GREAT III

Great River Resource Management Study — 14028

MISSISSIPPI RIVER
(Saverton, Missouri to Cairo, Illinois)

Lower Mississippi Valley Division

US Army Corps of Engineers
St. Louis District

FINAL REPORT
SEPTEMBER 1982

DEPARTMENT OF THE ARMY
ST. LOUIS DISTRICT, CORPS OF ENGINEERS
210 TUCKER BOULEVARD, NORTH
ST. LOUIS, MISSOURI 63101

REPLY TO
ATTENTION OF

GREAT RIVER RESOURCE MANAGEMENT STUDY
GREAT III

SYLLABUS

This report addresses a multi-agency, interdisciplinary approach to planning for the management of the Mississippi River and related land resources from Saverton, Missouri to Cairo, Illinois.

It is recommended in the report that:

1. A program to modify, design, and evaluate regulatory works structures to benefit aquatic resources in the unpooled portion of the GREAT III area be initiated;

2. Pre- and post-dredging coordination activities, improved during the GREAT III Study, be continued;

3. The Corps update and monitor its permit system to a level of accuracy so that facilities (including fleeting areas) and their current responsible officer or agent can be identified;

4. The Corps strictly enforce existing regulations (Sections 15, 16, 19, and 20 of the Rivers and Harbors Act of 1899) requiring the owners to remove sunken commercial vessels. Where the owners cannot be located or forced to remove them, specific funding should be sought for removal at Federal expense;

5. Movable bridges be left open for the free passage of tows unless the frequency of train traffic exceeds that of barges and other vessels;

6. An active program of nonstructural and structural maintenance and improvements at all locks, as appropriate, be adopted by the Corps to improve operating efficiency, particularly during peak periods (i.e., Lock and Dam No. 26);

7. Local port authorities and development agencies continue to develop: (1) programs to promote coordinated port expansion, including the initiation of environmental, archaeological, and flood hazard analyses at preferred industrial sites; and (2) funding mechanisms for site improvements;

8. State and Federal regulatory and review agencies seek methods to improve coordination with local entities to insure that valid regulatory concerns are dealt with early in the permit and development processes. Additionally, local development agencies provide detailed information to potential industrial candidates on rules and regulations affecting development in the study area;

9. Local port development agencies develop an inventory of potential fleeting sites and take steps to insure their future availability and acceptability;

10. Local development agencies routinely identify local, state, and Federal rules and regulations which are redundant and submit them to responsible authorities for appropriate action;

11. Erosion control measures in critical upland sediment source areas be installed, and individual source areas be studied to determine the most cost effective measures;

12. Bedload movement in the Mississippi River be studied;

13. Scientific research be directed to develop acceptable methods to predict transport of suspended sediment and associated contaminants;

14. Valuable scenic resources be identified and a program to conserve these resources be developed;

15. An analysis of recreation conflicts with other users, and the applicability and efficiency of current procedures to resolve those conflicts, be conducted;

16. A coordinated program to provide a cleaner river for recreationists (e.g. litter and water quality) be developed;

17. A coordinated program to meet recreational needs identified in the GREAT III Recreation Needs Assessment be developed;

18. Intensive hydraulic and biological investigations of side channels in the GREAT III study area be initiated to determine measures for conserving and improving these productive habitats;

19. A program to coordinate interstate flood plain management regulations and policies recognizing the requirements of river dependent uses be developed;

20. A comprehensive mussel survey to inventory bed locations, species composition, and abundance in the GREAT III reach be conducted;

21. A comprehensive long-term study to monitor the quantity and quality of fish and wildlife habitats be initiated;

22. The GREAT III cultural resource inventory be updated on a regular basis through mapping and computer files using uniform minimal standards;

23. The US Coast Guard and the Corps conduct a joint annual review and analysis of commercial marine accidents to identify problem areas and possible corrective measures;

24. Studies to determine the effects of water level fluctuation in the pooled portion of the river on fish and wildlife habitats be conducted; and

25. The Corps (St. Louis District), as lead agency with assistance from GREAT III participating agencies, establish an interagency coordination process to address river resource management concerns.

District Commander's Conclusions and Recommendation:

The District Commander for the St. Louis District, Corps of Engineers, made the following Conclusions and Recommendation.

Conclusions:

1. The organizational arrangement for the study was established to achieve resource management that results from a cooperative effort of various agencies, organizations, and disciplines. As envisioned by Section 117 (P.L. 94-587), this structure has provided an opportunity to bring together diverse river resource management interests. A willingness to discuss common concerns is desirable in other studies and projects.

2. It was recognized early in the planning process that the quantity and complexity of the perceived resource management problems would prohibit a study of all issues. Given these constraints, the studies that have been completed make significant strides toward the resolutions of these important concerns. However, there still remain a number of concerns that require additional investigation and others that have yet to be addressed.

3. The UMRBC Master Plan recommendations are presently being considered by Congress. These recommendations address many GREAT III study objectives.

4. The costs associated with additional studies and investigations must be developed as they are scoped by the appropriate agencies which may pursue these efforts within new or existing authorities and program priorities.

5. There are few activities contained herein that require Congressional authorization for the Corps of Engineers; however, where Congressional authorization is required by any agency, it is that agency's responsibility to seek that authorization.

Recommendation:

The study be forwarded to Congress for information and serve as a document which sets forth actions that need to be taken to manage the resources of the study area.

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GREAT III

INTRODUCTION

The Great River Resource Management Study was divided into three studies, conducted by separate Corps Districts. The St. Paul, Rock Island, and St. Louis study reaches were named GREAT I, II, and III, respectively. The GREAT I and II implementation reports were completed by the District Commanders. The Board of Engineers for Rivers and Harbors (BERH) and the Office of the Chief of Engineers (OCE) have recommended that the reports be forwarded to Congress for information.

Three circumstances led to early termination of the GREAT III study. The first is that budget constraints have caused extensive program and priority changes. The second is that the GREAT I and GREAT II reports have been completed, and although the teams made numerous recommendations about resource management, it was recognized that most are already within the authorities of existing agencies, and therefore Congressional action was not needed. In GREAT III, it has not been fully determined that recommendations require Congressional authorization. Third, the UMRBC Master Plan was submitted to Congress on 1 January 1982, and it contains 12 recommendations on resource management needs of the Upper Mississippi River System. These recommendations, which are presently being deliberated by Congress, address all but two of the GREAT III study objectives. There are present laws and authorities which encompass those two objectives: to reduce flood damage and to manage cultural resources.

The GREAT III report documents work completed, activities which were suspended, recommendations of the GREAT III study participants, and conclusions and recommendations of the District Commander. Study participants collected and refined resource management data; and there was considerable exchange of information between participants. Coordination, cooperation and a better understanding of the numerous competing interests on the river was a valuable part of the study effort. The report will serve a useful purpose in that the data developed in the study can be utilized through existing river resource management programs. This resource management study alternative is consistent with findings of the Master Plan institutional arrangements study.

BACKGROUND

In past years, organizations and individuals have been concerned about the operation and maintenance of the inland waterway system of the Upper Mississippi River. In 1973, the State of Wisconsin initiated a lawsuit against the Corps' dredging practices in the St. Paul District. This action resulted in an announcement in September 1974 by the North Central Division Engineer of the Corps of Engineers (COE) and the North Central Regional Director of the US Fish and Wildlife Service (FWS) that they planned to establish a partnership team within the North Central Division area. This team would work out a long-range management strategy for the multi-purpose use of the river. This move led to the establishment of a broad-based Federal-state task force. Previously, the former Upper Mississippi River Basin Commission (UMRBC)[1] had established a special Dredged Spoil Disposal Practices Committee to begin laying the groundwork for such a cooperative effort. This committee was composed of delegates representing the five river basin states and five Federal agencies. Thus, what became known as the Great River Environmental Action Team (GREAT) was set up in October 1974 as a working partnership of Federal and state agencies.

The North Central Division (NCD), Corps of Engineers was originally assigned as the lead division for all the GREAT studies and was primarily accountable for the GREAT I and II studies. The GREAT III segment of the study was conducted by the St. Louis District (SLD) which is part of the Lower Mississippi Valley Division (LMVD). Due to the completion of the GREAT I and II studies, the Office of the Chief of Engineers (OCE), in September 1981, reassigned primary responsibility for completion of the GREAT III study to LMVD.

GREAT I covered the reach of the Mississippi River between St. Paul Minneapolis, Minnesota, and Guttenberg, Iowa (St. Paul District). GREAT II extended from Guttenberg to Saverton, Missouri (Rock Island District). GREAT III extended from Saverton, Missouri, to the confluence of the Mississippi with the Ohio River at Cairo, Illinois (St. Louis District), and is referred to as the Great River Resource Management Study. (See FIGURE 1.)

[1] Executive Order 12319, dated 9 September 1981, terminated river basin commissions.

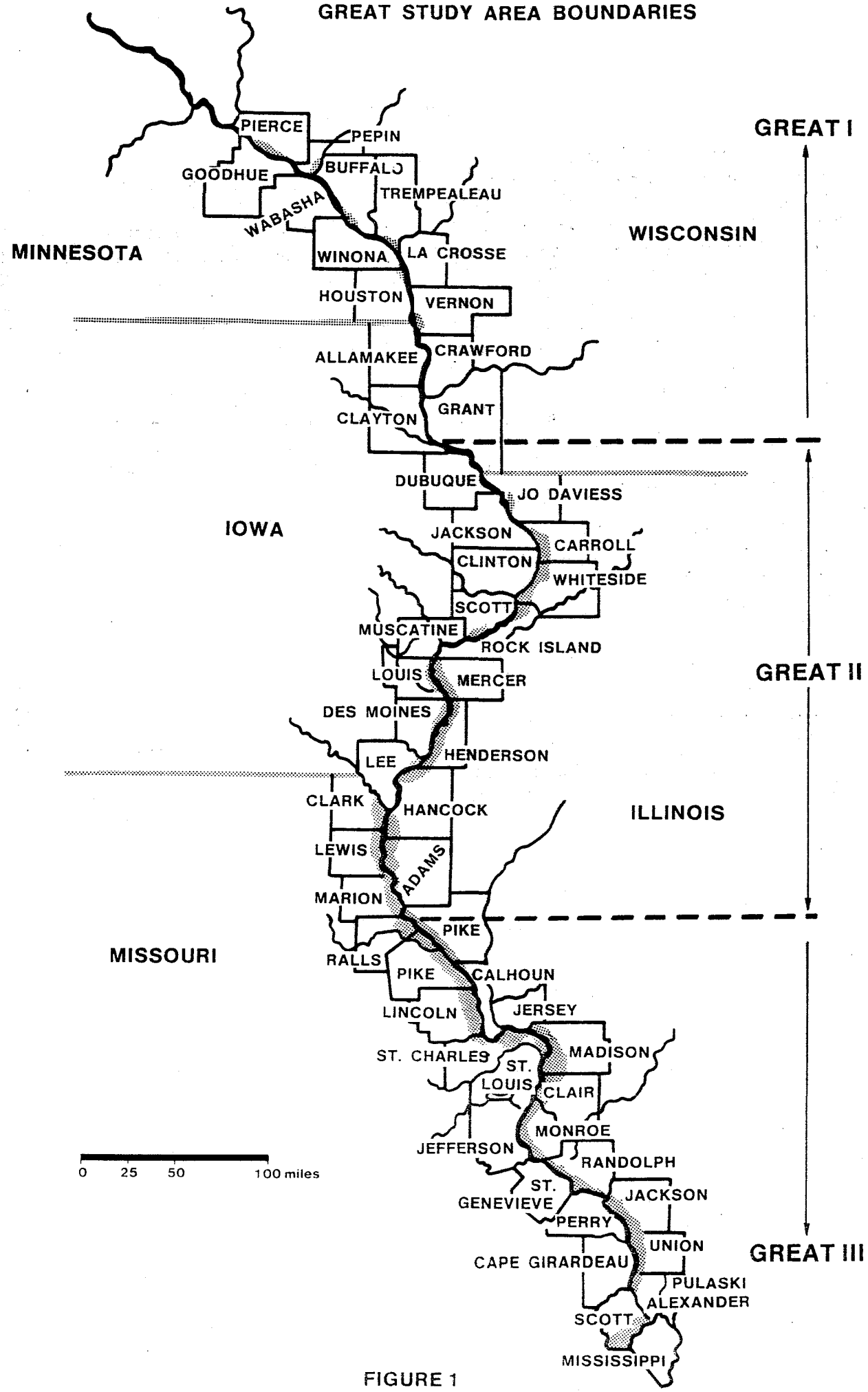

GREAT STUDY AREA BOUNDARIES
GREAT I
GREAT II
GREAT III
MINNESOTA
WISCONSIN
IOWA
ILLINOIS
MISSOURI
PIERCE
PEPIN
BUFFALO
GOODHUE
TREMPEALEAU
WABASHA
WINONA
LA CROSSE
HOUSTON
VERNON
ALLAMAKEE
CRAWFORD
CLAYTON
GRANT
DUBUQUE
JO DAVIESS
JACKSON
CARROLL
CLINTON
WHITESIDE
SCOTT
MUSCATINE
ROCK ISLAND
LOUIS
MERCER
DES MOINES
LEE
HENDERSON
CLARK
HANCOCK
LEWIS
ADAMS
MARION
PIKE
RALLS
PIKE
CALHOUN
LINCOLN
JERSEY
ST. CHARLES
MADISON
ST. LOUIS
CLAIR
MONROE
JEFFERSON
RANDOLPH
ST. GENEVIEVE
JACKSON
PERRY
UNION
CAPE GIRARDEAU
PULASKI
ALEXANDER
SCOTT
MISSISSIPPI
0 25 50 100 miles

FIGURE 1

STUDY AUTHORITY

The GREAT River studies (GREAT I, II, and III) were authorized by Section 117 of the Water Resources Development Act of 1976 (P.L. 94-587, passed on 8 October 1976). The GREAT III segment of the study began in late 1977. Former Senator Gaylord Nelson (Wisconsin), former Representative Alvin Baldus (Wisconsin), and Representative Albert Quie (Minnesota) sponsored the enabling legislation. Section 117 of P.L. 94-587 states that:

> "The Secretary of the Army, acting through the Chief of Engineers, is authorized to investigate and study, in cooperation with interested States and Federal Agencies, through the Upper Mississippi River Basin Commission the development of a river system management plan in the format of the "Great River Study" for the Mississippi River from the mouth of the Ohio River to the head of navigation at Minneapolis, incorporating total river resource requirements including, but not limited to, navigation, the effects of increased barge traffic, fish and wildlife, recreation, watershed management, and water quality at an estimated cost of $9,100,000."

Although the Corps of Engineers had overall responsibility for the study, GREAT III was a cooperative effort of the following state and Federal agencies:

Illinois
- Department of Conservation
- Environmental Protection Agency
- Department of Transportation

Missouri
- Department of Conservation
- Department of Natural Resources
- Highway and Transportation Department

Bi-State Development Agency

US Agencies
- Fish and Wildlife Service
- Soil Conservation Service
- Army Corps of Engineers
- National Park Service
- Environmental Protection Agency
- Coast Guard
- Maritime Administration
- Department of Housing and Urban Development

STUDY PURPOSE

The purpose of this study was to develop a total river system management plan for the water and related land resources of the Mississippi River from Saverton, Missouri (Lock and Dam No. 22) to Cairo, Illinois (the mouth of the Ohio River). This study presents the cooperative efforts of the participating state and Federal agencies, as well as the contributions of other public and private organizations and individuals.

The original focus of the study was:

> To identify conflicts and inadequacies in existing river resource management procedures and to provide decision-makers with improved management procedures and programs. The River Resource Management Plan was to contain policy recommendations for responsible and coordinated environmental, economic, and social uses of the GREAT III reach of the Mississippi River.

Specific functional management objectives were formulated to guide the development of a resource management plan. These were:

- Ensure a safe navigation channel
- Continue movement of commodities by barge to meet transportation needs
- Manage the sediment affecting the river
- Provide recreation opportunities to meet demand
- Protect and provide for aquatic and terrestrial wildlife resources
- Maintain or improve water quality
- Reduce flood damage
- Manage cultural resources
- Provide for industrial and economic development needs

GREAT III STUDY AREA

The GREAT III study area consists of about 300 miles of the Mississippi River, including its flood plain and bluffs, from River Mile (RM) 0.0, the mouth of the Ohio River at Cairo, Illinois, upstream to RM 301.2 at Lock and Dam No. 22 at Saverton, Missouri. (See FIGURE 2.) For operation and maintenance of a 9-foot channel, the river has been divided into two reaches: (1) an open river from RM 0.0 to the low water dam at RM 190.3; and (2) a series of slackwater navigation pools with locks and dams from RM 190.3 to RM 301.2. (See TABLE 1.)

TABLE 1
Locks and Dams

Lock and Dam Number	Location	River Mile above the Mouth of the Ohio River
22	Saverton, Missouri	301.2
24	Clarksville, Missouri	273.4
25	Winfield, Missouri	241.4
26	Alton, Illinois	202.9
Low Water Dam 27	Granite City, Illinois	190.3
Lock 27 (Chain of Rocks Canal)	Granite City, Illinois	185.1

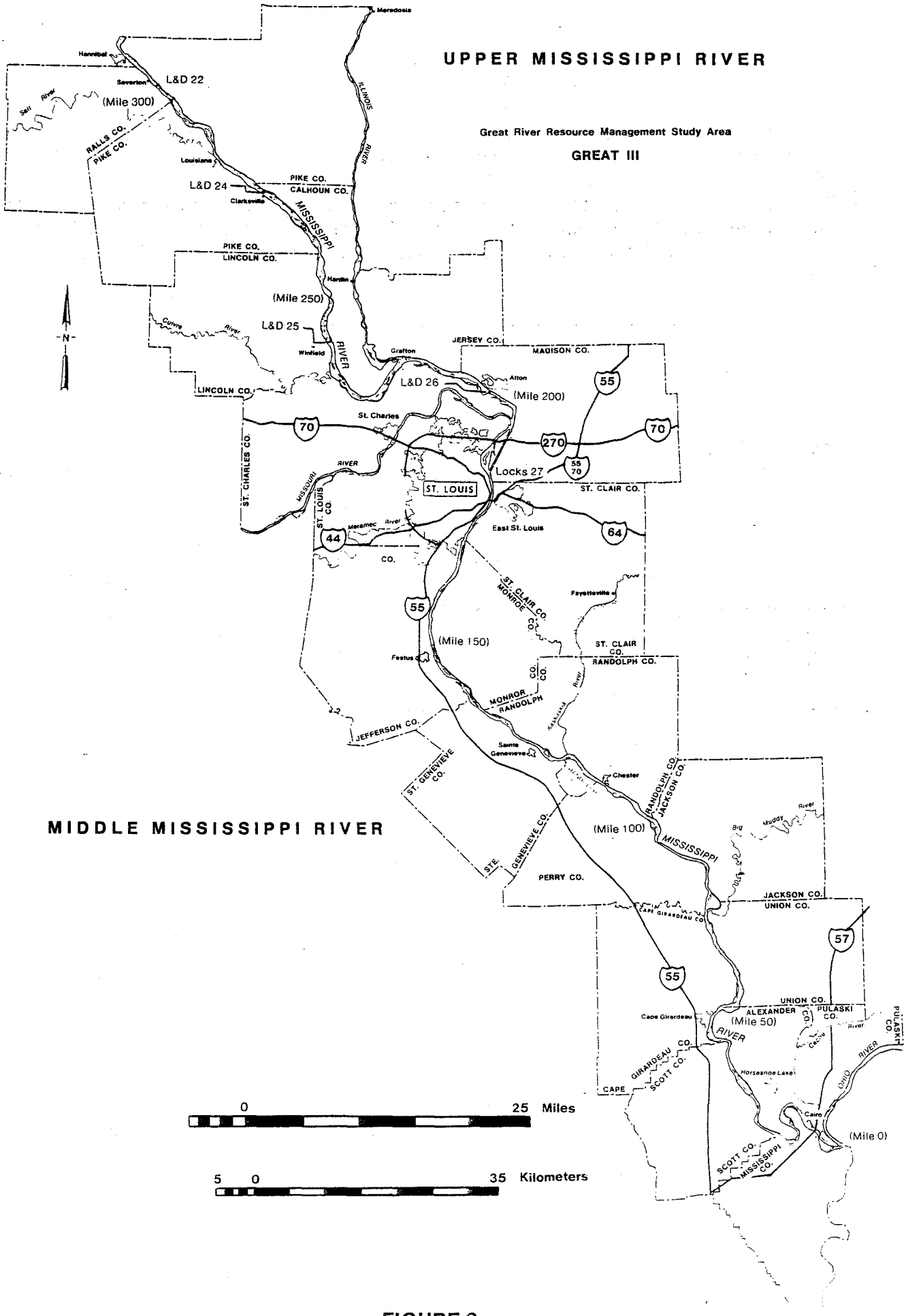

UPPER MISSISSIPPI RIVER
Great River Resource Management Study Area
GREAT III
MIDDLE MISSISSIPPI RIVER
L&D 22
(Mile 300)
L&D 24
L&D 25
(Mile 250)
L&D 26
(Mile 200)
Locks 27
(Mile 150)
(Mile 100)
(Mile 50)
(Mile 0)
ST. LOUIS
Meramec River
Missouri River
Illinois River
Mississippi River
Ohio River
Big Muddy River
Cache River
Horseshoe Lake
Hannibal
Meredosia
Clarksville
Louisiana
Winfield
Grafton
Alton
St. Charles
East St. Louis
Fayetteville
Festus
Sainte Genevieve
Chester
Cape Girardeau
Cairo
PIKE CO.
CALHOUN CO.
RALLS CO.
LINCOLN CO.
JERSEY CO.
MADISON CO.
ST. CHARLES CO.
ST. LOUIS CO.
ST. CLAIR CO.
MONROE CO.
RANDOLPH CO.
JEFFERSON CO.
ST. GENEVIEVE CO.
PERRY CO.
JACKSON CO.
UNION CO.
ALEXANDER CO.
PULASKI CO.
GIRARDEAU CO.
SCOTT CO.
CAPE
MISSISSIPPI CO.
70
55
270
64
44
57
0 25 Miles
5 0 35 Kilometers

FIGURE 2

PRIOR STUDIES AND REPORTS

GREAT I AND II

Like GREAT III, the objective of these two studies was to develop a river system management plan. As a result, many of the same subjects were studied in each GREAT area. In some cases the knowledge gained in one GREAT study was used as the basis for further study in another GREAT area. The problems solutions did not apply universally, however, and it is generally agreed that the river is very much different in each GREAT study area. Study completion for GREAT I and II was announced by the NCD Engineer's Notice, issued in July 1981. The following is a brief description by subject area of the activities addressed by those studies.

Commercial Navigation. Developed traffic forecasts; addressed trash disposal, pollution control, lock operation, bridge safety, fleeting requirements, channel maintenance, underkeel clearances and fuel efficiency, and impacts of various regulations.

Channel Maintenance. Assessed channel maintenance equipment capabilities and practices; conducted hydraulic studies on sediment transport and regulating structures; developed a reduced depth dredging program; identified beneficial uses for dredged material and potential users; and formulated a channel maintenance plan with preselected disposal sites and conditions.

Erosion and Sediment. Studied upland and streambank erosion, backwater and side channel sedimentation rates, and various land treatment programs; established sedimentation budgets and analyses for tributary and main stem waters.

Flood Plain Management. Evaluated flood plain regulations and the impacts of dredged material disposal; produced a predictive math model for flooding, flood plain maps, and an education program.

Fish and Wildlife. Developed base data on various types of fish and wildlife habitats; investigated side channel and backwater rehabilitation, wing dams, and pool fluctuations; conducted a literature search and review; and assessed impacts of channel maintenance, recreation, industrial development, and navigation on fish and wildlife resources.

Water Quality. Conducted water sampling programs and identified problem areas; evaluated water quality standards in a riverine environment; and developed a predictive math model for dredging and disposal.

Recreation. Assessed the various types of recreation, their demands, and how those demands could be met; reviewed legal and institutional frameworks; developed a recreation plan; and assessed recreational boating safety.

Recommendations contained in these studies do not require Congressional authorization. The Board of Engineers for Rivers and Harbors (BERH) reviewed these studies in March 1982. BERH found that the studies adequately addressed many water-oriented problems in the Upper Mississippi River Basin and that solutions to these problems can only be reached through continued study and coordination. Therefore, the BERH recommended that the GREAT I and II reports be provided to Congress for information.

THE UMRBC MASTER PLAN

In 1978, the Inland Waterways Authorization Act (P.L. 95-502) authorized the UMRBC to prepare a Comprehensive Master Plan for Management of the Upper Mississippi River System (Master Plan) in cooperation with appropriate Federal, state, and local interests. It was recognized in the Master Plan authorization that the GREAT studies were underway and the potential for duplication existed. The legislation indicated that the resources and results of the GREAT studies were to be used to the fullest extent possible. GREAT studies were generally scoped toward problems and needs of a specific reach of the Upper Mississippi River, whereas the Master Plan was intended to respond to system-wide resource management issues. Specifically, the Master Plan focused on the economic, environmental, and recreation impacts resulting from any expansion of navigation capacity of the system. During the early stages of GREAT III and the Master Plan, it was decided by the GREAT III Team that the UMRBC had the responsibility to determine the utility of the GREAT studies and that the GREAT III study should not investigate any topics specifically designated for study by the UMRBC. The Master Plan was submitted to Congress on 1 January 1982.

PLAN FORMULATION PROCESS

STUDY ORGANIZATION

The principal organizational levels involved in the study process included the Steering Committee, the Team, and the Technical Work Groups. FIGURE 3 shows the hierarchy and coordination. Agency representatives on the Steering Committee and the Team and the Work Group Chairmen are presented in APPENDIX A. The Steering Committee was composed of executive personnel from each participating Federal agency and the states of Illinois and Missouri. The Steering Committee established policy, reviewed program management, and resolved major conflicts about various matters. The GREAT III Team was composed of representatives from each participating state and Federal agency. The Team was responsible for program management, directing, and reviewing Work Group efforts. The Work Groups were composed of technical personnel. Each Work Group was chaired by a representative from the agency with the lead role. Representation by outside interest groups, individuals, or other technical personnel was encouraged at the Work Group level. The Work Groups were responsible for directing the GREAT III technical studies and assisting in the formulation of recommendations.

GREAT III
ORGANIZATIONAL CHART

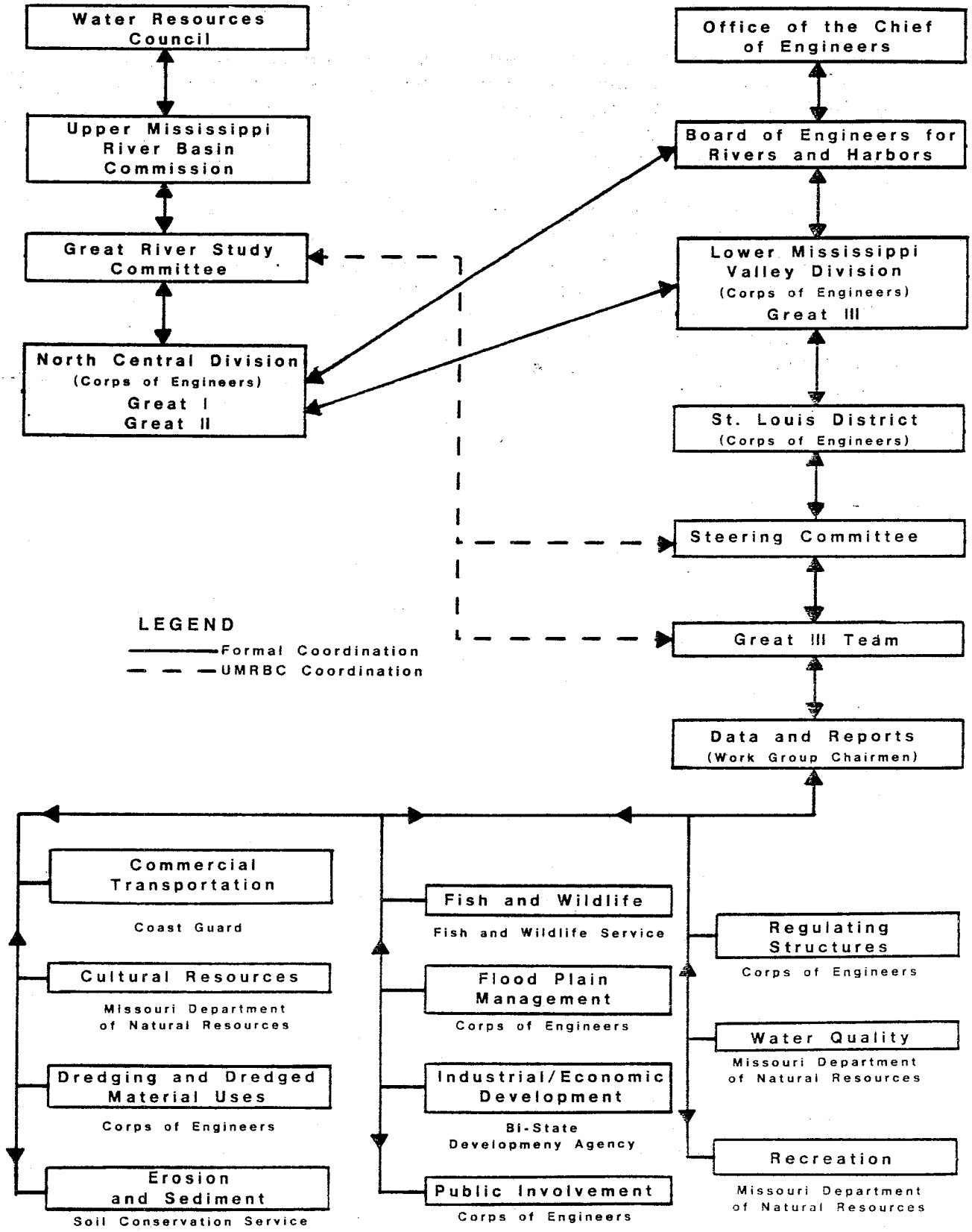


FIGURE 3

STUDY ACTIVITIES

Initiated at an organizational meeting on 1 September 1977, the GREAT III Study has progressed through a series of events leading to this report. The goal that guided this study was to develop a program of resource management which would insure responsible and coordinated environmental, economic, and social uses of the water and related land resources in the GREAT III reach.

Reconnaissance Stage

During this stage, the scope of the study was established; planning constraints were recognized; subsequent planning activities were specified; and potential management measures were identified and screened through a preliminary impact assessment and evaluation process.

A Plan of Study (POS) was completed and submitted to LMVD on 1 June 1978. In order to comply with revisions of the Water Resources Council's Principles and Standards for Water Resources Planning (P&S) and to accommodate comments from participating agencies on the POS, the study participants proceeded and developed the Reconnaissance Report. During the preparation of this report, technical work groups developed plans of action and scopes of work for technical studies.

The Reconnaissance Report was prepared in two phases: (1) a preliminary report; and (2) a final report. LMVD approved the Reconnaissance Report on 2 October 1980.

It was recognized in the Reconnaissance Report that the quantity and complexity of resource management problems identified precluded an adequate in-depth investigation of all perceived problems. Therefore, screening was necessary to determine which concerns should be addressed during the study.

Initially, GREAT III encountered difficulties in defining and limiting the scope of the study. Considerable confusion and misunderstanding were major problems in deciding what would constitute a River Resource Management Plan for the GREAT III study area. Finally, it was decided that funds would be allocated to investigate the higher priority resource management problems. This procedure was followed with minor exceptions. The following section identifies the universe of perceived resource management problems and indicates those that were addressed. Funding limitations precluded implementation of several proposed technical and institutional studies.

Stage 2 Study Activities

The purposes of this stage were to analyze the identified water and related land resource problems and opportunities and to explore a broad range of management measures in order to formulate alternative plans for comparison and selection.

Subsequent to the approval of the Reconnaissance Report, study activities centered on an analysis of management measures, initiating and monitoring contract studies, coordinating work group activities, and further detailing of plan formulation and procedures to resolve conflicts.

A complete plan formulation process which develops and evaluates an array of feasible alternative plans was not fully developed beyond analysis of management measures in the Reconnaissance Stage and in various technical studies. Most work group activity has centered on the monitoring of contract technical studies and the collection of resource data. Since a major purpose of this report is to document accomplishments to date, technical studies are abstracted in a subsequent section.

In addition, technical work groups made attempts to improve the coordination of dredging activities, in the interest of minimizing impacts of dredged material disposal. Each year, pre- and post-dredge site inspections were scheduled. GREAT III study participants, particularly the Fish and Wildlife Work Group, and members of the St. Louis District Channel Maintenance staff cooperated in these inspections.

It was recognized that the plan formulation activities should concentrate on recognition of conceivable management measures which could be acted on by decision makers allowing flexibility to integrate measures or separate measures for implementation as opportunities are presented.

Public Involvement and Coordination

Public contact was maintained throughout the study using a variety of techniques. The Public Involvement Work Group played a key role during the early problem identification phase and in helping to keep the public informed and involved. Coordination was a continuous process throughout the study by virtue of the study organization.

During 19-22 September 1978, a river orientation trip was conducted to acquaint study participants with the GREAT III reach. Approximately 100 persons, representing different public and private interests, participated. They got a firsthand look at recreation areas, dredged material disposal sites, side channels, islands, dike fields, and revetment locations.

Between 2 and 20 November 1978, public meetings were held at five different locations (Louisiana, St. Louis, and Cape Girardeau in Missouri, and Alton and Chester in Illinois). The purpose of these meetings was twofold: (1) to explain the purpose of the study; and (2) to begin the planning process by identifying problems resulting from the many uses of the Mississippi River. Comments received in these meetings were used in developing the Reconnaissance Report. Fact sheets summarizing the results of the meetings and how the information would be incorporated in the study were provided the public.

A fact sheet, which briefly described the status of the study, was mailed to approximately 1,500 individuals and/or organizations. It also offered the public an opportunity to obtain a copy of the Reconnaissance Report. At the same time, this Report was provided to the UMRBC and its Great River Study Committee. The UMRBC accepted the document as a basis for continued planning. Seventy-six copies, excluding those provided to UMRBC, were mailed upon request. Most agency comments were accommodated by active involvement. Written comments were received from two agencies: the National Oceanic and Atmospheric Administration and the US Environmental Protection Agency.

In June, 1982, the public was notified that the GREAT III study was being concluded and a final report was to be prepared. It was announced in late July, 1982, that a draft report had been completed. The public was then provided an opportunity to receive copies of the draft report for review and comment. Most of the comments received came from state and Federal agencies active in the study. Where possible, these comments were incorporated by the Team in the final report. The Steering Committee accepted the report, as modified by the Team, during their final meeting on 10 September 1982.

NATURE OF IDENTIFIED WATER AND RELATED LAND RESOURCE PROBLEMS

The overall planning objective of providing decision makers with improved management procedures and programs was the guide used in synthesizing the problems identified (approximately 440) by the public and the problems identified by the technical work groups. Each work group examined these problems to eliminate those that were either duplicative, beyond the scope of the study, or previously studied by another program; and to determine the relationship of the remainder to the existing and projected future conditions. Subsequently, about 50 perceived problems were considered to be within the scope of the study. These problems were ranked by the work groups and presented to the Team, where the problems received additional screening, consolidation, and priority ranking.

Problem Statements

The following resource management problems were identified by each technical work group through an examination of the existing and anticipated future conditions of the GREAT III reach of the Mississippi River and related land resources. Work group study participants analyzed the problems as perceived by work group members and the public and combined these problem statements into a priority array of public and professionally perceived problems. Subsequently, all study participants reviewed this synthesis of concerns expressed by the work groups and the public. This section presents these problem statements with the priorities as first assigned by the technical work groups and then by a combination of the work groups and the Team. The numbers in parentheses indicate this *combined* priority ranking.

Two work groups (i.e., Data and Reports and Public Involvement) functioned somewhat differently than the other work groups in that these work groups provided the necessary coordination among study participants and between study participants and the public throughout the planning process. As a result, resource management problems identified by Data and Reports and communication concerns identified by Public Involvement were formulated based primarily on the concerns expressed by the public during the Stage 1 public meetings, and were not given a priority order. The perceived problems, represented by Data and Reports and Public Involvement, were distinct from those presented by the other technical work groups. These problems interfaced all work groups and were pertinent to the overall development of a resource management plan.

Data and Reports Work Group

- Lack of coordination and cooperation between different and sometimes conflicting users of the river.
- Insufficient coordination in river management and funding.
- Corps of Engineers' resource management is limited by a single purpose authorization.
- Duplicate studies waste time and money.
- Lack of public awareness of the river.

Public Involvement Work Group

- There is a need to make information available to the public in order to increase public awareness and understanding of the GREAT III Study.
- There is a need to assist the public in conveying its views, preferences, and concerns relative to GREAT III before decisions are made on studies and projects.
- There is a need to maintain cooperation between study participants and the public in the understanding and formulation of common goals.
- There is a need to give full consideration to public views and preferences in the GREAT III planning process.

Commercial Transportation

1. (11 Tie) Current and future barge traffic is constrained from meeting transportation needs.

2. (34) The role, characteristics, and requirements of the waterway transportation system are not understood by the general public.

3. (42) Increased collisions due to increased traffic.

4. (35) Waste disposal control from towboats.

5. (51) Better shore facilities for radio communications in the marine band.

6. (49) Adverse effect of GREAT III on commercial navigation.

Cultural Resources

1. (29) Management of known cultural resources in all areas of the GREAT III reach is extremely limited. The absence of a comprehensive summary of published and unpublished literature, an inventory of recorded cultural resources, and an inventory of areas surveyed, prevents the development of any useful cultural resource management plan.

2. (30) Cultural resource management procedures and programs, as required by Federal laws and regulations, of some of the agencies are often unknown or unclear to both agency individuals and other institutions conducting cultural resource management projects in the area. This results in a lack of communication and coordination between the two groups and their activities.

3. (47) The lack of communication between the public and those individuals and institutions managing cultural resources results in the unnecessary public misunderstanding and apprehension of the role cultural resource management plays in development activities.

4. (40) The lack of long-range planning for flood plain development often results in the direct, indirect, or potential adverse impact on known and unknown cultural resources.

5. (44) Systematic survey data for cultural resources are often lacking for present and most future development and land disturbance activity areas.

6. (46) Many cultural resources are generally known to exist in the GREAT III area but extensive and reliable up-to-date information for many of these resources is not available.

7. (50) Methods for the preservation of cultural resources (e.g. physical site maintenance, protection, or public education) have not been adequately developed or utilized.

8. (52) Need for access to historical/cultural sites.

Dredging and Dredged Material Uses

1. (4) Decisions on the placement locations of dredged material may be affected by the impacts to the other river resources such as fish and wildlife habitats, recreation, industrial development, and cultural sites, and are limited by dredge plant capacity, volume of material displaced, and placement technology for beneficial uses of dredged material for commercial, industrial, and recreational purposes; and the legality of any proposed beneficial use of dredged material.

2. (31) Shoaling may occur in the open reach of the river at many crossings simultaneously reducing the progress of commercial traffic which may be intensified by the recommendations of the Industry Capability Program and the Corps of Engineers' Minimum Dredge Fleet Study.

3. (22) Projected flow depletions may increase future dredging requirements through consumptive and non-consumptive water uses.

4. (21) Lack of authority to dredge outside of the authorized channel by the Corps of Engineers.

5. (45) Economic factors have limited the implementation of technological advances necessary to developing modern dredging equipment.

Erosion and Sediment

1. (11 tie) Sediment produced at upland sites affects the river corridor.

2. (7) River training works affect aquatic habitat by limiting water surface area and modifying sediment deposition and erosion patterns.

3. (5) River regulating works trap sediment, induce bed scour, and change fish and wildlife habitat.

4. (38) Erosion of the river banks affects the river resources.

5. (48) Overflows cause sediment deposition and scour on flood-prone lands.

Fish and Wildlife Work Group

1. (1) Channel regulating structures (i.e., revetments, dikes, and dams) may result in alterations of valuable fish and wildlife habitats by modifying water surface, changing water velocities, changing bed scouring and sedimentation patterns, and altering riparian habitat.

2. (3) Dredging and the disposal of dredged material has been conducted in a manner affecting fish and wildlife.

3. (12) Inventory data on biological resources are insufficient for planning purposes.

4. (23) Improved flood protection has altered fish and wildlife habitat.

5. (19) Increased tow traffic may affect the biological productivity on the river.

6. (16) Increased tow traffic may result in increased demands for support facilities (fleeting areas, harbors, docks, etc.), thereby resulting in additional fish and wildlife losses.

7. (36) Regulation of water levels in the pooled river does not include consideration for the needs of fish and wildlife resources.

8. (37) Federal lands in the pooled portion of the GREAT III study area are not being developed to their full fish and wildlife resource potential.

9. (33) Increased tow traffic may create additional demands for year-round operations. This will compound other tow traffic problems and place fish and wildlife under additional stress.

Flood Plain Management

1. (14 tie) There needs to be a greater reduction in flood damages.

2. (14 tie) The social, economic, and environmental impacts of governmental flood plain management are not known.

3. (13) The social, economic, and environmental impacts of the lack of flood plain management are not known.

4. (20) There is a lack of flood plain mapping and resources inventory.

5. (28) The interrelationship between land use, groundwater system, and fish and wildlife is not known.

Industrial and Economic Development

1. (17) Institutional and regulatory impacts on economic development need to be assessed.

2. (24) Physical barriers, intermodal conflicts, and inadequacies of existing transportation systems hinder industrial operations and future economic development.

3. (39) There is a lack of fully serviced or reasonably serviceable industrial and commercial lands.

Recreation Work Group

1. (15) There is a lack of recreation opportunities in the GREAT III study area.

2. (25) Funding and coordination of law enforcement and education programs regarding the use of the river are inadequate.

3. (18) Undisturbed areas in the GREAT III study area with the potential to be designated as natural areas have not been protected.

4. (27) Developments in the river corridor adversely impact the recreation experience by diminishing the aesthetic and safety qualities of the river resources.

5. (32) The development, operation, and maintenance of the navigation project affects recreation activities and opportunities.

6. (43) Land use plans, developments, and regulations often adversely impact the quantity and quality of recreation resources and opportunities.

7. (41) Information about recreation facilities, impacts, needs, and potential in the GREAT III study area is inadequate.

Regulating Structures

1. (2) It is presently unknown what effect river regulating structures have on *main channel corridor* aquatic and terrestrial habitat.

2. (6) Effects of regulating structures on channel geometry and their relationship to problems 1 and 3.

3. (8) It is presently unknown what effect river regulating structures have on *side channel* aquatic and terrestrial habitat.

Water Quality Work Group

1. (9) The adverse impact on water quality of increased and more powerful barge traffic and maintenance of navigation channel on the Mississippi River adversely impact on water quality.

2. (10) The adverse impact on water quality of municipal, commercial, agricultural, and industrial discharges to the Mississippi and its tributaries.

These two general problems (Numbers 1 and 2) raise these specific concerns: (a) water supplies endangered by toxic materials; (b) aquatic habitat endangered by toxic materials and suspended sediment; (c) periodic low dissolved oxygen concentration in certain segments of the river; and (d) reduction of the value of sport and commercial fisheries due to bioaccumulation and biomagnification of toxic materials and taste and odor producing materials.

3. (26) Lack of coordination between local, state, and Federal agencies on water quality.

Investigated Resource Management Problems

The problems, related objectives, and specific studies that evolved after considerable and lengthy screening and integration by the Work Groups and the Team were:

1. *Problem:* River regulating structures (i.e., revetments and dikes) can result in alterations of valuable aquatic and terrestrial habitats by modifying water surface, changing water velocities, changing bed scouring and sedimentation patterns, and altering riparian habitat.
   Objective: Obtain a better understanding of the relationships between regulating structures and aquatic and terrestrial habitats.
   Study Title: Influence of Regulating Structures on Fish and Wildlife Habitat.

2. *Problem:* Impacts of dredged material placement on other river resources and resource uses may influence decisions on placement locations.
   Objective: Determine how other river resources may benefit by alternative dredging practices.
   Study Title: Due to study curtailment, no study was completed. Based on the results of the Dredged Material Research Program (WES) it was proposed that a study be accomplished to determine the predominant species and associated spawning seasons by general reach which could result in scheduling of dredging to lessen impact on aquatic life. In addition, a study: Fish and Wildlife Habitat Evaluation Report was approved but not funded. It was intended to develop data that could be considered in performing channel maintenance.

3. *Problem:* Current and future barge traffic may be constrained from meeting transportation needs.
   Objective: Provide means to insure enough channel depths and widths for efficient and safe passage of vessels.
   Study Title: Navigation and Industrial Forecasts, Needs Analysis, and Recommendations. (Joint study - Refer to No. 11.)

4. *Problem:* Sediment produced at upland sites affects the river corridor.
   Objective: Lessen the adverse impacts of sediments in the river corridor.
   Study Title: Sediment Inventory and Gaging. Quantification of Minor Sediment Sources, Bank Erosion, and Sediment Scour.

5. *Problem:* There may be a lack of recreational opportunities in the study area.
   Objective: Gather information about outdoor recreation areas and facilities, use and demands for them, to provide opportunities for improved outdoor recreational experiences.
   Study Title: Recreation and Natural Area Needs Assessment.

6. *Problem:* River regulating structures can have an effect on side channel aquatic and terrestrial habitats.
   Objective: Same as Problem 1.
   Study Title: A study of side channels was proposed but cancelled due to the cost.

7. *Problem:* Increased and more powerful barge traffic and the maintenance of the navigation channel may have an effect on water quality.
   Objective: Collect data on the effects of dredging, placement and disposal, and barge traffic on water quality.
   Study Title: Refinement and Verification of Predictive Models of Suspended Sediment Dispersion and Desorption of Toxics from Dredged Material.

8. *Problem:* Flood damage reduction can have an impact on social, economic, and environmental resources.
   Objective: Develop programs that will reduce damages from flooding.
   Study Title: Studies would have duplicated research performed by other organizations. Hence, the Team decided not to pursue a specific study to address this objective.

9. *Problem:* Inventory data on biological resources are insufficient.
   Objective: Inventory biological resources.
   Study Title: Habitat Characterization Study.

10. *Problem:* Management of known cultural resources is difficult due to the fragmentation of information.
    Objective: Provide an organized and usable inventory of archaeological and historical resources.
    Study Title: Cultural Resources Inventory.

11. *Problem:* Industrial and economic development activity may be constrained from meeting needs.
    Objective: Obtain means to reduce and/or simplify institutional and regulatory constraints that hamper commercial and industrial developments.
    Study Title: Navigation and Industrial Forecasts, Needs Analysis, and Recommendation. (Joint study - Refer to No. 3.)

Other Work Group Investigations

During the study, some of the technical work groups investigated a number of important resource management problems using work group expertise. These endeavors were conducted at the discretion of each work group. The level of detail devoted to these investigations varied considerably between work groups.

Commercial Transportation Work Group.

Fleeting. Documented various types of fleeting and fleeting procedures, conducted guest speaker program on fleeting impacts, reviewed Corps of Engineers fleeting regulations and policies, and developed a scope of work to investigate the environmental and physical impacts of fleeting.

Commercial vessel safety. Obtained Coast Guard accident records for a ten-year period. Plotted accidents by river mile segments to identify problem areas.

Work Group Recommendation:

Conduct an annual Coast Guard and Corps of Engineers review and analysis of marine accidents to identify problem areas and possible corrective measures.

Role, characteristics, and requirements of water transportation. Developed a scope of work to review various ways to translate barge transportation benefits into impacts for the average person. Reviewed existing media programs in preparation for producing a new program.

Cultural Resources Work Group.

The Work Group has established and maintained topographic maps indicating known resources and surveys, established and maintained library files of survey reports and pertinent publications, and updated files of Archaeological Survey of Missouri computer listings, microfiche cards of reported cultural resources, and computer printouts of National Register of Historic Places including listed and eligible properties.

Fish and Wildlife Work Group.

Dredging and Dredged material disposal. The Work Group reviewed impacts of dredging and dredged material disposal, developed priorities for disposal, and established an Onsite Inspection Team (OSIT) to evaluate dredge sites. The OSIT attempted to make pre- and post-dredging inspections of all sites. Several sites will require long-term solutions to alleviate continued high volume dredging.

Work Group Recommendations:

1. Study methods to coordinate dredged material disposal, with specific consideration of establishing an Onsite Inspection Team.

2. Study long-term solutions for chronic high volume sites.

3. Conduct the Fish and Wildlife Habitat Evaluation Study.

4. Study additional dredging equipment needs for avoiding environmental impacts and promoting beneficial use of dredged material.

Inventory of biological resources. The Work Group evaluated literature on Mississippi River side channels and sampled fish in some side channels. Middle Mississippi River side channels provide essential and diminishing habitat for fish and wildlife. The Work Group concentrated its efforts on that reach.

Work Group Recommendations:

1. Study the Middle Mississippi River side channels using a method similar to Waterways Experiment Station (1974), with the objective being to recommend means to maintain and improve aquatic habitat.

2. Investigate impacts of structural modifications to regulating structures on side channel aquatic habitats.

Freshwater mussels. The Work Group sampled mussels and reviewed literature in an attempt to determine their status. The 35 mussel species in the GREAT III reach of the Mississippi River constitute an important and fragile resource.

Work Group Recommendations:

1. A comprehensive inventory of mussels (mussel beds) should be completed in the GREAT III reach.

2. Studies of the host fish species, critical habitat for endangered mussel species, and reestablishment of habitat and/or mussels should be conducted.

Tow traffic spills. The Work Group compiled data from three sources on spills of toxic materials from barge loading and unloading and from tow accidents. Data available from the US Coast Guard, US Environmental Protection Agency, and Illinois Environmental Protection Agency are not correlated, each indicating different levels of spill occurrence.

Work Group Recommendations:

1. Study methods to correlate toxic spill data and evaluate it with an objective being to identify causes of toxic spill accidents and actions needed to correct identified problems.

2. Investigate mechanisms to improve coordination on toxic spills.

Tow traffic and barge fleeting increases. The Work Group conducted a limited review and developed a scope of work to study biological impacts of fleeting. The objective of the study was to identify the impacts which could lead to changes in operation and location of fleeting areas. Further, its objective was to reduce conflicts and allow for optimum development while protecting biological resources.

Work Group Recommendation:

A comprehensive biological and industrial study of fleeting impacts should be conducted.

Pool water level regulation. Numerous fish species and wildlife, especially waterfowl and furbearers, depend on water levels for favorable habitat. The pooled river constitutes an opportunity to manage water levels for those resources. The Work Group evaluated available data relative to pool level, flow, and vegetative conditions.

Work Group Recommendation:

Evaluate flow, pool level, and vegetative condition data for the development of pool level management plans for fish and wildlife.

Industrial and Economic Development Work Group.

The Work Group considered a variety of methods for resolving the following development issues: (1) improved cooperation between transportation modes; (2) better intermodal transfer facilities; (3) improved public awareness of the economic impact of port and industrial development; and (4) the need for financing and development of fully serviced port-related industrial sites.

Work Group Recommendation:

Further study on these issues is recommended.

EXISTING CONDITIONS

The region's physical characteristics combined with its central continental location have provided a unique socioeconomic and environmental setting. This overview provides a basis for understanding the problems and needs that were identified.

The Resource Base

The Land

The Mississippi River flows through three major landform regions. North of Crystal City, Missouri, is the Central Lowland Province. South of this city, the river enters the Ozark Plateau Province. Between Cape Girardeau, Missouri and Thebes, Illinois, the river flows into the Coastal Plain Province.

The drainage area of the Mississippi increases between Saverton, Missouri, and Cairo, Illinois, from 137,500 square miles to 921.000 square miles. This increase is due to the addition of seven major rivers and a narrow corridor of minor tributaries.

Rolling narrow ridgetops, moderate to steep valley slopes, and bluffs characterize the area. The flood plain of the Mississippi averages about 5 miles in width from bluff to bluff. This alluvial valley is quite wide in three locations: (1) at the confluences of the Missouri and Illinois Rivers with the Mississippi River; (2) the American Bottoms in Madison and St. Clair Counties, Illinois; and (3) at the reach near Cairo, Illinois which is in the Coastal Plain Province. The major tributaries have nearly level, broad flood plains, with extensive bottomlands.

Minerals

Major coal deposits are found in the region. In addition, lead, zinc, stone, sand, clay, and crude oil are mined and quarried.

Climate and Weather

Climate and weather are generally continental. Hot, humid summers and relatively mild winters characterize the region. The mean monthly temperatures range from 50° F. at the northern part to 58° F. at Cairo, Illinois. The average July temperature is 79° F. at St. Louis, Missouri and Cairo, Illinois. The mean January temperature ranges from 32° F. at St. Louis to 36° F. at Cairo. Average annual precipitation is about 35 inches.

The weather varies greatly from day to day and season to season. Major weather disturbances are thunderstorms, tornadoes, blizzards, ice storms, cold waves, heat waves, and occasional droughts.

Air quality, except for the St. Louis Metropolitan area, is relatively good, because of the area's predominantly rural character.

Soils

The fertile soils derived from the alluvial deposits are primarily composed of fine textured clays intermingled with fine sandy loams. Major difficulties with these soils are weed control, maintaining fertility, and drainage. Relatively fertile, dark, grayish-brown soils with silt loam surfaces have developed from loess overlying glacial tills on the gently sloping to rolling areas of the Illinois plains. Light-colored soils with silt loam surfaces have developed on the loessial deposits and the moderately to steeply sloping areas on the Missouri side. These soils are less fertile than those found in the flood plains and the Illinois plains.

Erosion and Sediment

This study did not quantify erosion outside of the study area. In the uplands adjacent to the river corridor, sixty-seven million tons of soil are dislodged annually. Agricultural sheet-rill erosion accounts for 85 percent of this dislodged soil. Twenty-nine percent of this dislodged soil is delivered to the Mississippi River and accounts for 17 percent of the average annual sediment yield at Alton, Illinois and 6 percent of the average annual sediment yield at Thebes, Illinois. A reduction in sediment discharge has occurred over the last 25 years.

Control activities have retarded the river's natural migration. The pools in the Upper River have inundated many of the previous river courses. In the open river, shifting of the channel has been minimized by regulating works (dikes and riprap) which have significantly reduced the caving of banks and levees. The alluvial riverbed, however, continues to erode and fill. Sediment deposition in dike fields is a function of numerous variables. The most significant is the volume of sediment in transit. Some tributaries to areas controlled by pools are aggrading in lower reaches. Estimated daily suspended sediment transport at St. Louis, Missouri, ranges from 28,000 tons to 7 million tons and averages 370,000 tons. Average annual sediment yields at selected gaging stations are presented in TABLE 2.

TABLE 2
Average Annual Sediment Yield at Gaging Stations

Station	Drainage Area (sq. mi.)	Sediment Yield (tons per sq. mi. per year)	Total Tons
Mississippi River at Keokuk, Iowa	119,000	79	9,401,000
North Fabius River at Monticello, Mo.	452	973	439,790
Mississippi River at Hannibal, Mo.	137,300	181	19,400,000
Salt River near Monroe City, Mo.	2,230	454	3,300,000
Missouri River at Hermann, Mo.	528,200	295	70,700,000
Mississippi River at St. Louis, Mo.	701,000	258	115,000,000

The sediment particles range from silt, clay, and sand to gravel. Coarser materials are carried along the thalweg in contact with the riverbed. Suspended sediment sampled at St. Louis contained 47 percent clay, 38 percent silt, and 15 percent sand. Sediment is trapped in the pools, and builds up in backwater areas, on islands, in regulating structures, and in crossings where the main channel shifts from one side of the river to the other. Sediment particles in the pooled portion are over 98 percent by weight fine sand. The open river section contains appreciable amounts of sand, coarse sand, gravel, and small amounts of cohesive silt and clay particles.

The principal source of sediment is sheet-rill erosion. Other sources are gully erosion, flood plain scour, bed and bank erosion, and resuspension due to water craft movements and dredging. Fine sediments have tendencies to deposit in side channels and backwaters, and coarser materials are most often found in the main channel. Land accretion due to sediment deposits reduces the surface area of water temporarily and permanently.

It has been indicated that 73 percent of the sediment load in the open reach of river originates in the Missouri River drainage. In the pooled area, sediment transport varies with river stages. During low flows, erosion occurs below the dams in the upper ends of the pools where velocities are greatest. Deposition occurs in the deeper parts of the pools. During high flows, this process is reversed. The net change is aggradation in shallow areas.

Dredging and Dredged Material Uses

When maintenance dredging occurs, excavated material is placed along the shore or between the channel and the bank. This material is almost always put back into the Mississippi River. River stage; hydrologic, geomorphologic, and geometric properties of a particular reach of the river; volume of material to be dredged; capability of the equipment used; river structures in a reach such as dikes, revetments, and locks and dams; the volume of river traffic; and recommendations received from Federal and state conservation and fish and wildlife agencies, are considered before locating a disposal site. Approximately 150 sites in the GREAT III reach have been dredged at one time or another. Between 30 to 50 of these locations are dredged regularly. Some of these have to be dredged very infrequently, others annually, and some more than once during the navigation season. All dredging activities comply with applicable Federal and state regulations.

The SLD coordinates with affected agencies regarding locations which may require dredging and the proposed disposal sites. Recently, pre- and post dredge site inspections have been scheduled by the GREAT III Fish and Wildlife Work Group in conjunction with SLD Channel Maintenance personnel. Agency representatives occasionally recommend alternative disposal sites. Some of these are accepted wherever and whenever feasible. Others, however, are rejected because of insufficient equipment capability, namely, a lack of enough pipeline to reach an alternate site or not enough pumping capacity to dispose dredge materials onshore. While this coordination is beneficial, between 25 and 50 percent of the sites dredged each season are not known in advance for coordination purposes.

The average annual amount of material dredged over the last 15 years is about seven million cubic yards. This material is temporarily resuspended during disposal. While sizable, this amounts to only seven percent of the suspended material passing St. Louis annually.

With the exception of sand and gravel dredged by private contractors outside the channel for individual and construction purposes, material dredged to maintain the authorized navigation channel has been used for beach nourishment, creation of sandbars and islands for recreational boaters and fish and wildlife. During 1977, commercial dredging produced approximately 2,227,000 tons of sand and gravel with a value of about 4.1 million dollars.

Water Resources

The water resources serve many needs. Variations in precipitation, topography, regulation and flood control works, and land use practices cause fluctuations in flow volume. Average annual flow of the Mississippi almost doubles between Alton, Illinois (2,802 cubic meters per second) and Thebes, Illinois (5,480 cubic meters per second).

The Mississippi River is the major source of surface water supplies. The average flow meets current demands and will satisfy projected demands. Extensive groundwater supplies of high-yielding sand and gravel aquifers underlie major parts of the region. The thicknesses of these layers vary from 70 to 100 feet. Industrial and municipal pumpage accounts for most of the water withdrawals. Yields of 1,000 gallons per minute and over are common for individual wells.

Regulating Structures

The Navigation Pools. During the latter part of the 19th century, the currently pooled portion of the Mississippi River above the confluence with the Missouri River was wide and generally shallow, with numerous islands and emerging sandbars during periods of low flow. Since 1824, the Federal Government has been involved in improving river conditions for navigation.

Dikes made of wood and stone were used to confine the low flows to the main channel and temporarily increase stream velocities within the contracted reach, thereby increasing the stream's sediment transport capacity, thus deepening the navigation channel by scouring the riverbed. The sandbars between adjacent dikes soon became vegetated, with subsequent inundations depositing layers of finer-grained sediments such as silts and clays.

To alleviate the increased scouring action on the opposite bank due to the confinement of low flows, the lower portion of the riverbank was first usually protected with woven wooden mats placed against the bank and sunk with stone before the upper portion of the bank was revetted. Current methods to revet banklines utilize stone riprap. Stabilization of the riverbanks reduced the amount of lateral channel migration, thus reducing the number of new side channels that were being formed.

Prior to the establishment of Pools 24, 25, and 26, approximately 300 dikes and 65 miles of revetments were built. Due to their general deterioration and heavy ice-pack damage, a substantial portion of these structures was severely damaged or completely destroyed, thus significantly reducing their effectiveness. Until recently, only very minor repairs were made to these regulating structures. Minor maintenance efforts are now used more extensively in repairing existing revetment works and dikes.

The Open River. The reach of river from the mouth of the Missouri River to the mouth of the Ohio River is called the Middle Mississippi River. This reach has characteristics which are a composite of those of the Upper Mississippi and the Missouri. From St. Louis to Grays Point, a distance of 134 river miles, it flows between bluffs in an alluvial valley generally 4 to 5 miles wide. Its characteristics change in passing through the 7-mile rock-bound gorge from Grays Point to Commerce, and again when it emerges into the wide delta-like valley of the lower Mississippi. Historical accounts indicate that about 1820 the Middle Mississippi River passed from its natural state into a state where man's activities had a significant effect on the morphological processes.

As the timber from the banklines of the river was being removed, the banks became less stable and began to deteriorate. The river width increased from an average of 3,600 feet in 1821 to an average 5,300 feet in 1888. In the 1880's, the Federal Government began the task of obtaining and maintaining a navigation channel. After many years of progress on the navigation project and associated studies, planning, and analysis, the river of today provides an improved navigation channel. The average width of the Middle Mississippi River was changed from about 5,300 feet in the 1880's to an average width of 3,200 feet today, as compared to the 3,600 feet in the 1820's. The navigation project has caused geomorphic changes as shown in TABLE 3. River length has varied from a minimum of about 186 miles to a maximum of about 195 miles.

TABLE 3
Open River: Geomorphic Changes

Year	Surface Area sq. mi.	Island Area sq. mi.	Riverbed Area sq. mi.
1821	109	14	95
1888	163	35	128
1968	100	17	83

Source: Simons, et al. Geomorphology of the Middle Mississippi River. 1974.

SLD has been cooperating with concerned agencies since 1969, in an effort to make the Nine-Foot Navigation Channel Project more compatible with aquatic and terrestrial habitats. Since 1971, all contract work calling for the construction and maintenance of river regulating structures has been reviewed by concerned conservation agencies. This review process has resulted in the elimination of some proposed dikes, lowering the crown elevation on numerous other dikes, and construction of approximately 50 stone-fill dikes which contain a notch. Model and prototype studies indicate that not constructing of some stone-fill dikes may eventually have an adverse impact upon the authorized channel dimensions and may result in some increased dredging at some future date. A complete evaluation of approximately 50 notched dikes has not been made as to their effectiveness for the enhancement of aquatic and terrestrial habitat. Model studies indicate that notched dikes in certain situations may have a tendency to draw material into a field at a faster rate than unnotched dikes.

Water Quality

The reach studied is composed of slow-flowing or still waters in sloughs or backwaters and faster-flowing, more turbulent waters in the main channel. The major tributaries, the Missouri and Illinois Rivers, and direct discharges from the St. Louis region change the Mississippi's water quality. Although the river provides a very valuable resource, the interstate nature of the region has hampered water quality management efforts. Therefore most Federal, state, or local data gathering or management efforts have been aimed at specific issues.

Many instances of water quality degradation are present. These are: (1) violations of secondary drinking water supply standards for iron and manganese; and (2) low dissolved oxygen (DO) concentrations, Dieldrin and other pesticides, polychlorinated biphenols (PCB's) and other toxic materials, heavy metals, and turbidity. All of these affect aquatic and terrestrial species. Moreover, disposal of dredged materials modify the aquatic environment.

Eighty-seven permit holders discharge directly into the Mississippi or into a tributary less than 2 miles from the river. Of these, 26 are municipalities. Industries and utilities account for 35 permits. The remaining 26 are comprised of housing authorities, public institutions, and recreation areas. Their treatment facilities and procedures vary greatly due to the variety of discharges that have to be accommodated.

Fish and Wildlife

The region has two biotic environments, viz., the slackwater navigation pools and the open river. The structures, facilities, and maintenance activities used to facilitate navigation and to protect urban and agricultural areas have affected fish and wildlife habitats. Thus, the floral and faunal species in these two communities are changing due to natural and man-induced influences.

Navigation Pools. These impoundments consist of two habitat types: (1) aquatic. and (2) terrestrial.

Aquatic habitat. The aquatic habitat has six subtypes (see FIGURE 4). These are: (1) The 300-foot wide, nine-foot deep main channel which has a current that varies in velocity according to water stages. Rooted vegetation is lacking. (2) The main channel border habitat lies between the main channel and the ends of wing dikes, the main riverbank, and islands or submerged parts of the old main river channel. This part of the river may or may not have aquatic vegetation. Forage, commercial, and sport fish are abundant. The habitat also provides reproductive and nursery needs for some fish species. Mussels are found in the main channel and main channel border. Due to their immobility, they are susceptible to destruction from a variety of activities, including dredging and disposal, sedimentation, fleeting, and drastic changes in water levels. (3) The tailwater habitat lies immediately downstream of the dams. This subtype attracts an abundance of forage and sport fish. (4) The side channel habitat is off the main channel and main channel border. Rooted aquatic vegetation may be absent or present. This habitat supports a great variety of fish species, and is highly valued for fishing. (5) The lake and pond subtype has shallow water with normally little or no flow. These habitats may, at times, be connected with other water bodies. Heavy growths of aquatic vegetation and a variety of fish species are normally present. Aquatic furbearers and waterfowl use this habitat heavily. (6) The slough habitat is similar to the lake and pond subtype except that it is a relatively narrow branch or offshoot of another body of water. An abundance of submerged and emergent vegetation typifies this habitat. Several fish species, aquatic furbearers, and waterfowl are found in the sloughs.

Terrestrial habitat. Numerous wooded ridges and bottomland forest are typical of the riparian borders and islands of this habitat. Scattered permanent, seasonal, and ephemeral wetlands are also found on the flood plain proper. Many of these habitats are highly productive in food and cover vegetation. A variety of wildlife species utilizes them.

Bottomland forests are primarily confined to the unprotected flood plain and low, poorly drained areas behind levees. Fauna native to the region inhabit these wooded areas. Some of these species are furbearers which are commercially important. Moreover, the navigation pools are part of a major flyway for migrating waterfowl.

A total of 416 species and subspecies of vertebrate animals other than fish have been recorded in the navigation pools. These species and subspecies are composed of 49 mammals, 286 birds, and 81 reptiles and amphibians. In terms of total faunal diversity, flood plain forests, backwaters, wetlands, and old fields are the most invaluable habitats.

Open River. The open river community, like the pools, has two habitats: (1) aquatic, and (2) terrestrial. The open river differs substantially from the pooled segment because of: (1).a higher turbidity; (2) higher current; (3) greater fluctuations in water levels; (4) pollution in the St. Louis region; and (5) differences in methods used to provide the navigation channel.

Aquatic habitat. The three subtypes in this habitat are: (1) the main channel, (2) the main channel border, and (3) side channels. These habitats are important for fish because they may provide nursery areas which are scarce in the open river.

Terrestrial habitat. The six subtypes composing this habitat are: (1) agricultural fields; (2) bottomlands forests; (3) old fields; (4) sand bars; (5) mud flats; and (6) wetlands.

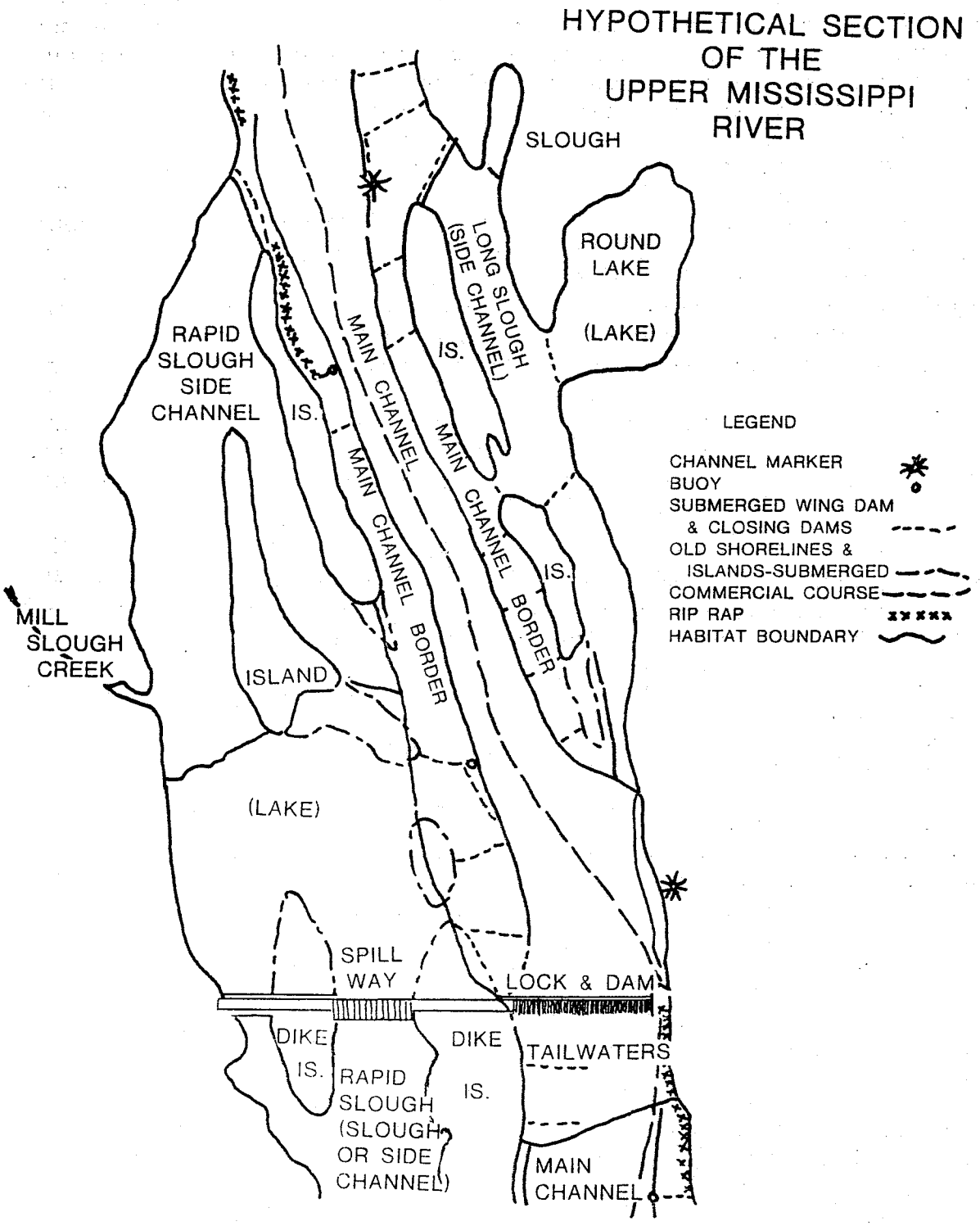

HYPOTHETICAL SECTION
OF THE
UPPER MISSISSIPPI
RIVER
SLOUGH
ROUND
LAKE
(LAKE)
LONG SLOUGH
(SIDE CHANNEL)
IS.
RAPID
SLOUGH
SIDE
CHANNEL
IS.
MAIN CHANNEL
MAIN CHANNEL BORDER
MAIN CHANNEL BORDER
IS.
MILL
SLOUGH
CREEK
ISLAND
(LAKE)
SPILL
WAY
LOCK & DAM
DIKE
IS.
DIKE
IS.
TAILWATERS
RAPID
SLOUGH
(SLOUGH
OR SIDE
CHANNEL)
MAIN
CHANNEL
LEGEND
CHANNEL MARKER
BUOY
SUBMERGED WING DAM
& CLOSING DAMS
OLD SHORELINES &
ISLANDS-SUBMERGED
COMMERCIAL COURSE
RIP RAP
HABITAT BOUNDARY

FIGURE 4

The open river flood plain is reported to be inhabited by more than 300 naturally occurring plant species and utilized by more than 310 animal species.

Endangered Species. Plant and animal species designated threatened or endangered are: the Higgin's eye pearly mussel, the bald eagle, the peregrine falcon, and the gray and Indiana bats. The status of these species and their habitats in the two biotic communities has not as yet been determined. The States of Illinois and Missouri also maintain lists which identify other endangered species.

Flood Plain Management

Flood plain management has evolved as a response to the ever increasing costs of flood damages. Presently, flood plain management in the region is emerging and needs to be further developed and utilized. The information about flood plains lacks information about the location of many parameters such as drainage outlets, land use types, mineral resources, types of water uses, and land ownership. Moreover, hydraulic and hydrologic data about flood plain delineation and groundwater resources have to be more fully developed.

Presently, Federal, state, and local agencies are interested in flood plain management, resulting in a variety of studies and regulations. Coordination of flood plain management activities is not well-executed and could be improved.

State regulations differ between Illinois and Missouri. The latter lacks comprehensive management legislation for flood plains. A referendum is required to plan and zone in third and fourth class counties. In Illinois, flood plain planning and zoning authorities rest in the Rivers, Lakes and Streams Act of 10 June 1911, as amended, which authorized the Department of Transportation to issue permits dealing with encroachments on and obstructions of public waters. Specifically, Section 65f requires flood plain mapping and subsequent regulation to avoid increasing flood damages. The two states have signed a joint agreement to coordinate flood plain management activities.

Socioeconomic Characteristics

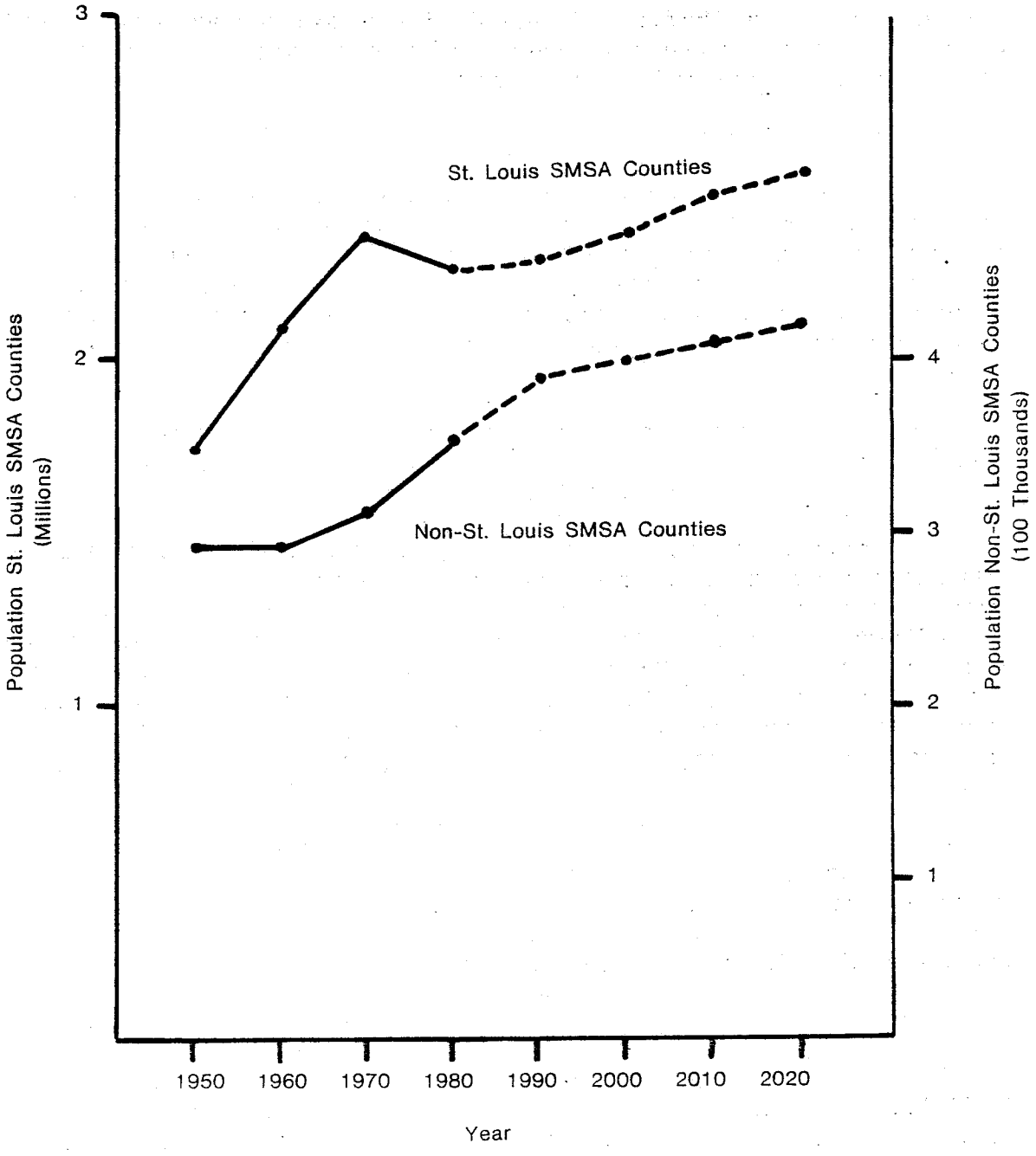
The socioeconomic profile shows that the first tier of counties on either side of the river are socially and economically similar to neighboring counties. Differences between the St. Louis Standard Metropolitan Statistical Area (SMSA) counties and non-SMSA counties of GREAT III, however, are quite marked.

Population

The 1980 population of the region, based on Bureau of the Census estimates, was 2,602,050. This figure represents a 1.3 percent decrease from the 1970 total of 2,637,443. Approximately 89 percent of the total population is concentrated in the St. Louis SMSA. The city of St. Louis lost 27 percent of its population between 1970 and 1980. The Missouri SMSA counties, however, experienced a 10 percent population growth, suggesting an internal shift of population in the St. Louis Metropolitan Area, rather than a mass migration out of the area. The population of the non-SMSA counties in the study area increased approximately 13 percent between 1970 and 1980. FIGURE 5 presents historical and projected population totals for the region based on the 1980 Obers BEA Regional Projections, Volumes 3 and 7.

Historical and Projected Population

Great III Study Area Counties



Historical Figures, U.S. Department of Commerce Bureau of the Census

Projected Figures

Figure 5

Economic Activities and Employment

The region is a major transportation center, because it is bisected by the main national north-south water transportation artery and traversed by numerous railroad and highway facilities. Its strategic location and the intermodal transportation network have provided the impetus for developing an extensive and intensive industrial, commercial, and transportation infrastructure. All of these conditions have led to making the Port of Metropolitan St. Louis the nation's largest inland port in terms of tonnages.

The region contains a large, diverse labor supply. Its location in regard to its ability to serve domestic and foreign markets, the waterway system, readily available mineral and agricultural resources, and numerous other factors have made the St. Louis SMSA the fifth largest corporate headquarters in the United States for domestic and multinational firms. It is also a major manufacturing center, generating and receiving substantial amounts of domestic and foreign commodities by utilization of the inland waterway system. Recreation, tourism and resource utilization also represent additional economic activity.

Employment in the transportation and wholesale sectors is relatively greater than their national mix. Manufacturing of aircraft, automobiles, iron and steel shoes, textiles, oil refining, chemicals, and the processing of agricultural commodities and metal products play major roles. Employment in the agricultural, forestry, and fisheries, and mining sectors is relatively less than that of the nation. These data reemphasize the importance of transportation activities in the region's economic well-being.

Manufacturing and industrial markets in Illinois and Missouri are well diversified in regard to the major standard industrial classification (SIC) groups. This economic strength is aided by its situation in the middle of a 20-state industrial area which is growing more rapidly than the national average. Although industrial activities have grown in this 20-state industrial region and along the inland waterway system, this is not the case for the GREAT III region. A comparison of various socioeconomic indicators of the region with the states of Missouri and Illinois and the Nation indicates that in almost all categories, the area is socioeconomically not keeping pace with the two states or the nation.

There are many Federal, state, county, municipal, regional, and private agencies charged with the responsibilities for planning and implementing industrial and economic development. Often little or no coordination exists between these organizations. All levels of Government and private industry have committed staff and budgets to maximizing the usage of available resources into economic and employment gains.

Water Transportation

Historically, water transportation has been a key factor in the development of the area's economic strengths. The full potential of the Port of Metropolitan St. Louis has not been realized as yet.

The volume of commodities carried on the GREAT III reach has grown from about two million tons in 1940 to approximately 70 million tons in 1980, a 3,276 percent increase. (See FIGURE 6.) The large capacity of barge transportation has made this growth possible. Adjacent to the navigation channel, fleeting areas and terminals have been developed to accommodate barges and the transfer of cargoes to other modes of transportation. During peak periods, however, the present Locks and Dam No. 26 situation causes delays of several days to commercial traffic. The Inland Waterways Authorization Act of 1978 (P.L. 95-502) has authorized the construction of a new dam and a single, 1,200' x 110' lock. This law also contains provisions for studying future expansion. Construction of this project was started in the fall of 1979 and should be in operation by winter 1987. Moreover, there are legal and institutional constraints, and growing competition for land and water resources by environmental, recreational, and industrial interests. This competition affects efficiency and safety of water transportation. Conflicting economic and environmental factors need to be balanced so that steady economic development can proceed while sound and reasonable environmental policies are pursued.

Social Well-Being

Income, poverty levels, housing quality, and unemployment rates relate to people's well-being. These indicators are shown in TABLE 4.

TABLE 4
Social Well-Being

Indicator	SMSA	Non-SMSA Counties	United States
Income (median family income)	$10,503	$7,504	$9,589
Poverty (percent families below poverty line, 1969)	8.1	15.9	10.7
Housing Quality (percent homes without all plumbing)	3.6	12.5	5.5
Unemployment (unemployment rate, 1970)	4.9	4.4	4.4
Migration (Net migration rate 1960-1970)	.8	−1.6	-

Source: US Census of Population, 1970.

LOCKAGES AND TONNAGES

LOCKS AND DAM NO. 26

1940-1980

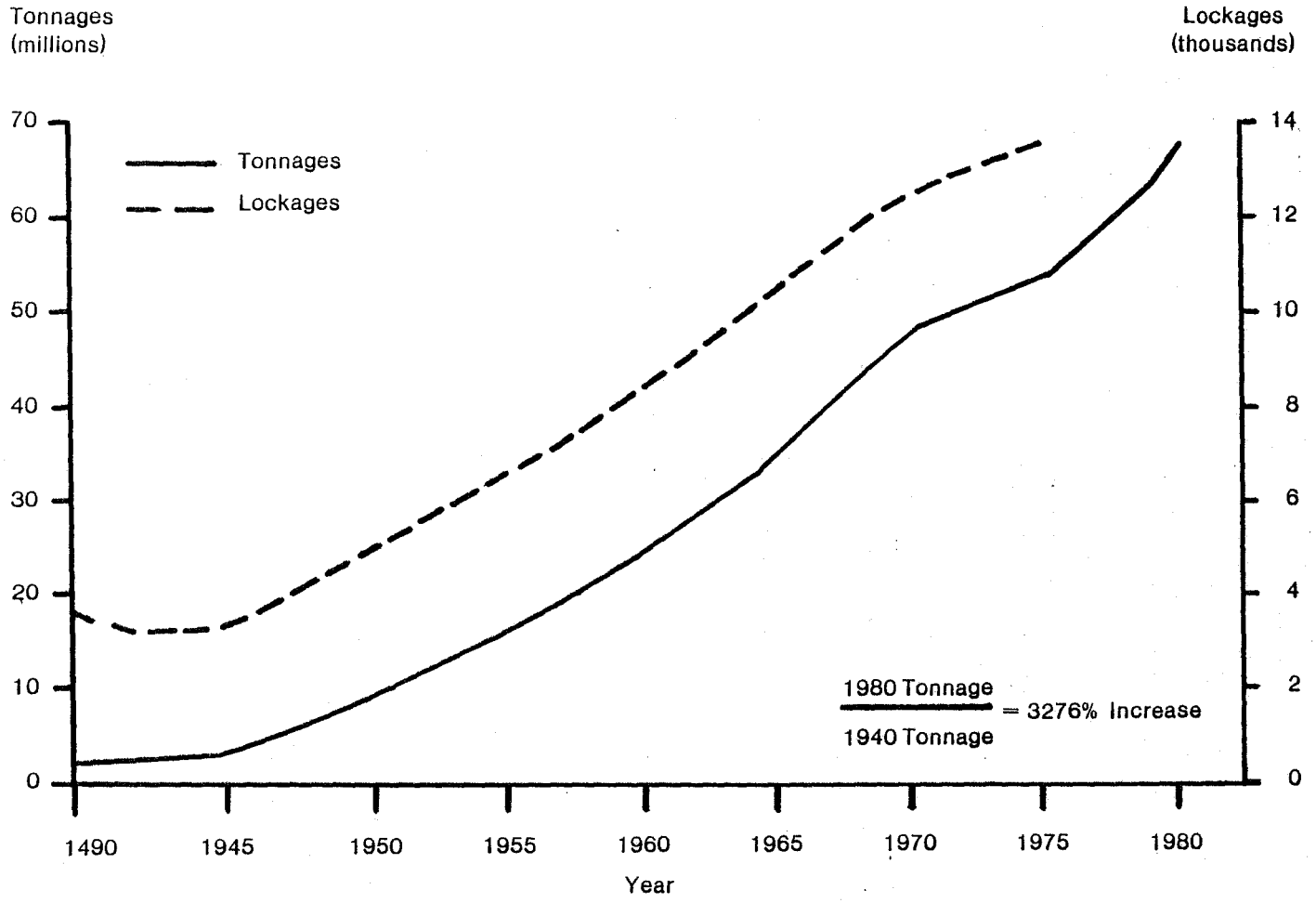


Figure 6

Recreation

The Mississippi River, a large and diverse area capable of satisfying many recreation needs, is an important recreational resource. In recent years the demand for outdoor recreation has increased. Some popular forms of outdoor recreational activities are bicycling, bird watching, camping, fishing, hiking, hunting, power boating, sailing, sightseeing, swimming, and water skiing.

Public access to the navigation pools is generally limited to dispersed Federally-owned shoreline lands, located predominantly in the lower reaches of the pools. The Corps of Engineers, the US Fish and Wildlife Service, and the Illinois and Missouri Departments of Conservation have developed public access areas and facilities adjacent to the navigation pools. There are a number of commercial concessions and marinas offering public access and service, some of which are on privately-owned lands.

Opportunities for public access in the open river reach are limited due to private ownership of the shoreline and intervening lands between the highways, railroad tracks, and the river. The most visual identification with the river below St. Louis occurs at bridge crossings and at river communities. Most of the public land that is available in this reach is located in state parks, state conservation areas, and US Forest Service lands. Roadside parks, points of interest, and city parks comprise a minor amount of the total acreage. Fuel stops for transient recreation craft along this reach are extremely limited, forcing most craft to carry extra fuel and provisions.

Regardless of the constraints on the use of the river and related land resources, the existing recreational resources and the cooperative efforts among governmental agencies and private enterprise combine to provide an opportunity to experience the diversity of the river's recreational, natural, cultural, and historic values.

Specific examples of areas with high recreation potentials are: (1) the confluences with major tributaries - the Illinois, the Missouri, the Meramec and the Kaskaskia Rivers; (2) major islands such as Clarksville and Mosenthein Islands; (3) scenic bluff or river hills areas, e.g. Alton Bluffs, Fountain Bluff, and Grand Tower in Illinois, and the river hills at Clarksville and Louisiana in Missouri; and (4) unique natural areas.

None of the Federal or state agencies dealing with outdoor recreation have more than a partial authority for planning and management of the recreational resources. Coordination of planning has been haphazard at best and nonexistent in many cases. There is no accepted standardized system of collecting recreation use data for the river corridor which impedes the coordination of activities.

Cultural Resources

The region has a long and complex cultural history. People have moved into the area for about 14,000 years. They took advantage of the fertile flood plain and the great variety of available resources.

Seven time periods of settlement have been discerned. These are: (1) Early Man (20,000 - 12,000 B.C. or earlier) - Hunting and gathering characterized this era; (2) Paleo-Indian (12,000 - 8,000 B.C.) - During this period small subsistence bands or family groups of hunter and gatherers were organized; (3) Dalton (8,000 - 7,000 B.C.) - This was a transitional period between Paleo-Indian and Archaic times with a shift from hunting to a greater emphasis on foraging; (4) Archaic (7,000 - 1,000 B.C.) - In this period subsistence patterns became more diversified and special purpose tools of stone were developed; (5) Woodland (1,000 B.C. - 900 A.D.) - Population increases, improved agricultural practices, sedentary settlements, complex social and religious practices, and trade relations developed during this millennium; (6) Mississippian (900 - 1700 A.D.) - The high point of this culture occurred between 1200 and 1500 A.D. when Cahokia, the largest North American prehistoric site, functioned as an urban center; and (7) Historic (1700 A.D. to the present) - Numerous Indian groups occupied and traversed the region. Europeans settled in the valley and settlers founded cities such as St. Louis, Ste. Genevieve, Cape Girardeau, towns and farming communities.

About 6,700 prehistoric and historic sites are known to exist in the study area, which also contains 65 archaeological and historic districts on the National Register. Prehistoric intensively utilized or occupied areas so far identified are: (1) confluences of the Mississippi with major tributaries such as the Illinois, Salt, Missouri, Meramec, and Kaskaskia Rivers; (2) sand ridges and terraces in the Mississippi flood plain; and (3) bluffs and their slopes.

Land Use

Navigation Pools. Over 60 percent of the land in this area is used for agricultural endeavors. Along the three pools, farming occurs on the flood plains, adjacent uplands, and some of the larger islands. Farming activities have substantially altered the natural environment by causing erosion of steep slopes, the destruction of forests, and the construction of levee and drainage systems. Forests account for about 20 percent of the land use. Wooded areas are mainly found on land with physical restrictions for farming such as low-lying lands in the flood plain, ditches, steep slopes, and around lakes.

Publicly owned and administered lands are primarily confined to low-lying parts of the flood plain along the banks of the pools, and some of the islands. The US Fish and Wildlife Service and the Illinois and Missouri Departments of Conservation manage much of this land for fish and wildlife refuge and outdoor recreational purposes.

Although urban land use is very noticeable, its percentage of the total land use is considerably less than that used for agriculture or in forests. Except for Alton, Illinois, the urban-type developments are small in size and population. These small towns, which are regularly spaced along the river and in the transition zone between the upland and the flood plain and provide services for the surrounding farming communities.

Open River. In the open river reach, there are nearly 78,000 acres of flood plain, of which 34,800 acres are used for farming. Other major land use categories are lakes and wetlands, forests, and urban developments.

Agriculture is practiced on the flood plain and many of the larger islands. Farmers cleared forests to obtain fields and constructed levees to protect them. Levee construction has led to the present flood protection and surface drainage systems which now provide for a complex pattern of agricultural, transportational, industrial, and residential needs. Woodlands remain in low-lying areas susceptible to periodic flooding. They occur along streams and lakes, in wetlands and side channels, and on the flood plain and islands. Backswamps and lakes on the flood plain are widely scattered. Lakes are also found in closed side channels or chutes.

Urban land makes up only a small percentage of total land use. Urban centers include the St. Louis SMSA in Illinois and Missouri, Ste. Genevieve and Cape Girardeau, Missouri, and Chester, Illinois. Smaller river communities are Herculaneum and Commerce, Missouri, and Prairie de Rocher, Grand Tower and Thebes, Illinois.

As private ownership of riverbanks and intervening lands between highways, railroad tracks, and the river limits public access, recreational land use accounts for a very small percentage in this reach. Hunting for ducks, geese, and small game; fishing; and trapping occur on islands and in side channels.

Institutions

Institutional, management, and legal frameworks and their relationships in regard to the use of the Mississippi and adjoining lands were not investigated by GREAT III. Neither funding nor time was available to perform the necessary studies. All study participants, however, recognized the importance of institutional analyses necessary to enhance management procedures for the river's resources. The UMRBC Master Plan did address institutional arrangements for the entire Upper Mississippi River Basin and it was determined that existing institutional arrangements will meet resource management needs. The Corps of Engineers, US Coast Guard, and US Fish and Wildlife Service; the Illinois Departments of Conservation and Transportation - Division of Water Resources, and Environmental Protection Agency; and the Missouri Departments of Conservation and Natural Resources, have major authorized management responsibilities for channel maintenance, environmental, cultural, and recreational resources, and public safety for the river and Federally and state owned and administered lands.

A "General Plan and Cooperative Agreement" between the Corps of Engineers, the US Fish and Wildlife Service, and the two state Departments of Conservation is the basis by which land and water areas acquired for the navigation project are managed for fish and wildlife habitat and recreation. Formal and informal arrangements and procedures aid in coordinating and managing many of the other needs and activities engendered in the use of this river.

FUTURE CONDITIONS

The future condition that will most likely happen without changing existing programs for resource management is termed the "most probable future." It provides the framework used to define the "without condition," the condition that is anticipated to prevail in the absence of a plan for resource management through the period of analysis: the year 2000. The assumptions made when determining future trends were: (1) continued growth of waterborne commerce; (2) continued enforcement of flood plain management and protection of wetlands; and (3) an ongoing flood plain insurance program. A description of the "without condition" is presented categorized by the principal topics investigated.

Commercial Transportation

River navigation will continue to help meet the nation's transportation needs safely and economically. While the volume of barge traffic is expected to increase, the sizes of barge tows are not expected to change. The number of double hull barges may increase, and therefore the possibility of cargo spills could be reduced. The numbers of terminals, docking facilities, and fleeting areas are not anticipated to grow at a corresponding rate with the expected growth in traffic. It is foreseen that better utilization of existing facilities will probably be stressed rather than construction of new developments. Continued environmental objections to adequate channel maintenance may inhibit the growth and safety of commercial navigation. Locks with insufficient capacity and restrictive bridges may remain impediments to navigation. Future political decisions and developments could affect the rate of growth of barge movements.

Cultural Resources

It may continue to be difficult to systematically coordinate cultural resource planning and management practices. This could impede compliance with several Federal laws and regulations.

Moreover, conflicts which often arise between developers and preservationists when cultural resources are threatened will probably continue, which could result in hurried decisions to protect or at least minimally disturb cultural resources.

Dredging and Dredged Material Uses

Dredging will continue to be required to maintain the authorized navigation project. While some adverse impacts of dredging may be reduced by implementation of the recommendations presented in the recently completed Dredged Material Research Program directed by WES, all real and perceived adverse effects to other river resources may not be totally eliminated.

Section 404(t) of the Clean Water Act gave states the authority to impose their own permit programs and other requirements. Depending on the programs and requirements passed by the States of Illinois and Missouri, additional constraints on the COE maintenance dredging program may generate new problems. In the future, some dredged material may be classified as "hazardous solid waste" which may require COE compliance with the provisions of the Resource Conservation and Recovery Act of 1976. It was concluded in the GREAT III water quality study regarding dredged sediments that maintenance dredging and disposal of main channel sediments, as presently practiced by the Corps of Engineers, is not a significant water quality problem.

Recommendations made at the completion of the Industry Capability Program and the COE Minimum Dredge Fleet Studies may result in increased delays to commercial transportation when channel closures occur and alter the operations and maintenance programs.

Erosion and Sediment

Erosion and sedimentation are expected to remain at present levels. If the pools are operated in the present-day manner for the next 50 years, and if the sediment load to the study reach remains essentially unchanged, the following geomorphic changes can be expected to occur: (1) the riverbed in Pool 24 will degrade approximately 1.5 feet overall; (2) Pool 25 will degrade 3.0 feet immediately upstream of the control point and remain unchanged in the lower portion; and (3) Pool 26 will degrade between 6 and 7 feet immediately downstream of Lock and Dam No. 25 and will aggrade approximately 2.5 feet in the middle and near Locks and Dam No. 26. Construction of Clarence Cannon Dam will significantly reduce sedimentation outflow of the Salt River Basin.

Fish and Wildlife

If present conditions persist, wildlife and fisheries habitats may continue to decline. Valuable fish spawning and nursery areas could be lost. Riparian borders may be modified and the number and size of productive wetlands could continue to decline. Development in the flood plain may continue, resulting in increased demands for flood protection and subsequent losses of habitat. Navigation and navigation channel developments may proceed in a manner which is detrimental to fish and wildlife resources.

Provisions exist within present authorizations by which significant losses in fish and wildlife resources may be lessened. However, because most losses result from the cumulative effects of many actions, it will remain difficult to predict the effect of a single action.

Flood Plain Management

The fragmented activities of agencies may diminish as coordination of programs and flood plain mapping and resource inventories are completed. The Illinois and Missouri interstate agreement and resultant coordination may reduce interagency and interstate conflicts about flood plain activities. Costs attributable to flood damages could subsequently be decreasing.

Industrial and Economic Development

People will continue to demand increases in industrial and economic growth. Future industrial activities will be influenced by governmental policies and decisions about energy production and consumption, national transportation, environmental elements, and foreign trade.

If economically possible, private enterprise will continue to meet the needs of the marketplace. Industrial and financial institutions will hesitate to make investments without assurances that Federal, state and local governments will continue to finance and construct infrastructural projects required to support industrial and commercial developments. Environmental and regulatory constraints may continue to require industry to prove that all regulations are met. This burden of proof is expensive and time-consuming, and therefore may impede developments and economic growth.

Congress has enacted a waterway user charge which will increase future operating costs of the barge industry. Although the effect that this law will have is uncertain, indications are that it could have a significant effect on employment depending on the magnitude of cost recovery prescribed.

The availability of waterfront land for industrial and economic development will continue to be a concern.

Recreation

An increased demand for outdoor recreation is expected. Conversion of parts of the river, riverbank, flood plains, backwaters, bluffs, and hills for agricultural, residential, industrial, and transportation uses may continue to preempt lands with potentials for recreation. These conversions may also degrade the scenic quality of the river corridor and possibly the air and water quality which could diminish the recreational experience.

The abundance of fish and wildlife habitats may also affect some recreation opportunities. Lack of access to many parts of the river and the absence of public lands along the open river will make it difficult to meet some recreational needs.

Conflicts among different recreational uses and conflicts between commercial navigation and recreation may continue. Based on projections of increases in boating activity, the probability of boating accidents could increase. However, recent evidence indicates a downward trend in accident rates. Expanded state enforcement and education programs are expected to reduce overall accident rates, losses of life, and property damages significantly within the next 20 years if enforcement and education capability correspond to the growth in recreational activities.

Regulating Structures

Continued progress on the development of a dependable navigation channel by present design criteria is anticipated. Further study could provide the basis for revised teria and guidelines which would incorporate considerations of other resources.

Water Quality

The lack of a comprehensive water quality overview of the Upper Mississippi River, which would put major pollutants and water quality processes into perspective, makes sound water quality management decisions difficult. Water quality conditions will continue as present with the following changes: (1) the production and domestic use of certain toxic compounds found frequently in the Mississippi River, its sediments, and biota will have been curtailed; and (2) the use of PCB's and chlorinated hydrocarbon insecticides will have been reduced; hence, future levels of these compounds in the aquatic environment will also decline.

The present need for information to make sound water quality management decisions may be aggravated in the future by: (1) a profusion of new chemicals appearing in wastewater discharges; (2) a decline in water quality which would make information deficiencies more critical than at the present; and (3) the importance of the Mississippi River as a natural resource, thereby enhancing the need for water quality management.

TECHNICAL STUDY ABSTRACTS

A major purpose of this report is to document accomplishments of the study. This section contains abstracts from studies conducted by contractors specifically retained for the GREAT III Study. Copies of these studies are available from the National Technical Information Service (NTIS) Springfield, Virginia 22161.

Contract studies were based upon scopes of work developed by the work groups and reviewed by the GREAT III Team. SLD served as the contracting agent for these studies, and lead agencies, represented by technical work group chairmen, provided reviews and coordinated comments.

Abstracts contained herein are presented in the following order:

Study Abstract	Lead Work Group(s) and Contractor
Influence of Channel Regulating Structures on Fish and Wildlife Habitat	Regulating Structures, and Fish and Wildlife - University of Missouri at Rolla (Institute for River Studies)
Navigation and Industrial Forecast, Needs Analysis, and Recommendations	Commercial Transportation, and Industrial and Economic Development - Kearney Management Consultants
Sediment Gaging	Erosion and Sediment - Illinois and Missouri US Geological Surveys
Erosion and Sediment Inventory Report	Erosion and Sediment - US Department of Agriculture, Soil Conservation Service
Quantifying Bank Erosion and Flood Plain Scour (Minor Sediment Sources)	Erosion and Sediment - University of Missouri at Rolla (Institute for River Studies
Recreation and Natural Area Needs Assessment	Recreation - Oblinger-McCaleb Architects, Engineers and Planners
Refinement and Verification of Predictive Models of Suspended Sediment Dispersion and Desorption of Toxics from Dredged Sediments	Water Quality - University of Iowa (Institute of Hydraulic Research)
Ecological and Habitat Characterization	Fish and Wildlife - Environmental Science and Engineers
Cultural Resource Inventory	Cultural Resources - Environmental Research Center of Missouri

STUDY ABSTRACT

Influence of Channel Regulating Structures On Fish and Wildlife Habitat

Introduction. The Army Corps of Engineers is charged by the Congress to provide and maintain channels to sustain the requirements of commercial river transportation. In carrying out this mandate, the Corps has constructed a system of river control structures. Under the Water Resources Development Act of 1976 (P.L. 94-587) the Corps has been authorized to study problems such as the one addressed herein. With this in mind, the Regulating Structures and Fish and Wildlife Work Groups of the Great River Resource Management Study determined that a study was warranted as a means of establishing the extent of effect that stabilization of the Middle Mississippi River has had on fish habitat. This is a formidable task which was made more difficult by lack of historical data on fish habitat and water quality. Because of this deficiency and in order to arrive at meaningful conclusions within the constraints of limited time and resources, the study focused on measuring existing conditions and fish habitat around a selected group of river control structures. Therefore, prototype data was collected at dikes of varying design and location. Such data was subsequently used to determine specifics in regard to the fish habitat that exists around each type of dike analyzed.

Purpose. The purpose of this study was two-fold: (1) to evaluate aquatic habitat diversity, accretion patterns, flow patterns, and bed material gradation existing around in-place channel regulating structures at different locations and of varying design; and (2) to recommend, where possible, data needs and structure modifications which will maintain or improve existing fish and wildlife habitat while preserving the geometry needed to maintain an acceptable navigation channel.

Engineering Study. Eight dikes located within the reach of the Middle Mississippi River between river miles 95 and 115 were selected for intensive study. Five of the eight structures are located on the left bank (114.0L, 113.9L, 113.5L, 103.2L, 102.2L) and three on the right bank (103.3R, 100.1R, 98.9R). River stage, velocity, bed configuration, and sediment data were collected downstream of each of these eight dikes four different times within a 140-day study period. Available low water stage aerial photographs of the study area were analyzed for changes in water surface area and wetted edge downstream of the dikes.

Biological Study. The species composition and abundance of fish and aquatic macroinvertebrates at eight rock dikes of different design (including five notched dikes) listed above were studied. Data on fishes were obtained by electrofishing and with nets. In addition, measures of water quality were monitored and qualitative observations of wildlife were recorded during the study. A literature review of the effects of channel regulating structure design on fish and wildlife and their habitat was also conducted.

Summary and Recommendations. The samples collected during this study indicate that the bed material downstream of notched structures contains a higher percentage of sand than the material downstream of an unmodified structure. The addition of a trail to one notched structure studied indicated trails may reduce the amount of sand in the bed downstream of the structure. As a result, this is a parameter that should be investigated further.

The suspended sediment samples collected during this 140-day study show that the suspended sediment concentration has been greatly reduced as compared to 1937 data. This would indicate a potential decrease in the rate of land accretion around regulating structures, thus indicating a potential decrease in the rate of loss of fish and wildlife habitat.

Water surface area and wetted edge data obtained from the four study areas were analyzed. Three of the four areas had a loss rate between 1970 and 1980 that was less than the rate between 1965 and 1970.

The location of a structure, with respect to the thalweg, appears to influence the type and rate of deposit of land accretion associated with regulating structures more than type or location of modification.

The point velocity data collected during this study indicates that there is a correlation between the flow pattern downstream of regulating structures and the type of accreted material and accretion pattern.

Diversity of both fish and aquatic macroinvertebrate communities was found to be greater at notched dikes than at unnotched dikes. This was due to the greater variety of habitats created below notched structures. Suitable habitat was available to more species. In addition, the length-frequency analyses of fish showed that the dissimilar habitat conditions at conventional and modified structures suited different life stages of fish. Selective modification of channel regulating structures in the Middle Mississippi River would make additional diverse habitats available to greater numbers of the resident fauna.

Fish abundance at conventional modified dikes was not shown to be significantly different; however, aquatic macroinvertebrates were more abundant at notched dikes. The similar catch rates of fish at each type of dike are not surprising during a year of high water in a large, open river system in which many of the species are extremely mobile. Future research should be directed towards species of fish (e.g., gizzard shad, carp, bigmouth buffalo, channel catfish, blue catfish, flathead catfish, and freshwater drum) that are especially important to the recreational and commercial fisheries.

Integrated, long-term, physical and biological studies of channel regulating structures in the Middle Mississippi River should be conducted to gain a better understanding of the relationship between this habitat and its inhabitants. Future research should attempt to subdivide the habitat at a dike (e.g., dike tip, dike proper, size of rock, pilings, notch, scour hole below a notch, trail dike, revetment, sand shoreline, mud shoreline, etc.) and determine the value of each subhabitat to the fishery. Future dike construction and maintenance work could then accommodate desirable subhabitats.

The previous findings appear to justify the extension of this investigation into a second phase. This seems warranted in light of the fact that many serious questions remain in regard to the impact of structures on fish and wildlife habitat. It is believed by the investigators that a second phase of effort might result in the elimination of some questions and assumptions which could not be addressed in this effort.

Long-term trends cannot be established without further investigation. The response of the system to the yearly hydrograph is needed and can be determined with yearly visits over a period of time.

STUDY ABSTRACT

Navigation and Industrial Forecast, Needs Analysis, and Recommendations

This combined study by the Commercial Transportation (CTWG) and the Industrial and Economic Development (IEDWG) Work Groups was conducted by A. T. Kearney, Inc. under contract with the St. Louis District Corps of Engineers. The overall objective was to generate navigation and industrial forecasts; to identify physical, institutional, and regulatory constraints to barge traffic and related economic development; to translate these constraints into needs and analyze their impact; and to recommend actions that will alleviate the constraints and fill the needs.

The study involved the development of inventories for terminal facilities, fleeting areas, and land available for river-related economic development. In order to identify constraints and analyze needs, the study developed several forecasts of future commercial use of the Mississippi River, including baseline, low, and high use projections, with and without rail mergers, and increased waterway user fees.

Using information from the inventories and commodity forecast (to the year 2000), a constraint analysis, impact assessment and evaluation were performed on the following variables: channel capacity, bridges, locks, fleeting, terminals, other navigational considerations, and regulatory and legal matters.

The study also produced maps of the GREAT III area showing docks, fleeting areas, flood plain boundaries, recommended development sites, and the categorization of land, i.e., cities, farms, conservation areas, government workshop, parks, vegetation, and wetlands. These maps are on file at the St. Louis District, Corps of Engineers.

Based on the above described analysis, this contract study generated the following conclusions and recommendations.

Inventories. Data base discrepancies, in waterborne commerce data and the status and location of terminals, make analysis and consequent effective management of the navigation system difficult.

Recommendation:

It is recommended that the Corps update and monitor its permit system to a level of accuracy that at least identifies facilities (including fleeting areas). The Corps should consider requiring permit holders to keep them informed of their current responsible officer or agent.

Channels. Channels in the GREAT III study area are not expected to constrain traffic growth. Some existing hazards to navigation are the result of natural conditions, inadequate maintenance in some areas, and sunken barges in others. Although the reliability of channel markings has improved markedly in recent years, further improvement in reliability is desirable and additional markings are needed at some locations.

Recommendation:

1. It is recommended that Congress provide adequate funding for the required maintenance of channels, including both dredging and river training works. The Corps should consider either increasing the frequency of dredging or increasing overdraft dredging of sites where pilots have reported problems.

2. Adequate funding should be insured for maintenance of channel markers and buoys. The Coast Guard should evaluate the need for additional channel markers at the known hazardous sites.

3. The Corps should strictly enforce existing regulations (Sections 15, 16, 19, and 20 of the Rivers and Harbors Act of 1899), requiring the owners of all sunken commercial vessels and barges to remove them routinely. Where the owners cannot be located or forced to remove them, specific funding should be sought for removal at Federal expense.

Bridges. Bridges in the GREAT III study area create safety problems for commercial traffic but will not constrain traffic during the time horizon of the study. Many bridges in the study area are hazardous for navigation and are sites of frequent marine casualties. The physical settings of bridges contribute to problems at some locations, and narrow horizontal clearances, particularly at movable bridges, impose one way traffic restrictions. These constrictions in turn create occasional delays and additional hazards in passing through the bridges. Late openings by bridge operators also create hazards.

Recommendation:

It is recommended that movable bridges be left open for the free passage of tows unless the frequency of train traffic exceeds the frequency of barges and other vessels. The Coast Guard should immediately review with the bridge owner the operation of the Louisiana Railroad Bridge, operated by the Illinois Central Gulf Railroad, to determine the feasibility of leaving it open.

Locks. Lock and Dam No. 26 will constrain future growth of waterborne commerce in the study area, even after the new single 110' x 1,200' chamber currently under construction is completed. According to UMRBC analysis, constraint will occur in 1995. The National Waterways Study predicts a constraint in 1990.

Lock and Dam No. 25 will constrain the growth of waterborne commerce late in the study period, according to the UMRBC Master Plan analysis. However, this lock constraint will be effective only if additional capacity is added at both Lock and Dam No. 26 and Lock and Dam No. 22.

Recommendation:

1. It is recommended that Congress accept the recommendation of the UMRBC Master Plan for a second chamber at the new site of Lock and Dam No. 26 and provide adequate funding for the completion of all construction on a timely basis in order to accommodate projected traffic.

2. Dam No. 25 should be reexamined in detail in 5 years by the Corps to verify the need for additional capacity. The Corps should adopt an active program of nonstructural and minor structural maintenance at all locks, as appropriate, to improve operating efficiency, particularly during peak periods.

Terminals. A need for additional terminal capacity for four major commodity groups is expected to occur by the end of the study period. Higher user charges on the inland waterways and/or mergers of key railroads will probably reduce this need somewhat. Nevertheless, even under the most pessimistic combination of scenarios, shippers are expected to construct additional terminal capacity.

Recommendation:

1. It is recommended that local port authorities and development agencies continue to develop programs to promote port expansion, including the funding of necessary infrastructure improvements for preferred industrial sites and to insure the timely identification and resolution of other problems impeding growth.

2. Federal, state and local agencies should seek closer consultation to insure that valid concerns are dealt with early in the development process.

Fleeting. A lack of fleeting space is a localized problem rather an an areawide problem. Most sub-reaches of the study area subjected to analysis will have adequate fleeting capacity in the foreseeable future. One sub-reach, from Locks 27 to mile 136, will experience a substantial shortfall of fleeting capacity by the end of the study period. Whether additional capacity is provided by increasing utilization of existing facilities or by adding capacity, the cost to users is expected to increase.

Recommendation:

It is recommended that local agencies develop an inventory of potential fleeting sites in the areas where problems are expected, and take steps to insure their availability in the future. These steps could range from zoning, to obtaining options, to outright acquisition. The cooperation of Federal agencies should be sought in resolving regulatory problems for these sites in advance of needs.

Regulatory Constraints. Numerous instances of delay, additional cost, and confusion were found. In general, those private interests who initiated their applications early in the development planning process and maintained continuous liaison with the various public agencies and other affected groups, fared better in completing their projects on schedule.

While individual regulatory requirements may seem to serve sound public purposes, overlapping and redundant regulatory requirements were found. The permit requirements of the state of Illinois were singled out by survey respondents as being particularly onerous and serving purposes already served by Federal requirements.

The number of requirements, in itself, is a major source of confusion resulting in uncertainty and additional delay. The situation is expected to continue in the future, making it more difficult to develop river-related growth opportunities. At the same time, valid regulatory objectives are served less effectively than they could otherwise be served.

Regulatory bodies have a responsibility to disseminate timely and accurate information about requirements and procedures for obtaining permits. Moreover, Federal, state, and local authorities should be explicit about the criteria used in applying their laws, and be consistent in their administration.

Recommendation:

It is recommended that local development agencies provide informational packets to potential industrial candidates cataloging all laws and rules affecting development in the study area. Such a catalogue would also provide a more complete basis for identifying and eliminating unnecessary laws and regulations. Federal, state, and local laws and rules identified as unnecessary or redundant should be submitted to responsible authorities for action.

Land Availability. Ample supplies of potentially developable land exist in the GREAT III study area. Thirty-four locations with the best potential were identified out of 136 which were screened.

Recommendation:

It is recommended that local development agencies initiate the necessary environmental, archaeological, and flood hazard analyses to insure timely resolution of problems. Sites with significant problems should be removed from the inventory or assigned low development priority. The necessary financing and infrastructure improvements for sites with very good potential should be pursued by local port authorities and development agencies.

STUDY ABSTRACT

Sediment Gaging

Daily suspended sediment concentration and load, particle size analyses of suspended sediment (approximately six samples per year), bed materials grain size classification (monthly samples during open water season), and bedload grain size classification and grain size distribution (approximately three rises per year) were done by the Illinois and Missouri US Geological Surveys from May, 1980 to September, 1981 at the following locations:

Sediment Data Collection Gaging Responsibilities

Illinois	Missouri
Illinois River at Valley City, Ill.	Mississippi River at Alton, Ill.
Big Muddy River at Murphysboro, Ill.	Mississippi River at Chester, Ill.
Kaskaskia River at Venedy Station, Ill.	Mississippi River at Thebes, Ill.
	Salt River near Monroe City, Mo.
	Salt River near New London, Mo.
	Meramec River near Eureka, Mo.
	Saline Creek near Minnith, Mo.

The sampling program was initiated to improve knowledge of sediment transport in the GREAT III study area. Collected data was used in the GREAT III Erosion and Sediment Inventory Report to estimate grain size distribution of sediment yields. Due to drought conditions, that persisted during most of the sampling period, the data was of limited use in estimating yields, or improving delivery ratio curves. Sampling stations established for this study will continue to be used under the auspices of the St. Louis District, Corps of Engineers, and will be of benefit to future data collection and analysis. Data from these stations will be summarized and published by US Geological Survey on a water year basis.

STUDY ABSTRACT

Erosion and Sediment Inventory Report

Erosion and sediment data for the Mississippi River from Saverton, Mo., river mile 303, to Cairo, Ill., river mile 0, and 12 Water Resource Hydrologic Units adjacent to the Mississippi River, was gathered and analyzed. An estimated 67 million tons of annual soil loss from the 12 Water Resource Hydrologic Units accounts for 6 percent of the average annual sediment discharge passing Thebes, Ill., on the Mississippi River. At present, an estimated 115 million tons of sediment on the average annually passes by St. Louis, Mo. The weighted average sediment discharge of the Missouri River at Hermann, Missouri between 1929 and 1952 was 243 million tons. The sediment discharge at Hermann continued to decrease to 70.7 million tons in 1980. However, the sediment discharge at St. Louis has remained fairly constant since 1960. Beginning in 1966 at the Hermann, Mo. river gage, average annual suspended sediment concentration declined while average annual flow rate increased. Since 1960, total water discharge at St. Louis appears to be increasing.

Regression analysis ran on suspended sediment concentration versus flow rate for the stations: Missouri River at Hermann, Mo.; and Mississippi River at Hannibal, Mo. have coefficients of determination (R^2) of 0.50. Untreated and treated analyses for grain size determinations of suspended sediment taken from the Missouri and Mississippi Rivers were significantly different. Specific surface area of sediment samples ranged from 87 to 203 square meters per gram. Surface area determinations using ethylene glycol monoethyl ether (EGME) were not significantly different for treated samples vs. native water samples. Aggregate size distribution measured from native water samples is not useful in computing surface area. Of four chemicals added during water treatment at the St. Louis, Mo., and Alton, Ill. water treatment plants to facilitate filtering and settling of impurities, only ferric sulfate correlated with suspended solids.

The *Recommendations* presented are as follows:

1. Consistent methodology needs to be adopted by scientists attempting to quantify soil loss and sediment transport. Natural water analyses should be run in conjunction with conventional dispersed analyses to determine if correlations exist.

2. Gaging stations need to be distributed from headwaters to stream outlets to monitor physical and chemical changes in sediment.

3. The relative importance of upland sediment sources needs to be determined to maximize sediment reductions per treatment dollar expended.

4. Methodology for computing sediment loads need to be developed to statistically validate published data.

5. Bedload needs to be quantified. Gridded sonic plots should be conducted over time at selected river locations as a means of quantifying bedload transport. Concurrently, sediment samples should be taken to determine the nature of the recorded particles. Analyses should be made that best depict the natural state of the particles.

6. The mechanics of sediment and associated contaminant transport needs to be reevaluated based on natural particle characteristics.

7. In Missouri, install erosion and sediment control measures, land treatment and structural, in the tributary drainage areas to reduce sediment load in the Mississippi River and enhance the life and usefulness of the Clarence Cannon Dam. Prioritization for installation should be based on current planning, applications, and recommendations to be listed in the proposed USDA Salt River Basin report.

8. In Illinois, install erosion and sediment control measures on the Mississippi River and lower Illinois River bluff drainage areas (primarily in Major Land Resource Area 115). This includes parts of hydrologic units 07110004, 07130011, 07130003, 07130012, 07110009, 07140101, and 07140105. The majority of this area is included in the area designated in Illinois as Targeted Area Number 2 for erosion and sediment control.

STUDY ABSTRACT

Quantifying Bank Erosion and Flood Plain Scour (Minor Sediment Sources)

This study attempts to quantify bank erosion and/or fill and flood plain scour and fill as sources of sediment yield within the GREAT III study area. Mapping of the high bank along the entire stretch of the Mississippi under study was the method used to quantify bank erosion and/or fill.

Various methods are available for delineation and mapping of the high bank. The method chosen included a method of resection using a boom stereoscope. A more exact method of delineation and mapping of the bank was prohibited due to costs, availability of equipment, a difference of scale between maps and photos, and the accuracy of existing sediment records.

The results obtained from the method used indicates that there have been only small changes in the bankline location over the 22 years studied. Sensitivity analyses are included in order to show what effect the error incurred in the methodology used may have on results.

STUDY ABSTRACT

Recreation and Natural Area Needs Assessment

Fifty-nine unique geologic or biological communities were identified. The inventory includes location, ownership, type, and significance of each site, along with a map series showing each area. This information is in the "Natural Areas Inventory, 1981" appendix. A "Recreation Area and Facility Inventory, 1981" appendix includes the name, location, and characteristics of recreation sites as well as individualized comments. A map series is included which shows the geographic location of areas and facilities.

Utilizing an on-site interview system, recreation activity for 1981 was measured. It showed 448,400 recreation visitors in 1981. The average size of the recreation party was 2.86 persons. Over 93 percent were repeat users, and 49.4 percent used the river six or more times per year. The vast majority (88.2 percent) arrived by car, truck, or van, while 9.6 percent of the parties were in groups of two or more vehicles. Approximately 81.9 percent of the respondents resided within 50 miles of the recreation sites at which they were interviewed.

The most frequent individual activities were Viewing the River and Loafing/Relaxing, reported by 44.1 percent and 38.5 percent of river users, respectively. Runabout Boating was reported by 22.7 percent of recreationists and ranked as the third most frequent activity. Boat Fishing (16.8 percent) and Bank Fishing (15.0 percent) were common, as were Picnicking (21.5 percent), Water Skiing (17.7 percent), and Swimmming (14.7 percent). Differences in popularity between recreation and natural areas are also listed.

A second survey was conducted by telephone to determine latent, or unexpressed, demands of the population-at-large along GREAT III. Interviewees were asked what improvements or conditions would increase their recreation participation on the Mississippi. By far the most common response was Clean Up the River, an answer given by nearly 10 percent of the interviewees.

Projections of future recreation use for the years 1990 and 2000 were prepared under two alternative assumptions. First, it was assumed that recreation use would increase in direct proportion to population growth. A second projection was made based upon the telephone survey respondents' planned increase in Mississippi River activity. A resultant range of visitation for 1990 was projected to be 549,500 to 692,200 visitor days, growing to a range of 567,000 to 890,000 by the year 2000.

These projections were then translated into land needs and use-intensity measures. According to these projections, intensity of use (as measured in visitor days per acre of recreation land) may double by the year 2000, resulting in a deficit of nearly 36,000 acres of recreation lands.

STUDY ABSTRACT

Refinement and Verification of Predictive Models of Suspended Sediment Dispersion and Desorption of Toxics From Dredged Sediments

Field monitoring, laboratory elutriate and kinetic tests, and mathematical modeling have been performed for dredge disposal operations over a 600-mile stretch of the Mississippi River from Guttenberg, Iowa, to Cairo, Illinois, during 1979-1981, as part of the GREAT II and GREAT III studies.

The objectives of the study were threefold:

(1) To determine the concentrations of suspended sediments, traditional pollutants (COD, PO_4-P, NH_3-N, TSS, VSS, and oil and grease), and toxic pollutants (heavy metals and priority organics) discharged to the Mississippi River as a result of dredge disposal operations;

(2) To evaluate the standard elutriate test for main channel and slough sediments as a screening procedure in disposal operations; and

(3) To develop and test a steady-state, two-dimensional mathematical model for suspended sediment and toxics concentrations as a result of side-bank and open-water dredge disposal.

Six main channel disposal operations were monitored including cutterhead dredging and dustpan dredging procedures. A total of 36 sediments were collected from main channels and sloughs for sediment elutriate testing. Results from over 100 sediment elutriate tests were analyzed for correlations to bulk sediment chemistry, redox potential, and other sediment characteristics. Six traditional pollutants, nine heavy metals, and 129 priority pollutants were analyzed including PCB's, pesticides, and plasticizers.

Results have shown that elutriation of traditional and toxic pollutants is not a significant problem in the dredging and disposal of main channel sediments. These are mostly "clean" sediments of fine-to-medium sand with very low organic contents. Mucky sediments from sloughs (and occasionally from the main channel) showed a greater potential for desorption of toxic organic pollutants and ammonia. Desorption was frequently noted for COD, NH_3, and Mn, but excursions of water quality criteria were rare.

Suspended solids concentrations in the shore-attached plumes ranged from 0-125 mg/l over ambient. The standard elutriate test proved to be a reasonable screening methodology for Mississippi River sediments. However, it does not reflect in situ conditions due to differences in suspended solids concentrations, redox potentials, and a number of other variables.

Monitoring and modeling results for two suspended sediment plumes are presented in FIGURES A, B, and C. There was good agreement between model results and field measurements under moderate flow conditions (velocities of 1-2 fps). For high velocity disposal, the plume was ill-behaved and did not exhibit a true steady-state. The model did not apply for these cases, especially in the open river segment where tested.

It is concluded that maintenance dredging and disposal of main channel sediments, as is presently being practiced by the Corps of Engineers, is not a significant water quality problem. In this study, models have been developed to estimate prior to dredging the relative pollution potential of suspended solids and toxic chemicals.

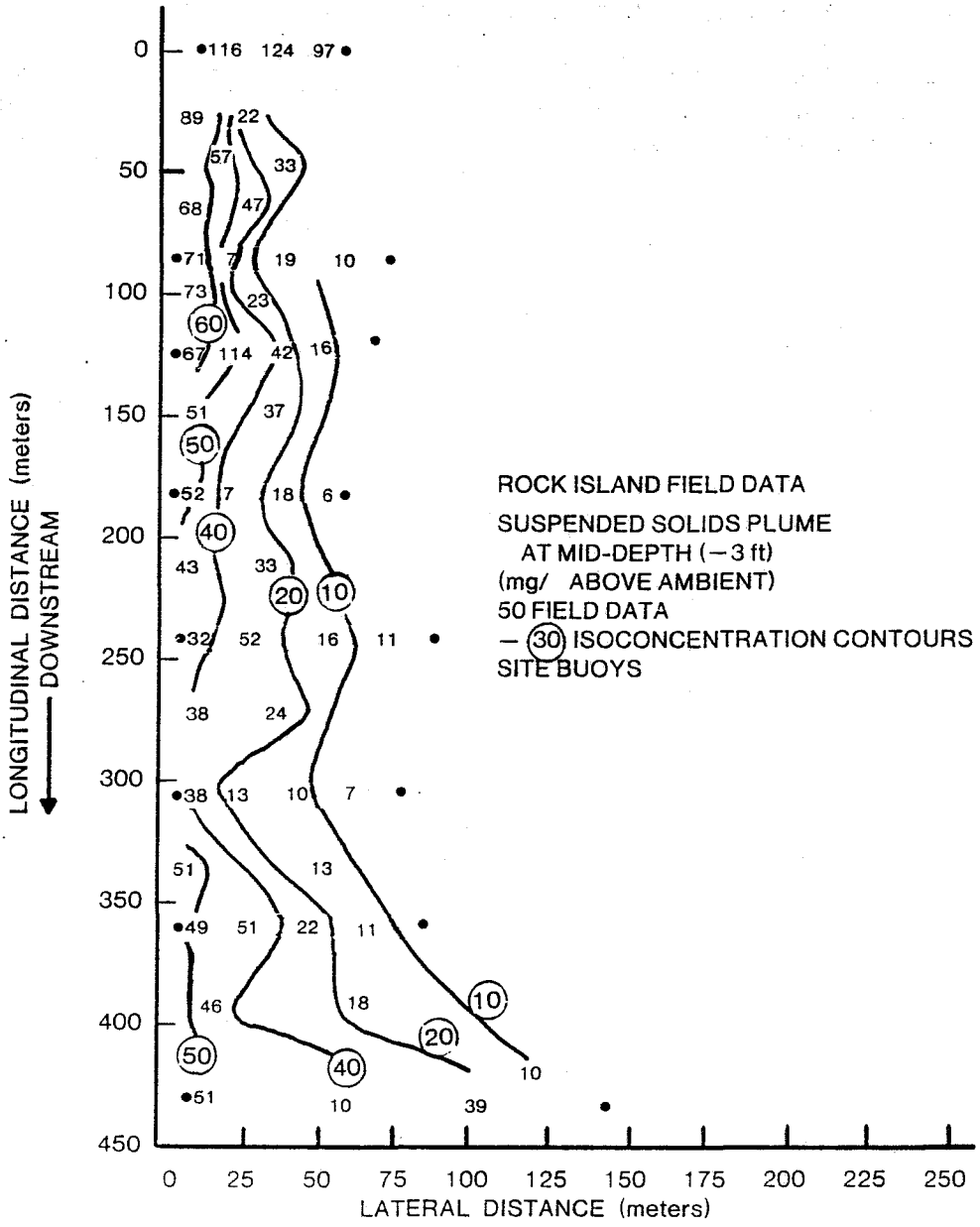


Figure A. Total Suspended Solids Concentration above Ambient for Side-Bank Dredge Disposal at Rock Island, Illinois

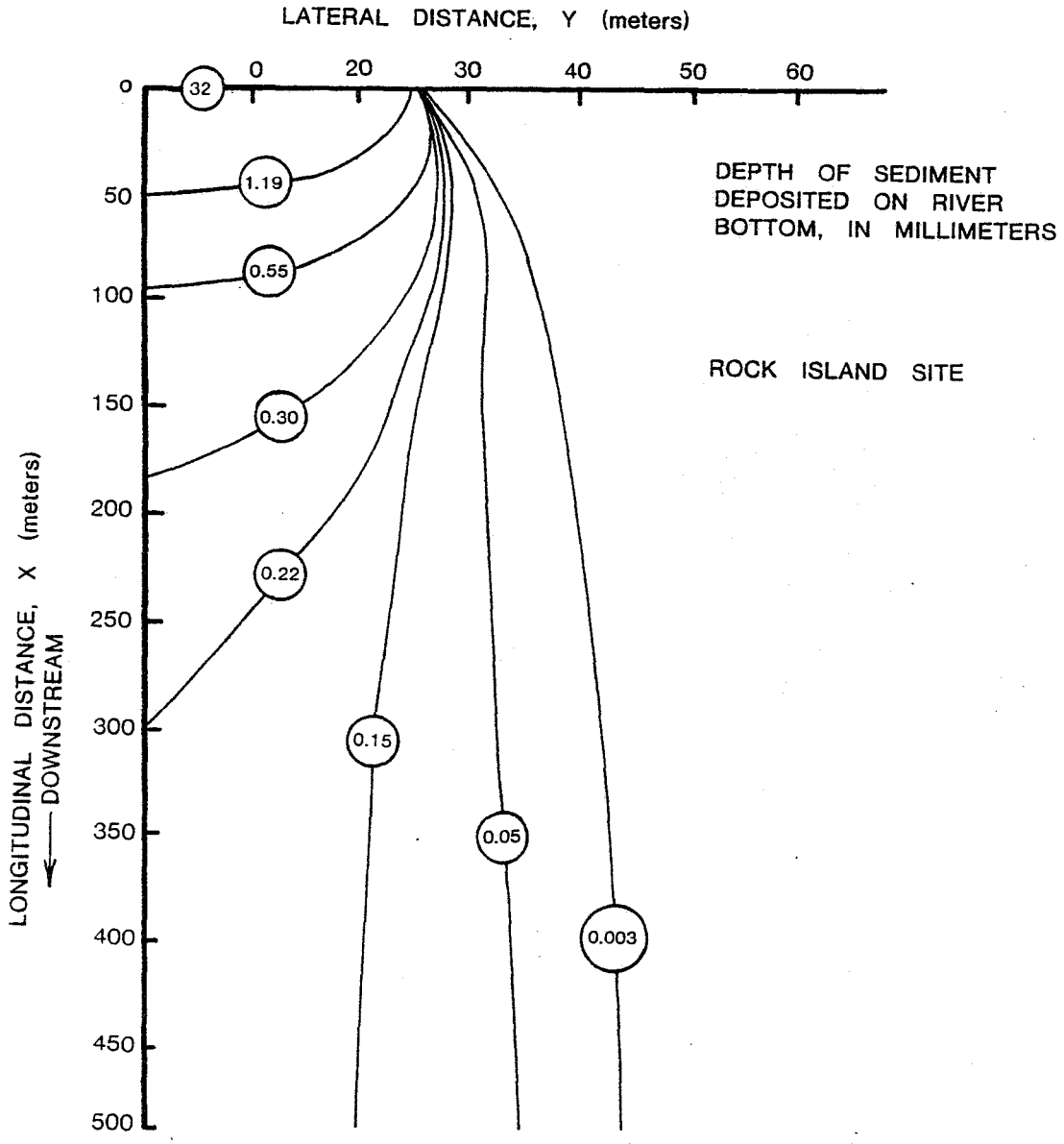


Figure 5-15. Death of sediment deposited from plume at Rock Island, Illinois, mm.

Figure B. Model Results — Depth of Sediment Deposited for the Rock Island Dredge Disposal Operation

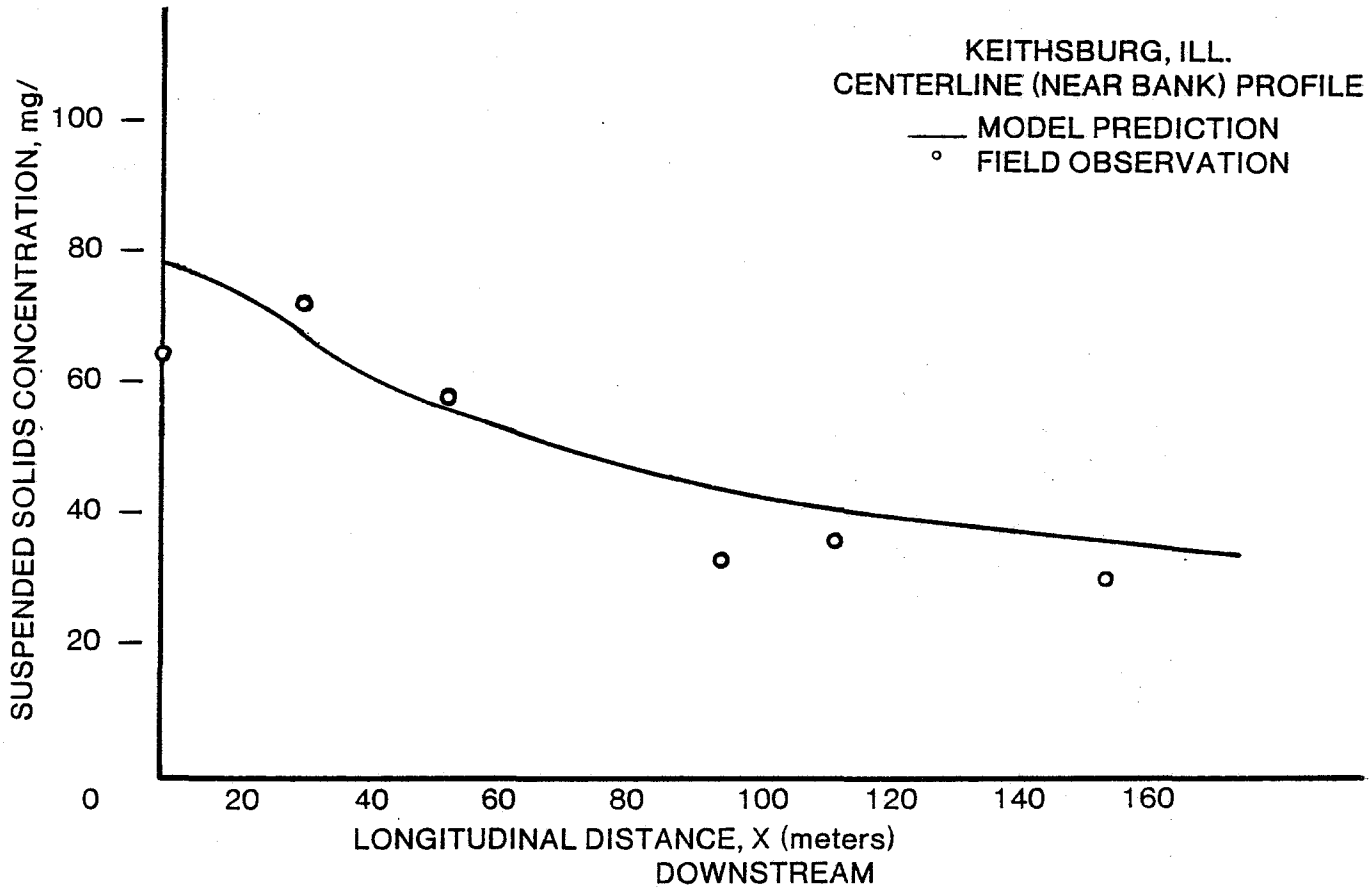


Figure C. Model Results and Field Data for Suspended Solids Centerline Concentrations of a Bank Disposal near Keithsburg, Illinois

STUDY ABSTRACT

Ecological and Habitat Characterization

The purpose of this study was to identify the type and quantity of aquatic habitats in the GREAT III reach, as well as the importance of these habitats to the fauna of the river throughout various life cycles and seasons.

The pooled river contains 46,705 acres of aquatic habitat. The main channel border was most abundant comprising 38 percent of the total. Side channel habitat made up 23 percent, and the main channel 18 percent. The middle river contains 52,717 acres of aquatic habitat. The main channel border made up the largest percentage of habitat at 50 percent, the main channel 40 percent, and side channels only 10 percent.

Fish sampling was conducted quarterly, and resulted in a total of 50,032 fish comprising 65 taxa. Fifty-five percent (27,458) of these fish, comprising 35 species, were collected in the Kaskaskia side channel during a single chemofishing effort. Other fish collections were made by electrofishing; gill, trammel, hoop, and frame netting; otter trawling; seining; and metered larval fish tow nets.

The most abundant fish species encountered was the gizzard shad *(Dorosoma cepedianum).* This important forage fish was collected in all habitats during all sampling periods. Carp *(Cyprinus carpio).* an important commercial species, was second in overall abundance. Other sport and commercial fishes common in the study area include: freshwater drum *(Aplodinotus grunniens),* buffalo *(Ictobus* spp.), channel catfish *(Ictalurus punctatus),* crappie *(Poxomis* spp.), green sunfish *(Leponis cyanellus),* white bass *(Morone chrysops),* bluegill *(Lepomis macrochirus),* flathead catfish *(Pylodictis olivaris),* blue catfish *(Ictalurus furcatus),* and largemouth bass *(Micropterus salmoides).* Ichthyoplankton sampling (quarterly only) resulted in the collection of 22 identifiable taxa throughout the study area. Abundant ichthyoplankters in the collections were *Dorosoma* spp. or *Alosa* spp., *Cyprinus carpio* or *Carrassius aratus, Carpoides* spp. or *Ictiobus* spp., *Stizostedion* spp., and *Aplodinotus grunniens.* Seasonal abundance varied with specific taxa throughout the study period. Densities were highest in littoral areas (natural and revetted). Field sampling was probably not initiated early enough to collect peak numbers of early spring spawners, often found in the tailwaters.

Benthic invertebrates were collected in all seasons, from soft substrates only, with the petite ponar dredge. The Oligochaeta (worms) and Diptera (flies) dominated these samples. Chironomidae represented the most abundant Diptera taxon; however, Certapogonidae were also common and widely distributed. Ephemeroptera (mayflies) were common in many habitats, especially the genera *Hexagenia* and *Pentagenia.* The following taxa were collected in lesser numbers and did not appear to be as widely distributed: Nematoda (roundworms), Hirudinea (leeches), Hydracarina (water mites), Isopoda (aquatic sow bugs), Collembola (spring tails), Odonata (dragonflies, damselflies), Hemiptera (bugs), Trichoptera (caddisflies), Coleoptera (beetles), Gastropoda (snails), and Pelecypoda (mussels).

High trophic level predators, such as Odonata and Hirudinea, are expected to be less abundant. Other investigators have found different relative abundances in the benthic composition using methods for sampling hard substrates.

Fingernail clams were collected at all four sample sites in the pooled river (Pools 24, 25, and 26). The sample sites were based on historic locations and 1981-82 aerial surveys of diving duck concentrations. Diving ducks utilize fingernail clams as a major food source and, therefore, are thought to be an indicator of fingernail clam concentrations. The dominant sphaerid collected was *Sphaerium* spp. The genera *Musculium* and *Pisidium* were less common.

Aquatic faunal-habitat characterizations are documented for each habitat type. Important associations are presented by habitat type.

Tailwater. The tailwaters are thought to be an important spawning habitat for white bass, sauger, and walleye. These sport species are often found to concentrate in the tailwater during spawning season and in late summer.

Navigation Pool. The navigation pool supports diverse and high density populations of benthic invertebrates and fishes. Factors favoring biotic development include a variety of water depths and substrate types, abundant slack water areas, and availability of protective cover around the periphery. Siltation may lead to deterioration of many favorable habitat characteristics.

River Lake. Habitat features of the river lake are quite similar to those of the navigation pool and slough. High density populations of benthic invertebrates inhabit the river lake. The species composition of fishes varies with successional stage and eutrophic conditions. Highly eutrophic conditions with heavy siltation support mainly forage and commercial species, whereas less eutrophic deep water areas support diverse sport fish assemblages. Species collected nearly exclusively in the river lake include warmouth, brown bullhead, yellow bullhead, bowfin, spotted gar, yellow bass, and green sunfish.

Slough. Slough habitat supports abundant benthic invertebrate and sport fish populations. The value of sloughs as spawning and/or nursery habitat is evident for bluegill and other sunfishes, crappie, buffalo, and river carpsucker. Losses due to siltation are a concern in this habitat, as well as the navigation pool and river lake.

Downstream End of Island. Relatively diverse but small populations of fishes are found in this habitat. Collection of young-of-the-year green sunfish and largemouth bass indicate utilization as nursery habitat. This habitat is sometimes used as a dredged material disposal area.

Dike Fields (Stone). The rock riprap of dikes provides excellent substrate for benthic invertebrate colonization. Therefore, dike fields support a diverse assemblage of benthos not well represented in other habitats. The presence of cover (in the form of natural logs, snags, and debris) and slackwater zones provides habitat for fishes in all stages of life history. The importance of dike fields is increased in the open river due to limited areas with favorable habitat conditions. This habitat has been affected in many areas by accretion behind unnotched channel regulating structures.

Main Channel. Strong currents and deep water make collection of fish and benthic invertebrates difficult in the main channel of the Mississippi River. Intensive sampling efforts reveal the importance of areas within the main channel (in large pooled and channelized rivers) for wintering catfish. This habitat may also play a role as nursery habitat for channel catfish. The value of the main channel for fishes increases during low flow periods. In many areas this habitat is frequently dredged.

Main Channel Border. The main channel border represents an ecological transition between the main channel habitat, and near shore (littoral) and backwater habitats. Depths decrease, as does current velocity, in most cases. Substrates become less coarse but are generally more stable, and slightly more cover is available. Primarily because of current, depth, and substrate variability, the main channel border has been categorized into three habitat types: inside bend, outside bend, and straight stretch. This habitat's importance also increases during low river stage. Mussel beds are often located in the main channel border. Dredged material is often spoiled in this habitat.

Side Channel. Side channel habitats have been found to number among the most biologically productive habitats in the Mississippi River. Habitat features which influence this productivity include reduced current speed, and substrates which are generally soft but stable, with little current scouring. Cover is generally abundant and includes snags and logs, as well as bank vegetation and some aquatic macrophytes. Other factors influencing side channel suitability are annual flow regimes and the presence of sustained flow and depth. Side channels are an important habitat for vital fish life history requirements such as feeding, spawning, and nursery activities.

Littoral Habitat. The littoral habitat combines features of quiet backwaters with those of main river habitats. Water is relatively shallow with at least moderate current at most times. The natural littoral zone provides sediments which are generally soft. The revetted littoral habitat provides substrate in the form of rock riprap. Cover in the form of logs, snags, and bank vegetation is common in the natural littoral habitat, but very limited in the revetted littoral habitat. Another factor affecting littoral habitats is the frequent fluctuation of water level, due to natural hydrologic changes, wave action from barge traffic, and pool level fluctuations. This habitat is also frequently used as a dredge disposal area. Sampling indicated the importance of natural littoral zone as nursery habitat for numerous fish taxa. The littoral habitat in general is very important for spawning and nursery activities.

Pile Dike. This habitat is uncommon due to the few remaining pile dikes and their usual isolation within a stone dike field. Pile dikes generally do not influence currents and substrate to the degree of stone dikes because of their generally decayed condition and lesser extension into the river. Potential fish cover and substrates for invertebrate colonization are provided by (1) the piles themselves, (2) the holes formed by scour around the piles, and (3) accumulated debris. The pile dike habitat was notable for its blue catfish populations.

Mouth of Tributary. The point or area in which tributaries enter the Mississippi River provides a transitional habitat in terms of faunal associations and characteristics. Key habitat features include reduced current velocities, relatively stable substrates, generally good cover conditions, and a variety of depths and substrate types. The tributary streams often provide key life history or natural history roles, such as serving as spawning habitats and providing refuge from main river conditions and high flows. Faunal species not commonly associated with larger rivers can be found in limited numbers in the tributary streams.

Recommendations:

The objective of this study, to characterize the value of aquatic habitats to riverine fauna, was a formidable task. It was not possible to gather all the necessary information to accomplish this in just one year, although this study provides a considerable amount of valuable information.

1. A more intensive study of the aquatic life of the main channel, especially in the middle river, should be conducted. Particular attention should be directed at seasonal differences.

2. Much more study effort should be directed at documenting important habitats for fish spawning, such as tailwaters, side channels, and littoral zones.

3. A comprehensive mussel survey should be conducted of inventory bed locations, species abundance, and composition in the GREAT III reach.

4. More study effort is needed to document the status of habitats associated with the river and their importance to wildlife species.

5. This comprehensive study effort should be continued so that changes in habitat quantity and quality can be monitored for the improvement of fish and wildlife management.

STUDY ABSTRACT

Cultural Resource Inventory

The GREAT III Cultural Resource Inventory is presented in the form of four separate documents: (1) Volume I Summary of Findings, (2) Volume II Bibliography, (3) Corps Base Maps showing site locations, characteristics, and areas which have been subject to intensive cultural resource survey, and (4) a computer data file and programs. Volume I presents a summary of the findings of the investigation. The methodological considerations involved in all processes of the investigation are discussed in the text and outlined in the appendices. The setting in which the GREAT III inventory takes place is discussed in terms of legal background, prehistoric setting, and historic setting. Results of the previously recorded site record review are incorporated in the background setting as well as in the summary of findings which follows. The summary of findings primarily involves presentation of the data generated from the mapping and computer application components of the study in table form. Recommendations to the Corps of Engineers for cultural resource management are in the main text. The appendices include listings, tables, definitions, site form examples, data sheets, computer programs, correspondence, reviews and responses, architectural resources, and other Scope of Work requirements.

The information contained in Volumes I and II is available to agencies and others involved in cultural resource management. The Corps Base Maps and computer record and programs are placed with the St. Louis District, Corps of Engineers, the Missouri Department of Natural Resources/Historic Preservation Program, and the Illinois Department of Conservation/Division of Historic Sites, and are considered sensitive information.

The major values of the four GREAT III cultural resource inventory report documents are in their potential use as planning tools. Base maps will suggest areas which are known to contain high site potential which would hopefully be avoided by projects that would threaten impact. The maps and computer file have suggested some interpretations of low site probability zones (i.e., historic river channels). The summary statements should be incorporated in interpretation involving high priority occupations.

The *Recommendations* presented are as follows:

1. Survey of Corps Jurisdiction Lands. This recommendation, based on review of available cultural resource management data and compliance regulations, suggests that the Corps initiate an intensive survey of areas under their jurisdiction. Areas to be included would be selective and determined through State Historic Preservation Officers, Illinois Archaeological Survey, Missouri Association of Professional Archaeologists, and the Corps. Results would be directed toward fulfilling 36 CFR 800 as specified in Executive Order 11593 compliance requirements.

2. Shoreline Survey. A recommendation of reduced scope directed toward fulfillment of Corps jurisdiction lands cultural resource inventory requirements.

3. Steamboat Wrecks. Recommendation that the Corps initiate evaluation of these resources as recovered within jurisdiction lands as specified in Section 106 of P.L. 89-665 as amended.

4. Geomorphic Studies. In conjunction with cultural resource inventory compliance requirements, it is recommended that geomorphic studies be initiated by the Corps in order to establish a more informed data base line involving cultural resource location potential within Corps jurisdiction lands.

5. Cultural Resource Management Organization and Clarification. A set of minimal standards is recommended for inclusion in all CRM reports submitted to the Corps in order to maintain consistency necessary for project planning and inventory and particularly for overview purposes.

6. Public involvement in cultural resource preservation should be increased.

7. Record Update. Recommendation that the GREAT III inventory be updated on regular basis for planning and inventory purposes through mapping and computer file update.

RECOMMENDATIONS

Recommendations for resource management and further study contained in this report have been based upon available information. This information includes analyses of the existing and future conditions, public and professional perceptions of river resource management, technical studies, and the experiences of study participants in an interdisciplinary, multi-agency approach to resource planning. A consensus of the Team was required for these recommendations.

Due to the abbreviated nature of this planning effort, these recommendations have not been evaluated by a cost-benefit analysis, an environmental impact evaluation, or a conflict resolution and trade-off process. Although these items are presented as recommendations and a consensus of the study participants was required for them to be included, the final decision on implementation will ultimately be the responsibility of the appropriate agencies. Implementation of these recommendations will be dependent upon the existing and new authorities, and priorities of appropriate agencies, pertinent laws and regulations, and the availability of resources. It is recommended that:

1. A program to modify, design, and evaluate regulatory works structures to benefit aquatic resources in the unpooled portion of the GREAT III area be initiated;

2. Pre- and post-dredging coordination activities, improved during the GREAT III Study, be continued;

3. The Corps update and monitor its permit system to a level of accuracy so that facilities (including fleeting areas) and their current responsible officer or agent can be identified;

4. The Corps strictly enforce existing regulations (Sections 15, 16, 19, and 20 of the Rivers and Harbors Act of 1899) requiring the owners to remove sunken commercial vessels. Where the owners cannot be located or forced to remove them, specific funding should be sought for removal at Federal expense;

5. Movable bridges be left open for the free passage of tows unless the frequency of train traffic exceeds that of barges and other vessels;

6. An active program of nonstructural and structural maintenance and improvements at all locks, as appropriate, be adopted by the Corps to improve operating efficiency, particularly during peak periods (i.e., Lock and Dam No. 26);

7. Local port authorities and development agencies continue to develop: (1) programs to promote coordinated port expansion, including the initiation of environmental, archaeological, and flood hazard analyses at preferred industrial sites; and (2) funding mechanisms for site improvements;

8. State and Federal regulatory and review agencies seek methods to improve coordination with local entities to insure that valid regulatory concerns are dealt with early in the permit and development processes. Additionally, local development agencies provide detailed information to potential industrial candidates on rules and regulations affecting development in the study area;

9. Local port development agencies develop an inventory of potential fleeting sites and take steps to insure their future availability and acceptability;

10. Local development agencies routinely identify local, state, and Federal rules and regulations which are redundant and submit them to responsible authorities for appropriate action;

11. Erosion control measures in critical upland sediment source areas be installed, and individual source areas be studied to determine the most cost effective measures;

12. Bedload movement in the Mississippi River be studied;

13. Scientific research be directed to develop acceptable methods to predict transport of suspended sediment and associated contaminants;

14. Valuable scenic resources be identified and a program to conserve these resources be developed;

15. An analysis of recreation conflicts with other users, and the applicability and efficiency of current procedures to resolve those conflicts, be conducted;

16. A coordinated program to provide a cleaner river for recreationists (e.g. litter and water quality) be developed;

17. A coordinated program to meet recreational needs identified in the GREAT III Recreation Needs Assessment be developed;

18. Intensive hydraulic and biological investigations of side channels in the GREAT III study area be initiated to determine measures for conserving and improving these productive habitats;

19. A program to coordinate interstate flood plain management regulations and policies recognizing the requirements of river dependent uses be developed;

20. A comprehensive mussel survey to inventory bed locations, species composition, and abundance in the GREAT III reach be conducted;

21. A comprehensive long-term study to monitor the quantity and quality of fish and wildlife habitats be initiated;

22. The GREAT III cultural resource inventory be updated on a regular basis through mapping and computer files using uniform minimal standards;

23. The US Coast Guard and the Corps conduct a joint annual review and analysis of commercial marine accidents to identify problem areas and possible corrective measures;

24. Studies to determine the effects of water level fluctuation in the pooled portion of the river on fish and wildlife habitats be conducted; and

25. The Corps (St. Louis District), as lead agency with assistance from GREAT III participating agencies, establish an interagency coordination process to address river resource management concerns.

We the undersigned, as members of the Steering Committee, endorse the Recommendations as presented.

Colonel Gary D. Beech,
District Engineer
US Army Engineer District, St. Louis
Corps of Engineers
Co-Chairman: Steering Committee

John D. Booth, General Manager
of Development
Bi-State Development Agency

Walter L. Eschbach
St. Louis Area Office
US Department of Housing and
Urban Development

Alan Hutchings
Division of External Affairs
National Park Service,
Midwest Region

Joe B. Marshall
Soil Conservation Service
US Department of Agriculture

Edward Tralka
Maritime Administration
US Department of Transportation

Dr. David Kenney, Director
Illinois Department of Conservation
Co-Chairman: Steering Committee

Jerry Vineyard, Assistant
State Geologist
Missouri Department of Natural
Resources

Donald R. Vonnahme, Director
Division of Water Resources
Illinois Department of
Transportation

Thomas Groutage
US Fish and Wildlife Service
Rock Island Field Office (ES)

Robert Koke
US Environmental Protection Agency

Jack F. Rasmussen, P.E.
Assistant Chief, Engineering
Division
US Army Engineer District, St. Louis

CAPT. Richard C. Walton
US Coast Guard
Second Coast Guard District

DISTRICT COMMANDER'S CONCLUSIONS AND RECOMMENDATION

CONCLUSIONS

1. The organizational arrangement for the study was established to achieve resource management that results from a cooperative effort of various agencies, organizations, and disciplines. As envisioned by Section 117 (P.L. 94-587), this structure has provided an opportunity to bring together diverse river resource management interests. A willingness to discuss common concerns is desirable in other studies and projects.

2. It was recognized early in the planning process that the quantity and complexity of the perceived resource management problems would prohibit a study of all issues. Given these constraints, the studies that have been completed make significant strides toward the resolutions of these important concerns. However, there still remain a number of concerns that require additional investigation and others that have yet to be addressed.

3. The UMRBC Master Plan recommendations are presently being considered by Congress. These recommendations address many GREAT III study objectives.

4. The costs associated with additional studies and investigations must be developed as they are scoped by the appropriate agencies which may pursue these efforts within new or existing authorities and program priorities.

5. There are few activities contained herein that require Congressional authorization for the Corps of Engineers; however, where Congressional authorization is required by any agency, it is that agency's responsibility to seek that authorization.

RECOMMENDATION

I have given consideration to the results of the GREAT III study and recommend the following:

The study be forwarded to Congress for information and serve as a document which sets forth actions that need to be taken to manage the resources of the study area.

GARY D. BEECH
Colonel, CE
Commanding

APPENDIX A

GREAT III STUDY PARTICIPANTS

GREAT III Steering Committee

Co-Chairman
Colonel Gary D. Beech, District Engineer
US Army Engineer District, St. Louis
Corps of Engineers
210 Tucker Boulevard, North
St. Louis, Missouri 63101

Co-Chairman
Dr. David Kenney, Director
Illinois Department of Conservation
605 State Office Building
Springfield, Illinois 62706

John D. Booth, General Manager
of Development
Bi-State Development Agency
707 N. First St.
St. Louis, Missouri 63101

Mr. Walter L. Eschbach
St. Louis Area Office
US Department of Housing and
Urban Development
210 Tucker Boulevard, North
St. Louis, Missouri 63101

Mr. Thomas Groutage
US Fish and Wildlife Service
Rock Island Field Office (ES)
1830 Second Avenue
Rock Island, Illinois 61201

Mr. Alan Hutchings
Division of External Affairs
National Park Service, Midwest Region
1709 Jackson St.
Omaha, Nebraska 68102

Mr. Robert Koke
404 Program
US Environmental Protection Agency
324 East 11th Street
Kansas City, Missouri 64108

Mr. Joe B. Marshall
Soil Conservation Service
US Department of Agriculture
555 Vandiver Drive
Columbia, Missouri 65201

Mr. Jack F. Rasmussen
Assistant Chief, Engineering Division
US Army Engineer District, St. Louis
210 Tucker Boulevard, North
St. Louis, Missouri 63101

Mr. Edward Tralka
Maritime Administration
US Department of Transportation
400 7th Street, SW
Washington, DC 20590

Mr. Jerry Vineyard
Assistant State Geologist
Department of Natural Resources
Division of Geology and Land Survey
P. O. Box 25
Rolla, Missouri 65401

Mr. Donald R. Vonnahme, Deputy Director
Illinois Department of Transportation
Division of Water Resources
2300 South Dirksen Parkway
Springfield, Illinois 62764

CAPT. Richard C. Walton
Second Coast Guard District
1430 Olive Street
St. Louis, Missouri 63103

GREAT III Team

Chairman
George A. Clapp
Plan Formulation Branch
US Army Engineer District, St. Louis
210 Tucker Boulevard, North
St. Louis, Missouri 63101

Study Manager
Thomas R. Hewlett
Plan Formulation Branch
US Army Engineer District, St. Louis
St. Louis, Missouri 63101

Bill Boyd
Illinois Department of Conservation
RR 2, Box 62A
Nashville, Illinois 62263

William B. Bristor, Jr.
Maritime Administration
US Department of Transportation
400 7th Street, SW
Washington, DC 20590

Robert Clark
Illinois Environmental Protection Agency
2300 Churchill Road
Springfield, Illinois 62702

William Dieffenbach
Missouri Department of Conservation
P.O. Box 180
Jefferson City, Missouri 65102

Walter L. Eschbach
St. Louis Area Office
US Department of Housing and Urban Development
210 Tucker Boulevard, North
St. Louis, Missouri 63101

Alan Hutchings
National Park Service
1709 Jackson Street
Omaha, Nebraska 68102

Joe Janecek
US Fish and Wildlife Service
Carbondale Sub-Office
250 W. Cherry Street
Carbondale, Illinois 62901

Robert J. Koke
404 Program
US Environmental Protection Agency
324 East 11th Street
Kansas City, Missouri 64106

Joe B. Marshall
Soil Conservation Service
US Department of Agriculture
555 Vandiver Drive
Columbia, Missouri 65201

Sam Masters
Missouri Highway and Transportation Department
P.O. Box 270
Jefferson City, Missouri 65102

Charles Michaels
Division of Environmental Quality
Missouri Department of Natural Resources
P.O. Box 176
Jefferson City, Missouri 65102

CAPT. Richard Walton
Second Coast Guard District
1430 Olive Street
St. Louis, Missouri 63103

Wayne E. Weidemann
Bi-State Development Agency
707 N. First Street
St. Louis, Missouri 63101

Kay Whitlock
Division of Water Resources
Illinois Department of Transportation
2300 South Dirksen Parkway
Springfield, Illinois 62764

Data and Reports Work Group
(Work Group Chairmen)

Chairman
Thomas R. Hewlett
Plan Formulation Branch
US Army Engineer District, St. Louis
210 Tucker Boulevard, North
St. Louis, Missouri 63101

Commercial Transportation
CAPT. Richard C. Walton
Second Coast Guard District
1430 Olive Street
St. Louis, Missouri 63103

Cultural Resources
Judith Deel
Division of Parks and
Historic Preservation
Missouri Department of Natural Resources
P.O. Box 176
Jefferson City, Missouri 65102

Dredging and Dredged Material Uses
Michael J. Cullen
Navigation Branch
US Army Engineer District, St. Louis
210 Tucker Boulevard, North
St. Louis, Missouri 63101

Erosion and Sediment
Vern L. Finney
Soil Conservation Service
US Department of Agriculture
555 Vandiver Drive
Columbia, Missouri 65201

Fish and Wildlife
William Ziegler
Fish and Wildlife Service
Carbondale Sub-Office
250 W. Cherry Street
Carbondale, Illinois 62901

Flood Plain Management
Henry Martin
Hydrologic and Hydraulics Branch
St. Louis District, Corps of Engineers
210 Tucker Boulevard, North
St. Louis, Missouri 63101

Industrial and Economic Development
Wayne E. Weidemann
Bi-State Development Agency
707 N. First Street
St. Louis, Missouri 63101

Public Involvement
Chuck Franco
Plan Formulation Section
US Army Engineer District, St. Louis
210 Tucker Boulevard, North
St. Louis, Missouri 63101

Recreation
Julie McQuary
Division of Parks and Historic Preservation
Missouri Department of Natural
Resources
P.O. Box 176
Jefferson City, Missouri 65102

Regulating Structures
Claude N. Strauser
Hydrologic and Hydraulics Branch
US Army Engineer District, St. Louis
210 Tucker Boulevard, North
St. Louis, Missouri 63101

Water Quality
John Ford
Department of Natural Resources
Division of Environmental Quality
P.O. Box 1368
Jefferson City, Missouri 65102