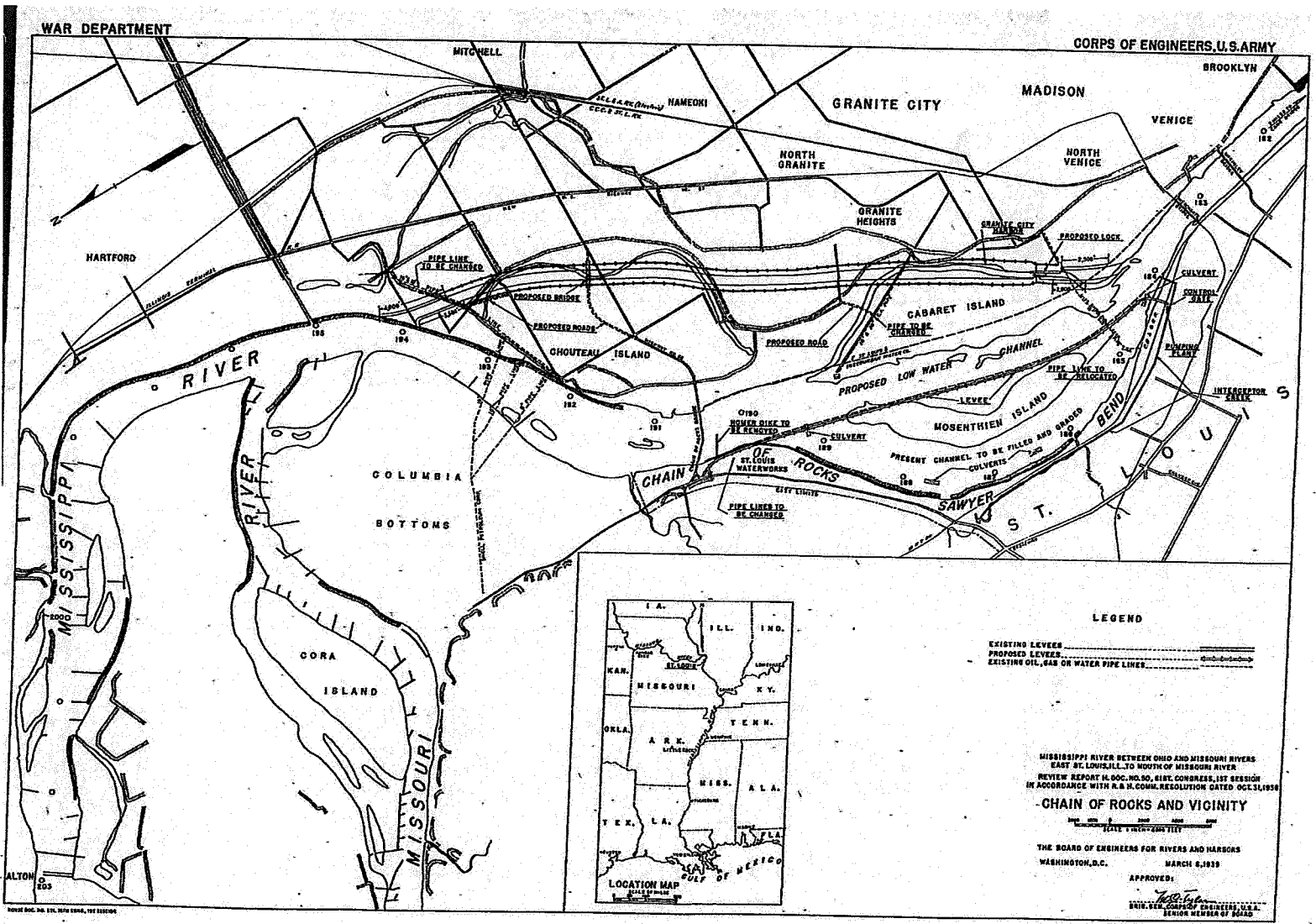
9. Plan II (b) requires a substantial amount of work, not needed for navigation, to be undertaken at the time the navigation channel is provided. I do not consider it proper that the excess expenditure should be made from river and harbor funds. A source of funds is problematic, and the lack might delay the work if plan II (b) were selected without an alternate provision. Only a reasonable delay in the interest of coordination would be warranted, as there is immediate need for the navigation improvement. Plan II (a), involving a slightly different location of channel, would not require any immediate expenditure of funds other than required for navigation and would fit in with a comprehensive development, though of somewhat less extent than the plan of which II (b) is a part. I believe that other interests should be afforded a reasonable time in which to cooperate in plan II (b) and that in event such cooperation is lacking at the end of that time, the navigation improvement described in plan II (a) should be undertaken.

10. I recommend that the Mississippi River between the vicinity of Merchants Bridge and the mouth of Missouri River be further improved in accordance with plan II (a), or such modification thereof as the Chief of Engineers considers advisable, at an estimated construction cost of \$9,250,000 and increased annual operation and maintenance cost of \$50,000, provided that the Chief of Engineers be authorized to construct, as a substitute therefor, the navigation channel and minimum auxiliary features embodied in plan II (b) if additional funds from any source amounting to \$6,290,000 become available within 1 year from the date of the authorization of plan II (a). I concur in the recommendation of the district engineer as contained in paragraph 118 of his report relative to approval of the plans for plan II (b) and supervision of work in connection therewith if undertaken.

MALCOLM ELLIOTT,
Lieutenant Colonel, Corps of Engineers,
Division Engineer.

WAR DEPARTMENT

CORPS OF ENGINEERS, U.S. ARMY



LEGEND

EXISTING LEVEES
 PROPOSED LEVEES
 EXISTING OIL, GAS OR WATER PIPE LINES

MISSISSIPPI RIVER BETWEEN OHIO AND MISSOURI RIVERS
 EAST ST. LOUIS, ILL. TO MOUTH OF MISSOURI RIVER
 REVIEW REPORT (A.O.C. NO. 100, RISE, CONGRESS, 1ST SESSION
 IN ACCORDANCE WITH H.A.S. COM. RESOLUTION DATED OCT. 31, 1928)

-CHAIN OF ROCKS AND VICINITY

SCALE 1:100,000

THE BOARD OF ENGINEERS FOR RIVERS AND HARBORS
 WASHINGTON, D.C. MARCH 6, 1933

APPROVED:
 SENIOR MEMBER OF BOARD

NOTED: See also 100, 101, 102, 103, 104, 105, 106, 107, 108, 109, 110, 111, 112, 113, 114, 115, 116, 117, 118, 119, 120, 121, 122, 123, 124, 125, 126, 127, 128, 129, 130, 131, 132, 133, 134, 135, 136, 137, 138, 139, 140, 141, 142, 143, 144, 145, 146, 147, 148, 149, 150, 151, 152, 153, 154, 155, 156, 157, 158, 159, 160, 161, 162, 163, 164, 165, 166, 167, 168, 169, 170, 171, 172, 173, 174, 175, 176, 177, 178, 179, 180, 181, 182, 183, 184, 185, 186, 187, 188, 189, 190, 191, 192, 193, 194, 195, 196, 197, 198, 199, 200, 201, 202, 203, 204, 205, 206, 207, 208, 209, 210, 211, 212, 213, 214, 215, 216, 217, 218, 219, 220, 221, 222, 223, 224, 225, 226, 227, 228, 229, 230, 231, 232, 233, 234, 235, 236, 237, 238, 239, 240, 241, 242, 243, 244, 245, 246, 247, 248, 249, 250, 251, 252, 253, 254, 255, 256, 257, 258, 259, 260, 261, 262, 263, 264, 265, 266, 267, 268, 269, 270, 271, 272, 273, 274, 275, 276, 277, 278, 279, 280, 281, 282, 283, 284, 285, 286, 287, 288, 289, 290, 291, 292, 293, 294, 295, 296, 297, 298, 299, 300, 301, 302, 303, 304, 305, 306, 307, 308, 309, 310, 311, 312, 313, 314, 315, 316, 317, 318, 319, 320, 321, 322, 323, 324, 325, 326, 327, 328, 329, 330, 331, 332, 333, 334, 335, 336, 337, 338, 339, 340, 341, 342, 343, 344, 345, 346, 347, 348, 349, 350, 351, 352, 353, 354, 355, 356, 357, 358, 359, 360, 361, 362, 363, 364, 365, 366, 367, 368, 369, 370, 371, 372, 373, 374, 375, 376, 377, 378, 379, 380, 381, 382, 383, 384, 385, 386, 387, 388, 389, 390, 391, 392, 393, 394, 395, 396, 397, 398, 399, 400, 401, 402, 403, 404, 405, 406, 407, 408, 409, 410, 411, 412, 413, 414, 415, 416, 417, 418, 419, 420, 421, 422, 423, 424, 425, 426, 427, 428, 429, 430, 431, 432, 433, 434, 435, 436, 437, 438, 439, 440, 441, 442, 443, 444, 445, 446, 447, 448, 449, 450, 451, 452, 453, 454, 455, 456, 457, 458, 459, 460, 461, 462, 463, 464, 465, 466, 467, 468, 469, 470, 471, 472, 473, 474, 475, 476, 477, 478, 479, 480, 481, 482, 483, 484, 485, 486, 487, 488, 489, 490, 491, 492, 493, 494, 495, 496, 497, 498, 499, 500, 501, 502, 503, 504, 505, 506, 507, 508, 509, 510, 511, 512, 513, 514, 515, 516, 517, 518, 519, 520, 521, 522, 523, 524, 525, 526, 527, 528, 529, 530, 531, 532, 533, 534, 535, 536, 537, 538, 539, 540, 541, 542, 543, 544, 545, 546, 547, 548, 549, 550, 551, 552, 553, 554, 555, 556, 557, 558, 559, 560, 561, 562, 563, 564, 565, 566, 567, 568, 569, 570, 571, 572, 573, 574, 575, 576, 577, 578, 579, 580, 581, 582, 583, 584, 585, 586, 587, 588, 589, 590, 591, 592, 593, 594, 595, 596, 597, 598, 599, 600, 601, 602, 603, 604, 605, 606, 607, 608, 609, 610, 611, 612, 613, 614, 615, 616, 617, 618, 619, 620, 621, 622, 623, 624, 625, 626, 627, 628, 629, 630, 631, 632, 633, 634, 635, 636, 637, 638, 639, 640, 641, 642, 643, 644, 645, 646, 647, 648, 649, 650, 651, 652, 653, 654, 655, 656, 657, 658, 659, 660, 661, 662, 663, 664, 665, 666, 667, 668, 669, 670, 671, 672, 673, 674, 675, 676, 677, 678, 679, 680, 681, 682, 683, 684, 685, 686, 687, 688, 689, 690, 691, 692, 693, 694, 695, 696, 697, 698, 699, 700, 701, 702, 703, 704, 705, 706, 707, 708, 709, 710, 711, 712, 713, 714, 715, 716, 717, 718, 719, 720, 721, 722, 723, 724, 725, 726, 727, 728, 729, 730, 731, 732, 733, 734, 735, 736, 737, 738, 739, 740, 741, 742, 743, 744, 745, 746, 747, 748, 749, 750, 751, 752, 753, 754, 755, 756, 757, 758, 759, 760, 761, 762, 763, 764, 765, 766, 767, 768, 769, 770, 771, 772, 773, 774, 775, 776, 777, 778, 779, 780, 781, 782, 783, 784, 785, 786, 787, 788, 789, 790, 791, 792, 793, 794, 795, 796, 797, 798, 799, 800, 801, 802, 803, 804, 805, 806, 807, 808, 809, 810, 811, 812, 813, 814, 815, 816, 817, 818, 819, 820, 821, 822, 823, 824, 825, 826, 827, 828, 829, 830, 831, 832, 833, 834, 835, 836, 837, 838, 839, 840, 841, 842, 843, 844, 845, 846, 847, 848, 849, 850, 851, 852, 853, 854, 855, 856, 857, 858, 859, 860, 861, 862, 863, 864, 865, 866, 867, 868, 869, 870, 871, 872, 873, 874, 875, 876, 877, 878, 879, 880, 881, 882, 883, 884, 885, 886, 887, 888, 889, 890, 891, 892, 893, 894, 895, 896, 897, 898, 899, 900, 901, 902, 903, 904, 905, 906, 907, 908, 909, 910, 911, 912, 913, 914, 915, 916, 917, 918, 919, 920, 921, 922, 923, 924, 925, 926, 927, 928, 929, 930, 931, 932, 933, 934, 935, 936, 937, 938, 939, 940, 941, 942, 943, 944, 945, 946, 947, 948, 949, 950, 951, 952, 953, 954, 955, 956, 957, 958, 959, 960, 961, 962, 963, 964, 965, 966, 967, 968, 969, 970, 971, 972, 973, 974, 975, 976, 977, 978, 979, 980, 981, 982, 983, 984, 985, 986, 987, 988, 989, 990, 991, 992, 993, 994, 995, 996, 997, 998, 999, 1000