Environmental & Water Quality Operational Studies

MISCELLANEOUS PAPER E-80-1

AQUATIC HABITAT STUDIES ON THE LOWER MISSISSIPPI RIVER, RIVER MILE 480 TO 530

Report 1

INTRODUCTION

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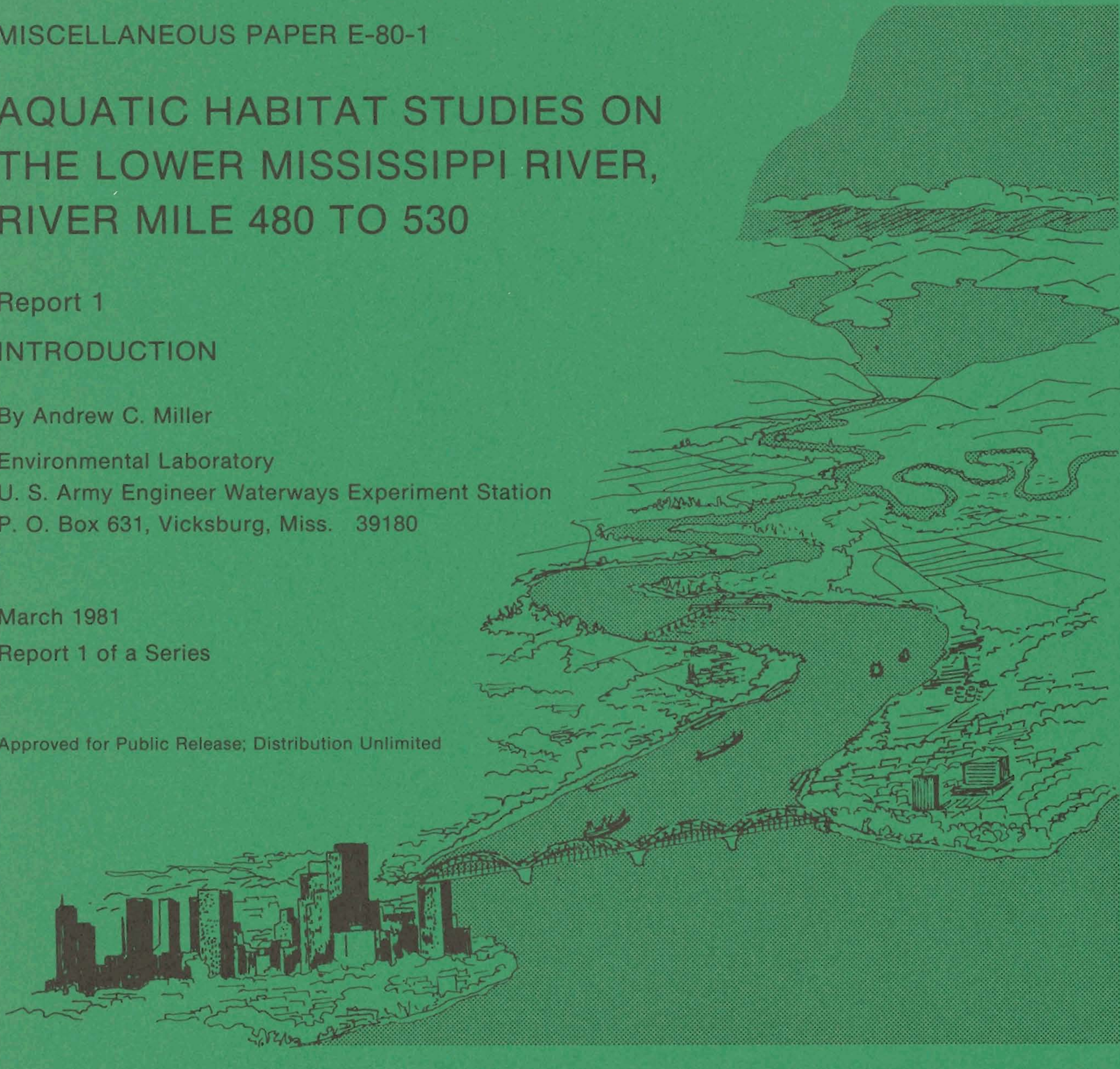

March 1981
Report 1 of a Series

Prepared for Office, Chief of Engineers, U. S. Army
Washington, D. C. 20314

Under EWQOS Work Unit VIIB

Unclassified
SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER Miscellaneous Paper E-80-1	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) AQUATIC HABITAT STUDIES ON THE LOWER MISSISSIPPI RIVER, RIVER MILE 480 TO 530; Report 1, INTRODUCTION		5. TYPE OF REPORT & PERIOD COVERED Report 1 of a series 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Andrew C. Miller		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS U. S. Army Engineer Waterways Experiment Station Environmental Laboratory P. O. Box 631, Vicksburg, Miss. 39180		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS EWQOS Work Unit VIIB
11. CONTROLLING OFFICE NAME AND ADDRESS Office, Chief of Engineers, U. S. Army Washington, D. C. 20314		12. REPORT DATE March 1981 13. NUMBER OF PAGES 34
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) Unclassified 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Aquatic habitats
Aquatic life
Fishes
Lower Mississippi River
Water quality

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

A pilot survey on the Lower Mississippi River, river mile 480 to 530, was conducted from April to October 1978. The objectives of this field survey were to collect data on fish, benthos, and water quality as they are impacted by the placement and design of navigational structures such as dikes and bank revetments. Information obtained on gear types and procedures from the pilot study was used to design further waterway studies on the Lower Mississippi
(Continued)

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Unclassified
SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

20. ABSTRACT (Continued)

River. Rationale for selection of sample sites, description of the study area and the 12 habitat types investigated, literature review, and general information on navigational structures are presented in this introductory report. A complete discussion of the fishery, benthos, water quality investigations, and other results of these studies as they relate to the Lower Mississippi River are found in Reports 2 through 8 of this series. The following is a complete list of all the reports in this series:

Report 1: Introduction
Report 2: Aquatic Habitat Mapping
Report 3: Benthic Macroinvertebrate Studies--Pilot Report
Report 4: Diel Periodicity of Benthic Macroinvertebrate Drift
Report 5: Fish Studies--Pilot Report
Report 6: Larval Fish Studies--Pilot Report
Report 7: Management of Ecological Data in Large River Ecosystems
Report 8: Summary

PREFACE

The work described in this report is part of the Environmental and Water Quality Operational Studies (Project VIIB of EWQOS) conducted by the U. S. Army Engineer Waterways Experiment Station (WES) for the Office, Chief of Engineers. This is Report 1 of a series of eight which discuss the results of a pilot study on the Lower Mississippi River, river mile 480 to 530, from April to October 1978.

This report contains introductory material that pertains to all of the reports. Included herein are rationale for selection of sample sites, descriptions of the study area, a general literature review, and information on navigational structures in major waterways.

This report was written by Dr. Andrew C. Miller, Environmental Laboratory (EL), WES. It was based in part on information supplied by personnel of the Waterway Habitat and Monitoring Group (WHMG), EL, including Mr. David Mathis, Dr. Harold Schramm, and Mr. Stephen Cobb. The study was under the supervision of Mr. Cobb and Dr. Walter G. Gallaher, Chief, WHMG, at the onset of the study. Dr. Thomas Wright, present Chief of the WHMG, supervised the later phases of the work. General supervision was provided by Mr. Bob O. Benn, Chief, Environmental Systems Division, EL, Dr. John Harrison, Chief, EL, and Dr. Jerome Mahloch, Program Manager, EWQOS.

Commanders and Directors of WES during the period of this study were COL John L. Cannon, CE, and COL Nelson P. Conover, CE. Technical Director was Mr. Fred R. Brown.

CONTENTS

CONVERSION FACTORS, U. S. CUSTOMARY TO METRIC (SI) UNITS OF MEASUREMENT

U. S. customary units of measurement used in this report can be converted to metric (SI) units as follows:

Multiply	By	To Obtain
acres	4046.856	square metres
cubic feet per second	0.02832	cubic metres per second
cubic yards	0.7645549	cubic metres
Fahrenheit degrees	5/9	Celsius degrees or Kelvins*
feet	0.3048	metres
inches	2.54	centimetres
miles (U. S. statute)	1.609344	kilometres
tons (2000 lb, mass)	907.1847	kilograms
yards	0.9144	metres

* To obtain Celsius (C) temperature readings from Fahrenheit (F) readings, use the following formula: C = (5/9)(F - 32). To obtain Kelvin (K) readings, use: K = (5/9)(F - 32) + 273.15.

AQUATIC HABITAT STUDIES ON THE LOWER MISSISSIPPI RIVER, RIVER MILE 480 TO 530

INTRODUCTION

PART I: BACKGROUND

1. The U. S. Army Engineer Waterways Experiment Station (WES) is conducting a nationwide program of applied research to solve selected environmental quality problems associated with Civil Works activities of the Corps of Engineers (CE). The study is being sponsored by the Office, Chief of Engineers, and is entitled Environmental and Water Quality Operational Studies (EWQOS).

2. During the early planning phase of EWQOS, visits by WES personnel were made to each Corps Division office in the United States to identify and assess the magnitude of environmental quality problems associated with CE water resource projects. A total of 420 problem statements directly applicable to EWQOS were identified (Keeley et al. 1978). Areas of interest to the field offices concerned reservoirs and large rivers and involved data collection and interpretation, assessment of existing chemical and biological conditions, and determination of project impacts. One study area of high priority involved the many activities occurring on major, navigable waterways of the United States. Specifically, the man-made structures that assist in navigation, such as dikes, revetments, and locks, were isolated as problem areas where little information on environmental impacts exists.

3. The waterway field studies, a portion of the EWQOS studies, were designed to evaluate the impacts of navigational structures on fish, benthic (bottom) invertebrates, and water quality in large rivers. Productivity, the effects of high water, and the relationship between slackwater habitats (oxbow lakes and bendway cutoffs) and the nutrient budget of the riverine ecosystem were also investigated. These waterway field studies were conducted on the Mississippi River in Mississippi, the Tombigbee River in Alabama and Mississippi, and the Verdigris River in

Oklahoma. Data collected provided specific information on the interaction between aquatic organisms and the man-made navigational structures. All information was not expected to be directly applicable nationwide, but general principles identified were expected to assist in impact assessment for large river systems. Additional reports on the Verdigris and Tombigbee River studies will be forthcoming.

4. The data collected and concepts developed were designed to provide information relative to environmental considerations in the design and location of dikes, revetments, and bendway cutoffs. Application of the U. S. Fish and Wildlife Habitat Evaluation Procedures (HEP) demonstrates that not all aspects of water resource projects are negative (U. S. Fish and Wildlife Service 1980). Planning with foresight is imperative if this country is to efficiently use its resources without unrestrained environmental degradation.

5. In the early stages of the waterway field studies, a preliminary survey, or pilot study, was undertaken on the Lower Mississippi River (Figure 1). The purposes of this initial survey, conducted from April to October 1978, were to evaluate sample methods, to identify habitats and navigational structures for more detailed studies on the Mississippi and other rivers, and to develop an initial understanding of the complexities of large river habitats.

6. The purpose of this report is to introduce the pilot survey on the Lower Mississippi River. Additional reports in this series will detail the species of aquatic organisms collected and the efficiencies of various types of sampling gear used during the study. Contained herein are descriptions of the study area, habitats evaluated, goals, and the rationale used for development of procedures that were a part of the pilot survey. To maintain continuity, each report on the pilot study will contain a brief discussion of areas sampled and objectives. This report contains material applicable to all areas of investigation in the pilot study on the Lower Mississippi River.

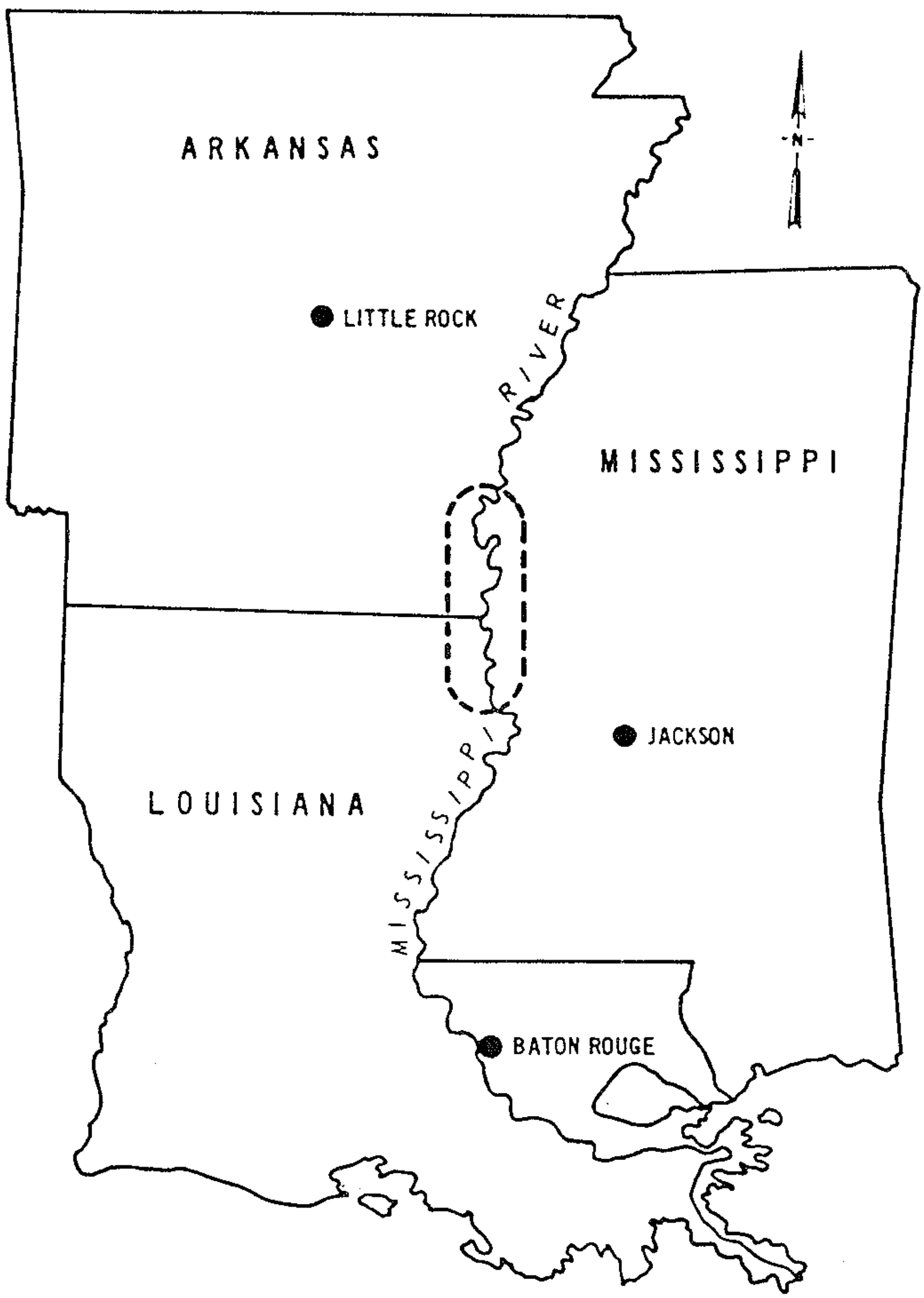

Figure 1. Area map of the Lower Mississippi River field studies

PART II: OBJECTIVES

7. The goal of the waterway field study on the Lower Mississippi River was to assess the ecological significance of navigational structures in major rivers. Information developed from the study was to be used to formulate environmental guidelines for the design of new dikes, dike fields, or revetted banks or the modification of these existing navigational structures.

8. These studies were to clarify the biological characteristics ofboth natural habitats (sandbars, abandoned channels, natural banks, etc.) and man-made habitats (dikes, dike fields, and revetted banks) in the Lower Mississippi River. Specific objectives were:

- a. To quantitatively define the age, size, building materials, and the effects on hydrologic characteristics of the river of dikes and revetments.
- b. To describe the physicochemical characteristics of both natural and man-made habitats in the river. Significant parameters include water depth, flow, sediment size, major cations and anions, dissolved oxygen, specific conductance, and water temperature.
- c. To provide qualitative and quantitative information on phytoplankton, zooplankton, particulate organic matter, and detritus associated with the various habitat types.
- d. To identify the abundance and distribution of benthic organisms associated with the habitat types, to calculate species diversity, and to describe utilization of the various habitat types by all species.
- e. To define the species diversity, abundance, and distribution of fish in the Lower Mississippi River and to examine the various habitat types used for spawning, feeding, and nursery areas.

9. As part of the overall goal, a pilot survey was conducted from April to October in 1978. Results of this study were used to design the planned major habitat analysis of the Lower Mississippi River (1979-1983). The seven-month pilot survey provided:

- a. Data on currents, sediments, bathymetry, river stage, and shoreline vegetation.

b. An evaluation of the most efficient sampling techniques for biological and physicochemical data in the various habitats.

c. Baseline biological, physical, and chemical data for designing the sampling program for the intensive field studies.

d. A basis for further studies on the Lower Mississippi River and other large navigable rivers as a part of the EWQOS Program.

PART III: SELECTION OF SITES

10. As part of the waterway field studies, study sites for evaluation of the impacts of major navigational structures such as dikes, dike fields, and bank revetments on the riverine ecosystem were chosen. Study sites were evaluated according to the following criteria:

a. Location on a large river of importance as a commercial waterway. The sites selected were to be on a large river with significant commercial traffic and with existing dikes, dike fields, or revetments. The data collected from the primary sites should be suitable for use in the evaluation of other major waterways in the United States.

b. Presence of unaltered river reaches for comparative studies. Data were to be collected from both altered and unaltered stretches of the river. These reaches of the river should be close and should not differ with respect to tributary inputs, point source discharges, or other variables that would make the data incomparable.

c. Presence of a variety of types of navigational structures. Existing dikes and revetments should differ with respect to age, size, building materials, depth, and proximity to the river, so that comparisons can be made between dissimilar structures and between similar structures in different habitats.

d. Existence of planned (authorized) navigational structures proximal to the study area. Where feasible, data should be collected to provide baseline information for navigational structures authorized for construction. This should allow for postconstruction studies to assess the impacts of placement of navigational structures on the riverine ecosystem.

e. Representative study sites. The river, study sites, and navigational structures should have characteristics similar to those of other major waterways. The existence of natural and navigational features should be such that maximum extrapolation to other systems in the United States can be achieved. It was recognized that ecosystems differ from river to river; however, it was felt that general principles could be developed that are applicable to navigational structures on major waterways of the United States.

f. Accessibility. To allow for maximal data collection under a variety of environmental conditions, the study area should be readily accessible for field studies. If possible, all-weather roads and boat-launching sites should be available.

g. Absence of excessively degraded water quality. The riverine ecosystem in the study area should not be directly affected by industrial or municipal discharges, so that areas chosen will provide data to isolate the positive and negative effects of navigational structures, not the effects of water quality on riverine habitats.

11. In addition to the above, other criteria were deemed significant for these studies:

a. Cooperation of local, state, and Federal conservation agencies. Every effort was to be made to coordinate these studies with other conservation agencies.

b. Presence of active commercial or sport fisheries. Data from commercial or sport fishermen would be obtained and compared with the results of these studies. This was to provide comparisons with the field studies as well as information on the fishing success of the area.

c. Availability of background information. The data retrieval systems of the U. S. Geological Survey (NAWDEX, WHATSTOR) and the U. S. Environmental Protection Agency (STORET) were accessed to provide additional biological and water chemistry information. These background data provided a check on field and laboratory results and assisted in displaying trends in certain parameters such as flow, water temperature, and dissolved oxygen, which are influenced by season and rainfall.

12. Based on an intensive survey of CE waterway navigation projects, the site selection criteria indicated a study site should be located on the Lower Mississippi River. After more detailed study of the Lower Mississippi River from Natchez, Mississippi, to Memphis, Tennessee, the 50-mile* reach of the river between Lake Providence, Louisiana, and Greenville, Mississippi, (river mile 480 to 530) was selected for the pilot study. The specific reach was selected because of an extensive hydraulic and hydrologic data base, the presence of a representative variety of navigational structures, and a high diversity of characteristic floodplain and riverine habitats. In addition, the Vicksburg District of the Corps of Engineers planned to conduct potamological (riverine) studies along this portion of the river concurrently with the EWQOS studies.

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* A table of factors for converting U. S. customary units of measurement to metric (SI) units is found on page 3.

PART IV: DESCRIPTION OF THE STUDY AREA

13. The study area encompassed a 50-mile reach on the Lower Mississippi River between Lake Providence, Louisiana, and Greenville, Mississippi, river mile 480 to 530. For the purposes of the pilot survey this included the main channel of the river and any additional water bodies between the main-line levees.

14. The climate of the study area is subtropical and humid with a short cold season and a relatively long warm season (Lower Mississippi Region Comprehensive Study Coordinating Committee 1974). The predominant air mass is maritime tropical and originates over the Gulf of Mexico. Based on meteorological data obtained at Vicksburg, Mississippi, mean monthly temperatures range from about 82.4°F in July and August to 48.9°F in January. Record maximum and minimum temperatures at Vicksburg were 104°F in September 1925, and -0.4°F in February 1899. Precipitation occurs mainly as rain, with annual snowfall averaging about 1.5 in. in the region. Precipitation reaches a maximum in March with a monthly average of about ,8 in. and a minimum in October of about 2.0 in. Annual precipitation is approximately 51 in. Relative humidity is generally high throughout the year and averages about 75 percent. Heavy fog occurs frequently in the area and may be expected an average of 32 days annually.

15. The study area is located in the Central Coastal Plains Region, one of the major physiographic provinces of North America. The plains were created when prehistoric ocean waters began to withdraw. The entire plain is an extensive lowland lying at or near sea level and underlain by nearly horizontal beds of marine shales and limestone.

16. The geological formations in the study reach can be divided into two types: the uppermost Recent alluvial deposits and deeper Tertiary deposits. The Recent soils include natural levee deposits, abandoned channel or clay plug deposits, backswamp deposits, and point bar deposits. The natural levees were created by soil deposits during stream overflow. They are composed primarily of silts, silty sand, or

silty clay. Point bar deposits are the predominant upper strata sediments in the area. These 5- to 25-ft-deep deposits were laid down on the inside of riverbanks and consist of tan to gray clayey silts, silts and silty sands in the ridges, and soft, gray, silty and sandy clays in swales. The abandoned channel deposits are in old cutoff meander loops and are filled with fine, clayey sediments with high water content and are known as "clay plugs." Some abandoned channels are filled with interbedded clays, silts, silty clays, silty sand, and sandy clays, depending on how the channel was cut off from the river. Backswamp deposits are chiefly interbedded, thinly laminated silty clays and clays with high percentages of organic matter.

17. The Recent alluvial deposits are underlain by Pleistocene fluvial sand and gravel. These deposits range from 80 to 100 ft thick. The Tertiary deposits are composed of two types found immediately beneath the sand and gravel substratum. The Yazoo clay of the Jackson formation is found from the upper end (river mile 525 to 530) downriver to Grand Lake (river mile 510 to 517). The second type of deposit is the Cockfield formation, which is located in the reach below Grand Lake.

18. The land between the main-line levees in the study area falls within three states and five counties or parishes. These are Chicot County in Arkansas, Washington and Issaquena Counties in Mississippi, and East Carroll and Madison Parishes in Louisiana. Most of this land is bottomland forest with some pastureland and cotton and soybean fields. Although the area has recreational potential because of its size and the number of backwater lakes and sloughs with abundant fish and wildlife, nearly all of the land is privately owned and inaccessible to the general public.

19. The Lower Mississippi River is an alluvial river with a mature drainage system and abundant meanders and oxbow lakes. The entire study reach is confined on both sides by main-line levees constructed by the CE for flood control. Leveed floodplain width ranges from 2 to 6 miles. The backwaters between the levees and the Mississippi River channel have indirect or seasonal connections with the river

and are submerged during floods. There are no tributaries directly entering the river in the study area.

20. The average discharge of the Mississippi River at Vicksburg is about 561,000 cfs. Recorded discharges have ranged from about 100,000 cfs at extreme low river stage to 2,700,000 cfs at high stages, with a differential of 60 ft in water level. The average water velocity within the main channel is from 3 to 6 fps with a maximum recorded velocity of 15 fps during extremely high flows. The estimated average sand transport at Vicksburg is 1,000,000 yd^3/day. At Vicksburg the highest discharge occurs from March through May.

21. Because of the high annual runoff and the inflow from large rivers upstream, groundwater is found throughout the study area. The principal aquifers in the region are beds of coastal plain sands and locally occurring gravels. Groundwater is abundant and usually close to the surface. Supplies of deeper artesian water are available throughout most of the region, and in many locations potable water has been encountered at depths of more than 3500 ft.

22. Navigation and flood control efforts within the study reach are directed by the CE and are included in the Mississippi River and Tributaries (MR&T) Project. This project was authorized by the U. S. Congress in 1929 to provide for flood control in the valley and for navigation improvement on the Lower Mississippi River. The four major features of the MR&T Project are: (a) levees to confine floodwaters; (b) structures to direct excess water to the main channel; (c) channel improvements, such as artificial cutoffs to prevent the loss of irreplaceable lands and improve channel alignment and depth; and (d) tributary basin improvement.

23. The MR&T Project as modified by the Flood Control Act of 1944 provides for a navigation channel not less than 12 ft deep and 300 ft wide. Authority to proceed with this channel-deepening construction is still pending and the channel is presently maintained at not less than 9 ft deep by hydraulic dredging. Waterborne commerce in the study area is increasing substantially each year. In 1950, 64 million short tons of goods were transported, and in 1964 a total of 311.2 million short tons

of goods were moved on the river. Major goods include petroleum and chemical products, grain, coal, and coke.

24. Flood control measures of the MR&T Project are concerned primarily with the construction and maintenance of main-line levees on both sides of the Lower Mississippi River and its major tributaries. Although the flood control measures are not scheduled to be fully operational until 1995, main-line levees are designed for a flood discharge of 2,710,000 cfs, which corresponds to 104.4 ft msl at Vicksburg. The flood of record (as modified for a leveed floodplain) occurred in 1929 with a discharge of 2,270,000 cfs or 100.5 ft above sea level. This flood would have been about 4 ft lower than the existing main-line levee.

PART V: HABITAT TYPES

25. A total of 14 distinct habitat types were identified within the study area in the Lower Mississippi River, river mile 480 to 530 (Table 1). All areas were located between the main-line levees. Habitat types were identified from base maps prepared by the U. S. Army Engineer Comprehensive Survey in 1975, scale 1:20,000, black and white aerial photography (18 June 1976, 18 December 1978, and 5 December 1978), and by ground observation. The number of acres in each habitat type was measured from the base maps by use of a polar compensating planimeter. For the purposes of this habitat analysis, mapping was conducted at three river stages: low flow (+13.2 ft), average flow (+24.6 ft), and high flow (+38.4 ft). These river stages are at the Greenville, Mississippi, gage (river mile 531.3). Flood stage at this gage is +48 ft while late summer or early fall low stages are usually less than 10 ft. Additional information on habitat characteristics in the study area appears in Report 2 of this series.

26. Out of the 14 habitats identified, the 12 types described in the following paragraphs were sampled for the pilot study on the Lower Mississippi River (Figure 2).

Main Channel

27. This included the thalweg and on either side up to the -10-ft low-water reference plane (LWRP). For the bendways the main channel was considered to lie between the -10-ft LWRP on the convex (inside) bank and the toe of the concave (outside) bank. Each station on the main channel was defined as a zone approximately 1 mile long and equal to the width of the river channel. Sample sites in this habitat type were characterized by deep, usually turbid, fast-moving water. The bottom was well scoured and consisted of coarse sand and gravel.* Nine

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* Sediment size was determined by wet sieving with standard U. S. Geological Survey (USGS) sieves. Particle size was: mud (<125 m), fine sand (125-250 μm), sand (250-500 μm), coarse sand (0.5-2.0 μm), and gravel (>2.0 μm).

Table 1

Acres and Percentage of Total Acres in Each Habitat Type Along the Lower Mississippi River, River Miles 480 to 530 at Different Flows*

Habitat Type	Low Flow		Average Flow		High Flow	
	Acres	Percentage of Total Acres	Acres	Percentage of Total Acres	Acres	Percentage of Total Acres
Main channel**	8,435	45	8,435	29	8,435	15
Permanent secondary channel**	530	2	630	2	630	1
Temporary secondary channel**	708	4	990	3	2,553	5
Natural sandbars**	962	5	2,397	8	6,285	11
Natural banks**	166	1	281	1	448	1
Revetted banks**	842	5	1,536	5	1,791	3
Dike field sandbars**	848	5	7,393	26	10,441	18
Dike field pool areas	311	3	600	2	0	0
Abandoned river channels (Type I)**	801	4	1,424	5	2,230	4
Abandoned river channels (Type II)**	1,860	9	1,860	7	1,860	3
Oxbow Lake**	2,191	12	2,309	8	2,309	4
Borrow pit**	826	4	1,165	4	4,798	8
Inundated floodplain**	0	0	0	0	15,122	27
Sandbar slackwater pools	101	1	0	0	0	0
Total	18,581	100	29,020	100	56,902	100

* Recorded on Greenville, Mississippi, gauge at river mile 531.3.
** Sampled during the pilot survey.

sample sites were studied on the main channel of the Lower Mississippi River. Sample sites were at river mile 506, 509, 512, 514, 517, 521, 524, 527, and 530 and are labeled 1a to 1i, respectively, in Figure 2.

Permanent Secondary Channel

28. This habitat type was connected to the main channel and carried less than 40 percent of the discharge for the year. The only permanent secondary channel in the study area ranged from 10 to 40 ft deep at the upper end and was approximately 20 ft deep at the lower end. Current was equal to or less than main channel velocities. The substrate was composed primarily of sand with patchy areas of very fine to coarse sand. The sample site was at American Cutoff, northeast of Lake Towhead at river mile 525 to 528.6.

Temporary Secondary Channel

29. The temporary channel was at an elevation greater than 0 ft LWRP and carried less than 40 percent of the discharge of the Lower Mississippi River. A secondary channel exists during high flows and can revert to a slack-water pool at low flow. During low flow in the summer of 1978 the sample site at this habitat type contained slowly flowing water but was not passable by boat. The bottom was composed primarily of sand mixed with gravel. The sample site was at Kentucky Bend, north of Kentucky Bend Bar at river mile 515 to 519.

Natural Sandbars

30. Sandbars were found between the edge of the water and the main channel down to -10 ft LWRP. Typically, water was shallow and the current was reduced over this habitat type. The sandbars were composed of sand with patches of fine and coarse sand. The size of the sandbar varied according to river stage. Sample sites were at the upstream end of Lakeport Towhead at river mile 528 to 529 and at the downstream end of Kentucky Bend Bar at river mile 515 to 516.

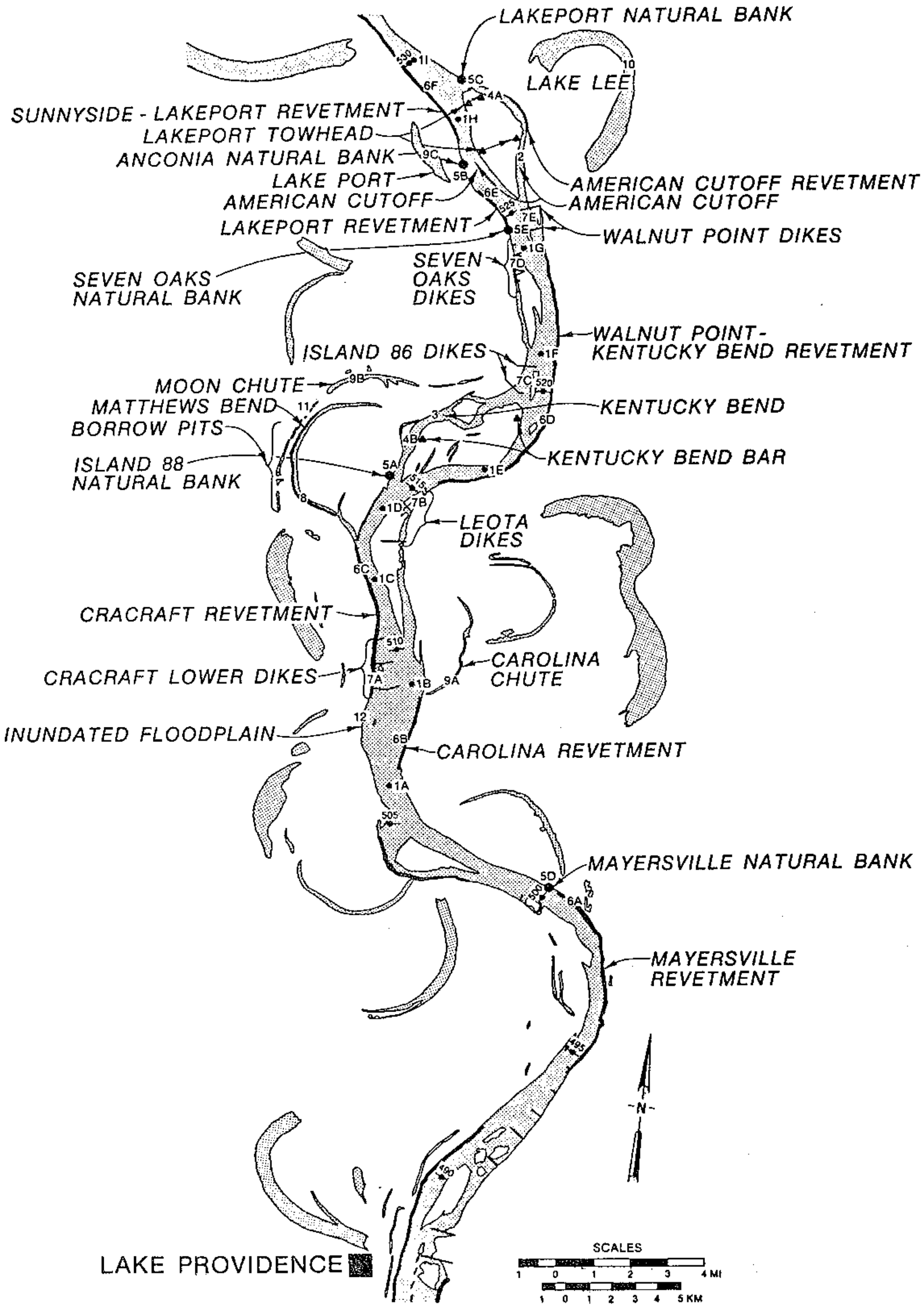

Figure 2. Habitats sampled during the Pilot Study, Upper Mississippi River, April to October 1978

Sample Site	Reference No.
Main Channel	
River Mile:	
506	1a
509	1b
512	1c
514	1d
517	1e
521	1f
524	1g
527	1h
530	1i
Permanent Secondary Channel	
American Cutoff	2
Temporary Secondary Channel	
Kentucky Bend	3
Natural Sandbars	
Lakeport Towhead	4a
Kentucky Bend Bar	4b
Natural Banks	
Island 88	5a
Anconia Natural Bank	5b
Lakeport	5c
Mayersville	5d
Seven Oaks	5e
Revetted Banks	
Mayersville	6a
Carolina	6b
Cracraft	6c
Walnut Point-Kentucky Bend	6d
Lakeport	6e
Sunnyside-Lakeport	6f
Dike Fields	
Cracraft Lower Dikes	7a
Leota	7b
Island 86	7c
Seven Oaks	7d
Walnut Point	7e
Abandoned River Channel (Type I)	
Matthews Bend	8
Abandoned River Channels (Type II)	
Carolina Chute	9a
Moon Chute	9b
Lake Port	9c
Oxbow Lake	
Lake Lee	10
Borrow Pit (near Matthews Bend)	11
Inundated Floodplain	12

Reference numbers for Figure 2

Natural Banks

31. This habitat type was adjacent to the river and had a steep bank consisting primarily of hard cohesive clay. The natural banks were considered to extend from the shore to the main channel bed. Compared with the main channel, the current was moderate along the natural banks at all times except during high flow. Where portions of the banks had collapsed there were fallen trees which often trapped other logs and debris. Sample sites were:

- a. Island 88 Natural Bank, the right bank at river mile 514.8 to 515.2 in Kentucky Bend Chute.
- b. Anconia Natural Bank, the right bank at river mile 526 to 527.5 downstream of Sunnyside-Lakeport Revetment and upstream of the Lakeport Revetment.
- c. Lakeport Natural Bank, the left bank at river mile 528 to 529.
- d. Mayersville Natural Bank, on the left bank of the river at river mile 500.
- e. Seven Oaks Natural Bank, on the right bank of the river at mile 524.

Revetted Banks

32. These were areas along the river where a structure was placed to protect the bank. All of these structures consisted of articulated concrete mattress (ACM) with riprap or asphalt on the upper bank. Currents were similar along the revetted banks to flow rates in the main channel. Substrate consisted primarily of the revetting material with isolated areas of sand and silt. With the exception of one site (the Carolina Revetment) all of these areas contained little or no vegetation on the upper bank. Sample sites were:

- a. Mayersville revetment (river mile 494.5 to 501.1, left bank). This was constructed in five stages from 1949 to 1978. The section from river mile 499.6 to 501.1 was constructed during the pilot study in 1978; prior to this it was classified as a natural bank.

b. Carolina Revetment (river mile 506.5 to 509.8, left bank). This was built in 1955, 1958, and 1959. At this site there were considerable numbers of willow trees growing through the asphalt over riprap on the upper bank.

c. Cracraft Revetment (river mile 508.8 to 512.6, right bank). This bank was constructed from 1943 to 1968. Cracraft revetment below river mile 511 is influenced by the Cracraft Lower Dikes and was considered part of that habitat type.

d. Walnut Point-Kentucky Bend Revetment (river mile 516 to 523, left bank). This was developed during the years 1944 to 1968.

e. Lakeport Revetment (river mile 524.8 to 526, left bank). This was constructed from 1961 to 1962.

f. Sunnyside-Lakeport Revetment (river mile 527.5 to 532.5, right bank). This was constructed in 1923, 1959, and 1966. Only the lower 3 miles of this revetment (built in 1954) were sampled during the pilot survey.

Dike Fields

33. Dikes are transverse structures that are constructed of quarry-run limestone rock fill or wooden piling and project into the river from the bank. Dikes, occurring singly or in small groups, are usually perpendicular to the direction of the river at low flow or project slightly upriver. Dikes are usually placed no lower than -10 ft LWRP. At high flows the current is swift and water can top the dikes by 20 to 30 ft. At low discharge the dikes are as much as 10 or 12 ft above the water level.

34. A total of five dike fields, consisting of from two to five dikes each, were studied in the pilot survey. Data on the physical characteristics of these structures and the associated sediments and vegetation appear in Tables 2 and 3, respectively.

35. All dikes studied have been constructed since the early 1960's. The Seven Oaks Dike Field had additional work done on dikes 2 and 3 in the 1970's. In 1972, 1060 ft were added to dike 2. This portion was tied to the original dike 300 ft from shore and now angles upriver. New elevations are +14 ft at the tie-in point and +7 ft in the main channel. In 1973, 2500 ft were added to dike 3 of the Seven Oaks

Table 2

Physical Characteristics of Five Dike Fields Studied During Pilot Survey, Lower Mississippi River, April to October 1978

Dike Field	River Mile	Bank	Design	Purpose	Dike No.*	Length ft	Elevation ft	Construction Date
Cracraft Lower	506.5-511.0	Right	Stepped down, stone construction	Secondary channel closure and point bar stabilization	1	1834	+16	1971
					2	3620	+14	1971
					3	4320	+13	1972
Leota	510.0-515.5	Left	Stepped down, stone construction	Secondary channel closure and point bar stabilization	1	1080	+16	1968
					2	2340	+15	1968
					3	3710	+12	1968
Island 86	518.9-521.0	Right	Transverse, stone construction	Secondary channel closure and point bar stabilization	1	2880	+12	1971
					2	3660	+16	1971
Seven Oaks	521.0-524.2	Right	Piling and stone	Channel alignment	1	660	+13	
					2	1360	+8	1962-1963
					3	2010	+5	1962-1963
					4	515	+14	1962-1963
					5	670	+14	1962-1963
Walnut Point	524.4-525	Left	Transverse, stone construction	Secondary channel closure	1	2925	-2	1970
					2	1670	-8	1970

* Dikes are numbered sequentially from upstream to downstream.

Table 3

Vegetation, Substrate Type, and Sedimentation Characteristics at Five Dike Fields as Noted During Pilot Survey, Lower Mississippi River, April to October 1978

Dike Field	Vegetation	Substrate	Sedimentation
Cracraft	Dense woods along the bank about 1 mile below dike 3 are inundated at high flows	Mud is found above and below the dikes near shore. Plunge pools between the dikes have coarse sand, and below the dikes the substrate is sand/fine sand and sand/mud	Extensive sand and gravel bars were found between the dikes and downriver for 3 miles. Deep plunge pools occurred behind each dike
Leota	Isolated areas of willow and cottonwood trees occur on the middle bars and in shallow areas between dikes. On the bank below dike 3 the area is heavily vegetated	Predominantly coarse sand throughout the dike field. Several small gravel bars and and clay banks were in these pools	Extensive sand and gravel middle bars were found between dikes 2 and 3. Sedimentation below each dike has developed small shallow pools between dikes at low water. Below dike 3 the pool was fairly large
Island 86	Isolated areas of woody vegetation occur above dikes 1 and 2 and along the bank	Sand and coarse sand	Extensive sedimentation below both dikes has resulted in the creation of sloping sandbars visible at low water
Seven Oaks	Vegetation was scarce except upstream of dike 5	Predominantly medium to coarse sand, small areas of gravel, fine sand, and clay banks were noted	Middle bars are found above and below dike 3. Below dike 5 a large bar is visible at all water stages. Small isolated pools are present below dikes 1, 2, and 4
Walnut Point	Vegetation was absent, except for the bank and wooded island near the bank below dike 1	Coarse sand	Both dikes are almost completely covered with sand, and a small middle bar extends below dike 1

Dike Field. The new section originated from the bank 100 ft downstream and tied into the main channel end. New elevations are 14 ft above LWRP (for a total of 200 ft), down to -5 ft LWRP at the channel end. Sample sites were the Cracraft Lower Dike Field, the Leota Dike Field, the Island 86 Dike Field, the Seven Oaks Dike Field, and the Walnut Point Dike Field.

Abandoned River Channel (Type I)

36. Abandoned river channels were slack-water areas contiguous to the main channel during periods of high and low flow on the river. The abandoned channel studied during the pilot study, Matthews Bend, was 5 miles long from its head to its confluence with the Mississippi River. The substrate consisted of mud, and the water exhibited no current except during periods of high river discharge. The adjacent floodplain was heavily vegetated with living and dead black willow and cottonwood trees. These trees were inundated with varying depths of water during periods of high discharge. The sample site was at Matthews Bend at river mile 513.

Abandoned River Channel (Type II)

37. These areas were not contiguous with the Mississippi River except during periods of high water. Typically these habitats were shallow, nutrient-rich waters with a substrate composed mainly of mud. Three separate areas were sampled:

a. Carolina Chute. This channel was approximately 4 miles long and joined the river at mile 508.9, left bank, during high flow. The upper portion of the Carolina Chute was shallow and covered with trees and hydrophytic vegetation.

b. Moon Chute. This area was about 2.5 miles long and contiguous with Matthews Bend. At its upper end, at about river mile 517, Moon Chute was shallow with a stand of dense vegetation. To the north the water was deep and adjacent to tree-lined banks. On the south side the water was shallower and was bordered by farmland.

c. Lake Port. This site was on the right bank at river mile 526.5 to 528.5 and had no obvious connection with the main channel. Lake Port was about 1.7 miles long and one-half mile wide. Dead willow trees extended from 50 to 100 yd into the lake on all sides. The banks were vegetated with mixed lowland trees, shrubs, and grasses. At its deepest point Lake Port was 17 ft deep; the upper one-third consisted of a shallow mud flat.

Oxbow Lake

38. Oxbow lakes are crescent-shaped water bodies between the main levees that connect with the Mississippi River only at high water if at all. Oxbow lakes were formed by the natural cutoff of a bendway or meander loop. The sample site was at Lake Lee at river mile 528 in Chicot County, Arkansas, and Washington County, Mississippi. Lake Lee was about 6 miles long, shallow at both ends, and up to 40 ft deep in the center two-thirds. The concave bank on the left side was steep and covered with grass, shrubs, and woody vegetation. The right bank was gradually sloping and contained dense lowland vegetation.

Borrow Pit

39. Borrow pits, located within the main-line levees, were formed by excavation of fill material to be used for levee construction. The sample site was at one borrow pit near Matthews Bend. This site occupied about 3.7 acres and had a maximum depth of 10 ft. Bottom material consisted of soft mud. Standing timber remained in the center of this borrow pit, and clumps of *Typha* sp. were scattered along the shoreline. Bank vegetation consisted of trees, brush, and grasses.

Inundated Floodplain

40. The inundated floodplain consisted of about 15,122 acres or 27 percent of the total study area during high-flow conditions. During medium and low flow, this area was completely dry. The inundated floodplain was sampled for fish near Cracraft Dike Field.

PART VI: RELATED STUDIES

41. Ecological studies on large rivers in the east and southeast are uncommon when compared with the tremendous volume of literature on small streams and lakes; i.e., Hynes (1960, 1970), Pennak (1953), Macan (1975), Hart and Fuller (1974), Edmondson (1966), and Frey (1966). Large rivers, with their deep, turbid waters, fast currents, frequent fluctuations in level, and presence of recreational and commercial traffic, are difficult to study. However, some studies of water pollution problems on large rivers such as the Ohio River and associated tributaries have been conducted by Purdy (1923), Love (1956), Mangan (1956), Tebo (1965), Streeter and Phelps (1958), and Crohurst (1933). Fishery studies in rivers such as the Ohio, Mississippi, and Monongahela Rivers have been conducted by Lachner (1956); Evermann and Bollman (1886); Rafinesque (1820); Trautman (1957); Jackson (1962); Smith, Lopinot, and Pflieger (1971); and Johnson et al. (1974). Water quality data on large rivers are compiled by the U. S. Geological Survey NAWDEX/NASQUAN system and have been reported by Anderson (1963), the University of Louisville (1974), and the U. S. Army Engineer District, Louisville (1977). Biological studies of large river systems have been conducted by Woods (1965a, 1965b), Seilheimer (1963), Riley (1969), Nall (1965), Panitz (1964), Jackson and Wieise (1962), Hartman (1965), Brinkley and Katzin (1962), and the University of Louisville (1974).

42. The use of artificial substrate samplers has played a large part in the assessment of large river benthic populations. Elbert (1978) collected and identified benthos from basket samples placed at lock and dam structures in the Ohio River. He calculated species diversity by numbers and biomass and defined the optimal sampling conditions for benthos by use of these samplers. Brooks (1971), Mason and Sublette (1971), and Mason et al. (1973) analyzed the efficiency of several artificial samplers in various large rivers. Mason, Lewis, and Anderson (1971) and Anderson and Mason (1968) analyzed both benthos and water quality at a series of stations on the Ohio River using a variety of sampling techniques and artificial substrate samplers.

43. Bank protection measures such as riprap, fences, and pavements are common on large and small rivers. Dikes, bendway cutoffs, and dredging operations are usually restricted to the larger waterways. A discussion of different types of streambank protection measures appears in Keown et al. (1977), and descriptions of design of spurs and guide banks are found in Richardson and Simons (1974).

44. Numerous studies of the impact of navigation development on large rivers have been done. A complete analysis of development and the environmental and cultural impacts of the McClellan-Kerr Arkansas River system, which includes dredging, snagging, bank stabilization, and operation and maintenance of navigational structures, has been completed recently. The U. S. Army Engineer Tulsa District prepared an Environmental Impact Statement (U. S. Army Engineer District, Little Rock 1979) and contracted for environmental studies concerning this action (U. S. Army Engineer District, Tulsa 1979). Reports from the Institute for Water Resources (1977a, 1977b, 1979) deal with environmental impacts and changes to the local population associated with development of the Arkansas River navigation system. The Arkansas Water Resources Research Center (1976, 1977) conducted baseline and impact studies of phytoplankton, zooplankton, benthos, and fish within the Arkansas River navigation system. In a related study, Jennings (1979) analyzed the aquatic habitats associated with notched dikes in the Missouri River. In addition, Robinson (1980) and Segelquist (1980) have conducted surveys on the benthic assemblage associated with dikes in the Missouri River. On a smaller scale, the impacts of stream channelization, snagging, and clearing have been documented by Schmal and Sanders (1978), Griswold et al. (1978), and Marzolf (1978).

PART VII: USE OF DIKES AND REVETMENTS IN LARGE RIVER SYSTEMS

45. Dikes have been placed in major rivers by the CE for many years. The Lower and Middle Mississippi, Missouri, and Arkansas Rivers all have a considerable number of dikes. Dikes are used to adjust channel width, depth, and alignment and to close secondary channels and chutes. Dikes are probably the most effective and inexpensive means of channel alignment and constriction in use today.

46. In the past, dikes have been constructed of permeable wooden piles, although today most are composed of stone riprap. These structures can be placed along a river singly or in series to form a dike field. Most dikes are transverse and extend directly out from the bank, perpendicular to the current. Occasionally, an extension or L-head is placed at the offshore end parallel to the current to retard scouring and turbulence. A vane dike is placed in the channel and lies either parallel or oblique to the current.

47. Water is shunted by a dike toward the opposite bank, and the river channel is deepened by scouring. Dikes typically are placed on the convex side of a bendway or in straight reaches to achieve some degree of channel sinuosity and constriction. Suspended sediments are carried below dikes and settle in areas where current velocities are reduced. In dike fields sediment accretion may be appreciable; these accumulated sediments can further serve to confine the flow of water. Additional information on dikes may be found in Richardson and Simons (1974) and Keown et al. (1977).

48. Despite the large number of dikes in many of the major river systems of the United States, the ecological effects of these structures are not well-known. Data on the environmental characteristics and habitat value of these structures could be used to assist in designing these structures to meet environmental quality objectives.

49. Revetments are installed along riverbanks to prevent erosion. Although variable in design, these structures usually consist of an erosion-resistant material, which is placed on a pregraded bank from the top to the toe of the channel. In navigation and flood control projects,

revetments are usually placed on the concave bank and in association with dike fields. Revetments are also constructed on banks where erosion threatens.

50. Revetments can be constructed from stone riprap, asphalt pavement, or ACM. In the past, asphalt was frequently used instead of riprap for bank paving. Prior to this, willow mats were used.

51. When a riverbank is revetted, its natural character is altered. Several variables should be considered when evaluating the effects of a revetment. Older revetments that have large sediment deposits and have become vegetated with grasses, sedges, and sapling-sized willow and cottonwood trees usually provide more diverse habitat for wildlife than a newly constructed structure. Based on a preliminary observation, stone riprap can provide a more productive substrate for invertebrates than asphalt can. Revetments placed on sinuous banks provide a better fish habitat than do structures built on straight banks. When the bank is not straight, water velocities along the shore are reduced, providing a more desirable fish habitat.

52. The distribution, abundance, species composition, and diversity of organisms in free-flowing waters are dependent on such variables as geomorphology, flow, sediment load, water quality, critical water temperatures, and substrate size. Other factors such as land-use practices, terrestrial vegetation types, runoff rates, and physiography also affect the character of the aquatic biota.

53. The navigational structures placed in a large river can affect some or all of these variables. Not only are sedimentation rates, depths, and flow characteristics altered, but the structures themselves can provide substrate for benthic species and congregators for fish. The purpose of the Waterway Field Studies is to assess the magnitude of both the positive and negative impacts of navigational structures on the aquatic organisms in a major waterway.

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In accordance with letter from DAEN-RDC, DAEN-ASI dated 22 July 1977, Subject: Facsimile Catalog Cards for Laboratory Technical Publications, a facsimile catalog card in Library of Congress MARC format is reproduced below.

Miller, Andrew C.
Aquatic habitat studies on the Lower Mississippi River, river mile 480 to 530 : Report 1, Introduction / by Andrew C. Miller (Environmental Laboratory, U.S. Army Engineer Waterways Experiment Station) ; prepared for Office, Chief of Engineers, U.S. Army. -- Vicksburg, Miss. : U.S. Army Engineer Waterways Experiment Station ; Springfield, Va. : available from NTIS, 1981.
34 p. : ill. ; 27 cm. -- (Miscellaneous paper / U.S. Army Engineer Waterways Experiment Station ; E-80-1, Report 1)
Cover title.
"March 1981."
"Under EWQOS Work Unit VIIB."
Bibliography : p. 30-34.

1. Benthos. 2. Environmental engineering. 3. Fresh water fauna. 4. Fishes. 5. Marine biology. 6. Mississippi River. I. United States. Army. Corps of Engineers. II. United States. Army Engineer Waterways Experiment Station. Environmental Laboratory. III. Title

Miller, Andrew G.
Aquatic habitat studies on the Lower Mississippi : ... 1981.
(Card 2)

IV. Series: Miscellaneous paper (United States. Army Engineer Waterways Experiment Station) ; E-80-1, Report 1
TA7.W34m no.E-80-1, Report 1