Comprehensive Master Plan for the Management of the Upper Mississippi River System

January 1, 1982
Upper Mississippi River Basin Commission

Locks and Dam 26 Legislation: P.L. 95-502 (Section 101) Inland Waterways Authorization Act

Sec. 101(a). The Upper Mississippi River Basin Commission (referred to in this section as the "Commission") shall prepare a comprehensive master plan for the management of the Upper Mississippi River System in cooperation with the appropriate Federal, State and local officials. The Commission shall publish a preliminary plan not later than January 1, 1981. The Commission shall hold public hearings on the preliminary plan in each State which would be affected by the plan, shall review all comments presented at such hearings or submitted in writing to the Commission, and after making any revisions in the plan it decides are necessary, submit to Congress a final master plan not later than January 1, 1982. All decisions of the Commission related to the master plan shall be made by a two-thirds majority vote of the Commission. (b) The Commission shall provide for public participation in the development, revisions, and implementation of said plan and shall encourage and assist such participation. The Commission shall, within 150 days after the date of enactment of this Act, publish guidelines in the Federal Register for public participation in the development, revision, and implementation of the plan. The final master plan shall not be implemented without the express approval of the plan by an Act of Congress enacted after the date of enactment of this Act. After such approval, no change may be made in the master plan except as may be provided by an Act of Congress enacted after the date of enactment of the Act approving the master plan. No person shall engage in any activity which violates any provision of the plan or which is inconsistent (as determined under regulations promulgated by the Commission) with the plan.

(c) The Commission, in developing the plan, shall identify the various economic, recreational and environmental objectives of the Upper Mississippi River System, recommend guidelines to achieve such objectives, and propose methods to assure compliance with such guidelines and coordination of future management decisions affecting the Upper Mississippi River System, and include with the proposed master plan any legislative proposals which may be necessary to carry out such objectives.

(d) For the purposes of developing the plan, the Commission shall conduct such studies as it deems necessary to carry out its responsibilities under this section, utilizing to the fullest extent possible, the resources and results of the Upper Mississippi River resources management (GREAT) study conducted pursuant to section 117 of the Water Resources Development Act of 1976 (Public Law 94-587) and of other ongoing or past studies. The Commission may request appropriate Federal, State, or local agencies to prepare such studies. Any Federal Agency to which such a request is submitted may conduct any such study for the purpose of this section.

(e) Studies conducted pursuant to this section shall include, but not be limited to, the following: (1) The Secretary of the Interior and the Secretary of the Army, working through the Commission shall undertake a study to determine the carrying capacity of the Upper Mississippi River System, and the long- and short-term systematic ecological impacts of (A) present and any projected expansion of navigation capacity on the fish and wildlife, water quality, wilderness, and public recreational opportunities of said rivers, (B) present operation and maintenance programs, (C) the means and measures that should be adopted to prevent or minimize loss of or damage to fish and wildlife, and (D) specific analysis of the immediate and systematic environmental effects of any second lock at Alton, Illinois, and provide for the mitigation of any adverse impact on, and the enhancement of such resources.

(2) The Commission shall undertake studies to determine —

(A) the relationship of any expansion of navigational capacity on the Upper Mississippi River System to national transportation policy,

(B) the direct and indirect effects of any expansion of navigational capacity on the Nation's railroads and on shippers dependent upon rail service, and

(C) transportation costs and benefits to the Nation to be derived from any expansion of navigational capacity on said River System.

The Commission is directed to immediately initiate a specific evaluation of the economic need for a second lock at Alton, Illinois and the direct and indirect systematic effects and needs for such a second lock at Alton, Illinois.

(3) The Commission shall undertake a program of studies, including a demonstration program to evaluate the benefits and costs of disposing of dredge spoil material in contained areas located out of the floodplain. The program shall include, but shall not be limited to, the evaluation of possible uses in the marketplace for the dredge spoil studies and demonstration programs to minimize the environmental effects of channel operation and maintenance activities.

(4) The development by the Commission of a computerized analytical inventory and system to facilitate evaluation of the comparative environmental effects of alternative management proposals.

(f) Any Secretary responsible for conducting a study under subsection (e) of this section, and other studies conducted under this section, shall produce one or more draft reports containing study conclusions and appropriate appendix materials and shall present the reports to the Commission for approval and inclusion in the master plan process.

(g) To carry out the provisions of this section, there are authorized to be appropriated to the Commission, through the United States Water Resources Council, $12,000,000. The Commission is authorized to transfer funds to such Federal, State or local government agencies as it deems necessary to carry out the studies and analysis authorized by this section.

(h) For purposes of this section, the Upper Mississippi River System consists of those river reaches containing commercial navigation channels on the Mississippi River main stem north of Cairo, Illinois; the Minnesota River, Minnesota; Black River, Wisconsin; Saint Croix River, Minnesota and Wisconsin; Illinois River and Waterway, Illinois; and Kaskaskia River, Illinois.

(i) No replacement, construction, or rehabilitation that expands that navigation capacity of locks, dams, and channels shall be undertaken by the Secretary of the Army to increase the navigation capacity of the Upper Mississippi River System, until the master plan prepared pursuant to this section has been approved by the Congress except as provided in section 102 and except for necessary operating and maintenance activities.

(j) The lock and dam authorized pursuant to section 102 shall be designed and constructed to provide for possible future expansion. All other construction activities initiated by the Secretary of the Army on the Upper Mississippi River north of Cairo, Illinois, and on the Illinois River north of Grafton, Illinois, shall be initiated only in accordance with the guidelines set forth in the master plan.

Comprehensive Master Plan for the Management of the Upper Mississippi River System

January 1, 1982

Upper Mississippi River Basin Commission

Environmental Impact Statement
And
Comprehensive Master Plan for the Management of the Upper Mississippi River System

( ) Draft (X) Final

Responsible Agencies:

- Upper Mississippi River Basin Commission
- U.S. Department of Army
- U.S. Department of Interior
- U.S. Department of Transportation

The following Federal members of the Upper Mississippi River Basin Commission participated in the study:

- Department of Agriculture
- Department of Army
- Department of Commerce
- Environmental Protection Agency
- Department of the Interior
- Department of Transportation

The following State members of the Upper Mississippi River Basin Commission participated in the study:

- Illinois
- Iowa
- Minnesota
- Missouri
- Wisconsin

Name of Action:

( ) Administrative Action
(X) Legislative Action

This report contains the conclusions and recommendations resulting from a two year study conducted by Federal and State agencies in cooperation with local government and the public. The studies were designed and conducted in response to the directives contained in P.L. 95-502, Section 101. The studies addressed economic, environmental, and recreational management of the Upper Mississippi River System and focus on the impacts to those areas as related to any expansion of navigation capacity of the system. The area of study is the Upper Mississippi River System which is defined to be those river reaches containing commercial navigation channels on the Mississippi River main stem north of Cairo, Illinois; the Minnesota River, Minnesota; Black River, Wisconsin; Saint Croix River, Minnesota and Wisconsin; Illinois River and Waterway, Illinois; and Kaskaskia River, Illinois.

Public hearings on the draft Environmental Impact Statement were held in the following locations:

St. Louis Missouri	- November 2
Peoria, Illinois	- November 3
Davenport, Iowa	- November 4
La Crosse, Wisconsin	- November 5
Roseville, Minnesota	- November 9

The Commission considered comments regarding the draft Environmental Impact Statement and responses to those comments are reflected in this report.

The final report was approved by the Commission on December 14, 1981. Because the Commission has been terminated by Executive Order and because this report has been forwarded to Congress, any further comments should be directed to the Speaker of the House or President of the Senate, Washington, D.C., or to the reviewer's Congressional Representative or Senator.

Preface

The Comprehensive Master Plan for the Management of the Upper Mississippi River System has been prepared by the Upper Mississippi River Basin Commission to comply with the congressional charge in Public Law 95-502. The draft of the plan underwent public hearings in the five states and appropriate responses and revisions were formulated and incorporated by the Commission in the final plan.

This document is the result of a three year effort by Federal, State, and local officials and presents the conclusions and recommendations of the technical studies conducted in conjunction with the plan. This Comprehensive Master Plan for the Management of the Upper Mississippi River System was developed in accordance with the provisions of P.L. 95-502, Section 101 and was approved for transmittal to the U.S. Congress by the Upper Mississippi River Basin Commission on December 14, 1981. This report by the Commission completes its Congressional mandate. The Commission was terminated on December 31, 1981 by Executive Order 12319.

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Chapter I. Study History, Scope, and Organization

On October 21, 1978, President Carter signed into law the Inland Waterways Authorization Act (P.L. 95-502) which in addition to authorizing replacement of Locks and Dam 26 and establishing an inland waterway user tax, directed the Upper Mississippi River Basin Commission to prepare a Comprehensive Master Plan for the Management of the Upper Mississippi River System in cooperation with appropriate Federal, State, and local officials. The events leading to the signing of P.L. 95-502 provide insight into the issues involved in the mandate of the law.

In 1968, the District Engineer of the U.S. Army Corps of Engineers, St. Louis District, recommended for Locks and Dam 26 at Alton, Illinois a replacement project consisting of a new dam and two 1200-foot locks two miles downstream of the existing dam. In 1969, the Board of Engineers for Rivers and Harbors recommended that the proposed project be implemented immediately. The Secretary of the Army approved the project under the authority of the River and Harbor Act of 1909. On the advice of the Secretary of the Army, the U.S. Congress appropriated funds for the design of the Locks and Dam 26 replacement project in fiscal year 1970 and continued appropriations through fiscal year 1975.

On August 6, 1974, the Izaak Walton League, the Sierra Club, and 21 western railroads filed lawsuits in the U.S. District Court to enjoin the U.S. Army Corps of Engineers from beginning construction of the Locks and Dam 26 replacement project. Essentially, the plaintiffs contended that Locks and Dam 26 replacement project plans had not been duly authorized by Congress. The plaintiffs also contended that the Environmental Impact Statement was inadequate because it did not fully consider the systemic effects of the project. The lawsuits also contended that the Corps had ignored the objectives of national economic development and environmental quality, improperly and inadequately assessed project costs and benefits, and failed to consider feasible alternatives.

The U.S. District Court ruling of September 5, 1974 stopped further actions toward construction of the Locks and Dam 26 replacement. It was the opinion of the Court that the project be enjoined until the U.S. Army Corps of Engineers obtained the consent of Congress and remedied the defects in the Environmental Impact Statement or a trial on the merits of the plaintiff's arguments be held. In response to this ruling, the Corps of Engineers decided to conduct additional studies which were submitted to Congress (House Document No. 9A-584, 26 August, 1976) and to ask for specific Congressional authorization.

The Chief of Engineers recommended that:

"a. Congress authorize the replacement of Locks and Dam 26 with a new dam and 110-foot by 1,200-foot main lock at a location two miles downstream from the existing dam, the design and construction of the new dam to provide for the addition of an auxiliary lock at such time as it may be authorized. The estimated cost to the United States of initial construction based on January 1976 prices is $391 million."

"b. As a separate feature, independent of the navigation elements, the project-related recreation development on Ellis Island, Missouri, requiring no separable lands be developed in cooperation with the State of Missouri. Prior to implementation of such development, the State should agree to share the first cost of $4,000,000 (January 1976 prices) consistent with the Federal Water Project Recreation Act, Public Law 89-72 as amended."

"c. The terrestrial wildlife habitat inundated by the two miles of new pool and affected by the siting of structures be replaced in the respective States of Missouri and Illinois by approximately 1,450 acres as recommended by the U.S. Fish and Wildlife Service at an estimated cost of $1.8 million, including initial development, as part of the Federal project cost."

"d. Congress authorize the Secretary of the Army, acting through the Chief of Engineers, in cooperation with the Departments of Transportation and Interior, the Environmental Protection Agency, and other interested Federal and State agencies, to make an economic evaluation and a comprehensive study of the river environment to determine the impacts of increased navigation which would result from provision of a second lock and submit a report to the Congress on the feasibility and desirability of constructing a second lock."

The Chief of Engineers' recommendations were based on the report of the Board of Engineers for Rivers and Harbors (BERH) dated February 24, 1976. The Board recommended immediate Congressional approval of $9.7 million to fund studies to measure the environmental and other impacts of increased barge traffic on the Illinois and Upper Mississippi Rivers. The design and construction of the single lock structure would provide for the efficient addition of a second lock at a future date, should the additional economic and environmental studies justify future expansion of capacity to pass barge traffic at Alton.

During 1976 and 1977, the U.S. Congress debated several bills to authorize the Corps of Engineers to begin construction of a replacement for Locks and Dam 26. The authorization for a Master Plan for the Upper Mississippi River System grew out of this Congressional debate. Other navigation improvements had been proposed including a second lock at Alton and duplicate locks on the Illinois Waterway. Because construction of these locks would increase the river system's capacity for waterway traffic, Congress requested more information about the impact of increased traffic on environmental and recreational resources and on other modes of transportation. At issue were conflicts that had been developing for decades: the demand for increased waterway commerce; environmental demands to preserve natural wildlife habitats and prevent damage to the rivers' ecology; and the impact that increased waterway commerce could have on other modes of commercial transportation, particularly the railroads.

The Inland Waterways Authorization Act (P.L. 95-502) addressed many of these concerns. The Act included sections which:

a. authorize the Army Corps of Engineers to replace Locks and Dam 26 with a new dam and single lock (Section 102);

b. impose a tax on fuel used in commercial transportation on inland waterways (Section 202);

c. establish a trust fund for the use of the tax revenues (Sections 203, 204); and

d. authorize the Secretaries of Transportation and Commerce to conduct a study with respect to inland waterway user charges (Section 205).

Section 101 of the Act directed the Upper Mississippi River Basin Commission to prepare a Comprehensive Master Plan for the Management of the Upper Mississippi River System in cooperation with appropriate Federal, State and local officials. Furthermore, no replacement, construction, or rehabilitation that would expand the navigation capacity of the system can be undertaken until the Master Plan has been approved by Congress. The law specified that the Master Plan be submitted to Congress by January 1, 1982, with a preliminary plan completed by January 1, 1981. This document constitutes the final plan as mandated by Congress.

A document entitled "Preliminary Plan" was published on January 1, 1981. It served two main purposes. It provided the public, interested State and Federal agencies, and decisionmakers with a summary of the direction, status, and anticipated nature of the results of the technical studies which had been designed to answer the questions in the law. In addition it generally outlined alternative institutional arrangements under consideration for resolving conflicts and managing the System's varied resources.

Scope

In developing the Master Plan, the Commission was directed to:

- identify the economic, recreational, and environmental objectives of the Upper Mississippi River System,
- recommend guidelines to achieve such objectives,
- propose methods to assure compliance with such guidelines and coordination of future management decisions, and
- include any legislative proposals which may be necessary to carry out such recommendations and achieve such objectives.

As part of this general charge, the Commission was to conduct studies which address key issues of Congressional concern including:

- the navigation carrying capacity of the Upper Mississippi River System
- the relationship of capacity expansion to national transportation policy
- the effect of expansion of navigation capacity on the railroads
- the transportation costs and benefits to the nation of expanded navigation capacity
- the economic need for a second lock at Alton, Illinois
- the systemic ecological impacts of present and expanded navigation capacity on fish and wildlife, water quality, wilderness, and recreational opportunities
- the means and measures to prevent or minimize such impacts
- the immediate environmental effects of a second lock at Alton, Illinois
- the benefits and costs of disposing of dredged material in areas outside of the floodplain
- the development of a computerized analytical inventory and analysis system

The Master Plan thus presents the results of mandated studies and technical recommendations based on those findings and recommendations from other studies. In addition, the Plan contains a management framework for resolving differences among competing interests and implementing the technical recommendations.

Study Approach

The Upper Mississippi River Basin Commission's initial response to this Congressional mandate was the preparation and transmittal of a "Plan of Action" for the implementation of the Master Plan to the Water Resources Council on October 30, 1978. The "Plan of Action" provided an outline of the program and the budget for fiscal years 1979 and 1980. At the request of the Water Resources Council and the Office of Management and Budget, a supplement to the "Plan of Action" entitled "Fiscal Years 1979-80 Budget Proposal for Federal Funds to Implement Upper Mississippi River System Master Plan Provisions of Locks and Dam 26 Legislation" was prepared and transmitted to the Water Resources Council.

At the 28th Quarterly Meeting of the Upper Mississippi River Basin Commission on November 13-14, 1978, the Commission established the Master Plan-Plan of Study Task Force to prepare the first draft Plan of Study for consideration by the Commission. On August 15, 1979, the Commission adopted a Plan of Study for the development of a Comprehensive Master Plan for the Management of the Upper Mississippi River System. The Commission had expressed concern about the time constraints of the law and, thus, outlined a study effort in the Plan of Study, with an additional 19 months beyond the time specified in P.L. 95-502. The adopted Plan of Study initiated studies in a time frame which the Commission determined would be necessary to adequately answer the questions and concerns raised by Congress.

The Congressional response to the Commission's identified additional nineteen months in the Plan of Study was expressed in September 1980 through Appropriation Senate/House Conferees language which indicated the need to have the findings of the Master Plan study effort on the date specified in P.L. 95-502. The Conferees directed the Commission, under the direction of the Chairman, "to take the necessary steps, including revising and rescoping the current plan of study...to insure the completion of the entire plan by January 1, 1982." The Commission, having received that direction from Congress, rescoped all study efforts as necessary to meet the dates specified in the law.

The environmental studies were rescoped by curtailing extensive field studies and increasing efforts to develop qualitative assessments based on existing information and defined relationships. The transportation studies were redesigned by substituting an unconstrained waterway demand analysis for a modal share analytical approach. The dredged material disposal study had previously been rescoped to meet budget limitations by eliminating a physical demonstration program. The computer inventory and analysis system study was not rescoped but was designed as an incrementally enhanced program feasibility study rather than an immediate system implementation.

The limitations of time have had an impact on the level of detail and overall scope of many of the Master Plan studies. The degree of specificity with which the Commission has responded to Congressional concerns is thus constrained by data limitations inherent in a short-term study approach. The rescoped studies have provided valuable information to formulate a Comprehensive Master Plan which addresses the systemic, regional, and national issues contained in the study mandate.

P.L. 95-502 authorized a total of $12 million to carry out the provisions of Section 101 of the Act pertaining to the Master Plan. Appropriations for the Master Plan were made by Congress in three separate appropriation actions totaling $8.4 million. A supplemental Fiscal Year 1979 appropriation of $2 million was approved in July 1979. Fiscal Year 1980 appropriation of $4 million was approved in October 1979, and a $2.4 million appropriation for Fiscal Year 1981 was approved in September, 1980. An appropriation of $1.0 million for Fiscal Year 1982 was approved by Congress in December, 1981 but had not been signed as of Commission action on this document.

Study Management and Organization

Initially in 1979, the Commission had formed committees, referred to as Work Teams, consisting of Commission members and public representatives responsible for designing studies and conducting the necessary research and analysis. During the rescoping effort in October 1980, a "lead member" approach was also instituted. Agencies and States of the Commission were given lead responsibility to carry out and complete specific study elements. The Work Teams guided the conduct and accomplishment of the studies assigned to lead members. The Commission's Great River Study Committee was given the responsibility of overall study policy guidance, budget, and plan formulation. However, ultimate decisions and final plan recommendations were made by the Commission. Fourteen study elements were established to respond to the questions raised in P.L. 95-502 and to provide information with which to formulate a comprehensive management plan (Figure I-1).

The work accomplished in the fourteen study elements constituted the majority of the first three plan formulation steps. First, for each element the Work Teams defined and clarified the problems, needs, and opportunities which were to be addressed by that component of the Master Plan. Secondly, data were gathered, analytical processes were developed, and evaluations conducted. During the development of these first two steps, the preliminary input from the Citizen Review Council and public meetings was provided to the Work Teams. Each team evaluated their procedures and objectives in view of that input. As the Work Teams proceeded into the next step of developing scenarios, public preferences were assessed by a review of the first phase of Survey Research and the CRC Delphi process. Using the results of the first two steps and public input, Work Teams developed several future scenarios which could be achieved with different management actions. These scenarios consti-

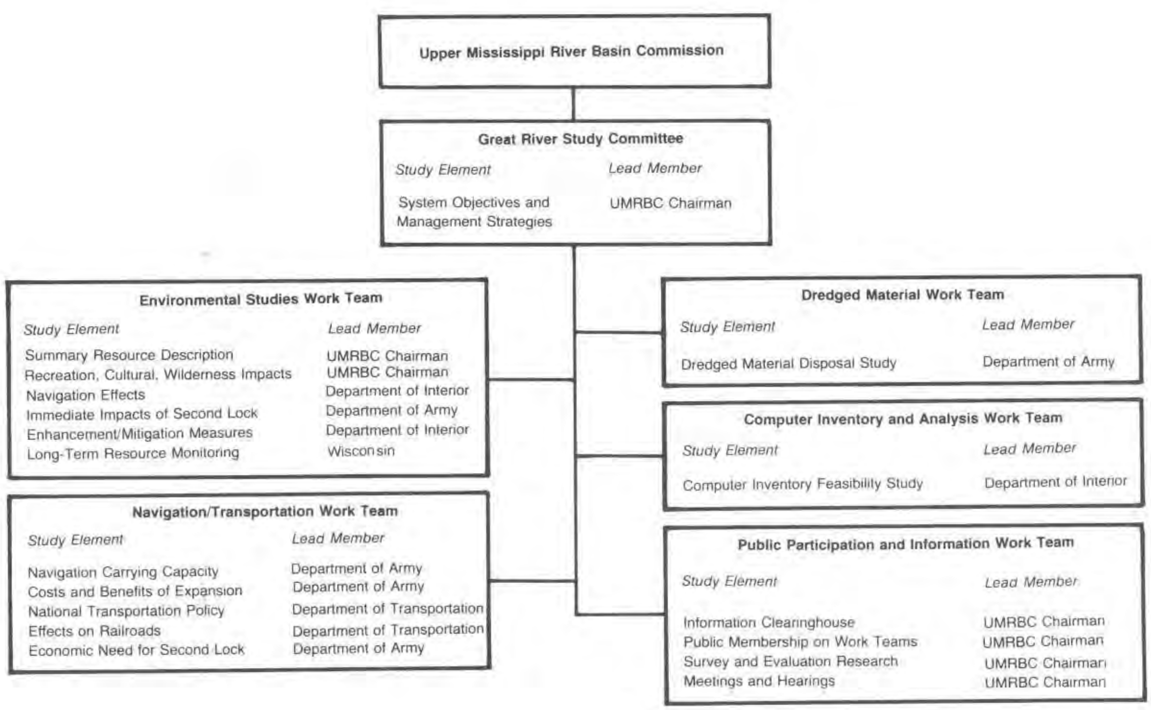


Figure I-1. Study Organization

tuted alternative components for formulation of the recommended Master Plan.

The Great River Study Committee's responsibilities included the remaining steps of the plan formulation process. These included review and evaluation of the results of the fourteen study elements and the public Survey Research, public meetings, and Citizen Review Council conclusions. The outputs were first evaluated within each element to determine which available alternative was most suitable, given the objectives of the study. The alternatives from all elements were then compared for compatability to determine those combinations which best address the questions posed in Section 101 of P.L. 95-502.

With these reviews and evaluations completed, the Great River Study Committee integrated the selected components into a recommended Master Plan for consideration by the Commission. This document contains the Plan adopted by the Commission.

Public Participation

As mandated in Section 101 (d) of P.L. 95-502, the Upper Mississippi River Basin Commission (UMRBC) provided for public participation in the development, revision, and implementation of the Master Plan. The public participation and information effort for the Master Plan program was carried out by the Public Participation and Information Work Team (PPIWT). The activities of the Work Team were based on the Master Plan-Plan of Study and the "Adopted Guidelines for Public Participation" that were drafted and adopted by the UMRBC and published in the Federal Register (18 CFR. 708.1 to 708.5), as required by Congress.

The guidelines contain general procedures for promoting public participation in the Master Plan process and also articulate the Commission's overall commitment to a public participation process in stating that: "The Commission seeks to foster a spirit of openness and a sense of mutual trust between the public and the planners. Public participation is expected to result in greater responsiveness of the Master Plan to public concerns and priorities, as well as improved popular understanding of official studies, planning processes, and decisions."

The guidelines also provide specific methods for developing, executing, and evaluating the public participation program for the Master Plan. Detailed direction is provided in the areas of policy, objectives, standards, required programs and reports, and program objectives implementation. The overall public participation program and process utilized by the Work Team was tailored to fully comply with the Adopted Guidelines for Public Participation. The following sections discuss the public participation process during the development of the Master Plan and the activities and reports which resulted from the process.

PROCESS

The public participation process for the Master Plan was developed in response to the policies, objectives, and standards set forth in the guidelines. The objectives stated by the Team were those contained in the adopted guidelines: 1) to develop awareness of public preferences by those preparing and approving the plan; 2) to anticipate and resolve conflicts during the study; 3) to provide periodic and final reviews of plan development; 4) to evaluate public participation in the planning process; and 5) to improve information transfer and public awareness of the study.

The public participation process involved a series of activities designed to foster the capability for continued interaction with the public throughout the development of the Master Plan. Many of these activities were already being conducted at some level as part of the Commission's existing public involvement effort, and were upgraded significantly to respond to the special needs of the Master Plan.

Public Information/Communication

A major component of the public participation effort involved a series of activities to improve public awareness of the Commission. The Commission provided a centralized capability for the dissemination of information and provided a contact point for interested persons. Commission staff were available to answer questions and respond to public requests for information and publications.

Since most interest in the Commission's planning effort came from special audiences who are directly or indirectly affected by the river sytem, the Commission sought to upgrade its direct mailing capability. Computerized mailing lists were developed that had the capability to target UMRBC affiliates, government policymakers, public policymakers, media, and unaffiliated citizens.

Other public information/communication activities included speaking engagements by staff, announcements on public radio and television, publication of a Master Plan Brochure, a series of fact sheets about each study component, news releases, and newsletters. Newsletters included "River Ramblings" which is the official UMRBC quarterly publication recording Commission actions and events. "Mississippi Issues: Upper Basin Views and Previews" was also published to highlight Master Plan public participation opportunities in each phase of the planning process.

Input from Organized Interest Groups

In order to obtain direct input form numerous interested publics as described in the guidelines, proposals for direct involvement of organized interest groups was solicited. Such a proposal resulted in the establishment of the River Country Voices Program. River Country Voices (RCV) was a project designed to improve dialogue between the Commission and the environmental community. Formed from a coalition of the Sierra Club, Izaak Walton League, and the Environment Policy Center, RCV operated through a representative assigned as liaison to Master Plan processes and people. The representative monitored and participated in the discussions of the system objectives, the environmental and navigational transportation studies, and the overall budget. A position paper prepared as input to the institutional arrangements component of the plan was submitted.

Citizen Representation

Public participation has been an integral part of the planning process for all levels of the Master Plan; the Work Team or technical level, and study management level, and the policy level.

At the technical and management levels, citizen involvement was obtained through public comments and through the four public members appointed to each Master Plan work group. The PPIWT selected the four public members for each Work Team. Using nominations solicited from the general public and interest groups, the PPIWT appointed four public representatives as members of its own Team in September 1979. These four members, in turn, assisted in selection of public members for the other Work Teams and Great River Study Committee. The Plan of Study guidelines indicate that of the four citizen members, two should represent economic interests and one each should represent the environmental and recreational interests.

As part of the Master Plan Public Participation program, the Commission directed the PPIWT to create a Citizen Review Council for the purpose of frequent and coordinated consultation with a group of interested citizens. Moreover, the Council was needed to bring citizen opinions and suggestions into direct contact with policymakers on issues of significant importance. The Citizen Review Council was involved directly through a modified Delphi process. The charge to the Citizen Review Council was to take an active role in the development of institutional alternatives. Creative and independent ideas relating to that goal were solicited and facilitated through the Delphi process. The process guaranteed anonymity and by virtue of idea refinement and information exchange, allowed the independent comments of the participants to be evaluated by decisionmakers.

PROGRAMS AND REPORTS

In addition to the establishment of a public participation process for the Master Plan, the guidelines call for a series of specific programs and reports to be prepared. The required programs and reports were developed in accordance with the "Program Objectives Implementation" procedures described in the guidelines.

Work Plans

The Commission prepared a work plan for the execution of all public participation-related activities in the Master Plan. This work plan is part of the Master Plan-Plan of Study, which was adopted by the Commission in August, 1979.

Progress Reports

The Commission has prepared reports describing the participation programs as developed or implemented during designated reporting periods. Each report includes a brief description of the participation elicited, the cost of the effort, and the use made of the information in the planning process.

Survey Research

Survey research was a required activity described in the guidelines. During the summer of 1980, special audiences and the general public were surveyed to identify and profile the various Commission audiences.

These surveys determined what these audiences knew about the UMRBC, identified their perceptions about changing the river system conditions, and examined their views of the river system's economic, environmental, and recreational importance. The surveys also pinpointed what people perceive as the best method for influencing government decisions. Survey results were used to identify trade-offs among potential river system users, as well as factors which influence perceptions of the river system and its uses. The results of the surveys were made available to decisionmakers for use in designing the information and education program, and to other Work Teams and contractors of the Master Plan, private decisionmakers, and government bodies.

To assess the impact of the Commission's public education effort and Master Plan awareness, a resurvey was conducted late in the summer of 1981. This resurvey, required by the guidelines, focused on three audiences: 1) the general public; 2) special audiences on the mailing list; and 3) local officials.

Public Meetings

During the spring of 1981, a series of eight public workshops in four locations were held. The workshops were designed as unconstrained question-and-answer sessions, in keeping with the directives in the guidelines that the public participation program should foster openness and trust between the public and planners. The meetings provided an opportunity to report to the public on the progress of the Master Plan and provide information to those unfamiliar with the program.

A second series of public meetings were scheduled for October of 1981, to present the draft Master Plan to the public and report on the recommendations contained within the Plan. These meetings also provided the public with an opportunity to view how the Plan responded to the public concerns expressed during the process.

Formal Public Hearings

The Commission provided for formal public hearings in each state affected by the Master Plan during November, 1981, to receive formal public response to the recommendations contained in the Plan. The Commission considered the public preferences expressed during the hearings, as well as all other public comments during the course of the study effort, when preparing the recommendations contained in this report.

Evaluation

The PPIWT developed mechanisms to evaluate the entire public participation program in the Master Plan. The purpose of the evaluation was to determine the extent of actual participation; the degree to which the participation was utilized; regional or local differences in the effectiveness of participation; and needed modifications during the Master Plan process. The results of the evaluations will be valuable in designing guidelines for a public participation program related to the implementation of the Master Plan.

Chapter II. Environmental, Recreational, and Economic Setting

The Upper Mississippi River System is composed of nearly 1300 miles of commercially navigable portions of the Upper Mississippi River north of Cairo, Illinois, the Kaskaskia River in Illinois, the Minnesota River in Minnesota, the Black River in Wisconsin, the Saint Croix River, Minnesota and Wisconsin, and the Illinois Waterway (Figure II-1).

Several vegetation types are found in the Upper Mississippi River Basin, including small areas of both the boreal and southeastern needleleaf evergreen forests, an extensive area of broadleaf deciduous forest in the eastern half of the basin, and areas of grasslands in the western half of the basin. The Upper Mississippi River System is situated, for much of its course, in an overlap zone of major botanical and zoological regions, which afford the local river environs an abundance of plant and animal varieties. By far the most extensive land use activity of the Upper Mississippi River Basin is agriculture, with commercial crop and livestock farming comprising the bulk of the agricultural land area.

The Upper Mississippi River System is a major multi-purpose water resource. It provides commercial transportation and water supplies for domestic use, industrial use, and for energy production. It also plays a vital role in providing habitat for aquatic and terrestrial species and serves as an important regional recreation resource. The Upper Mississippi is the only inland river in the United States serving under federal law as both a major national wildlife refuge and a federal commercial navigation project.

The rivers that make up the Upper Mississippi River System have diverse physical and cultural characteristics. This diversity is reflected in basic use differences between rivers and various river segments (Table II-1).

As an important corridor of transportation, the Upper Mississippi River System has, since 1824, been subjected to alteration for navigational purposes. In the 1930's, 9-foot navigation channel projects were authorized by Congress for both the Mississippi and Illinois Rivers. The 9-foot channel was achieved by the construction of locks and dams, wing dikes, and by dredging. Construction of the locks and dams was essentially completed by 1940. The series of locks and dams on the Upper Mississippi from southern Missouri to Upper St. Anthony Falls provides a "stairway of water" from St. Louis to Minneapolis. The Illinois River and Waterway provides a connection between the St. Lawrence-Great Lakes and Mississippi-Ohio-Missouri Navigation Systems. Below Lock No. 27 at Granite City, Illinois, the Mississippi River navigation channel is maintained through the placement of flow regulating structures such as wing dikes and by dredging.

In addition to the construction and maintenance of the locks and dams, the river channel itself requires maintenance to provide for commercial navigation. Over 200 sites along the river require periodic dredging. On the average each year some 9.5 million cubic yards of material are dredged from the Upper Mississippi River System and must be disposed. In addition, about 2,400 submergent and 700 emergent wing dikes have been constructed to reduce main channel sedimentation and 420 miles of bankline stabilization are maintained.

In recent years, pressure for expanded development of the river system raised questions concerning the effect on fish and wildlife habitats and opportunities for adequate and safe recreation. The ensuing conflicts have not been fully resolved and have led to a recognition that a more effective balancing of competing interests is needed. The Master Plan addresses these issues -- issues which are best understood within the context of the sometimes conflicting use of these environmental, economic, and recreation resources.

This chapter provides background information on these three key resources of the Upper Mississippi River System. Environmental resource information is

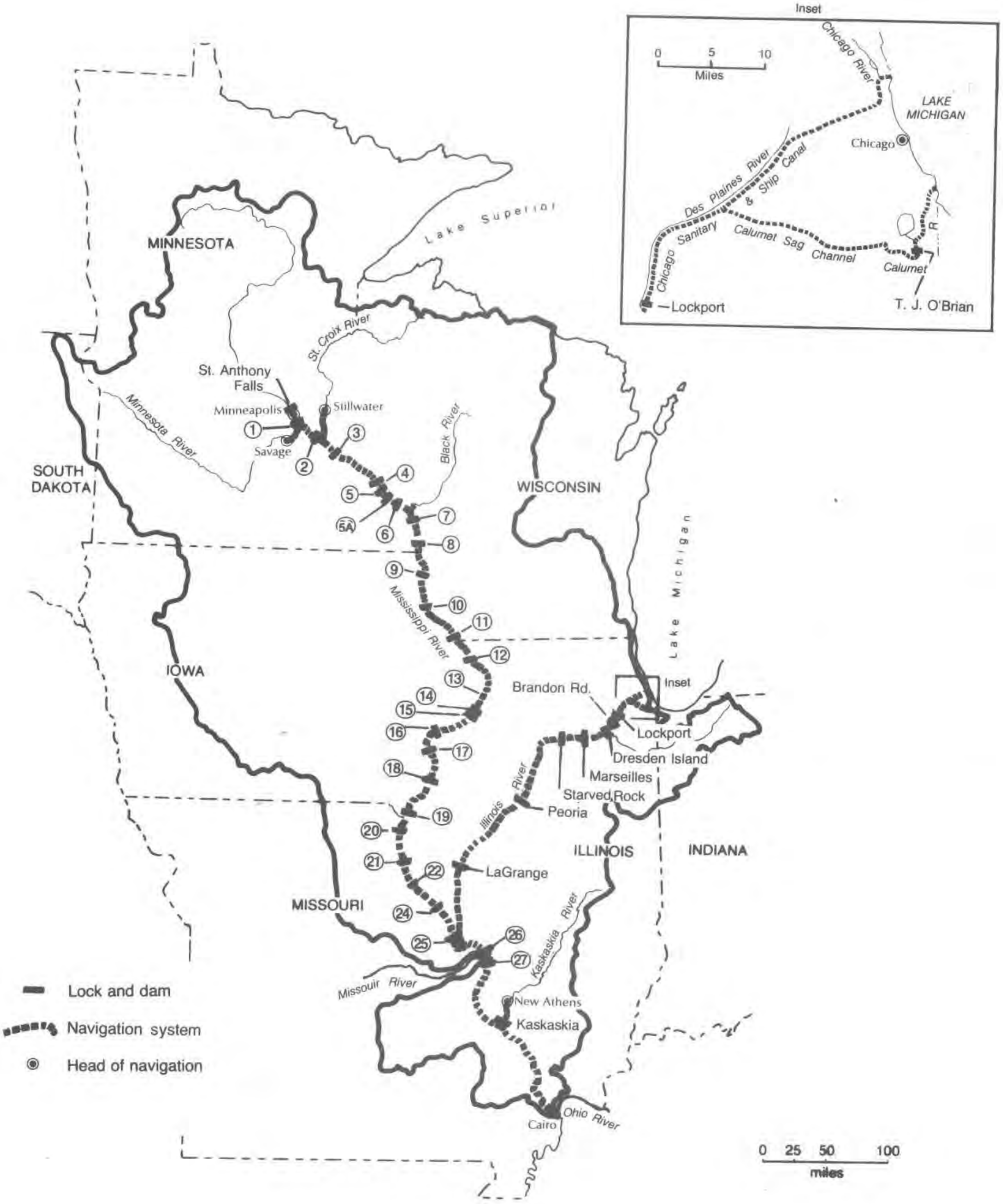


Figure II-1. Upper Mississippi River Navigation System provided in greater detail in accordance with the requirements of the National Environmental Policy Act.

Table II-1. Summary of Upper Mississippi River System Commercial and Recreational Facilities

River Segment(s)	River Miles Number (% of total)		Commercial Docks and Terminals Number (% of total)		Water-oriented Recreation Sites Number (% of total)		Small-Boat Harbors or Marinas Number (% of total)	
Mississippi River upstream of Lock and Dam 10 and Black, Minnesota, and St. Croix Rivers	290	(24.3%)	97	(20.4%)	252	(56.6%)	55	(27.5%)
Mississippi River Lock and Dam 10 to Lock and Dam 22	315	(26.4%)	103	(21.7%)	129	(29.0%)	55	(27.5%)
Illinois River and Waterway1/	290	(24.3%)	141	(29.7%)	47	(10.6%)	34	(17.0%)
Mississippi River Lock and Dam 22 to Cairo, Illinois	300	(25.0%)	134	(28.2%)	17	(3.8%)	56	(28.0%)
Totals	1,195	(100%)	475	(100%)	445	(100%)	200	(100%)

1/ Computation limited to riverine portions of Illinois Waterway (Des Plaines and Illinois Rivers); connecting channels such as Chicago Sanitary and Ship Canal and Calumet Sag Channel excluded.

Sources: Upper Mississippi River Navigation Charts, U.S. Army Corps of Engineers, North Central Division, 1978
Charts of the Illinois Waterway, U.S. Army Corps of Engineers, Chicago District, April 1974

Environmental Resources

The Upper Mississippi River System is one of North America's greatest environmental resources. Its channels, river lakes and ponds, sloughs, wetlands, and adjacent valley lands have created a wide range of habitats. In turn these habitats provide food and cover for fish and wildlife.

The rivers that make up the system and reaches within individual rivers have different physical, water quality, biological and use characteristics. The history of land use change, commercial and industrial development, and the construction of the navigation system have had varying effects on the environment of the UMRS. All of these complex and interacting characteristics determine the environmental quality of the system. Alterations in any one characteristic can affect other aspects of the riverine environment. In order to consider the potential for long-term change within a river system associated with expansion of navigation it is essential to develop an understanding of the interrelationships of the many factors involved.

The following paragraphs summarize the system environment under the following resource topics:

- Physical Characteristics
- Water Quantity and Quality
- Biological Characteristics
- Cultural Resources
- Potential Wilderness Areas

This summary is a major requirement of an Environment Impact Statement (EIS). Further details can be found in the Summary Resource Description working papers.

PHYSICAL CHARACTERISTICS

The rivers that make up the UMRS are alluvial rivers. An alluvial river generally is continually changing its position and shape as a consequence of hydraulic forces acting on its bed and banks and related biological forces interacting with these physical forces. These changes may be slow or rapid and may result from natural environmental changes or from human induced changes.

The major features of the drainage pattern in the Upper Mississippi River basin were established prior to the Pleistocene glaciation; however, successive continental ice sheets during the Pleistocene produced significant modifications. The last glacial epoch, the Wisconsin, basically established the Upper Mississippi River System in its present course. Drainage of large volumes of water from glacial lakes scoured the river valleys far below present floodplain levels. The melting of the Wisconsin ice sheets uncovered drainage paths to the north through Hudson Bay and St. Lawrence River, and as a result, discharge to the south decreased. These smaller flows were unable to transport glacial sediments on the flat slopes established by earlier torrents and a wave of alluviation partially filled the river valleys. Finally, as the ice front moved further north, the reduction in sediment load enabled the rivers to incise the alluvial valley floors, leaving terraces and terrace remnants. Subsequent valley widening and floodplain development occurred in post-glacial time.

The picture of the natural rivers that emerges is one that strongly reflects the influence of Pleistocene glaciation, and its aftermath, on the character of the rivers. The sequence of trenching of the preglacial sedimentary surface, then filling with glacial outwash, followed by incision of the alluvial deposits, produced the natural rivers of the 19th century. In general the rivers follow a winding course between low natural levees in a wide floodplain bordered by the high bluffs of sedimentary rock.

As early descriptions indicate, the Mississippi above the Missouri can be considered a clearwater river; however, the Missouri transports so much sediment that the Middle Mississippi must be classed as a heavy sediment carrier. The broad classification of the Upper Mississippi as a clearwater stream is relative. In fact the Mississippi above the Illinois River transports over 20 million tons of sedimentary material annually while that portion below the Missouri River transports 100 million tons annually.

In addition to the natural and other man-induced environmental changes, the development of the present day navigation system altered the physical characteristics of the UMRS (Table II-2). Limited efforts to improve navigation conditions on the System began in 1824 when Congress authorized the removal of snags and other local obstructions such as shoals, sandbars, and rock in several reaches of rapids.

Table II-2. Timetable of Navigation Development Activities

Activity	Year
Mississippi River:	
Congress authorizes removal of snags and local obstructions	1824
Congress authorizes 4½-foot channel from mouth of Missouri to St. Paul	1878
Congress authorizes 6-foot channel	1907
Construction of Lock and Dam 19	1914
Construction of Lock and Dam 1	1917
Congress authorizes 9-foot deep, 300-foot wide channel from St. Louis to Cairo	1927
Congress authorizes extension of 9-foot channel to St. Paul through construction of locks and dams	1930
Construction of 29 lock and dams	1930-1950
Construction of Lock and Dam 27	1953
Construction of 1200-foot chamber at Lock and Dam 19	1957
Illinois River:	
Congress authorizes construction of the Illinois and Michigan Canal	1822
Construction of Chicago Sanitary and Ship Canal and 5 low navigation locks and dams	1900
Construction of present day system of 7 locks and dams	1933-1939
Kaskaskia River:	
Congress authorizes navigation project	1962

The River and Harbor Act of 1878 constituted the first comprehensive plan to improve navigation through the authorization of a 4½-foot channel from the mouth of the Missouri to St. Paul. The 4½-foot channel was to be achieved by closure of side channels, bank revetment, and contraction of the channel by wing dams (which were low structures extending laterally from the bankline into the river to constrict low-stage flows). The 1907 River and Harbor Act authorized a 6-foot channel on the upper river. The depth increase over the 4½-foot project was to be obtained by construction of rock and brush wing dams. Normally, the bankline opposite the wing dams was protected with rock revetment or riprap to prevent erosion by currents redirected by the dikes. In addition, Lock and Dam 19 at Keokuk, Iowa was constructed as part of a hydroelectric facility in 1914, and Lock and Dam 1 at Minneapolis was completed in 1917 as part of the 6-foot channel navigation project.

In 1927, in response to increased traffic and a demand for deeper draft vessels on the river, Congress authorized the Corps of Engineers to obtain and maintain a 9-foot navigation channel, 300-feet wide, within the Mississippi River from St. Louis to Cairo using additional regulating works and bank protection. Adequate channel depths for the earlier 8-foot channel on the Middle Mississippi had proved difficult to obtain and maintain, particularly in the crossing sections between bendway pools. As a result, dredging had been required on many of the crossings. It was assumed that a 9-foot minimum depth channel could be obtained through the construction of additional contraction dikes to constrict the river to widths ranging from 2500 to 2000 feet. By 1944 most of this contraction work had been completed; however, dredging was still required to maintain project depth. Development of the project has been evolutionary with annual reports submitted to Congress.

In 1930 Congress authorized the extension of the 9-foot channel project to include the river from the mouth of the Missouri to St. Paul. However, the approach authorized by the River and Harbor Act of 1930 was radically different from the contraction efforts of the 4½-foot and 6-foot channel projects.

The authorizing legislation provided for a 9-foot navigation channel, 300-feet wide, to be achieved by construction of a system of locks and dams, as well as supplemental dredging to maintain the channel.

Before construction of the locks and dams system, the river bottoms were primarily wooded islands. The islands also contained some hay meadows and small farming areas. Deep sloughs were the rule, but hundreds of lakes and ponds were scattered through the wooded area. Marshes were limited to the lakeshores and ditches leading off the sloughs. These marshes often dried up completely. Fish rescue work was a big activity, with crews rescuing fish trapped in bottomland lakes and ponds when the river receded.

In the early thirties, the Corps of Engineers initiated work on the 9-foot channel commercial navigation project. The 9-foot channel project was largely completed between 1930 and 1950 resulting in the construction of 29 lock and dam structures on the Mississippi River. The resulting impoundments abruptly changed the riverine ecosystem into a series of pools, with relatively stable water levels.

In each of the pools, three distinct zones occur. The upper end of each pool is in essentially the normal river condition where the water levels were not raised to any large extent. In this portion of the pools, marsh development is limited and the old conditions of deep sloughs and wooded islands are found. In the middle portion of each pool, impoundments backed up water over islands and old hay meadows, spreading out over large areas of comparatively shallow water. It is in the middle portion of the pools that the best marsh development occurred. Immediately above each dam, the water was impounded to a depth which precluded marsh development; at present, this area is essentially deep, open water with practically no marsh.

These impoundments created valuable habitat and protected it from the rapid rate of agricultural encroachment through private levee building and bank stabilization which, over time, has significantly reduced similar areas that were not subject to some form of land use control. However, even this habitat is not totally immune to change, as man-induced activities and natural forces, such as flooding, continue to alter this resource base. Over time, natural and man-induced sedimentation has, and is, effecting changes in the system. Backwater areas are being filled in some areas, and will eventually succeed into marsh or bottomland hardwood habitat. In other areas, scour has resulted in the deepening of areas and the attendent loss of marsh as terrestrial vegetation. Overall, the trend appears to be toward more terrestrial and wetland habitat at the expense of aquatic habitat. It must be noted, however, that in the absence of the navigation project and the Federal acquisition of lands within the project limits, the river system might have been subjected to even greater perturbations.

Two extensive wildlife refuges are located on the Mississippi River. The Upper Mississippi River Wildlife and Fish Refuge, authorized in 1924, extends from Wabasha, Minnesota, mile 760, to Rock Island, Illinois, mile 490. The Mark Twain National Wildlife Refuge, established in 1958, covers the area from Rock Island, Illinois, mile 490, to St. Louis, Missouri, mile 195. About 227,000 acres of refuge lands are distributed along 534 miles of the Mississippi River. The river valley is well known for its value as a migratory corridor for birds, especially waterfowl, which are of international significance.

Development of the Illinois River for navigation purposes began in 1822 when Congress authorized the construction of the Illinois and Michigan Canal. This canal, completed in 1848, enabled mule drawn barges to travel between Lake Michigan and La Salle. The Chicago Sanitary and Ship Canal, completed in 1900, replaced the Illinois and Michigan Canal as far south as Lockport. Constructed primarily for diluting Chicago's sewage, the canal diverted water from Lake Michigan at Chicago into the Illinois River. Diversions have ranged from an average of 500 cubic feet per second (cfs) to a maximum of 10,000 cfs. Presently the legal diversion limit from Lake Michigan is an average annual of 3,200 cfs.

Construction of a modern lock and dam

system on the Illinois was basically completed in 1939 with a final lock and dam constructed in 1965. A total of eight navigation locks operate on the Illinois River and Waterway. Lock and Dam 26 at Alton controls depths and velocities on the lowest segment of the Illinois at normal stages.

The Kaskaskia River navigation project was authorized by Congress in 1962. The Kaskaskia is a canalization project. A single lock and dam near the mouth and two major upstream reservoirs provide adequate flows for navigation. Construction of the project was accomplished by enlarging the main channel, making overbank cutoffs to eliminate sharp bends, altering bridges, and placing riprap on banks to prevent erosion and sedimentation. The canalization and disposal of dredged material caused destruction of bottomland hardwood and riffle habitat.

There are no lock and dam structures on the Minnesota, St. Croix, or Black Rivers.

WATER QUANTITY AND QUALITY

The quantity of water flowing in the Upper Mississippi River System has a direct impact on the quality of water, fish and wildlife, navigation, and other water related or water enhanced activities. Flows of the rivers are affected by natural events and human activities. River flows fluctuate with seasonal variations in rainfall occurring throughout the Basin. Spring flows are affected by rainfall, the amount of ice in the river and snow on the ground, and the timing of its melt. Land use practice, the construction of levees, and the operation of locks and dams also affect stream flows.

The relatively low rainfalls of late summer and fall contribute little water to the River. Base flow provided by groundwater becomes the major water source for the River. The presence of prolonged low flows in the River, due to sparse rainfall within the Basin, can limit the beneficial use of the River. When low flows occur water quality standards may not be met. This can have adverse impacts on public health, fish and wildlife, and water-related activities. Low flows can also affect navigation capability.

Surface water quality problems occur in many locations throughout the Upper Mississippi River System. The most serious problems on the Mississippi occur between Minneapolis and Lock and Dam 2, south of Clinton, Iowa, and below the St. Louis Metropolitan area. The Minneapolis-St. Paul and St. Louis regions have problems with excessive amounts of toxic metals, turbidity, and low dissolved oxygen (DO). South of Clinton, Iowa, toxic metals and turbidity values are high and some local problems exist with low DO and high PCBs in fish.

The entire Illinois River has lower water quality than the Mississippi River main stem. The Chicago area -- including the Chicago River System and the Calumet-Sag System -- has extremely poor water quality. Standards for turbidity, DO, toxic metals, fecal coliforms and biochemical oxygen demand (BOD) are exceeded. Problems with DO, toxic metals and turbidity persist throughout the Illinois River.

Point sources are single-location sources of material that are capable of polluting the river if not treated. Point sources in the UMRS are many and varied, but are for the most part industrial facilities, power plants and municipal wastewater treatment plants.

Some of the largest sources are wastewater treatment plants in the Minneapolis-St. Paul, St. Louis, and Chicago areas, power plants in several parts of the system, and large steel, oil, and chemical facilities in the St. Louis and Chicago areas.

Because of the enormous size of the UMRS and the large flow at any given point, point discharges are miniscule by comparison. It is generally accepted that treated point sources of discharge are not the dominant factor influencing the overall water quality of the system, although localized problems may occur. In general, nonpoint pollution is a serious problem in the Upper Mississippi River System and nonpoint pollution inputs are often much greater than point pollution sources.

The most severe water pollution problems attributed to nonpoint pollution in the UMRS are excessive loadings of suspended solids and sediment and the contamination of sediments by toxic materials. Sediment yields range from 10 to 500 tons/mile^2/yr in the northern portion of the basin to yields exceeding 6000 tons/mile^2/yr (0.06 inches/year) in the south. Major sediment sources are cropland, construction sites, streambanks, and localized mining areas.

Other problems associated with nonpoint pollution of the system include siltation and sediment accumulation in backwaters of the UMRS, increased rates of eutrophication attributed to increased nutrient levels, pesticide and toxic metal inputs, and contamination resulting in general impairment of the major beneficial uses of the river (recreation, fish and wildlife protection, and water supply).

Organic chemicals of concern in the UMRS include PCBs and some pesticides. Unacceptable PCB levels have been found in the Mississippi River from Minneapolis-St. Paul, Minnesota, to St. Louis, Missouri, and in the Illinois River. The PCB levels in fish in Lake Pepin, Lake Onalaska (Wisconsin), and elsewhere often exceed the FDA standards by more than ten times the existing standards.

BIOLOGICAL CHARACTERISTICS

Construction of wing dams throughout most of the Upper Mississippi River System, the construction and operation of locks and dams on the Upper Mississippi and Illinois Rivers, the canalization of the Kaskaskia River, and developments adjacent to all rivers of the UMRS have altered the riverine environment and created habitat types substantially different from free flowing alluvial rivers.

Habitat types within the UMRS are created by coincident physical, water quality, and botanical characteristics. River position, depth, water surface area, stage and discharge, vegetation, river bottom types, water quality, and the superimposed structural elements within the river define the various habitats. A standardized habitat classification scheme was developed to aid in the study and management of fisheries. The classification scheme incorporates general factors that affect the quality of habitat. The various classes in the scheme define to a large extent the affected environments within the UMRS. Figure II-2 provides a generalized map and discussion of these habitat types.

In addition to the six broad classes of aquatic habitat, there are distinct terrestrial habitat types which provide food and cover for both semi-aquatic organisms and wildlife. The six major classes of terrestrial habitat are:

Marsh Vegetation: This category can be considered the transition zone between open water and terrestrial habitat. Frequently flooded areas of this type support prolific populations of wildlife because of their habitat diversity, available food, and breeding habitat. Many species of birds, amphibians, reptiles, furbearers, and other mammals depend on these areas. Marsh vegetation produce and sustain higher numbers of wildlife than any other land category.

Sand and Mud: Sand and mud is deposited by floodwaters and dredged material disposal. Accreted silt material usually becomes quickly revegetated, however, most sandy areas are essentially sterile and support minimal growth. This habitat acts as loafing areas for waterbirds and waterfowl.

Meadow: These lands support mixed stands of grasses, other mixed forbs and broadleaf weeds. Except for overlap occurring near marsh edges and occasional openings in timber that provide good habitat interspersion, these grassy areas are generally not as productive for wildlife compared to forest lands or marshland. They offer moderate loafing cover for deer and nesting cover for certain bird species.

Forest Lands: Much of the underdeveloped land in the river valley is forest land. Species composition varies from north to south ranging from cypress bottomlands in Missouri to the elm-ash-cottonwood-river birch-silver maple forests found in the middle and upper reaches of the river. Mast producing trees such as hickory, oak, and walnut produce the greatest amount of food for floodplain dwelling wildlife species.

Agricultural Lands: These lands include open areas which are devoted to annual crops, pastures, fallow ground, and fields that show some sign of recent cultivation. These cultivated areas are located on the driest parts of the floodplain. This habitat type is an important food source for mammals. Many of the small rodent-type species make extensive use of this habitat throughout all phases of their life cycle.

Urban Land: This category includes areas dominated by industrial or commercial types of structures and those environs which are greatly influenced by industrial development and urbanized areas. Common industries are grain elevator operations, power companies, fertilizer plants, barge docking and loading areas. Very few species depend on developed land for the completion of any life stage. Use is normally transitory providing resting perch for birds or travel routes for mammals.

Remote sensing via aerial photography, limited field surveys, and map interpretations have provided rough quantitative estimates of these various habitat types for much of the UMRS. Summarized results of these inventories for the Mississippi River are presented in Figure II-3. Because the UMRS is a dynamic system the quantities of the various habitat types are constantly changing. For example, backwater areas are subject to sedimentation and agricultural and urban encroachment resulting in losses to this habitat type. Thus in order to adequately assess these short and long-term changes the inventories must be regularly updated.

Additional descriptions of quantities of habitat types and the variety of fish and wildlife that use these habitat types are contained in the Summary Resource Description Working Papers.

CULTURAL RESOURCES

Cultural resources includes both historic and prehistoric information, objects, places and remains relating to human life, culture, cultural development and activities. The Mississippi River System consisting of important arteries of travel, commerce, and communication gave impetus to significant, numerous, and varied cultural activities and settlements along their shores.

There are a great number of cultural, historic, and anthropological sites along the Upper Mississippi River System which form a continuous chain along the rivers. In fact, portions of the UMRS have the highest density of cultural sites in North America.

The most comprehensive cultural resources inventory in the UMRS was conducted by the GREAT II (Great River Environmental Action Team) Study in pools 11 through 22 of the Mississippi River. Nearly 4,000 historic sites and over 1,000 anthropological sites were identified in that reach.

POTENTIAL WILDERNESS AREAS

There are no designated wilderness lands in the Upper Mississippi River System. Federal and state governments have established programs to protect and preserve lands representative of selected natural environments or which are important to the maintenance of wildlife or vegetation species. In addition to the preservation value of these programs,

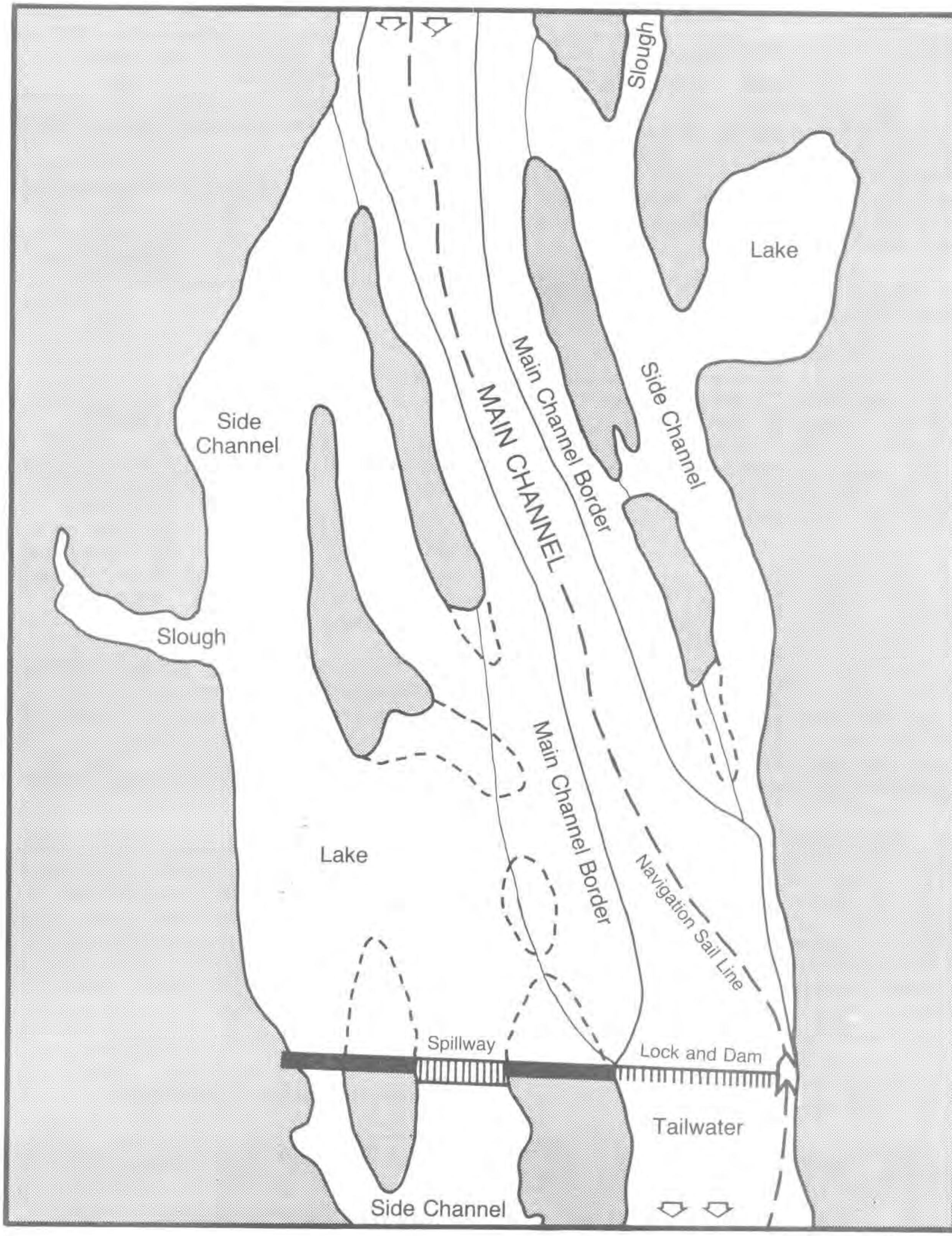


Figure II-2. Aquatic Habitat Types in the Upper Mississippi River System

Description of Aquatic Habitat Types Corresponds with Figure II-2

Main Channel

This includes only the portion of the river through which the large commercial craft can operate. It is defined by combinations of wing dams, river banks, islands, and buoys and other markers. A 9-foot navigation channel with a minimum width of 300 feet wide is maintained. A current always exists, varying in velocity with water stages. The bottom type is a function of current. The upper section usually has a sand bottom, changing to silt over sand in the lower section. Occasional patches of gravel are present in a few areas. The main channel is subject to scouring action during flood periods and by passage of towboats in the shallower stretches. No rooted aquatic vegetation is present.

Main Channel Border

This is the zone between the 9-foot channel and the main river bank, islands, or submerged definitions of the old main river channel. It includes all areas in which wing dams occur along the main channel. Buoys often mark the channel edge of this zone. Where the main channel is defined only by the bank, a narrow border still occurs, and often the banks have riprap. Dredge spoil has been placed in some sections of this zone, sometimes covering wing dams. The bottom is mostly sand in the upper sections of the pools and silt in the lower. Little or no rooted aquatic vegetation is present. This zone provides some of the better fishing along the river at certain times of the year.

Tail Waters

These include the main channel, main channel border, and the areas immediately below the dams which are turbulent due to the passage of water through the gates of the dams and out of the locks. Since these areas change in size according to water stage, an arbitrary lower boundary has been set at a distance of one-half mile below the dams. The bottom is mostly sand. No rooted aquatic vegetation is present.

Side Channels

These include all departures from the main channel and main channel border, in which there is current during normal river stage. The gradations in this category are widespread, ranging from fast flowing watercourses with high banks to sluggish streams winding through marshy areas. Undercut or eroded banks are common along side channels near their departure from the main channel. This occurs mainly in the upper sections of the pools where banks are highest and the current is swifter. Closing or diversion dams are usually present where the side channel leaves the main channel or main channel border, and infrequently at other locations. In the impounded section of the river, these are mostly submerged. The bottom type usually varies from sand in the upper reaches to silt in the lower. In the swifter current, there is no rooted aquatic vegetation, but vegetation is common in the shallower areas having silty bottoms and moderate to slight current.

River Lakes and Ponds

The following types of lakes and ponds can be found in the river bottoms of the UMRS:

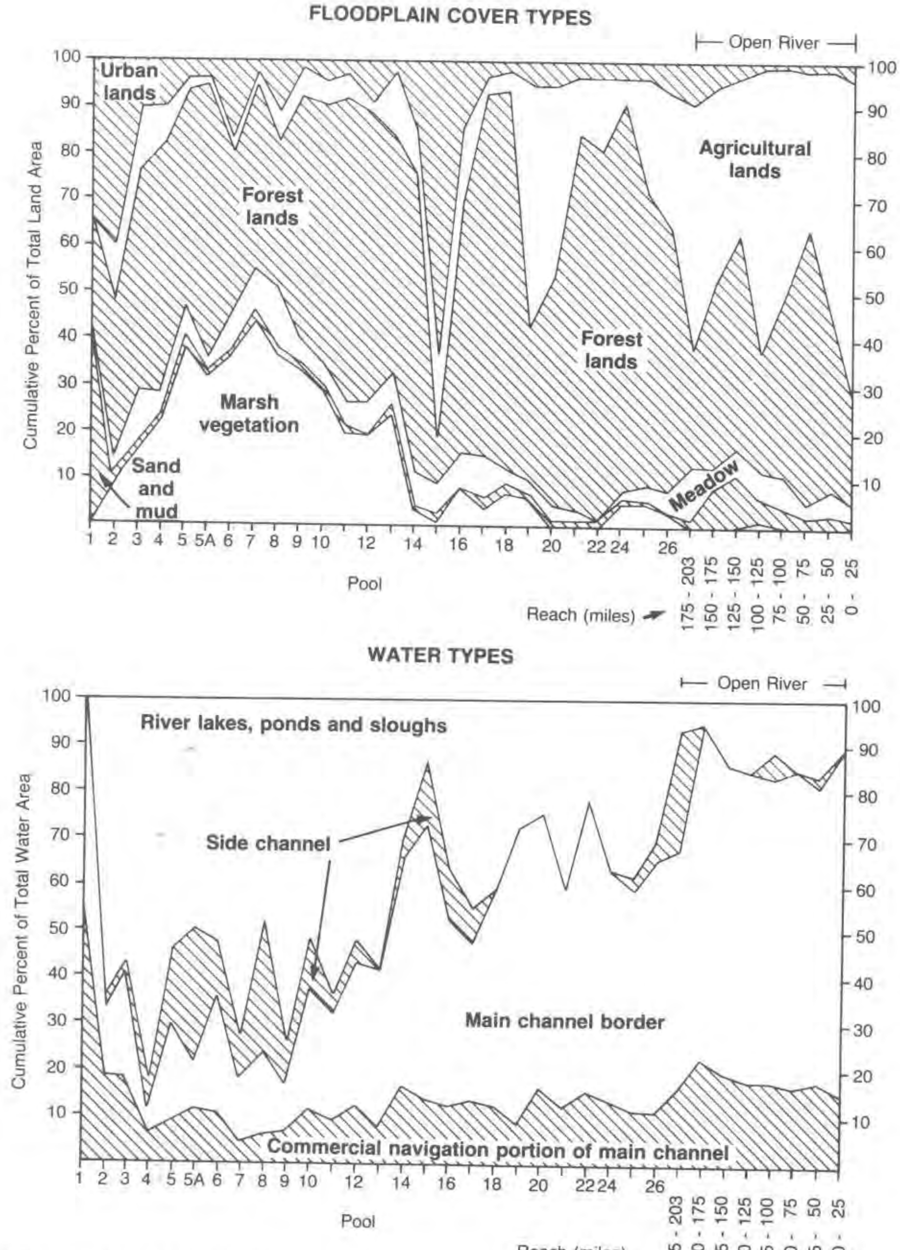
- Lakes of formation due to fluviatile dams: (Lake Pepin, between Minnesota and Wisconsin).
- Lakes of mature flood plains: Oxbows or isolated loops of meanders (Spring Lake near Buffalo City, Wisconsin).
- In depressions formed on flood plains: (Sturgeon Lake in Minnesota).
- Between natural levee and swamp: (Chautauqua Lake in Illinois).
- Lakes due to behavior of higher organisms: Dams built by man (Keokuk Lake between Iowa and Illinois. Large open areas, usually not named, off the main channel and main channel borders just above many of the dams).

In river studies, only those lakes having some connection with the river during normal water stages are usually considered. River lakes and ponds may or may not have a light current, depending on their location. Most of the bottoms are mud or silt, often consisting of a layer two or more feet thick. These waters may have an abundance of rooted aquatic vegetation, both submergent and emergent. They may be surrounded by marshland.

Sloughs

This category includes all of the remaining aquatic habitat found in the river. Sloughs often border on the lake or pond category on the one side and on the side channel category on the other. They may be former side channels that have been cut off, or that have only intermittent flows in them. They may be relatively narrow branches or off shoots of other bodies of water. They are characterized by having no current at normal water stage, muck bottoms, and an abundance of submergent and emergent aquatic vegetation. These sloughs and some of the ponds and smaller lakes are most often representative of the ecological succession taking place in the river bottoms, from aquatic to marsh habitat.

Figure II-3. Relative Distribution of Water Types and Floodplain Cover Types on the Upper Mississippi River



Note: Pools 1 and 2 from 1973 data.
Pools 3 to Reach 0-25 from 1975 data.

they afford people opportunities to understand their environment and its importance through education and scientific programs and in some cases also provide recreational opportunities.

"Primitive," "wild," and Federal Research Natural Area (RNA) are the designations now in use or likely to be used to protect Mississippi River lands. Five national wildlife refuges in the system have been the focus of consideration for wilderness designation. Four Federal Research Natural Areas are located in the Upper Mississippi Wildlife and Fish Refuge. Such designations can be as restrictive as the wilderness designation, but they lack the permanency of wilderness because the federal agency can remove its designation at any time.

Each state has developed a program to identify and protect its scientific and natural areas. These designations typically include lands that cannot be managed by federal agencies because they are not federal lands. Protective controls generally can be applied to state owned land, but not private lands. Protection of private lands can be encouraged, but it is voluntary, unless the state can arrange for legal restrictions through easements, leases, or other arrangements. These state programs are in various stages of completion.

Recreational Resources

The Upper Mississippi River System provides one of the major opportunities for water based recreation in the midwest. Natural vegetation, variable topography, and proximity to water are significant features that enhance its attractiveness for recreational purposes.

A wide range of public recreation opportunities are available. Typical activities associated with these opportunities include trapping, picnicking, sightseeing, fishing, boating, water skiing, sailing, swimming, hunting, hiking, camping, and winter sports. Recreational use intensity is a function of the available physical resources, access, management, and proximity of population centers. The recreational resource is dependent on the physical, biological, and water quality characteristics of any given segment of the system. These characteristics will, to a large extent, determine the types of recreational activities occurring within any given reach. This relationship will not hold true, however, when access is limited or where high urban concentrations are the major factor in determining recreational use intensity and density.

The recreational resources of the UMRS vary considerably between segments of the system. High amenity resources exist within most of the St. Croix and Upper Mississippi River main stems. The St. Croix River is a prime recreation resource and a component of the National Wild and Scenic Rivers System. Proximity to the Minneapolis-St. Paul metropolitan area and clean water result in intense recreational use of this resource. Environmental issues concerning the St. Croix River have centered on preserving and managing the remarkable scenic and recreational qualities of the river.

High public demands for use of these resources in selected reaches of the UMRS are expected to intensify. Much of the System's shoreline is presently privately owned and large sections of the rivers are paralleled by railroad tracks, impeding access. Furthermore, about 75 percent of the Federally-owned lands along the Mississippi are managed for fish and wildlife purposes which may be incompatible with intensive recreational use.

Towns and metropolitan areas exert a high demand on the recreational resource. Currently, Minnesota, Iowa, and the St. Louis metropolitan area are all projecting deficiencies in the availability of access for water-based recreation. This high demand produces intensive use of the resource, especially during weekends and holidays. Conflicts between these users has occurred during high activity periods. Major boating activity occurs in the navigation channel and the main channel corridor. Major hunting and fishing activity occurs along the main channel border and backwaters. Camping, picnicking, swimming and other river-oriented recreation activities occur throughout the system.

The expanse of water created by the locks and dams of the navigation project provided additional opportunities for recreation use and enjoyment of the Upper Mississippi River System corridor. Conflicts exist between recreation use and maintenance of the channel and commercial navigation use. Portions of the navigation pools have very shallow areas and stump fields. While these areas provide good fish nursery and waterfowl areas, they are hazards to the boater unfamiliar with the river. Channel structures, such as wing dikes and closing dams, used to help maintain the navigation channel, also present a hazard to the novice or inexperienced boater.

Beaches created with dredged material have historically received intensive use on the Upper Mississippi River System. They provide primitive types of recreation with make-shift facilities. These beaches are used for camping, swimming, sunbathing, picknicking, and partying. They form base locations for water skiing, hunting, and fishing groups and provide important destination points for recreation visits.

Economic Resources

The Upper Mississippi River System is an integral part of a broad regional, national, and international transportation network. As such, it has played a key role in the economic growth and development of the Upper Midwest and numerous river communities including Minneapolis-St. Paul, the Quad Cities, Dubuque, St. Louis, Peoria, and Chicago. The river system provides an important link in the movement of goods both into and out of America's heartland.

In 1980 the Upper Mississippi River System transported over 126 million tons of commodities. Unconstrained traffic is projected to more than double by the year 2010 (Table II-3). Four commodity groups--grain, coal, chemicals, and petroleum products--constitute 75 percent of all waterborne tonnage in the region.

Agricultural products, particularly grain, are the primary commodities moving out of the eight-state crop-growing region served by the rivers, including Illinois, Indiana, Iowa, Minnesota, Missouri, North Dakota, South Dakota and Wisconsin. Corn, soybeans and wheat comprise nearly 40 percent of the traffic originating on the system (33 percent of the total traffic).

Following the trend of the last two decades grain is projected to account for an increasing share of future traffic, due to a number of production and export factors, including:

a) a 22 percent increase in the amount of available cropland used for harvest, from 56 percent in 1980 to 73 percent in 2000 and beyond,

b) continuing increases in the average harvest yields per acre from 1980 to 2040 for corn (+46%), soybeans (+28%) and wheat (+62%),

c) no significant increase from 1980 levels in domestic consumption of cash grains on a per capita basis,

d) continuing increase in the export portion of the disposition of cash grain production, and

e) continuing increase in the waterway traffic share of grain shipments as a percent of production, from 27.2% in 1980 to 41.3% in 2040.

Table II-3. Summary of Unconstrained Waterborne Commodity Projections

Commodity Group	Annual Tonnage and Percent of Total Commodity Movement				
	1980[1/]	1990	2000	2010	2040
	(Million Tons)				
Grain	48.8 (38.6%)	69.5 (39.9%)	98.5 (43.8%)	119.1 (46.5%)	138.3 (46.8%)
Coal	16.4 (13.0%)	27.9 (16.0%)	35.9 (16.0%)	40.3 (15.7%)	44.1 (14.9%)
Chemicals	8.3 (6.6%)	14.5 (8.3%)	20.7 (9.2%)	23.8 (9.3%)	29.3 (9.9%)
Petroleum Products	21.2 (16.8%)	19.8 (11.4%)	19.8 (8.8%)	19.5 (7.6%)	19.5 (6.6%)
All Other	31.5 (25.0%)	42.6 (24.4%)	50.0 (22.2%)	53.3 (20.8%)	64.3 (21.8%)
Total	126.1	176.5	224.9	256.0	295.5

1/ Approximates lock traffic by commodity group based on Corps of Engineers Performance Monitoring System (PMS) Lock Data

The river system also provides a major artery for the transport of bulk commodities into the region for industrial production. Coal alone accounts for over 30 percent of the traffic terminating on the system or 18 percent of total traffic. Coal and chemicals are projected to increase in terms of percentage of total traffic. Petroleum products are expected to show an actual decline as well as a sharp percentage decline in their future commodity share.

The river system is a vital source of water supply for domestic and manufacturing purposes. Recreation activities, waterfowl hunting, sport and commercial fishing and commercial trapping are also valuable to local and regional economies.

Chapter III. System Objectives and Issues

During the development of the Master Plan the term "objectives" has been used in two different contexts with two different meanings. The initial phase in any planning effort is the statement of objectives, problems, needs, or opportunities. These are often referred to as study objectives. That is, what is the study or plan process going to achieve as a study result. To a large extent the problem identification phase, or study objectives, of the Master Plan is contained in the legislation (P.L. 95-502) charging the Commission with conducting specified studies to determine the navigation carrying capacity of the system, the environmental impacts of the expansion of navigation capacity, and other specific studies.

In the Master Plan "objectives" is also used in a more specialized way. Although the specific study objectives were stated in the Congressional mandate, the law further directed the Commission to specify "objectives of the system." This can be viewed as an implicit recognition of the problems associated with a river system which serves multiple functions as a major commercial transportation route, an extensive recreational resource and as an area of diverse aquatic and terrestrial wildlife habitats. That problem recognition is drawn from Section 101(c) of P.L. 95-502 which states that "The Commission...shall identify the various economic, recreational, and environmental objectives of the Upper Mississippi River System...".

It was, therefore, recognized by the Commission early in the Master Plan process that due to concurrent development, the system objectives would not provide a framework for the Master Plan technical study goals. The system objectives represent the needs, uses, and perceived opportunities of the public, elected officials, and the governmental entities responsible for the UMRS resources. These identified objectives are not simple needs to be provided for by a single study. They are in fact statements of the many and often competing uses of the river system which decision-makers and resource managers must continually consider in each future resource decision within the UMRS.

System Objectives

The Upper Mississippi River System has two national purposes mandated by Congress. Federal policy is reflected in both the authorized responsibility of the Department of Interior for fish and wildlife management, and the authorized responsibility of the Department of Army for operation and maintenance of the navigation system. In addition to these two specific purposes, the UMRS provides a diverse array of opportunities and experiences making it a unique multi-purpose system.

It is also recognized that objectives for the river system are not the sole propriety of government but are shared by the users of the system. The users range from commercial interest and organized special interest groups to the individual citizens who utilize the river resource. In order to identify the objectives of the system, the two primary Federal objectives were considered in conjunction with various Federal and State management policies. An extensive effort was made to identify objectives through a process of inventorying State and Federal authorizations and policies as revealed in Legislative mandates, policy statements, reports, plans, and studies, and private and public group's concerns revealed in by-laws, letters, and published materials.

The process used to identify the system objectives was a comprehensive evaluation and integration of statements made by various actors within the Upper Mississipi River Basin. The process was designed to identify a set of system objectives based on as much information as possible and which represents a diversity of actors and agencies.

The initial step of the objective identification process was to obtain reports, letters, and other statements regarding the use of the Upper Mississippi River System. Approximately 2,000 documents were collected, representing views of about 550 government agencies and private organizations.

To facilitate an organized retrieval of data to formulate objectives, information from the documents was coded for entry into a computerized system. A team of readers identified statements of use, need, and conflict and recorded these statements by author, geographic area, and subject area. In all, about 7,000 statements were entered into a permanent computer data file, which allows data to be retrieved according to specified criteria.

From the data base, specific objectives for each pool of the river by individual author were identified. Over 8,000 objectives were identified in 33 subject (or functional) areas within the categories of economics, environment, and recreation. The functional objectives were reviewed and evaluated as to their applicability to the entire UMRS. The functional objectives were examined for similarity and differences and were synthesized into a small set of objectives of the system. Analysis of the diverse objectives yielded many common perspectives in some functional areas. Planning and implementation objectives, as well as areas of conflict, were formulated for different functional areas. Recurring and similar statements were further examined and synthesized into a set of 16 system objectives, or "objectives of the system," representing the collective perspectives of the river system's community (Table III-1).

These statements are considered to be systemwide objectives. Variable resource characteristics, localized uses, and localized management priorities influence their interpretation on a site-specific basis. The degree to which each objective may be pursued or the necessary management actions to achieve the objectives will vary for different reaches of the system. However, these objectives are broad statements of goals for the Upper Mississippi River System.

Table III-1. System Objectives

Economic Objectives

- To meet the future demand for the movement of goods through development and maintenance of a dependable and efficient transportation system which makes wise use of our Nation's resources including energy.
- To provide those economically justified commercial navigation improvements and expansion projects which are found to be needed and of advantage to the nation's total transportation system.
- To encourage economic and energy efficient site selection and facility design for commercial and industrial activities.
- To minimize the potential for flood damage and reduce the economic impact of flooding.
- To ensure the reliable and equitable delivery of water for consumptive and nonconsumptive uses.
- To achieve efficient, safe, and reliable forms of water-related energy reduction.
- To ensure the viability of commercial fishing, clamming, and fur-trapping enterprises.
- To achieve the wise use of agricultural, forest and urban lands.
- To ensure the economic viability of recreation such as boating, camping, fishing, hunting, and sightseeing.

Environmental Objectives

- To maintain and improve the quantity and quality of physical and biological resources which contribute to aquatic and terrestrial wildlife habitat.
- To provide fishable and swimmable waters and protect the system's water from future degradation.
- To preserve and protect unique physical, biological, and cultural resources of the system.
- To protect and enhance environmental resources which may be affected by existing and future operations and maintenance of the navigation system.

Recreation Objectives

- To maintain and improve the quantity and quality of physical, biological, and cultural resources which contribute to recreational experiences.
- To provide improved access to the river system for water and land based recreation.
- To provide a greater degree of safety for water based recreation.

Issues

The system objectives by their very nature are often conflicting or in competition. Competing demands are placed on the river system for a variety of purposes and by a multitude of users. Competition is not the intent of the user but is the result when one portion of the system or one aspect of the system has the capability to satisfy different objectives singularly but not totally when in combination. When such competition or conflict exists or develops it becomes an issue not only for the users but for the responsible management entitites.

Numerous past and ongoing studies have dealt with issues of both immediate and long-range concern. Among the many issues are those related to the scope of the Master Plan as defined in P.L. 95-502 and those which are only indirectly related or unrelated. The nine issue areas addressed are intended to represent those aspects of the system objectives which are germane to the focus of the Master Plan.

- Natural Recreation Environment
- Water Recreation Access and Recreational Boat Lockages
- Recreational Boating Safety
- Commercial Navigation
- Industrial and Port Site Selection
- Energy Development
- Maintenance of Habitats
- Unique Areas
- Channel Maintenance of the Navigation System

To better prepare responsible entities to address these issue areas, questions concerning the capability of the management system to resolve conflicts and appropriately manage system resources were assessed. The following issues thus serve as a basis for the evaluation of the present institutional system and alternative systems discussed in Chapter IV.

NATURAL RECREATION ENVIRONMENT

The Upper Mississippi River System provides one of the major opportunities for diverse water based recreation in the upper midwest. Variations in vegetation, topography and unique scenic areas are significant features that enhance its attractiveness for recreational purposes. To maintain the quality of recreational experiences on the system, it is desirable to maintain and enhance this diverse environment that makes recreational opportunities so attractive. However, the maintenance of this environment may produce conflicts with the growing needs for developing facilities related to industrial, intensive recreational, and commercial activities. These conflicts may relate to both the development of riparian lands and use of river.

WATER RECREATION ACCESS AND RECREATIONAL BOAT LOCKAGES

Recreational boating on the Upper Mississippi River System is very popular. Opportunities may be limited, however, due to insufficient or inadequately distributed access points. Some high amenity areas suffer from overcrowding. The recreational use of some pools is limited because of insufficient land access and delays at locks. Overcrowding and long delays occur at lock facilities during periods of peak commercial and recreational use. In part, this issue is one of maintaining and expanding recreational facilities and access points.

RECREATIONAL BOATING SAFETY

An overall increase in boating will cause more localized crowding and result in an increased burden upon enforcement capabilities. Unsafe recreational boating practices such as speeding, drinking, and recklessness around locks and in other areas of the rivers are key items of concern. In addition, incompatible recreational uses, such as swimming, water skiing, and fishing, can create safety hazards.

COMMERCIAL NAVIGATION

The navigable portion of the Upper Mississippi River System is an integral part of a broad regional, national, and international transportation network. Commercial transportation demands on the UMRS can exceed the system's physical capacity and create problems of congestion and delay. As part of a multimodal transportation system, capacity, demand, and investment decisions for the waterway are very complex. Tow traffic and channel maintenance activities can have an adverse effect on environmental resources and recreational opportunities.

INDUSTRIAL AND PORT SITE SELECTION

As part of a vast multimodal transportation network, the Upper Mississippi River System supports industrial facilities, terminals, and ports. Access to water transportation is important to the economic vitality of the agricultural community and other industrial and commercial activities. Land requirements for intermodal transfer facilities and related port developments may compete with other industrial needs or with needs for environmental resource protection. The selection of appropriate sites and development requirements which minimize these conflicts is a complex and intricate management problem for the regulatory and permitting processes.

ENERGY DEVELOPMENT

Due to the projected increase in the area's population and associated commercial and industrial development, demand for electricity is expected to increase substantially in the future. The river system has both existing and potential

roles in the region's energy needs. It presently provides for transport of coal for power production, and a source of cooling water for the generation systems. The development and siting of energy facilities in a manner compatible with the maintenance of environmental quality are of continuing importance. In addition, the increases and shifts in both regional and national population induce changes in energy distribution patterns and needs. With these changes new energy transmission and distribution needs as well as production needs will occur. The recognition and consideration of these needs by related land and water users is of increasing importance.

MAINTENANCE OF HABITATS

The Upper Mississippi River System provides habitat for numerous fish and wildlife communities. Various habitat types have been destroyed as well as created by natural processes and human alteration of the system. Navigation activities, floodplain land use, sedimentation, and recreation activities may conflict with the maintenance or enhancement of aquatic and terrestrial habitats.

UNIQUE AREAS

The Upper Mississippi River System possesses a wide range of unique, critical, and scenic areas along the river's corridor. In some cases the development of land for industrial, residential, and recreational uses has contributed to a loss or degradation of unique areas. In the competition for utilization of corridor lands, the unique cultural, historic, and scenic values of many areas may be threatened.

CHANNEL MAINTENANCE OF THE NAVIGATION SYSTEM

In order to maintain a 9-foot navigation channel, it is necessary to periodically remove deposited sediments from the channel bottoms. However, the method and location for the disposal of this material is an ongoing issue. Placement of dredged material in certain locations may result in damage to wetland habitats and water quality. Thus the search for disposal sites and methods which minimize environmental damage is an ongoing issue which must be addressed in the management of the system.

A KEY TO MANAGEMENT NEEDS

By reviewing and analyzing the management aspects of the identified issues, management needs as perceived by the Commission were defined. In order to ensure that these issues can be adequately dealt with in both the near and long-range future, Federal, State, regional and local management authorities and practices were evaluated.

The issues which were defined provide the key to identifying the management capabilities which are necessary to describe and evaluate the aspects of competing uses of the river system. More importantly they identify the critical aspects system objectives which were evaluated both locally and regionally, as well as, from a national perspective.

The identified objectives of the system and the Master Plan related issues within these issues provide a primary set of criteria in developing and selecting institutional and management arrangements for the Upper Mississippi River System.

Chapter IV. Institutional Arrangements for System Management

The Master Plan undertook a study to explore alternative management arrangements. The alternatives must be responsive to the study participants' perceived needs related to the identified system objectives, to the conflicts between competing objectives, and to implementation needs of Master Plan recommendations.

The objective was to evalute institutional alternatives to satisfy the need for sound management of the river resource recognized by Congress in P.L. 95-502 and by the Commission. The study recognizes the need for State and local governments' management responsibilities to be blended with Federal responsibilities for future management of the river system's resources.

During the course of this study, data inventories, bibliographies, working papers, and preliminary analysis were prepared. The material presented in this chapter is highly summarized and focuses primarily on study results. A complete list of data sources, technical papers, contractors' reports, and working papers which were prepared as part of the Master Plan Study effort are listed in the section of this report entitled Master Plan Study Documentation - Technical Reports and Working Papers.

Characterization of Present Management System

In order to better define current and future management needs and develop feasible alternatives for meeting those needs, it is important that the existing management system is understood. How the present system manages conflicts; initiates programs; and coordinates activities, plans, and regulations are all elements of a characterization of the present management system.

The initial characterization of current management arrangements for the Upper Mississippi River System was refined through analysis of Federal, State, and regional laws, authorities, and program documents. The characterization was used to evaluate existing management arrangements with respect to system objectives, perceived resource management needs, and the institutional needs for implementation of resource management actions recommended by the Master Plan.

In order to evaluate modified, existing, or new institutional arrangements to resolve resource management problems in the Upper Mississippi River System it was necessary to develop an evaluation process. The process can be described in three steps.

In Step 1, resources management problems and issues in the Upper Mississippi River System (UMRS) were identified. Sources of information included, but were not limited to:

- GREAT I, Study of the Upper Mississippi River (plus Appendices)
- GREAT II, Study of the Upper Mississippi River, Draft May 1980
- Draft Report on the Upper Mississippi River Main Stem Level B Study, June 1980
- Annual Priorities for Fiscal Year 1982 (UMRBC), June 1980
- U.S. Water Resources Council - Improving the Planning and Management of the Nation's Water Resources, 1980
- Master Plan, Citizen Review Council (CRC) Round 1, Delphi Results, September 1980
- National Waterways Study - Water Transportation Users (Review Draft), April 1980

These problems and issues were reduced to a list of statements germane to the UMRS as grouped into three broad areas which reflect the groupings in P.L. 95-502. The general categories of problems and issues statements are as follows:

RECREATION
- I. Natural recreational environment
- II. Recreation boat access and lockages
- III. Boating safety

ECONOMIC
- IV. Commercial navigation
- V. Industrial and port site selection
- VI. Energy development

ENVIRONMENT
- VII. Maintenance of habitats
- VIII. Unique areas
- IX. Channel maintenance of the navigation system

In Step 2, this list of perceived problems and issues statements served as a basis for determining how the existing management system can and does work. Each agency with regional and/or system-wide resources management capabilities (defined broadly to include a range of functions from coordination and planning to regulation and enforcement) was identified and reviewed for the role it plays in addressing UMRS issues.

In Step 3, an assessment and a list of priority issues were developed which included detailed potential management need statements corresponding to each problem and issue statement. Each assessment and statement either indicated a need for more management capability or indicated that the existing arrangements were appropriate to meet the system needs. The management need statements served as a major part of the criteria for the design and evaluation of institutional arrangement alternatives.

Development of Institutional Arrangements

Alternative institutional arrangements were developed with these criteria. Alternatives were designed to provide the decision information for more detailed evaluation. For each alternative, ten items of key decision information were displayed and evaluated. This involved:

- Purpose: The overall scope and intent of the organization.
- Geographic Coverage: The area involved in river management.
- Authority/Functions: Activities the organization is authorized to perform; responsibilities of the organization.
- Organizational Form/Structure: The structure or framework through which the organization operates; where decision are made, advice and assistance originate.
- Representation: Membership of the committees and coordinating groups; how members are selected.
- Charter: Sources of authority (e.g., interstate compact, federal- interstate compact, interstate agreements, executive order, memoranda of agreement, etc.)
- Funding Structure: Mechanisms utilized to finance the organization; sources of revenue, sponsoring entities.
- Staffing: Manpower requirements for the organization; staff size and location (e.g., regional agency, shared staff of existing agencies).
- Conflict Resolution: Methods used by the organization to work with entities, either within or outside of the member parties, to resolve conflicts. Plan preparation, policy statements, standards, guidelines, and coordination sessions are example conflict resolution mechanisms.
- Planning Approach: Approach to plan preparation, relationship of river basin plan to other planning; responsibility of the organization in plan preparation and implementation.

Institutional Arrangement Alternatives

In the Preliminary Plan document January 1, 1981, an initial broad array of conceptual alternatives was presented. These alternatives provided a range of institutional/management capabilities, beginning with a very limited voluntary coordination approach, and moving through progressively more structured and capable organization arrangements. As a result of the evaluation process, five Prescreened Institutional Arrangement Options were selected for more study. An analysis framework was developed and careful attention was given to problems and issues, objectives and management needs which were consistent with the Master Plan Study requirements. The existing institutional arrangements were studied concurrently with the analysis of problems, issues, objectives, and arrangement needs.

As a result of this study effort and related reviews a report, "Alternative Institutional Arrangements for UMRS Systemwide Resources Management" detailed and compared six arrangement options. These options were further reviewed and revised. As a result institutional management needs in the UMRS were described with two alternative arrangements: the Base Condition and a State Coordinative Arrangement. While initial study analysis was oriented toward decision-making for the system, the studies led to the conclusion that certain political decisions could not be made by any regional entity.

BASE CONDITION OPTION

The Base Condition Option depends upon existing agencies to execute their programs to carry out local and systemic functions (Table VI-1). Each agency can strengthen existing programs by modifying

Table IV-1. Institutional Arrangement Alternatives for Systemwide Water Resources Management

	Base Condition	Coordinative Arrangement
Purpose	Utilize existing authorities in Federal, State, and regional agencies to provide solutions to accommodate water resources management needs.	Utilize new arrangement to focus intra-regional and national attention on specific regional water resources management needs.
Geographic Coverage	Upper Mississippi River System	Upper Mississippi River System
Charter	No new authorization is necessary. Utilize existing authority to provide systemwide perspective.	Concurrence by governors to establish a State Coordinative body.
Organization and Membership	State and Federal agencies provide systemwide perspective through organization and membership arrangements established under current authority for various projects.	Level 1 - Governors Council with governors or their designee as members.
Committees	Established as needed by agency responsible for individual projects and programs.	Standing or ad hoc committee involvement as determined by Board of Directors.
Funding	Agency funding from regular program or project appropriations.	Carry-over UMRBC funds initially and state allocations.
Regional Agency Staff	Coordination activities will be staffed by responsible agency.	Maximum of 5 to 10 technical and support staff.

agency priorities, budgets, and program emphasis to focus upon the UMRS needs. Many modifications can be made within the current institutional framework (i.e., base condition) to improve the effectiveness of the current framework to deal with UMRS systemic issues. For example, joint agency reviews in permit processing and coordinative committees have been established within the existing institutional framework. Multiple reference points could be established through the federal agency programs and the independent coordinative mechanisms (e.g., Minnesota-Wisconsin Boundary Area Commission) to help provide a common focus for UMRS management.

Advantages and disadvantages were considered for both options. A brief description of the Base Condition advantages includes, but is not limited to:

1) Laws and authorities (for the most part) currently exist to provide the necessary management in the UMRS. With increases to annual budgets agencies could under existing authority provide staffing and programs sufficient to meet the management needs of the UMRS. Recognition by Congress for systemwide approach would allow currently active agencies to effectively utilize these existing laws to provide this management.

2) Government is presently perceived as "too big" by many sectors of the public. The Base Condition does not require any additional layers of government.

3) Legislative requirements for implementing the base condition option as the arrangement for systemwide management are minimal.

Relatively easy implementation, low cost, and the lack of new governmental layers are conditions that a base condition would satisfy. In contrast, however, the disadvantages of this approach are as follows:

1) This alternative would place the emphasis for systemwide program orientation on Federal programs, but does not insure the formalization of a systemwide perspective for the States of the UMRS.

2) In order for the base condition to function on a more systemic basis, a reorientation of priorities among existing Federal and State programs would be required. This reorientation could adversely affect other agency programs.

COORDINATIVE ARRANGEMENT OPTION

This option provides a coordination-communication mechanism for States and Federal agencies involved in UMRS issues. This option could be structured as a non-profit corporation (building on state incorporation laws) of the five states of the UMRS. Membership would be in the name of the Governors of these States (comparable to shareholders). Federal membership could also be invited, to include Federal agencies. State Governors and appointees of these Federal agencies would participate in the key UMRS management decisions.

Operating and business actions of the Coordinative Arrangement Option would be under the direction of a Board of Directors who are appointed as designees by each governor. These state representatives would be voting members of the Board. Day to day operations would be conducted by a small permanent staff that would occupy centrally located office space. Funding for the operation would be provided by or through member states.

The programs of the U.S. Department of Army, U.S. Fish and Wildlife Service, and U.S. Environmental Protection Agency would carry out their UMRS management and operations in cooperation with the states. The Coordinative Arrangement would provide a centralized state coordination point for the Federal agencies.

The advantages of this coordinative arrangement are:

1) It provides the necessary focus for addressing systemic issues in the UMRS. The focus is provided through the cooperative efforts of the States with input from

Federal agencies as these program needs arise.

2) The approach does not represent a dramatic shift of authority. It, furthermore, is built upon the base condition.

3) The implementation of a coordinative arrangement, such as this, could be accomplished through the use of a nonprofit corporation. Legislative changes would not be necessary.

4) As a State-oriented arrangement, this option would provide a mechanism for States to take a more direct role in regional (multi-State) river management concerns. Expanded regional institutional arrangements could originate from this cooperative base.

Its disadvantages include:

1) The cooperative arrangement is limited in scope. It provides a forum and a means for interagency and intergovernmental communications, but falls short of providing broad-based river management functions such as planning and plan implementation.

2) The cost of maintaining a technical staff may influence the attractiveness of this option. Considerable variability exists with respect to staff size, as determined by its functions and responsibilites. Whether the agency should include a technical assistance/data management orientation or be limited to a coordination/communication role would have to be decided.

The basic distinction between the two options is the degree to which the States wish to formalize coordination and input (as a group) in regional decisions. Another distinction is the degree to which both the State and Federal agencies desire to formally institutionalize a systemwide perspective in river management issues. The need to provide some focus for UMRS management and for formal State-Federal coordination to large extent is determined by the resource management recommendations developed by the Master Plan.

FUTURE MANAGEMENT

With the completion and implementation of the Master Plan, under the Base Condition or Coordinative Arrangement, systemwide management issues will continue to arise and change. Two additional options were also considered as potential long-term arrangements: a Federal Interstate Compact and a River Basin Commission (structured along the lines suggested by H.R. 3432 or S. 1095). These options were developed in less detail than the Coordinative Arrangement option, since it is not likely that these options can be implemented immediately. These options could have greater decision making capability and authority for implementation of management recommendations. These two arrangements are structured to reflect two basic resource management approaches.

- Federal Interstate Compact - To address a specific resource management need such as systemwide transportation and related water resource issues.

- River Basin Commission - To address broad water resources coordination and planning needs, to provide a forum for discussion and to promote resolution of systemwide problems.

Chapter V. River System Resource Management Studies

The studies conducted pursuant to P.L. 95-502 provided the basis for formulating a comprehensive Master Plan for the Management of the Upper Mississippi River System. As described in Chapter I, these studies were conducted under the direction of lead agencies and the guidance of work teams. This chapter describes the study approach, results, and conclusions of each of the studies undertaken in the five major study areas.

- Navigation/Transportation
- Environmental Studies
- Dredged Material Disposal
- Computerized Inventory and Analysis System
- Public Participation and Information

During the course of each of these studies data inventories, bibliographies, working papers, and preliminary analysis were prepared. The material presented in this chapter is highly summarized and focuses primarily on study results. A complete list of data sources, technical papers, contractors reports, and working papers which were prepared as part of the Master Plan Study effort are listed in the section of this report entitled <u>Master Plan Study Documentation - Technical Reports and Working Papers.</u>

Navigation Transportation Studies

The Navigation/Transportation studies of the Master Plan were designed in response to five major studies mandated under P.L. 95-502:

- To determine the navigation carrying capacity of the Upper Mississippi River System,
- To determine the transportation costs and benefits to the nation to be derived from any expansion of navigational capacity of the system,
- To determine the effects of any expansion of navigational carrying capacity on the nation's railroads and shippers dependent upon rail service,
- To determine the relationship of any expansion of navigational carrying capacity to national transportation policy,
- To evaluate the economic need for a second lock at Alton, Illinois.

The studies of navigation carrying capacity including the costs and benefits of expansion and the economic need for a second lock at Alton are interrelated. In response to these questions, an integrated analytical process was developed. The study is based on the assessment of system-wide improvement scenarios. Each of the scenarios consists of different combinations of indiviudal measures for increasing lock capacity. The study approach including assumptions, input data, and evaluation process, as well as the results of the evaluation, are presented in the following sections.

ANALYTICAL APPROACH

Waterway system capacity can be thought of as the quantity of goods transported at tolerable levels of delay. Waiting time at locks plus lock service times produce delays far greater than any other constraints. Thus lock delays effectively control system capacity and "lock capacity" is the central variable. There are three definitions of lock capacity used in the Master Plan:

- Existing Operational Capacity - the limits of tonnage thruput for each lock, together with other system constraining points, measured in terms of collective lock capacities to arrive at a system capacity. Within this definition, capacity varies with commodity mix and traffic origin/destination patterns. For example, upbound/downbound balance and barge configurations by commodity affect the tonnage thruput.
- Non-Structural Operational Capacity - the limit of tonnage thruput at a lock with one or more non-structural features added (capacity improvements excluding larger or additional chambers).
- Structural Operational Capacity - the limit of tonnage thruput at a given lock site after the replacement and/or modification of the lock size at the site (including larger or additional chambers).

There are other definitions of capacity, two of which are mentioned here only to note that these capacity concepts were <u>not</u> used in the studies:

- System Capability - It is important to distinguish between total river system carrying capacity, in terms of all demands placed on the river eco-system, as opposed to the demands only of commercial and recreational navigation. The capacity estimates used in the Master Plan assume no reduction in water volume, surface, or access resulting from allocation of the resource to other competing uses. The carrying capacity of the system with respect to the capability of the natural resources to assimilate expanded navigation development was not considered as a factor in the navigation/transportation studies.
- Maximum Lock Capacity - For these studies, system capacity was defined in terms of the collective

operational capacities of the locks in the system. Operational capacity is less than the absolute physical capacity of the lock structures (Figure V-1). The example shown is a delay curve using the relationship between operational capacity and maximum physical capacity at Lock and Dam 10 on the Upper Mississippi River. The rule used in these studies is that operational capacity, when that concept is used, represents 95-percent of maximum physical capacity for a 600-foot lock and 98-percent of maximum physical capacity for a 1200-foot lock. These values were selected to best represent the "tolerance" level of the lock based on the relationship between tonnage thruput and delay levels by average delay per tow. Using the above values for operational capacity definition, delays reach an average of 30 to 40 hours per tow before structural additions are considered.

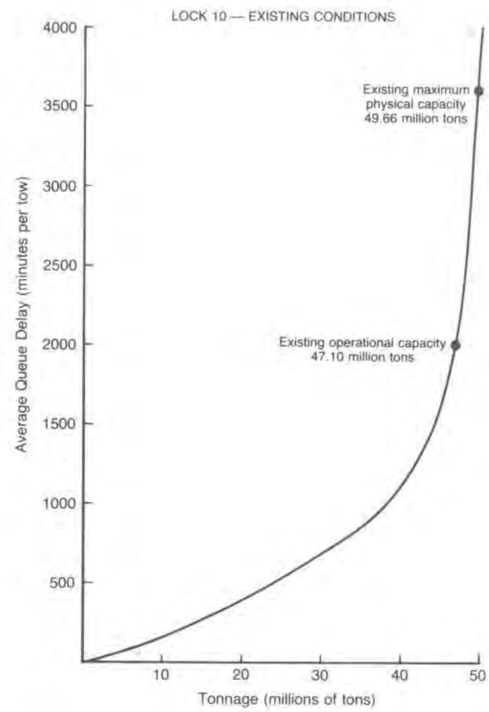


Figure V-1. Relationship Between Maximum Physical Capacity and Operational Capacity

An integrated study process was developed to examine three of the study elements: navigation carrying capacity, costs and benefits of expansion, and the economic need for a second lock at Alton. The key input and output parameters of the process are graphically displayed in Figure V-2. The basic evaluation tool is a lock simulation model. Such a computer model can simulate the effect of instituting various improvements at the locks on the system. The major input variables, the simulation model development, and the simulation process are described in the following sections.

Traffic Projections

Commodity projections were developed in two formats: lock by lock projections and port-to-port (origin/destination matrix) projections. Both formats categorized traffic by 14 commodity groups for 1980. Projections were made for the years 1990, 2000, 2010, and 2040. The unconstrained projections are based on the Corps of Engineers' National Waterways Study under contract with Data Resources, Incorporated. Composite growth rates for all commodities are shown in Table V-1. As is evident in these growth rates, the projections reflect considerably higher growth potential in the 1990-2010 near term than in the later 2010-2040 time frame. A detailed analysis of long term growth was not made for the 2010-2040 projections. Instead, nominal rates of growth averaging 0.5 percent compounded annually were assumed.

Table V-2 is a summary of total traffic by lock for 1980 and four projection years. Both constrained and unconstrained traffic projections are displayed. These figures can be viewed as the range of waterborne traffic demand. Unconstrained projections show the total demand by lock which could occur in the future if there were no delays in the system. Constrained projections show the level of traffic that could be anticipated if no improvements are made in the system. To arrive at the constrained tonnage, as lock capacity is reached, through traffic requiring use of the lock is curtailed at the level of capacity.

Figure V-2. Navigation Studies Process

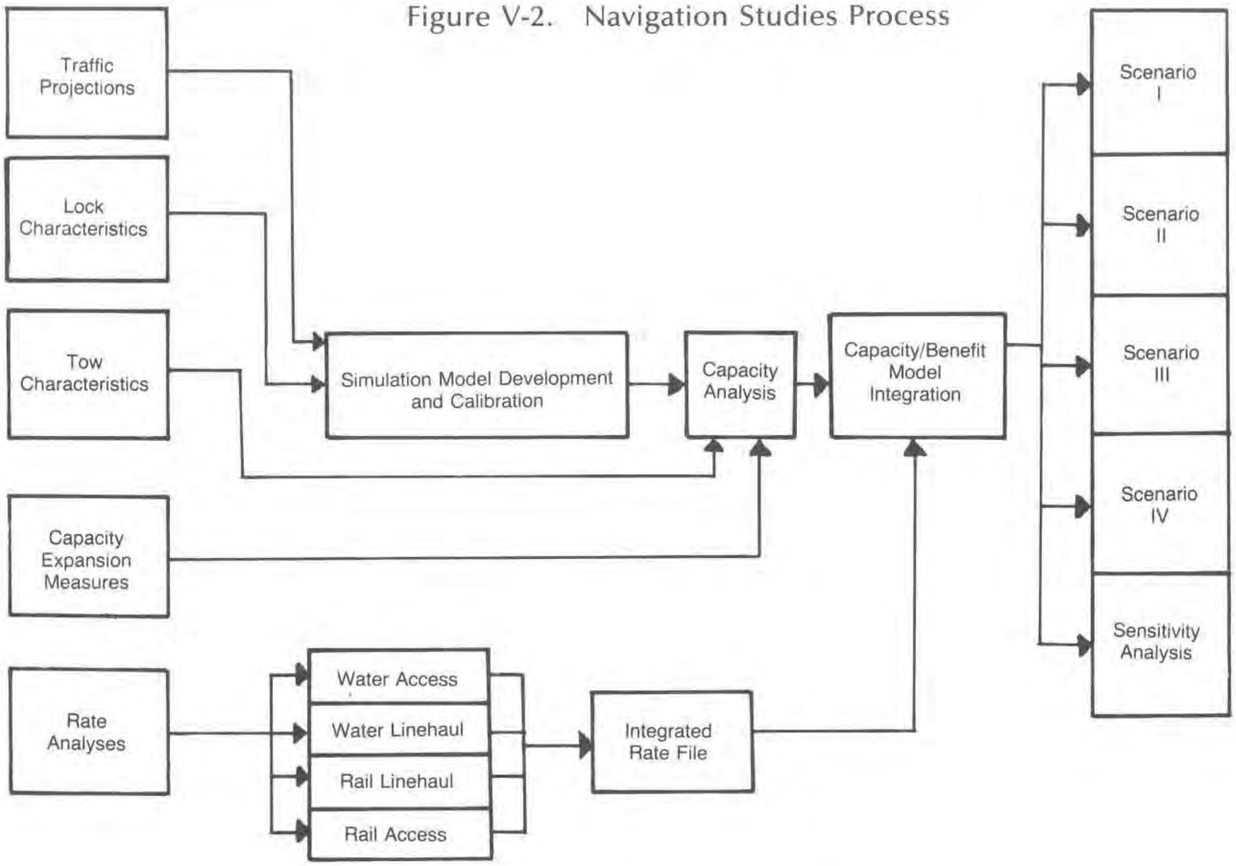


Table V-1. Waterborne Commodity Projected Growth Rates[1]

Commodity Group	1977-1990			1991-2000			2001-2010			2011-2040		
	Shipped	Received	Local	Shipped	Received	Local	Shipped	Received	Local	Shipped	Received	Local
UPPER MISSISSIPPI												
Farm Products	4.3	0.3	0.5	3.5	0.3	0.3	2.0	0.3	0.9	0.5	0.5	0.5
Coal	10.4	5.6	5.5	3.4	2.1	2.8	1.5	1.0	1.3	0.3	0.3	0.3
Crude Petroleum	(0.4)	(0.8)	0.0	0.7	(0.1)	0.0	0.7	0.1	0.0	0.0	0.0	0.0
Stone, Clay & Glass	1.5	1.5	1.5	0.4	0.5	0.4	1.3	1.3	1.3	0.5	0.5	0.5
Primary Metals	0.4	2.0	1.7	0.5	1.6	1.4	1.0	1.6	1.7	0.7	0.7	0.7
Chemicals	4.0	3.8	3.9	4.4	4.3	4.3	0.0	(0.6)	(0.5)	0.7	0.7	0.7
Non-Metallic Minerals	(2.1)	(2.4)	(2.3)	(1.5)	(1.0)	(1.3)	(3.9)	(1.8)	(2.9)	0.0	0.0	0.0
Metallic Ores	1.7	1.7	0.0	1.1	1.2	0.0	1.7	1.3	0.0	0.5	0.5	0.5
Food & Kindred Prod.	4.5	0.5	(2.2)	1.8	0.5	2.9	2.8	0.5	0.0	0.5	0.5	0.5
Lumber & Wood	3.4	5.1	8.1	0.5	0.7	0.0	1.6	0.0	0.0	0.1	0.1	0.1
Pulp & Paper	2.4	0.8	0.0	7.2	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1
Petroleum & Coal Prod.	0.0	(0.5)	(0.2)	0.2	(0.2)	0.1	0.2	(0.1)	0.1	(0.2)	(0.2)	(0.2)
Waste & Scrap	2.6	2.0	0.0	0.0	0.0	0.0	0.7	0.0	0.0	0.0	0.0	0.0
Other	0.5	0.1	0.2	0.5	0.3	0.3	0.8	0.2	0.4	0.5	0.5	0.5
ILLINOIS RIVER												
Farm Products	2.0	0.0	0.1	3.7	0.0	0.1	1.8	0.0	0.0	0.5	0.5	0.5
Coal	3.1	4.5	4.3	1.9	2.3	1.9	0.9	1.0	0.8	0.3	0.3	0.3
Crude Petroleum	(0.8)	(0.8)	0.0	0.0	(0.2)	(1.1)	0.4	0.6	0.0	0.0	0.0	0.0
Stone, Clay & Glass	2.2	2.8	2.8	1.1	1.6	1.6	2.0	2.4	2.4	0.5	0.5	0.5
Primary Metals	1.2	1.9	1.5	1.3	1.5	1.3	1.4	1.5	1.3	0.5	0.5	0.5
Chemicals	3.1	3.6	3.5	3.1	3.4	3.4	2.8	2.0	2.0	0.7	0.7	0.7
Non-Metallic Minerals	(1.9)	(1.9)	(1.9)	(1.3)	(1.1)	(1.2)	(3.4)	(1.7)	(2.4)	0.0	0.0	0.0
Metallic Ores	0.2	5.5	0.0	0.1	2.4	0.0	0.5	2.8	0.0	0.5	0.5	0.5
Food & Kindred Prod.	4.3	0.8	1.6	1.8	1.0	0.9	2.8	1.1	0.0	0.5	0.5	0.5
Lumber & Wood	0.7	1.1	0.0	0.5	1.3	0.0	0.0	0.0	0.0	0.1	0.1	0.1
Pulp & Paper	0.0	2.4	2.4	0.0	2.1	2.1	0.0	2.0	2.0	0.1	0.1	0.1
Petroleum & Coal Prod.	(0.7)	(1.0)	(1.3)	0.0	0.0	(0.6)	0.2	0.2	(0.1)	(0.2)	(0.2)	(0.2)
Waste & Scrap	(1.1)	(2.0)	(3.7)	(1.0)	(1.5)	(3.1)	(0.5)	(0.8)	(2.5)	0.0	0.0	0.0
Other	3.8	3.8	3.5	3.3	3.3	3.3	3.9	3.6	3.6	0.5	0.5	0.5

1/ - Growth rates based upon National Waterway Study-Baseline Scenario through 2010 and low or no growth thereafter.

Growth rates are in percent, compounded annually between periods; rates in parentheses (1.0) are negative or rate of reduction in traffic between periods.

Table V-2. Summary of Waterborne Constrained and Unconstrained Projections[1]

(thousand tons)

Lock	1980	1990 Con[2]	1990 Uncon[3]	2000 Con	2000 Uncon	2010 Con	2010 Uncon	2040 Con	2040 Uncon
1	2,162	3,768	4,082	3,465	5,185	3,721	5,897	4,092	6,623
2	13,598	17,803	19,649	14,645	26,375	14,007	30,746	14,506	35,281
3	12,451	17,399	19,246	13,893	25,838	12,249	30,130	12,583	34,608
4	13,166	18,230	20,126	15,094	27,051	13,664	31,606	14,218	36,318
5	13,180	18,321	20,167	15,123	27,096	13,217	31,653	13,730	36,370
5A	13,180	18,321	20,167	15,123	27,096	13,217	31,653	13,730	36,370
6	14,050	19,803	21,649	17,186	29,163	15,615	34,095	16,465	39,207
7	14,050	19,803	21,649	17,186	29,163	15,615	34,095	16,465	39,207
8	15,076	20,072	21,919	17,547	29,527	16,044	34,540	16,948	39,730
9	16,132	21,584	23,431	17,457	31,499	15,599	36,722	16,461	42,173
10	17,912	23,284	25,130	19,843	33,885	18,493	39,670	19,158	45,537
11	18,192	23,828	25,675	19,610	34,594	18,222	40,480	18,866	46,426
12	19,442	25,772	27,618	21,130	37,347	19,400	43,694	20,232	50,192
13	19,734	25,882	27,728	21,249	15,469	19,526	43,824	20,380	50,344
14	21,881	29,675	31,521	25,601	42,667	23,569	49,734	24,090	57,170
15	22,904	30,924	32,770	27,047	44,132	25,117	51,430	25,711	59,094
16	25,386	34,501	36,348	31,597	49,059	29,516	57,315	29,911	65,891
17	26,415	36,036	37,882	33,478	51,203	31,721	59,857	31,981	68,844
18	27,039	37,519	39,365	35,548	53,311	34,224	62,433	34,279	71,835
19	29,074	41,113	42,959	40,527	58,377	40,020	68,523	39,655	78,911
20	29,698	41,507	43,353	41,015	58,925	40,554	69,181	40,245	79,673
21	30,999	43,335	45,181	43,378	61,362	43,369	72,101	43,484	83,041
22	31,404	43,915	45,762	44,130	62,161	44,140	73,051	44,250	84,150
24	32,233	45,082	46,929	45,240	63,669	45,244	78,849	45,346	86,257
25	32,519	45,173	47,019	45,173	63,742	45,173	74,995	44,173	86,408
26	69,604	92,414	94,227	96,764	126,379	97,365	148,613	97,740	171,632
27	76,384	99,647	101,461	105,477	135,006	107,240	157,853	109,113	182,284
Lockport	20,250	25,092	25,092	24,552	23,003	23,077	33,556	23,080	38,276
Brandon Road	20,765	26,811	26,811	26,739	32,218	25,556	36,291	25,722	41,503
Dresden Island	22,704	28,980	28,980	29,238	34,733	28,397	39,177	28,627	44,808
Marseilles	25,539	30,930	30,931	32,523	38,071	32,585	43,607	32,585	50,130
Starved Rock	27,522	32,968	32,968	35,478	41,042	36,116	47,192	36,666	54,295
Peoria	35,591	42,936	42,936	44,409	55,121	43,951	63,904	43,569	73,585
LaGrange	35,759	43,258	43,258	46,736	56,769	49,110	66,603	48,899	77,154

1/ Estimated 1980 traffic base and future tow size conditions.
2/ Constrained as lock capacity is reached sequentially throughout the system.
3/ Unconstrained.

Lock Characteristics

Physical and operating characteristics of each of the locks in the system are important inputs to the simulation model. Table V-3 displays the physical characteristics of the thirty-four locks in the evaluation. In addition, a distribution of timings for all lockage components was a key input. Lock processing times include 1) approach time, 2) entry time, 3) chambering time and 4) exit time. Double lockages also require reversing the chamber and comparable times for the second lockage cut. Break-up and reconfiguration times for double lockages are also added to processing time. Corps of Engineers Performance Monitoring System (PMS) lock data were used as the basis for the lock operations input. Lock processing times for the new 1200 foot lock at Lock 26 were estimated from data at Lock 27 and locks on the Ohio River.

Tow Characteristics

One of the most sensitive data inputs, from the standpoint of lock capacity, is future tow size defined as average number of barges per tow. Future tow sizes are related to such factors as commodity mix, commodity volume, lock utilization, and fuel costs. Table V-4 represents the input on future tow sizes.

Simulation runs were made using both existing (1977) and future (2040) tow sizes. However, the results of the evaluations reported in this chapter are those which used future (2040) tow size and an intermediate (2000) tow size. These were chosen because they were judged to most closely approximate future conditions.

Table V-3. Physical Lock Characteristics [1]

Lock	Size(ft.)	Lift(ft.)	Year Built
Mississippi River:			
1	400 x 56	38	1948
	400 x 56	38	1932
2	600 x 110	12	1930
3	600 x 110	8	1938
4	600 x 110	7	1935
5	600 x 110	9	1935
5A	600 x 110	5.5	1936
6	600 x 110	6.5	1936
7	600 x 110	8	1937
8	600 x 110	6	1937
9	600 x 110	9	1938
10	600 x 110	8	1936
11	600 x 110	11	1937
12	600 x 110	9	1939
13	600 x 110	11	1939
14	600 x 110	11	1939
	320 x 80	11	1939
15	600 x 110	16	1934
	320 x 110	16	1934
16	600 x 110	9	1937
17	600 x 110	8	1939
18	600 x 110	10	1937
19	1200 x 110	38	1951
20	600 x 110	10	1936
21	600 x 110	10.5	1938
22	600 x 110	10.5	1938
24	600 x 110	10.4	1940
25	600 x 110	10.3	1939
26	1200 x 110 2/	14.9	(1989)
27	1200 x 110	13	1963
	600 x 110	13	1963
Illinois River:			
Lockport	600 x 110	40	1933
Brandon Road	600 x 110	34	1933
Dresden Island	600 x 110	24.8	1933
Marseilles	600 x 110	24.3	1933
Starved Rock	600 x 110	18.7	1933
Peoria	600 x 110	11	1939
LaGrange	600 x 110	10	1939

1/ The locks at the head of navigation (Upper and Lower St. Anthony, O'Brien, and Kaskaskia) are not included in the evaluation because they have low traffic relative to operational capacity and do not present a constraint to the system.

2/ Authorized project under construction assumed in place for study purposes.

Capacity Expansion Measures

A wide range of capacity expansion measures was considered for study in the capacity analysis. These measures were used to construct the four basic system scenarios which were evaluated. An inventory was conducted of potential structural and non-structural measures that could be instituted to increase the ability of the system to handle additional traffic. Forty-three measures were initially identified. Ten were eliminated from further consideration due to their low impact on capacity, high cost, safety problems, or availability of information needed to quantify performance. The remaining 33 measures are displayed in Table V-5. These measures were further screened and prioritized, resulting in a list of eleven measures used in the design of system capacity expansion scenarios.

These remaining eleven measures include both structural and non-structural options with a wide range of costs and capabilities. A brief description of the measures follows:

A) Improve Physical Performance: The time it takes to fill and empty the locks could be decreased by improving the hydraulic system at some locks, thus improving the chambering performance. Such design improvements could involve building auxiliary discharge outlets, relieving air entrainment in the conduits, correcting valve vibrations, or modifying the inlet or outlet structures. In addition installing self-cleansing trash racks can keep the intakes clear of debris and thus reduce filling times at some locks.

B) Improve Approaches: The time required for a tow to leave the waiting area and become properly aligned for entrance into the lock chamber is a major portion of the total lock service time. As such, any modifications which can be made to reduce the approach time can have a significant effect on capacity.

When locks are placed in the channel they form an obstruction which alters stream flow. The channel contraction results in outdrafts or crosscurrents in the upper lock approach. The sudden channel expansion in the lower approach forms eddies which alter the current. Thus, a tow's approach to the lock can be complicated from both upstream and downstream. Various improvements to the approaches can be made to alleviate these problems and thus reduce the time it takes to approach the lock chamber. Possible modifications include: widening or realigning approach channels; extending guidewalls; realigning or extending auxiliary walls; installing submerged dikes, angled guard cells, or wing dikes; or eliminating obstructions.

In addition, approach times can be reduced by shortening the approach distance. Mooring cells are sheet pile structures provided for vessels to tie-up

Table V-4. Average Number of Barges Per Tow

Lock Number/Name	Actual 1977	Projected 1990	2000	2010	2040	PERCENT LOADED
1	1.66	1.80	1.90	2.05	2.50	50
2	7.29	7.66	7.96 1/	8.69	10.90 1/	62
3	7.74	8.06	8.30	8.99	11.05	66
4	8.11	8.43	8.67	9.38	11.50	66
5	8.10	8.42	8.67	9.38	11.50	67
5A	8.05	8.40	8.67	9.38	11.50	67
6	8.46	8.75	8.98	9.61	11.50	68
7	8.07	8.36	8.59	9.32	11.50	68
8	8.36	8.65	8.88	9.59	11.70	68
9	9.09	9.38	9.61	10.16	11.80	74
10	8.18	9.49	10.50 1/	10.80	11.70 1/	74
11	8.51	9.85	10.88	11.11	11.80	74
12	8.98	10.23	11.20	11.35	11.80	75
13	8.79	10.04	11.00	11.20	11.80	75
14	7.41	8.66	9.62	9.87	10.60	71
15	6.22	7.47	8.43	8.70	9.50	72
16	7.18	8.43	9.39	9.67	10.50	72
17	8.18	9.43	10.40	10.73	11.70	72
18	8.19	9.44	10.40	10.73	11.70	71
19	8.42	9.67	10.63	10.93	11.80	71
20	8.70	9.95	10.91	11.13	11.80	71
21	8.75	10.02	11.00	11.20	11.80	70
22	9.10	10.34	11.30 1/	11.43	11.80 1/	70
24	8.94	10.19	11.15	11.24	11.50	69
25	8.94	10.19	11.15	11.24	11.50	67
26	7.60	8.50	9.20 1/	9.48	10.30 1/	65
27	6.50	7.65	8.50	8.78	9.60	65
LaGrange	8.00	8.55	9.00	9.25	10.00	64
Peoria	7.10	7.60	8.00 1/	8.25	9.00 1/	63
Starved Rock	6.38	6.85	7.20	7.45	8.20	62
Marseilles	6.27	6.75	7.10	7.35	8.10	62
Dresden Island	6.35	6.80	7.20	7.45	8.20	60
Brandon Road	6.10	6.40	6.60 1/	6.75	7.10	59
Lockport	5.44	5.80	6.10	6.25	6.70	59

1/-Based on contract study: Sensitivity of Tow Size to Traffic Volume, Fuel Price and Delay at Locks, April 1981, by Louis Berger & Associates

All other locks extrapolated from contractor data.

while waiting their turn to lock. If the mooring cells can be located closer to the locks, it decreases the approach distance and thus reduces approach time.

C) Increase lock staffing: The time it takes to service a tow at a lock could be reduced by increasing the number of personnel operating the locks. Overall chambering performance could be improved by reducing general inefficiencies, however, the primary benefit of increased staffing would come from reducing the time involved in turnback approaches under N-up/N-down operating policies. An additional staff person at the lock could assist a tow in tying up to the guidewall and preparing for entry into the chamber while the lock is devoted to the service of the previous tow. Approach time for turnback lockages is thus decreased because tows can wait for lockage at the guidewall directly in front of the gates rather than at some point between the chamber and the approach point.

Table V-5. Selected Measures to Increase System Capacity

	Quantitative Aspects			Qualitative Aspects			
	Annualized Cost ($000)	% Increase in Capacity (typical range)	Cost ($000) for each % Increase	Safety	Operation/ Investment	General Usage	Applicability
SCHEDULING OF LOCK OPERATIONS - ASSISTANCE TO MULTICUT LOCKAGES							
Institute N-up/N-down Policy	0	13-16	0	HIGH	-	COMMON	MOD.
Provide Helper Boats	964	16	60	MOD.	OPER.	RARE	WIDE
Provide Switchboats	1420	16	89	LOW	OPER.	RARE	LTD.
Institute Ready to Serve Policy	2092	33	63	LOW	OPER.	PROPOSED	LTD.
Improve Tow Haulage Equipment	751	28	27	LOW	INV.	PROPOSED	WIDE
Increase Lock Staffing	52	1-2	39	HIGH	OPER.	PROPOSED	MOD.
Institute Lock Scheduling	9	3	3	HIGH	OPER.	RARE	MOD.
IMPROVEMENTS TO APPROACHES							
Improvements to Approaches	116	3	39	HIGH	INV.	COMMON	MOD.
Provide Adjacent Mooring Cells	18	1-2	14	HIGH	INV.	COMMON	LTD.
Provide Funnel Shaped Guidewalls	U/A	U/A	U/A	HIGH	INV.	PROPOSED	LTD.
Install Wind Deflectors	2-20	0-.1	25-200	HIGH	INV.	PROPOSED	LTD.
TOW CONFIGURATION AND OPERATION							
Use of Regular Bow Thrusters	U/A	4	U/A	HIGH	INV.	RARE	WIDE
Use of Bow Boats	U/A	21	U/A	HIGH	INV.	PROPOSED	WIDE
Tow Size Standardization	U/A	17	U/A	MOD.	OPER.	PROPOSED	WIDE
Cooperative Scheduling	U/A	13	U/A	MOD.	OPER.	PROPOSED	WIDE
Waterway Traffic Management	5-15	4	3	HIGH	OPER.	PROPOSED	WIDE
Expand Fleeting Areas	200	U/A	U/A	MOD.	INV.	COMMON	WIDE
Bridge Maintenance and Operation	U/A	0-5	U/A	HIGH	OPER.	COMMON	WIDE
LOCK OPERATING CONTROLS							
Modify Intake/Outlet Structures	70	4	16	MOD.	INV.	RARE	LTD.
Install Trash Racks	29	4	7	MOD.	INV.	COMMON	LTD.
Expedite Operations in Ice Condition	23	2	12	MOD.	INV.	COMMON	WIDE
Install Air Bubbler System	38	0	-	HIGH	OPER.	COMMON	LTD.
Install Floating Mooring Bitts	14	0	-	HIGH	OPER.	COMMON	LTD.
Improve Lock Operating Equipment	191	0	-	HIGH	INV.	RARE	LTD.
Install Gate Wickets	HIGH	0-3	-	LOW	INV.	PROPOSED	LTD.
Provide Operating Guides	MOD.	0-3	-	HIGH	OPER.	PROPOSED	WIDE
Centralize Controls	104	1	104	HIGH	INV.	RARE	WIDE
Provide Replaceable Fenders	LOW	0-1	-	LOW	INV.	PROPOSED	WIDE
Clear Vessel From Filling/ Emptying System	LOW	0	-	HIGH	INV.	COMMON	WIDE
STRUCTURAL ACTIONS							
Reduce Interference from Recreation	419	6	65	MOD.	INV.	COMMON	WIDE
Improve Use of Auxiliary Chamber	U/A	10-50	U/A	MOD.	OPER.	COMMON	LTD.
Enlarge Lock to 1200 Feet	4575	48	95	LOW	INV.	RARE	WIDE
Physical Lock Replacement	8950	148	61	HIGH	INV.	COMMON	WIDE

U/A = Unavailable

Source: Louis Berger and Associates, Inc., Inventory of Potential Structural and Non-Structural Alternatives for Increasing Navigation Capacity, April, 1981.

D) Institute N-up/N-down service order: Currently, most locks operate on a First In-First Out schedule which means that the tows are serviced in the order of their arrival. If the time required to reverse the lock to service a tow going in the same direction as the previous one is greater than the time required for an exchange of up and down-bound tows, then an alternative rule could be involved where a 1-up/1-down procedure would be followed.

These tow rules are commonly followed at most locks. However, at high traffic levels, a multi-up/multi-down policy can often reduce average service time and thus increase capacity. The so called N-up/N-down rule is effective only if the average time to reverse the lock and service a new tow in the same direction is less than the time it takes for two tows to exchange use of the lock. This appears to be wasteful since the lock must be either filled or emptied without a tow in it. However, there can be considerable time savings because currents and maneuverability problems make it easier for one tow to follow another in line than for two opposing tows to pass each other.

Therefore, the N-up/N-down rule sometimes allows several tows moving in one direction to pass through a lock in a shorter period of time than the same number of tows that must pass each other in opposite directions.

E) Expedite operations in ice conditions: Ice can present several difficulties to lock operations. Floating ice and ice on chamber walls can take up so much of the chamber that it must either be pushed out to accomodate the tow or tow size must be decreased. Ice accumulated on the bottom of the barges must be removed or it may damage the gate sill when the vessel enters the chamber. In addition, drifting and frozen-on ice can build up on gates and sills and prevent the gates from closing securely. Measures to alleviate some of these problems include the use of skin plates over gate niches, application of polymer coatings on gates and walls, utilization of an ice cutter, and the use of air curtain or air bubbler systems.

F) Recreational locks or lockage hours: At many existing locks, lockages for recreational users are a substantial portion of the total number of annual lockages. Conflicts between commercial and recreational users result in delays for both. The problem can be alleviated by either scheduling recreational lockages or by providing separate locking facilities for recreational craft.

G) Traveling kevel: Most of the locks on the system are currently 600 feet in length. Tows with 9 or more barges must therefore break apart and pass each section separately through the lock. Typically, a 15 barge tow is broken into a set of nine barges and then a set of six barges plus the towboat. This is known as a double lockage.

Many locks utilize a cable assembly to extract the first half of a split tow from the chamber. Another method for guiding the unpowered barges in and out of the chamber is a traveling kevel. The traveling kevel can be installed on rails running along the entire length of the guidewalls. The tow could then be pulled into, through, and out of the chamber with greater speed and control. A powered traveling kevel can provide time savings for each double lockage. However, to get the maximum impact, the traveling kevel must be used with extended guidewalls to 1200 feet and implemented with an N-up/N-down policy. (See D above.)

H) Build additional locks: Major increases in capacity can be achieved by providing additional chamber space. This can be accomplished by either replacing existing locks with larger locks or by adding an additional chamber.

I) Mandate bowthrusters for large tows: A bowthruster or bowboat is a propulsion unit which increases the maneuverability of tows. Their use could reduce the time required for a tow to become aligned with the lock and reduce the extraction time for the first cut of a double lockage. Also, if guidewalls are extended to 1200 feet and an N-up/N-down policy is implemented, bowboats can conceivably eliminate the extra time for breaking up and making up double tows.

J) Helper boats: Where heavy traffic conditions occur frequently, the use of extra towboats at the lock is very effective in passing traffic. The helper boat, a low horsepower towboat, extracts the unpowered portion of a tow during a double or setover lockage. It often holds the barges along an extended guidewall where the recycling of the cuts does not interfere with the operation of the lock. Helper boats thus eliminate part of the extra time required for locking double and setover tows.

This measure must be used with an N-up/N-down operating policy (see D above) because the make-up or reconfiguration time cannot be saved if the following tow processed is from the opposite direction and thus obstructs the lock entrance.

K) Switchboats: Like a helper boat (see J above), a switchboat is an extra towboat at the lock which extracts the unpowered portions of a tow in a double lockage from the chamber. It then moves the barges to remote mooring facilities where the recoupling of the powered and unpowered portions do not interfere with the operation of the lock. Switchboats can be used regardless of whether an N-up/N-down operating policy is being followed. Therefore, at locks where N-up/N-down policy is not beneficial, switchboats should be used. They have

greater horsepower than helper boats to pull the cuts quickly and safely away from lock approaches.

Rate Analysis

The rates charged for the transport of commodities are necessary data to calculate the savings to shippers resulting from expansion of navigation capacity. Rate data were collected for a sample of 2,460 commodity movements (25 percent of the total origin to destination movements in the Master Plan region) stratified by commodity group, distance, and seasonality factors. Individual data collection efforts were undertaken for rail line haul rates, rail access charges, water line haul rates, and water access charges. Shippers were contacted and asked to provide information on rates. Since all information requested was on a voluntary basis, significantly fewer than the 2460 rates represented in the sample were actually obtained. On the average, about half of the rates were collected. The remainder of the rate file was completed through the use of regression equations based on the range of actual rates collected extrapolated to the total sample. Filling these data gaps by regression analyses is a necessary qualification of the transportation rate savings portion of the benefit calculations.

It was assumed that sufficient capacity exists on the rail network to carry the traffic which a constrained waterway system could not accommodate. Therefore, no major additional future capital expenditures were added to the line haul rail rates used in the evaluation. Normal capital needs (depreciation) were assumed to be reflected in estimated rail rates.

Model Development and Operation

The major element in determining the capacity of a lock is the size of the lock and the average process time per lockage. This, in turn, is affected by the different types of lockages which are likely to occur - each having its own characteristics and average process times. The conversion from lockages and process time to capacity expressed in tonnage involves another set of variables. These include tons per barge, lock down-time (including tow and lock equipment malfunctions), length of the navigation season and seasonal traffic patterns, lock time devoted to non-commercial vessels, percent of empty barges, and tow size.

In order to capture the interactions of commodity projections and lock capacity, a simulation model of lock operations was developed. Such a model can be used to test various structural and non-structural measures to discover their effectiveness in decreasing lockage time, thus decreasing delay and increasing capacity. Commodity flow forecasts were converted to lock traffic and then evaluated under existing and projected tow size conditions, under alternative system conditions, and under selected combinations of capacity expansion measures (scenarios). From these evaluations, delay curves were estimated for both average delay per tow and annual tow hours of delay.

The two most sensitive inputs in the process are the traffic flow forecasts and the tow sizes. Traffic forecasts impact lock capacity (as measured in tonnage) by affecting the number of empty barges. For example, increases in downbound grain movements are likely to result in increased numbers of upbound empty barges as long as those commodities which comprise the upbound "backhaul" do not increase. Traffic forecasts also affect average tow size. Grains and coal tend to move in larger tows. Therefore, as the commodity mix changes with a greater relative increase in grain movement, average tow sizes will also tend to increase. Since traffic forecasts are so important in the evaluation of lock capacity, they likewise have a direct impact on the timing, sizing, and sequencing of improvements.

Tow size projections are the second critical variable. Basic changes in the distribution of tow sizes will also impact lock capacity. The effect on the capacity of 1200 foot chambers is rather direct. Greater utilization of the lock chamber results with only small increases in the processing time necessary to service larger tows. Larger tows have a small impact on average processing time because generally only approach times increase slightly. At 600 foot chambers, lock capacity also increases with greater tow size, however, there is a more significant trade-off between chamber utilization and processing time. Larger tows increase the need for double lockages at 600 foot locks. This increases average process time since double locakges have greater overall process time than two single lockages. However, because of greater chamber utilization overall capacity is still increased slightly. In addition, because increased future tow sizes will increase the number of double lockages, measures such as helper boats, switchboats, and kevels are highly effective under these conditions.

CAPACITY EXPANSION SCENARIOS

The study of navigation capacity expansion is based on the assessment of system-wide improvement scenarios. Four main scenarios were formulated covering a variety of expansion measures and a range of system traffic capacity. Each system scenario consists of various combinations of individual structural and non-structural capacity expansion measures. Each scenario was initially designed to test specific "packages" of these improvements. Table V-6 displays the measures eligible for inclusion in the design of the scenarios.

Scenario I was designed to approximate likely future conditions with no major structural or non-structural changes. It includes measures deemed most likely to be implemented under current navigation budgets. Therefore, it represents a "without" condition for the system.

Scenario II measures build upon those included in Scenario I. However the main thrust of Scenario II was to examine a system-wide mandated use of bowthrusters on tows requiring a double lockage. Most of the costs, would be operating costs as opposed to capital costs, which would be borne by the inland waterway industry.

Scenario III was designed to exhaust the application of non-structural

Table V-6. Capacity Expansion Scenarios

MEASURES	SCENARIOS I	II	III	IV
Government				
A1 Improve Physical Performance (C/PIC[1]/<$20K)	•	•		
B1 Improve Approaches (C/PIC <$20K)	•	•		
C1 Increase Lock Staffing (C/PIC <$20K)		•		
A2 Improve Physical Performance (C/PIC <$50K)			•	•
B2 Improve Approaches (C/PIC <$50K)			•	•
C2 Increase Lock Staffing (C/PIC <$50K)			•	•
D Institute N-up/N-down where Appropriate	•	•	•	•
E Expedite Operations in Ice Conditions			•	•
F1 Recreational Locks, Lock 2 - Lock 11			•	•
F2 Recreational Lockage Hours		•	•	•
G Traveling Kevel Where Appropriate As Alternative to Helper Boats			•	•
H Build Additional Locks Where Appropriate				•
Industry				
I Mandate Bowboats for Large Tows		•		
J Helper Boats Where Appropriate			•	•
K Switchboats Where Appropriate			•	•

[1]/ C/PIC = Cost per percent increase in capacity.

measures without any major structural changes (additional chambers). Measures to assist double lockages (helper boats, switchboats, or traveling kevels) were selected on a site specific basis as opposed to the systemwide use of bowthrusters in Scenario II.

Scenario IV was intended to formulate a package of measures which would virtually pass the total unconstrained traffic projection. Non-structural measures similar to Scenario III are included as well as additional chambers at selected sites throughout the system. Both 600 and 1200 foot chambers were tested (Scenarios IVA and IVB).

In addition to the four basic scenarios, four additional scenarios where developed to address the questions concerning a second lock at Lock and Dam 26 at Alton, Illinois. Scenarios Ia, Ib, IIIa, and IIIb were designed to test the impact of providing a second lock at Alton in addition to the measures already included in the basic scenarios. Scenarios Ia and IIIa added a 600 foot lock and Scenarios Ib and IIIb added a 1200 foot lock.

Each scenario had specific objectives in the initial stages of design. However, not all measures eligible for inclusion in the scenarios were ultimately included. Nor were all measures applicable to all locks. The actual packaging or development of these system alternatives is significantly more complex than developing alternatives at a given site and independent of the rest of the system. Complexities arise due to timing of implementation, sequencing, dependence on traffic levels, and relationships to upstream and downstream constraint points. The analysis of site applicability and system synergistics ultimately defined the scenarios as described in Tables V-7 through V-15.

Two different models were used for the economic evaluation of the Scenarios - the Percent of Capacity (PC) model and the General Equilibrium (GE) model. Although the measures included in each scenario remained the same, the separate economic evaluations resulted in somewhat different timing and sequencing of measures. The economic evaluation of Scenarios is described in the section following the tables. However, timing

Table V-7. **Scenario I**: System Modifications

General Description: N-up/N-down lockage policy. Relatively low cost, highly effective approach and performance improvements.

Sequencing and Timing: All measures "in-place" in 1990. No timing evaluation performed.

Measures by Lock: N-up/N-down lockage policy plus the following measures.

Lock 1	-
Lock 2	-
Lock 3	-
Lock 4	-
Lock 5	-
Lock 5A	- Auxiliary discharge outlet
Lock 6	- Upper mooring cells
Lock 7	- Upper mooring cells
Lock 8	- Angle upper guard wall
Lock 9	- Upper and lower mooring cells
Lock 10	-
Lock 11	-
Lock 12	-
Lock 13	-
Lock 14	-
Lock 15	- Lower mooring cells, auxiliary discharge outlet
Lock 16	- Extension of upper guidewall
Lock 17	-
Lock 18	-
Lock 19	- Remove upper dikes, correct filling valve
Lock 20	-
Lock 21	-
Lock 22	-
Lock 24	-
Lock 25	- Auxiliary discharge outlet
Lock 26	-
Lock 27	-
Lockport	- Auxiliary discharge outlet, trash racks
Brandon Road	- Auxilary discharge outlet, trash racks, relieve air entrainment in culverts
Dresden Island	- Relieve air entrainment in culverts
Marseilles	- Widen upper canal, auxiliary discharge outlet, relieve air entrainment, trash racks
Starved Rock	-
Peoria	-
La Grange	-

Table V-8. **Scenario Ia**: System Modifications

General Description: Same as Scenario I except a 600 foot chamber added to Lock 26.

Sequencing and Timing: All Scenario I measures in-place in 1990. Second 600 foot chamber added at Lock 26 in 1993 (PC) or 1990 (GE).

Table V-9. **Scenario Ib**: System Modifications

General Description: Same as Scenario I except a 1200 foot chamber added to Lock 26.

Sequencing and Timing: All Scenario I measures in-place in 1990. Second 1200 foot chamber added at Lock 26 in 1993 (PC) or 1990 (GE).

Table V-10. **Scenario II**: System Modifications

General Description: Scenario I measures plus system wide mandated use of bowthrusters on all tows requiring a double lockage. Increased lock staffing.

Sequencing and Timing: All measures in-place in 1990.

Measures by Lock: Scenario I measures plus the following measures.

Lock 1	-
Lock 2	- Bowthrusters
Lock 3	- Bowthrusters
Lock 4	- Bowthrusters
Lock 5	- Bowthrusters
Lock 5A	- Bowthrusters
Lock 6	- Bowthrusters
Lock 7	- Bowthrusters
Lock 8	- Bowthrusters
Lock 9	- Bowthrusters
Lock 10	- Bowthrusters
Lock 11	- Bowthrusters
Lock 12	- Bowthrusters
Lock 13	- Bowthrusters
Lock 14	- Bowthrusters
Lock 15	- Bowthrusters
Lock 16	- Bowthrusters
Lock 17	- Bowthrusters
Lock 18	- Bowthrusters
Lock 19	- Bowthrusters
Lock 20	- Bowthrusters, lock staffing night shift
Lock 21	- Bowthrusters, lock staffing night shift
Lock 22	- Bowthrusters, lock staffing night shift
Lock 24	- Bowthrusters, lock staffing night shift
Lock 25	- Bowthrusters, lock staffing night shift
Lock 26	- Bowthrusters
Lock 27	- Bowthrusters
Lockport	-
Brandon Road	- Bowthrusters
Dresden Island	- Bowthrusters
Marseilles	- Bowthrusters
Starved Rock	- Bowthrusters
Peoria	- Bowthrusters
La Grange	- Bowthrusters

Table V-11. **Scenario III**: System Modifications

General Description: Includes Scenario I and II measures except for bowthrusters. One of three double lockage measures - helper boats, switchboats, or kevel systems - was selected where needed.

Sequencing and Timing: Kevel systems and switchboats added when delay reduction equalled annual costs.

Measures by Lock: All Scenario I and II measures except bowthrusters plus the following measures.

Lock 1 -
Lock 2 -
Lock 3 -
Lock 4 -
Lock 5 -
Lock 5A -
Lock 6 -
Lock 7 -
Lock 8 -
Lock 9 -
Lock 10 -
Lock 11 -
Lock 12 -
Lock 13 -
Lock 14 -
Lock 15 -
Lock 16 - Kevels (1995-PC) (1990-GE)
Lock 17 - Kevels (1995-PC) (1990-GE)
Lock 18 - Kevels (1995-PC) (1990-GE)
Lock 19 -
Lock 20 - Kevels (1990-PC & GE)
Lock 21 - Kevels (1990-PC & GE)
Lock 22 - Kevels (1990-PC & GE)
Lock 24 - Kevels (1990-PC & GE)
Lock 25 - Kevels (1990-PC & GE)
Lock 26 -
Lock 27 -

Lockport -
Brandon Road -
Dresden Island - Switchboats (1998-PC) (1990-GE)
Marseilles - Switchboats (1990-PC & GE)
Starved Rock - Switchboats (1990-PC & GE)
Peoria - Switchboats (1993-PC) (1990-GE)
La Grange -

Table V-12. **Scenario IIIa**: System Modifications

General Description: Same as Scenario III except a 600 foot chamber added at Lock 26.

Sequencing and Timing: Scenario III measures but second 600 foot chamber added at Lock 26 in 1995 (PC) or 1990 (GE).

Table V-13. **Scenario IIIb**: System Modifications

General Description: Same as Scenario III except a 1200 foot chamber added at Lock 26.

Sequencing and Timing: Scenario III measures but second 1200 foot chamber added at Lock 26 in 1995 (PC) or 1990 (GE).

Table V-14. **Scenario IVA**: System Modifications

General Description: Includes Scenario III measures plus additional 600 foot chambers where needed. Helper boats replace kevel systems from Scenario III at some Mississippi River locks.

Sequencing and Timing: Double lockage measures timed when annual delay cost reduction equalled annual costs. Additional chambers timed when the change in system costs equalled the change in system benefits, ± 2 years.

Measures by Lock: Scenario III measures plus the following changes.

Lock 1 -
Lock 2 -
Lock 3 -
Lock 4 -
Lock 5 -
Lock 5A -
Lock 6 -
Lock 7 -
Lock 8 -
Lock 9 -
Lock 10 -
Lock 11 - Kevels (1997-PC) (1990-GE)
Lock 12 - Kevels (1999-PC) (1990-GE)
Lock 13 - Kevels (1999-PC) (1990-GE)
Lock 14 - Helper Boats (1999-PC) (1990-GE)
Lock 15 - Helper Boats (1998-PC) (1990-GE)
Lock 16 - Helper Boats (1996-PC) (1990-GE)
Lock 17 - Helper Boats (1996-PC) (1990-GE)
Lock 18 - Helper Boats (1995-PC) (1990-GE)
Lock 19 -
Lock 20 - Helper Boats (1994-PC) (1990-GE)
600' Chamber (2009-PC) (2010-GE)
Lock 21 - Helper Boats (1990-PC & GE)
600' Chamber (2006-PC) (2005-GE)
Lock 22 - Helper Boats (1990-PC) (1990-GE)
600' Chamber (2001-PC) (2000-GE)
Lock 24 - Helper Boats (1990-PC & GE)
600' Chamber (2004-PC) (2005-GE)
Lock 25 - Helper Boats (1990-PC & GE)
600' Chamber (1998-PC) (2005-GE)
Lock 26 - 600' Chamber (1995-PC) (1995-GE)
Lock 27 -

Lockport - 600' chamber (2008-PC) (2010-GE)
Brandon Road - 600' chamber (2004-PC) (2005-GE)

Dresden Island - Switchboats (1998-PC) (1990-GE)
600' chamber (2030-PC) (2010-GE)
Marseilles - Switchboats (1990-PC & GE)
600' chamber (2009-PC) (2000-GE)
Starved Rock - Switchboats (1994-PC) (1990-GE)
600' chamber (2016-PC) (2010-GE)
Peoria - Switchboats (1994-PC) (1990-GE)
600' chamber (2010-GE)
La Grange - 600' chamber (2010-GE)

Table V-15. **Scenario IVB**: System Modifications

General Description: Same as Scenario IVA except 1200 foot chambers are added instead of 600' foot chambers.

Timing and Sequencing: Same as Scenario IVA.

differences are noted in the following tables by designating years according to the PC or GE model. Improvement dates shown on the various scenario tables were based on best estimates of when traffic demand would render the various improvements economically justified. These dates are not always totally consistent due to a need to develop a range of dates showing the economic impact of various improvements. As a result the dates should be looked upon as approximations subject to later detailed optimization.

EVALUATION OF SCENARIOS

The economic evaluation of the scenarios was directed toward assessing the national economic development benefits and costs. Impacts on local and regional economies including the financial health of river communities and employment shifts resulting from rail abandonment or port development were beyond the scope of designed studies.

Two different models were used in the economic evaluation of the scenarios -the "Percent of Capacity" (PC) model and the "General Equilibrium" (GE) model. Both models used the data from the rate file in combination with delay reductions to calculate transportation benefits.

Transportation savings in both models are measured by the product of traffic flow times the rate savings for each movement. Rate savings are total charges to the shipper of moving by an alternate mode less the total charges of moving by water. The latter includes the full delay cost through that portion of the system where a movement occurs. The transportation rate savings are defined in the Principles and Standards (18 CFR 713.703(e)) as the appropriate measure of National Economic Development Benefits. The analysis was made with the understanding that the commodities moved by water would in the absence of expanded navigation capacity move by an alternate mode from the same origin to destination.

Transportation benefits for both models are derived by taking the difference or change in total system transportation savings from one scenario to another - or one system condition to another. Differences between the two model approaches occur in computing which movements might remain on the waterway system and in the delay cost incurred as system constraints are approached.

The Percent of Capacity Model (PC) computes delay costs for the system. However, if a lock reaches within a few percentage points of its physical capacity, delay costs are held constant at that level. Also, no movement is diverted from the waterway until at least one such condition occurs. Movements are diverted based on those with the lowest net savings (on per ton basis) leaving first. Movements, or fractions of movements, are diverted until traffic no longer exceeds its practical capacity. This is repeated until all locks are at or below their practical capacities. Transportation savings are then computed for the traffic which remains on the system.

The General Equilibrium (GE) model likewise computes delay costs for the system for each movement. Physical capacity estimates and the delay costs associated with a given traffic level are the same at a lock in each model as long as traffic is within the practical or operational capacity. In the GE approach, delay costs accumulated for each movement are allowed to rise to the point where net savings are zero. At this point the movement is diverted from the waterway. Since this diverted traffic changes the delay costs for the remaining traffic, further itertions are needed until the point is reached where all movements remaining on the water mode have net savings greater than zero. Transportation savings are then computed.

Transportation benefits from each approach result from both delay reduction and from traffic that would not otherwise move on the water mode unconstrained. Delay reduction benefits in the GE approach are greater since delay costs are allowed to rise to whatever level is needed to divert traffic. Transportation benefits to flows that would not otherwise move in the PC approach are affected by movements with no current net savings as currently estimated. These movements in the PC model remain on the system unless they move through a lock at its operational capacity. This may result in lower transportation savings for certain measures.

The scenarios were evaluated using traffic projections with both 1977 and 1980 base years. In addition they were evaluated using both existing and future tow size conditions. The evaluation results presented in this report are those using 1980 base traffic forecasts and future tow size (Table V-16, Figure V-3). The PC model used projected tow size figures for the year 2040. The GE model used the median of 1977 and 2040 tow size. As noted previously, the evaluations are particularly sensitive to these two variables. However, future tow size and 1980 base projections were judged to most closely approximate future conditions. In general, these factors may affect timing and sequencing of improvements and thus costs and benefit evaluations (Table V-17 and V-18). In all cases, the single 1200 foot lock now under construction at Lock and Dam 26 is assumed to be in place for the evaluations. Thus 1990 is the base year.

Table V-17. Cost for Implementation of Scenarios

Costs in thousand 1980 dollars

Scenario		Total Capital Cost1/	Average O & M2/
Scenario	I	12,386	1,295
	Ia	263,086	1,515
	Ib	369,419	1,515
Scenario	II	135,000	44,500
Scenario	III	58,235	9,250
	IIIa	308,900	9,470
	IIIb	415,200	9,470
Scenario	IVA3/	1,738,000 (PC)	16,000 (PC)
		1,948,000 (GE)	21,000 (GE)
	IVB3/	2,305,000 (PC)	16,000 (PC)
		2,580,000 (GE)	21,000 (GE)

1/ Total Capital Cost is the undiscounted total of all first costs, including 7-5/8% interest during construction for additional chambers.

2/ Average O & M is a simple average over 50 years of operation, maintenance, and replacement costs. This does not include existing system O & M.

3/ Cost figures are given for both Percent of Capacity and General Equilibrium model evaluations because GE model included 2 additional locks (Peoria and LaGrange).

Table V-16. System Traffic Based on Percent of Capacity Model1

(millions of tons)

	Scenarios								
YEAR	I	I-a	I-b	II	III	III-a	III-b	IV-A	IV-B
1980	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
1990	125.9	125.9	125.9	127.7	127.7	127.7	127.6	127.6	127.6
2000	131.2	133.2	142.5	136.7	136.7	155.5	155.5	155.5	155.5
2010	129.1	142.7	150.7	138.2	139.3	171.5	171.5	178.3	178.3
2020	129.2	145.5	150.8	139.8	139.3	173.6	173.6	186.6	186.6
2030	128.6	148.3	151.4	140.2	139.2	173.8	173.8	195.2	195.2
2040	128.9	150.6	152.3	140.0	139.6	174.4	174.4	204.3	204.3

1/ System traffic represents origins or terminations of shipments within the system. Intra-pool traffic which does not transit any lock in the system is not included in this figure.

Traffic levels for the General Equilibrium model are not available for the system but are estimated to be approximately 10 percent less than with the Percent of Capacity Model due to diversion of traffic that is shown to be uneconomical.

Average annual transportation costs were derived by discounting all costs to the base year using the 7-5/8 percent interest rate nationally mandated for water resource projects in 1982 as defined in 18 CFR 704.39(a) by the Water Resources Council. Thus the costs and benefits were applied to each scenario in constant value dollars. If the current 10 percent inflation rate was computed into the analysis, the 7-5/8 percent would actually result in an approximate interest rate of 17½ percent over the term of the project and annual benefits (and operating costs) would be increased by a rate of 10 percent compounded annually.

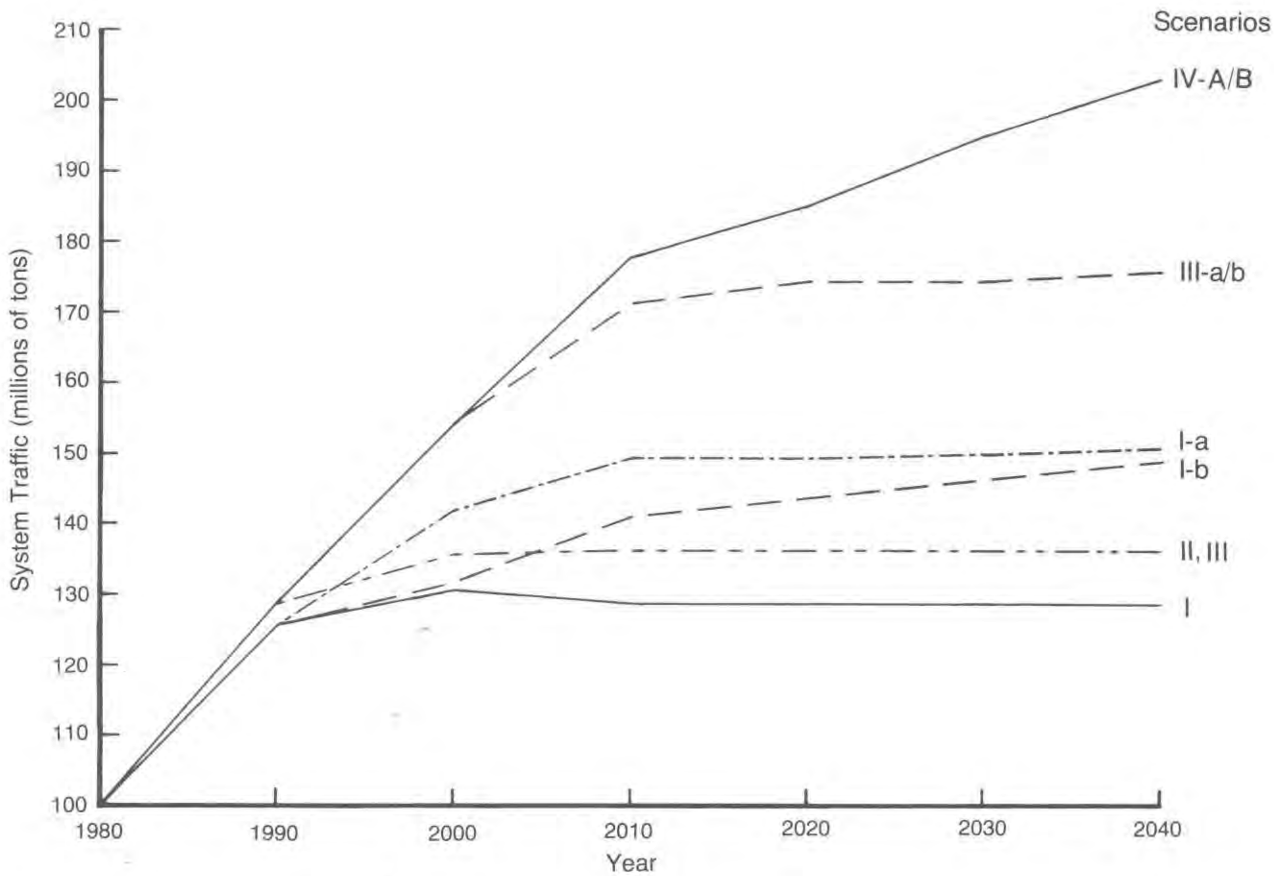


Figure V-3. System Traffic*

*System traffic represents origins or terminations of shipments within the system. Intra-pool traffic which does not transit any lock in the system is not included in this figure.

Table V-18. Evaluation of Scenarios: Incremental Average Annual Costs and Benefits[1]

(in thousands of 1980 dollars)

Scenario/ Condition	Percent of Capacity Model Benefits[3/]	Costs[4/]	Excess B-C	Without Condition	General Equilibrium Model Benefits[3/]	Costs[4/]	Excess B-C	Without Condition
No Action	---	---	---	---	581,700	not available	---	over closing the river down to navigation
Scenario I	1,904	1,070	834	No Action	not available	not available	---	---
Ia	23,135	17,082	6,053	I	105,100	18,300	86,800	No Action
Ib	24,274	22,556	1,718	I	105,600	24,800	80,800	No Action
Scenario II	23,341	54,350	-31,009	I	152,400[2/]	54,400	98,000	No Action
Scenario III	5,783	17,335	-11,552	I	152,400[2/]	21,000	131,400	No Action
IIIa	33,691	13,716	19,975	III	134,500	17,200	117,400	III
IIIb	35,124	19,472	15,652	III	135,200	23,700	111,500	III
Scenario IVA	77,531	49,290	28,241	III	294,700	59,200	235,500	III
Scenario IVB	82,985	67,080	15,905	III	306,600	77,700	228,900	III

1/ Average annual transportation costs are derived by discounting all costs at the FY82 interest rate as defined by the Water Resources Council for water resource projects (7-5/8 percent) to the base year 1990. Operation and maintenance costs also vary over time within a scenario. These are, likewise, discounted to 1990. The total present worth in 1990 of both first costs and O & M is then amortized over 50 years to obtain average annual costs. The comparable figure for the without condition scenario is then subtracted from the scenario being evaluated. Transportation benefits and costs, therefore, are the changes in transportation savings and costs between scenarios.

2/ Scenarios II and III were assumed to be equally effective.

3/ Transportation Rate Savings.

4/ Excluding any mitigation costs.

Discussion of Scenario Evaluation

Scenario I: The transportation benefits for Scenario I were derived from the increase realized over the base or "no action" condition. Most of the benefits were in delay reduction since system traffic did not change. It is likely that a substantial portion of these benefits are due to the N-up/N-down lockage policy and the measures included at Marseilles Lock.

Scenario II: The evaluation of Scenario II measures started with bowthrusters in combination with Scenario I measures. The resulting lock and system capabilities precluded the need for any additional measures initially intended for inclusion in Scenario II (additional approach improvements and recreational lockage hours). The absence of additional chambers in Scenario II, especially at Lock and Dam 26, severely limited realizing the full potential benefits of the systemwide bowthruster measures. This was due to constraints on system traffic. In addition, since bowthrusters were applied systemwide, the number of such units required and the corresponding costs appeared to exceed the benefits provided. If there was a way to limit the application of bowthrusters to just a portion of the system, most of the benefits would still be realized and costs would be less but this would ignore industry logistics.

Scenario III: The screening of eligible measures for Scenario III included selecting appropriate double-lockage improvement measures by site (either kevels, helper boats, or switchboats). Since a system constraint still existed at Lock 26 (as in Scenario II) the selected double-lockage improvement measures were not all realizing their potential benefits. In addition, the capacity increases of the double lockage improvement measures were sufficiently large, given the system constraint at Lock 26 that other non-double lockage measures added more to costs than to benefits.

There are no net positive transportation benefits for Scenario III under the 1980 base traffic forecasts and future tow size (PC model). Part of this result is due to increases in total system delay costs. Another factor was the sequencing of improvements over the period 1990 to 2040. Certain double lockage measures in Scenario III could have been sequenced differently and therefore resulted in greater benefits. Surprisingly, the Scenario III evaluation using existing tow size (distributions) provided greater net benefits than the future tow size projection -- both with the 1977 and 1980 baseline traffic forecast. This could be attributed to a lower starting point, (Scenario I) under existing tow size and corresponding lock capacity estimates. In essence, the increase in capacity and hence delay reduction was more valuable under existing tow size because the base was smaller.

Scenario IV: The major difference between Scenario III and IV in nonstructural measures was a substitution of helper boats for kevel systems at certain Mississippi River lock sites. This change was made because the rate of projected traffic growth limited the time over which kevel systems provided a reduction in delay. Since the kevel system costs were largely capital costs as opposed to the operating costs for helper boats, the shorter use period of kevels over which the capital costs yielded a return reduced their economic feasibility compared to helper boats. The sequencing and timing of Scenario IV measures was very complex. The addition of a chamber at a constraining site "induced" the need for upstream nonstructural measures. These nonstructural measures in a virtually unconstrained scenario proved economically efficient while they were in place plus allowed for deferred additional chambers where needed to pass the forecasted traffic. This latter impact reduces the discounted costs (or present worth of costs) for the additional chambers. In comparing the net benefits of Scenario IV and III it is apparent that the major nonstructural measures are more effective and efficient in the context of a structural improvement program than without.

The evaluation results of Scenario IV indicated that while total program capital costs were substantial, transportation benefits compared to annual costs provided a sizable excess return to the investment. Also, since the timing of additional chambers has a direct affect on annual costs, excess benefits over costs could be greater with a closer to "optimal" sequencing. This holds for both the Scenario IV using 600 foot additional chambers as well as the evaluation using 1,200 foot chambers.

Economic Need for a Second Lock at LD26

In an attempt to arrive at a better understanding of how a second lock at Lock and Dam 26 would effect the transportation savings, four specific first-added scenarios were evaluated -- Scenarios Ia, Ib, IIIa, and IIIb. Under both the "Percent of Capacity" model and "General Equilibrium" model, Scenarios Ia and Ib show substantial excess benefits over costs. In the Percent of Capacity model, these two scenarios used Scenario I as the point of departure, while the "General Equilibrium" model used the base case (no action) as the point from which benefits were computed. The difference between the base case and Scenario I is slight, and the use of different bases does not materially effect the results.

Scenarios IIIa and IIIb also show substantial excess transportation benefits over costs. These two scenarios measure the impact of adding a second lock at the new Lock and Dam 26, assuming an array of non-structural improvements, including switchboats and traveling kevels, will be utilized when cost effective. This set of assumptions results in even higher net benefits for a second lock at Lock and Dam 26 under both the "Percent of Capacity" and "General Equilibrium" models than under Scenarios Ia and Ib.

Scenarios IVA and IVB also include adding a second lock at the new Lock and Dam 26. However, here the lock change is not an individual lock change, but part of a system package of lock changes.

When viewed in this context, as well, the excess benefits over costs are positive.

One can conclude from the above that a second lock at Lock and Dam 26 is justified on transportation savings criteria, since positive net benefits result on a first-added basis, as well as on a system basis.

Conclusions regarding the approximate size of the second lock are less clear. Under the "Percent of Capacity" model, the difference in benefits between Scenarios IVA and IVB is $5.4 million average annual (this assumes all 11 locks are 1200' rather than 600' long), while the incremental cost of a second lock 1200' long versus 600' at Locks and Dam 26 alone is $5.7 million. (See the difference between Scenarios IIIa and IIIb costs for the "Percent of Capacity" model.) Using this model, the 1200' length is not justified on economic grounds alone.

Using the "General Equilibrium" model, the results are less clear, since the difference in benefits between Scenarios IVA and IVB is $11.9 million average annual (again, these benefits are for 13 locks in the system being 1200' long), compared with costs of $6.5 million at Lock and Dam 26 alone. (See the difference between Scenarios IIIa and IIIb costs for the "General Equilibrium" model.) Using this model without further detailed information, it is not possible to determine whether a 600' or 1200' lock is optimal, although both are economically positive.

In order to determine the appropriate size of a second lock, one would need to consider, besides the specific benefits discussed above, the impact of safety, risk, uncertainty, discount rates, national emergencies, and defense considerations. For instance, the traffic projections used after 2010 (i.e., less than one-half of one percent per year) could be viewed as quite conservative if viewed from an historical prospective. Higher levels of growth may significantly impact the economic results. Also additional costs may be incurred at the first 1200' lock at Lock and Dam 26 if the decision is made to build something less than a 1200' second lock at Lock and Dam 26, i.e., dual lift and miter gates on the upstream end.

Approximate timing of a second lock at Lock 26 is also a key question. The evaluation using the "Percent of Capacity" model did not attempt to determine the optimum year for a second lock to open. Instead the year 1993 was selected for evaluation purposes as the year approximating the equalization of delay reduction benefits associated with an additional chamber and the average annual cost of that chamber. In the General Equilibrium model, 1990 was assumed to be the beginning year for all Scenarios except IVA and IVB where 1995 was used. These years were initially selected as best estimates of probable optimum points. Based on output from the GE model, it was possible to specifically determine the optimum year for selected conditions. Thus using the 1980 base traffic projections, median tow size, and base rates, the optimum year for a second lock to open would be 1991 if demobilization/remobilization costs are not included and 1990 if they are considered. Initial planning estimates set demobilization/remobilization costs at $30 million for a 600-foot lock and $50 million for a 1200-foot lock.

SENSITIVITY ANALYSIS

Three key areas were identified and used to assess the sensitivity of the evaluation results. These were the duration of open pass available at Peoria and LaGrange Locks and Dam, an increase in the tax on fuel used by towboats, and an increase of 10 percent in the estimated line-haul rail rates.

Open Pass Sensitivity

The duration of navigable (open) pass at Peoria and LaGrange locks was reviewed over a 15 year period, 1964 - 1978. The navigation evaluations used the 15-year average duration in computing the traffic throughput for the lock plus that expected during open pass periods. As part of the sensitivity analysis these durations were reduced by about 50 percent. These lower open pass durations could be expected to be equalled or exceeded 80 to 90 percent of the years.

Using lower levels of open pass in the sensitivity analysis increased delays at both Peoria and LaGrange sites and caused these sites to be constraining earlier in the forecast period. Therefore, in the sensitivity analysis, the sequencing of measures had to be moved up several years in Scenarios III and IV for Peoria and LaGrange. The revised timing of measures increased system costs on an average annual basis. However, transportation benefits increased by more than the increase in costs because of greater delay reduction benefits and from reducing diverted traffic.

The lower open pass analysis did not change the relative ranking of the scenarios in terms of net benefits. Sensitivity analyses of a 30 cent per gallon fuel tax and a 10 percent increase in rail line haul rates showed the same relationship with lower open pass as they did with the historical average durations.

User Fee Sensitivity

The issue of user fees was not addressed in the Master Plan. The U.S. Department of Transportation was directed to conduct such a study under separate authorization. However, the impact of a user fee on the results of the scenario evaluation was assessed by the application of one form of fee -- a fuel tax.

A $0.30 per gallon additional tax on fuel used by towboats was assessed by increasing estimated line haul barge rates by 15 percent. The impact on gross transportation savings in the system is a reduction of 15 to 16 percent. Average annual revenues generated by such a tax varied from an estimated $130 million in Scenario I to $144 million in Scenario IV. In all cases, the estimated tax revenues on an average annual basis (1990, base year) exceed the average annual costs for the scenario even when current operations expenses and rehabilitation costs for the system are included. Thus, although the purpose of the fuel tax sensitivity analysis was not to identify a full cost recovery scenario, the results indicate the $0.30 per gallon fuel tax would on an average annual basis provide more than full cost recovery for the most expensive system improvements and ongoing operation and maintenance. The impact on measure sequencing may be to defer measures by several years if the additional tax results in diverting additional waterway traffic.

Rail Line Haul Rate Sensitivity

An increase of 10 percent in estimated rail line rates provided an indication of the sensitivity of net transportation savings to changes in the basic rate data. Gross transportation system savings increased 32 percent in all the scenarios. Excess benefits over costs for Scenarios II, III, and IV all increased substantially, although those for Scenario II still remained negative with the "Percent of Capacity" Model.

As expected, the results from the rail line haul sensitivity analysis and those from the fuel tax sensitivity analysis bracketed the results from the baseline scenarios. A 10 percent decrease in rail line haul rates would have an impact similar to that presented for the 30 cent per gallon fuel tax increase.

OTHER ASPECTS OF SYSTEM CAPACITY

Although locks are the constraining factor in system capacity, there are other aspects of the navigation system which can affect the movement of traffic on the system. Such variables include channel dimensions, bends, bridges, terminal facilities, and fleeting areas.

The width and depth of the channel affect both the size of the tows and the speed at which they can safely travel. Likewise sharp bends in the river can produce delays due to reductions required in speed to maneuver the tow and waiting time involved if the bend restricts the ability of two tows to pass each other. Narrow bridge spans can increase the difficulty of passage of large tows and thus reduce the speed of the vessel.

Fleeting areas are areas of the river used for the temporary storage or reconfiguration of barges. As traffic increases, the demand for fleeting space is also expected to increase. No projections of fleeting area needs were undertaken as part of the Master Plan. As a non-constraining aspect of capacity it was assumed that apart from the role government plays in the permitting of fleeting areas, the location and amount of fleeting space is an industry decision in response to demand. It is recognized that the siting of fleeting areas is an important environmental and economic consideration; however, fleeting does not present a constraint to capacity expansion.

Like fleeting areas, terminal facilities are not considered to be constraining aspects of system capacity as they reflect private sector investments in response to demand. However, an inventory of current terminal capacity was undertaken to identify possible future capacity deficits. Barge terminals were inventoried including relevant information about each terminal's characteristics. The annual cargo transshipment capacity of each terminal was then estimated. The individual capacities were aggregated by commodity group within each river pool to develop the estimated transshipment capacity for each pool and commodity group.

The estimated transshipment capacities were compared to the cargo flows forecast for 1990 and 2000, as well as to the actual 1977 interpool tonnages, to identify projected capacity deficits.

The capacities calculated do not consider the economic efficiency of the existing terminals. It is expected that in many instances new, more efficient terminals will be constructed to compete with older, less efficient terminals before the physical capacity of the existing terminals is reached. Such additional terminals are not identified because of methodology limitations.

Three commodity groups dominate the projected additional capacity needs of the Upper Mississippi River System: chemicals, coal, and farm products.

Chemicals will require additional transshipment capacity in Mississippi River pool numbers 13, 15, 25, and 27 and in Brandon Road pool on the Illinois River.

Coal will require additional transshipment capacity in Mississippi River pool numbers 1, 11, 12, 15, 20, and 24 and in Brandon Road, Starved Rock, and LaGrange pools on the Illinois River.

Farm products will require additional transshipment capacity in Mississippi River pool numbers 12, 13, 14, 15, 17, 18, 19, 21, 24, 25, and 27 and in Dresden Island pool on the Illinois River.

Other commodity groups have more localized commodity transshipment needs.

EFFECTS ON RAILROADS

Because inland waterways compete with railroads for many kinds of traffic, investments which expand the capacity of such waterways or extend their reach will, obviously, have some impact on the economic fortunes of the railroads. Thus, the potential impact of waterway investments on railroad's revenues has often been part of the discussion of the desirability of proposed expansion projects and was specified for study in P.L. 95-502, Section 101(e)(2)(B).

Concern About Railroad Impacts

From an economic standpoint only a few reasons warrant governmental interference in the private marketplace. In a free market economy, the normal forces of competition are usually sufficient to enforce efficient resource allocation through the price mechanism. If the prices of each industry and firm correctly reflect costs, then the proper amounts and types of products and services will be produced in the most efficient economic manner.

There are, however, circumstances in which this free market decision making process does not hold and where the issue of railroad impact should be considered:

1) When costs are not fully internalized to the firm or industry, the price mechanism does not produce an efficient allocation of traffic. Today, the Federal government provides and maintains the navigation channel at almost no cost to the industry. Since these costs are not fully, or even substantially, reflected in waterway transportation rates, the shipper does not have to take them into account when deciding which mode to use.

2) When regulation of railroad rates and common carrier service requirements restrict price and service flexibility of the railroads and prevent them from abandoning or reducing service on unprofitable lines. The government has, in effect, used its regulatory power to provide more rail capacity than the private market would have otherwise provided.

3) When there are differences in government taxing policies which distort cost relationships. For example, railroads pay taxes on their rights-of-way while barge operators are not directly taxed on their use of the navigation channel. A tax on fuel is imposed, however.

4) When there are social considerations relating to communities which might lose all rail service if a railroad were to be financially burdened by loss of revenue to water competition.

In the last several years, there have been a number of major changes in Federal policy both in regard to the railroads and to public investments in waterways. Regulation of the railroads has been relaxed to the extent that the government is no longer requiring the railroads to maintain unneeded capacity or to underprice some services. The government, in its response to rail bankruptcies in the midwest, has actively encouraged the elimination of excess rail capacity. There has also been some modest success in recovering from waterway users the public costs of maintaining and building the inland waterways. Public Law 95-502 provided a fuel tax on commercial barge operators that will reach ten cents a gallon in 1985. Moreover, the present Administration has proposed legislation requiring full cost recovery for the inland waterways. Under these new conditions and those that have been proposed, the special circumstances which might warrant governmental concern over rail impact are significantly diminished.

However, in the absence of full cost recovery, the impact of waterway investments on rail fortunes would remain a matter of government concern. Because barge rates are artificially reduced when government assumes part of the waterways costs, the demand for additional waterway capacity is artificially stimulated. Conversely, the railroads are deprived of the revenues that would have accrued to them in a truly competitive environment.

Character of Railroad Impact

It is important to understand the nature of the impact on rail revenues of public investments in more waterway capacity. It is unlikely that the waterway improvements considered under many of the scenarios in this study are so extensive that they would reduce revenues that the railroads are receiving now. In such cases, what is at issue is the relative share between rail and barge of future traffic growth. Clearly, if waterway capacity is not increased at all, sooner or later, traffic that might have gone on the water is going to have to go by rail or truck because of lack of capacity on the river. Conversely, as waterway capacity is increased barges are free to compete for and capture a larger share of future growth traffic. However, navigation benefits were computed in this study based on the assumption that the waterway's share of future growth traffic would remain the same as its present share.

The fact that it is revenue from future traffic growth, not current revenues, that is at issue is important for two reasons. One is that the traffic base for the existing level of rail services and revenues is not threatened by future expansions of waterway capacity. The other is that the railroads should have ample time to anticipate increases in waterway capacity and thereby be able to avoid a situation in which they would find themselves with fixed costs that they would be unable to cover. In other words, any potential future revenues lost by the railroads to the waterways need not lead to a reduction in railroad return on investment. To this extent, the problem of impact on railroads' financial condition from investment return and current revenues is ameliorated, if not eliminated.

In Scenario IV which provides for a number of improvements to increase waterway capacity, the potential for diversion of current railroad traffic due to cost reductions in barge transportation is greater.

Impact of Diverted Growth Traffic

The decision to increase waterway capacity can have a significant impact on the rate of growth in rail traffic in the future. The following sections a) identify the railroads which might be affected by this loss of growth traffic and assesses their current and likely future financial condition, b) outlines the methodology underlying the estimates of traffic diversion and reports projected losses in revenue growth to the railroads under alternative waterway improvements, and c) assesses the validity of the assumptions that no current rail traffic is diverted to the waterway as a result of waterway improvements.

Financial Condition of Selected Railroads

A large number of railroads serve the Upper Mississippi River Basin, either directly or by connecting routes. Some of these railroads have their operations concentrated in this region. For others the Upper Mississippi region is only part of a much larger service area. Some railroads operate primarily along north-south routes to the Gulf; others serve networks that include points in the West and Southeast. The north-south routes are directly competitive with the river and some of the western routes are becoming competitive for export movements. The impacts of capacity expansion in the Upper Mississippi River System may be felt in varying degrees by many of these railroads. The problem is to identify the set of railroads that is likely to bear the primary impacts of any change in waterway capacity.

Three groupings of railroads were considered: 1) the railroads that filed suit to halt Locks and Dam #26, 2) railroads which derive a significant portion of their revenue from grain, and 3) those railroads which have mainline track in at least three of the five UMRS states. The three groupings constitute a total of fourteen railroads for which financial and traffic statistics were available. Most fall into two of the groupings and several in all three. All these railroads were considered in the study and are displayed in Table V-19 identified by groups.

Based on an analysis of these railroads'return on equity, ratio of operating expenses to operating revenues, and cash safety factor, the fourteen railroads listed in Table V-19 appear to be in acceptable financial condition as a group. It is important to remember, however, that the latest financial information available in the necessary detail is for 1979 or prior years. There have been significant changes in the rail industry since then, including deregulation and a wave of mergers and proposed mergers. These changes will affect the railroads' financial condition and their ability to respond to and take advantage of competitive market place situations. One indication that the influence will be positive and that financial outlooks are improving is that railroad stocks, as a group, are now commanding higher prices than in the past fifteen years.

The aggregate financial condition of the railroads affected by capacity expan-

Table V-19. Railroads Likely to be Affected by Capacity Expansion

	Services UMRB Area	Transports Grain	Part of LD 26 Lawsuit
Soo Line (controlled by the Canadian Pacific, Limited)	•	•	•
Missouri Pacific Railroad Company (controlled by Missouri Pacific Corp.)	•	•	•
Burlington Northern, Inc. (Chicago, Burlington & Quincy; Great Northern; Northern Pacific; Spokane, Portland & Seattle Railway Company; Fort Worth & Denver; Colorado & Southern; St. Louis-San Francisco)	•	•	•
Chicago & Northwestern Railway	•	•	•
Illinois Central Gulf Railroad Company (controlled by IC Industries, Inc.)	•	•	•
Chicago, Milwaukee, St. Paul & Pacific Railroad	•	•	•
Kansas City Southern Railway Company (subsidiary of Kansas City Southern Industries, Inc.)		•	•
Missouri-Kansas-Texas Railroad Co. (controlled by Katy Industries, Inc.)		•	•
Union Pacific Railroad (controlled by Union Pacific Corp.)		•	•
Atchison, Topeka & Santa Fe Railway (wholly owned by Santa Fe Industries, Inc.)		•	•
Denver & Rio Grande Western Railroad (controlled by Rio Grande Industries, Inc.)			•
Norfolk & Western; System (Norfolk & Western; Akron, Canton & Youngstown Railroad)			•
Southern Pacific Transportation System (Southern Pacific Transportation Co.; Northwestern Pacific; St. Louis Southwestern)			•
Southern Railway Company (Southern; Alabama Great Southern; Cincinnati, New Orleans & Texas Pacific; Central of Georgia)			•

sion of the Upper Mississippi River System depends on the group of railroads which is analyzed. The profile of the group of thirteen is bolstered by the inclusion of several large healthy railroads. Nonetheless, that group also contains several railroads whose condition is poor by almost any standard. Most of these, all but the Missouri-Kansas-Texas Railroad, are also in the group of six primary carriers in the region. The financial outlook for the latter group, as a group, is therefore less encouraging. The condition of the grain-hauling railroads is somewhere between these two extremes. These impressions are reinforced by the presence of several marginal railroads in the area. It should be pointed out that the present financial condition of the railroads is not necessarily caused by waterway competition nor should the financial condition, in and of itself, be a sole reason to limit future waterway capacity improvements. Nevertheless, the extent of the impact of any future waterway improvement will be strongly influenced by the financial condition of the railroad system and thus its ability to respond to increased competitive pressures.

Recent development such as mergers, bankruptcies, and abandonments affect the financial outlook for these railroads. Railroads are purchasing those portions of the Rock Island and of the old Milwaukee which they expect to be profitable. Railroads in general are likely to benefit financially from regulatory reform.

One possible exception to this generally positive outlook on recent events would be the Missouri-Kansas-Texas Railroad. It is already an unprofitable railroad and will be adversely affected by certain recent or proposed mergers. Nevertheless, the system as a whole will be in better financial condition and better able to respond to any change in expected traffic or revenue due to increased waterway capacity.

Data and Methodology

The analysis focused on changing shares of future growth traffic that would move on the river if capacity were increased. The current level of rail revenue was considered to be unlikely to fall because of waterway expansion.

It is important that this concept be understood clearly. Consideration was given to a body of future growth traffic that will go either by rail or by barge. This is referred to as "swing" traffic. If delay costs on the river start to rise as current capacity is reached, this traffic could go by another mode. If capacity keeps up with growth so that delay costs do not rise, all of this growth traffic will be on the river.

The basic data for this analysis were the estimates of increased rail traffic when waterway capacity becomes constrained under a set of alternative scenarios and the rail rates associated with each movement.

The estimates of rail traffic under the various waterway expansion scenarios were generated the General Equilibrium model that compares rail-barge rate differences to the approximate delay costs associated with projected waterway traffic levels. If the cost of delay for a movement (commodity and origin/destination combination) exceeds the difference between the rail and water rates, the shipment is presumed to go by rail. The unconstrained waterway traffic levels for which delays were estimated were derived from the National Waterways Study projections of waterway traffic growth which are based on 1977 traffic levels. Rail and barge rate data, both line-haul rates and accessorial charges, were collected. Barge rates were for 1977, and did not include the current waterway fuel tax. All rail rates except coal and load/unload costs were also for 1977. Exceptions were adjusted from 1980 to 1977 price levels.

Estimates of rail traffic changes were made for eight individual years in the period 1990-2040 for each navigation expansion scenario.

The rail revenue associated with each shipment was computed from tonnage and rate data and summed across movements for each of the eight years. Revenue estimates for the intervening years were then approximated by linear interpolation. The rail revenue impact was calculated by

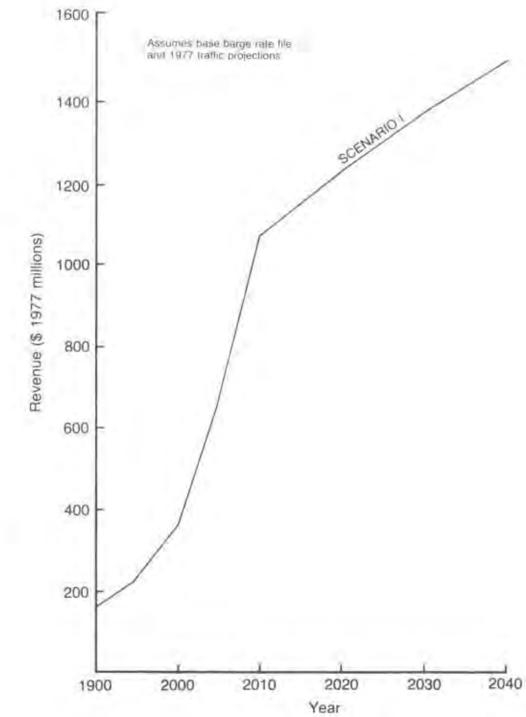


Figure V-4. Revenue from "Swing" Traffic

subtracting the revenue growth estimated for the expansion scenario from the equivalent estimate in the base case. Thus railroad impact was estimated as the amount of "swing" traffic which the railroads will not receive as waterway capacity is expanded.

Estimates of Rail Share of Traffic and Revenue

Figure V-4 presents the estimate of rail growth revenue under Scenario I. Obviously, the highest rail traffic and revenue growth occurs in the base case, Scenario I, in which no major waterway improvement takes place. This is the total amount of the "swing" traffic.

Figure V-5 presents the estimates of the rail revenue from "swing" traffic foregone under the various expansion scenarios. These estimates represent the difference from Scenario I in Figure V-4. All estimates assume that the traffic projections and on the base barge rate file. In all scenarios, the revenue from

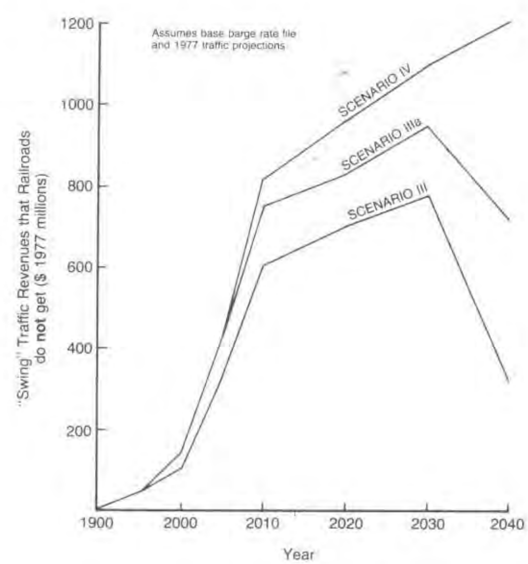


Figure V-5. Rail Revenue from "Swing Traffic that is Foregone because of Waterway Expansion

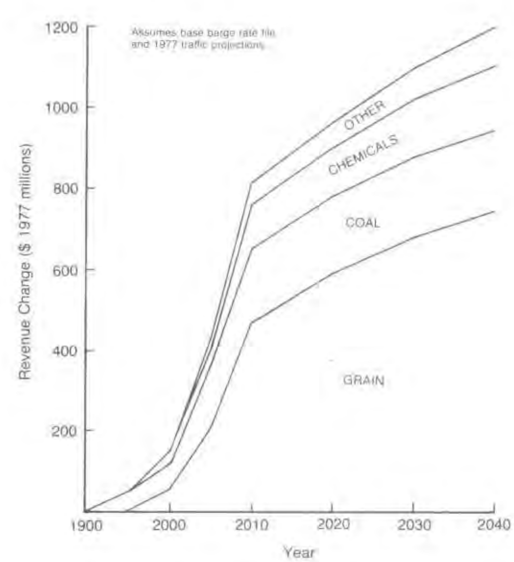


Figure V-6. Commodity Composition of Rail Revenue from "Swing" Traffic that is Foregone under Scenario IV "swing" traffic starts out small in early years and grows rapidly until 2010 when it levels off due to projected growth rates. After 2030, Scenarios III and IIIa are affected by capacity constraints and thus railroad revenue foregone declines.

Figure V-6 shows the commodity composition of the decrease in the rail share of "swing" revenue with Scenario IV waterway improvements. Except in early years, grain revenue growth changes account for more than half of the total. Coal and chemicals revenues are the second and third largest components of the total. In order of importance, the other commodities include petroleum products, iron and steel products, and cement and stone.

Table V-20 presents estimates of revenue growth changes from Scenario IV under other assumptions about barge rates and future traffic levels. Higher barge rates reduce somewhat the rail revenue changes resulting from Scenario IV improvements. The 15% barge rate increase in Column 3 corresponds roughly to a 30¢ per gallon fuel tax. While it gives some indication of future traffic impacts under a fuel tax, it should not be treated as a user charge impact analysis. The simple percentage increase does not reflect any tax reductions for increasing traffic levels nor was it meant to identify any specific level of tax needed to recover capital costs of any specific construction undertaken.

The 1980 traffic base projections are significantly higher than 1977. This higher traffic assumption results in significantly higher revenue changes to the railroads as a result of making the Scenario IV improvements. Higher unconstrained barge traffic levels would encourage earlier timing of improvements, however the improvement timing in the Scenario was based on 1977 traffic projections. Therefore, the estimates of rail revenue changes presented in Table V-20 are probably somewhat low.

Table V-21 shows the annualized revenue changes which result from the waterway capacity expansion scenarios as a percent of rail revenue. Because rail revenue change is sensitive to the traffic base year, Scenario IV results are presented for both 1977 and 1980 traffic bases. The annualized rail revenue gain which would result if there were no waterway expansion (Scenario I) is added to the 1979 rail revenues to approximate the revenue base from which the changes should be measured. This revenue base is somewhat smaller than it would be in 1990, the base year, because rail revenues will grow over the period 1979-1990 as a result of real growth in rail traffic. The very large revenue growth losses in the 2010-2040 time period dominate the annualized revenue loss estimates. This fact is shown in Figure V-5. Therefore, the estimated percentage change in rail revenue will be substantially less in the 1990's. Further, rail revenues should grow in the 2010-2040 period as well, so the percentage changes should not grow dramatically.

Table V-20. Sensitivity of Rail Revenue Under Scenario IV to Traffic and Rate Assumptions

Year	Rail Revenue Growth Change Under Scenario IV (million of 1977 $)		
	Base Rates, 1977 Traffic Base Projections	15% Increase in Barge Rates, 1977 Traffic Base Projections	Base Rates, 1980 Traffic Base Projections
1990	$ -6.5	$ -4.0	$ -10.6
1995	-46.7	-65.8	-96.3
2000	-146.7	-134.6	-766.8
2005	-429.8	-326.6	-977.0
2010	-817.8	-697.6	-1176.2
2020	-962.5	-882.1	-1303.6
2030	-1099.8	-1030.9	-1444.3
2040	-1205.6	-1435.7	-1591.5

Table V-21. Rail Revenue Change Due to Waterway Expansion [1]

Railroad Group	1979 Rail Revenue (million of 1977 $)	Annualized Rail Revenue Change w/o Expansion (Scenario I)[2/] (million of 1977 $)	Total Rail Revenue w/o Expansion[2/]	Total Revenue Change Due to Waterway Expansion[3/] million of 1977 $/percent: Scenario III	Scenario IIIa	Scenario IV[2/]
13 RR's from L&D 26 Lawsuit	$13,002.8	$772.9 ($1,152.7)	$13,775.7 ($14,155.5)	-$369/-2.7%	-$467/-3.4%	-$540/-3.9% (-6.1%)
10 RR's with Large % Grain Revenue	$8,778.0	$772.9 ($1,152.7)	$9,550.9 ($9,930.7)	-$369/-3.9%	-$467/-4.9%	-$540/-5.7% (-8.7%)
6 RR's with mainlines in 3 or more UMRS states	$5,535.0	$772.9 ($1,152.7)	$6,307.9 ($6,687.7)	-$369/-5.9%	-$467/-7.4%	-$540/-8.6% (-13.0%)

1/ Assumes base rate file, 1977 traffic base projections

2/ Numbers in parenthesis represent base rate file, 1980 traffic base projections

3/ Discounted at 3 percent

Diversion of Current Railroad Traffic

If barge costs are reduced significantly below the levels in the base year as a result of waterway improvements, current railroad traffic would be diverted to the waterways. The reduction in barge costs could occur because current delays on the waterways are reduced or because larger facilities such as 1200' locks allow increased waterway efficiencies. To judge the significance of this possibility, 1990 delay costs for Scenario I were compared to the delay costs for the same barge shipments under Scenario IV for each of eight years between 1990 and 2040. Table V-22 shows the results of this comparison. The first column in the table shows that most shipments experienced some reduction in delay and delay costs due to the Scenario IV improvements.

This measurement thus represents one limit on the amount of impact on current rail traffic. This measure would, of

Table V-22. Estimates of Rail Traffic Change

Year	% of Tons of Barge Traffic With Reduced Delay	Weighted Average Delay Reduction as a % of Total Barge Cost[1/]	Estimated Change in Current Rail Traffic (million tons): Elasticity = -1	Elasticity = -3	Estimated Change in Growth Traffic (million tons)
1990	92.3 %	3.0	-3.4	-10.1	-1.0
1995	89.9 %	2.4	-2.9	-8.7	-9.2
2000	85.9 %	1.8	-2.3	-7.0	-18.7
2005	84.7 %	1.2	-2.1	-6.4	-43.1
2010	89.2 %	2.7	-4.2	-12.5	-68.5
2020	88.6 %	2.3	-3.7	-11.1	-79.6
2030	63.4 %	2.6	-3.1	-9.4	-90.9
2040	60.1 %	2.4	-2.8	-8.7	-98.9
All Scenario IV Improvements in 1990	98.5	4.3	-5.0	-15.0	---

1/ Shipments with delay increases not included.

course, be smaller for each of the other scenarios for which data are not shown. The largest percentage of traffic experiencing delay reductions occurs in 1990, before traffic grows to fill the extra capacity provided by the non-structural and minor structural improvements. The percentage generally falls as traffic growth erodes the extra service provided by these and other Scenario IV improvements.

The second column in Table V-22 shows the average delay cost reduction as a percentage of total barge transport cost. This average is calculated over traffic which actually experiences a delay saving. Traffic which experienced a higher delay under Scenario IV was excluded from this calculation. Note that the percentage reduction in total barge transport cost is quite small, even in 1990.

The next two columns present estimates of possible diversion of current rail traffic under some alternative assumptions about the price elasticity of demand for barge traffic. The estimates were developed by assuming that any traffic gain by barge would come at the expense of the railroads. Then, the percent reduction in barge transport cost was multiplied by the tonnage experiencing the reduction and finally by the elasticity. The resulting tonnage was summed over all barge shipments to obtain the estimates in Table V-22. The estimates provided in the table are extremely rough and are only provided to help gauge the importance of the possible diversion of current rail traffic.

The final column presents the traffic analyzed. This traffic would be gained by the railroads in Scenario I but not in Scenario IV. Except in the 1990's, this traffic exceeds even the high estimates of possible current rail traffic losses by very large amounts. Even in the 1990's, the estimated tonnage diverted is quite small compared to current railroad total tonnage. (Traffic originated by the 14 railroads in 1980 was 913.5 million tons.)

The last row in Table V-22 shows what would happen to delay and diversion in 1990 if all Scenario IV improvements were in place in that year. This row shows the sensitivity of current rail traffic diversion to improvement timing. While the estimated diversion is significantly higher than when the improvements are more properly staged, it is still fairly small compared to the total tonnages originating on any of the railroad groups.

The issue of railroad impacts arises from a concern that there are factors not fully considered in current cost/benefit analysis and which might affect the overall judgment as to the worth of a waterway expansion project. In the case of railroad impact for the waterway scenarios considered, evidence was not found that would suggest either the diversion of current traffic or that potential change in future growth traffic was sufficient to affect the regional level of railroad service or rail revenues in a manner which should significantly affect decisions on this project.

NATIONAL TRANSPORTATION POLICY

The relationship of any expansion of navigation capacity of the Upper Mississippi River System to national transportation policy is primarily an issue of Federal transportation policy since the construction, operation and maintenance of the inland waterway system is done by the Federal government. In addition, most of the waterborne traffic is either export or interstate in nature, and the inland waterway system competes directly with other interstate freight modes such as the railroads and the highways. This is not to suggest, however, that state and local government does not have a substantial stake in navigation capacity decisions. Most waterborne commodity movements are intermodal in nature. Highways must be provided and maintained to move the commodities to the river. Alternatively, if those commodities do not move on the river, then other highway connections and railroad facilities are necessary to move the products. Each state has a responsibility for insuring that the state's total transportation system among all modes is sufficient to move its products to market and also to bring in the necessary interstate freight such as energy products, fertilizer and food products. Therefore, although the emphasis of the Master Plan analysis is on Federal transportation policy, the state of state and local governments in the Federal decision process should not be minimized.

From the earliest days of the republic, the government has sought to ensure that adequate transportation facilities existed to provide for commercial freight transportation. This governmental role has existed in a blend of public and private investment decisions which has varied from mode to mode. The role has been promotional as in the early development of highways, railroads and waterways, and it has been regulatory to prevent economic abuse, to promote safety, or to protect the environment. In recent years, there has been a conviction that national transportation goals can best be achieved by placing maximum reliance on decision making in the private market sector.

In recent years some important additional emphases have been added to this policy. One is the recognition that, for the most part, the country's transportation system is built. The Federal attitude toward major transportation investments is no longer based heavily on promotional or development objectives. Expansion of existing facilities and new facilities must meet strict economic standards.

For the last few years, Federal policy has shifted toward improving reliance on the marketplace in two important ways. One is by trying to eliminate Federal actions such as regulations or subsidies that unduly constrain or distort the decisions made in the marketplace. Federal policy seeks to minimize economic regulation so that shippers and carriers interact freely in the marketplace. It also seeks to eliminate subsidies so that the costs of providing services are fully taken into account in private decision making.

Where the Federal government must act directly, as in waterway investments, it seeks to make its decisions in a way compatible with the decision-making process in the private marketplace. This is done in two ways. Through careful benefit-cost analysis the Federal government tries to establish a proposed facility's value to its users as compared to the costs of providing the facility. In other words, the benefits a facility provides to shippers through improved services or reduced rates or both should exceed the cost of achieving those improvements. The policy as defined by the Water Resources Council in 18 CFR 704.39(a) directs the use of a standard interest rate which currently (1982) is 7-5/8 percent for project analysis. The Principles and Standards for inland navigation project evaluation (18 CFR 713 Part I) state that transportation rate savings will be presented as the measure of direct project benefits in the national economic development account.

Cost recovery through user charges is another important aspect of this policy. With full cost recovery for all modes of transportation (including elimination of all direct and indirect subsidies), transportation services can approach true market prices. This could insure the most efficient level of transportation investment in each mode. The U.S. Department of Transportation and Department of Commerce are currently completing a thorough nationwide study of user charges. The decision regarding who shall pay for navigation system improvements is a Congressional decision based on information from other studies and other considerations in addition to the Master Plan. User charges or fees might include fuel taxes, facility use fees, segment charges or direct private financing.

The economic policies of the Reagan Administration have greatly strengthened and reinforced these views. Economic subsidies which distort the market process are to be reduced and eliminated in all modes.

These principles intensify the concern that any proposals for new waterway improvements be truly well justified and provide for cost recovery.

From the standpoint of the Administration's transportation policy, therefore, projects which increase the navigational capacity of the Upper Mississippi River are not inconsistent if they can meet these strict economic tests, if construction and operating costs are recovered to an appropriate degree, and if they pose no significant environmental or safety obstacles.

A study of the history of national transportation policy as revealed through its formal statements and its regulatory and promotional progams reveals:

- When transportation policy is viewed apart from past and present overriding public interests, such as the opening of the West, the national defense, the economic development of depressed regions, etc., the basic philosophy or theme behind transportation policy has been the maintenance of an orderly marketplace.

- The recent trends in national transportation policy have been toward reduced regulatory restrictions and reduced Federal aid.

- Recent transportation policy supported by both republican and democratic administrations has four basic tenets:

  (1) Transportation must be considered as a system not modally;

  (2) Reduce transportation subsidy with the users paying for the construction, operation, and maintenance of facilities and rights-of-way and the additional costs of special programs;

  (3) Reduce restrictive regulation; and

  (4) The transportation network no longer is in a developmental phase.

- Present national transportation policy has the following emphasis:

  Ensure a stable and orderly marketplace, where the market mechanism will permit private enterprise to make transportation decisions that will economically and efficiently allocate transportation resources, thereby providing the nation with adequate, efficient, reasonably priced transportation service while maintaining carrier profitability, by reducing arbitrary and restrictive regulation and eliminating subsidy in favor of a systemwide user pay approach to the development, operation, and maintenance of transportation facilities.

- This policy likely is to hold for the remainder of this century.

- This policy does not negate or undermine the policy as expressed in the Interstate Commerce Act of 1940.

- This policy does not preclude national defense or civil defense considerations as they impact on the transportation system.

Analysis of the relationships between Upper Mississippi River Basin capacity expansion and national transportation policy shows:

- Implementation of national transportation policy may result in a slow down of, but not an elimination of, the need for UMRB capacity expansion.

- National transportation policy supports transportation capacity expansion based on demand and the willingness of the users to pay for it.

- UMRB future capacity expansion resulting from the working of the market mechanism will be in consonance with national transportation policy.

- Interim negative effects of UMRB capacity expansion on other land modes, particularly the railroads, will be mitigated by other elements of national transportation policy, notably waterway user charges and regulatory reform.

Environmental Studies

The purpose and major objectives of the environmental studies are specified in P.L. 95-502, Section 101(e)(1). This section states that the Master Plan include a determination of the long- and short-term systemic ecological impacts of present and any projected expansion of navigation capacity and present operation and maintenance of the existing navigation system on the fish and wildlife, water quality, wilderness, and public recreational opportunities of the Upper Mississippi River System. In addition the means and measures that should be adopted to prevent or minimize loss of or damage to fish and wildlife shall be identified in the Master Plan. Finally, the Master Plan shall include a specific analysis of immediate and systemic environmental effects of any second lock at Alton, Illinois and provide for the mitigation of any adverse impact on, and the enhancement of, environmental and recreational resources.

The unique character of the system is based on its varied physical and biological resources and recreational opportunities. Prior to navigation development the Upper Mississippi River System was self-renewing. Natural processes created new backwaters and side channels and filled old ones. The system's balanced ecosystem supported a diverse array of fish and wildlife. Congress has designated over 230,000 acres of the Upper Mississippi River System as components of the U.S. Fish and Wildlife Refuge System.

To begin to accomplish the objectives of the environmental studies a detailed series of field investigations and technical evaluations were conducted. These work activities were designed to compile existing information, identify data gaps, and to the extent possible fill those gaps. Data collected in the course of the Environmental Studies have been evaluated and synthesized and are contained in the Environmental Report which provides the basis for this section.

The Environmental Studies included the following six study elements:

- Summary Resource Description
- Navigation Effects Study
- Mitigation and Enhancement Study
- Long-Term Resource Monitoring
- Recreation, Cultural Resources, and Wilderness Study
- Immediate Environmental Impacts of a Second Lock at Alton, Illinois

The six study elements were designed to provide the technical information needed to 1) assess the long and short-term impacts of navigation and operation and maintenance on the environmental resources and recreational opportunities of the system, 2) identify mitigation and enhancement methods, and 3) provide a framework for the future management of the resources and opportunities of the system.

The Summary Resource Description study element became the overall systemic information base on water quality and quantity, fish and wildlife, cultural resources, and potential wilderness areas.

Information on the systemic impacts of navigation and operation and maintenance on physical characteristics, fish and wildlife resources, and water quality were examined in the Navigation Effects study element. To the extent possible the nature of these impacts and a systemic analysis of current and projected impacts of navigation were assessed in this study element. The results of the systemic environmental impacts evaluation are provided on the map Displays 1 through 5 in the Navigation Effects Study section. Potential structural and non-structural solutions to current and anticipated environmental problems in the system were identified in the Mitigation and Enhancement study element. An example of solutions to representative environmental problems are presented on map displays in the Enhancement/Mitigation section.

The foundation for the future management of the environmental resources and recreational opportunities of the system was developed in the Long-Term Resource Monitoring study element.

Impacts on the other resources and opportunities of the system were derived from the Recreation, Cultural Resources, and Wilderness Study element. A separate study element examined the Immediate Environmental Impacts of a Second Lock at Alton, Illinois.

The following sections discuss the results of the Master Plan Environmental Studies.

SUMMARY RESOURCE DESCRIPTION

Data on the environmental resources of the Upper Mississippi River System have been generated by a number of previously authorized studies by State, Federal, and local entities, public and private learning institutions, and the private business sector. Much of this information is useful for providing a systemic overview of the UMRS. Its collection was essential in undertaking a systemic impact assessment.

The objective of the Summary Resource Description was to compile pertinent data on the physical characteristics, biological resources, cultural sites, recreational opportunities, and potential wilderness areas within the UMRS. The quality of this data base, although incomplete in some respects, was evaluated and important information gaps were described.

Part of this data base was used to describe the environmental setting of the UMRS both in Chapter II of this report and the Environmental Report. In addition selected information is presented on the map Displays 1 through 5 in the Navigation Effects Study section. Data on the biology of the UMRS were entered into a computer system to provide one component of a partial computerized inventory of environmental information. The establishment of this computerized data base and the identification and evaluation of existing data bases was coordinated with the Computerized Inventory and Analysis study element.

Significant information gaps in key resource areas and geographic locations, the lack of consistent data collection and evaluation techniques, and the lack of information awareness and exchange are the most serious obstacles to conducting systemic assessments. The identification of data gaps, problem areas, and incompatible analysis techniques through the Summary Resource Description Study aided in the Long-Term Resource Monitoring Study.

NAVIGATION EFFECTS

The objectives of the Navigation Effects Study were:

- to identify the direct and indirect effects of navigation, operation and maintenance, and induced development on fish, wildlife, and water quality;
- to assess the systemic impacts of current navigation levels, operation and maintenance, and induced development on fish, wildlife, and water quality; and
- to assess the systemic impacts of projected expansion of navigation capacity and future operation and maintenance on fish, wildlife, and water quality.

Comprehensive discussion of environmental impacts of navigation alternatives are contained in the Environmental Report.

Study Methodology

To accomplish these objectives a detailed study plan for assessing navigation effects was developed. This study plan was limited to: 1) a literature survey to assess current knowledge of impact relationships; 2) the conduct of field studies on pools 4, 9, and 26 of the Mississippi River, Alton pool on the Illinois River, and the Kaskaskia River; 3) use of, to the extent possible, field study results, other studies, and simulations to evaluate effects throughout the UMRS; and 4) use of panels composed of experts to further evaluate effects on fish, wildlife, and water quality.

The field studies included 1) an inventory of physical, biological, and water quality conditions at four sites in order to identify factors unrelated to navigation that may affect biota and water quality and 2) studies to evaluate direct physical effects of navigation and operation and maintenance on the river's environment. An additional type of field study to assess navigation effects on biological resources, given the magnitude of the physical effects, was not completed.

Field study results and other studies on the effects of tow passage were evaluated and used to simulate the current and projected physical effects of navigation throughout the UMRS. Simulations were calibrated with initial study results, other applicable studies, and laboratory findings. Protracted periods of high water during 1981 did not allow data collection throughout a normal flow regime, however, the results of the completed field studies verified most conclusions derived from simulations, which did consider a wide range of flows. Additional data are necessary for refining simulations. Available physical impact data were provided to fish and wildlife experts for use in describing the types of impacts of navigation and operation and maintenance on biota.

Types of Impact

The navigation project and navigation traffic significantly affect the ecosystem of the UMRS. Impacts can generally be grouped into: 1) ongoing activities including operation and maintenance of the project, 2) navigation traffic, 3) structural and non-structural improvements, and 4) induced development.

Operation and Maintenance Impacts

The navigation dams and river control structures essentially stopped the meandering processes of the river which create backwaters and side channels. By changing flow in certain regimes and diverting water to the main channel, these contributed to accelerated sedimentation in backwaters and side channels and limited new formation. The increase in water surface areas through construction of navigation dams led to an initial explosive growth in the population of fish and wildlife species which thrive in pooled conditions and a decrease in those which require free flowing conditions. The pools also expanded water-oriented recreational opportunities.

The navigation pools, side channels, and backwaters of the UMRS are complex components of the river ecosystem. Extensive sedimentation reduces backwater depths and results in loss of pools, side channels and backwaters and eventual conversion to shallow marshes and bottomland hardwood habitats. Studies of Pools 1-10 indicate that in the last 35 years, 25 percent of the open water area has filled with sediment and been converted to marsh or terrestrial habitat. In Pools 11 to 22, reductions in water surface area range from 8 percent to 31 percent depending on the pool. Extensive use of dikes in the open river below St. Louis has reduced water surface area by 40 percent from an 1880 data base. Similar occurrences have been noted on the Illinois River. Lakes that once had depths up to 15 feet now resemble platter shaped basins with maximum depths of less than 2 feet. At current sedimentation rates substantial backwater areas will be eliminated in 50 years or less. Within a century, much of the UMRS will consist of a main channel and major side channels bordered by terrestrial vegetation or shallow marsh. Directly associated with this loss is the loss of aquatic resources and recreational potential.

Sedimentation on the UMRS is affected by three major factors, sediment volume, sediment size, and water velocities. The first two factors are a function of the severe upland and bank erosion that takes place in the river basin. The third factor is greatly influenced by the navigation dams which reduce water velocities to backwater areas to the extent that many are now filling in. Associated with this is the additional sediment input to backwaters caused by passage of commercial tows.

Other impacts associated with operation and maintenance of the navigation system result from dredging, control of water levels, dike maintenance and construction, and bank stabilization and clearing and snagging. These activities greatly influence the characteristics of the UMRS. Dredging causes temporary local turbidity and water quality impacts and loss of benthos. Disposal of dredged material could result in aquatic and terrestrial habitat losses. Proper placement could make the material available for beneficial use such as recreational beaches. Although construction of the navigation dams stabilized water levels, fluctuating water levels to maintain navigation could expose and destroy benthic and floral colonies, inundate waterfowl and furbearer nests, and affect spawning success of some fish. The biological effects of wing and closing dams are both detrimental and beneficial. They induce sedimentation and reduce aquatic habitat by channelizing the river. However, they also provide aquatic habitat by adding large rocky substrate to the system. Similar to dikes, revetments often provide additional substrate. They reduce erosion but in great quantities also reduce riparian habitat.

Navigation Traffic Impacts

Based on the Navigation Effects Study, it can be concluded that the movement of existing levels of commercial navigation through the UMRS has adverse physical and biological effects. A moving towboat and associated barges have a variety of interactions with the hydraulics of the river. Included in these effects are changes in velocity, pressure, direction of flow, and wave generation. The extent of these changes are dependent upon a variety of factors including: channel depth, width, and discharge; and direction of travel, draft, width, speed, and alignment of the tows to the channel. Recreational boats can also generate physical changes when they operate near shore and in side channel and backwater areas. These physical alterations can result in adverse biological effects primarily caused by increased turbidity and suspended sediment levels, degradation of water quality, increased sediment input to backwaters, and increased shoreline erosion. The degree and magnitude of these physical disturbances can be estimated, however, the specific biological impacts are not well understood.

Increased levels of navigation will increase the magnitude of the physical effects - particularly turbidity, the erosion of streambanks, and the inflow of sediment into backwater areas. In effect, the current rate of filling in of the backwaters will be increased further by higher levels of navigation traffic. Impacts will be greatest in areas that have a narrow channel width, large sinuosity, short distance from the sailing line to the bank, frequent dredging requirements, high erosion potential, and large sediment inflow to side channels and backwater areas. The biological implications of these physical effects include substantial loss of habitat; loss of biological productivity, diversity, and abundance; and disruption of the normal behavior patterns. Specific impacts on some organisms are unknown.

The impacts of construction of a second lock are understood in terms of immediate impacts. The construction of a second lock will enable the system to operate efficiently and provide for significant increases in navigation, the systemic effects of which are only partially understood.

Structural and Non-Structural Measures Impacts

A number of structural and non-structural improvements have been proposed to increase the navigation capacity of the UMRS. Alternatives identified by the Navigation/Transportation studies include: 1) N-up/N-down lockage policy, 2) approach improvements, 3) mooring cells, 4) bow boats, 5) ice-operating improvements, 6) helper boats, 7) switchboats, and 8) additional lock chambers.

These measures will have, for the most part, systemic impacts similar to those discussed under "Operation and Maintenance" and "Navigation Traffic." Site specific impacts cannot be assessed until additional planning is completed.

Induced Development Impacts

Increases in the navigation capacity of the UMRS are expected to induce expansion or development of fleeting areas and terminals in the river corridor. A deficit in terminal capacity for various pooled reaches of the UMRS is projected. Although this deficit may be relieved to some extent through expansion of existing facilities, new terminals and associated development will likely occur. Although specific locations for terminal development are unknown, the pool segments where construction of special terminal facilities may be warranted were identified. Potential sites for future fleeting areas were not studied due to the fact that fleeting was not judged to be a constraining factor in the capacity analysis.

Lack of site specific designations for future terminal and fleeting area development and the scope of the Master Plan precluded detailed systemic analysis of the associated environmental impacts. However, new terminal development will likely occur on undeveloped or open lands adjacent to urban areas. These areas normally have greater habitat value than developed lands. Similarly, fleeting areas are usually developed in open water areas. Fleeting development will likely affect aquatic habitat and to a limited extent terrestrial habitat.

Development caused by increased levels of navigation will affect aquatic and terrestrial habitat. This impact can be considered on a site specific or systemic basis. Evaluations of the value of the affected habitat would have to be performed on a case by case basis.

Description of Impacts

The present environment of the Upper Mississippi River System is degrading in part as a result of a combination of natural forces, past and existing operation and maintenance activities, movements of tows and recreation craft, upland erosion, and induced development. Many factors contribute to change within a river system. Its character is influenced by land use and point and non-point sources of pollution within the river corridor and also by land use and non-point source pollution in the river basin. Natural factors such as rainfall and river flow, wind, and the physical dynamics of moving water also affect the river environment. Many of these factors are interrelated and these relationships are complex. As physical and chemical components of river systems change the fish and wildlife community that uses that system also changes.

The major environmental problems within the system are:

- Loss of Backwater and Side Channels Environments
- Deteriorated Water Quality
- Deterioration of Main Channel Border and Shoreline Environments
- Loss of Aquatic, Semi-Aquatic, and Terrestrial Habitats

Generalized descriptions of the problems, the causes, and the net environmental effects are provided below.

Loss of Backwater and Side Channel Environments

Research and planning efforts over the past decade clearly indicate that, within the next 50 years, many of the system's ecologically rich backwaters and side channels will be eliminated or severely degraded due to sedimentation. The causes of this problem vary considerably between segments of the system. To aid in understanding the problem the pooled portions of the Mississippi River above St. Louis, the Middle Mississippi river (unpooled portion) below St. Louis, and the Illinois River are discussed separately.

Mississippi River Above St. Louis (pooled portion)

Studies show that the backwater and side channels in this reach are being filled with sediments resulting in increased loss of important habitat, reduced biological productivity, and eventual loss and reduction in fish and wildlife resources.

Creation of the 9-foot navigation channel through construction of the lock and dam systems converted a major portion of the floodplain from wooded islands and meadows into marsh and aquatic habitat.

After more than 30 years of operation, sediment is accumulating in many of these habitat areas. Few of the backwater areas exceed a depth of ten feet. Data show that non-main channel water areas are filling in with sediment at rates ranging from ½ inch to over 2 inches per year. A sedimentation rate of one inch per year is equivalent to eight feet per century. However, a GREAT II study showed that there are locally scoured areas even in problem backwater areas, resulting in lowered bed elevations.

The main source of fine sediment is upland erosion. When flows are high, large quantities of sediment enter the Mississippi River from tributaries and non-point sources. These sediments are transported to the pools and are deposited in areas where the velocity is insufficient to retain the particles in suspension.

Tow passage and dredging operations resuspend sediments which can move laterally into side channels and backwater areas. Effects of navigation activities are most significant in reaches with a small meander radius, narrow channel width, large sinuosity, short distance between sailing line to bank, frequent dredging requirements, high erosion potential and large inflows to side channels and backwater areas. The impacts are also a function of direction of travel, draft, width, speed, and sailing position of the tows.

Simulations have been performed to identify meander reaches that are currently susceptible to navigation induced sediment transfer. Field investigation and simulations show that increased navigation will aggravate the problem by increasing rates of sediment discharge into these areas.

At current levels of navigation activities and if the present rate of sedimentation in non-main channel areas is allowed to continue, most of the open water areas of the backwater lakes will become bottomland hardwood and wetland habitat within the next century. Adverse impacts to fish and wildlife resources will occur with loss of this aquatic habitat.

Adverse impacts from increased levels of navigation that are not mitigated will aggravate the problem by increasing rates of sediment transport and will result in losses of backwaters in a shorter time period. The relationships in Figure V-7 illustrate the potential for adverse impacts depending on tow size and number. An increase in either the number of tows per day or the number of barges per tow or both will increase the amount of suspended sediments entering backwaters above sediment input levels that would occur without tow traffic.

The Middle Mississippi

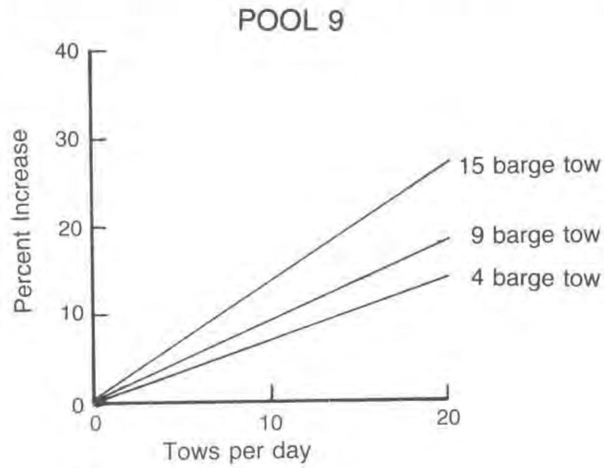
This reach of the UMRS differs from the upper reaches discussed earlier in that there are no locks and dams used to maintain the navigation channel. This unpooled portion of the UMRS is called the Middle Mississippi.

From 1820 to 1888 significant logging of the river banks caused severe erosion resulting in a widening of the river to 5300 feet. Between 1888 and 1968 sedimentation and resultant conversions to land area have resulted in a 40 percent reduction in average river width from 5300 feet to 3200 feet, or over 40,000 acres of water surface area.

This reach of the Mississippi River has been reduced in width and natural environmental complexity through extensive dredging and construction of wing dams and bank stabilization to provide a navigable channel. The end result of these maintenance activities has been a major loss in aquatic habitat abundance and diversity, and a decrease in flood plain storage. Future constriction of river widths through emergent wing dam extension and construction will further reduce aquatic habitat.

On March 31, 1881, a comprehensive plan for regulation of the Middle Mississippi River was approved by Congress. The plan called for the continuous improvement of the navigation channel by reducing the width of the river to 2500 feet. The Corps of Engineers started the work at St. Louis and continued downstream with construction of revetments and permeable timber pile wing dams.

In 1927, the Corps of Engineers was authorized by Congress to obtain and maintain a 9-foot navigation channel 300-feet wide (and wider at bends) for the Middle Mississippi River. This was initiated with the construction of additional regulatory works and bank protection to reduce the river width to 2250 feet except for a 2000 foot width in the lower 32.2 miles. Development of the



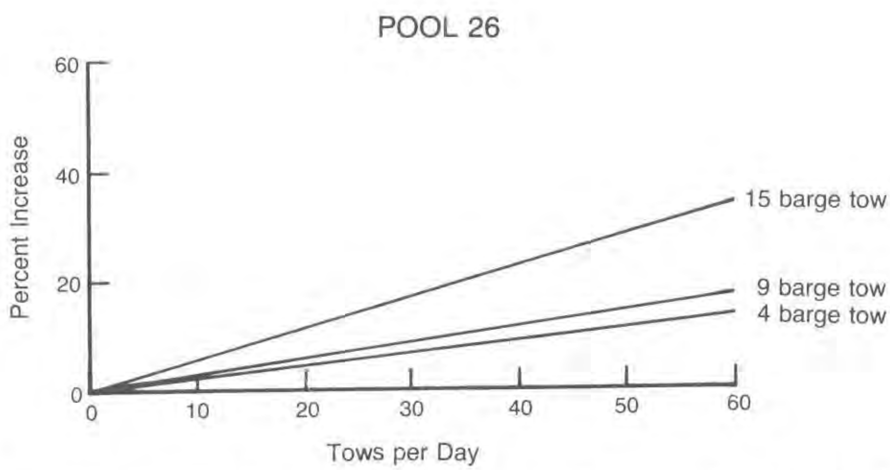


Figure V-7. Estimates of Percentage Increases in Sediment Entering Backwaters Due to Tow Size and Traffic Levels in Pools 9 and 26 desired river stabilization plan has been an evolutionary process with annual observances and reports being submitted to Congress. The 9-foot navigation channel has been obtained with supplemental dredging, especially in areas where the main river flow crosses from one bank to the other. Adequate depths in channel crossings prone to sedimentation have been maintained by dredging, but dredging is only a temporary solution because the dredged sections generally fill again. Dredging has most often been accomplished by side casting of material which may result in blockage of flow to side channels and backwater areas.

By 1973, almost the entire river from the mouth of the Missouri River north of St. Louis to Thebes Gap south of Cape Girardeau was lined with Corps of Engineers mainline levees on one bank or the other. Over 800 wing dams having a total length of 91 miles project out from the river banks into the river channel resulting in approximately 4 wing dams per river mile. Current average river width is approximately 1800 feet.

Work continues by the Corps of Engineers to further contract the width to 1500 feet by extending the wing dams. Current construction, which consists of impermeable stone wing dams is estimated to be completed in 1992.

The purpose of wing and closing dams is to confine the low flows and temporarily increase velocities within the contracted reach thereby increasing the river's ability to scour the channel and transport sediment. These structures prevent movement of water to biologically productive side channels and backwater areas.

Areas downstream of wing dams trap sediments. High sediment loads existed during the period of construction of permeable timber pile dikes. Coarse sediments accumulated downstream of these structures. The impermeable stone wing dams are more efficient in trapping fine sediments.

Construction of high rock and pile wing dams causes deposition in the wing dams fields. Trees and willow grow on and stabilize the deposit, and they encourage additional deposition whenever the area is flooded. In most cases a high wing dam field causes the river to develop a new bankline at the extremity of the wing dam field, resulting in reduced channel width. The width of the open river in 1968 was approximately the same as in 1820.

At current levels of operation and maintenance sedimentation in wing dam fields and side channels will result in continued losses of aquatic habitat. Accumulations of fine sediments in wing dam fields will alter the suitability of that habitat for aquatic organisms and will destroy species that cannot adapt. At anticipated future levels of operation and maintenance wildlife and fisheries habitat will decline, fish spawning and nursery areas will be lost, riparian borders will deteriorate, and productive wetlands will continue to decline.

Illinois River

The backwaters and bottomland lakes of the Illinois River, were, and are critically important to fish and wildlife production. Since the early 1900's the most productive fish and wildlife bottomland habitat areas were within reaches from the mouth at Alton to the Starved Rock Lock and Dam at mile 231. This includes the Alton Pool (20 lakes totaling 7,950 acres) controlled by Mississippi River Lock and Dam 26, the LaGrange Pool (43 lakes totaling 29,360 acres) controlled by the LaGrange Lock and Dam and the Peoria Pool (35 lakes totalling 33,140 acres) controlled by the Peoria Lock and Dam.

Major changes in the character of the Illinois River lakes have occurred since the late 1800's. Five low dams built along the river prior to 1900 to improve navigation created slightly higher water levels. This action combined with construction of the Chicago Sanitary & Ship Canal, which diverted water from Chicago into the Illinois River, resulted in a temporary increase of bottomland lakes and marshes from 54,000 acres to 120,000 acres. The primary purpose of the diversion was to transfer sewage effluent to the Illinois River which resulted in decreased water quality and general decline in habitat quality. Levee and drainage districts built between 1903 and 1920 drained bottomland lakes and marshes behind the levees. This, combined with reduced diversions, decreased bottomland water areas from 120,000 acres to 70,000 acres, which is the approximate existing bottomland lake area.

The five original navigation structures were reconstructed and two addition navigational locks and dams were constructed in the 1930's to provide a 9-foot navigation channel. An eighth dam, controlling levels of the Illinois River from Alton to the LaGrange Dam, was built at Lock and Dam 26 on the Mississippi River. The dams reduced velocities in the Illinois River.

Intensive farming activities and navigation traffic during the period from the late 1930's to present time have resulted in extensive sedimentation of the river in the navigation pools and backwaters. Sedimentation in the Illinois river valley is severe. Clay and fine silt particles enter the Illinois River as a result of sheet erosion on the intensively farmed Big Prairie region of Illinois, which is drained by numerous tributary streams. The almost colloidal nature of the sediments and the velocity of the tributaries cause much of the sediment load to be transported to the main stem of the Illinois.

Sedimentation is rapidly filling in the bottomland lakes of the Illinois Valley, reducing their size, degrading water quality, and minimizing the diversity of bottom depths. The fine silts and clays deposited on the bottoms are readily resuspended by wind generated waves, navigation traffic induced waves, and the activity of rough fish. This results in constant turbidity thereby reducing photosynthesis and primary productivity.

Sedimentation occurs at a higher rate in deep water than in shallow water. Thus, most lakes now possess a uniform platter shaped bottom instead of the turn-of-the-century variation in bottom depths.

In 1977 studies of 11 bottomland lakes in the Alton, LaGrange and Peoria pools show that under present rates of sedimentation 9 of the 11 lakes which presently have depths of 4 inches to 3 1/2 feet at the center, with mean depths of 1.5 feet, will be filled with sediment in periods of 5 to 89 years assuming no corrective actions are taken.

Aquatic plants are essential for fish and wildlife and are affected by water turbidity, water depth, and substrate. Increased turbidity and sedimentation are the major contributing factors to reduction of aquatic plant communities on the Illinois. Sedimentation also creates a soft bottom substrate unsuitable for rooted emergent and submergent vegetation. The accumulation of silt on leaves can further impair photosynthesis.

The abundance of certain species of waterfowl in the Illinois Valley is related to the abundance of native food resources. Among the dabbling ducks, the size of fall populations of the pintail, green-winged teal, and widgeon correlated with the abundance of wetland plants. Mallards feed extensively on waste grain in harvested fields, but even so, when annual variations in the continental mallard population were taken into account, moist-soil plant abundance influenced the abundance of mallards. The net effect of the decline and loss in aquatic plant life has been a major decline in numbers and kinds of waterfowl which once were extremely abundant.

The commercial and sport fisheries in the Illinois River have declined from levels at the turn of the century. The decline is attributable to a loss of habitat and pollution. Habitat was lost due to leveeing and draining of bottomland areas in the period 1903-1926 and sedimentation in the remaining areas. Sedimentation has resulted in undesirable habitat change and habitat reduction.

Northern pike, yellow perch, and walleye were once abundant in the river but are now rare or limited in their distribution. Yellow perch populations have declined probably as the result of the disappearance of beds of aquatic plants and disappearance of clean sand or pebble substrates perch use for spawning. In the past the bottomland lakes and backwater areas offered havens for fish and fish food organisms, as the main channel became increasingly polluted.

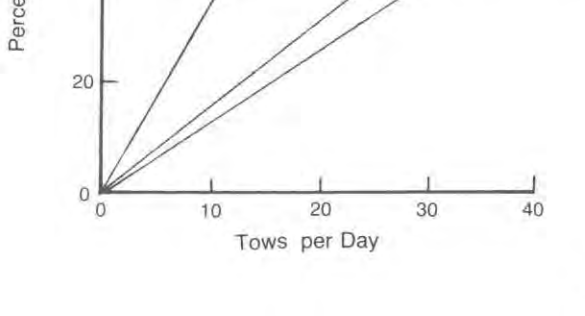
Now dissolved oxygen levels in the main channel seem to have improved, while the dissolved oxygen levels of the lakes have declined due to increased sedimentation and resultant reductions in plant biomass.

Increases in navigation will accelerate sedimentation rates on the Illinois River and will further degrade remaining backwater and side channel habitat. The relationships in Figure V-8 illustrate the potential for adverse impacts depending on tow size and number. An increase in either the number of tows per day or the number of barges per tow or both will increase the amount of suspended sediments entering backwaters above sediment input levels that would occur without tow traffic.

Other Navigable Tributaries

Specific analyses were not completed for other navigable tributaries, however, their impacts are thought to be similar to those described depending on location, channel configuration, bottom substrate, sediment load, and amount of tow traffic.

Figure V-8. Estimates of Percentage Increases in Sediment Entering Backwaters Due to Tow Size and Traffic Levels on the Illinois River



Deteriorated Water Quality

Toxic and hazardous substances, sedimentation, and organic and chemical pollutants deteriorate water quality resulting in poisoning of organisms, high turbidity and low levels of dissolved oxygen. Poor water quality affects human health and results in a loss of biological productivity and destruction or impairment of productive backwaters.

Pollutants enter the river system through point discharges from municipal waste treatment plants, industrial developments, and accidental spills and through non-point (diffused) discharges from undeveloped, agricultural, and urban areas, and mining activities. The pollutants are transported in the river by natural and traffic induced currents and waves.

Toxic organic and metal compounds are transported mainly through attachment to fine grained sediment particles. When suspended sediments enter low velocity areas, such as backwaters, a large portion settles out.

Polluted sediments are generally located below urban areas and in harbors, sloughs, and backwater areas, where fine sediments are deposited. Locations where bottom sediments are known to be contaminated are based on limited investigations.

The main channel contains mostly coarse sand to which most pollutants do not adhere, however, barge traffic resuspends fine grained bottom sediments and may result in the release of chemical pollutants. Toxic substances can be detached from sediments and released into the water column, or attached to sediments particles, removing them from the water column. These processes are affected by particle size and amount, dissolved organic matter, types of toxic metals and organics present, and resuspension time. Release of pollutants varies widely from site to site. Pollutants most likely to be released are the following: manganese, ammonia, oil, and grease. Pollutants that may be attached or released by sediment include heavy metals such as copper, mercury, lead, and zinc; and toxic organics such as PCB's, DDT, DDE, and dieldrin.

Field studies indicate that navigation may deterioriate water quality. Resuspended contaminated and uncontaminated sediment may be transported to backwaters, in certain areas, by barge traffic. Further suspension and resuspension of sediments in backwaters may occur due to recreational boat traffic.

Resuspension of contaminated sediments may increase the quantity of pollutants in certain fish species as they ingest the suspended sediment particles to which pollutants are attached. PCB's, pesticides such as Dieldrin and Chlordane, mercury, and lead pose the greatest problems since they are accumulated in the tissues of the biota.

Resuspension of fine grained sediments increases turbidity. Increased turbidity by definition reduces light penetration and causes losses in aquatic plant growth. This reduction in food chain productivity can lower dissolved oxygen concentrations thereby affecting aquatic organisms that require oxygenated water. Fish reproduction may be reduced by increases in turbidity. Thirteen of the fish species in the upper pools of the Mississippi River are complex spawners that require clear water conditions. The effects of present and increased levels of navigation on suspended sediment concentrations and turbidity have been simulated for reaches of the UMRS (Displays 1-5). These are averages for each reach and do not represent worst case occurrences of turbidity increases.

Field studies have shown that sediment concentrations in the water column are increased by resuspension attributed to tow traffic. Such increases can affect the respiration of fish through clogging and abrasion of gills. Benthos may be similarly affected and aquatic plant productivity may be reduced. The effects of current and increased navigation levels on average suspended sediment concentrations have been simulated for reaches of the river. Again these are averages for changes in sediment concentrations and do not represent the most serious problems.

Deterioration of Main Channel Border and Shoreline Environments

Main channel border and shoreline environments are important for fish and wildlife. Many species of fish use the main channel border areas for spawning, feeding, and resting. Riparian lands provide habitat for beaver, otter, muskrat, and other aquatic furbearers. Wing dams can contribute to the habitat diversity of the system.

Navigational activities in the main channel have significant effects on the main channel border and adjacent shoreline areas. These effects involve aquatic and terrestrial habitats, plants, and animals including free floating and bottom dwelling organisms, fish and birds. Data collected in the field have demonstrated that these effects result directly from 1) waves and drawdowns caused by navigational traffic; 2) water level fluctuations caused by operation of the dams; 3) sediment deposition due to the existence and operation of locks and dams; 4) sediment removal and deposition by dredging to maintain navigational depths; 5) existence, construction, and maintenance of wing dams, levees, and bank stabilization structures, and 6) direct losses due to induced development.

Waves and Drawdowns

Tow and wind generated waves and fluctuations in flows and water levels cause erosion of river banks. Energy exerted on the banks by boat-generated waves can be a major erosive force. The magnitude of boat-wave energies increases with increased tow velocity, draft, depth, and tow width. Distance to the bank is the most important factor affecting tow induced bank erosion.

In general, an equilibrium state exists between the soil particles which comprise the bank and the forces exerted by the flow of the river. Erosion results when the force exerted by the flow on the bank exceeds the soil strength. It is extremely difficult to pinpoint a specific cause of erosion at any given location. Vessel traffic is one of the contributing factors. Other factors include river discharge and stage, amount of suspended sediment, and development activities. Erosion results in loss of riparian habitat and localized increases in turbidity due to resuspended sediments.

Adverse ecological impacts due to turbidity and sedimentation are briefly discussed under Deterioration of Water Quality and Loss of Backwaters. These adverse ecological impacts ultimately result in significant decreases in fish, wildlife, and plant diversity.

In some locations vessel passage may result in periodic exposure of the bottom of the main channel border and backwater areas . There may also be a flushing action which pulses water from connected non-main channel areas back into the main channel.

A large loaded barge tow moving downstream creates the greatest impact whereas small, empty or slow moving vessels or recreational craft may have little measurable impact. The magnitude of the drawdown effect is directly related to the ratio of the cross-sectional submerged area of the tow to the river cross-section. The adverse effects on the biological community include the periodic exposure of bottom organisms which are intolerant of such exposures.

Although a single tow event may have slight effects on the biological systems in certain areas, increases in number and timing of tow passages would result in increased erosive forces and prolonged exposure of organisms. These increases over time should have a major adverse effect on long-term biological productivity.

Water Level Changes

The purpose of the lock and dam system was to maintain a 9-foot navigation channel. Operation of the dams control upstream water levels. During critical spawning, nesting, feeding, migration and other periods of life cycles, fish, wildlife and plants can be drastically affected by sudden fluctuating water levels due to natural and man-caused adjustments of pool levels.

These effects may include:

1) exposure and destruction of bottom organisms and plant colonies which are primary food sources for fish, waterfowl and furbearers,

2) island inundation during waterfowl nesting,

3) furbearer nest exposure or inundation during critical times,

4) exposure of erodable shorelines and an inconsistent littoral zone, and

5) damage to the reproduction of fish species that spawn in shallow areas by exposing eggs to the atmosphere and washing eggs out of nests or off of supporting substrate.

Sediment Deposition Due to Dams

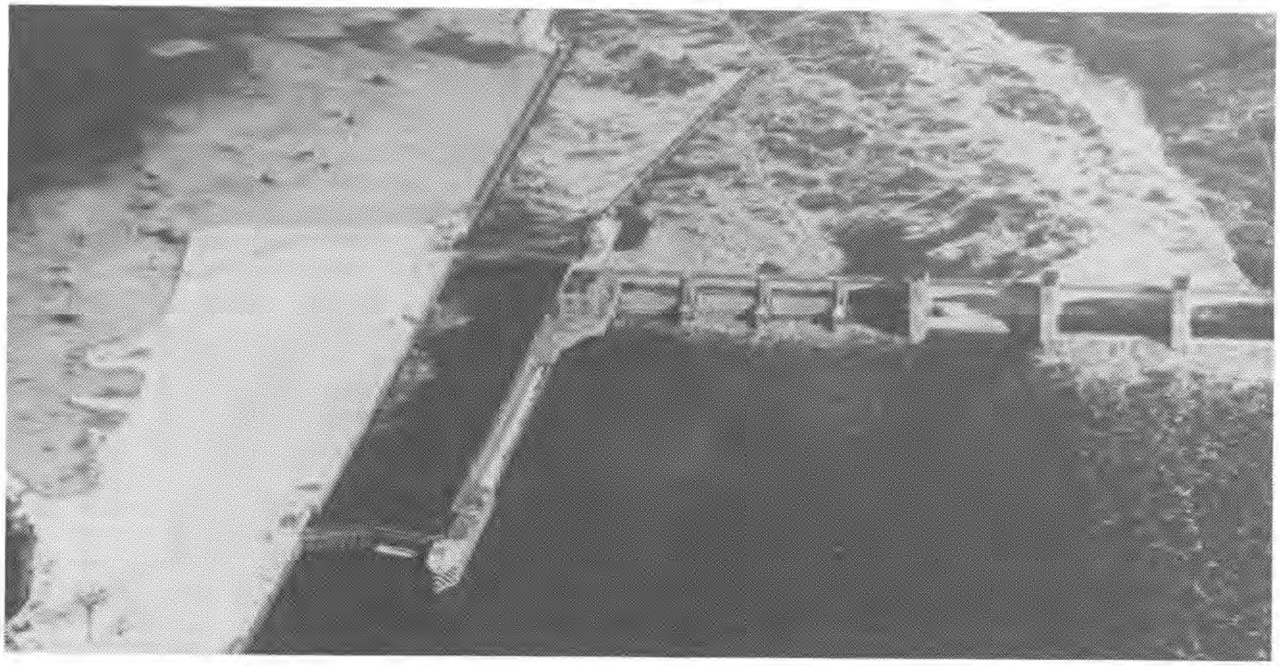
Dams create efficient sediment traps. By slowing river velocities they allow sediments to fall out of the water column and accumulate on the riverbed. As a result of the locks and dams construction in each pool, the elevations of the main channel were altered. Stabilization of water levels and backwater areas in conjunction with increases in upland erosion and tow traffic has resulted in high sedimentation rates. Backwater areas have been lost and productive littoral zones have been substantially reduced.

Dredging

Dredging is required in many locations throughout the entire UMRS. Major problems result from dredging and disposal. Environmental effects of dredging operations depend on the conditions at the disposal site. Site specific short-term effects may include:

1) increased turbidity that effects all fish life stages and reduces light penetration and, therefore, may interfere with primary production;

2) increased sedimentation that could result in the smothering of bottom dwelling organisms, destruction of



spawning areas for fish, reduced habitat diversity, and reduced vegatative cover;

3) reduction of dissolved oxygen concentration that could suffocate or stress organisms in the immediate vicinity and/or release noxious materials, such as sulfides, methane, and heavy metals, into the water column;

4) potential release of contaminants from polluted sediments; and

5) destruction of aquatic and terrestrial habitat depending on disposal methods and location.

Long-term effects include cumulative habitat losses and the presence of nutrients and chemical toxins in the sediment that may be released and subsequently affect the ecosystem.

Wing Dams, Levees and Bank Stabilization

Wing and closing dams have been used along the Upper Mississippi River since the late 1800's. The principal purpose of wing dams is to concentrate flow in the main channel. Depending on their heights, configurations and angle to the shoreline, wing dams can result in either increased or decreased bank erosion in the vicinity of the dam or on opposite shorelines. Emergent wing dams have greater adverse impacts than submergent ones. Closing dams extend completely or partially across the upstream openings of side channels or backwater areas to divert flows to the main channel. They tend to slow flows in the backwater areas causing an increase in sedimentation if not properly designed. Both types of dams have been constructed of various materials; however, recently they have been constructed more of rocks than wood-pilings and brush. These dams vary in height, length and configuration depending on site specific requirements for diverting flow. The magnitude of their effect is dependent on the height and length of the wing or closing dam and its efficiency in blocking normal flow.

The detrimental effects of wing and closing dams in some locations may include:

1) increased sedimentation rates in main channel border and backwater areas and the resulting loss of aquatic habitat;

2) reduced oxygen production through increased accumulations of fine silt resulting in increased turbidity;

3) reduce interchange of nutrients and organisms with the main river system; and

4) accumulation of toxic materials attached to sediments and potential release through disturbances.

In some river segments wing dams may be beneficial since they increase the amount and diversity of substrate.

Levee structures are primarily for flood protection. In a few cases, levees were designed to help constrict the river, by diverting flow toward the main channel to maintain the 9-foot project. As a result, these levees terminated the flow of water through large non-channel areas -- thereby accelerating the sedimentation process and/or degrading water quality such as lowering of dissolved oxygen levels.

Often agricultural practices further accelerated filling in order to farm these once productive aquatic areas. For example, on the Illinois River, levee and drainage districts have placed over 205,000 acres of bottomland behind levees. Levees constructed for flood control have further limited backwater areas.

Most bank stablization is interrelated to dike maintenance and construction in that it also serves to channelize the river for navigation. Bank stabilization for navigation on the UMRS is used primarily to maintain channel alignment. Properly designed it will protect the upper portion of the bank from wave action and the submerged portion from scouring. Depending on the amount of area stabilized, aquatic and terrestrial habitat may be either reduced or enhanced. Organisms depending on undercut banks and riparian vegetation will be lost. However, in some areas the additional aquatic substrate is beneficial.

The overall consequence of these measures is to channelize the UMRS. The adverse effects of channelization on fish and other aquatic resources are well documented. A highly simplified general consensus is that channelization usually results in the large reductions of fish species diversity and biomass.

Loss of Aquatic, Semi-aquatic, and Terrestrial Habitats and Organisms

Specific biological impacts resulting from the environmental problems described above are difficult to assess. Although some quantitative data are available on the physical impacts, data which evaluates corresponding biological impacts are limited. Therefore, analysis of the impacts on the ecosystem of the UMRS is incomplete. Since biological impacts could not be quantified, the potential impacts of the alternatives on endangered and threatened species of the UMRS were not assessed. General impacts described below may also affect protected species.

Potential biological impacts are summarized as follows and depend on the characteristics of the river at a particular location:

- Terrestrial Plants and Habitat: loss of terrestrial vegetation and habitat due to accelerated bank erosion, and excessive revetment.

- Aquatic Habitat: degradation due to elevated suspended sediment and turbidity levels, increased sedimentation of backwater areas, potential degradation of water quality, some gain in substrate from wing dams and revetments, loss in habitat due to dredging and disposal.

- Aquatic Vegetation: impairment of photosynthesis, growth, and reproduction due to increased turbidity and suspended sediments; potential burial of macrophytes; creation of unsuitable substrates; and degradation of water quality.

- Plankton: populations reduced or limited by elevated levels of suspended solids and turbidity; potential degradation of water quality; forced movement into areas unsuitable for photosynthesis.

- Benthos: elimination or alteration of habitat by scouring, dredging, or sedimentation; altered densities and diversity from increased suspended sediment and turbidity levels; increased drift; potential degradation of water quality; exposure by water level fluctuations and drawdowns.

- Fish: elimination or alteration of critical spawning, nursery, feeding, and resting areas and interference of vital like processes such as respiration, feeding, and reproduction due to increased concentrations of suspended sediments and turbidity, increased sedimentation, and alteration of the chemical environment such as decrease dissolved oxygen or potential degradation of water quality; increased direct damage or mortality due to barge hulls and propellers, increased winter stress.

- Birds: loss or reduction of feeding, resting, or nesting areas and food supply (i.e. benthos, fish or aquatic plants); increased disturbance; potential degradation of water quality.

- Aquatic Furbearers: degradation of denning habitat, potential degradation of water quality, increased winter stress.

- Other Wildlife: degradation of habitat, potential degradation of water quality, increased winter stress.

Systemic Impacts of Navigation, Operation and Maintenance

Projections of average numbers of tow lockages per day were developed within the Navigation/Transportation Study for four scenarios of future development. Seasonal estimates of projected traffic levels are contained in Table V-24. These projections encompass the anticipated range of future traffic levels.

The projections in Table V-24 represent average numbers of tows per day. On some days tow traffic will surpass this average. The peak daily number of tows that could operate on the system are displayed below. (Table V-23) These peak events assume Scenario IV navigation improvements and a locking capacity of 19 tows per day at a 600 foot lock and 41 tows per day at a 1200 foot lock. Open pass conditions were not considered for La Grange and Peoria Lock. In addition, numbers of tows per day on the Open River were based on projections for Lock and Dam 27.

During these peak events the increased tow traffic will increase suspended sediment concentrations and turbidity levels. This "worst case" analysis information is presented in Displays 1, 2, 3, and 5 for "Daily Tow Induced Changes in Suspended Sediment Concentration at Low Flow" and "Daily Induced Changes in Turbidity Levels at Low Flow." All other graphs and tables in Displays 1-5 depict annual changes and correspond to the four levels of tow traffic which correspond to the four scenarios. This analysis was not conducted for the Mississippi River below St. Louis. This information is based on simulations which can be refined with more data.

Results of field investigations provided the additional data needed to begin to assess the environmental impacts of navigation traffic, operation and main-

Table V-23. Peak Number of Tows per Day

Reach	Peak
Pools 1-10	19
Pools 11-19	19
Pools 20-25	38
Pool 26	60
Illinois River	38

Table V-24. Average Current and Projected Tows Per Day in Reaches of the Upper Mississippi River System

1977 (Current)

Reach	Dec-Feb (W)	Mar-May (Sp)	June-Aug (Su)	Sept-Nov (F)
Head of Navigation-L/D 10				
1	-	10	12	6
2-10	0	5	5	5
Pool 11-L/D 19				
11-13	0	5	6	5
14-19	2	8	8	8
Pool 20-L/D 26				
20-25	2	9	9	9
26	16	26	26	26
Open River				
27	20	32	31	31
Illinois River	12	12	11	11

Projected Average Tows/Day and Percent Increase Over 1977 Traffic Levels

SCENARIO I[1]/

	1990				2000				2040			
	W	Sp	Su	F	W	Sp	Su	F	W	Sp	Su	F
HN-L/D 10												
1	-	15 (50%)	19 (58%)	10 (67%)	0	14 (40%)	17 (42%)	9 (50%)	0	13 (30%)	17 (42%)	9 (50%)
2-10	0	7 (40%)	8 (60%)	8 (60%)	0	7 (40%)	8 (60%)	7 (40%)	0	6 (20%)	7 (40%)	6 (20%)
Pool 11-L/D 19												
11-13	0	7 (60%)	9 (50%)	8 (60%)	0	7 (40%)	8 (33%)	7 (40%)	0	6 (20%)	7 (17%)	6 (20%)
14-19	3	12 (100%)	11 (63%)	12 (63%)	3 (50%)	11 (38%)	11 (38%)	11 (38%)	3 (50%)	10 (25%)	10 (25%)	11 (38%)
Pool 20-L/D 26												
20-25	4 (50%)	13 (44%)	12 (33%)	13 (44%)	3 (50%)	13 (44%)	13 (44%)	13 (44%)	3 (50%)	13 (44%)	13 (44%)	13 (44%)
26	22 (38%)	31 (19%)	30 (15%)	30 (15%)	21 (31%)	34 (31%)	33 (27%)	33 (27%)	21 (31%)	34 (31%)	33 (27%)	33 (27%)
Open River												
27	26 (30%)	38 (34%)	37 (32%)	37 (32%)	24 (20%)	40 (25%)	38 (23%)	38 (23%)	24 (20%)	39 (22%)	38 (23%)	38 (23%)
Illinois River	15 (25%)	14 (17%)	13 (18%)	13 (27%)	25 (15%)	15 (25%)	14 (27%)	14 (27%)	15 (25%)	14 (17%)	13 (27%)	13 (27%)

SCENARIO II[2]/

	1990				2000				2040			
	W	Sp	Su	F	W	Sp	Su	F	W	Sp	Su	F
HN-L/D 10												
1	0	14 (40%)	18 (50%)	9 (50%)	0	14 (40%)	18 (50%)	9 (50%)	0	12 (20%)	15 (25%)	8 (33%)
2-10	0	9 (80%)	10 (100%)	9 (80%)	0	9 (80%)	10 (100%)	9 (80%)	0	7 (40%)	8 (60%)	7 (40%)
Pool 11-L/D 19												
11-13	0	8 (60%)	9 (50%)	8 (60%)	0	9 (80%)	10 (67%)	9 (80%)	0	8 (60%)	10 (67%)	9 (80%)
14-19	4 (100%)	13 (63%)	13 (63%)	13 (63%)	4 (100%)	15 (88%)	14 (75%)	14 (75%)	4 (100%)	14 (75%)	14 (75%)	14 (75%)
Pool 20-L/D 26												
20-25	4 (100%)	15 (67%)	14 (56%)	15 (67%)	4 (100%)	17 (89%)	16 (78%)	17 (89%)	5 (150%)	19 (111%)	18 (100%)	19 (111%)
26	22 (38%)	35 (35%)	34 (31%)	34 (31%)	24 (50%)	39 (50%)	38 (46%)	38 (46%)	22 (38%)	35 (35%)	34 (31%)	34 (31%)
Open River												
27	26 (30%)	43 (34%)	41 (32%)	41 (32%)	34 (70%)	57 (78%)	55 (77%)	55 (77%)	26 (30%)	42 (31%)	41 (32%)	41 (32%)
Illinois River	15 (25%)	14 (17%)	13 (18%)	14 (27%)	17 (42%)	16 (33%)	15 (36%)	15 (36%)	16 (33%)	16 (33%)	15 (36%)	15 (36%)

Table V-24. Continued

SCENARIO III2/

	1990				2000				2040			
	W	Sp	Su	F	W	Sp	Su	F	W	Sp	Su	F
HN-L/D 10												
1	-	14 (40%)	18 (50%)	9 (50%)	0	14 (40%)	17 (42%)	9 (50%)	0	12 (20%)	15 (25%)	8 (33%)
2-10	0	9 (80%)	10 (100%)	9 (80%)	0	9 (80%)	10 (100%)	9 (80%)	0	7 (40%)	8 (60%)	8 (60%)
Pool 11-L/D 19												
11-13	0	8 (60%)	9 (50%)	8 (60%)	0	9 (80%)	10 (67%)	9 (80%)	0	8 (60%)	10 (67%)	9 (80%)
14-19	4 (100%)	13 (63%)	13 (63%)	13 (63%)	4 (100%)	14 (75%)	14 (75%)	14 (75%)	4 (100%)	14 (75%)	14 (75%)	14 (75%)
Pool 20-L/D 26												
20-25	4 (100%)	15 (67%)	14 (56%)	15 (67%)	4 (100%)	17 (89%)	16 (78%)	17 (89%)	5 (150%)	18 (100%)	18 (100%)	18 (100%)
26	22 (38%)	35 (35%)	34 (31%)	34 (31%)	24 (50%)	39 (50%)	38 (46%)	38 (46%)	22 (38%)	35 (35%)	34 (31%)	34 (31%)
Open River												
27	26 (30%)	43 (34%)	41 (32%)	41 (32%)	28 (40%)	45 (41%)	44 (42%)	44 (42%)	26 (30%)	42 (31%)	41 (32%)	41 (32%)
Illinois River	15 (25%)	14 (17%)	13 (18%)	14 (21%)	17 (42%)	16 (33%)	15 (33%)	15 (36%)	16 (33%)	15 (36%)	14 (27%)	14 (27%)

SCENARIO IV2/

	1990				2000				2040			
	W	Sp	Su	F	W	Sp	Su	F	W	Sp	Su	F
HN-L/D 10												
1	0	14 (40%)	18 (50%)	9 (50%)	0	15 (50%)	20 (67%)	10 (67%)	0	15 (50%)	19 (58%)	10 (67%)
2-10	0	9 (80%)	10 (100%)	9 (80%)	0	11 (120%)	12 (140%)	11 (120%)	0	11 (120%)	11 (120%)	11 (120%)
Pool 11-L/D 19												
11-13	0	8 (60%)	9 (50%)	8 (60%)	0	10 (100%)	12 (100%)	10 (100%)	0	13 (160%)	15 (150%)	13 (160%)
14-19	4 (100%)	13 (63%)	13 (63%)	13 (63%)	4 (100%)	16 (100%)	16 (100%)	16 (100%)	5 (150%)	19 (138%)	19 (138%)	19 (138%)
Pool 20-L/D 26												
20-25	4 (100%)	15 (67%)	14 (56%)	15 (67%)	5 (150%)	18 (100%)	18 (100%)	18 (100%)	6 (200%)	23 (156%)	23 (156%)	23 (156%)
26	22 (38%)	35 (35%)	34 (31%)	34 (31%)	27 (69%)	44 (69%)	43 (65%)	43 (65%)	33 (106%)	53 (104%)	52 (100%)	52 (100%)
Open River												
27	26 (30%)	43 (34%)	41 (32%)	41 (32%)	31 (55%)	51 (59%)	49 (58%)	49 (58%)	38 (90%)	61 (91%)	59 (90%)	59 (90%)
Illinois River	15 (25%)	14 (17%)	13 (18%)	14 (27%)	17 (42%)	17 (42%)	15 (36%)	15 (36%)	20 (67%)	21 (75%)	18 (64%)	18 (64%)

1/ 1977 Base Year Projections, existing tow size

2/ 1980 Base Year Projections, future tow size

tenance. Simulation models, calibrated with the available field data, were used to assess systemic impacts of current and projected levels of navigation traffic.

The causes of navigation traffic, operation and maintenance impacts are complex and vary from reach to reach. The severity of impacts and the affected environment vary considerably from reach to reach. To adequately depict the estimated impacts of current and projected levels of navigation, operation and maintenance. Map Displays 1 through 5 have been developed for the following reaches:

- Mississippi River Pools 1 through 10
- Mississippi River Pools 11 through 19
- Mississippi River Pools 20 through 26
- Mississippi River Pool 27 and below to Cairo, Illinois
- Illinois River
- Analyses were not conducted on other navigable tributaries

Affected Environment

This reach of the Mississippi River includes 13 pools created by navigation dams. Based on inventories of land and water habitat areas conducted in 1976 and 1977 the total area, including both land and water, is 288,000 acres. This includes 140,000 acres of aquatic habitat and 148,000 acres of semi-aquatic and terrestrial habitat. A National Refuge System covers 46 percent of the total area. Numerous side-channels and non-channel areas of high biological productivity constitute 37 percent of the total area.

Diversity of habitat contributes to the biological activity and abundance within this reach. Numerous species of fish, birds, mammals, and mussels inhabit the area. The Upper Mississippi is part of a major international waterfowl flyway and is a significant habitat for colonial birds. Statistics on fish and wildlife species diversity are listed below.

- 100 species of fish--37 of which are common species, 13 sport-fishing species, and 8 rare species
- 300 species of birds, 100 of which nest in the reach
- 59 species of mammals including such aquatic mammals as beaver, river otter, mink, muskrat, and raccoon and such upland mammals as white tail deer, fox, coyote, and bobcat
- 50 species of mussels and clams including the small fingernail clam which is a food source for fish and waterfowl

Species with Federal endangered or threatened status include the Bald Eagle, the Indiana Bat, Fat Pocketbook Pearly Mussel (believed extirpated), Higgin's Eye Pearly Mussel, American Peregrine Falcon, and Artic Peregrine Falcon. There are other species protected by State laws.

Navigation Operation and Maintenance

The river has been continuously developed for navigational purposes since 1824. The earliest works involved removal of snags. Later, wing dams and shoreline structures were built to confine low flows to a narrow channel. In the 1930's the series of existing locks and dams were built to provide a 9-foot navigation channel which created the series of pools behind the dam.

Navigational activity in the main channel is facilitated by operation and maintenance of 13 locks and dams, existence of 10.7 miles of levees, 115.5 miles of bank protective works, and 1,190 wing dams. Dredging is required at a number of locations to maintain a 9-foot channel. The most frequently dredged locations are straight reaches located upstream of each pool's primary control point. These are areas divided by alluvial islands. Periodic dredging operations (cuts) occur at 105 locations. From 1965 to 1980 there were approximately 30 cuts per year. The yearly average dredged material removal for 1970-79 is about 1,300,000 cubic yards. Dredged volumes have ranged from 5,445,000 cubic yards in 1938 to 205,000 cubic yards in 1977. The largest volume dredged during 1970-79 was 2,261,000 cubic yards in 1970.

Physical Impacts of Increased Navigation (Mississippi, Head of Navigation — Pool 10)

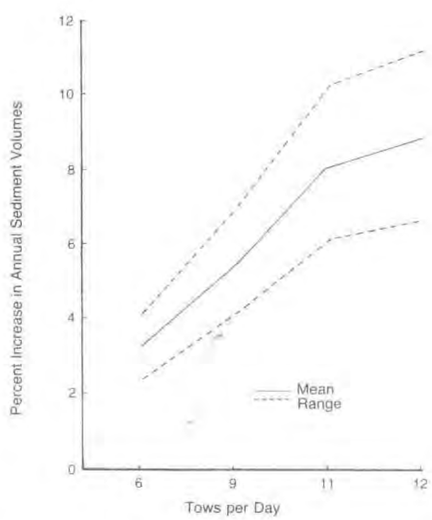
Tow Conditions Used For Impact Assessment

Tows per Day	Barges per Tow
6	8
9	9
11	11
12	11
19 (peak)	11

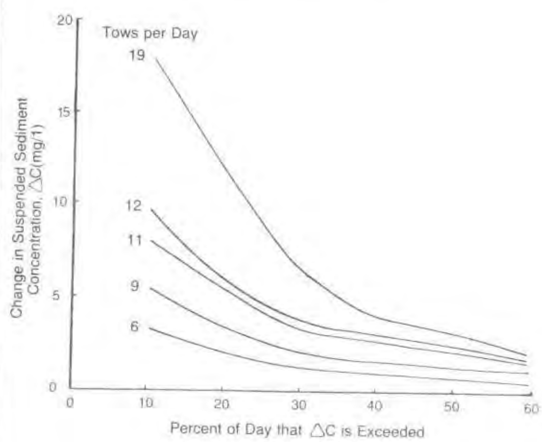
Annual Percentage Increases Above Natural Erosive Forces Due To Tow Induced Waves (Simulated)

	Tows per Day			
	6	9	11	12
Percent Increase	7	11	13	14

Percentage Increases In Annual Sediment Volumes Entering Side Channels And Backwaters Due To Navigation (Simulated)



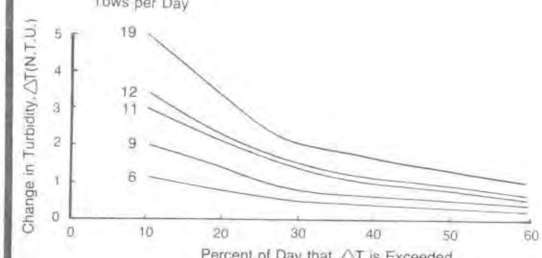
Daily Tow Induced Changes In Suspended Sediment Concentrations At Low Flow (Simulated)



Annual Sediment Volumes Entering Side Channels and Backwaters (Simulated)

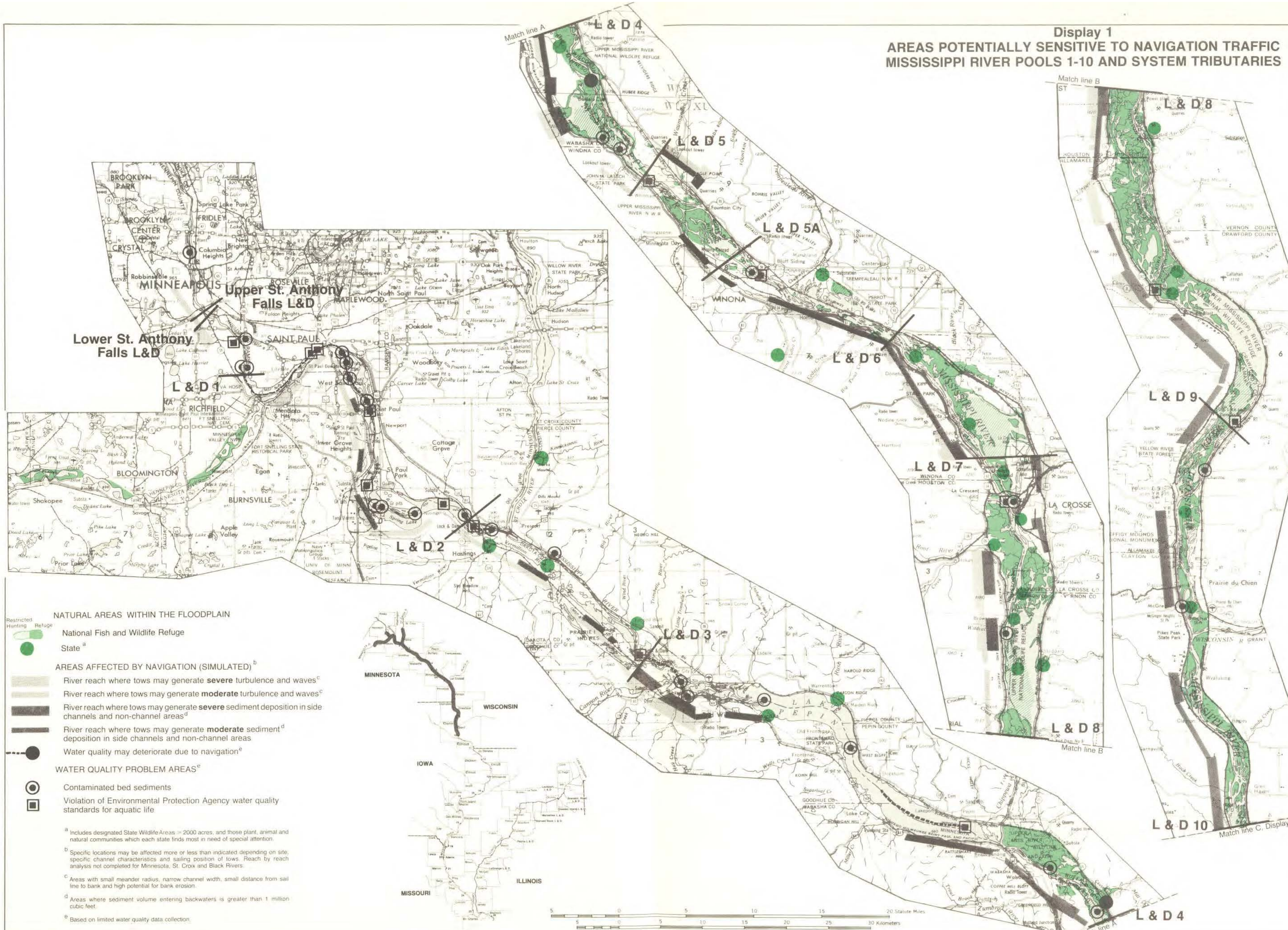
Natural Sediment (yd.³)	Tow Induced Sediment (yd.³)			
	Tows per Day			
	6	9	11	12
5,500,000 to 11,652,000	133,000 to 481,000	226,000 to 800,000	333,000 to 1,167,000	367,000 to 1,307,000

Daily Tow Induced Changes In Turbidity Levels At Low Flow (Simulated)



Display 1

AREAS POTENTIALLY SENSITIVE TO NAVIGATION TRAFFIC MISSISSIPPI RIVER POOLS 1-10 AND SYSTEM TRIBUTARIES



[a] Includes designated State Wildlife Areas ≥ 2000 acres, and those plant, animal and natural communities which each state finds most in need of special attention.

[b] Specific locations may be affected more or less than indicated depending on site, specific channel characteristics and sailing position of tows. Reach by reach analysis not completed for Minnesota, St. Croix and Black Rivers.

[c] Areas with small meander radius, narrow channel width, small distance from sail line to bank and high potential for bank erosion.

[d] Areas where sediment volume entering backwaters is greater than 1 million cubic feet.

[e] Based on limited water quality data collection.

Display 2: Mississippi River Pools 11-19

Affected Environment

This reach of the Mississippi River includes 9 pools created by navigation dams. Based on a 1977 inventory of land and water habitat areas, the total area, including both land and water, is 241,000 acres. This includes 123,000 acres of aquatic habitat and 118,000 acres of semi-aquatic and terrestrial habitat. State and federal agencies manage 28 percent of the total area for fish and wildlife purposes. Large main channel borders and numerous non-channel areas of high biological productivity constitute 44 percent of the total area.

Diversity of habitat contributes to the biological activity and abundance within this reach. Numerous species of fish, birds, mammals, and mussels inhabit the area. The Upper Mississippi is part of a major international waterfowl flyway and is a significant habitat for colonial birds. Statistics on fish and wildlife species diversity are listed below.

- 102 species of fish--36 of which are common species, 31 sport-fishing species, and 23 rare species
- 300 species of birds, 100 of which nest in the reach
- 52 species of mammals including such aquatic mammals as beaver, river otter, mink, muskrat, and raccoon and such upland mammals as white tail deer, fox, coyote, and bobcat
- 50 species of mussels and clams including the small fingernail clam which is a food source for fish and waterfowl

There are 19 fish and 6 plant species with Federal or State endangered or threatened status.

Navigation Operation and Maintenance

The river has been continuously developed for navigational purposes since 1824. The earliest works involved removal of snags. Later, wing dams and shoreline structures were built to confine low flows to a narrow channel. In the 1930's the series of existing locks and dams were built to provide a 9-foot navigation channel which formed the series of pools behind the dams.

Navigational activity in the main channel is facilitated by operation and maintenance of 9 locks and dams, existence of 134.9 miles of levees, 80.7 miles of bank protective works, and 823 wing dams. Dredging is required at a number of locations to maintain a 9-foot navigation channel. Recurrent dredging operations (cuts) occur at 48 locations. Dredged volumes have ranged from 2,055,000 cubic yards in 1973 to 68,000 cubic yards in 1978.

Physical Impacts of Increased Navigation (Mississippi, 11-19)

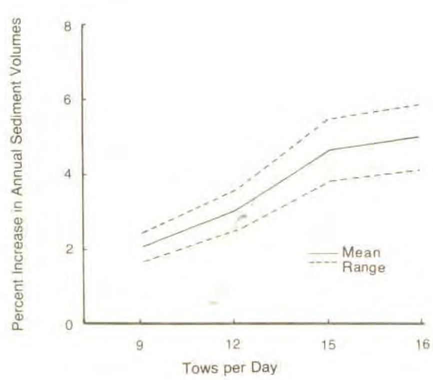
Tow Conditions Used For Impact Assessment

Tows per Day	Barges per Tow
9	8
12	9
15	11
16	11
19 (peak)	11

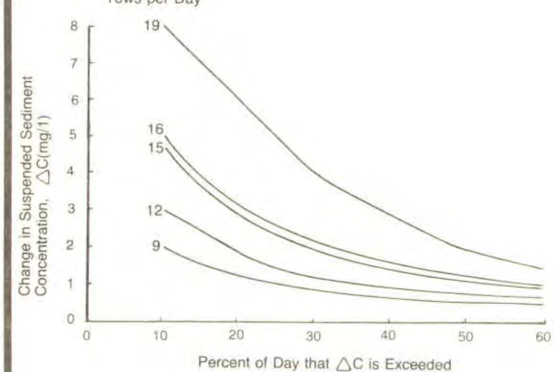
Annual Percentage Increases Above Natural Erosive Forces Due To Tow Induced Waves (Simulated)

	Tows per Day			
	9	12	15	16
Percent Increase	6	8	9	10

Percentage Increases In Annual Sediment Volumes Entering Side Channels And Backwaters Due To Navigation (Simulated)



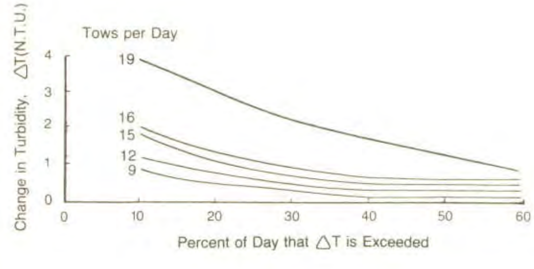
Daily Tow Induced Changes In Suspended Sediment Concentrations At Low Flow (Simulated)

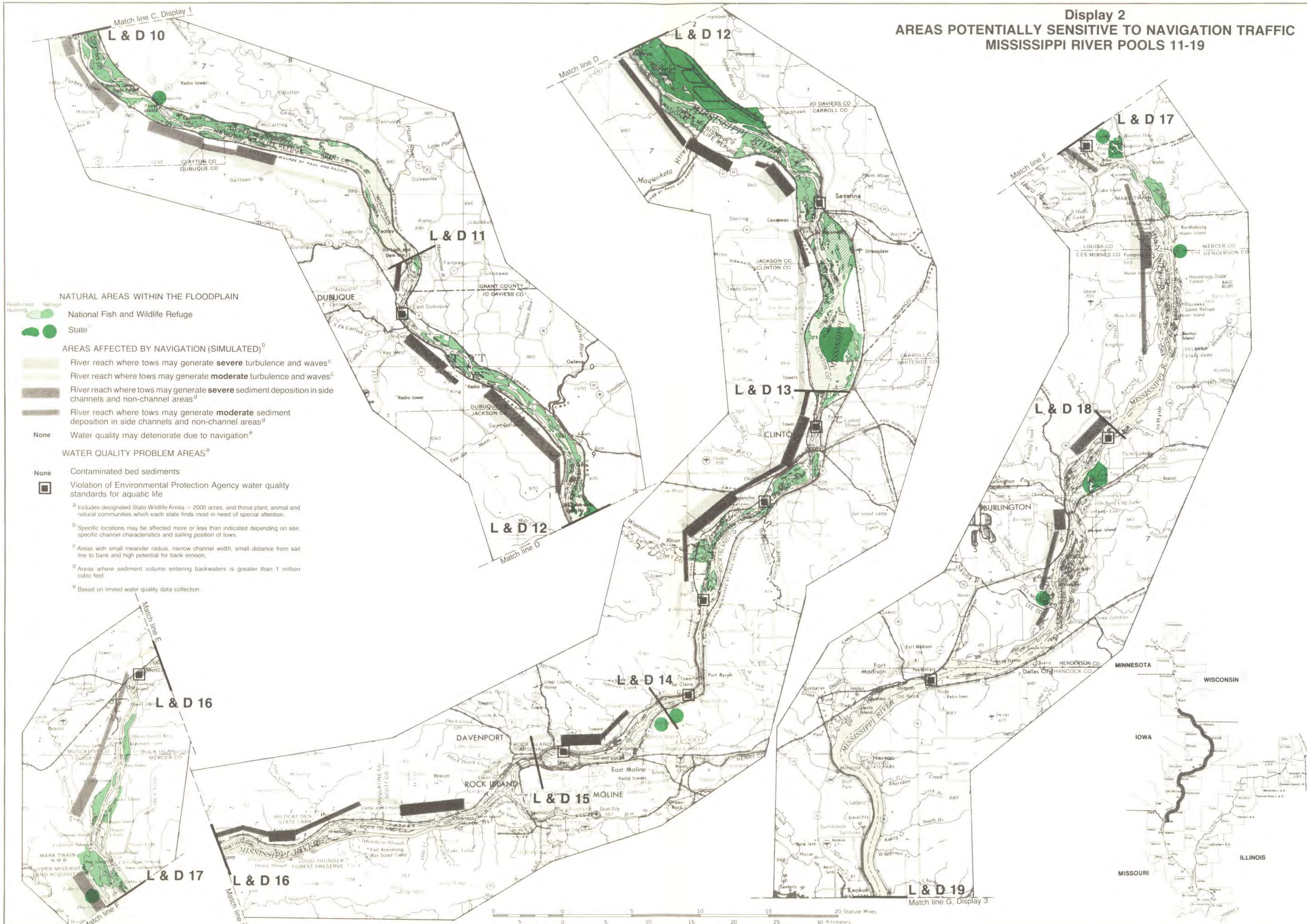


Annual Sediment Volumes Entering Side Channels and Backwaters (Simulated)

Natural Sediment (yd.³)	Tow Induced Sediment (yd.³)			
	Tows per Day			
	9	12	15	16
4,744,000 to 10,611,000	81,000 to 256,000	119,000 to 378,000	181,000 to 574,000	196,000 to 626,000

Daily Tow Induced Changes In Turbidity Levels At Low Flow (Simulated)




Display 2
AREAS POTENTIALLY SENSITIVE TO NAVIGATION TRAFFIC
MISSISSIPPI RIVER POOLS 11-19
NATURAL AREAS WITHIN THE FLOODPLAIN
Restricted Hunting
Refuge
National Fish and Wildlife Refuge
State[a]
AREAS AFFECTED BY NAVIGATION (SIMULATED)[b]
River reach where tows may generate severe turbulence and waves[c]
River reach where tows may generate moderate turbulence and waves[c]
River reach where tows may generate severe sediment deposition in side channels and non-channel areas[d]
River reach where tows may generate moderate sediment deposition in side channels and non-channel areas[d]
None
Water quality may deteriorate due to navigation[e]
WATER QUALITY PROBLEM AREAS[e]
None
Contaminated bed sediments
Violation of Environmental Protection Agency water quality standards for aquatic life
[a] Includes designated State Wildlife Areas ≥ 2000 acres, and those plant, animal and natural communities which each state finds most in need of special attention.
[b] Specific locations may be affected more or less than indicated depending on site, specific channel characteristics and sailing position of tows.
[c] Areas with small meander radius, narrow channel width, small distance from sail line to bank and high potential for bank erosion.
[d] Areas where sediment volume entering backwaters is greater than 1 million cubic feet.
[e] Based on limited water quality data collection.
Match line C, Display 1
L & D 10
L & D 11
L & D 12
Match line D
L & D 13
L & D 14
L & D 15
L & D 16
L & D 17
L & D 18
L & D 19
Match line E
Match line F
Match line G, Display 3
DUBUQUE
CLINTON
DAVENPORT
ROCK ISLAND
MOLINE
East Moline
BURLINGTON
Savanna
Fort Madison
Keokuk
MINNESOTA
WISCONSIN
IOWA
ILLINOIS
MISSOURI
20 Statute Miles
30 Kilometers

Display 3: Mississippi River Pools 20-26

Affected Environment

This reach of the Mississippi River includes 6 pools created by navigation dams. Based on 1977 inventories of land and water habitat areas, the total area, including both land and water, is 142,000 acres. This includes 65,000 acres of aquatic habitat and 77,000 acres of semi-aquatic and terrestrial habitat. Less than 10 percent of the total area is managed by state and federal agencies for fish and wildlif

This reach is characterized by few side-channels and non-channel areas. Approximately 24 percent of the total area consists of main channel border habitat. This segment of the Upper Mississippi is part of a major international waterfowl flyway and is a significant habitat for colonial birds. Statistics on fish and wildlife species diversity are listed below.

- 88 species of fish--30 of which are common species, 31 sport-fishing species, and 7 rare species
- 142 species of birds, some of which nest in the reach
- 28 species of mammals including such aquatic mammals as beaver, river otter, mink, muskrat, and raccoon and such upland mammals as white tail deer, fox, coyote, and bobcat
- 29 species of mussels and clams including the small fingernail clam which is a food source for fish and waterfowl

There are 88 species with Federal or State endangered or threatened status.

Navigation Operation and Maintenance

The river has been continuously developed for navigational purposes since 1824. The earliest works involved removal of snags. Later, wing dams and shoreline structures were built to confine low flows to a narrow channel. In the 1930's the series of existing locks and dams were built to provide a 9-foot navigation channel which created the series of pools behind the dam.

Navigational activity in the main channel is facilitated by operation and maintenance of 6 locks and dams, existence of 130.5 miles of levees, 88.1 miles of bank protective works, and 445 submerged wing dams. Dredging is required at a number of locations to maintain a 9-foot channel.

Physical Impacts of Increased Navigation (Mississippi, Pools 20-25, 26)

Tow Conditions Used For Impact Assessment

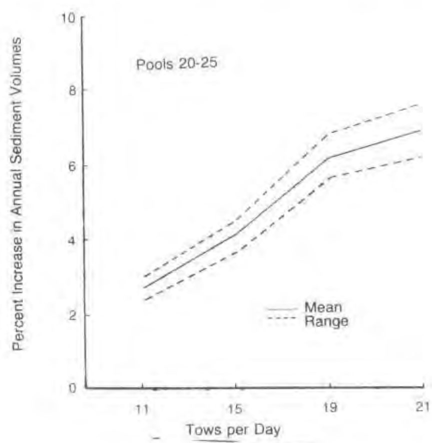
	Tows per Day	Barges per Tow
Pools 20-25	11	9
	15	10
	19	12
	21	12
	38 (peak)	12
Pool 26	28	8
	36	8
	44	9
	48	9
	60 (peak)	10

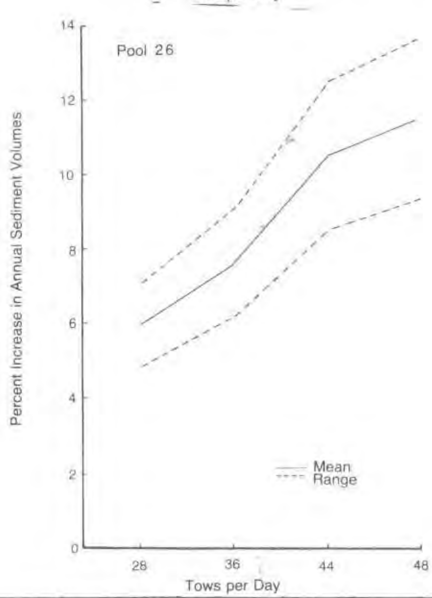
Annual Percentage Increases Above Natural Erosive Forces Due To Tow Induced Waves (Simulated)

	Tows Per Day (Pools 20-25)			
	11	15	19	21
Percent Increase	6	8	10	11

	Tows per Day (Pool 26)			
	28	36	44	48
Percent Increase	9	11	14	15

Percentage Increases In Annual Sediment Volumes Entering Side Channels And Backwaters Due To Navigation (Simulated)

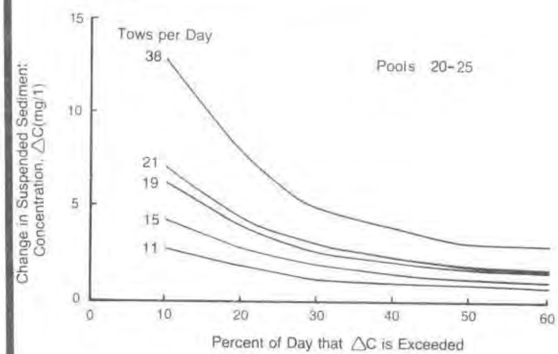


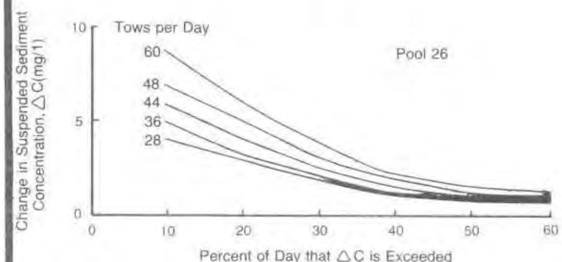


Annual Sediment Volumes Entering Side Channels and Backwaters (Simulated)

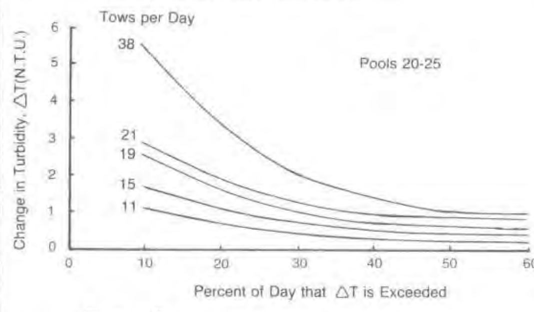
Natural Sediment (yd.³)	Tow Induced Sediment (yd.³)			
	Tows per Day			
	11-28	15-36	19-14	21-48
4,789,000 to 10,733,000	130,000 to 400,000	189,000 to 567,000	289,000 to 830,000	289,000 to 919,000

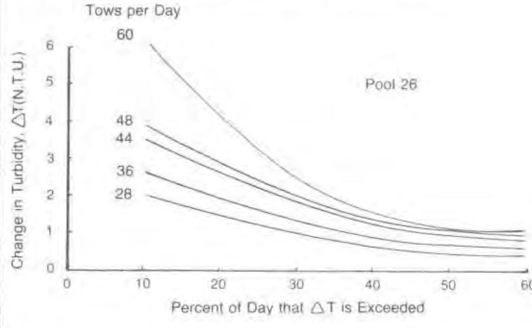
Daily Tow Induced Changes In Suspended Sediment Concentrations At Low Flow (Simulated)

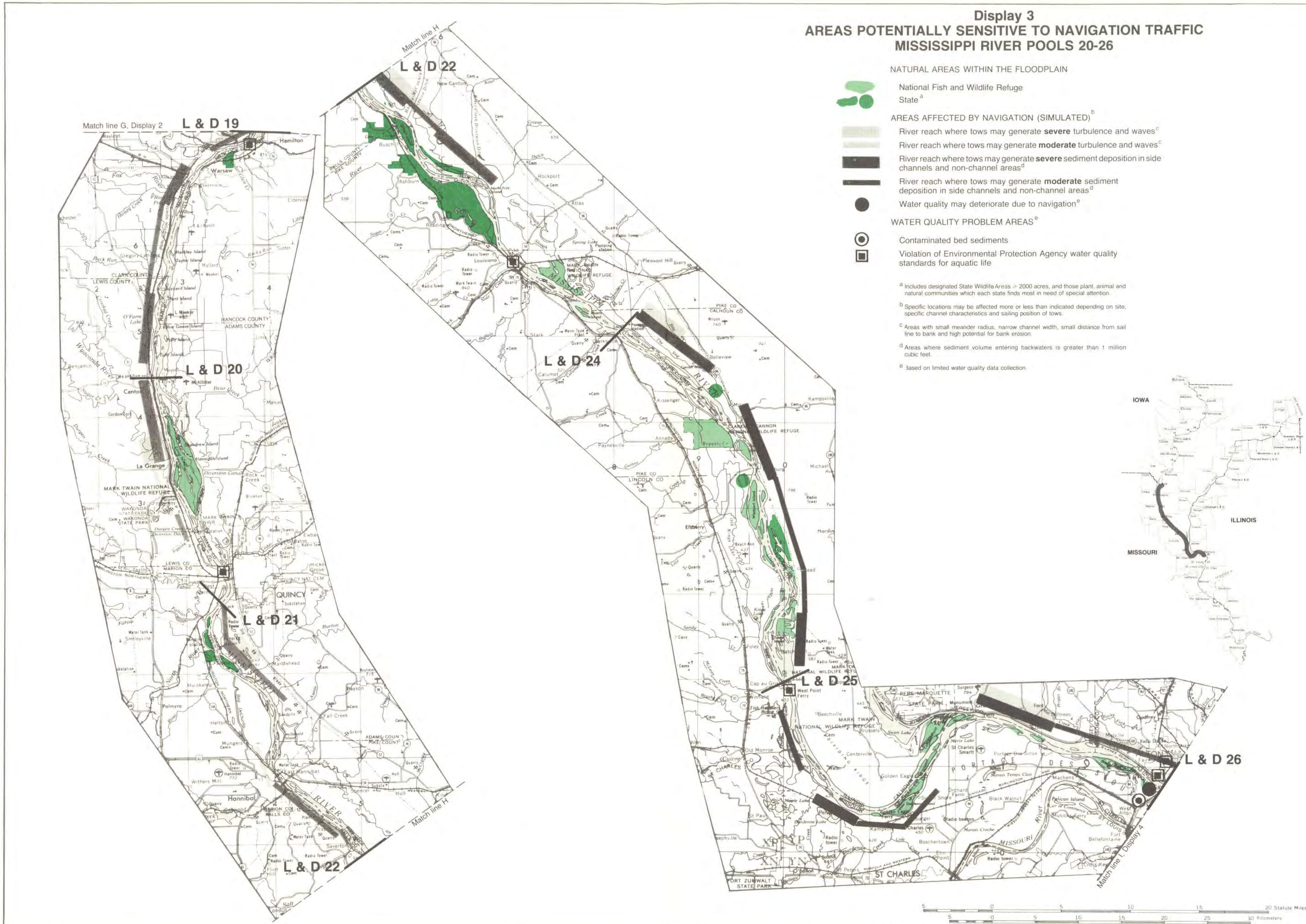




Daily Tow Induced Changes In Turbidity Levels At Low Flow (Simulated)







Display 3
AREAS POTENTIALLY SENSITIVE TO NAVIGATION TRAFFIC
MISSISSIPPI RIVER POOLS 20-26
NATURAL AREAS WITHIN THE FLOODPLAIN
National Fish and Wildlife Refuge
State[a]
AREAS AFFECTED BY NAVIGATION (SIMULATED)[b]
River reach where tows may generate severe turbulence and waves[c]
River reach where tows may generate moderate turbulence and waves[c]
River reach where tows may generate severe sediment deposition in side channels and non-channel areas[d]
River reach where tows may generate moderate sediment deposition in side channels and non-channel areas[d]
Water quality may deteriorate due to navigation[e]
WATER QUALITY PROBLEM AREAS[e]
Contaminated bed sediments
Violation of Environmental Protection Agency water quality standards for aquatic life
[a] Includes designated State Wildlife Areas ≥ 2000 acres, and those plant, animal and natural communities which each state finds most in need of special attention.
[b] Specific locations may be affected more or less than indicated depending on site, specific channel characteristics and sailing position of tows.
[c] Areas with small meander radius, narrow channel width, small distance from sail line to bank and high potential for bank erosion.
[d] Areas where sediment volume entering backwaters is greater than 1 million cubic feet.
[e] Based on limited water quality data collection.
Match line G, Display 2
L & D 19
L & D 20
L & D 21
L & D 22
L & D 24
L & D 25
L & D 26
Match line H
Match line I, Display 4
QUINCY
Hannibal
La Grange
Canton
Warsaw
Hamilton
Louisiana
ST CHARLES
MARK TWAIN NATIONAL WILDLIFE REFUGE
CLARENCE CANNON NATIONAL WILDLIFE REFUGE
PERE MARQUETTE STATE PARK
MISSISSIPPI RIVER
MISSOURI RIVER
IOWA
ILLINOIS
MISSOURI
20 Statute Miles
30 Kilometers

Affected Environment

This reach of the Mississippi River is lined with revetments and wing dams to provide the navigation channel. Based on 1977 inventories of land and water habitat areas the toal area, including both land and water, is 205,000 acres. This includes 61,000 acres of aquatic habitat and 144,000 acres of semi-aquatic and terrestrial habitat.

This reach is characterized by a lack of side-channels and non-channel areas. These areas of high biological productivity constitute less than 5 percent of the total area. This reach of the Upper Mississippi River is part of a major international waterfowl flyway. Statistics on fish and wildlife species diversity are listed below.

- 102 species of fish have been recorded-- 20 of which are common species, 21 sport-fishing species, and 11 rare species
- 296 species of birds, some of which nest in the reach
- 49 species of mammals including such aquatic mammals as beaver, river otter, mink, muskrat, and raccoon and such upland mammals as white tail deer, fox, coyote, and bobcat
- Species with Federal endangered or threatened status include the Indiana Bat, Gray Bat, Bald Eagle, American Peregrine Falcon, Artic Peregrine Falcon, Higgins Eye Pearly Mussel, and Fat Pocketbook Pearly Mussel (believed extirpated). Other speices are protected by State laws.

Navigation Operation and Maintenance

The river has been continuously developed for navigational purposes since 1824. The earliest works involved removal of snags. Later, wing dams and shoreline structures were built to confine low flows to a narrow channel. Begininning in the 1930's an extensive series of rock wing dams were constructed to provide a 9-foot channel. This constricted channel widths to scour the main navigation channel.

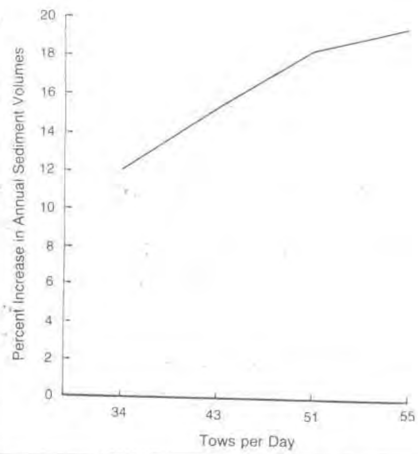
Navigational activity in the main channel is facilitated by levees, 139.6 miles of bank protective works, and 800 wing dams with a total length of 91.4 miles. Dredging is required at a number of locations to maintain a 9-foot channel. The most frequently dredged locations are at channel crossings areas. The yearly average dredged material removal is about 4,000,000 to 5,000,000 cubic yards at approximately 35 sites.

Physical Impacts of Increased Navigation (Mississippi, Lock and Dam 27 and Below)

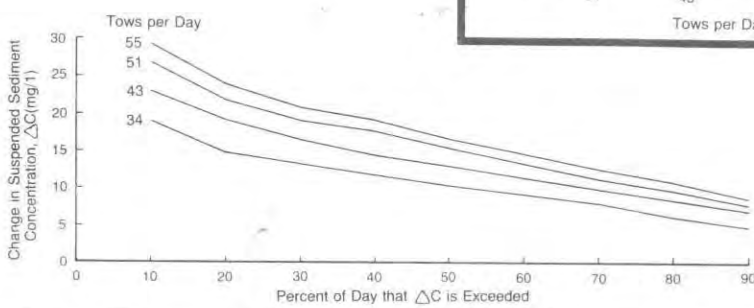
Tow Conditions Used For Impact Assessment

Tows per Day	Barges per Tow
34	35
43	35
51	35
55	35

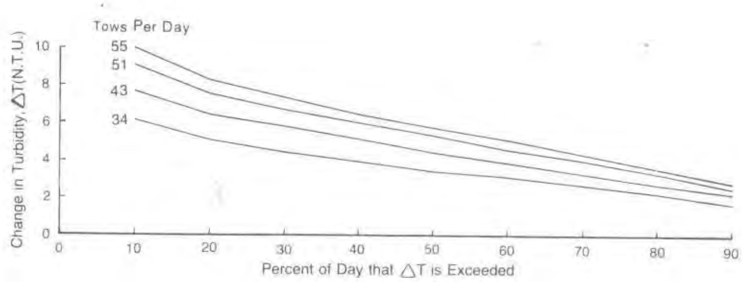
Percentage Increases In Annual Sediment Volumes Entering Side Channels And Backwaters Due To Navigation (Simulated)



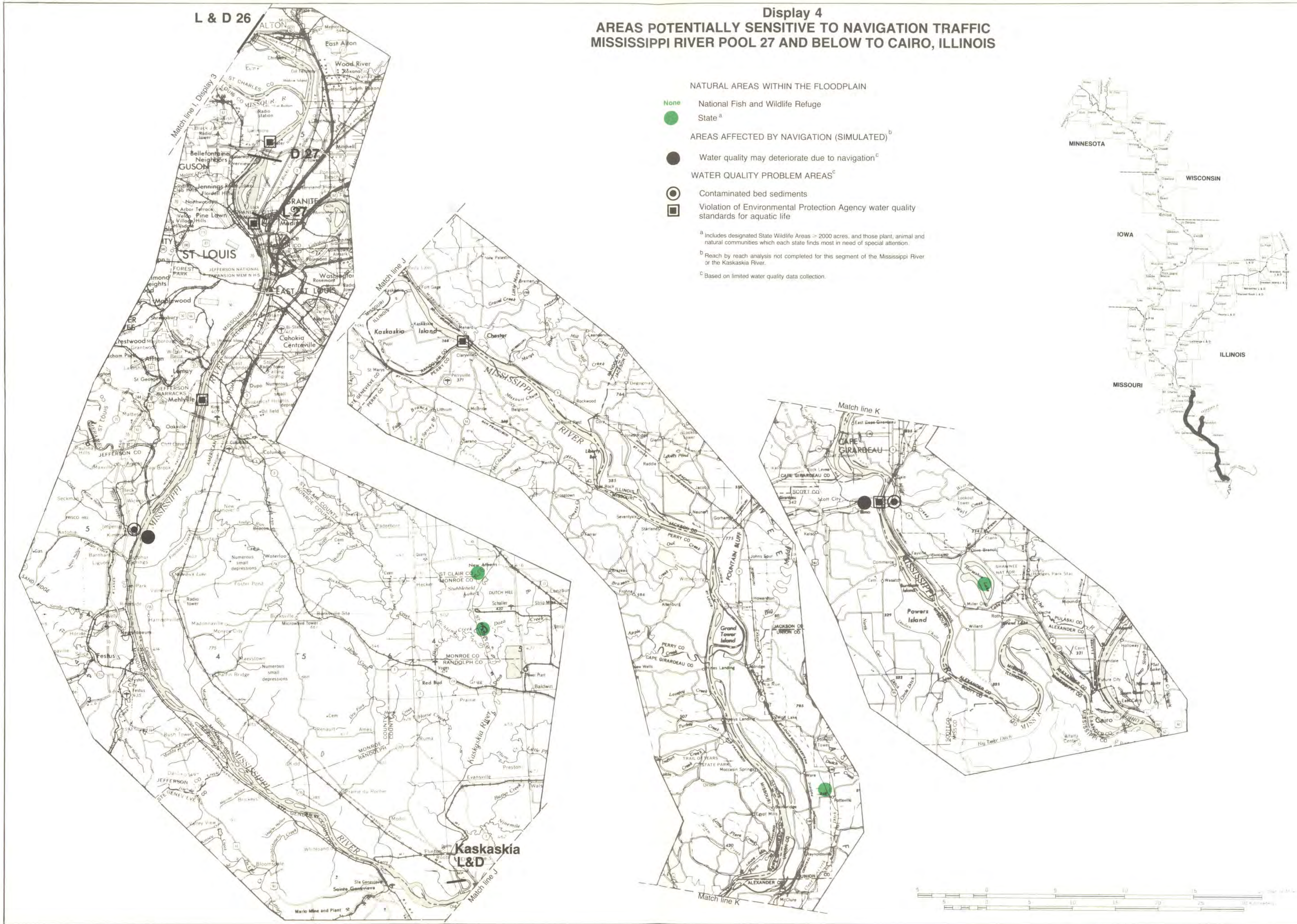
Daily Tow Induced Changes In Suspended Sediment Concentrations At Low Flow (Simulated)



Daily Tow Induced Changes In Turbidity Levels At Low Flow (Simulated)



Display 4
AREAS POTENTIALLY SENSITIVE TO NAVIGATION TRAFFIC MISSISSIPPI RIVER POOL 27 AND BELOW TO CAIRO, ILLINOIS



NATURAL AREAS WITHIN THE FLOODPLAIN

None — National Fish and Wildlife Refuge

● State[a]

AREAS AFFECTED BY NAVIGATION (SIMULATED)[b]

● Water quality may deteriorate due to navigation[c]

WATER QUALITY PROBLEM AREAS[c]

◉ Contaminated bed sediments

▣ Violation of Environmental Protection Agency water quality standards for aquatic life

[a] Includes designated State Wildlife Areas ≥ 2000 acres, and those plant, animal and natural communities which each state finds most in need of special attention.

[b] Reach by reach analysis not completed for this segment of the Mississippi River or the Kaskaskia River.

[c] Based on limited water quality data collection.

Display 5: Illinois River

Affected Environment

The Illinois River and Waterway includes the following segments: the river portion which is the Illinois River from its mouth at Grafton to the confluence of the Kankakee and Des Plaines Rivers; and the Waterway portion which is the Des Plaines River to Lockport Lock, the Chicago Sanitary and Ship Canal to Sag Junction, and the Calumet-Sag Navigation Project. An alternative route to Lake Michigan is also provided from Sag Junction to Chicago Harbor via the Chicago Sanitary and Ship Canal and the Chicago River.

This reach consists of 8 pools. One (Alton Pool) is formed by Lock and Dam 26 of the Upper Mississippi River. Four others (La Grange, Peoria, Starved Rock, and Marseilles) make up the rest of the river portion of the reach. Three pools Dresden Island, Brandon Road and Lockport form the waterway.

An inventory of land and water habitat areas excluding the Sanitary and Ship Canal and Alton Pool was conducted in 1977 for this reach. The total for this area, including both land and water, is 92,000 acres. This includes 81,000 acres of aquatic and wetland habitat and 11,000 acres of terrestrial habitat. Eight percent of the total area is designated as part of the National Refuge System.

This reach is characterized by a relatively narrow main channel, few side-channels and a number of large backwater lakes. These are areas of high biological productivity. Approximately 57 percent of the area inventoried consists of side channel and non-channel habitat. Statistics on fish and wildlife specks diversity are listed below.

- 150 species of fish--30 species of which are common
- over 250 species of birds frequent the area some of which use nesting habitat--2 species are on the federal endangered species list, 31 on the state endangered list, and 7 on the state threatened list
- 49 species of mammals including aquatic mammals such as beaver, river otter, mink, muskrat, and raccoon and upland mammals such as white tail deer, fox, coyote, and bobcat (2 species listed on both the state and federal endangered lists and 2 additional species are state threatened)
- 24 species of mussels and clams (25 have been extirpated since 1900) including the small fingernail clam which is a source of food for fish and waterfowl

Species with federal endangered or threatened status include the Bald Eagle, Fat Pocketbook Pearly Mussel (believed extirpated), Higgin's Eye Pearly Mussel, American Peregrine Falcon, Arctic Peregrine Falcon, Indiana bat, and Gray bat.

Navigation Operation and Maintenance

The river has been continuously developed for navigational purposes since 1822. The earliest works involved removal of snags and construction of the Illinois and Michigan Canal. Prior to 1900, 5 low dams were built. The series of existing locks and dams were completed in 1939 to provide a 9-foot navigation channel.

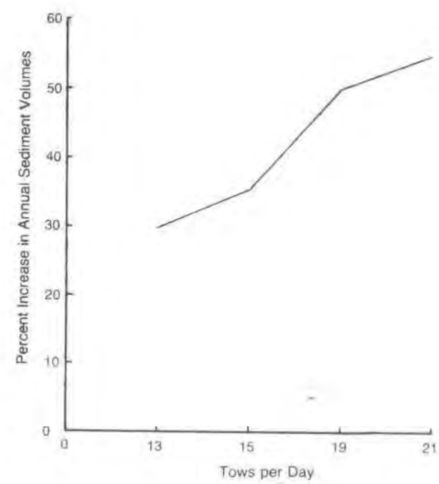
Navigational activity in the main channel is facilitated by operation and maintenance of 8 locks and dams, existence of 157 miles of levees, minimal bank protective works, and 27 wing dams. Dredging is required at a number of locations to maintain a 9-foot navigation channel. From 1965 to 1979 approximately 129,000,000 cubic yards of material was dredged at 38 sites.

Physical Impacts of Increased Navigation (Illinois, Alton Pool)

Tow Conditions Used For Impact Assessment

Tows per Day	Barges per Tow
13	8
15	8
19	9
21	9
38 (peak)	9

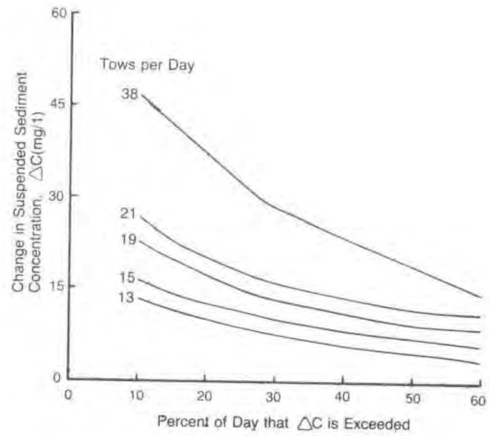
Percentage Increases In Annual Sediment Volumes Entering Side Channels And Backwaters Due To Navigation (Simulated)



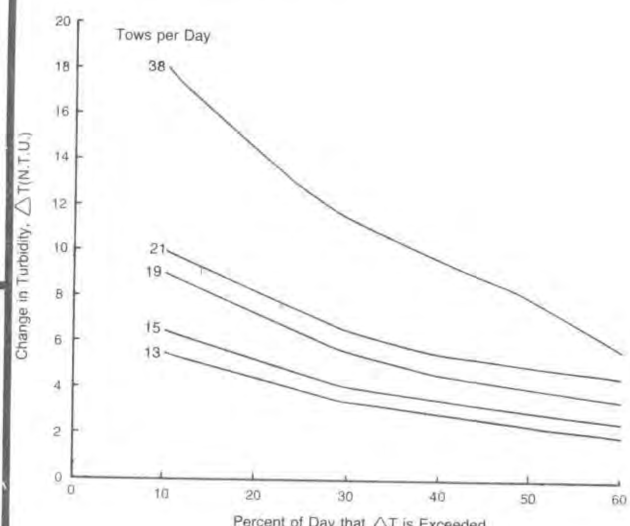
Annual Percentage Increases Above Natural Erosive Forces Due To Tow Induced Waves (Simulated)

	Tows Per Day			
	13	15	19	21
Percent Increases	13	15	19	21

Daily Tow Induced Changes In Suspended Sediment Concentrations At Low Flow (Simulated)



Daily Tow Induced Changes In Turbidity Levels At Low Flow (Simulated)

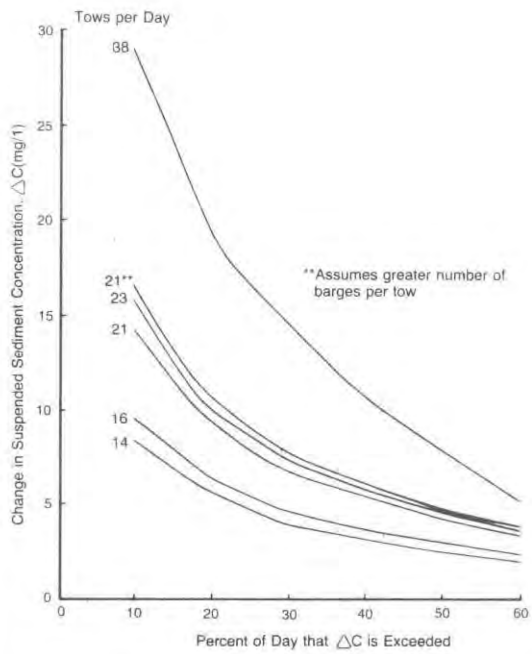


Physical Impacts of Increased Navigation (Illinois, Peoria Pool)

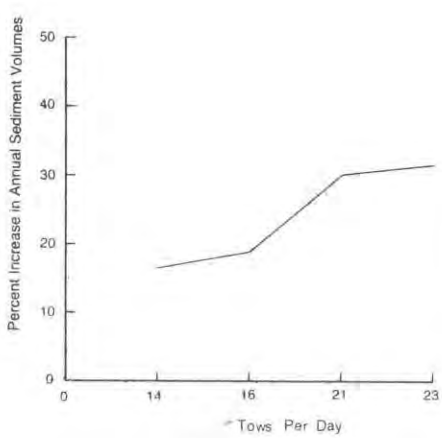
Tow Conditions Used For Impact Assessment

Tows per Day	Barges per Tow
14	8
16	8
21	8
23	8
38 (peak)	9

Daily Tow Induced Changes In Suspended Sediment Concentrations At Low Flow (Simulated)



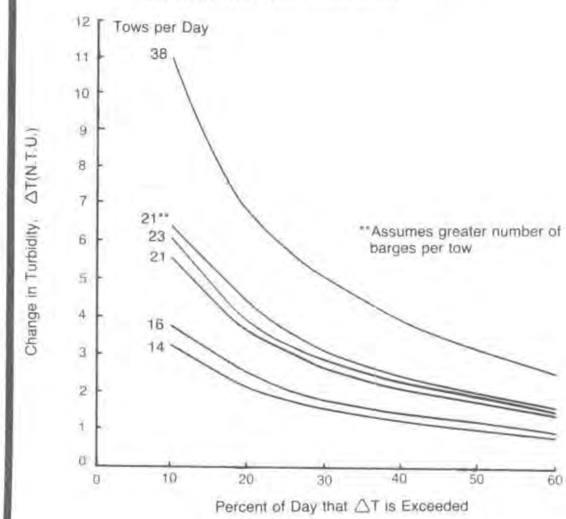
Percentage Increases In Annual Sediment Volumes Entering Side Channels And Backwaters Due To Navigation (Simulated)



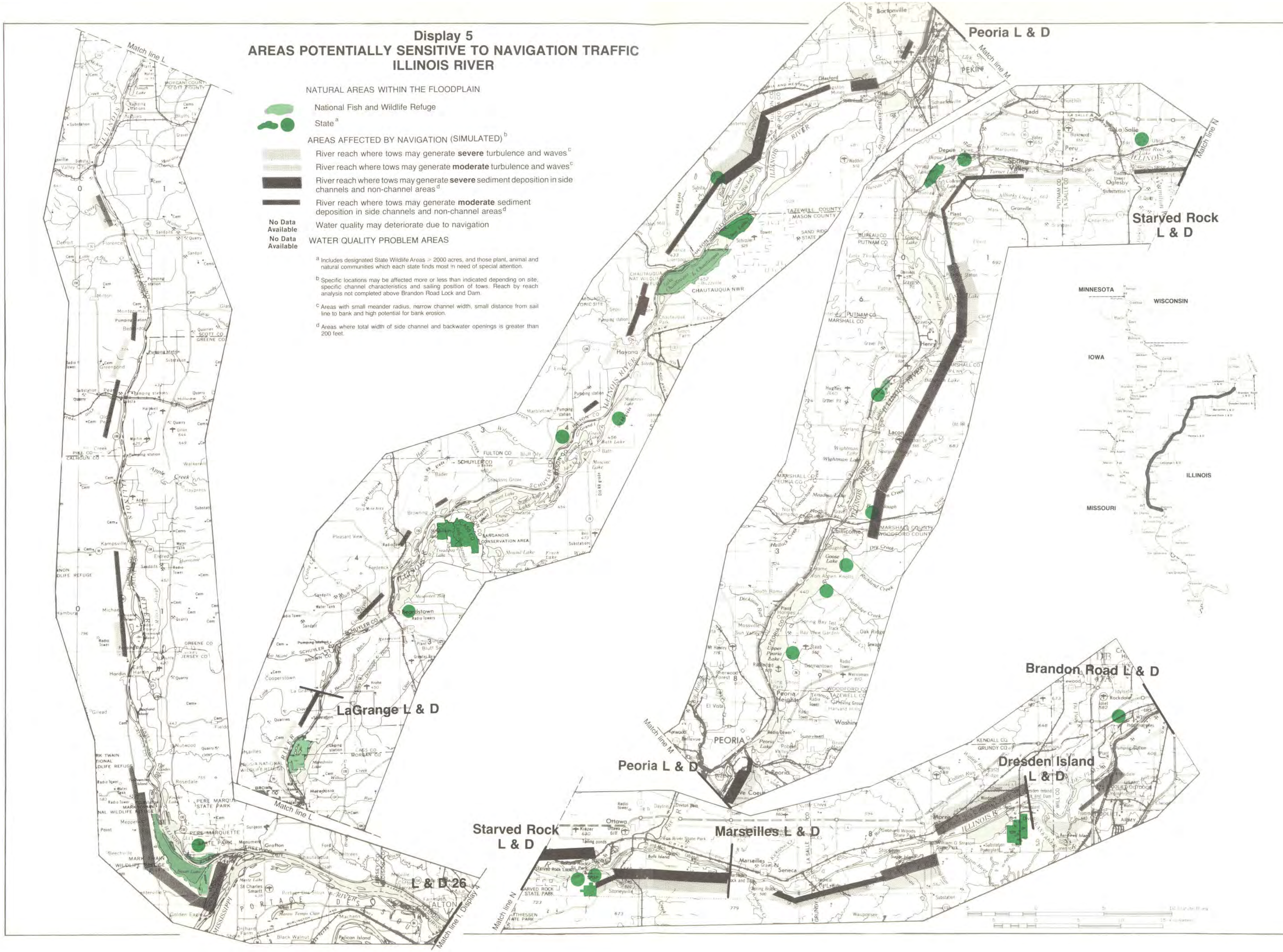
Annual Percentage Increases Above Natural Erosive Forces Due To Tow Induced Waves (Simulated)

	Tows Per Day			
	14	16	21	23
Percent Increases	23	27	35	38

Daily Tow Induced Changes In Turbidity Levels At Low Flow (Simulated)



Display 5
AREAS POTENTIALLY SENSITIVE TO NAVIGATION TRAFFIC ILLINOIS RIVER



MITIGATION AND ENHANCEMENT STUDY

One of the objectives of the comprehensive master plan is to identify mitigation and enhancement measures appropriate to the UMRS. These measures can then be utilized by resource managers to minimize the impacts of increased navigation, operation and maintenance of the 9-foot navigation channel, industrial and urban development, and natural processes, especially sedimentation.

Mitigation is defined to include:

- avoiding certain actions (preventive),
- minimizing impacts by limiting the degree or magnitude of the action and its implementation,
- rectifying the impact by repairing, rehabilitating or restoring the affected environment,
- reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action, and
- providing substitute resources (compensatory).

Mitigation measures are keyed to impacts identified in the Navigation Effects Study section. The four major problems described in that section were:

- Loss of Backwater and Side Channels Environments
- Deterioration of Water Quality
- Deterioration of Main Channel Border and Shoreline Environments
- Loss of Aquatic, Semi-Aquatic and Terrestrial Habitats

Enhancement refers to the improvement of natural resources beyond that which would exist without a specific project or improvement beyond that which satisfies an appropriate mitigation goal.

The final product for this study effort is entitled: Mitigation/Enhancement Handbook for the Upper Mississippi River System and Other Large River Systems. The mitigation and enhancement measures identified in the Handbook are appropriate for implementation on the UMRS. In the handbook the measures have been divided into four major sections: bank stabilization, dredging and dredge material disposal, fisheries management, and wildlife management. Certain techniques, such as water level control, have applicability to more than one section. When this has happened, the measure has been thoroughly discussed in one section. The specific applications are discussed in each relevant section with reference to the more detailed treatment.

Discussions on each measure or groups of measures included description, impact to be mitigated/situation to be enhanced, adverse/beneficial impacts, costs, and evaluation of measure for UMRS. The basic utility of the handbook is for the development of Mitigation/Enhancement Plans. The Environmental Report contains a detailed description of Mitigation/Enhancement Plan Development which provides further detail on a systemic program for the UMRS.

Example of Enhancement Plan — Weaver Bottoms

Weaver Bottoms is located in Pool 5 of the Upper Mississippi River. Since construction in the late 1930's, the Weaver Bottoms area has changed from a biologically productive area to a windswept, riverine lake. Photographs and maps delineating vegetative patterns document the development of this lake condition and the progressive loss of aquatic vegetation(Figures V-9 and V-10).

Prior to the completion of Lock and Dam 5, the Weaver Bottoms area was a combination of marshes, grasslands, and wooded areas with several streams flowing through the area. The loss of vegetation is related to: 1) increased water depth following lock and dam construction; 2) erosion associated with increased current velocities from main channel flow that enters through side channels; 3) high water turbidity produced by waves stirring the bottom sediments; and 4) increased sand influx from the main channel, creating a poor-quality substrate for aquatic flora and fauna. The current

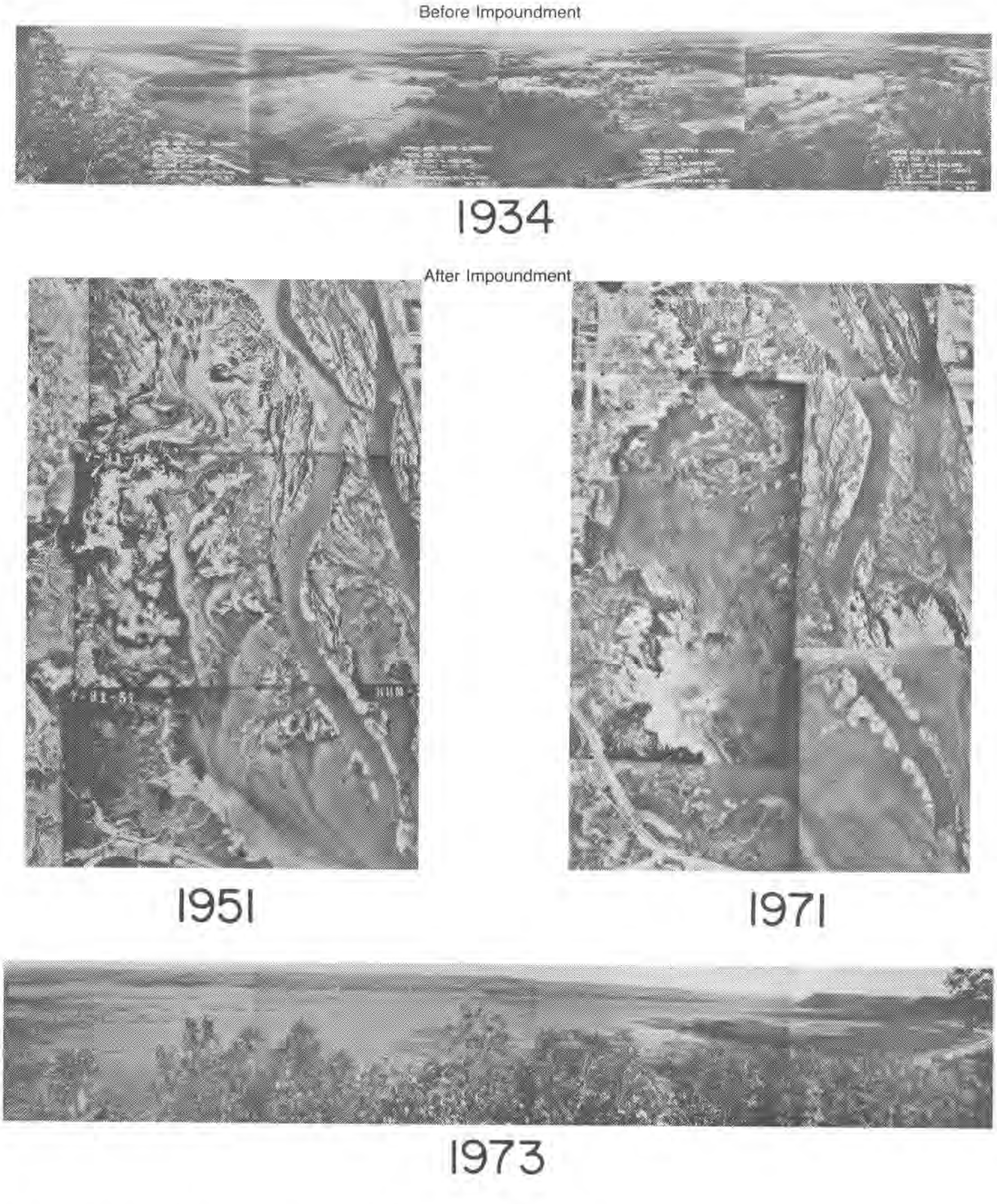


Figure V-9. Evolution of Weaver Bottoms Before and After Impoundment

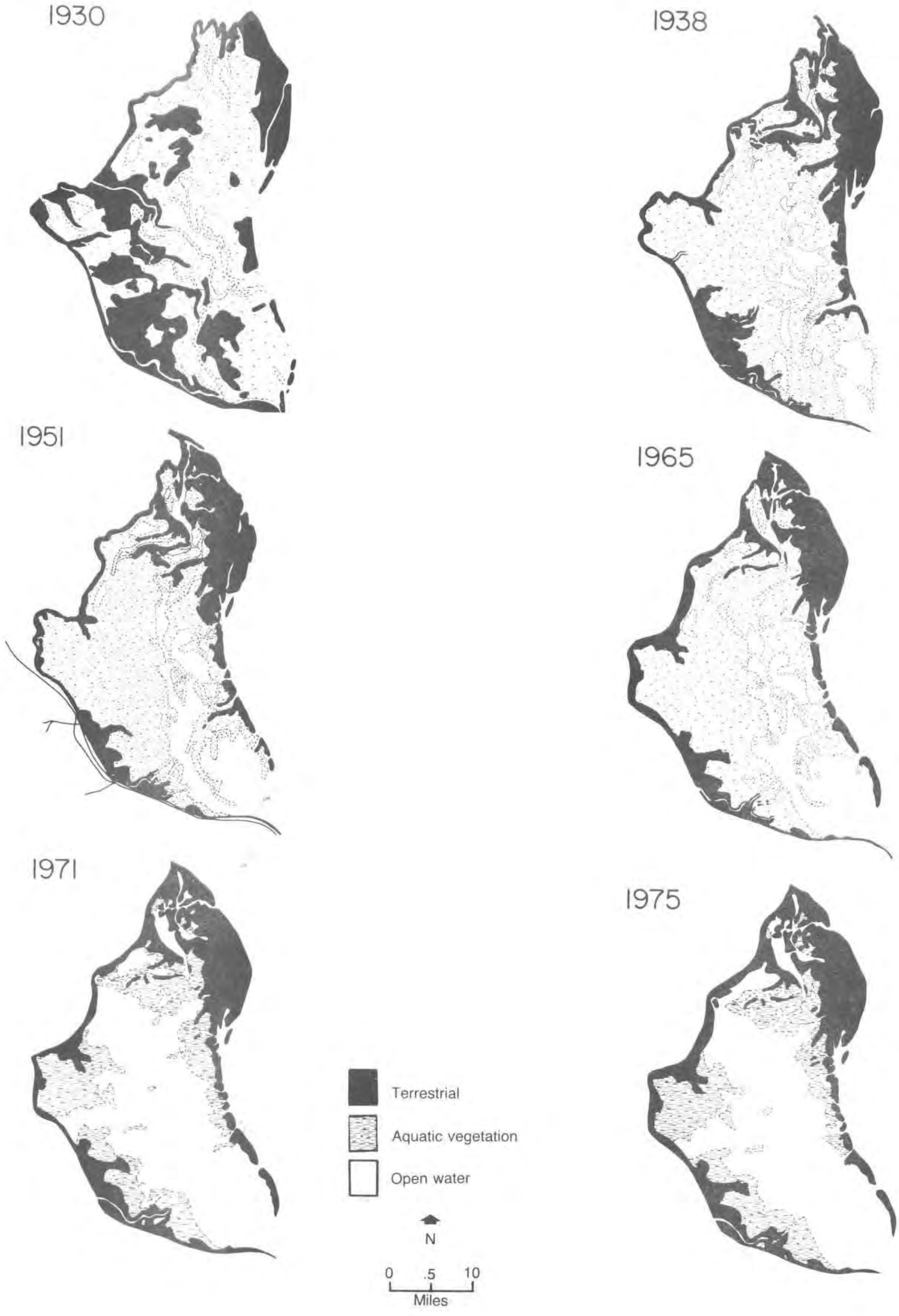


Figure V-10. Vegetative Patterns of Weaver Bottoms (1930-1975) velocity patterns in Weaver Bottoms is illustrated in Figure V-11a. High velocities create erosion near the center of the lake and deposition near the edges (Figure V-11b). Deposition of the sand load buries colonizing marsh plants. The rapid currents prevent vegetation from colonizing the bottom substrate in areas shown to be eroding. Wind-generated waves also disrupt vegetative growth and create bank erosion problems (Figure V-11c). Wind-caused waves and high current velocities create turbid conditions that inhibit the establishment of aquatic vegetation.

Figure V-12 shows an example of enhancement plan for the Weaver Bottom areas. The locations of specific enhancement features are shown on the figure.

The following is a list of candidate rehabilitation or enhancement features applicable to the Weaver Bottoms site. This list was developed based on the Mitigation/Enhancement Handbook which contains additional information on each measure.

1) Measures to protect banks from erosion include:

   - Riprap
   - Cellular Concrete Grids
   - Articulated Concrete Mattresses
   - Gabions
   - Sand or Concrete filled synthetic revetments
   - Bulkheads

2) River training structures which guide or train river flow and thereby indirectly protect banks from the scouring processes of river flow include:

   - Stone Wing Dams
   - Timber Pile Dikes
   - Timber Cribs

3) Breakwaters reduce wave action on the shore by wave deflection and absorption. These waves may be wind-or boat-generated.
   Breakwaters are unique structural mitigation measures because they are designed to dissipate wave energy prior to its incidence upon the shore. Types include:

   - Rock breakwaters
   - Concrete breakwaters
   - Steel sheet pillings
   - Synthetic bags filled with sand

4) All of the methods listed previously to stabilize the banks of large rivers are mainly substantial, permanent structures (i.e. revetments, river training structures, and breakwaters). The measures listed here are generally not considered structures, per se, but are materials or measures which reduce the effects of wave and current action on the river bank itself or on permanent bank stabilization structures, and thereby contribute to bank stability. They include:

   - Vegetation establishment
   - Erosion Control Matting
   - Filter Fabrics

5) Dredge material derived from excavations to remove accumulated sediments within selected areas of Weaver Bottoms may be used to create islands. The islands serve to shorten the fetch length of the wind and to reduce wind-caused bank erosion. Dredge material derived from the main channel may be used to plug certain side channels, thus reducing the velocity of the current in the lake.

6) Side channel entrances may be partially closed with rock riprap closing dams. A 3-foot deep notch in the dam allows water to enter, but prevents the entrance of large volumes of sand. The reduction in water flow decreases current velocities, thus decreasing turbidity levels, and bed and bank erosion.

7) Fisheries Management.

   "Fishery management can be defined as the art and science of producing sustained annual crops of wild fish for recreational and commercial uses". The objective of all fisheries management techniques is the elimination of physical and physiological barriers to the well-being of those fish species that are being managed.

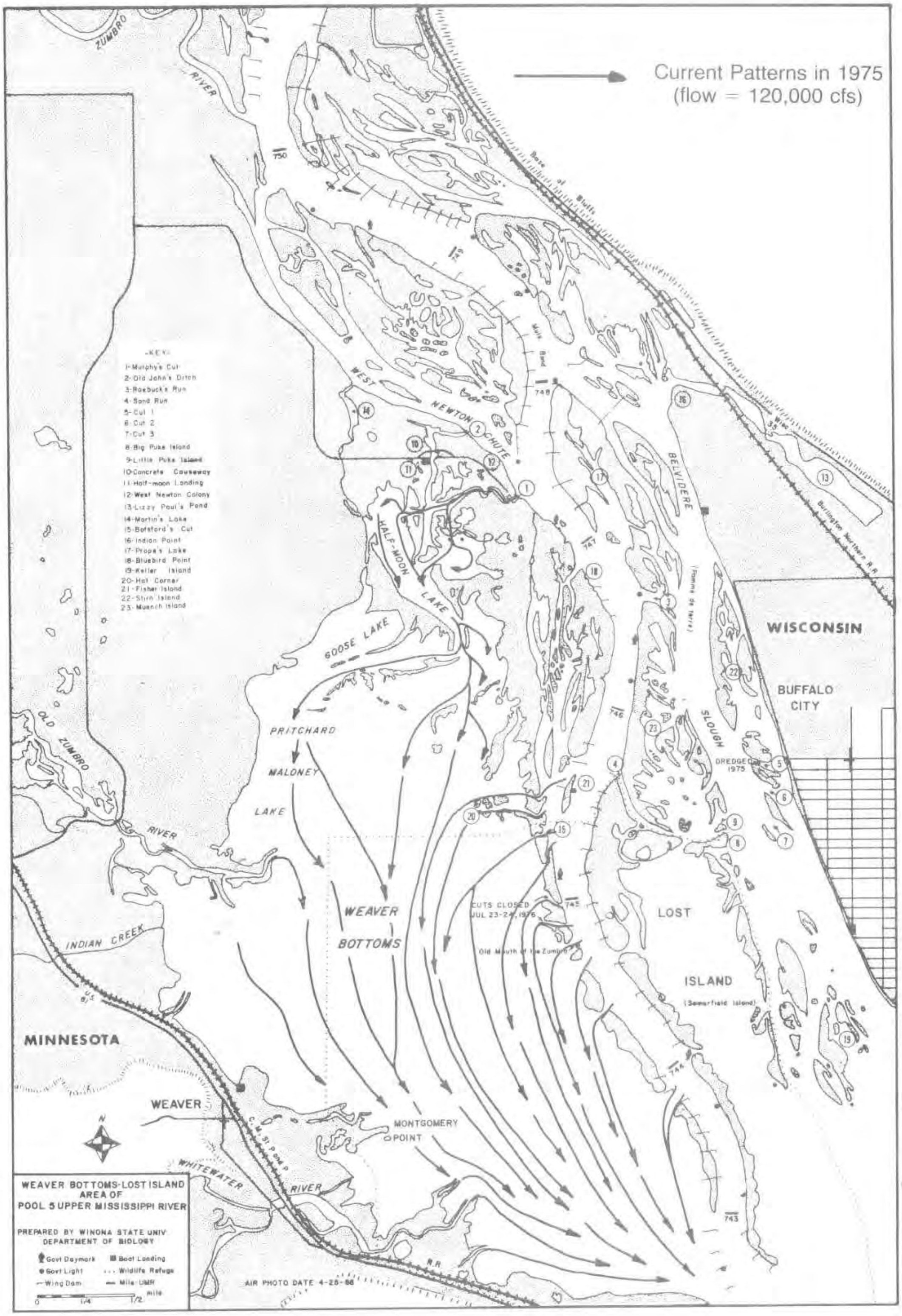


Figure V-11a. Major Problem Factors at Weaver Bottoms — Current Velocity

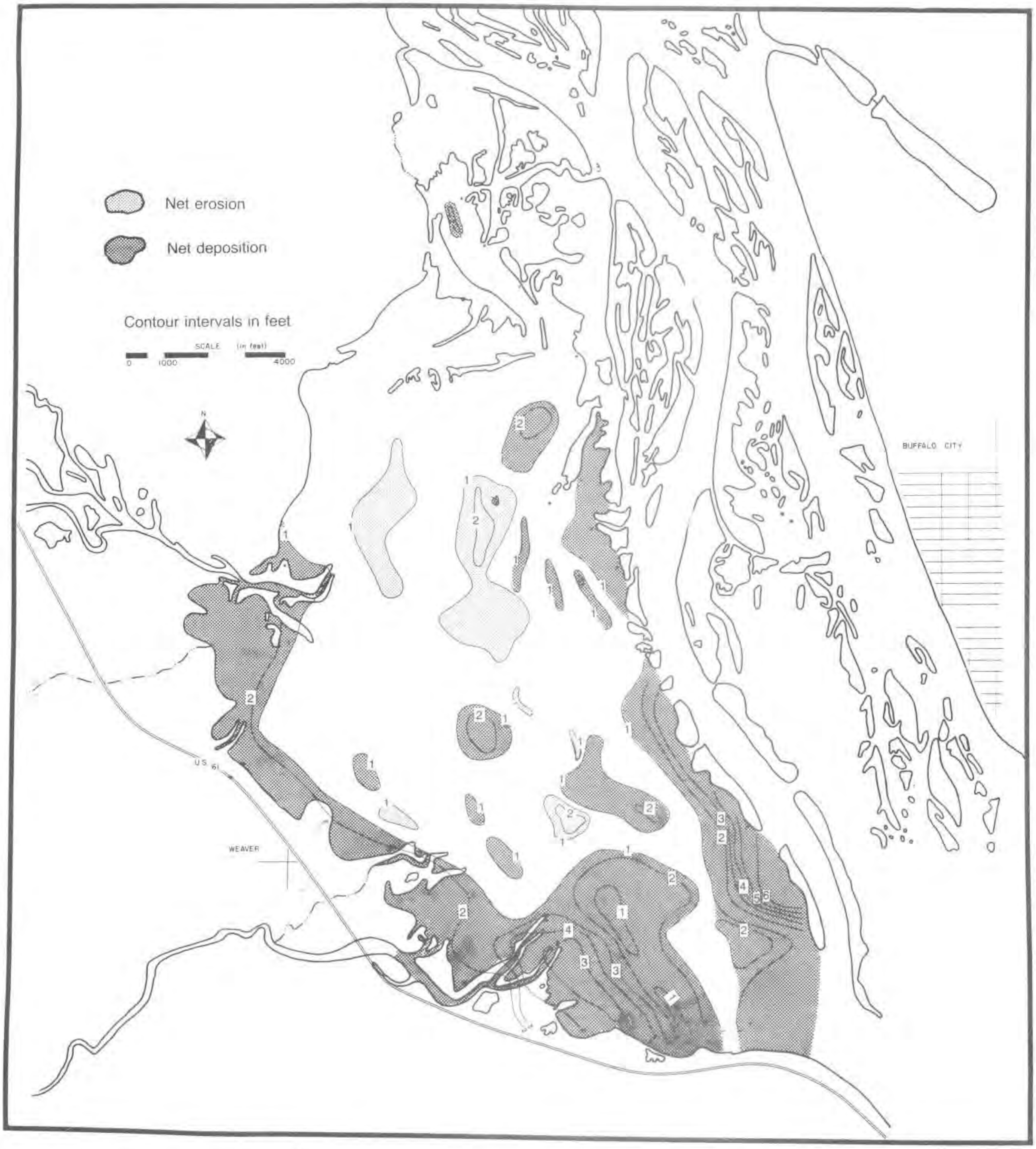


Figure V-11b. Major Problem Factors at Weaver Bottoms — Erosion and Deposition

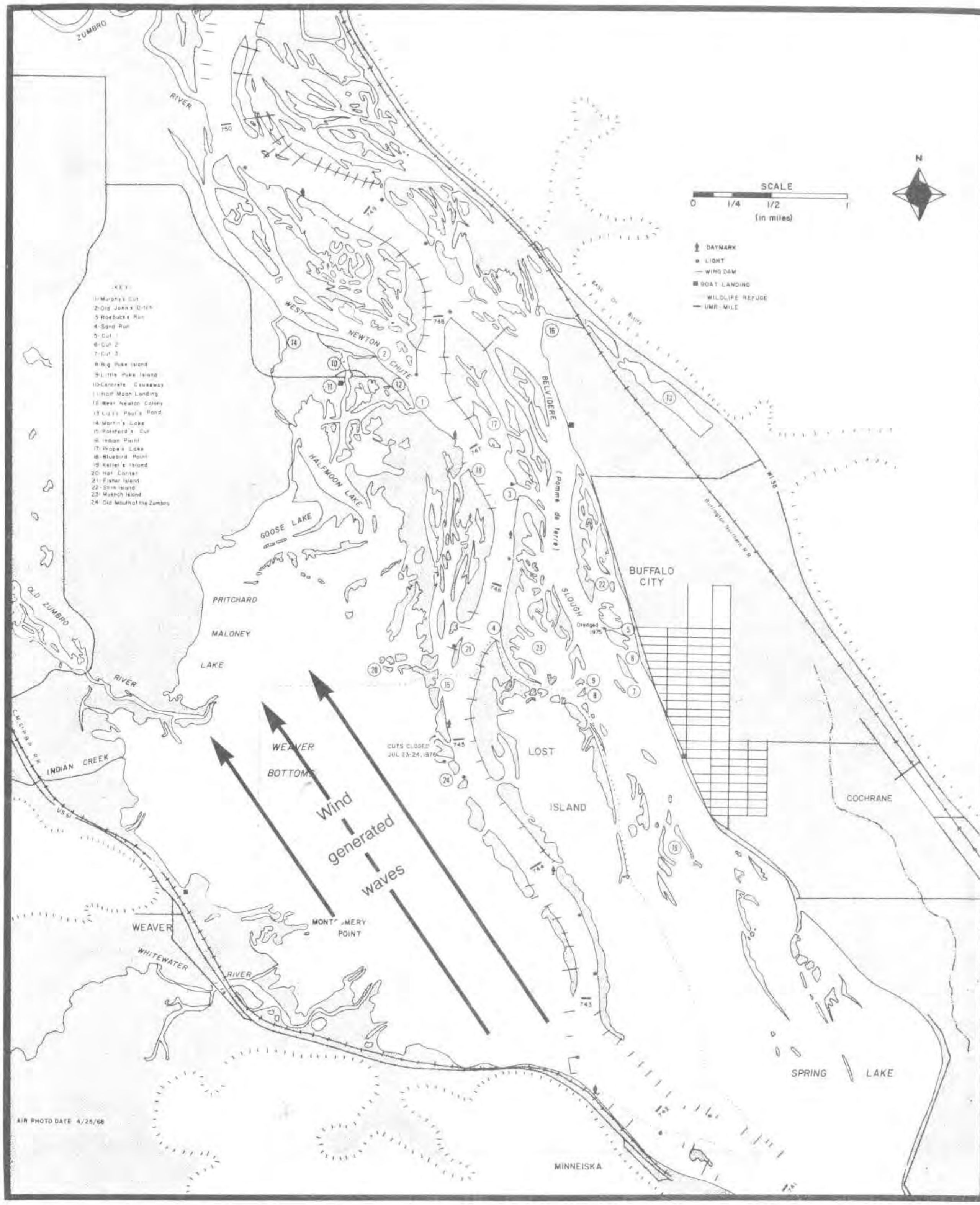


Figure V-11c. Major Problem Factors at Weaver Bottoms — Wind-Generated Waves

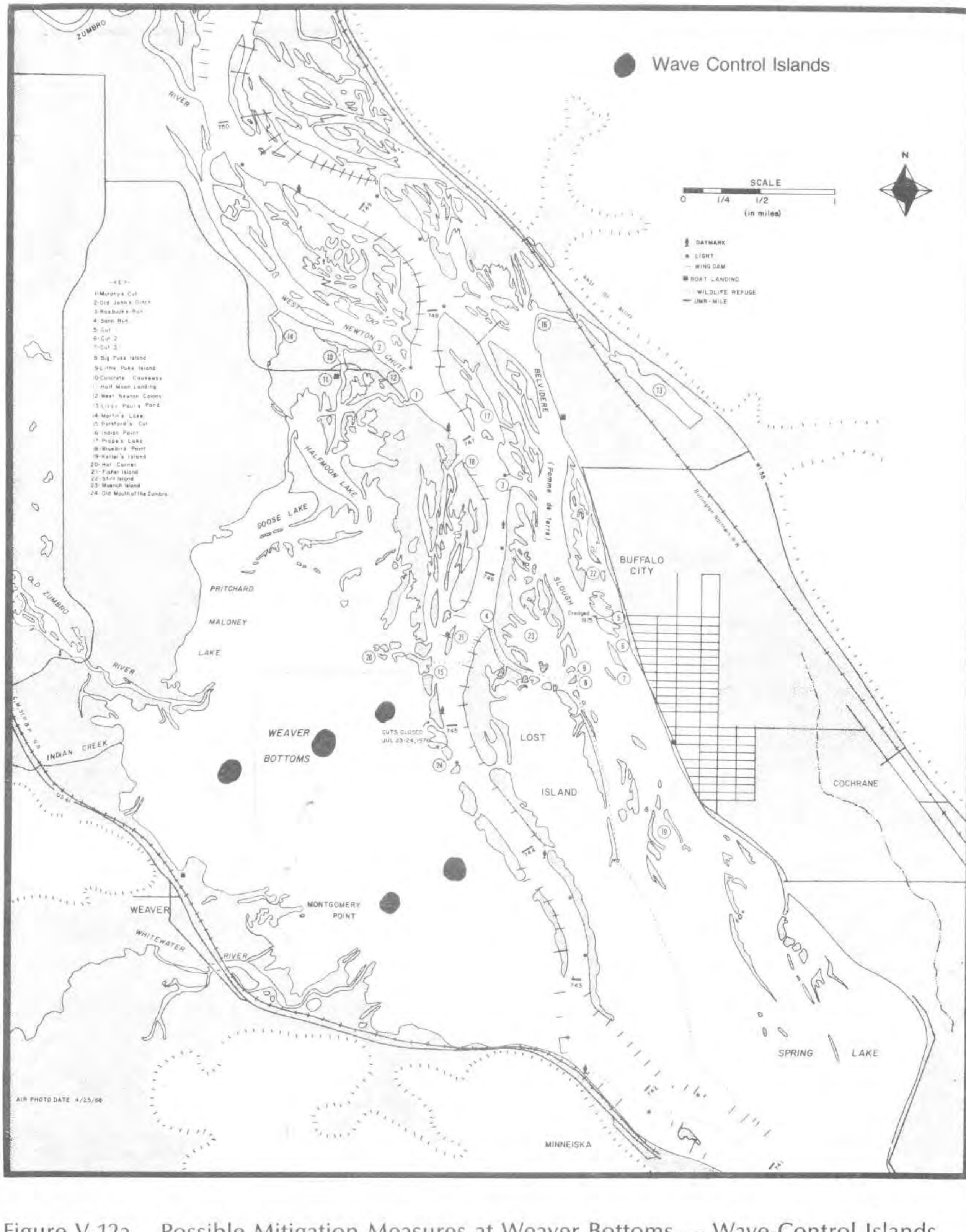


Figure V-12a. Possible Mitigation Measures at Weaver Bottoms — Wave-Control Islands

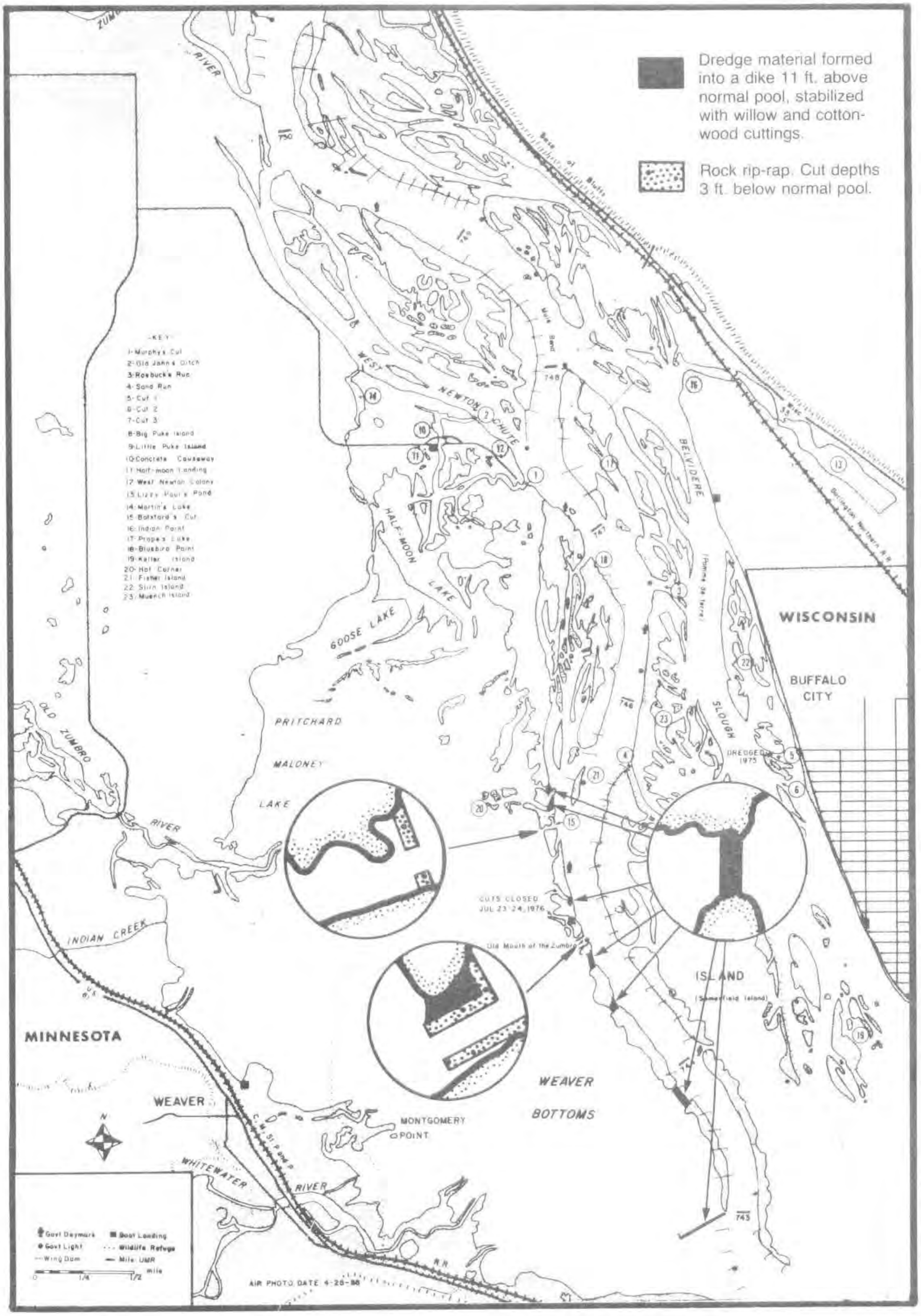


Figure V-12b. Possible Mitigation Measures at Weaver Bottoms — Closing Dams and Dikes

LONG-TERM RESOURCE MONITORING

The purpose of this study was to establish a foundation for the development of a comprehensive Long-Term Resource Monitoring Program (LTRMP) for the Upper Mississippi River System (UMRS).

The study process involved 1) identification of potential users of a monitoring system; 2) a literature search of resource documents related to monitoring systems and the preparation of an annotated bibliography; 3) compilation of resource variables that could be monitored; 4) selection of resource variables for inclusion in a monitoring program; 5) development of a plan for monitoring the effects of signficant short-term impacts; and 6) alternatives for long-term resource monitoring including compilation of a list of various ongoing monitoring efforts and detailed maps indicating these efforts, resource impacts including point-source discharges, and important resource areas.

Background

The UMRS has long been recognized as a unique national resource. Within the past sixty years, Congress has authorized a federal navigation project and several wildlife and fish refuges for major portions of this river system. Presently, over 420,000 acres of land and water are under federal ownership and management. Large investments of money are made each year to maintain and improve the commercial navigabilty of the UMRS. Conversely, relatively few investments have been made to maintain or enhance the natural resources of the same area.

Problems on the UMRS are becoming increasingly complex and lack of information has made it difficult for federal and state agencies to manage the river system for the competing uses. It is mandatory that managers and administrators be provided with scientifically sound information on which to base decisions. Information on a system as large and diverse as the UMRS can only be provided through a properly designed and implemented comprehensive data collection and interpretation program. Past attempts to implement such a program on the UMRS have been unsuccessful because of 1) lack of an integrated plan, 2) lack of a designated coordination agency, and 3) program priorities of State and Federal agencies which do not provide adequate funding and personnel for management of the UMRS as a multiple-use resource.

The Mississippi River and its tributaries are being rapidly and irreversibly altered by impacts resulting from increased urban, industrial, and agricultural development. Activities such as increased navigation, dredging, barge fleeting, construction, wetland development, intensive agricultural practices and their associated sediment and chemical impacts, industrial waste discharges, and increased recreational pressures, have stressed many areas of the system. The impact of these various activities on the biological, physical, water quality, land use and recreational characteristics of the UMRS could be evaluated with a properly designed and applied monitoring system.

Status of Current Monitoring Efforts

Many State, Federal, and private entities are involved in research, management, or monitoring activities cn the UMRS. These include numerous State and municipal agencies; the United States Department of the Army, Corps of Engineers; United States Environmental Protection Agency; United States Department of Transportation; United States Department of the Interior, Fish and Wildlife Service; United States Department of the Interior, Geological Survey; Upper Mississippi River Basin Commission; Upper Mississippi River Conservation Committee; several colleges and universities; electric utilities, private consulting groups, and individuals. The efforts of many of these entities are generally localized, limited in scope, or duplicative from lack of coordination.

While data regarding various aspects of the UMRS are available, inconsistent and incompatible resource assessment techniques, instruments, and methodologies have hindered comprehensive resource monitoring efforts and made systemwide comparisons virtually impossible.

Furthermore, dissemination of research information and uniform adoption of state-of-the-art advances in assessment technology and methodology has been slow.

Description of Alternative Monitoring Efforts

A Long-Term Resource Monitoring Plan has been developed in this study element. Monitoring will not substitute for research but it will enable investigators to build on collected and analyzed data and more easily focus their efforts. The completion of the plan addresses the significant environmental variables, methodologies, data managment systems, and administrative requirements necessary to initiate a program. Extensive research on the success of similar programs and an evaluation of the specific needs of the UMRS have been used to develop several alternative levels of effort for implementation of the Long Term Resource Monitoring Program.

No Action

This alternative would involve no additional monitoring efforts on the UMRS. The advantages of this short term approach would be strictly budgetary. If a program is not implemented, problems associated with incremental habitat encroachment and degradation would continue with no appreciation of the system's ability to assimilate these impacts. Lack of data will slow all decision making processes and each new major project proposal will require intensive and expensive research efforts to resolve environmental questions. Current problems of coordination, cooperation and information transfer will continue.

Level I

This alternative would involve minimal budgetary and personnel committments to collate historical and future research and monitoring information. This information would be provided to resource managers. This would involve considerable cooperation and coordination among the various entities involved with the UMRS. Distinct disadvantages would be inherent in a program at this level of effort. Funding and manpower requirements would be subject to state and federal program priority considerations. Assuming these problems could be overcome, consideration of the quality of data would be essential. Because of a general lack of standardization in methodologies, data would have to be critically reviewed to insure its analytical and statistical validity. Manual dissemination of new information would be slow and may not be responsive to the critical needs of decision makers. Informational voids would also persist since there are many areas with only a few current or proposed research or monitoring efforts.

Level II

This alternative would involve an integrated Long Term Resource Monitoring Program for selected areas of the UMRS. Alternative areas have been identified in the plan in consultation with various researchers, managers, and administrators on the UMRS. Designations are based on consideration of the availability of historical information, geographic location, resource significance (biologically, economically, or socially), overall influence on the system, representativeness, degree of degradation, and potential for mitigation, enhancement, or habitat alteration. Computer capabilities would be included at this level to assimilate and store historical data as well as data generated through the LTRMP. A computerized information transfer system would provide resource managers with site-specific and systemwide data from a monitoring effort utilizing standardized and state-of-the-art methodologies. This program would be able to address the causes and effects of natural and anthropogenic impacts. Information from this program would be useful for recommending mitigation and enhancement measures or habitat rehabilitation projects and documenting their effects. A short-term resource monitoring program is also included to document the physical, chemical, and biological changes in the system due to localized impacts.

Disadvantages of this program would be that areas would have to be prioritized. Undoubtedly, certain important site-specific resources and impacts would be missed, but the advantages far outweigh the disadvantages. Also, a long-term resource monitoring program must remain flexible. If undesignated areas are confronted with specific problems, they can initially be incorporated into a short-term monitoring program with eventual inclusion in the long-term program if merited.

This level of effort would require $7,680,000 for the first year. An annual budget of $5,080,000 would be required thereafter to continue the monitoring effort.

Level III

This alternative would involve a completely integrated Long-Term Resource Monitoring Program for the entire system. Each pool or reach within the UMRS would be monitored including physical characteristics, water chemistry, and aquatic and terrestrial organisms. Intensive monitoring of habitats within these pools would be included in this effort. This effort would involve complete cooperation and coordination among the various federal, state, and private groups involved in research, management, or monitoring on the UMRS. Computerization of data and information transfer capabilities would be included in this effort.

The most significant disadvantage of this level of effort is cost. A program of this magnitude would be expensive, administratively complex, and difficult to manage. Very preliminary cost estimates indicate that this level of effort would require $20,000,000 to $30,000,000 for the first year of effort. An annual budget of $15,000,000 would be required thereafter to maintain the monitoring effort.

Based on an analysis of these alternatives a Long Term Resource Monitoring Program was developed and is presented in Chapter VI.

RECREATION, CULTURAL, AND POTENTIAL WILDERNESS IMPACT STUDIES

General Approach

As part of the Master Plan Study effort, studies were conducted to better understand how expansion of commercial navigation could impact recreational use of the river, as well as potential wilderness resources and historical and archeological sites along the river system. The general approaches adopted for carrying out this analysis are described below, followed by a description of the methodologies employed in the studies. A detailed explanation of this study is contained in the Report entitled: Impacts of Navigation on Recreation, Potential Wilderness and Cultural Resources.

Current Relationships

The first task carried out involved an assessment of current relationships between commercial navigation, operations and maintenance, and recreation, cultural resources, and potential wilderness of the UMRS. A series of three surveys were designed and administered to assess responses of various user groups on the river system to current levels of navigation and operations and maintenance activity. These groups included recreational users; commercial barge operators; and managers/providers of recreational services. Secondary data were used to describe navigation and operations and maintenance activity on the river system.

The analysis was structured by specifying various "system parameters" which took the role of hypothesized impact sources. They were: the number of commercial barge tows passing through a pool, the amount of dredging in terms of volume and days per pool (a ten-year average was employed for these measures), the amount of pool fluctuation, the number of fleeting areas and barge terminals per pool, the number of recreational access points per pool, water turbidity levels, and the amount of lockage delay experienced by recreational boaters on the UMRS. These system parameters were initially proposed to affect the following general recreation-related factors: recreational behavior, boating safety, recreationists' attitudes toward current system parameter levels, and recreational resources. In addition to these recreation-related variables, an assessment was made of the impacts of selected system parameters on the qualities that would make an area eligible for wilderness designation and on various types of threats to historic and prehistoric sites located within the UMRS.

Projected Impacts

In order to evaluate projected impacts on recreation, cultural resources, and potential wilderness due to expanded navigation and operations and maintenance associated with a second new lock at Alton, Illinois, a multi-method approach was adopted. This consisted of the development of a computerized model, called a cross-impact simulation model, which was designed to project trends in 37 individual variables over a 25-year period, given different policy decisions related to increases in commercial navigation on the river system. In addition to the simulation model, a cross-check was performed on the model results by asking respondents contacted in the manager-provider survey to supply their independent evaluations of the probable effect of increases in navigation and operation and maintenance activity on various recreation, wilderness, and cultural resource parameters.

Both the simulation model and the manager-provider assessments were designed in such a way as to project future relationships between many of the same system parameters and recreation, wilderness and cultural resource variables considered in the analysis of current relationships. In this way continuity was maintained between the assessment of both current and projected impacts on these variables.

A measure of "displacement" was included in the surveys of recreational users, managers and providers, and barge operators. Displacement refers to the tendency of recreationists to shift participation to other locations when conditions at their current site become too crowded, or otherwise change in a fashion that is perceived as undesirable.

Methodology

Various methods were used in carrying out each of these studies. An overview for each major element follows:

- Survey of Recreation Providers and Resource Managers Along the Upper Mississippi River System

  This survey was carried out during spring and summer of 1981 with lockmasters, marina operators, wildlife area managers, and other identified providers of public and private recreation opportunities along the Mississippi and Illinois Rivers.

- Survey of Barge Operators on the Mississippi and Illinois Rivers

  The survey was carried out during the spring and summer of 1981, and included personal interviews and mailed questionnaires. The data from this survey provided the basis for a comprehensive analysis of the interaction between commercial and recreational traffic on the river system, and problems arising from an increased level of interaction between segments of river users.

- Surveys of Users of the Illinois River, Pool 26 of the Mississippi River and Northern Reaches of the Main Stem

  On-site interviews with users of recreation facilities were conducted during the spring and early summer of 1981 with users of recreation facilities along the Illinois River and Pool 26 of the Mississippi River. Similar surveys were previously conducted on the other reaches of the Mississippi River during the GREAT studies. Sample surveys were conducted to verify those results. The interviews dealt specifically with the relationships identified between expanded navigation and operation and maintenance and recreation activities.

- Inventory of Recreation Facilities and Services on the Upper Mississippi River System

During the spring of 1981, each recreation facility, service, and access point on the Upper Mississippi River System was visited by an interviewer.

- Existing Surveys of Recreation Users

The University of Wisconsin-Madison maintains several data files on recreational users of the St. Croix River and Pools 1 through 22 of the Mississippi River. These data were collected as part of the GREAT I and GREAT II studies. An assessment was made of the contents of the files in relation to the current and projected impact issues described in the introductory section of this report. Three data sets were identified as particularly relevant to impact analysis. These were the GREAT II dredge island user survey and two versions of the GREAT I dredged island user study.

- Secondary Data Collection

The secondary data collected during the study were used in two ways. First, certain analyses were carried out entirely with secondary data. Secondly, secondary data was used in comparisons between objective measures of navigation-related parameters and manager-provider and user responses to these parameter levels. Such an analysis required linking the secondary data up with the manager-provider and recreational user computer files.

- Cross-Impact Simulation Model

The cross-impact simulation model represented one of the more complex data collection and anlaysis efforts of the study. It was designed to assess future impacts of policy decisions, given expert panel judgements of certain baseline trends, and current relationships between variables. Thus, the cross-sectional surveys and the simulation model complement each other. The surveys measured current relationships (with some speculation on future trends incorporated for cross-check purposes), while the simulation model, using many of the same variables, projected future impacts.

The simulation model integrated the judgement of a series of expert panels, comprised of persons having extensive knowledge of various aspects of UMRS management and policy, to produce projected trends in 37 individual variables over 25-year period, given different policy decisions related to commercial navigation on the river system. The variables contained in the simulation model and a detailed documentation of the logic of the simulation model and the selection of expert panel members are contained in the separate recreation, cultural and wilderness study report.

- Cultural Resources Workshop

The impact of navigation and operations and maintenance on cultural resources was dealt with in the manager-provider survey by asking respondents to check items of the questionnaire describing the extent of various types of impacts in their areas. Because managers and providers are not necessarily experts in cultural resource management, a workshop of professional archaeologists and historians from river basin states was convened to evaluate current and projected navigation-related impacts.

Findings

The results of the various elements of the recreation, cultural, and wilderness studies were analyzed to arrive at the major conclusions and findings presented here. Projected impacts determined through this study relate to the time frame of the next 25 years. During this time the quality of recreational experience will decline for a significant number of current users, however, total recreational use of the river system is expected to increase. Fishing, boating, and camping activities will increase more rapidly. The rate of increase in use of cruisers, water skiing, and houseboats will be attenuated by increases in barge traffic, but some growth in participation in these activities is still expected. Overall, attitudes toward lock delays, barge traffic and fleeting areas are expected to become increasingly negative. An increase in barge traffic will only slightly accelerate this process.

Undeveloped land, open water (off channel), and backwater areas are expected to decrease as these areas are developed for commercial uses and as sedimentation eliminates some backwater areas or converts them to wetlands. Backwater sedimentation and the associated decline of backwater use will have a significant adverse impact on some recreation activities in the UMRS. Some recreation activities will be displaced or eliminated from such areas.

As both commercial and recreation traffic increase the perception of navigation dangers will also increase. Perceptions of accident potential by recreationists differ by river reach. Pools 1-10 users report substantially less serious problems with current safety related conditions than on other river stretches. Boaters on the Illinois River more often (72 percent) predict the accident potential will increase with increases in barge traffic than do visitors to other river stretches (50 - 59 percent).

If fleeting were increased substantially, many recreationists (40 percent) indicate they will be displaced.

If lockage waiting time increases substantially, recreationists who use the locks indicate they will use them less.

If increases in navigation result in an increase of man's presence (i.e. dredging; dredged material placement; municipal, industrial, commercial development) then the value of the areas with wilderness-like qualities will be decreased.

Impacts on cultural resources of the UMRS can be grouped into six categories. From most serious to least serious these include 1) bank erosion from pool fluctuation and wave action due to commercial and recreational river traffic, 2) vandalism in the form of artifact collection, 3) burial of sites by river sediments (often due to structural navigation aids such as wing dams and levees), 4) inundation of sites due to permanent changes in river levels, 5) burial of cultural sites under dredged material, and 6) ground disturbance from construction activities. Any activity that increases wave action, pool level fluctuation, sediment deposition, or recreational use has a high probability of generating adverse impacts on cultural resources of the UMRS. The location and condition of underwater cultural sites and the assessment of the significance of all existing cultural reource sites are

needed.

The results from the manager/provider survey indicate that resource managers do not consider vandalism an important threat to cultural resources in the UMRS, although this impact is currently widespread throughout the river system. This has serious implications for cultural resource management programs since many of these individuals have cultural resource management responsibilities. Therefore, more systematic information is needed on the knowledge and attitudes toward preservation of historic and archaeological sites among both resource managers and the public.

Three general mitigation strategies can be defined with respect to impacts on cultural resources. These include 1) reducing the source of impact, 2) protecting the resource physically from the impact source, and 3) excavating or recording information from those sites where destruction appears certain.

An increased understanding of total recreational use and behavior on an activity and pool specific basis is needed in order to more efficiently manage the recreation resources of the UMRS. This would include additional information on fall and winter recreational use of the river system. More information is also needed on displacement processes, resource conditions required for specific activities, and the availability of substitutes when displacement occurs.

Current statistics on recreation lockage delays are inadequate and these delays should be monitored to assess any changes due to increased barge traffic and how boaters cope with increased lockage delays.

The UMRS provides unique multiple recreation opportunities in terms of both sites and activities. The demand for recreation-related goods and services is extremely important to the economies of local communities along the river and to the overall economy of the region. Once the net value and benefits of the recreation industry are determined, specific actions can be outlined to protect and enhance the viability of recreation opportunities for the future.

IMMEDIATE IMPACTS OF A SECOND LOCK

This study element addressed the site-specific impacts that would occur under various alternatives for adding a second lock to the new Lock and Dam No. 26 facility now under construction on the Mississippi River near Alton, Illinois. The study area includes the construction site of Lock and Dam No. 26 (Replacement) at River Mile 200.78, the area that would be used for construction staging, the areas where dredged or fill material would be deposited and immediately adjacent areas.

In addition to the findings of this study a separate detailed evaluation of the impact of placing fill material in navigable waters of the United States, as required by the Clean Water Act, is presented as an addendum to the technical report Immediate Impacts of a Second Lock - Lock and Dam No. 26 (replacement) Alton, Illinois.

The various alternatives studied included:

1. No Action. Under this alternative no second lock would be built, and it is assumed that the capacity of a single 1200 foot lock would remain at about 92 million tons, with a possible increase to 100 million tons if innovative actions were taken by the Federal government and industry.

2. 600-Foot Lock. Under this alternative a second lock, 600 by 110 feet would be built between the authorized lock and the Illinois bank.

3. Greater than 600-Foot Lock. Under this alternative a second lock greater than 600 feet would be built.

The significant resources that were investigated include: air quality, noise, soils, water quality, wetlands, endangered species, terrestrial communities, aquatic communities, natural areas, archaeological sites, esthetics, community cohesion, community change, relocations and displacements of persons and businesses, employment, tax revenue, property value, public facilities, and leisure.

Table V-25. Site Specific Effects of the Addition of a Second Lock to the Replacement Lock and Dam No. 26

Effect Category	Alternative 2 600-Foot Lock and Alternative 3 Greater than 600-Foot Lock
Air Quality	Short-term changes in site specific air quality can be expected as tows pass through lock (variable)
Noise	Noise level will increase in magnitude and duration
Soils	No impacts
Water Quality	For 1½ years (or longer) construction activity, there will be increases in turbidity in vicinity of construction (vary with activity)
Wetlands	No site specific impacts
Endangered Species	Temporary disturbance of bald eagles in vicinity. No other endangered species known to exist in vicinity.
Terrestrial Communities	Contingent upon non-terrestrial placement of dredged material
Aquatic Communities	Benthic macroinvertebrates and fish could be smothered due to increased siltation during construction period. Consumer species indirectly affected by this. Fish displaced by 2nd lock (permanent). Sport fishing would be disrupted.
Natural Areas	No impacts
Archaeological Sites	No impacts
Aesthetics	New physical structures would change the aesthetics of the area
Community Cohesion	No significant impact
Community Change	No significant impact
Relocations-Displacements of Persons and Businesses	No displacements
Employment	Short-term increase in employment during construction period (approx. 2 years) under alternative 2 and 2-5 years under alternative 3
Tax Revenue	Increase in tax revenues during construction period (approx. 2 years) under alternative 2 and 2-5 years under alternative 3
Property Value	No significant impact
Public Facilities	Existing public facilities and services have adequate capacity to accommodate increased needs during construction period (approx. 2 years) under alternative 2 and 2-5 years under alternative 3. Increase in traffic congestion expected during construction period (approx. 2 years) under alternative 2 and 2-5 years under alternative 3. Potential short-term increase in crime at construction site. Decrease in barge traffic congestion.
Leisure	Less congestion at Ellis Island recreation site. Delayed development of visitor center and Ellis Island recreational site.

The site specific environmental effects on these resources are summarized in Table V-25. Under the "No Action" alternative the significant site-specific effects are those associated with barge congestion.

Dredged Material Disposal Study

Section 101(e)(3) states that, "The Commission shall undertake a program of studies, including a demonstration program to evaluate the benefits and costs of disposing of dredged spoil material in contained areas located out of the floodplain. The program shall include, but shall not be limited to, the evaluation of possible uses in the marketplace for the dredge spoil studies and demonstration programs to minimize the environmental effects of channel operation and maintenance activities." The Dredged Material Disposal Study was conducted in response to this section.

STUDY OBJECTIVES

The primary objective of this study was to evaluate the benefits and costs of disposing of dredge spoil material in contained areas located out of the floodplain, with the understanding that benefits include the evaluation of possible uses in the marketplace for the dredge spoil and the environmental effects of channel operation and maintenance activities.

The first sub-objective provided for the evaluation of ongoing and completed studies to identify feasible economic and environmental disposal alternatives. These alternatives to existing dredged material disposal methods were evaluated based on the determination of the costs, benefits, and environmental and social effects. The second sub-objective was the evaluation of possible uses and potential demand for dredged material in the marketplace. The third was to provide cost data related to the development of new programs, modified programs, new regulations, and authorities for dredged material disposal. The last sub-objective was the identification of existing conflicts within the system regarding the disposal of dredged material.

STUDY FINDINGS

To obtain the stated study objective and sub-objectives the following studies were conducted:

- Environmental impacts of dredged material disposal
- Sediment transport of the Upper Mississippi River
- Social impacts associated with the disposal or use of dredged material
- Geomorphic and land use classification of the floodplains of the Upper Mississippi River System
- Dredged material (productive) use and demand survey on the Upper Mississippi River System
- Cost and energy use analysis for individual and alternate dredged material disposal methods
- A hazard assessment approach for evaluating the chemical and environmental impacts of dredged material disposal for the Upper Mississippi River
- Land acquisition study
- Dredged material disposal legal study
- Dredged material disposal matrix

Environmental Impacts

The literature review identified environmental impacts of the dredged material disposal alternatives and methods of studying such impacts. Three general techniques, terrestrial disposal, aquatic disposal, and productive use were considered. The general environmental impact categories include water quality, substrate alteration/bulk placement, water flow, productivity, general habitat, and contaminants. These impacts will vary depending on the particle size of the material and the location of the disposal.

In aquatic disposal, physical changes of greatest concern are increased turbidity, suspended solids generation, lowered dissolved oxygen levels, change in elevations, burial, secondary movement and substrate alteration. The effects of increased turbidity and suspended sediments and decreased dissolved oxygen levels appear short-term, and thus, the overall significance to the biota has been debated. Species composition may be altered by burial of non-adaptive organisms, increased elevation in shallow water environments, and by a change from irregular to uniform substrate. Secondary movement of material from both aquatic and terrestrial disposal sites may adversely impact surrounding aquatic habitat. However, quantitative studies are not available to determine the nature of such movement.

In terrestrial disposal, the primary physical impact concern is bulk placement of the material and substrate alteration. Survival of plant and animal populations after burial and community recovery are limited depending on the depth of disposal and the particle size of the material. In general, the greater the depth of disposal the less the probability of survival. Recovery of a previously existing or establishment of a new terrestrial community is greater with finer particle size and higher percent organic material.

Chemical changes from dredged material disposal primarily affect water quality. They include general modification of conditions, such as pH range, which allows for potential release of contaminants. The greatest concerns are chemical conditions in surface waters for aquatic disposal and in groundwater for terrestrial disposal. The potential significance of water quality impacts is dependent upon the physical and chemical characteristics of the dredged material, fine-grained material generally representing the greatest adverse impacts.

The effects of contaminated dredged material are not clear-cut for any disposal type. Some contaminants have more severe adverse impacts as a result of land disposal, whereas others can cause greater problems in aquatic environments. Transport, transformation, and bioaccumulation of contaminants as the major secondary and long-term impacts are the subject of much recent research. For the most part, fine-grained dredged material poses the greatest potential for contaminant release.

Productive uses of dredged material, such as fill material, road sanding, strip-mined land reclamation, enhancement of marginal agricultural land, and habitat development could have beneficial impacts. The degree of benefits depends on particle size, organic content, and chemical contamination.

Although much information on the Upper Mississippi River System has been gathered, there are still very few studies available which can be used to determine the significance of impacts from particular disposal alternatives. It is evident that in-field monitoring, of both existing and impacted conditions, is a major data gap. This gap is inclusive of material movement from disposal sites, long-term biotic changes, transformation and transport of contaminants, water quality and flow alterations, general habitat displacement, and the comparison of disposal to other natural and man-made occurrences. The development of an environmental monitoring program is a recommended means to closing this gap.

Sediment Transport

The following is a summary of the various conclusions reached in the sediment transport literature reviewed:

- The major portion of coarse sediment responsible for recurrent shoaling problems in the Upper Mississippi River is transported by its tributaries into the Upper Mississippi River.

- Streambank erosion along the major tributaries of the Upper Mississippi River is their primary source of coarse sediment.

- Bank erosion along the Upper Mississippi River and secondary movement of dredged material into the main channel may also be an important source of coarse sediment; however, these contributions have not been estimated quantitatively.

- The locks and dams along the Upper Mississippi River affect flow conditions of tributaries because of backwater effects, especially during low and intermediate flows.

- The locks and dams along the Upper Mississippi River reduce the main stream energy slope and mean flow velocity during low flow resulting in local aggradation of the riverbed.

- Flow bifurcations along the Upper Mississippi River cause reductions of the flow velocity in the main channel, and produce shoaling problems in the main channel.

- The effects of ice covers in the Upper Mississippi River on dredging requirements are not significant.

- Local shoaling occurs in the Upper Mississippi River as a result of the imbalance in the sediment-transport capacity between tributaries and the Upper Mississippi River.

- Major tributaries carry a high percentage of coarse sediment in suspension, while the Upper Mississippi River flow transports a very minor portion of coarse sediment in suspension. The ratio of wash load to suspended load increases gradually along the Upper Mississippi River in the downstream direction.

- The dredging volume in the Upper Mississippi River navigation channel may be reduced by decreasing sediment inputs from the tributaries, and by increasing the sediment-transport capacity of the Upper Mississippi River.

- Successful application of computer-based numerical models to evaluate the method of reducing dredging amounts depends almost entirely on the quality of the available input data. If there are sufficient input data available, numerical models can accurately predict changes in a moveable riverbed.

Social Impacts

Social impacts of various disposal options tend to be specific to the location and type of disposal. These impacts are not normally the type that would cause major concerns. However, when disposal near population concentrations is anticipated, social impacts need to be assessed in depth.

Productive Uses

The productive uses study was addressed in two reports. The first report covers historic uses of material dredged by the Corps of Engineers. The second report is a survey of potential users along the Upper Mississippi River navigation system.

Various market survey results show that significant portions of material dredged on the UMRS would likely be used for beneficial purposes if it was made available at no charge to users. There are, however, some pools and open river locations where demand is less than amounts of material dredged. The use and availability of dredged material are limited by factors related to distance, both from the dredging site and from the disposal site to the use site; equipment capability; notification time required; and transportation costs.

A beneficial user demand for dredged material has been documented by GREAT I and GREAT II reports. The GREAT I dredged marketing survey documented a 40-year beneficial user demand of 23.2 million cubic yards, or 8.0 million cubic yards less than the estimated 40-year dredging requirement for the GREAT I area. A follow-up survey conducted by the Wisconsin Department of Natural Resources in order to expand these results into the private sector documented a 43.2 million cubic yards which exceeds a 31.2 million cubic yard dredging prediction. The GREAT II dredged material marketing survey documented a 50-year demand of 22.5 million cubic yards, which exceeds the 50-year dredging predictions by 7.8 million cubic yards for the GREAT II area.

Dredged material demand surveys conducted as part of the Master Plan documented an annual demand of 917,000 cubic yards on the Upper Mississippi River from Saverton, Missouri to Cairo, Illinois (GREAT III study area) and an annual demand of 328,000 cubic yards on the Illinois Waterway. One time project demands (an example would be a fill project) reported in the survey were 105,000 cubic yards for the GREAT III study area and 305,000 cubic yards for the Illinois Waterway.

Costs and Energy Use

Costs for a per cubic yard basis were determined for disposal distances of from 0.2 to 2,000 miles though not for all modes of transport. The results for hydraulic pipeline, barge, rail, and truck are summarized in the technical appendix.

The relationship between cost per cubic yard and fuel consumption for the various dredged disposal methods was evaluated. The cost comparison shows that truck haul is the cheapest method for distances up to about 4 miles, at which point barge haul of dry material is cheapest. Fuel consumption analysis indicates that the belt conveyor system is the most fuel efficient. These savings are offset by high capital investment and setup costs. Truck haul, on the other hand, is not fuel efficient, but is relatively cheap because of low capital costs.

The cost comparison indicates barge haul of dry material to be the least expensive method for the range of 5 to 100 miles. Truck haul is second cheapest up to about 30 miles, when rail becomes cheaper. Barge haul is the most energy efficient method, as well as the cheapest. Truck haul uses the most fuel per cubic yard. Mechanical dredging and rail haul fall somewhere in the middle.

Hazard Assessment

Although some previous studies have shown that dredging of sediments from the Mississippi River and open water disposal are unlikely to result in chemical contaminant releases adversely affecting other river uses, further information is necessary before an approach to hazard assessment could be recommended for adoption systemwide.

Land Acquisition

There do not appear to be any regulations or policies within the Corps of Engineers which would prevent the land acquisition of any disposal sites required to meet disposal requirements.

The use of temporary easements or permits is usually a fairly simple method of obtaining access to private lands for the disposal of dredged material. Obtaining fee title or a permanent easement can be a more time consuming process and require a willing seller and approval from the Chief of Engineers. The permits for disposal or temporary easements are more suitable for short-term sites and small volumes. They are dependent on the cooperation of the various land owners and subject to their constraints. The regulations also allow land to be traded for the sand or other consideration.

Legal Study

The legal study concluded there is ample authority for the Corps to sell dredged material on a competitive basis. The Corps may stockpile dredged material for sale, and it may transport the material in order to stockpile large enough quantities to make the sale practical. The Corps may donate the material to governmental or nonprofit organizations, or it may exchange the material for a place to dispose of it. Even though competing sand and gravel companies may be injured, there is currently no legal remedy available. Furthermore, State royalties are not enforced against the Corps. Nevertheless, Federal law and Corps regulations appear to promote the development of the sand and gravel industry.

DREDGED MATERIAL DISPOSAL MATRIX

Matrices were developed to be used to present generalized information on dredged material disposal. The matrices were then used to present alternative disposal methods and their related impacts for representative river categories in the study area. These matrices are based on broad averages and dominant existing situations; however, the matrix system can aid in evaluating each channel site requiring maintenance dredging. The matrices are limited to an evaluation of the transportation and disposal of dredged material.

River Categories in the Upper Mississippi River System

A system for categorizing general stream reaches along the Upper Mississippi River Basin based on physiographic features present along the Mississippi and Illinois Rivers was developed by the Master Plan. Each river category is defined by the particular combination of floodplain and terrace landforms located between the bluffs along the river valley. Levees are not considered as a geographic feature in establishing categories.

Identification of River Categories

Several river categories were defined during analysis of the existing Upper Mississippi River System. Evaluation of the river categories revealed several groups in which a given disposal method would result in similar social and environmental impacts. This resulted in the combination of several of the original specific categories into the general river categories used in this analysis.

River valley forms include valleys without a floodplain or terraces, valleys with floodplains only, valleys with adjacent terrace, and valleys with a floodplain that leads into terraces from one or more former floodplains.

By combining the various categories described in the river categorization report, a total of four general classifications were obtained. These distinct classifications are based on the different impacts that will result from a given disposal alternative in each river category. The four categories are:

1 - River valley bounded by bluffs.
2 - River bounded by floodplains
3 - River bounded by terraces.
4 - River with terraces located outside of a floodplain.

The physical appearance of each river category is illustrated in Figure V-13.

Several river segments in the Upper Mississippi River System are typified by bluffs on one side of the channel and a different landform on the other. These segments are included in the river category that is characterized by landform. This is based on the assumption that disposal can be accomplished on both sides of a channel and will occur on the side opposite the bluff because of the lack of disposal sites available in bluff areas.

Alternative Methods for Dredged Material Disposal

Dredged material must be dealt with when sufficient navigation channel depth in a river segment is threatened due to increased sediment accumulation. Once the dredged material is removed from the channel, an important issue is brought into focus: a decision must be made concerning the disposal of that material.

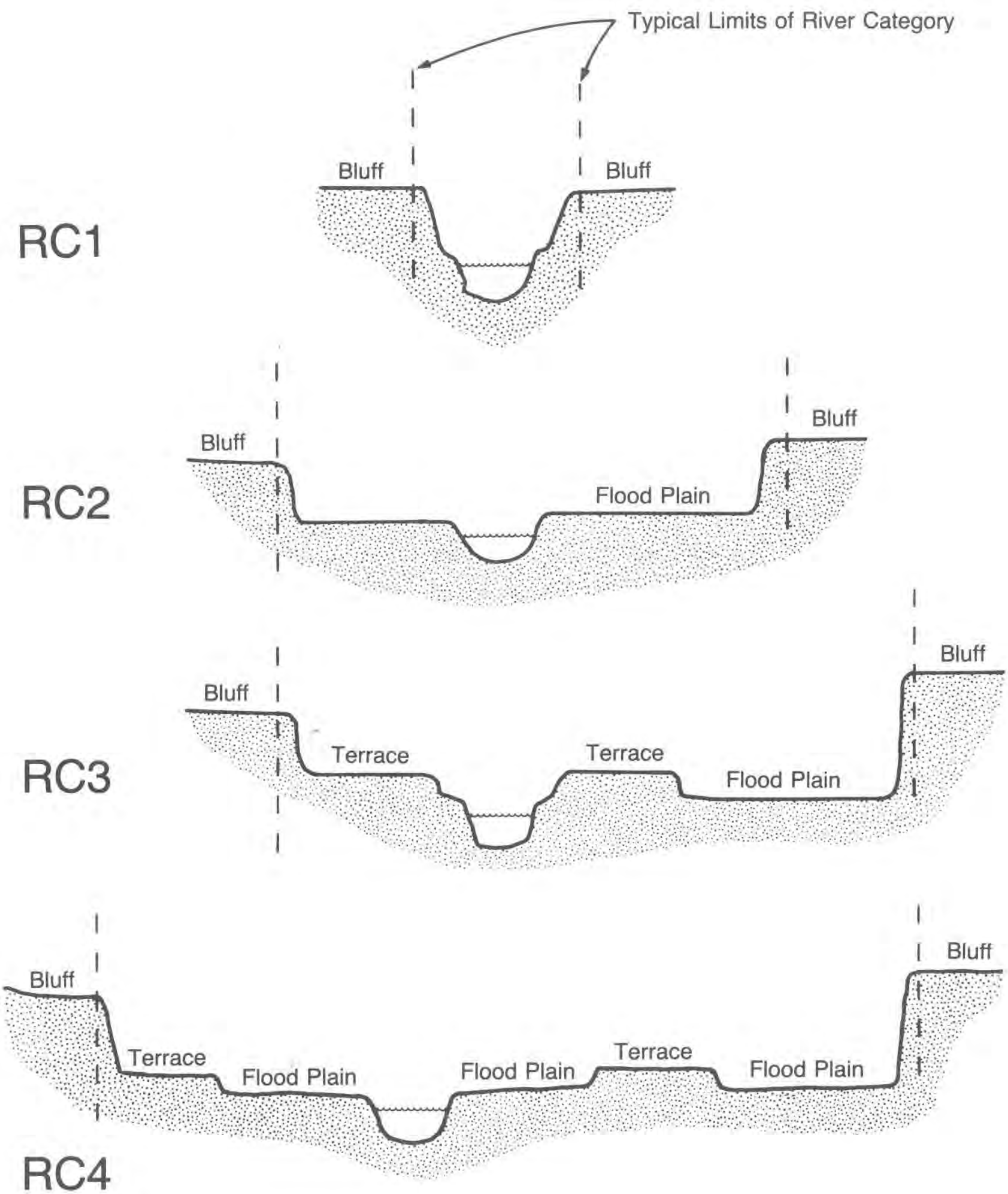
Presently, there are no disposal alternatives which are indiscriminately recommended because of the uncertainty arising from the various social and environmental impacts that would result from the implementation of any disposal program. In developing the matrix, existing and potential dredged material disposal alternatives were evaluated and compared with respect to the impacts associated with each.

Existing Disposal Practices

Under the provisions of the Clean Water Act, the Corps must comply with State substantive and procedural requirements respecting the discharge of pollutants. Thus, in its dredged material disposal program, the Corps must obtain either a National Pollution Discharge Elimination System permit or §401 (33 U.S.C. §1341) water quality certification (or waiver), and it must also comply with other State requirements concerning the discharge of dredged material under the authority of §404(t)[33 U.S.C. §1344(t)]. Under the Corps regulation EP 1165-2-1, ¶10-5, no maintenance dredging is to be done unless disposal is in full compliance with State requirements under §401 and §404(t). There is a provision, however, for emergency dredging under 33 C.F.R. §209.145 (f)(4) which allows the Corps to perform small amounts of dredging to avoid a continued risk of life or a significant property loss posed by a grounding in the channel. This may be performed without prior State approval. In addition to the emergency situation, sections 404(t) and 511(a) [33 U.S.C. §1371(a)] of the Clean Water Act allow the Corps to perform whatever dredging is necessary to keep the navigation channels open in a situation where compliance with State requirements would affect or impair the authority of the Secretary of the Army to maintain navigation. To date, this exemption has not been asserted by the Secretary of the Army. Emergency dredging is provided for in order to allow the Corps of Engineers to perform dredging when continued risk of life or property loss exists. Existing dredged material disposal requirements in the Upper Mississippi River Basin differ from state to state.

Illinois: Illinois regulatory agencies promote open channel thalweg disposal of dredged material that does not contain pollutants. Contaminated material is treated as a solid waste and must be disposed of in a landfill or other upland site with permit restrictions. Disposal practices in Illinois include placement on river banks owned by the Corps of Engineers, on private pro-

Figure V-13. River Categories



perty upon request, to sand and gravel companies, on island and sand bars.

Iowa: The State of Iowa requires that a permit be obtained for disposal of dredged material. Open water disposal can be performed below the normal high water elevation with the State's approval.

Minnesota: The State of Minnesota requires that a permit be obtained for disposal of dredged material below the normal highwater elevations. Open water disposal can only be performed below the normal highwater elevation with State approval. Channel thalweg disposal is not considered to be a desirable disposal method. Any disposal in a floodplain requires compliance with the State floodplain management standards and State approved local ordinances adopted to meet these standards.

Missouri: Disposal procedures in the State of Missouri depend on the geographic location of the dredging operations. On-land disposal is practiced above Lock and Dam 22 on the Mississippi River. Beneficial use has been accomplished at Palmyra and La Grange. Below Lock and Dam 22, main channel border disposal is practiced with 95 percent of dredged material. The remaining material is used for recreational purposes.

Wisconsin: The State of Wisconsin prohibits the disposal of dredged material in a floodplain and at elevations lower than the established, normal high water mark. A discharge permit is required when there is an effluent (return carriage water, for example) from a dredged material disposal site. Dredged material is considered a solid waste and therefore a permit is necessary for disposal. The Department of Natural Resources is the State agency which has the responsibility for administering these regulations.

Disposal Alternatives Used in the Matrix

In addition to existing dredged material disposal practices which are in use in the Upper Mississippi River Basin, several other alternatives have been suggested for use by various groups. Since it may not be possible to arrive at an optimum disposal recommendation for all dredging operations, several disposal alternatives are used in the matrix evaluation.

Disposal methods can be divided into three main functional groups. These functions consist of 1) providing material for beneficial uses, 2) disposing of material in the riverine system, and 3) non-productive onshore disposal. Examples of known impacts for each functional group are displayed on the sample Dredged Material Disposal Matrix.

Performance Parameters of Dredged Material Disposal Alternatives

One of the main purposes of this study was to evaluate the environmental impacts brought about by dredged material disposal practices. Environmental impacts are here defined as all conditions, circumstances and influences brought about by a project which affects people and their surroundings.

Early in the study it was determined that four main facets of the environment would be affected by dredged material disposal. These are economic, environmental, social, and legal/administrative factors. The range of possible variables was reduced to a few key parameters after careful review of the detailed reports completed on each facet. Each performance parameter is defined in dredged material disposal supporting documents.

Matrix Development

The specific disposal methods, river categories, and performance parameters which have been described constitute the components of the analytical matrix. However, it was decided that legal and administrative impacts were not reasonable parameters to evaluate on the matrix due to variations in State regulations concerning dredged material disposal.

The basic structure of the matrix is determined by how it will be used, which can be stated as follows:

For each river category compare alternative disposal methods in terms of performance and environmental impact.

The variables by which alternatives will be compared are grouped under the general headings economic, environmental, and social. The matrix system can serve as a display of effects or be used as a calculation tool.

Procedures

The evaluation of dredged material disposal alternatives is accomplished in four steps. In order, these steps are:

1) Raw data compilation
2) Conversion of data into standarized scores
3) Weighting of performance parameters
4) Calculation of net weighted scores and ranking of alternatives

A prerequisite to this process is to specify the technology involved in each disposal method so that impacts could be estimated. Without concrete alternatives to compare, the evaluation would be meaningless because so many variables are involved. Scenarios defining precise transportation modes and distances were selected based on calculated averages.

Specific disposal method equipment alternatives were established and their specific impacts on each parameter within each river category were estimated from information in individual study reports.

The next step of the analytical methodology was to convert the raw data for all variables, measured in a wide variety of units, to a common base. In making this conversion, two crucial characteristics of the measurement of an alternative's effect on a given performance parameter which must be preserved are the direction and the magnitude of the impact. Is the change positive or negative, large or small? With respect to the later characteristics, the analysis can be made more refined depending on the quality of the raw data. Where the quantification of impacts can be accomplished to a very high degree, a sophisticated scoring technique can be used to capture the subtle, but possibly important differences. The raw data to be entered into the Dredged Material Disposal Matrix are mostly qualitative. Therefore, the approach to scoring is used as follows:

+3 Large Positive Effect
+2 Moderate Positive Effect
+1 Small Positive Effect
0 No Effect
-1 Small Negative Effect
-2 Moderate Negative Effect
-3 Large Negative Effect

In converting the raw data entries into standard scores, judgements about the magnitude of impact were based on the relative differences in the effects of the various alternatives.

This step in the process involves analysis of impacts within each variable --i.e., the relative impacts of each alternative on a given variable -- the next step deals with decisions among variables -- i.e., trade-offs.

The next major step in the analytical approach is to consider whether some types of impacts are more significant than others, e.g., effects on water quality vs. effects on aesthetics.

With a matrix of the size involved, some prejudgments are necessary. In fact, they are desirable because some types of impacts are clearly more, or less, significant than others. Moreover, an explicit statement of the assumptions affecting such trade-offs broadens understanding of the selection process and aids communication.

As in the scoring procedure, more or less sophisticated systems can be devised. Because of the uneven quality of the raw data and the complexity of the task, a simple approach was suggested. The weighting process begins with the assignment of relative values to the three categories of parameters. The economic and environmental parameters are of equal significance and both are seen as three times as important as the social impact variables. Next, the specific parameters under each heading are ranked by relative importance and assigned values which sum to the category totals. It should be noted that the weighting values that appear in this text and on the sample matrix are examples for illustrating the matrix process. Weight determination is a key first step in actual application of the matrix. (To simplify the computations, the category weights are first multiplied by ten). The results of the study on weighting are listed in Table V-26.

These parameter-specific weights underlie the decisions about the differential significance of each impact. Because of the subjective nature of weighting it is important to emphasize that weights could be reevaluated before field use of the matrix.

Assigned weights can be changed and the re-evaluation of alternatives can be accomplished simply by recalculating the analytical matrix. At this time, however, this schedule of weights is seen as the most valid.

The final step in the selection of a preferred alternative begins by computing weighted scores. Weighted scores are calculated simply by multiplying the assigned unweighted scores in each cell by the weighting values. The general example below illustrates this procedure:

	Parameter Wt. = 2	Parameter Wt. = 3	Parameter Wt. = 1
Alt 1	+3 x 2 = +6	-1 x 3 = -3	-2 x 1 = -2
Alt 2	-1 x 2 = -1	+2 x 3 = +6	+1 x 1 = +1
Alt 3	+2 x 2 = +4	+1 x 3 = +3	+2 x 1 = +2

Then the weighted scores on all variables for each alternative are summed to derive net scores. Once the net scores of each disposal method in each river category have been computed, the alternatives can be ranked. Based on the conditions assumed, the resulting list indicated the preferred disposal methods in each river category.

Table V-26. Weighting Values[1]

PARAMETER		
Economic	30	
Land Acquisition		6
Transportation		12
Benefits		12
Environmental	30	
Water Quality		10
Acquatic Ecosystem		15
Terrestrial Ecosystem		5
Social	10	
Urban Development		2
Arch/Cult/Hist/Aesth		2
Recreation Resources		5
Traffic Flows/Noise Levels		1

1/ Weights in this table are examples for illustration purposes.

Dredged Material Disposal Evaluation Matrices

The evaluation of alternatives is presented in matrices following the four analytical steps just described. The matrices combine the first two steps, summarizing the impacts of each alternative as determined from information in the various topical reports and listing the standard scores assigned to these impacts in the lower right hand corner of each cell. Then, the weights listed in Table V-26 are applied to the standard scores and the results reported in the matrix series, along with the net scores (Tables V-27 athrough V-30).

The "lowest score is the preferred alternative. Note that the matrix shows impacts by river category in order to treat the system in general terms. However, disposal imapcts are site-specific and the evaluation of alternatives must recognize this fact. The following discussion illustrates how the matrix could be used.

One alternative, product manufacture, scores much higher than any of the others in river category four -- river with a terrace outside of a floodplain. It is followed by two groups which contain the rest of the productive uses and main channel thalweg disposal, with fill requirements and road sanding comprised by the second group. The non-productive disposal alternative makes up the "worst" group.

Several caveats must be stated with respect to this evaluation and its conclusions. Foremost is that this is a general analysis based on averages and of necessity replete with simplyfying assumptions. Selection of a disposal method in any specific, actual case would require detailed, site-specific analysis.

Following are some of the important assumptions:

- Alternative dredging processes were not evaluated. Only the impacts of various disposal method technologies were analyzed.

- All dredged material is assumed to have common characteristics.

- All examples of a given river category are assumed to be the same. No distinction is made between urban floodplain and rural floodplain.

- The river category segment is defined as the impact area. In the direction parallel to the river it ends where the next type of segment begins; in the direction perpendicular to the river it ends at the limit of its characteristic physiographic feature (RC 1 at the edge of the bluff, RC 2 at the edge of the floodplain, etc.) The dimensions of each category are constant and represent the averages of data reported in the River Categorization Report.

- There is no export of dredged material outside of the river category segment (the impact area), except for river category one.

In order to use this approach from a site-specific evaluation it must be expanded and refined. This includes specifying parameters and defining units of measurement more precisely, postulating explicit criteria for determining the range of values to which scores are assigned, and etc. However, because of the basic flexibility of the system the underlying assumptions can be changed easily and the methodology re-applied simply.

CONCLUSIONS

Due to the diversity of the UMRS each disposal site should be considered separately, moreover, there is no overriding need for general disposal of dredged material out of the floodplain. Master Plan studies and GREAT I and II studies indicate that in most cases the GREAT programs have developed acceptable solutions to the problem of dredged material disposal though not necessarily the most economic solution. The matrix is also a useful tool to help consider new situations. There are data gaps that still remain. A program to coordinate and encourage the productive uses of dredged material may have some benefit.

Table V-27. Dredged Material Disposal Matrix, River Category 1

RIVER CATEGORY 1 BOUNDED BY BLUFFS		EXAMPLE MATRIX[1/] PERFORMANCE PARAMETERS										
		ECONOMIC			ENVIRONMENTAL			SOCIAL				
	DISPOSAL METHODS	LAND ACQUISITION COSTS	TRANSPORTATION COSTS	BENEFITS	WATER QUALITY	AQUATIC ECOSYSTEM	TERRESTRIAL ECOSYSTEM	URBAN DEVELOPMENT	ARCHEOLOGICAL/ CULTURAL/HISTORIC/ AESTHETIC	RECREATION RESOURCES	TRAFFIC/NOISE	TOTAL WEIGHTED SCORE
BENEFICIAL USES	Product Manufacture	Purchase of In-floodplain Stockpile Area ($2,430/Acre) -1 x 6 = -6	Barge and Truck Transport ($71,500) -3 x 12 = - 36	Revenue from Sale Material 1 x 12 = +12	No Impact 0	No Impact 0	No Impact 0	Possibly Induce Development if Significant Increase in Industrial Activity 1 x 2 = +2	No Impact 0	No Impact 0	Possible Increase in Each -1 x 1 = -1	-29
	Levee Repair	No Impact - assume storage within right-of-way 0	Barge Transport ($32,500) -2 x 12 = -24	Public Savings on Maintenance Costs 1 x 12 = +12	Hydraulic Effluents Contain Solids -1 x 10 = -10	Temporary Turbidity and Potential Erosion -1 x 15 = -15	No Impact 0	Development Potential Created by Reduction of Flood Threat 1 x 2 = +2	No Impact 0	No Impact 0	Pipeline Potentially Disrupt River Traffic -1 x 1 = -1	-36
	Fill Material	No Impact 0	Barge and Truck Transport ($71,500) -3 x 12 = -36	Revenue from sale of Materials 1 x 12 = +12	Depends on Where Hydraulic Effluent is Channeled -1 x 10 = -10	No Impact 0	No Impact 0	Increase Developable Land 1 x 2 = +2	Possibly Disturb Natural Setting or Significant Site - Depends on Location -1 x 2 = -2	No Impact 0	Slight Increase -1 x 1 = -1	-35
	Recreational Beach Maintenance	No Impact - existing beaches already in public ownership 0	Barge Transport ($32,500) -2 x 12 = -24	Material Savings and Possible Increased Recreational use 2 x 12 = +24	Effluent into Receiving Water and Erosion -2 x 10 = -20	Erosion into Shallow Water -2 x 15 = -30	Prevents Plant Succession -3 x 5 = -15	No Impact 0	Improvement of Existing Facility 1 x 2 = 2	Create Additional Recreational Opportunities +3 x 5 = +15	Slight Increase -1 x 1 = -1	-49
	Road Sanding	Purchase of In-floodplain Stockpile Area ($2,430/Acre) -1 x 6 = -6	Barge and Truck Transport ($71,500) -3 x 12 = -36	Public Savings on Materials Requirement 1 x 12 = +12	No Impact 0	No Impact 0	No Impact 0	No Impact 0	No Impact 0	No Impact 0	Slight Increase -1 x 1 = -1	-31
MAIN CHANNEL	Main Channel Thalweg	No Impact 0	No Impact 0	No Impact 0	Temporary Downstream Effects -1 x 10 = -10	Depends on Downstream Movement of Materials -1 x 15 = -15	No Impact 0	No Impact 0	No Impact 0	No Impact 0	No Impact 0	-25
	Main Channel Border	No Impact 0	Hydraulic Transport ($17,900) -1 x 12 = -12	No Impact 0	Temporary Turbidity and Suspend Solids -2 x 10 = -20	Cover Primary Habitat -3 x 15 = -45	No Impact 0	No Impact 0	No Impact 0	No Impact 0	No Impact 0	-77
NON-PRODUCTIVE	Non-Productive Inland	Purchase of Disposal Site Possibly Required ($2,430/Acre) -1 x 6 = -6	Barge and Truck Transport ($71,500) -3 x 12 = -36	No Impact 0	Hydraulic Effluent Could Greatly Impact Surrounding Water -2 x 10 = -20	Change in Drainage and Reduced Productivity -1 x 15 = -15	Reduced Productivity -3 x 5 = -15	Possibly Displace Development -1 x 2 = -2	Possibly Disturb Significant Site -2 x 2 = -4	No Impact 0	Slight Increase -1 x 1 = -1	-99
	Non-Productive Shoreline	Purchase of Disposal Site Possibly Required ($2,430/Acre) -1 x 6 = -6	Barge Transport ($42,500) -2 x 12 = -24	No Impact 0	Effluent into Receiving Water -1 x 10 = -10	Erosion into Shallow Water -2 x 15 = -30	Prevents Plant Succession -3 x 5 = -15	No Impact 0	Possibly Disturb Significant Site -2 x 2 = -4	Possibly Reduce Opportunities for Boating, Fishing -1 x 5 = -5	Pipeline Potentially Disrupting River Traffic -1 x 1 = -1	-95
	Backwater/ Side Channel	No Impact 0	Barge and Truck Transport ($71,500) -3 x 12 = -36	No Impact 0	Change Elevation and Flow, Suspended Materials -2 x 10 = -20	Reduce Oxygen and Light, Change Substrate -3 x 15 = -45	No Impact 0	No Impact 0	Possibly Disturb Significant Site -2 x 2 = -4	Possibly Reduce Opportunities for Boating, Fishing -1 x 5 = -5	Slight Increase -1 x 1 = -1	-111

[1/] Does not include consideration of legal and administrative constraints.

Table V-28. Dredged Material Disposal Matrix, River Category 2

EXAMPLE MATRIX[1/]

RIVER CATEGORY 2 BOUNDED BY FLOODPLAIN		PERFORMANCE PARAMETERS										
		ECONOMIC			ENVIRONMENTAL			SOCIAL				
	DISPOSAL METHODS	LAND ACQUISITION COSTS	TRANSPORTATION COSTS	BENEFITS	WATER QUALITY	AQUATIC ECOSYSTEM	TERRESTRIAL ECOSYSTEM	URBAN DEVELOPMENT	ARCHEOLOGICAL/ CULTURAL/HISTORIC/ AESTHETIC	RECREATION RESOURCES	TRAFFIC/NOISE	TOTAL WEIGHTED SCORE
BENEFICIAL USES	Product Manufacture	Purchase of In-floodplain Stockpile Area ($2,430/Acre) -1 x 6 = -6	Hydraulic and Truck Transport ($52,400) -3 x 12 = - 36	Revenue from Sale of Material 1 x 12 = +12	No Impact 0	No Impact 0	No Impact 0	Possibly Induce Development if Significant Increase in Economical Activity 1 x 2 = +2	No Impact 0	No Impact 0	Possible Slight Increase -1 x 1 = -1	-29
BENEFICIAL USES	Levee Repair	No Impact 0	Hydraulic Transport ($31,400) -2 x 12 = -24	Public Savings on Maintenance Costs 1 x 12 = +12	Hydraulic Effluents Contain Solids, Turbidity -1 x 10 = -10	Temporary Turbidity and Potential Erosion -1 x 15 = -15	No Impact 0	Development Potential Created by Reduction of Flood Threat 1 x 2 = +2	No Impact 0	No Impact 0	Pipeline Potentially Disrupt River Traffic -1 x 1 = -1	-36
BENEFICIAL USES	Fill Material	No Impact 0	Hydraulic and Truck Transport ($52,400) -3 x 12 = -36	Revenue from Sale of Materials 1 x 12 = +12	Depends on Where Effluent is Channeled -1 x 10 = -10	No Impact 0	No Impact 0	Increase Developable Land Area 1 x 2 = +2	Possibly Disturb Significant Site -1 x 2 = -2	No Impact 0	Slight Increase -1 x 1 = -1	-35
BENEFICIAL USES	Beach Maintenance	No Impact - Use Existing Beaches 0	Hydraulic Transport ($31,400) -2 x 12 = -24	Material Savings and Possible Increased Recreational use 2 x 12 = +24	Effluent Into Receiving Water and Erosion -2 x 10 = -20	Erosion From Beach Into Shallow Water -2 x 15 = -30	Prevents Upland Plant Growth -3 x 5 = -15	No Impact 0	Improvement of Existing Facility 1 x 2 = 2	Create Additional Recreational Opportunities +3 x 5 = +15	Slight Increase -1 x 1 = -1	-49
BENEFICIAL USES	Road Sanding	Purchase of In-floodplain Stockpile Area ($2,430/Acre) -1 x 6 = -6	Hydraulic and Truck Transport ($52,400) -3 x 12 = -36	Public Savings on Material Requirement 1 x 12 = +12	No Impact 0	No Impact 0	Sediment Washed From Road, Temporary -1 x 5 =-5	No Impact 0	No Impact 0	No Impact 0	Slight Increase -1 x 1 = -1	-36
MAIN CHANNEL	Main Channel Thalweg	No Impact 0	No Impact 0	No Impact 0	Temporary Downstream Effects -1 x 10 = -10	Downstream Turbidity in Slower Flowing Segment -2 x 15 = -30	No Impact 0	No Impact 0	No Impact 0	No Impact 0	No Impact 0	-40
MAIN CHANNEL	Main Channel Border	No Impact 0	Hydraulic Transport ($31,400) -2 x 12 = -24	No Impact 0	Turbidity and Suspended Solid not Flushed Downstream -2 x 10 = -20	Coverage of Primary Habitat -3 x 15 = -45	No Impact 0	No Impact 0	No Impact 0	No Impact 0	No Impact 0	-89
NON-PRODUCTIVE	Non-Productive Inland	Purchase of Disposal Site Possibly Required ($2,430/Acre) -1 x 6 = -6	Hydraulic and Truck Transport ($52,400) -3 x 12 = -36	No Impact 0	Effluent Into Surrounding Water -2 x 10 = -20	Change in Drainage Pattern and Reduced Productivity -1 x 15 = -15	Reduce Habitat Production -3 x 5 = -15	Possibly Displace Development -1 x 2 = -2	Possibly Disturb Significant Site -2 x 2 = -4	No Impact 0	Slight Increase -1 x 1 = -1	-99
NON-PRODUCTIVE	Non-Productive Shoreline	Purchase of Disposal Site Possibly Required ($2,430/Acre) -1 x 6 = -6	Hydraulic Transport ($31,400) -2 x 12 = -24	No Impact 0	Effluent Into Receiving Water -2 x 10 = -20	Erosion Into Shallow Water -2 x 15 = -30	Prevents Plant Succession -3 x 5 = -15	No Impact 0	Possibly Disturb Significant Site -2 x 2 = -4	Possibly Reduce Opportunities for Boating, Fishing -1 x 5 = -5	Pipeline Potentially Disrupt River Traffic -1 x 1 = -1	-105
NON-PRODUCTIVE	Backwater/ Side Channel	No Impact 0	Hydraulic and Truck Transport ($52,400) -3 x 12 = -36	No Impact 0	Change Elevation and Flow -2 x 10 = -20	Altered Substrate With Temporary Reduced Oxygen and Light -3 x 15 = -45	No Impact 0	No Impact 0	Possibly Disturb Significant Site -2 x 2 = -4	Possibly Reduce Opportunities For Boating, Fishing -1 x 5 = -5	Slight Increase -1 x 1 = -1	-111

[1/] Does not include consideration of legal and administrative constraints.

Table V-29. Dredged Material Disposal Matrix, River Category 3

RIVER CATEGORY 3 BOUNDED BY TERRACES		EXAMPLE MATRIX[1/]										
		PERFORMANCE PARAMETERS										
		ECONOMIC			ENVIRONMENTAL			SOCIAL				
	DISPOSAL METHODS	LAND ACQUISITION COSTS	TRANSPORTATION COSTS	BENEFITS	WATER QUALITY	AQUATIC ECOSYSTEM	TERRESTRIAL ECOSYSTEM	URBAN DEVELOPMENT	ARCHEOLOGICAL/ CULTURAL/HISTORIC/ AESTHETIC	RECREATION RESOURCES	TRAFFIC/NOISE	TOTAL WEIGHTED SCORE
BENEFICIAL USES	Product Manufacture	Purchase Out-of-Flood-plain Stockpile Area ($2,320/Acre) -1 x 6 = -6	Hydraulic and Truck Transport ($48,700) -2 x 12 = -24	Revenue from Sale of Material 1 x 12 = +12	No Impact 0	No Impact 0	No Impact 0	Possibly Induce Development if Significant Increase in Industrial Activity 1 x 2 = +2	No Impact 0	No Impact 0	Slight Increase -1 x 1 = -1	-17
BENEFICIAL USES	Levee Repair	Levees Not Needed For Land Located Above Water Elevation	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
BENEFICIAL USES	Fill Material	No Impact 0	Hydraulic and Truck Transport ($48,700) -2 x 12 = -24	Public Savings on Maintenance Costs 1 x 12 = +12	Effluent Channeled Through Out-of-flood-plain Land -2 x 10 = -20	No Impact 0	No Impact 0	Increase Developable Land Area 1 x 2 = +2	No Impact 0	No Impact 0	Slight Increase -1 x 1 = -1	-31
BENEFICIAL USES	Beach Maintenance	Beaches Not Located on Terraces	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
BENEFICIAL USES	Road Sanding	Purchase Out-of-Flood-plain Stockpile Area ($2,320/Acre) -1 x 6 = -6	Hydraulic and Truck Transport ($48,700) -2 x 12 = -24	Public Savings of Material Requirement 1 x 12 = +12	No Impact 0	No Impact 0	Sediment Washed From Road, Temporary -1 x 5 = -5	No Impact 0	No Impact 0	No Impact 0	Slight Increase -1 x 1 = -1	-24
MAIN CHANNEL	Main Channel Thalweg	No Impact 0	No Impact 0	No Impact 0	Temporary Downstream Effects -1 x 10 = -10	Downstream Turbidity -1 x 15 = -15	No Impact 0	No Impact 0	No Impact 0	No Impact 0	No Impact 0	-25
MAIN CHANNEL	Main Channel Border	No Impact 0	Hydraulic Transport ($28,400) -2 x 12 = -24	No Impact 0	Turbidity and Suspended Solids Not Flushed -2 x 10 = -20	Coverage of Primary Habitat -3 x 15 = -45	No Impact 0	No Impact 0	No Impact 0	No Impact 0	No Impact 0	-89
NON-PRODUCTIVE	Non-Productive Inland	Purchase of Disposal Site Possibly Required -1 x 6 = -6	Hydraulic and Truck Transport ($48,700) -2 x 12 = -24	No Impact 0	Effluent Into Surrounding Water -2 x 10 = -20	Change in Drainage Pattern and Reduced Out-of-floodplain Productivity -1 x 15 = -15	Reduce Habitat Production -3 x 5 = -15	Possibly Displace Development -1 x 2 = -2	Possibly Disturb Significant Site -2 x 2 = -4	No Impact 0	Slight Increase -1 x 1 = -1	-87
NON-PRODUCTIVE	Non-Productive Shoreline	Purchase of Disposal Site Possibly Required -1 x 6 = -6	Hydraulic Transport ($28,400) -2 x 12 = -24	No Impact 0	Effluent Into Receiving Water -1 x 10 = -10	Erosion Into Shallow Water Along Terrace -2 x 15 = -30	Prevents Plant Succession -3 x 5 = -15	No Impact 0	Possibly Disturb Significant Site -2 x 2 = -4	Possibly Reduce Opportunities for Boating, Fishing -1 x 5 = -5	Slight Increase -1 x 1 = -1	-95
NON-PRODUCTIVE	Backwater/ Side Channel	No Impact 0	Hydraulic and Truck Transport ($48,700) -2 x 12 = -24	No Impact 0	Changed Elevation and Flow -2 x 10 = -20	Alter Substrate With Temporary Reduced Oxygen and Light -3 x 15 = -45	No Impact 0	No Impact 0	Possibly Disturb Significant Site -2 x 2 = -4	Possibly Reduce Opportunities For Boating, Fishing -1 x 5 = -5	Slight Increase -1 x 1 = -1	-99

[1/] Does not include consideration of legal and administrative constraints.

Table V-30. Dredged Material Disposal Matrix, River Category 4

RIVER CATEGORY 4 BOUNDED BY TERRACES OUTSIDE OF FLOODPLAINS		EXAMPLE MATRIX[1/]										
		PERFORMANCE PARAMETERS										
		ECONOMIC			ENVIRONMENTAL			SOCIAL				
	DISPOSAL METHODS	LAND ACQUISITION COSTS	TRANSPORTATION COSTS	BENEFITS	WATER QUALITY	AQUATIC ECOSYSTEM	TERRESTRIAL ECOSYSTEM	URBAN DEVELOPMENT	ARCHEOLOGICAL/ CULTURAL/HISTORIC/ AESTHETIC	RECREATION RESOURCES	TRAFFIC/NOISE	TOTAL WEIGHTED SCORE
BENEFICIAL USES	Product Manufacture	Purchase of Available Stockpile Area ($2,400/Acre) -1 x 6 = -6	Hydraulic and Truck Transport ($46,400) -2 x 12 = -24	Revenue from Sale of Material 1 x 12 = +12	No Impact 0	No Impact 0	No Impact 0	Possibly Induce Development if Significant Increase in Economic Activity 1 x 2 = +2	No Impact 0	No Impact 0	Possible Slight Increase -1 x 1 = -1	-17
BENEFICIAL USES	Levee Repair	No Impact 0	Hydraulic Transport ($26,500) -2 x 12 = -24	Public Savings of Maintenance Cost 1 x 12 = +12	Hydraulic Effluent Containing Solids -2 x 10 = -20	Temporary Turbidity and Potential Erosion -2 x 15 = -30	No Impact 0	Development Potential Created by Reduction of Flood Threat 1 x 2 = +2	No Impact 0	No Impact 0	Pipeline Potentially Disrupt River Traffic -1 x 1 = -1	-61
BENEFICIAL USES	Fill Material	No Impact 0	Hydraulic and Truck Transport ($46,400) -2 x 12 = -24	Revenue from Sale of Material 1 x 12 = +12	Effluent Channeled Through Floodplain and/or Terrace -2 x 10 = -20	No Impact 0	No Impact 0	Increase Developable Land Area 1 x 2 = +2	Possible Disturb Significant Site -1 x 2 = -2	No Impact 0	Slight Increase -1 x 1 = -1	-33
BENEFICIAL USES	Beach Maintenance	No Impact - Use Existing Beaches 0	Hydraulic Transport ($26,500) -2 x 12 = -24	Material Savings and Possible Increased Recreational Use 2 x 12 = +24	Effluent Into Receiving Water -2 x 10 = -20	Erosion Into Shallow Water -2 x 15 = -30	Prevents Upland Plant Growth -3 x 5 = -15	No Impact 0	Improvement of Existing Facility 1 x 2 = +2	Create Additional Recreational Opportunities 3 x 5 = +15	Slight Increase -1 x 1 = -1	-49
BENEFICIAL USES	Road Sanding	Purchase Of Available Stockpile Area ($2,400/Acre) -1 x 6 = -6	Hydraulic and Truck Transport ($46,400) -2 x 12 = -24	Public Savings of Material Requirement 1 x 12 = +12	No Impact 0	No Impact 0	Sediment Wash From Road, Temporary -1 x 5 = -5	No Impact 0	No Impact 0	No Impact 0	Slight Increase -1 x 1 = -1	-24
MAIN CHANNEL	Main Channel Thalweg	No Impact 0	No Impact 0	No Impact 0	Temporary Downstream Effects -2 x 10 = -20	Downstream Turbidity in Slower Flowing Segment -2 x 15 = -30	No Impact 0	No Impact 0	No Impact 0	No Impact 0	No Impact 0	-50
MAIN CHANNEL	Main Channel Border	No Impact 0	Hydraulic Transport ($26,500) -2 x 12 = -24	No Impact 0	Turbidity and Suspended Solids Not Flushed Downstream -2 x 10 = -20	Coverage of Primary Habitat -3 x 15 = -45	No Impact 0	No Impact 0	No Impact 0	No Impact 0	No Impact 0	-89
NON-PRODUCTIVE	Non-Productive Inland	Purchase of Disposal Site Possibly Required ($2,400/Acre) -1 x 6 = -6	Hydraulic and Truck Transport ($46,400) -2 x 12 = -24	No Impact 0	Effluent into Surrounding Water -2 x 10 = -20	Change in Drainage and Reduced Productivity -1 x 15 = -15	Reduce Habitat Production -3 x 5 = -15	Possibly Displace Development -1 x 2 = -2	Possibly Disturb Significant Site -2 x 2 = -4	No Impact 0	Slight Increase -1 x 1 = -1	-87
NON-PRODUCTIVE	Non-Productive Shoreline	Purchase of Disposal Site in Floodplain possibly Required -1 x 6 = -6	Hydraulic Transport ($26,500) -2 x 12 = -24	No Impact 0	Effluent Into Receiving Water -1 x 10 = -10	Erosion Into Shallow Water -2 x 15 = -30	Prevents Plant Succession -3 x 5 = -15	No Impact 0	Possibly Disturb Significant Site -2 x 2 = -4	Possibly Reduce Opportunities for Boating, Fishing -1 x 5 = -5	Pipeline Potentially Disrupt River Traffic -1 x 1 = -1	-95
NON-PRODUCTIVE	Backwater/ Side Channel	No Impact 0	Hydraulic and Truck Transport ($46,400) -2 x 12 = -24	No Impact 0	Changed Elevation and Flow; Also Suspended Solids -2 x 10 = -20	Altered Substrate With Temporary Reduced Oxygen and Light -3 x 15 = -45	No Impact 0	No Impact 0	Possibly Disturb Significant Site -2 x 2 = -4	Possibly Reduce Opportunities For Boating, Fishing -1 x 5 = -5	Slight Increase -1 x 1 = -1	-99

[1/] Does not include consideration of legal and administrative constraints.

Computer Inventory and Analysis System

The study of the feasibility of a Computerized Analytical Inventory and Analysis System was designed and conducted in response to Section 101(e)(4) of P.L. 95-502.

It was determined early in the study effort that the Computerized Analytical Inventory and Analysis System described in the Plan of Study is a geobased information system. A geobased information system (GIS) is defined to be:

> A computer assisted system for handling geographically retrieved data. The system is capable of 1) recording geographic data from maps, photographs, and satellite imagery, and related data in textual and tabular formats; 2) maintaining the data in an automated data base management system capable of manipulating the data for analysis and 3) providing output in various formats, including geographically based data, to aid in analysis, evaluation, and documentation of resources management decisions.

STUDY OBJECTIVES

The general objectives of this study were to identify, evaluate, and document geobased information systems which could provide an effective mechanism for the evaluation and analysis of the impacts associated with alternative river resource management proposals.

More specific objectives of this study were to evaluate a system capable of:

- addressing the regional and local impacts of alternative plans and policies produced as a result of the Master Plan,
- providing a computerized information system which can be utilized by federal and state agencies and the Commission staff for interagency analysis of management decisions,
- being used by non-computer oriented individuals after brief training seminars,
- providing a data management and retrieval system for the following types of data: socio-economic (e.g., population, industrial) and ecosystemic (e.g., wildlife habitat), and
- providing the capability to manipulate and display information which would help provide for an efficient and systematic evaluation of alternative management proposals.

GEOBASED INFORMATION SYSTEM CONSIDERATIONS

Four primary areas for consideration were identified as being of major importance in the development of a future geobased information system for the basin. These four areas include: institutional arrangements, system capabilities, system types and uses, and system failures. These major areas of concern and their associated problems are discussed below.

Institutional Arrangements

The problems considered to be the most difficult to solve were those involving institutional considerations. A number of these considerations were identified as having significant impact on the development of a GIS for the River System.

Initial development of a system involves determination of a host agency or organization to assume responsibility for the system. Possible candidates for the host agency include the Upper Mississippi River Basin Commission or its successor, federal agencies such as the Army Corps of Engineers or the U.S. Fish and Wildlife Service. Another possible alternative considered was the development of a network of basin agencies with no centralized host (e.g., a distributed system with individual geobased information systems operated and managed by participating agencies). Also considered was the possibility of using a private contractor, or a combination of one or more participating agencies.

Considerations underlying assignment of management responsibility for the system include the development and initiation of management controls, reporting procedures, and the establishment of project evaluation criteria. These items would be determined subsequent to the identification of host responsibilities and resources necessary to operate and maintain the system. Identified responsibilities include the development of agreements and policies necessary to:

- operate the system,
- ensure confidentiality of data,
- establish user access,
- initiate long-range development,
- acquire, maintain, and utilize data (including data not subject to public disclosure), and
- establish standards for data collection, storage, maintenance, exchange, and formats.

Resource needs to be considered include those necessary for development, operation, and continuation of a system that meets the defined objectives. Identified resource needs should be expressed in terms of manpower needs, time requirements, and dollars.

Identified funding sources considered for the development of a geobased information system include line item funding of the host agency by Congress, user charges or assessments based on products and services provided, available funding-at-large grants, and a combination of the methods mentioned above.

If user charges are to be the source of funding, a determination should be made of the administrative method for establishing and collecting user charges. Possible methods include charging individual users for special uses, charging institutions for their specific uses, or charging institutions by means of a fixed annual rate. Regardless of the method selected, computer service charges should be set by a user or management committee before being reviewed and approved by the host agency.

Questions of ownership of the system, data, and software as well as methods for user access must be addressed. Identified user access options include:

- no direct access by user community,
- access available through host agency staff,
- access available through GIS data center staff,
- direct access available to user community with
  - non-proprietary level data available to all users
  - multiple proprietary levels of data access according to clearance, and
- access through participating basin agencies

The formulation of a GIS management committee is another consideration. The objectives of the management committee would be to assist the host agency in the management of a GIS by proposing changes to existing policies, recommending new policies, and developing long-range plans and strategies. Membership on the management committtee should include at a minimum all participating federal, state, and local governments and private groups, so as to include those actively utilizing the system or having an interest in or desiring to make an ongoing contribution. The primary duties of the user advisory committee would be to survey and assess users and their needs and review and make recommendations to the management committee.

Training considerations are often neglected or overlooked completely during the development and initial operation of a geobased information system. To insure that the selected system is used to its fullest capacity, customized training sessions should be provided for administrators, top and middle management, and members of the user community.

Periodic evaluation of a geobased information system is a primary requirement for an effective ongoing system. Evaluation to assess how well the system is meeting its stated objectives should be required for all major activities, including system development and operation, data collection, and product use and dissemination. Periodic assessment should also be made of new technologies for system improvement and new data needs.

The primary legal consideration regarding the development of a geobased information system pertains to the use of its output. The main objective of any system is to provide assistance in decision-making, not to make decisions. Prospective users of any geobased information system must realize that computers do not make decisions. The law does not recognize computers as decision-makers nor computers as entities capable of making recommendations to decision-makers. These decisions have to be based on recommendations of qualified "experts" using valid data or information within their field of expertise.

System Capabilities

The second area reviewed was system capabilities. Generally, a system is complete if it is capable of data entry, data storage, data manipulation and analysis, and data output. This definition is true whether it is a general system having a range of capabilities or a limited system to accomplish specific objectives.

System Types and Application

The third major area for consideration involves the system types available and their uses. Four major types of systems were identified which can be programmed into a computer:

Policy planning system: to assist managers in conducting, reviewing, and evaluating data to assess alternative policies and management strategies. Its ability to analyze data is frequently based on trend projections.

Resource inventory system: to store and analyze data on natural and manmade resources, using optimal location and allocation capabilities to produce maps of vegetation cover types, land use, soil types, etc.

Impact assessment system: to provide assistance in the preparation of environmental impact assessments for proposed project developments. Key attributes of these systems include the capability to assist in monitoring physical resources and to maintain basic record keeping for key resources.

Regulatory system: to analyze variables important to regulatory actions (e.g., floodplain and shoreline zoning and management). This information, along with land records and property lines, constitutes an information source for regulation activities.

System Failures

During the study of potential alternative approaches for development of a geobased information system, known instances of geobased information systems failure and the reasons for their failure were reviewed. One of the primary reasons for systems failing to meet identified needs (both real and perceived) is the tendency to go with a "grand design" which becomes relatively inflexible rather than with an "incremental design" which is relatively flexible and emphasizes specific problem solving. Systems also fail due to the lack of immediate acceptance. Other system failures have occurred as a result of inadequate allocation of resources in both time and money; failure of system decision-makers, designers, and/or implementors to consider the user community prior to development of the system; using unproven new technology instead of existing technology as the heart of the system; and the failure to anticipate the costs for data collection.

ASSUMPTIONS

During the course of the study effort, several assumptions were made to aid in the development of study findings. These assumptions include the following:

- Data collection and maintenance costs were considered to be subject to extreme variations based upon data precision, complexity, scale or level of detail, volume, and frequency of update. In addition, data collection methodologies and data needs were assumed to be the responsibility of the user community. For these reasons, data collection and maintenance costs were not identified.

- Source funding for the selected system is not specifically addressed, however, funding alternatives include line item funding of a host agency by legislative action, or funding based on user charges for products and services provided.
- Any one of several agencies at the federal, state, local, private, or academic level would be capable of hosting the system.
- User needs and available funding will ultimately determine the level of geographic detail of the system.

OVERVIEW OF ALTERNATIVE APPROACHES

Several alternative approaches were identified during the feasibility study. These alternative approaches were reviewed in terms of various institutional considerations, system capabilities, system types, system failures, and cost factors.

Five major alternatives were developed to provide the broadest possible array of system possibilities. These consist of the following:

- Continue Present Arrangements
- Develop an Information Transfer Service
- Develop a Management Briefing System
- Develop a Distributed Process (Decentralized)
- Establish a Centralized Geographic Information System

Basic information for comparison of the five major alternatives is presented in Table V-31. The following discussion is referenced to that table.

Continue present arrangements: This approach provides for continued Master Plan activities and meets the study objectives. The Minnesota Land Management Information Center or other similar center would be retained for computer services and data storage. Little or no expansion of the data base would occur. The data base would be updated periodically. The estimated annual cost for continuing present arrangements, including contract for services and associated staff costs, is $40,000.

Develop an information transfer service: The information transfer service would provide for identification and transfer of information and technology while evaluating improvements to the system. This approach provides for the continuation of Master Plan data bases under current arrangements. In addition, a geographic information service management committee and an information transfer specialist would aid in the dissemination of information from Master Plan data bases and other nationally available data to participating agencies. The estimated annual cost for this approach would be approximately $105,000 in the first year and $95,000 for succeeding years.

An example of this approach would be the Great Lakes Regional Information Referral Center. The Center provides an extensive library referral service for water resources data and information but has no actual data bases.

Develop a management briefing system: This type of system provides support information to aid resource managers in making decisions. The management briefing system would be centrally located and utilize a staff of two persons. In addition to management briefing, it could also provide the capabilities of an Information Transfer Service. The management briefing system is extremely adaptable to graphic display of information. Estimated annual cost of this approach is $135,000 in the first year and $105,000 for succeeding years.

Develop a distributed process: A distributed process is a decentralized network of individual data bases which

Table V-31. Comparison of Geobased Information Systems

Considerations [1]	Continuation of Present Arrangements	Information Transfer Service	Management Briefing	Distributed Process	Geographic Information System
			(in thousands of 1981 dollars)		
Total Costs (Initial/First Year)	$40 (Contract for Services)	105	135	190	1020
Equipment Costs	0	15	40	50	380
Operation & Maintenance Costs	25	20	5	10	40
Staff Costs	15	70	80	120	500
Software Costs	0	0	10	10	100
Total Costs (Annual/Succeeding Years)	$40	95	105	150	575
Equipment Costs	0	5	10	10	25
Operation & Maintenance Costs	25	20	5	10	40
Staff Costs	15	70	80	120	500
Software Costs	0	0	10	10	10
System User	Field Level	Field Level	Executive Level	Field/Executive	Field/Executive
System Location	Decentralized	No Computer	Central	Distributive	Central
Special Facilities Needed	None	None	Minimal	Yes	Yes
Staff Required	½ Person Year	2	2	3 (Central Location Only)	20
User Training Required	None	None	None	Yes	Yes
System Development Time	None	3 Months	½ - 1 Year	1 - 2 Years	1 - 2 Years
Capabilities					
Data Entry	Yes	No	Limited	Yes	Yes
Data Retrieval	Yes	Yes	Yes	Yes	Yes
Statistical Analysis	Limited	No	Limited	Limited	Yes
Modeling (Non-Spatial)	Limited	No	No	Limited	Yes
Spatial Data Manipulation	Limited	No	Limited	Very Limited	Yes
Interface	Limited	No	Limited	Yes	Yes

[1] Total Cost =

- Equipment Costs = computer equipment, cabling, air conditioning, humidity controls, fire protection, etc.
- Operation and Maintenance Costs = computer supplies (paper, magnetic tape, etc.), electricity, equipment maintenance
- Staff Costs = salaries, benefits, training, etc.
- Software Costs = software acquisition costs, software update agreements, etc.

System Users = State, Federal, and local agencies within the basin. Specific categories of users considered were field level (technical personnel) and executive (policy makers).

System Location = Location(s) of host computer(s)
Centralized = single host computers, multiple locations
Distributed = network of multiple host computers, multiple locations
Decentralized = multiple independent computers, multiple locations

Special Facilities Needed = Special environmental controls, security and fire protection systems, etc.

Staff Required = Number of personnel required.

User Training Required = Training required to access use the system.

System Development Time = Time required for selection, acquisition, and testing.

Capabilities =

- Data Entry = Put data into the system.
- Data Retrieval = Sort, search, and output data.
- Statistical Analysis = Perform standard statistical operations on data.
- Modeling = Simulate, project, and develop scenarios.
- Spatial Data Manipulation = Overlay, measure, compare, and map geographic data.
- Interface = Network with other systems.

utilizes as much as possible the principles of common formats and central indexing. Each data base in the network would be operated and maintained by the agency or group creating it. A geographic management committee could be created to assist in establishing common formats and to assist in addressing other common problems.

The distributed process (decentralized network) approach combines the capabilities of an information transfer service with those of a distributed system of individual data bases within participating agencies. An information transfer specialist or computer specialist would be retained to aid in the dissemination of information. This approach would allow any participating agency access to agreed upon data bases within the system. Annual costs for this approach are estimated at $190,000 in the first year and $150,000 in succeeding years.

Establish a geographic information center: A geographic information center would provide a centralized processing and repository center for geobased information system data bases and information. A center of this type would provide a one-stop facility for the basin area together with centralized management of data collection, classification, and processing efforts. The geographic information center provides for the most complete type of system available. A host agency would continue to contract for computer services from off-site computer hardware until it could economically justify on-site computer hardware. This system would serve as a major data repository center in the basin. The center's development would be assisted by a management committee established and guided by the host agency. Estimated annual costs would be $1,020,000 during the first year and $575,000 in succeeding years.

An example of this approach is the Minnesota Land Management Information Center, which is a service bureau for all state agencies in Minnesota. It provides computer-based data analysis and graphic display of information for the managers and staffs of Minnesota's state agencies. Agency personnel can obtain completed summary data for planning and analysis of state resources. The Center promotes standardized data collection and storage for all state agencies.

Public Opinions and Conclusions

The Public Opinion Survey Research and the Citizen Review Council Conclusions, taken together with the Comments on the Draft Master Plan, comprise the three public participation products which the Guidelines require the Commission to consider prior to making final decisions on the Master Plan.

PUBLIC OPINIONS ABOUT THE RIVER

In 1980 and again in 1981, a telephone survey was given to the general public and a mail survey sent to special audiences.

The telephone survey was given to a representative sample throughout the UMRS The survey of special audiences consisted of a self-administered mail survey that was sent to local officials and interested groups, and citizens. Attention was paid throughout the resurvey analysis to audience and geographic differences (Figure V-14).

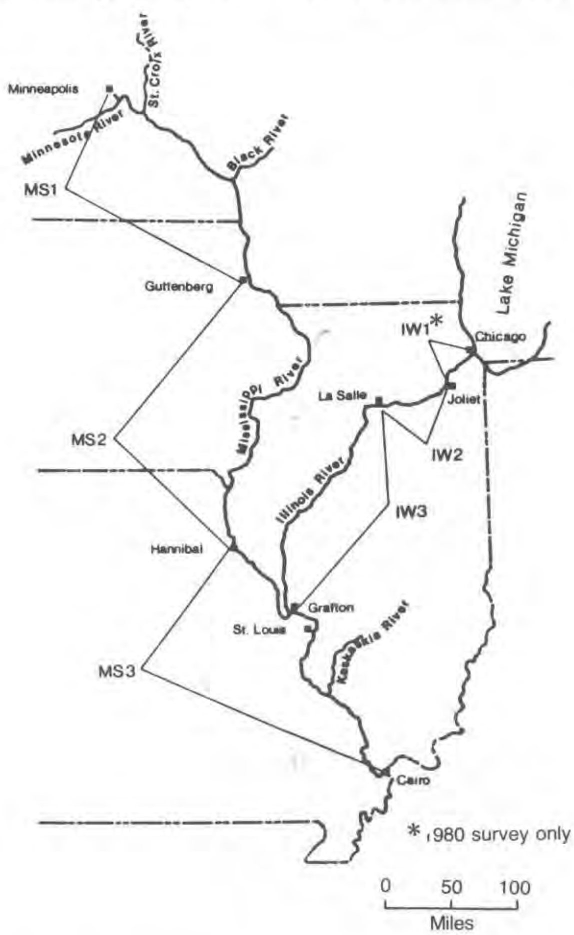


Figure V-14. Survey Research River Segments

Changes in Attitude, 1980-1981

Emphasis Trade-offs

All audiences emphasize environmental concerns over recreational or commercial/industrial activities with substantially more people among the general public choosing to do so in 1981. The general public also showed an increase in its emphasis on recreational activities over commercial/industrial use of the river if there is a conflict. Attitudes of the special audiences remained more stable although the local officials tended to change their emphasis similarly to the general public.

Among the general public , those emphasizing concern for the environment over both recreational and commercial/industrial use of the river system have increased from 44% in 1980 to 54% in 1981 (for a 23% increase in proportion). Geographic differences exist with major changes occurring in all areas except MS1. In particular, the proportion favoring emphasis on environmental concers in MS3 nearly doubled from 24% in 1980 to 47% in 1981 bringing opinions of residents of that area in much closer alignment with other river county areas than in 1980.

Among special audiences, local officials are more likely to stress environmental concerns in 1981 (25% increase from 1980). Geographically, the biggest environmental increases among the unaffiliated citizens occurred in MS3, IW2, and outer river basin areas. Residents of areas closer to the upper reaches of the Mississippi River such as Minneapolis/St. Paul, MS1, and MS2 have decreased their emphasis on the environment.

Recreational emphasis among the general public has increased primarily in MS1 and MS2 and among the special audiences in Chicago and IW3.

Commercial/Industrial emphasis has decreased within the general public primarily in Minneapolis/St. Paul (23% decreased) but has remained relatively consistent in the special audiences with the exception of MS3 and IW3 where over twice the respondents chose to emphasize commercial/ industrial concerns over environmental or recreational in 1981.

Perception of River Conditions

Significant differences were found between how the general public perceives river conditions in 1980 and 1981. Responses varied by issue and geographic region.

The general public continues to agree that commercial/industrial and recreational use of the river is increasing and that the economy is becoming more dependent on the river. They disagree (more strongly and in greater overall numbers than in 1980) that environmental quality is improving and that governmental quality is improving and that governmental regulations are adequate to protect the river environment.

There is a much greater diversity of opinion in 1981 within the various geographic areas and overall disagreement to statements that river environmental quality is improving, and related government regulations are adequate than there was in 1980. However, there is more geographic concensus on commercial/ industrial use increasing and whether the economy of the Upper Midwest is becoming more dependent on the river.

Special Audience Opinions of Issue Importance

Issue Ranking

River management is the issue that is of primary importance to all three audiences, especially to unaffiliated citizens. This contrasts sharply with only approximately a third of the general public which was aware of the issues.

Local officials ascribe less importance to most UMRBC issues than do private decision-makers or unaffiliated citizens. The unaffiliated tend to give the issues more importance than do the other two spcial audiences.

Issues ranked by the percent of the population who consider it important are:

Issue	LO*	PDM	C
Dredge Disposal	3	3	3
River Management	1	1	1
Navigation Effect on Economy	2	2	4
Navigation Effect on Transportation	4	5	5
Navigation Effect on Environment	5	4	2
Navigation Effect on Recreation	7.5	6	6
Navigation Effect on Historical Sites	7.5	7	7
Second Lock at Alton	6	8	8

LO*=Local Officials, PDM=Private Decision-Makers, C=Unaffiliated Citizen

Response to the issue of the "Second Lock and Dam at Alton, Illinois" received widely differing results in different geographic areas. Overall, it is not considered important by as many people as are other issues except in MS3 and St. Louis, near the location of the facility. A high percentage of the respondents (20-24%) are uncertain about how to rate this issue's importance as compared with other issues where the "don't know" rate ranges between 0% and 6%. Among the unaffiliated citizens, the perceived importance of other issues also varies by geographic area.

Issues Most Important to Respondents Personally and Regionally

"Methods of managing the river system" and the "effect of navigation expansion on the environment" are issues selected as being of greatest personal importance to all three audiences, while the "effect of navigation expansion on the economy" is considered to be the most important issue to the region in which respondents live; audience and geographic differences are found.

"Methods of managing the river system" is the most important personal issue to the largest proportion of local officials. The "effects of navigation expansion on the environment" is of primary personal importance to more private decision-makers and unaffiliated citizens (and to many local officials as well) followed by "river management." Other important issues to all three groups are: "the effect of navigation expansion on the economy" and "the second lock at Alton." Unaffiliated citizens frequently mention "dredge disposal" and the "effect of navigation expansion on recreation" as well.

When asked about regional importance of issues, however, all three groups choose "the effect of navigation expansion on the economy" as the most important issue to their region. Unaffiliated citizens give equal importance to the "effect on the environment" and this appears to be an important regional issue to many private decision-makers as well. All three groups continue to place "river management" and the "second lock at Alton" in important positions. Some geographical variation is observed in the shift between issues reported to be personnally important to those considered to be important to the region.

CITIZEN REVIEW COUNCIL CONCLUSIONS

The Public Participation and Information Work Team selected a Citizen Review Council (CRC) from nominations by the UMRBC member agencies and the public. The CRC consisted of 98 persons selected for their knowledge of the river system and of the functional areas in which the UMRBC is interested.

In a modified Delphi process the CRC response panel was asked to:

- define the planning/management issues and rank their importance for each of 17 functional areas;
- consider concepts of governance of the region;
- consider optional arrangements for the management of the river system in terms of ability to solve perceived problems, and feasibility of implementation; and
- identify barriers to the implementation of the options and recommend ways of overcoming these barriers.

This summary describes the major CRC recommendations. Additional details can be found in separate reports.

The following functional areas received the most comments in the first round and were, therefore, considered to be of greatest interest to the CRC:

- commercial navigation
- land use
- dredging and disposal
- locks and dams

The issues rated most important in this round were:

- lack of coordination between levels of government
- lack of sufficient research
- funding capability
- lack of system wide authority
- lack of coordination between government and private interests
- too little public participation

The functional areas within which the CRC found a large number of important management issues were:

- dredging and disposal
- commercial navigation
- water supply
- critical areas
- locks and dams
- energy
- flood management
- rail and truck transportation
- water quality

The pattern formed in the first round generally held through the ensuing three rounds and, therefore, should be taken into serious consideration in developing management alternatives for the river system.

The general conclusion is that the CRC does not believe that great change can be made in the current management system at this time. Coincidentally, the concept of partnership which underlies the current system was greatly favored by the panel. However, they felt that some changes in the current struture were imperative if the structure was to function more effectively.

The two alternative arrangements most favored by the CRC were Existing Systemwide Arrangements with either; 1. Membership Modification, or 2. Agenda Modification. Other options presented to the CRC consisted of reduced or expanded authority options. In all, the panel could select from 14 possible alternative management structures.

Chapter VI. Recommendations for Resource Management

The purpose of the Master Plan study was to develop a "comprehensive master plan for the management of the Upper Mississippi River System." In conjunction with this broad-based mandate, there was a directive to study issues of particular national concern including navigation carrying capacity, environmental impacts of navigation including mitigation measures, dredged material disposal out of the floodplain, and computer inventory and analysis capabilities. Studies were conducted under each of these issue areas as well as the general aspect of institutional arrangements for management. The recommendations presented in this chapter address each of these five aspects of resource management.

Section 101(d) of P.L. 95-502 directed the Commission to utilize "to the fullest extent possible the resources and results of the Upper Mississippi River resources management (GREAT) study ... and other ongoing or past studies." Throughout the course of the studies conducted as part of the Master Plan effort it was apparent that the directives in the specific studies mandated in Section 101(e) do not cover the broad range of resource problems and issues in the Upper Mississippi River System. Specific programs are recommended in response to those needs and problems which the Commission was directed to study and to which considerable analysis was devoted. However, there are additional needs which the Commission feels warrant mention and necessitate action.

Recommendations were formulated based on the individual study components as well as the inherent interrelationships of study findings. This series of recommendations provides a balanced comprehensive plan for the management of the System which recognizes its importance as an economic, environmental, and recreation resource.

Recommendation Strategy

In the formulation of recommendations, the Commission recognized three factors that serve as a basis from which a sound Master Plan must build. These three factors provide the foundation of the recommendations and resulted in the strategy suggested for future management.

- <u>The Upper Mississippi River System is a multi-purpose system with two Congressional mandates.</u> It is recognized both by UMRS resource managers and within the national decision-making arena that the Upper Mississippi River System is a nationally significant ecosystem and a nationally significant commercial navigation system. As a result of separate Congressional actions, this system is managed for two specific purposes: commercial navigation and national wildlife refuges. In addition to these two specific purposes, the UMRS provides a diverse array of opportunities and experiences which accommodate individual interests. The Commission recognizes that the viability of this multi-purpose system requires a commitment to maintain and enhance all aspects.

- <u>Immediate actions are necessary to further define and provide for the near term needs to achieve the multi-purpose objectives.</u> It was recognized in the legislative history of the Master Plan study authorization and reaffirmed by the studies conducted pursuant to that legislation that immediate decisions and actions are necessary. Projected commercial navigation growth beyond 1990 cannot be met by the system with presently authorized projects. Integrity of the existing system including fish, wildlife, and terrestrial and aquatic habitats cannot be properly maintained or enhanced under existing authorization and with current levels of funding.

- <u>Currently available economic and environmental data are not conclusive enough to make sound management deci-</u>

sions for the period beyond 1990-95. Although the studies conducted as part of the Master Plan effort provide substantial information concerning environmental and economic needs and have made great strides in the area of systemic analysis, long-term investment decisions would be tenuous. The combination of insufficient baseline data and dynamic economic and environmental conditions precludes long range recommendations at this time and necessitates continued system monitoring and responsive management.

This is especially critical in view of projected system transportation needs beyond 1990. After 1990, decision-makers are expected to be confronted with another major navigation expansion decision. Using the information gained from the implementation of the Commission's recommendations, these decision-makers will be better able to make decisions while including all multi-purpose considerations without expensive study and time delays.

In recognition of all these conditions a recommendation development strategy was pursued to assist Congress and the States of the UMRS in the decision making processes facing them in the immediate future. Maintaining and enhancing navigation, recreation, and fish and wildlife, as well as other UMRS resource use opportunities, is not simply a matter of improving resource conditions for each individual interest, because of the obvious and subtle interrelationships or conflicts each use has with the others. These use conflicts require comprehensive understanding and management so that UMRS resource needs are met within the capability limitations of the system. The resulting recommendations are presented here to provide a sound basis for resource management activities in the UMRS for the near term ten-year period. The recommendations include both special authorization for the near term period and authorization of activities which will provide critical assistance for multi-purpose resource management in perpetuity.

The Commission has not prioritized these recommendations. Collectively the recommendations provide for balanced comprehensive multi-purpose management of the UMRS in the near term as well as aid in long-term decision-making. The Commission recognizes the dual purpose designation which Congress has bestowed on the Upper Mississippi River System, and strongly urges that the recommendations concerning environmental monitoring and rehabilitation, recreational projects, erosion control and navigation improvements be given equal weight.

SUMMARY OF RECOMMENDATIONS

The Commission recommends:

- That Congress immediately authorize the engineering, design, and construction of a second chamber, 600 feet in length, at Lock and Dam 26.

- That Congress exempt the construction of a second chamber at Lock and Dam 26 from further action under the National Environmental Policy Act of 1969 (P.L. 91-190).

- Immediate action should be taken to reduce erosion rates to tolerable levels to help preserve the integrity of all resource values on the UMRS.

- Congress immediately authorize a Habitat Rehabilitation and Enhancement Program to plan, construct, and evaluate projects to protect, enhance or rehabilitate aquatic and terrestrial habitats lost or threatened as a result of man-induced activities or natural factors.

- Congress immediately authorize implementation of a long-term resource monitoring program.

- Congress immediately authorize implementation of a computerized inventory and analysis system for data storage and retrieval, and for use in the long-term resource monitoring program.

- Congress immediately authorize the implementation of a program of recreational projects and the conduct of an assessment of the economic benefits generated by recreational activities in the UMRS.

- As part of a total navigation improvement plan, steps be undertaken to increase the capacity of specific locks throughout the system by employing certain non-structural measures and making minor structural improvements.

- Traffic movements on the navigation system be monitored to update traffic projections, verify lock capacities, and refine economic justifications and implementation dates for future capacity expansion.

- Continue current disposal practices including those detailed in the GREAT channel maintenance programs in those areas where they have been developed. The Master Plan Dredged Material Disposal Matrix Process may be used as a tool in the site evaluation.

- A program for coordinating with potential users should be developed by the concerned states in coordination with the Corps of Engineers, utilizing and updating existing demand information, as well as the collection of empirical data to facilitate economically feasible productive uses of dredged material.

- The states of the UMRS should establish a cooperative arrangement to maintain coordinative and management activities for water and related land resources within the UMRS.

Master Plan Recommendations

> THAT CONGRESS IMMEDIATELY AUTHORIZE THE ENGINEERING, DESIGN, AND CONSTRUCTION OF A SECOND CHAMBER, 600 FEET IN LENGTH, AT LOCK AND DAM 26.

Alternative navigation improvement scenarios for the Upper Mississippi River System were evaluated with respect to economic costs, transportation rate savings, and environmental considerations. System scenarios were evaluated, some of which included a second chamber at Lock and Dam 26. Two separate methods of capacity expansion evaluation were used and were further subjected to three sensitivity analyses. In all cases the analysis showed an excess of benefits over costs for both a 600 and 1200 foot second chamber. Annual net benefits ranged from $20-$117 million for a 600-foot chamber and from $16-$112 million for a 1200-foot chamber. (Depending on which evaluation method is used.) The net benefits for the 1200-foot lock are limited by constraints at other locks within the system. Physical capacity at Locks and Dam 26 with the new 600-foot chamber is estimated to be 179 million tons while unconstrained traffic in 2040 is projected to reach 172 million tons at Lock 26, given nominal growth rates in the post 2010 period. Thus Locks 26 with the 600 foot second chamber is expected to be sufficient to accommodate the unconstrained projected traffic.

> THAT CONGRESS EXEMPT THE CONSTRUCTION OF A SECOND CHAMBER AT LOCK AND DAM 26 FROM FURTHER ACTION UNDER THE NATIONAL ENVIRONMENTAL POLICY ACT OF 1969 (P.L. 91-190).

This Master Plan recommends Congressional authorization of immediate construction of a second lock chamber at Locks and Dam 26 at Alton, Illinois. This recommendation for action reflects the Commission's intent to comply with perceived Congressional desires to have the Master Plan recommend action <u>now</u> instead of additional studies.

Based on projections used herein, the capacity of the already authorized 1200-foot lock will not be exceeded until 1990-1993. Thus, we have a decade of lead time to anticipate any systemic effects of the additional capacity provided by the second chamber. To propose a project EIS, one must consider lost time waiting for authorization and funding, mobilization time, the need for methodology and data to be widely accepted, the desirability of studying both high-and low-flow periods, and the need to produce a document able to withstand the inevitable legal challenges. If beyond the studies completed to date, an additional EIS able to withstand legal challenges is required, additional economic studies would by that time also be appropriate to re-affirm the economic justification of the project, including optimizing its size. A formal EIS now would be based on the information contained in this Master Plan and would serve to be of procedural value only. Recommendations leading only to further study would indicate the Master Plan process was of questionable value. The Commission recognizes that time does not stand still while we continue to study, hence the recommendations for actions now.

In order to realize the full benefits of the addition of a second chamber at Lock and Dam 26, some additional steps should be taken to increase the ability of the remainder of the system to handle increased demand. These additional measures should enable the system to accommodate traffic through the late 1990's, at which time other locks may become constraining. Additional chambers at locks other than Lock 26 may be justified at such a future time.

IMMEDIATE ACTION SHOULD BE TAKEN TO REDUCE EROSION RATES TO TOLERABLE LEVELS TO HELP PRESERVE THE INTEGRITY OF ALL RESOURCE VALUES ON THE UMRS.

The most pervasive and damaging problem for the Upper Mississippi River System as a diverse, vital natural ecosystem is excessive sedimentation from upland and streambank erosion in the watershed. Eroded material settles in the river backwaters, sloughs, and marshes. The natural erosion process has been intensified by agricultural practices and other land surface modifications; the riverine sedimentation process has been intensified by the placement of navigation system locks and dams and wing dikes in the river corridor. Thus, a total approach to river management, as called for in the Master Plan legislation, must extend into the upland areas adjacent to the river corridors.

While programs to significantly reduce the serious environmental impacts of this accelerated erosion and sedimentation in the UMRS have been recommended in earlier studies, e.g., the GREAT and Upper Mississippi River Main Stem Level B studies, the problem is so fundamental to the overall health and character of the rivers that it must be identified and dealt with in the context of the other major recommended actions in this plan for multi-purpose river management and uses.

The GREAT sediment rate studies performed in the upper reaches of the Mississippi River indicate that the life expectancy of many of the large river pools created by the navigation dams is very short. It is expected that unless upland soil conservation practices are greatly intensified and expanded beginning immediately, major segments of the rich, diverse, accessible fish and wildlife habitats, including national refuges, and recreation areas will become shallow marshes, mudflats, or even dry land within only 50 to 250 years. Streambank and tributary bedload control may also help reduce navigation channel maintenance dredging requirements. The relationship between dredging and sediment inputs is difficult to determine and correlation can be overshadowed by other factors.

In addition to the well-known benefits of retaining irreplaceable topsoil for food and fiber production and prolonging the life of the UMRS as a multipurpose river system, the reduction in sedimentation proposed by this plan will have a positive effect on water quality, floodplain management, energy fuel consumption by farmers who convert to conservation tillage farming, and highly-regarded scenic areas. GREAT I and II studies include detailed recommendations which are incorporated herein concerning implementation of pilot watershed projects, tributary stream sediment monitoring and bank erosion control measures, and expansion of existing soil conservation programs to reduce soil loss and sedimentation by one-third in the critical sediment source areas in each river segment (18.5 million acres in GREAT I and II segments). Ongoing programs in GREAT III, Illinois, and Kaskaskia River drainage areas should be accelerated as necessary to reduce erosion in critical sediment source areas.

CONGRESS IMMEDIATELY AUTHORIZE A HABITAT REHABILITATION AND ENHANCEMENT PROGRAM TO PLAN, CONSTRUCT, AND EVALUATE PROJECTS TO PROTECT, ENHANCE, OR REHABILITATE AQUATIC AND TERRESTRIAL HABITATS LOST OR THREATENED AS A RESULT OF MAN-INDUCED ACTIVITIES OR NATURAL FACTORS.

Existing data and studies completed under the Master Plan conclude that the natural environment of the UMRS is degrading at a rapid rate as a result of a combination of man-induced and natural forces, including past and existing operation and maintenance activities of the navigation system. These studies have further concluded that the degradation of the system is being hastened by the effects of commercial navigation.

In order to provide for the reasonable development and use of the system for commercial navigation without destroying the valuable environment which is unique to the system, a program of environmental protection and preservation should be immediately undertaken.

The Habitat Rehabilitation and Enhancement Program would consist of numerous enhancement efforts aimed at the implementation of techniques to preserve, protect, and restore habitat that is deteriorating due to natural and man-induced activities. The enhancement effort would extend for a ten-year period in order to adequately evaluate and understand the effectiveness of techniques and measures being applied to protect, enhance, or rehabilitate habitat. In addition to direct protection and enhancement of habitat, the results of the effort will also provide a better understanding of the various impacts on habitat, both natural and man-induced.

In addition to direct protection and enhancement of habitat, the results of the effort will provide a better understanding of the various natural and man-induced effects on habitat integrity. This knowledge will be useful in addressing future UMRS multi-purpose management decisions.

The Habitat Rehabilitation and Enhancement Program would consist of three basic program elements: planning, construction or non-structural equivalent, and evaluation.

Planning - The Upper Mississippi River System is extremely diverse in terms of habitat type, susceptibility to impact, and type of enhancement technique applicable. Therefore, separate plans are recommended for the following reaches:

- Pools 1-10 and navigable tributaries
- Pools 11-19
- Pools 20-27
- Open River above Cairo
- Illinois River
- Kaskaskia River

Rehabilitation and enhancement plans for each reach would identify refuge lands, natural areas, and critical habitat. In addition, areas would be identified where physical and biological impacts are occurring or are likely to occur including specific problem areas identified in the GREAT studies.

Plans will then locate, describe, and prioritize enhancement features (structural and non-structural) for implementation for each river reach. A primary source of this information would be the Mitigation and Enhancement Handbook.

This strategy of combining and relating baseline resource data, impact relationships, and enhancement techniques was initiated in the Master Plan studies. A sample rehabilitation and enhancement plan was prepared for the Weaver Bottoms area in Pool 5 of the upper river. Similar plans for each river reach would be developed and specific sites chosen within each reach to initiate the plan by instituting pilot projects.

The last step in the planning effort would be to develop detailed schedules and budgets for the implementation of each rehabilitation and enhancement plan in accordance with the established priorities.

Construction or Non-Structural Equivalent - It is recommended that a phased implementation of the habitat rehabilitation and enhancement plans be followed. Construction or non-structural equivalent activity would follow the priorities, schedule, and budget outlined in each of the Habitat Rehabilitation and Enhancement Plans prepared in the planning phase and would be further refined based on the evaluation of the pilot projects. Examples of potential rehabilitation and enhancement techniques include:

Backwater/Side Channels/Tributaries
- provide upland erosion control
- provide bank stabilization
- provide flow defectors
- realignment of navigation channel
- improve delineation of channel limits
- speed and timing restrictions near side channel openings
- install water control structures
- open side channels by dredging
- notch wing dikes or closing structures

Bank Erosion (Main channel, main channel border and tributaries)
- provide bank stabilization
- navigation channel alignment
- artificial island creation
- improve dredging practices
- speed and timing restrictions in narrow channels, tight turns

Water Quality
- reduce non-point discharges of hazardous or toxic material
- improved land treatment to reduce turbidity
- improve sediment flushing in the system so toxics do not persist

Fish and Wildlife
- manage pool level fluctuations

Evaluation - The Habitat Rehabilitation and Enhancement Program should be monitored and evaluated on a continuous basis. This will serve to:

(1) continuously monitor and evaluate impacts from natural and man-induced causes on habitat, and

(2) describe and analyze the effectiveness of various enhancement features in preserving, protecting, and restoring habitat areas.

As a result of the evaluation phase individual enhancement measures can be further refined to better accomplish their enhancement objective. Future enhancement activities will be designed based on the results of these evaluations. In addition, the evaluation phase will identify proven techniques that may be implemented to mitigate any adverse impacts of increased navigation in the system in the short-term as well as for evaluating any long-term navigation improvement considerations and thus provide a basis for future updates of the Mitigation and Enhancement Handbook.

CONGRESS IMMEDIATELY AUTHORIZE IMPLEMENTATION OF A LONG-TERM RESOURCE MONITORING PROGRAM.

In addition to immediate implementation of projects to rehabilitate and enhance habitat areas, the evaluation phase of those projects and the ability to understand complex and dynamic system relationships depends on continued monitoring. A long-term resource monitoring program (LTRM) is needed to enable decision-makers to measure ecological impacts attributable to a combination of natural and man-induced forces. Included in that program are specific actions to further our understanding of the physical, chemical, and biological relationships in the system. The program would improve the understanding of future multi-purpose management needs and help determine equitable management actions.

Data have been collected over the years on many aspects of the environment of the UMRS. Differences in sampling methods, assessment instruments and analysis have made systemwide comparisons difficult. The implementation of this recommendation would provide a consistent, standardized resource monitoring program.

The Master Plan studies have identified the environmental variables to be monitored with respect to fish and wildlife, water quality, wilderness, and public recreational opportunities of the UMRS. Such variables include but are not limited to:

- Land use changes with respect to agriculture, commercial, industrial, urban, forest, transportation, and flood control.
- Habitat changes for aquatic and terrestrial organisms due to natural forces and man's actions.
- Species composition and relationships with habitat types.
- Rates, sources, and causes of sedimentation, sediment deposition, and resuspension.
- Recreational uses including temporal and spatial variations.

It is anticipated that a period of five years will be required to fully implement the LTRM program. Once fully in operation the LTRM could be an integral part of the management of the UMRS. The success of the Long-Term Resource Monitoring Program depends on the development of a computerized analytical inventory and analysis system for data storage, retrieval, and comparison.

CONGRESS IMMEDIATELY AUTHORIZE IMPLEMENTATION OF A COMPUTERIZED INVENTORY AND ANALYSIS SYSTEM FOR DATA STORAGE AND RETRIEVAL, AND FOR USE IN THE LONG-TERM RESOURCE MONITORING PROGRAM.

Alternative levels of computerized information systems were evaluated in the context of UMRS systemic management needs as identified by all components of the Master Plan. The needs for centralized, consistent, comprehensive, and current data identified in the navigation, natural resource and recreation recommendations is recognized as critical for future multi-purpose resource management decisions in the UMRS.

The Commission recognized that a fully operational centralized data repository and processing center requires a sequencial development of the major components of the system. The Computerized Inventory and Analysis System should be developed according to the following steps, and be operational by 1987:

1) Continue utilization of the Minnesota Land Mangement

Information Center or similar system to maintain and update information gathered during the Master Plan process.

2) Develop an information transfer service to provide for identification and transfer of information and technology while evaluating and improving the system. This phase should provide full service in the storage and distribution of data being developed and analyzed in the programs outlined in both the environmental and transportation recommendations.

3) Develop a management briefing system to provide support information to resource management entities of the UMRS.

4) Establish a geographic information center to serve as a centralized processing and repository center for systemwide information. All data from the distribution process network would be centralized for utilization by all participating entities.

A Geobased Information System (GIS) would provide an effective mechanism for the evaluation and analysis of the impacts associated with alternative multi-purpose river resource management proposals. Such a system is an essential component of a Long-Term Resource Monitoring Program. It would enhance the effectiveness of such a monitoring program because it would provide the capability of entry and retrieval of data, statistical analysis, modeling, spatial data manipulation, and interface with other systems.

CONGRESS IMMEDIATELY AUTHORIZE THE IMPLEMENTATION OF A PROGRAM OF RECREATIONAL PROJECTS AND THE CONDUCT OF AN ASSESSMENT OF THE ECONOMIC BENEFITS GENERATED BY RECREATIONAL ACTIVITIES IN THE UMRS.

GREAT studies and SCORP (State Comprehensive Outdoor Recreation Plan) programs have identified the need for the development of river-oriented recreation projects to meet growing demands. In addition, the Corps of Engineers and the U.S. Fish and Wildlife Service are coordinating their efforts to develop recreation resource management plans for Federally-owned lands in the UMRS. The Commission recommends that recreational development projects be implemented at Federal expense on a priority basis as determined by the institutional arrangement recommended in the Master Plan. Funding should be provided through this program only for those projects not funded from other sources. Selection of projects should be based upon coordination with State and Federal agencies under whose management the program depends.

Although recreational use has been inventoried on portions of the UMRS by various studies including GREAT, the long-term resource monitoring program would complete and continuously update these inventories on a systemwide basis. In addition, preliminary estimates have been made which suggest that recreational activities and commercial fishing and trapping contribute substantially to the economic health of the region. However, the specific economic value of this resource has never been fully understood. Recreation on the UMRS supports hundreds of marinas, restaurants, sporting goods stores, motels, etc. The recreation industry and investments are a vital part of the economy of many local communities. However, the ramifications of fluctuations in the recreation industry on the local, regional, and national economy are not well understood. In addition, the value of the natural resources (wildlife habitat, beaches, and scenery) to the recreation industry and thus the economy is not fully understood. Therefore, an assessment of the economic aspects of recreational activity and resources should be undertaken. Data obtained should be provided as input to the Long-Term Resource Monitoring Program.

AS PART OF A TOTAL NAVIGATION IMPROVEMENT PLAN, STEPS BE UNDERTAKEN TO INCREASE THE CAPACITY OF SPECIFIC LOCKS THROUGHOUT THE SYSTEM BY EMPLOYING CERTAIN NON-STRUCTURAL MEASURES AND MAKING MINOR STRUCTURAL IMPROVEMENTS.

In order to realize the full benefits of the addition of a second chamber at Lock and Dam 26, some additional steps should be taken to increase the ability of the remainder of the system to handle increased demand. These additional measures should enable the system to accommodate traffic through the late 1990's, at which time other locks may become constraining. Additional chambers at locks other than Lock 26 may be justified at such a future time.

Table VI -1 displays the lock-by-lock non-structural and minor structural improvements that are to be considered as part of the navigation improvement plan. The dates in parentheses indicate the estimated time at which either kevels or switchboats/helper boats would come on line. The most environmentally acceptable, cost-effective, and efficient measures at the discretion of the Chief of Engineers should be implemented.

Table VI-1. Recommended Navigation Improvement Plan[1]

Lock 1	
Lock 2	
Lock 3	
Lock 4	
Lock 5	
Lock 5A	Auxiliary discharge outlet
Lock 6	Upper mooring cells
Lock 7	Upper mooring cells
Lock 8	Angle upper guard wall
Lock 9	Upper and lower mooring cells
Lock 10	
Lock 11	
Lock 12	
Lock 13	
Lock 14	
Lock 15	Lower mooring cells, auxiliary discharge outlet
Lock 16	Extension of upper guidewall, kevels/switchboats/helper boats (1990-95)
Lock 17	Kevels/switchboats/helper boats (1990-95)
Lock 18	Kevels/switchboats/helper boats (1990-95)
Lock 19	Correct filling valve
Lock 20	Lock staffing night shift, kevels/switchboats/helper boats (1990)
Lock 21	Lock staffing night shift, kevels/switchboats/helper boats (1990)
Lock 22	Lock staffing night shift, kevels/switchboats/helper boats (1990)
Lock 24	Lock staffing night shift, kevels/switchboats/helper boats (1990)
Lock 25	Auxiliary discharge outlet, lock staffing night shift, kevels/switchboats/helper boats (1990)
Lock 26	(600 foot second chamber as recommend)
Lock 27	
Lockport	Auxiliary discharge outlet, trash racks
Brandon Road	Auxiliary discharge outlet, trash racks, relieve air entrainment in culverts
Dresden Island	Relieve air entrainment in culverts, kevels/switchboats/helper boats (1990-98)
Marseilles	Widen upper canal, auxiliary discharge outlet, relieve air entrainment, trash racks, kevels/switchboats/helper boats (1990)
Starved Rock	Kevels/switchboats/helper boats (1990)
Peoria	Kevels/switchboats/helper boats (1990-93)
La Grange	

1/ N-up/N-down Lockage Policy at all Locks as appropriate

TRAFFIC MOVEMENTS ON THE NAVIGATION SYSTEM BE MONITORED TO UPDATE TRAFFIC PROJECTIONS, VERIFY LOCK CAPACITIES, AND REFINE ECONOMIC JUSTIFICATIONS AND IMPLEMENTATION DATES FOR FUTURE CAPACITY EXPANSION.

The economic evaluations and modeling activities undertaken in the navigation studies were based on a system approach to capacity analysis. Such an approach is particularly sensitive to traffic projections, lock capacity estimates, tow sizes, and rate data.

The ability to maintain accurate traffic, rate, and system simulation data is important for two reasons. The set of structural and non-structural measures recommended by lock (Table VI-1) provides a framework for navigation improvements in the near term. The choice between kevel systems and switchboats or helper boats at certain sites in the system would need to be made at some future time. Such a decision should be based on an ongoing evaluation of system needs, site applicability, and future investment strategies. It is recognized that appropriate timing and sequencing of such improvements depends on an accurate systems assessment.

In addition, it is recognized that prior to the year 2000 decisions regarding future capacity expansion will be necessary. Although the economic evaluations conducted as part of the Master Plan indicate that in the future, improvements may be warranted at as many as twelve additional locks, continued monitoring is necessary to refine the evaluation. Accurate timing, sequencing, and sizing of potential future improvements is critical for sound system planning. Economic justification of future capacity expansion depends on the ability to accurately forecast future conditions and simulate system operations.

CONTINUE CURRENT DISPOSAL PRACTICES INCLUDING THOSE DETAILED IN THE GREAT CHANNEL MAINTENANCE PROGRAMS IN THOSE AREAS WHERE THEY HAVE BEEN DEVELOPED. THE MASTER PLAN DREDGED MATERIAL DISPOSAL MATRIX PROCESS MAY BE USED AS A TOOL IN THE SITE EVALUATION.

The results of the dredged material disposal study were evaluated with respect to both environmental and economic costs and benefits. The results were considered in full recognition that each dredging area in the river system has a unique setting in terms of disposal site availability and site characteristics. Based on this evaluation the studies concluded that dredged material disposal out of the floodplain as a general rule is not warranted. Disposal should be evaluated on a site by site basis.

Dredged material disposal requirements have been addressed in the GREAT I and II studies. These results and dredged material disposal requirements in the remaining areas of the UMRS should be enhanced through the use of disposal impacts assessment methodology produced in the Master Plan. In addition, those GREAT recommendations on increasing disposal capability should be included. The Dredged Material Disposal Matrix presented in Chapter V provides a systematic tool for considering economic, environmental, and social parameters related to alternative disposal methods. This tool will provide a common basis to assist participants in making dredged material disposal decisions throughout the UMRS.

In those reaches of the UMRS where GREAT studies have not had the opportunity to evaluate dredged material disposal needs, the Dredged Material Disposal Matrix may be used to select disposal methods. In reaches where GREAT recommendations are available full consideration should be given to them. The Matrix can be used in conjunction with GREAT recommendations to verify and update disposal decisions on a case by case basis.

A PROGRAM FOR COORDINATING WITH POTENTIAL USERS SHOULD BE DEVELOPED BY THE CONCERNED STATES IN COORDINATION WITH THE CORPS OF ENGINEERS, UTILIZING AND UPDATING EXISTING DEMAND INFORMATION, AS WELL AS THE COLLECTION OF EMPIRICAL DATA TO FACILITATE ECONOMICALLY FEASIBLE PRODUCTIVE USES OF DREDGED MATERIAL.

The productive use studies have identified potential users of dredged material if it could be made available by the Corps of Engineers. Information to date indicates that productive use may be the best option in some situations. Additional information might generate productive uses that are feasible under future conditions.

THE STATES OF THE UMRS SHOULD ESTABLISH A COOPERATIVE ARRANGEMENT TO MAINTAIN COORDINATIVE AND MANAGEMENT ACTIVITIES FOR WATER AND RELATED LAND RESOURCES WITHIN THE UMRS.

During the Alternative Institutional Arrangements study several optional arrangements were identified and evaluated. Early evaluation was related to identified system objectives and perceived management needs. This provided a preliminary screening of available alternatives for consideration in the formulation of the Master Plan.

While initial study analysis was oriented toward decision-making for the system, the studies led to the conclusion that certain political decisions could not be made by any regional entity. Therefore, use of existing coordinating authorities is satisfactory.

In developing the recommendations of the Master Plan, extensive consideration was given to the institutional requirements for implementation. Implementation activities were identified for State, Federal, and regional entities. Evaluation of these implementation needs was conducted with respect to existing State, Federal, and regional authorities. As displayed and discussed in the following implementation chapter, agencies to implement are currently in existence.

Each agency when undertaking the implementation of the Master Plan recommendation has the authority to provide activities to coordinate with the States and agencies of the UMRS. Using these capabilities will ensure that the various recommendations will be implemented in such a manner that the economic, environmental, and recreational objectives of the UMRS will be taken into account where appropriate.

It was also recognized that the resource management actions contained in the Master Plan do not constitute all projects and programs which will occur in the UMRS for water and related land resources. In evaluating possible systemic management needs related to these projects a main conclusion was drawn. That is, communication and coordination among States of the UMRS would be beneficial to aid in the future resource management of the system. Those projects or programs affecting two or more States of the system or the entire system would constitute the main agenda for the State coordination body's agenda. Coordination arrangements and joint State positions could be fostered by the States in this arrangement. Once these positions are identified, the coordinative arrangement should, on an annual basis and in coordination with the appropriate lead agency(ies)/states, seek to carry out those projects and programs.

Chapter VII. Implementation

The recommendations presented in Chapter VI of this document constitute the Upper Mississippi River System Master Plan for resource management. In this chapter, the plan is clarified in terms of specific actions required for the implementation of the recommendations. Actions for the implementation of the recommendations are based upon the findings contained in various study elements of the Master Plan. Additional detail has been developed for the specific actions needed for plan implementation. Clarification is provided in terms of timetables for implementation, estimated costs, and a description of the roles of the responsible parties for plan implementation. The ability to implement the recommended actions is dependent upon authority and funding which would be provided through a combination of Congressional action and state funding initiatives. To facilitate the initiation of procedures toward those actions, proposed legislation necessary to carry out the Master Plan is also included in this chapter.

Program Implementation

The actions required for the implementation of Chapter VI recommendations are provided on Table VII-1. These actions are based on the findings, conclusion and recommendations of Master Plan Studies as mandated by PL 95-502. The Commission agreed to accept the UMRS in its present state as the base condition for the purpose of evaluating the users and beneficiaries. It was recognized that sufficient information does not exist to make quantitative judgements as to the benefits and adverse impacts on the system from past activities, or who the respective beneficiaries or responsible parties might be. Therefore, measures to correct past environmental and possible economic losses are considered rehabilitation and should be funded from general revenues. As a result of rehabilitation and monitoring programs the systemic effects of various uses and the effectiveness of mitigative measures should be known. At that time, identified impacts could be mitigated. The cost should be pro-rated based on the degree of impact caused by the users.

The following is a description of the format of Table VII-1. The details of implementation are explained in tabular form.

RESPONSIBILITY

The successful implementation of the Master Plan involves both State and Federal agency activities subsequent to Congressional action on the Plan. In implementing the various components of the Plan there are basically two types of responsibility required. The responsibility to manage the projects, programs, and related budgets is considered to be the "lead" responsibility. Implementing the recommendations successfully also requires coordination, contracted work performance, and program modification of other State and Federal agencies which may not have the lead responsibility. For purposes of describing plan implementation these are referred to as "support" responsibilities. In Table VII-1 both "lead" agencies and "support" agencies are identified for the implementation of each recommended action.

ESTIMATED COSTS

Cost estimates are provided for the various recommended actions as appropriate. These estimates are based on current information available as a result of technical studies conducted through the Master Plan. It is anticipated that affected lead agencies will provide more detailed analysis of budget needs during the regular budget and appropriation process. Because cost considerations fall into categories, they are presented in Table VII-1 in several formats.

For a few actions a total cost for the time frame is provided. This is most appropriate for those actions that are "project oriented". Costs for implementation of a specific measure or construction of a facility can be estimated. In most cases this is a one time cost for implementation.

The bulk of the actions will show specific start up costs for the first few years followed by an estimate of the annual funding requirements. This is most appropriate for the recommended actions that are "programmatic" in nature, that is they call for the implementation of a program to address a problem or issue. These recommended actions recognize that resource management problems and needs of the UMRS are not static. Therefore, these programs will continue to function in the future and will need annual appropriations. Annual costs are provided as a guide for the funding authorizations contained in the proposed legislation. Where there are first cost requirements to initiate the implementation of the Plan in the first year, these costs would be considered in the appropriation process during the same year that plan authorization is considered.

Costs for structural and nonstructural projects will be continually evaluated in the future with respect to changing needs. The costs of this type of plan elements are presented in terms of unit cost. Total costs for these items will be developed in subsequent years in the annual budget process of lead agencies.

TIME FRAMES

The recommendations of the Master Plan all require initiation activities in the first year. Beyond the first year schedules for the various parts of the plan differ due to the nature of the activities. Several of the activities and programs are intended to be permanent programs to satisfy needs which will continue in all future resource management activities and decisions.

On a practical basis the Master Plan has evaluated specific scheduling through an approximate ten year period. Even though each plan element has its own particular schedule the coordination of these schedules is critical. Throughout the next ten years and beyond key decisionmaking points are expected for Congress and the States. The schedules for the Master Plan have been designed to provide the best possible decision information base at any given point in the future. Caution must be exercised in modifying any scheduled Master Plan component as it may reduce the utility of the related economic, environmental, and recreation information at future decision points. The time frame reference for each recommended action appears in Table VII-1. Time requirements for authorization, planning, design, implementation, and evaluation are considered in the schedule.

DESCRIPTION OF ROLES

A general description of the roles of responsible parties is provided. The roles of both the lead agencies and support agencies is described along with a statement concerning needed congressional action.

Lead agencies identified in the Master Plan are for the most part Federal agencies which have existing statutory authority to carry out the necessary provisions of the Plan. Necessary project or program authorization and appropriations required for these agencies to perform their roles is included in the prepared legislation presented at the end of this chapter. Utilization of existing agency authority in the Master Plan reduces time and funding needs which would be related to establishing new special purpose authorities. The lead responsibility approach also streamlines the implementation process by centralizing program budget and management authority for each major program of the Master Plan. It is recognized that each lead agency has the authority to enter agreements with States, Federal agencies, and private entities to transfer funds for the conduct of implementation activities and support functions.

"Support" agencies identified in the Plan include but are not necessarily limited to States and Federal agencies. The performance of this role ranges from maintaining ongoing coordination to the actual conduct of projects through agreements with the lead agency. It is further suggested that each lead agency

Table VII-1. Program Implementation

Recommended Action	Responsibility Lead	Responsibility Support	Estimated Cost[1]	Time Frame	Description of Roles
Provide a second chamber (600' x 110') at Lock and Dam 26	Corps of Engineers (COE)	---	$195,000,000[2]	1982 - 1990	Congressional authorization should be provided to the U.S. Army Corps of Engineers for engineering, design, and construction of such a facility.
Provide measures to increase capacity of specific locks throughout the system:					
• Improve physical performance to reduce delays at Locks 5A, 6, 7, 8, 9, 15, 16, 19, 25, Lockport, Brandon Road Dresden Island, Marseilles	COE	---	$12,386,000	1982 - 1990	Additional Congressional appropriation should be provided to the U.S. Army Corps of Engineers to carryout these measures. Implementation should take place under the Corps existing operation and maintenance authority. The initiation of these measures should be considered as priority items by the Corps in the distribution of the O & M budget in subsequent years.
• N-up/N-down lockage policy where appropriate					
• Increased lock staff at Locks 20-25					
• Traveling Kevels or Switchboats or Helper Boats (chosen as appropriate at Locks 16, 17, 18, 20, 21, 22, 24, 25, Dresden Island, Marseilles, Starved Rock, Peoria)	COE	--- ---	Kevels - $1,304,000 per year per kevel system Switchboat - $2,350,000 per year per lock (2 vessels) Helper Boats - $1,620,000 per year per lock (2 vessels)	1982 - 1998 as appropriate	Kevels - Additional Congressional appropriation should be provided to the U.S. Army Corps of Engineers to carryout these measures. The Corps would be the responsible agency for the actual engineering, design, and construction of the system. Switchboats - the responsibility for the deployment of switchboats will rest either with the Corps or with private industry.
Continue monitoring traffic projections and system capacity.	COE	All UMRS States and U.S. Dept. of Transportation	$50,000/year	starting in 1982	Corps has lead responsibility under existing authorities for the periodic updating of projections used for economic analysis associated with projects. States would participate with the Corps. Roles of individual State would vary. U.S. DOT would also participate.
Habitat Rehabilitation and Enhancement Program					
• Planning - Development of habitat rehabilitation and enhancement plans (Pools 1-10, Pools 11-19, Pools 20-27, Open River, and Illinois River)	U.S. Dept. of the Interior (DOI)	All UMRS States, COE, EPA	$200,000 $300,000 $500,000	Year 1 Year 2 annual Year 3+	Congressional authorization and appropriation for the Habitat Rehabilitation and Enhancement Program should be provided to the U.S. Department of the Interior. The Department of Interior will provide lead agency responsibility for administration of all aspects of the program with close coordination with the UMRCC. Participation of the UMRS States, the Corps of Engineers and EPA would be accomplished through cooperative agreements with Interior. States would be funded by Interior for participation. Primary responsibility of the States will be participating in the planning and evaluation of projects in various river reaches. The Corps would be responsible for engineering and construction of the rehabilitation and enhancement projects, and would have a participating role in the planning and evaluation phases. Funding would be provided to the Corps through agreement with the Department of the Interior.
• Construction or non-structural equivalent	COE	All UMRS States, DOI	$8,000,000 $12,000,000	Year 1 annual Year 2+	
• Evaluation of Habitat Rehabilitation and Enhancement Program	DOI	All UMRS States, COE, EPA	0 $100,000 $500,000	Year 1 Year 2 annual Year 3+	
Provide a long-term resource monitoring program for the Upper Mississippi River System. Implementation steps would include:			$7,680,000 $5,080,000 $4,200,000	Year 1 annual Year 2-9 annual Year 10+	Congressional authorization and appropriation should be provided for a long-term resource monitoring program to the U.S. Department of the Interior. The Department of the Interior will provide lead agency responsibility for all aspects of the program. Participation of the States and other Federal agencies would be provided through cooperative agreements. States would have a role in program set-up, operation, and evaluation of this long-term resource monitoring program. Major participation would also occur in the establishment of field laboratories and collection of field data. Minnesota Land Management Information Center (LMIC) would assist in the computerization of data phase. The Corps would have a support/participant role in the set-up, operation, and evaluation of the program by providing technical assistance. The Corps would also have a role in data collection. EPA would have a role in the water laboratories and collection of quality related aspects of the long-term resource monitoring program.
• Establish administrative arrangements, lab and field data collection stations	DOI	COE, All UMRS States	---	Year 1	
• Establish monitoring locations	DOI	COE, All UMRS States	---	Year 1-2	
• Establish monitoring parameters	DOI	COE, EPA All UMRS States	---	Year 1	
• Conduct monitoring	DOI	COE, All UMRS States	---	annual Year 1+	
• Computerize information	DOI	Minnesota	---	annual Year 3+	
• Evaluation of parameters and/or locations	DOI	COE, EPA, All UMRS States	---	annual Year 3+	
• Establish short-term ecological impact assessment program	DOI	All UMRS States	---	annual Year 1+	
• Evaluation of findings	DOI	All UMRS States	---	annual Year 1+	

[1] Cost for the second lock and other system navigation improvements including the transportation monitoring system are in 1980 dollars. All other costs are 1981 dollars.

[2] The cost estimate is based on an uninterrupted construction schedule. Interest during construction of the second chamber, estimated at $25 million, is not included.

Table VII-1. Continued

Recommended Action	Responsibility Lead	Responsibility Support	Estimated Cost (1981 $)	Time Frame	Description of Roles
Continue current disposal practices including GREAT/ utilize dredged material disposal matrix process	COE	All UMRS States EPA	0	Year 1	The Corps and States currently have established methods and procedures for the identification and evaluation of dredged disposal sites. These roles would continue and the Master Plan matrix would be applied as an evaluation tool.
	COE	All UMRS States	$50,000/yr	annual Year 2+	
Provide a dredged material productive use program utilizing and updating existing demand survey information as well as collecting empirical data to facilitate productive use of dredged material.	COE	All UMRS States	$50,000/yr	annual Year 2+	Congressional appropriation would be needed to fund a program to gather information and facilitate productive uses of dredged material. Funds would be provided to the Corps under its continuing authority for operation and maintenance. Participation of the States would be accomplished through cooperative agreements. The Corps would have lead agency responsibility for providing data for evaluations and facilitating productive uses. States would have a coordinative and advisory role in the productive use program. The details of each State's role will be detailed in respective cooperative agreements between the Corps and States.
Provide a computerized inventory and analysis system for the Upper Mississippi River System. Implementation steps would include:					Congressional authorization and appropriation should be provided for a geo-based information system for the Upper Mississippi River System to the U.S. Department of the Interior. The Department of the Interior will take lead agency responsibility for all aspects of the program. Participation of the States and other Federal agencies would be provided through cooperative agreement with Interior. The States will utilize the Minnesota Land Management Information Center to maintain and update information during the first three years of the effort. Funding would be provided to Minnesota through Interior. Corps and Interior and States would develop an Information Transfer Service to provide for identification and transfer of information and technology while evaluating and improving the system. This phase will provide full service in the storage and distribution of data being developed and analyzed in the program outlined in the environmental and transportation recommendations. The Corps of Engineers Performance Monitoring System and Waterborne Commerce Data Collection System are established and operating and may not necessarily become integrated with the CIA. Corps, States, and Interior would also develop a Management Briefing System to provide support information to resource management entities of the UMRS. Interior would have responsibility for development of a Geographic Information Center to serve as a centralized processing and repository center for systemwide information in year 3. States would participate in an advisory capacity on matters of policy and long-range planning. States would also act in an advisory capacity on technical matters.
• Maintenance of present computerized data storage	DOI	All UMRS States	$ 40,000	Year 1-2	
• Develop Information Transfer Service (ITS)	DOI	All UMRS States, COE	$105,000 $95,000	Year 2 annual Year 3+	
• Develop Management Briefing Service (MBS)	DOI	All UMRS States, COE	$135,000 $105,000	Year 2 annual Year 3+	
• Develop Geo-based Information System (GIS)	DOI	All UMRS States, COE	$1,020,000	Year 3	
• Maintain and Operate ITS, MBS, and GIS	DOI	All UMRS States, COE	$775,000	annual Year 4+	
The states of the UMRS should establish a cooperative arrangement to maintain coordination and management activities for water and related land resources within the UMRS.	All UMRS States	Federal Agencies	---	starting in 1982	States would have the lead role in the establishment of a coordination arrangement. The program activities of such an organization would also be developed and lead by States. States would provide the funding for such an arrangement and may develop requests for funding to implement priority programs. Federal members would participate in the activities of the organization.
Provide a program of recreational projects. Projects will be identified, prioritized, and constructed.	DOI	COE, All UMRS States (cooperative arrangement)	$500,000/yr	annual Year 1+	Appropriations would be provided to Interior. Interior would be responsible for the identification and prioritization of projects. States would be involved in this effort by working through their coordinative arrangement. Funding would be provided by Interior to the state cooperative arrangement organization. Corps' funding would be provided through the Interior. Corps' responsibility would be in the area of project construction.

Table VII-1. Continued

Recommended Action	Responsibility Lead	Support	Estimated Cost (1981 $)	Time Frame	Description of Roles
Conduct an assessment of the economic benefits generated by recreational activities in the UMRS.	DOI	All UMRS States (cooperative arrangement)	$300,000 $300,000 $150,000	Year 4 Year 5 Year 6	The recreation assessment can be implemented through existing arrangements. Funding would be provided to Interior and Corps. States would participate through cooperative arrangement with the State cooperative arrangement organization.
Immediate action to reduce erosion rates to tolerable level.	USDA	All UMRS States	$912,000,000[3/]	Continuing program starting in 1982	USDA should accelerate their programs to provide the needed treatments. State programs also need acceleration. Targeting of present funds and increased funding for critical sediment source areas should be pursued.

3/ Estimated total cost of treating critical sediment source areas. Costs would be born approximately 50 percent government, 50 percent landowner. The governmental share would be funded by both Federal and State cost share program.

in designing and carrying out the management activities consider other governmental and private entities for inclusion in the support roles of implementation.

All roles are described by state or agency. No attempts were made to suggest implementation strategies within individual states or agencies. This is to afford states and agencies the maximum level of flexibility in developing their individual capabilities and priorities for the implementation of Master Plan recommendations.

Proposed Legislative Program and Congressional Responsibility

In order to provide for the phased implementation of Master Plan recommendations, several actions are required including legislation. To initiate and successfully carry out the proposed efforts, specific Federal legislative actions are necessary. Such actions include authorizing activities as well as the appropriation of funds to designated lead agencies.

Congressional action is needed on a legislative package to provide the needed authorizations as described in the implementation tables. A draft bill that provides the needed steps for Congressional authorization is provided here.

A Bill

To provide for the coordinated development and enhancement of the Upper Mississippi River System.

BE IT ENACTED BY THE SENATE AND HOUSE OF REPRESENTATIVES OF THE UNITED STATES IN CONGRESS ASSEMBLED:

Short Title

Sec. 101. (a) The short title of this act shall be the "Upper Mississippi River System Management Act".

Declaration of Policy

Sec. 101 (b) To ensure the coordinated development and enhancement of the Upper Mississippi River System it is hereby declared to be the intent of Congress to recognize that system as a nationally significant ecosystem and a nationally significant commercial navigation system. Congress further recognizes that the system provides a diversity of opportunities and experiences. The system shall be administered and regulated in recognition of its several purposes.

Definitions

Sec. 102. For the purpose of this Act,

(a) The "Upper Mississippi River System" or "system" means those river reaches having commercial navigation channels on the Mississippi River main stem north of Cairo, Illinois, the Minnesota River, Minnesota; Black River, Wisconsin; Saint Croix River, Minnesota and Wisconsin; Illinois River and Waterway, Illinois; and Kaskaskia River, Illinois.

(b) "Master Plan" means the Comprehensive Master Plan for the Management of the Upper Mississippi River System dated January 1, 1982 prepared by the Upper Mississippi River Basin Commission and submitted to Congress pursuant to and in compliance with P.L. 95-502.

UMRS Master Plan

Sec. 103. The Congress hereby approves the Master Plan.

Interstate Agreements

Sec. 104. (a) The consent of the Congress is hereby given to the states of Illinois, Iowa, Minnesota, Missouri, and Wisconsin to enter into agreements, not in conflict with any law of the United States, for cooperative effort and mutual assistance in the comprehensive planning for the use, protection, growth, and development of the Upper Mississippi River System, and to establish such agencies, joint or otherwise, as they may deem desirable for making effective such agreements.

(b) The officials of the Federal Government responsible for management of all or parts of the system are hereby authorized in accordance with their Congressionally established authorities to assist and participate, when requested by the states, in programs or deliberations of any agencies established under this section.

Management Program

Sec. 105. (a) The Secretary of the Army, acting through the Chief of Engineers, is authorized to provide for the engineering, design and construction of a second lock, with the dimensions of one hundred and ten feet by six hundred feet, at locks and dam 26, Mississippi River, Alton, Illinois and Missouri. This project is exempted from further action under the National Environmental Policy Act of 1969 (P.L. 91-190).

(b) There are authorized to be appropriated to the Secretary of the Army such sums as are necessary to carry out the provisions of subsection (a) of this section for fiscal year 1982 and succeeding fiscal years.

Sec. 106. (a) In order to monitor traffic movements on the system for the purpose of verifying lock capacity, updating traffic projections, and refining the economic evaluations and implementation dates for future capacity expansion of the system, the Secretary of the Army, acting in consultation with the Department of Transportation and the states in the system, is authorized to undertake such programs as are appropriate.

(b) There is authorized to be appropriated to the Secretary of the Army for fiscal year 1982 and for each fiscal year through fiscal year 1992 such sums as are necessary to carry out the programs authorized by this section.

Sec. 107. (a) The Secretary of the Interior, acting through the Fish and Wildlife Service, is authorized to undertake a Habitat Rehabilitation and Enhancement Program for natural and recreational resources of the system as identified in the Master Plan, including:

(1) A program for the planning, construction, and evaluation of measures for habitat rehabilitation and enhancement for the benefit of fish and wildlife resources;

(2) Implementation of a long-term resource monitoring program;

(3) Implementation of a computerized inventory and analysis system.

(b) There is authorized to be appropriated to the Secretary of the Interior the sums of $8,200,000 in the first fiscal year following the effective date of this Act and $12,400,000 in the second fiscal year following the effective date of this Act, and $13,000,000 in each of the following fiscal years to carry out the programs authorized in subsection (a)(1).

(c) There is authorized to be appropriated to the Secretary of the Interior the sums of $7,680,000 in the first fiscal year following the effective date of this Act and $5,080,000 in each of the succeeding fiscal year for the long-term resource monitoring program authorized in subsection (a)(2).

(d) There is authorized to be appropriated to the Secretary of the Interior the sums of $40,000 in the first fiscal year following the effective date of this Act; $280,000 in the second fiscal year following the effective date of this Act; $1,220,000 in the third year following the effective date of this Act; and $775,000 in each of the succeeding fiscal years for the development of a computerized inventory and analysis system authorized in subsection (a)(3) of this section.

Sec. 108. (a) The Secretary of the Interior and the Secretary of the Army, working through a cooperative arrangement established by the states for management of the system, are authorized to implement a program of recreational projects for the system and to conduct an assessment of the economic benefits generated by recreational activities in the system.

(b) There is authorized to be appropriated to the Secretary of the Interior the sums of $500,000 in the first fiscal year following the effective date of this Act and for each of the succeeding fiscal years for the program of recreation projects authorized in subsection (a) of this section and $300,000 in the fourth and fifth fiscal years following the effective date of this Act and $150,000 for the sixth fiscal year following the effective date of this Act for the assessment of the economic benefits of recreational activities as authorized in subsection (a) of this section.

Sec. 109. The Secretary of the Interior and the Secretary of the Army are authorized to transfer funds to such federal, state, interstate, or local government agencies or private contractors as it deems necessary to carry out the purposes of this Act.

Chapter VIII. Environmental Impact Summary

The Inland Waterways Authorization Act (Public Law 95-502) directed the Upper Mississippi River Basin Commission to prepare a comprehensive Master Plan for the management of the Upper Mississippi River System in cooperation with appropriate Federal, State, and local officials.

The study, as described in Chapter I, has three major focal points: evaluation of issues relating to navigation and transportation; evaluation of the natural resources of the river as they exist and as they may be affected by future navigation; and evaluation of institutional arrangements. The requirement for environmental evaluation is an integral part of the study and the results are reported in Chapter IV and V. Six of the issues identified in Chapter III are environmentally oriented. Seventeen of the 20 perceived management needs upon which institutional arrangements were evaluated are also environmental issues. The environmental studies section of Chapter V is the central evaluation of the environment, and is followed by sections related to the issues of dredged material disposal impacts and the use of a computer system to manage the system resources.

This study, being done at the direction of Congress, is primarily a proposal for their action and, therefore, the section of the CEQ regulations addressing proposals for legislation (40 CFR 1506.8) is applicable. In this case, the two-step process (draft and final) was utilized; however, the report is transmitted to Congress concurrently with the final release as an EIS. The Master Plan, including this environmental impact summary, functions as an environmental impact statement in compliance with Section 101(2)(c) of the National Environmental Policy Act of 1969, as amended. This integration, as recommended by 40 CFR 1506.4, is not conducive to the use of the standard format; however, all essential information is provided. Subsequent actions taken by Federal, State, or local agencies in the implementation of specific recommendations would normally necessitate a more thorough environmental analysis and separate environmental impact statements when determined necessary by the implementing or sponsoring Federal agency. However, for reasons stated in Chapter VI, the Commission recommends that no action under NEPA 1969 (P.L. 91-190) is required for the second chamber at Lock and Dam 26.

The need for the Master Plan study, which was to resolve management conflicts on the Upper Mississippi River System, is described along with the history of the study in Chapter I. These conflicts centered on the multipurpose use of the river, particularly its dual designation as a Federally maintained commercial waterway and a fish and wildlife refuge. This historic conflict was focused by the proposals to expand the navigation capacity through larger locks at Alton, Illinois, the effects on other modes of transportation, and the environmental effects throughout the system.

While this study was not required to formulate its recommendations within existing legislation, most of the programs were designed to be an extension of ongoing programs, but are given recognition through specific proposed legislation. Chapter VI and VII identify the items for which Congressional authorization is recommended. The successful implementation also depends upon the appropriation process to intitiate most of the actions.

Description of Affected Environment

Chapter II characterizes the UMRS as a multi-purpose water resource. Because of the diverse features over the 1300 miles in the study area, generalization beyond this is difficult. It is more important to realize and understand the diversity of the system when evaluating the environmental effects of proposed actions and alternatives. The system ranges from a designated National Scenic River on the St. Croix to the hearts of three large metropolitan areas: Twin Cities, St. Louis and Chicago. The character varies from almost unspoiled wilderness through sections which have been channelized by man to sections which are entirely man-made.

The average flow of water increases from 7,500 cfs at St. Anthony Falls to 78,000 cfs at L&D 25. The inflow from the Illinois River is 22,000 cfs and the inflow from the Missouri River is 80,000 cfs. The total discharge at Cairo, Illinois is 188,000 cfs. The Illinois River flow includes 3,200 cfs of diverted Lake Michigan Water. While the water quality is generally good and is used by major communities for water supply, there are problems with dissolved oxygen, turbidity, and toxic materials in and below the major metropolitan areas. Several other isolated areas are contaminated with toxic materials. Nonpoint sources contribute to degradation in urban areas. Sediment from rural areas is also significant (up to 6000 tons per square mile or ½ inch of erosion per year).

The biological resources of the river system have changed with the changes in the navigation system. Those species more suited to slack waters have increased on the upper reaches while those adapted to free flowing alluvial streams have decreased. The areas which have been channelized are generally less productive.

The use of the river during prehistoric periods through the present gave impetus to significant, numerous and varied cultural activities of which remnants are found today along the entire system. GREAT II inventoried nearly 4000 historic and over 1000 anthropological sites in pools 11 through 22.

More specific information is summarized in Chapter II and descriptions of pools are described and displayed on maps in Chapter V.

Description of Proposed Action and Alternatives

The proposed action of the Commission is the adoption of this Master Plan and transmittal to the Congress. There is no significant, immediate environmental effect of this process, nor is there any viable alternative. However, since this is a legislative EIS, the content more significantly addresses the recommended proposal for Congressional action.

Chapter VI contains the recommendations adopted by the Commission as part of the Master Plan. Most of these were derived from the studies requested by the Congress in the authorizing law (PL 95-502), but others are derived from and are supported by other studies.

These recommendations include: construction of a second lock (600 foot) at Lock and Dam 26 with an exemption with respect to NEPA; continuing study of the navigation system leading to other measures to increase capacity when warranted; a Habitat Rehabilitation and Enhancement Program; development and operation of a long term resource monitoring program; a computerized inventory and analysis system including a geographic information system; a program of recreational projects and assessment of recreational economics; use of the GREAT recommendations and an evaluation matrix for dredged material disposal; and the implementation of a major program of soil erosion control in the basin. These activities will lead to a definitive program for reducing the transition of the river system to a terrestrial habitat and to determine the mitigation requirements due to the effects of future traffic expansion.

In addition, the Commission recommends that the States establish a coordinating arrangement for continuing management of the system. This can be accomplished within existing authorities and will include cooperative assistance from lead Federal agencies.

Chapter IV describes the process by which the institutional arrangements were analyzed. The three primary options evaluated are the base condition which will exist without any action after the termination of the Commission and two long-term concepts which can evolve from the recommended structure. These are a Federal Interstate compact with issue orientation and a State oriented river basin commission. Other options are presented in supporting documents and the Preliminary Master Plan (January 1, 1981). Alternatives for resource management are presented in the text of Chapter V. Since the recommendations resulted from the studies and their conclusions, and not all studies were oriented to produce options for implementation, the definition of clear-cut options varies.

The no action alternative is generally applicable. However, under previous legislation and P.L. 95-502, the expansion of the navigation system requires mitigation. Therefore, specific legislation would be required if there is to be no mitigation. Likewise, it should be noted that no action, regarding the recommendation of GREAT studies, implies implementation under ongoing programs and funding. While termination is also an option, this is unrealistic.

The navigation studies compared the no action alternative with a 600-foot additional lock at Lock and Dam 26, a 1200-foot lock at Lock and Dam 26, and other measures for increasing navigation capacity. The recommended studies will refine the option of kevels, helper boats or switchboats and relative priorities for application of these measures. Additional lock chambers were studied in Scenario IV.

The environmental alternatives include the concept of an immediate mitigation program (although this could not be defined at this stage of analysis), wilderness designation, more intense resource management programs, and specific recommendations contained in the GREAT I, GREAT II and Main Stem Level B reports. The alternatives for implementing a resource monitoring and data analysis program included no action and various levels of the recommended programs.

As directed in PL 95-502, the policy of mandatory removal of dredged material from the floodplain was studied and found not acceptable. Chapter V evaluates dredged material disposal alternatives in conjunction with the matrix development. The sample matrix contains probable effects of various alternatives which are useful under the varying river characterizations.

Probable Environmental Impacts of the Proposed Actions

The proposed actions are intended to enhance the overall environmental quality in the UMRS, while providing for further development of the navigation system.

The primary impacts of the recommended plan relate to increased traffic. The impacts discussed are similar for each alternative considered, only the magnitude would vary with increased tow traffic. The environmental impacts of specific actions are presented in this report in Chapters IV and V. Additional support is provided by the Environmental Report.

The effects of increases in navigation on the river system present a complex interrelationship of physical, chemical, and biological factors. The increased movement of towboat traffic will have a variety of effects on the hydraulic parameters of the Upper Mississippi River System. Included in these effects are changes in water velocities, and direction of flow. Increases in towboat movement will also cause additional wave forces on the river system. All of these effects are most pronounced in narrower segments of the river channel. These effects contribute to increases in bank erosion, sedimentation, water quality problems, turbidity, and the resuspension of sediment in the river system. Sediment movement to backwaters increases with increased tow passage.

The potential effects of sediment movement by reach are presented in Displays 1-5 in Chapter V which include tables and charts showing the relationship between traffic levels and annual sediment volumes entering backwaters, annual natural erosive forces due to tow induced waves, daily suspended sediment levels, and daily turbidity levels. The number of tows per day range from the number expected for Scenario I to peak number of tows per day which represent a worst condition analysis of Scenario IV.

Changes in the physical and/or chemical composition of the Upper Mississippi River System will cause corresponding changes in the biology of the river system. Littoral vegetation and, to a lesser extent, terrestrial habitat will be lost due to increase in tow traffic as a result of bank erosion. The accretion of sediment along channel border areas and sedimentation of backwaters contributes to the expansion of terrestrial habitat. However, the loss of these valuable aquatic areas is undesirable. The valuable aquatic habitats are composed of main channel border, side channel, and backwater areas. These areas serve as essential breeding, resting, and feeding sites for the majority of the species which utilize the Upper Mississippi River System. Loss of terrestrial habitat may also be associated with navigation-induced riverfront development.

Additional reduction of aquatic plant communities and plankton may occur with increases in towboat movement. Aquatic vegetation and plankton play important roles in the life cycle of many species associated with the river system. Fish populations and diversity will also be affected by increases in towboat traffic. As fish are generally near the top of the food chain, they are affected by changes in the food chain. They are also directly affected by suspended solids and associated turbidity and sedimentation. These direct effects may be divided into those that are the most obvious (lethal) and those that are more subtle (sublethal) but cummulatively may significantly impact whole populations.

Bird populations will be impacted due to increases in navigation. Reductions and changes in feeding areas and food sources may serve to alter population numbers and diversity. Towboats have also been observed to cause hazing of ducks, which increases their energy expenditures during the time when they are preparing for migration.

Cultural resources will be adversely impacted due to increased erosion, as a result of tow traffic, and increased induced development. Increases in tow traffic will also increase competition and encounters with recreational users of the river system.

Additional traffic will result in secondary impacts from the expansion of existing fleeting and harboring areas when present facilities reach capacity levels. New facilities are also expected to be in demand as tow traffic increases. The impacts of expanding existing facilities and/or constructing new ones are primarily site specific and difficult to measure at this time. The recommended plan would serve to alleviate signficant congestion problems in the flow of river traffic at Lock and Dam No. 26, Alton Illinois. This would correspondingly have economic savings associated with it. This action would also serve to enhance the dependability of the Upper Mississippi River navigational system.

The transportation rate savings associated with a 600 foot additional lock at Locks 26 were estimated to be $134.5 million average annual. This is based on a 50-year economic life, October 1980 price levels, a discount rate of 7-5/8 percent, and use of the General Equilibrium Model. In addition, it assumes several non-structural improvements, including helper boats, switchboats, traveling kevels, minor lock improvements, and increased personnel at locks, will be implemented when cost effective. The cost for a new 600 foot lock is estimated at $17.2 million average annual, leaving a net of $117.4 million average annual per year. If these non-structural and minor structural improvements are not made, then the benefits drop from $134.5 million per year to $105.1 million per year. A 1200-foot lock costs $23.7 million per year and saves $135.2 million per year for an excess of $111.5 million per year.

The study identified 16 systemwide objectives. The study developed these from an analysis of agency and interest group objectives. This set of objectives conflicts within itself and therefore specific alternatives are consistent with some but in conflict with others. The recommended alternatives program is designed to continue a balanced program for the system.

P.L. 95-502 directed a specific analysis of the relationship between capacity expansion and national transportation policy. In the last several years, there have been a number of major changes in Federal policy in regard to the railroads and to public investments in the waterways. Regulation of the railroads has been relaxed to the extent that the government is no longer requiring the railroads to maintain unneeded capacity or to underprice some services. Investments in waterway facilities are not projected to divert existing traffic from the railroads but may reduce future use of the railroad's unused capacity. There has been some activity in recovering from waterway users the public costs of maintaining and building the inland waterways. Public Law 95-502 provided a fuel tax on commercial barge operation that will reach ten cents a gallon in 1985. Moreover, the present administration has proposed legislation requiring full cost recovery for the inland waterways. Under these new conditions and those which have been proposed, the special circumstances which might warrant governmental concern over rail impact are significantly diminished.

A viable waterway system will facilitate movement of coal and oil and will thereby enhance implementation of the nation's energy policies. The study did not evaluate savings in energy consumption. The monitoring and data analysis programs will assist in determing effects of present and projected energy facilities.

The impacts associated with the alternatives for disposal of dredged material are related to the amount of available placement capability, funding, and time and manpower expended to analyze the options available for the specific site. The Dredged Material Disposal Study, described in Chapter V, presents options and typical expected effects for the various methods of disposal in four geomorphic categories. While the option of out of floodplain disposal appears to be least detrimental to the riverine environment, the upland effects, in part, offset the benefits. Removal is most beneficial when it allows beneficial use.

The impacts of the management aspects, including the options for coordination, long-term monitoring, and data management, are not expected to have discernable immediate environmental consequences. The specific and indirect effects will be determined as the agencies pursue the programs. A fully funded program, as recommended, will provide for the best long-term management. Lesser programs will result in inadequate monitoring and less effective analysis and management. The implementation of the programs for soil erosion control will have significant environmental benefits. In the main stem, less sediment will be deposited, and fewer nutrients and pesticides will be conveyed to the river ecosystem. The same program will enhance long-term productivity and will reduce turbidity and deposition in tributaries. These effects will be relative to the extent of implementation of the program.

The program of enhanced recreation facilities will lead to improved management of the resources and more enjoyable use of the resources by the public. No action will allow continuing degradation of the resources through the aging processes or through excessive use by boaters and campers. Chapter V provides more detail on the recreational, cultural, and wilderness impact studies.

The proposed recommendations do not include mitigation for the indicated systemic effects of the construction of a second lock or other improvements. Although requested in P.L. 95-502, the study concluded that appropriate mitigation cannot be defined at this time, but instead provided for a program of rehabilitation and enhancement measures. This program will define mitigation measures during the ten year period and subsequent major Congressional actions will need to assess the application of retroactive and future mitigation as described in Chapter VII.

Adverse Environmental Effects Which Cannot be Avoided Should the Proposal be Implemented

The study recommendations are predominantly oriented toward institutional, policy, and management needs along the Main Stem. As such, provision will be made in detailed program development for adequate consideration of all subsequent environmental impacts.

The construction of a second lock will have limited local effects. These are described in the environmental studies section of Chapter V. Increased turbidity during construction and the extended construction disruption are the salient local effects. While the study projects increased systemic effects from the navigation expansion plan, the other recommendations are designed to better understand the relationship and to mitigate the impacts. Likewise, there will be adverse effects from dredged material disposal, but the recommendations will minimize these effects through use of GREAT recommendations and the matrix.

If a daily peak number of tows were to occur, the physical impacts will cause periods of increased turbidity, bank erosion, and accelerated filling of backwater areas such that the fish and wildlife resources of the UMRS will be degraded. The probability of this worst condition scenario occurring is dependent on frequency of daily peak number of tows and the physical characteristics of a reach. In turn the frequency of daily peak number of tows occurring is dependent upon growth in riverborne commerce and structural and non-structural improvements. Based on this report's recommendations, there is a medium probability of the peak impacts occurring in portions of Pools 1 through 13, a high probability in Pools 14 through 19, a very low probability in portions of Pools 20 through 25, a medium probability in Pool 26 and Alton and Illinois pools. No projections could be made for the Middle River and other navigable tributaries.

Recreation enhancement measures may have limited effects during construction and will increase human interaction with the environment.

Relationship Between Short-Term Uses and Long-Term Productivity

The recommended plan is primarily a long-range plan, designed to accommodate the multiple uses of the river system. The major short-term enhancement is the construction of a second lock to alleviate the projected congestion at Lock 26. As a result of other system improvements, including non-structural and minor structural components, the system will be more economically productive and will handle traffic (commercial and recreational) in a safer manner. While this increased traffic will accelerate the trend toward less biological productivity, other recommended measures relating to dredged material placement and soil erosion will enhance long-term productivity. The Habitat Rehabilitation and Enhancement Program will provide for limited short-term benefits and the design of the long-term program of mitigation measures. The recommendations for monitoring and systems analysis will primarily be of benefit in assessing the long-term trends and planning for future actions.

Irreversible and Irretrievable Commitments of Resources

Recommended policies and actions, Chapter VI, are designed to minimize the irretrievable commitments of natural resources. Implementation of the proposed programs and policies is intended to strengthen the ability of Federal, State, and local agencies to deal with long-term planning issues and avoid the irreversible loss of valuable resources. No action would be an irretrievable commitment that resources will be lost. All of the recommendations will involve substantial commitments of money and human resources. Structural project proposals will involve labor and materials associated with construction, operation, and maintenance. A major factor supporting the recommendation for a second lock at this time is the savings in resources through construction as a part of the larger Lock and Dam 26 project.

The planning process identified major objectives and issues (Chapter III), and clearly identified a need for increased efforts to manage the system (Chapter V). An increased awareness of the relationships of navigation and the environment, of sediment sources, and of the location and character of critical areas will more clearly delineate the tradeoffs and choices necessary to avoid the irreversible commitment of resources. The continuing program of analysis, planning, design, and implementation of enhancement and mitigation measures through a coordinative arrangement will retain the economic viability, the recreational amenities, and the ecological productivity of the system.

Master Plan Documentation — Technical Reports and Working Papers

The following pages list technical reports and working papers prepared by Federal and State agencies, private consulting firms, universities and colleges for the Master Plan process. These documents are not Commission approved but provided the necessary information and data for the development of the plan. Not every document has been published for distribution. The technical reports which have been published are listed below and are available through the National Technical Information Service and designated repository libraries in each of the five states. Working papers are listed by chapter.

TECHNICAL REPORT	AUTHOR
A Navigation and Transportation	U.S. Department of Army, Corps of Engineers
B Effects of Navigation Capacity Expansion on Railroads	U.S. Department of Transportation
C National Transportation Policy Relationship to Navigation Capacity Expansion	U.S. Department of Transportation
D Environmental Report	Environmental Studies Work Team
E Mitigation and Enhancement Handbook	U.S. Department of the Interior
F Long-Term Resource Monitoring Vol. I	U.S. Department of the Interior
Long-Term Resource Monitoring Vol. II	U.S. Department of the Interior
G Impacts of Navigation on Recreation, Potential Wilderness, and Cultural Resources	River Recreation Research Consortium
H Immediate Impacts of a Second Lock at Locks and Dam 26	U.S. Department of Army, Corps of Engineers
I Dredged Material Disposal	U.S. Department of Army, Corps of Engineers
J Computerized Analytical Inventory and Analysis Feasibility	U.S. Department of the Interior
K System Objectives	Bather, Ringrose, Wolsfeld, Jarvis, Gardner, Inc.
L Institutional Arrangements for System Management	Roy F. Weston, Inc.
M Evaluation of the Public Participation Program	Harris Consultive Services

CHAPTER III. SYSTEM OBJECTIVES AND ISSUES

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Volume 1: Recreation
Volume 2: Economic
Volume 3: Environmental

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Draft Recreational, Economic, and Environmental System Objectives by Bather-Ringrose-Woldsfeld-Jarvis-Gardner, Inc., October 1980.

Upper Mississippi River Master Plan: Needed Authorities by Bather-Ringrose-Woldsfeld-Jarvis-Gardner, Inc., October 1980.

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"Legislative History of the Master Plan Provision of P.L. 95-502" by Hessian, McKasy, & Soderberg Professional Asssociation, January 1981.

"Review of Reported Litigation Relating to UMRS (1960-1980)" by Hessian, McKasy & Soderberg Professional Association, June 1981.

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"Review of Available Rate/Cost Data" by U.S. Army Corps of Engineers, July 1980.

Navigation Carrying Capacity Analysis by U.S. Army Corps of Engineers, March 1981.
Appendix A: Delay Functions
Appendix B: Specifications for Analysis of PMS Data
Appendix C: Lock Capacity Model Specifications
Appendix D: Organization of PMS Data for Input
Appendix E: LOKSIM2 Sensitivity Tests
Appendix F: Traffic Projections (For Delay Function Estimates)

I-4: Informal Working Data by U.S. Army Corps of Engineers, April 1981.
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Acronyms

BOD	- biochemical oxygen demand
CEQ	- Council on Environmental Quality
CFR	- Code of Federal Regulations
cfs	- cubic feet per second
CIA	- Computerized Inventory and Analysis
COE	- Corps of Engineers
CRC	- Citizen Review Council
DO	- dissolved oxygen
DOI	- Department of the Interior
EIS	- Environmental Impact Statement
EPA	- Environmental Protection Agency
FDA	- Federal Drug Administration
GE	- General Equilibrium
GIS	- Geobased Information System
GREAT	- Great River Environmental Action Team
HN	- Head of Navigation
L/D	- Lock and Dam
LMIC	- Minnesota Land Management Information Center
LTRMP	- Long-Term Resource Monitoring Plan
MBS	- Management Briefing Service
NEPA	- National Environmental Policy Act
O&M	- Operation and Maintenance
PC	- Percent of Capacity
PCB	- polychlorinated biphenyls
P.L.	- Public Law
PMS	- Performance Monitoring System
PPIWT	- Public Participation and Information Work Team
RCV	- River Country Voices
RNA	- Research Natural Area
RR	- Railroad
SCORP	- State Comprehensive Outdoor Recreation Plan
UMRB	- Upper Mississippi River Basin
UMRBC	- Upper Mississippi River Basin Commission
UMRCC	- Upper Mississippi River Conservation Committee
UMRS	- Upper Mississippi River System
U.S.C.	- United States Code

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